AN ANALYSIS OF DIVERSITY IN AGRICULTURAL LAND USE IN OREGON

by

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AN ANALYSIS OF DIVERSITY IN AGRICULTURAL LAND USE IN OREGON

ABSTRACT. An index suitable for measurement of the diversity of agricultural land use is developed. This index is based on a principle of measuring the deviation of a distribution from an even distribution and is similar to indexes employed to measure diversity in manufacturing. The index is applied to the thirty-six Oregon counties, using land use data from the 1964 Census of Agriculture. The association of diversity, as measured by the index, with several physical and cultural variables in Oregon counties is then evaluated.

This paper is concerned with measurement and analysis of the diversity of agricultural land use in Oregon. The first objective is the development of a satisfactory means of measuring agricultural diversity and the application of this measurement to counties within the state. An evaluation of the association of diversity with several physical and cultural variables will follow. Primary concern throughout the paper is with the abstracted quality of diversity rather than with particular elements of land use.

The condition of diversity in agriculture is of interest for several reasons. Qualitative use of the term is common. It is often applied to the agricultural or industrial activities of a region, generally in a favorable sense. It usually implies that a region contains a wide variety or relatively full range of agricultural or industrial activities. The condition of diversity in agriculture may affect the economic stability of a region. Diversified agriculture may make more efficient use of the agricultural resources of some regions than specialized agriculture. A diverse agricultural economy may be better able to fulfill a goal of regional self-sufficiency.

Commercial agriculture is more notable for specialization than for diversity. Concentration on the most profitable crop is a natural result when agriculturalists produce for a market rather than for home consumption. Diversity, however, may enhance the economic stability of a region or an individual farm. If productive effort and income are divided among a number of enterprises, the effects of income fluctuation from any single enterprise may be cushioned by other income sources. Adjustments away from declining sources of income or toward profitable sources may be easier in an area where a variety of enterprises already exists and agricultural practices and the institutional framework are not keyed to a single commodity.

Economic difficulties have occurred in regions of agricultural specialization when the major commodity underwent large price fluctuations or a long term price decline. The single-crop economy of the old American cotton belt has been identified as a factor in the economic problems of that region. This area is presently noted as having diversified its agricultural economy.[1] Other regions where agriculturalists have concentrated on a single export commodity, such as the coffee and the cacao producing areas of Brazil, have also experienced severe problems when prices for that commodity declined.

A diversified pattern of land use and agricultural production may make more efficient use of a diverse variety of agricultural and human resources. A diverse pattern of land use may be the most effective adjustment in a region with a wide array of agricultural resources. In addition, farmers may be able to make more efficient use of their time and avoid seasonal underemployment by carrying on a number of enterprises.

There may be advantages to regional self-sufficiency in agricultural production. Regions which produce a variety of commodities may enjoy a more favorable balance of payments or be more able to benefit from favorable terms of trade. If regional self-sufficiency is a goal, a diversified economy should be better able to fulfill it.

A study of Rayfred Stevens and P. R. Brandão is concerned with the problems of diversifying the agricultural economy of the Cacao Coast of Bahia.[2] This region "has long suffered from dependence on the erratic market for its main crop."[3] Stevens and Brandão noted the problems of introducing other crops, notably rubber and food crops, as well as vitalization of non-agricultural sectors of the regional economy.

Yu Hsuen Mo and Emery Castle have investigated one aspect of agricultural diversity in Oregon: its effectiveness in reducing price variability.[4] The price variability of various commodities and commodity combinations was compared over a twenty year period. They concluded that diversity was generally ineffective in reducing income fluctuations due to price variation because the prices for most commodities rose or fell together.

Diversification is presented as a positive factor in economic development in Lester Brown's study of agricultural diversification in Thailand.[5] Thai farmers, acting in response to shifting prices for export crops, have supplemented rice production with other export commodities, notably rubber, corn, cassava, and fiber crops. Brown concludes that diversification has taken place through "more efficient use of an existing stock of resources," mainly uncultivated land and seasonally unemployed labor, and has "greatly stimulated the rate of growth of aggregate agricultural output."[6] The diversification of agriculture in Thailand has reduced the susceptibility of that nation's economy to fluctuations in world rice prices, and linkage effects have "done much to raise the level of economic activity throughout the country."[7]

The entire range of problems associated with agricultural diversity; the conditions that may lead to or result from diversity, and the process of diversification over time, are beyond the scope of this paper. This study has been limited to two objectives. The first is development of a satisfactory quantitative index for the measurement of the diversity of agricultural land use and application of this index at the county level in Oregon. The second objective is to evaluate the association of diversity, as measured by the index, with agricultural specialties and several physical and cultural variables in Oregon counties.

A distinction should be made at this point between two possible approaches to agricultural diversity. Farm economists are often concerned with questions of diversity on individual farm units as they relate to the viability of the unit and efficient utilization of the farmer's time and resources. This paper, however, will be concerned with the diversity of areal units of county size without regard to the texture of diversity within the unit. Primary concern lies with the diversity of whole counties, not with the diversity of individual farms within the counties.

AGRICULTURAL RESOURCES AND INDUSTRIES IN OREGON

The state of Oregon includes a wide array of land resource conditions and types of farming. A variety of topographic and soil conditions and a marked decrease in precipitation from west to east confront farmers in various parts of the state with widely different opportunities and problems.

The Cascade mountain range, which crosses the state from north to south, marks the most distinct separation of agricultural types. West of the Cascades, precipitation is adequate for most crops. Marked summer drought is a problem that has been alleviated in many areas by supplemental irrigation. The eastern portion of Oregon lies in the rain shadow of the Cascades and lack of moisture restricts most farming operations to irrigated crops, small grains, or grazing.

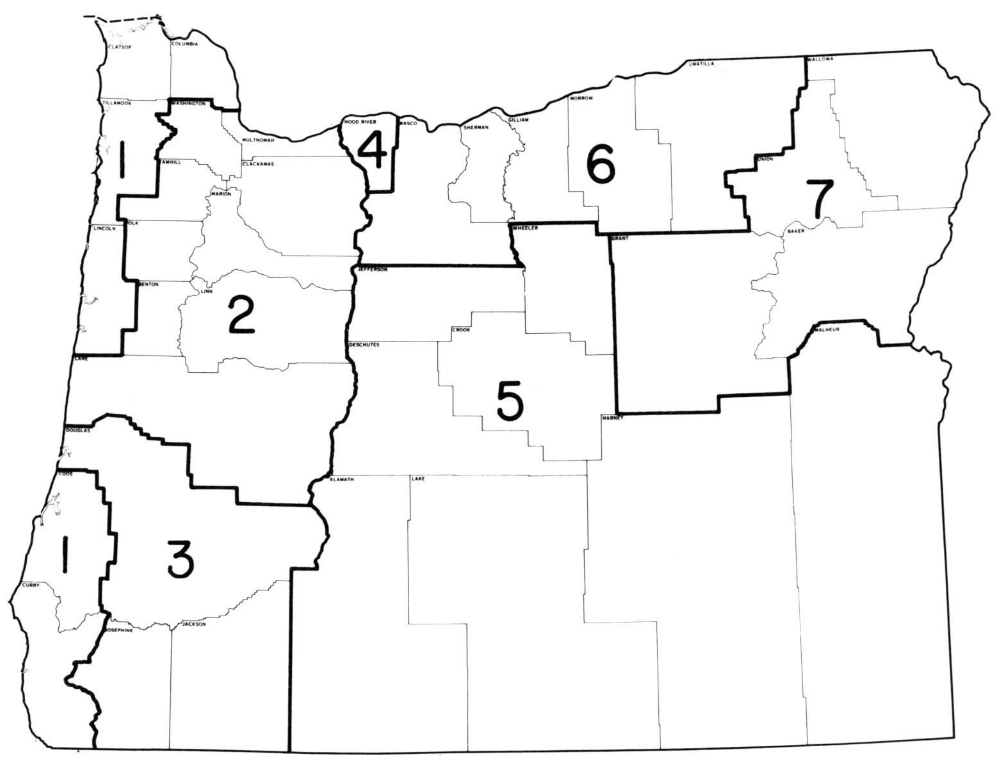
Map 1 shows generalized type-of-farming regions delimited along county boundaries. In the coastal area most land is too rugged for cultivation. Temperatures are cool and precipitation is abundant. Dairying, carried out mainly in coastal valleys, is the predominant agricultural enterprise.

The Willamette Valley contains the best agricultural land in the state. Precipitation is abundant; approximately forty inches per year throughout the valley. Supplemental irrigation is widely practiced to offset the summer drought. Agricultural land in the valley totals about 1.7 million acres on bench terraces and

MAP 1 – GENERALIZED TYPE-OF-FARMING AREAS

1. Pacific Coast: Dairy, livestock, and specialty crops
2. Willamette Valley: Dairy, seed crops, fruit, vegetables
3. Southern Oregon: Fruit and general farming
4. Hood River County: Specialized orchard crops
5. Central and Southeastern Oregon: Grazing, irrigated farming and hay
6. Columbia Basin: Small grains and grazing
7. Northeastern Oregon: Grazing and hay crops

Source: Bonneville Power Administration,
Economic Base Study for Power Markets



recent alluvial soils.[8] Dairying and the attendant production of forage crops are noteworthy. The area is also an important producer of grass seed, fruits and vegetables, and specialty crops such as mint oil. Most farms are prosperous and their average size is larger than those of most humid regions.[9]

Southwestern Oregon is a mountainous region and agriculture is confined to several fairly extensive lowlands. Livestock enterprises and orchard crops, particularly pears, are important.

Hood River county is also notable for orchard crops. This county lies within the Cascade mountains but a broad valley provides excellent sites for the production of apples, pears, and cherries.

The semiarid Columbia Basin region of eastern Oregon is a major producer of wheat. Precipitation varies from twelve to twenty inches over the area, making summer fallow rotation necessary in most localities. Farms are large, averaging about 2000 acres, and operations are highly mechanized. Peas are an important rotation crop in the eastern part of the region and range livestock grazing is an adjunct to many farm operations.

In central and southeastern Oregon lack of moisture restricts most farmers to irrigated crops and grazing operations. Extensive grazing of cattle and sheep is the leading type of agricultural enterprise throughout most of the area. Hay production, usually under irrigation, is widespread. Irrigated land in central Oregon and northern Malheur county produces potatoes, sugar beets and forage crops.

Extensive grazing is also the leading enterprise in mountainous northeastern Oregon, with most cropland devoted to forage crops for winter feeding of livestock.

MEASUREMENT OF DIVERSITY

The first requirement for establishing a measurement of diversity is a satisfactory definition. The term may be used in more than one sense. It may imply the presence of widely varied activities in an area. It may also imply a "balanced" economic structure, but use of such a definition leads to the difficult task of defining "balanced economic structure."[10] Furthermore, a condition of balance may be considered one of the benefits to be gained from diversity rather than a necessary component of it. For this paper the term will be taken to mean the presence in a region of a comparatively full range of agricultural enterprises. This definition avoids such subjective terms as "balance" and "variety" and is sufficiently objective to provide a basis for quantitative measurement.

Quantitative indexes for the measurement of diversity have been developed in the past, usually for application to diversity in manufacturing rather than agriculture. The basis of most of these indexes is a Lorenz curve analysis; a measurement of the deviation of a distribution from an even distribution.

<u>Literature on the measurement of diversity</u>

The earliest effort to measure diversity was an analysis of diversification in American cities by Glen E. McLaughlin.[11] McLaughlin actually measured the concentration of industry in American cities. He obtained two values, one by adding the per cent of the total value added in manufacturing accounted for by the five largest industries and the other, by adding the values for the twenty largest industries in each of fourteen American cities. These values indicated the proportion of a city's industry that was concentrated in a few industrial groups and, conversely, gave an indication of diversity.

R. C. Tress, in 1938, was the first to use the method of measuring deviation from an even distribution.[12] Tress used equal employment in twelve industrial categories as the criterion for an even distribution or "greatest diversity." A crude index of diversity for each areal unit was obtained by calculating the per cent of total employment accounted for by each industrial group, ranking the groups from largest to smallest, and adding the accumulated percentages. A refined index of diversity expresses the position of the crude index on the possible range between "greatest diversity" and "least diversity," the latter being a situation with all employment concentrated in a single category.

This method may be more clearly explained by an example illustrated graphically in Figure 1. In this example there are ten possible categories. Eight of them actually occur. The ranked percentages are 30, 25, 15, 10, 10, 5, 3, and 2. The situation for complete diversity, with equal employment in all categories is represented by the area under line A-C.[13] The crude index for complete diversity is 500 (10 + 20 +...+ 100). No diversity, with all employment in one category, is

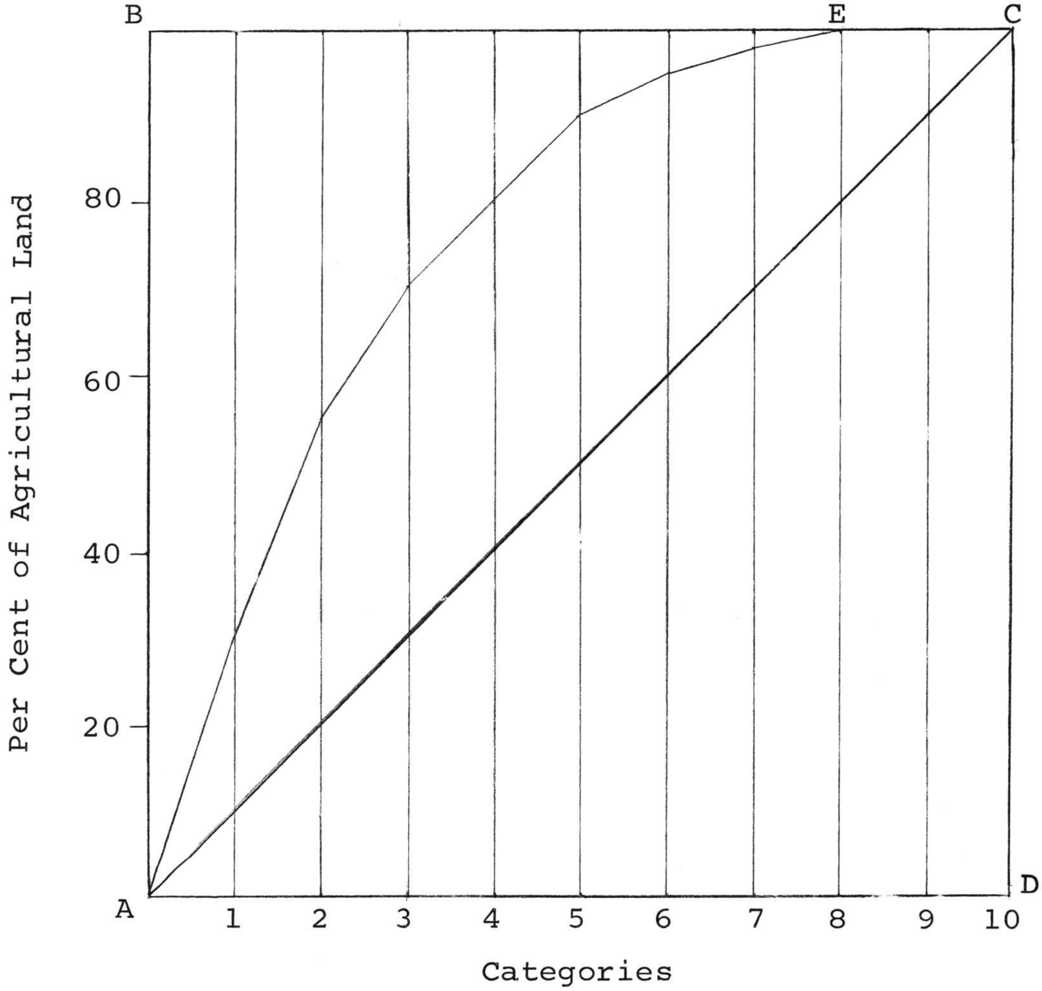


Figure I. Graphic Representation of the Diversity Index expressed by the total area, ABCD. The crude index for the actual distribution is expressed by the area under the uneven line AEC, and is calculated by adding the cumulative percentages (30 + 55 + 70 + 80 + 90 + 95 + 98 + 100 + 100 + 100) for a value of 818.

The refined index of diversity expresses the position of the curve AEC on the range between complete diversity and no diversity. Graphically, this is the area between the curve and the diagonal as a proportion of the total area above the diagonal. The refined index is obtained by the formula:

$$\frac{\text{Crude Index} - \text{Crude Index for complete diversity}}{\text{Crude Index for no diversity} - \text{Crude Index for complete diversity}}$$

in this case: $\frac{818 - 500}{1000 - 500} = \frac{313}{500} = .662$

The refined index is inversely proportional to diversity and has a possible range from zero (complete diversity) to one (no diversity).

Edgar C. Conkling used a similar index for studies of diversification in South Wales.[14] Conkling was concerned with the diversification of all aspects of the economy and used employment in the industry groups of the Standard Industrial Classification of Great Britain.

The industry groups were ranged from smallest to largest in terms of percent of employment. Conkling plotted a smooth Lorenz curve. The area beneath this curve was measured by graphic methods and a refined index was obtained by a method similar to that of Tress.

Conkling's index has two disadvantages. First, graphic measurement of the area under the curve is a laborious process. Second, there appears to be no advantage in connecting the discrete values of each class with a smooth curve.

Allan Rodgers also used a method similar to that of Tress in an analysis of diversification in 93 Standard Metropolitan Areas in the United States.[15] The major difference is the base value he employed. Rodgers used a crude index for all 93 SMA's taken together rather than a crude index for an even distribution among categories. He uses an actual situation, the average distribution over all areas rather than a theoretical "even distribution." Since the crude index for the average distribution is higher than that for an even distribution his index is somewhat more sensitive.

Rodgers' index has two drawbacks, however. The base value, average distribution for all areas, changes over time. Therefore, the refined indexes are not strictly comparable over time. Also, it is possible that some areal units may have a more even distribution than the average distribution. In this case, a negative value for the refined index would occur.

Shyam S. Bahtia developed a different type of index for studies of crop diversification in India.[16] Most of the areal units considered by Bhatia had from one to ten major crops. Therefore, he considered only crops that occupied at least ten per cent of the land of a unit. His index was obtained by dividing the per cent of the area occupied by such crops by the number of such crops. His index, therefore, is the average per cent of land occupied by crops that occupy at least ten per cent of the land.

This index is insensitive to differences in the per cent distribution of the component categories. If there are three crop categories, with values of 70, 10, and 10 per cent, the index is 30. If there are three categories; 30, 30, and 30 per cent, the index is also 30. Another problem is uneven sensitivity when the percentage of one or more categories is near ten per cent. In the first of the two examples above, a decrease from 10 to 9 per cent in one category would shift the index from 30 to 40.[17]

James Shear has proposed a general measure of diversity, based on the Lorenz curve method, that would be more widely applicable than those already discussed.[18] Shear pointed out that the number of categories employed is an important factor in the index. He also proposed a simplified method of calculation.

Since the range of possible values decreases for each successive category, Shear would calculate the index on the basis of only the three largest categories. This reduces the amount of labor necessary in calculation but yields an admittedly approximate value.

Irene Johnson also used the method of Lorenz curve analysis, or measurement of deviation from an even distribution, in a study of agricultural diversification in Georgia.[19] Johnson used counties as areal units and considered diversity on the bases of both land use and value of farm products sold.

An Index of Agricultural Diversity

The index used in this study is based on the same principle as that used by Tress; measurement of deviation from an even distribution by means of modified Lorenz curve. Briefly, the values of categories are ranked, largest to smallest; cumulative percentages are added; and the result is expressed as a proportion of the possible range from complete diversity to no diversity. The resulting value has a possible range from zero to one and is inversely proportional to diversity.

A basis for measuring the importance of each category must be chosen. The studies of industrial diversity discussed above have used employment as a measure of the importance of each category. There are at least three possible measures of the importance of agricultural categories; the amount produced, the value of production, and the acreage devoted to production. All three are enumerated in some form in the U. S. Census of Agriculture. The amount of production is enumerated as bushels for some crops and as tons for others. No measurement of the production of livestock is reported other than value of livestock sold.

Data for the value of farm products sold off the farm is enumerated. Production consumed on farms as animal feed is included only as an unknown component of the value of livestock and livestock products sold.

Furthermore, the value of farm products sold is a function of prices as well as the amount produced. Therefore, the value is subject to modification by market conditions rather than being solely determined by the actions of farmers.

A measurement of land use, the acreage of farm land devoted to each enterprise, will be employed here. This makes it possible for the index to utilize more categories. Hence, more sensitivity is obtained. Data is available for all types of land use, even if the products are consumed on farms. Finally, the values are determined solely by the actions of farmers without direct modification by pricing. The land use data employed in this report were obtained from the preliminary reports of the 1964 Census of Agriculture.

The categorization scheme employed is an important factor. As Shear pointed out, the index value is dependent on the number of categories as well as the evenness of the distribution. Indexes that employ different numbers of categories are not comparable.

The method of categorization is also a major factor in the effectiveness of the index. The shade of difference between categories should be approximately equal for the index to provide an effective expression of reality. Consider, for example, two agricultural regions, one producing wheat, barley, rye, oats, and corn, and the other producing apples, lettuce, soybeans, sugar beets, and beef cattle in the same proportions. The agricultural activities of the first region are fairly similar. They require similar practices, have similar land requirements, and have similar market situations. Those of the second region are more varied. They require widely different practices, and have widely different land requirements and marketing conditions. If the individual enterprises are used as categories, however, the index would indicate the same diversity for both. Therefore, it is desirable to categorize similar enterprises together in order to avoid this problem as well as to simplify the calculations. The categorization scheme used in this study has been arrived at subjectively, but the aim has been to place similar enterprises within the same categories.

It is also desirable to make the categorization as universal as possible so that it may be applied in other areas. The categorization scheme developed here is applicable anywhere in the United States. Four of the fifteen categories do not occur in Oregon but have been retained in order to keep the index comparable for the entire country. The categories are listed in Table 1.

TABLE I.--LAND USE CATEGORIES FOR THE DIVERSITY INDEX

Unimproved Pasture and Rangeland
Improved Pasture
Small Grains
Corn
Hay
Annual Legumes (soybeans, cowpeas, and peanuts)
Sorghums
Cotton
Orchard, Vine, and Berry Crops
Field Seed Crops
Vegetables
Dry Field Beans and Peas
Potatoes
Tobacco
Miscellaneous Field Crops

The Pattern of Diversity in Oregon

The diversity index described above was applied to all thirty-six Oregon counties. The index values are listed in Table II. Map 2 indicates the diversity of Oregon counties.

The most diverse counties in Oregon are those of the Willamette Valley. All counties with values below .8500 are Valley counties. Marion county, with an index of .7107 is the most diverse county in the state. All of the Valley counties have two leading categories, each accounting for only 20 to 35 per cent of the agricultural land. The leading categories in various counties are two of the following: unimproved pasture, improved pasture, hay, small grains, or seed crops. In addition, each county has two or three fairly strong secondary categories that together account for about 35 per cent. These secondary categories are generally pasture, hay, small grains, or orchard, vine, and berry crops.

TABLE II.--REFINED DIVERSITY INDEXES FOR OREGON COUNTIES

Baker	.9533	Lake	.9360
Benton	.7960	Lane	.8160
Clackamas	.7947	Lincoln	.9093
Clatsop	.8720	Linn	.7933
Columbia	.8667	Malheur	.9547
Coos	.9280	Marion	.7107
Crook	.9733	Morrow	.9547
Curry	.9520	Multnomah	.8067
Deschutes	.9387	Polk	.7667
Douglas	.9200	Sherman	.9360
Gilliam	.9640	Tillamook	.9147
Grant	.9813	Umatilla	.9107
Harney	.9653	Union	.8747
Hood River	.9293	Wallowa	.9493
Jackson	.9547	Wasco	.9707
Jefferson	.9307	Washington	.7960
Josephine	.8893	Wheeler	.9867
Klamath	.8987	Yamhill	.7520

Diversity is lower along the coast. Dairying predominates through the area and improved and unimproved pasture are the leading land-use categories. Land used for hay crops accounts for about thirty per cent in Clatsop and Columbia counties, lowering the index for these counties below .9000.

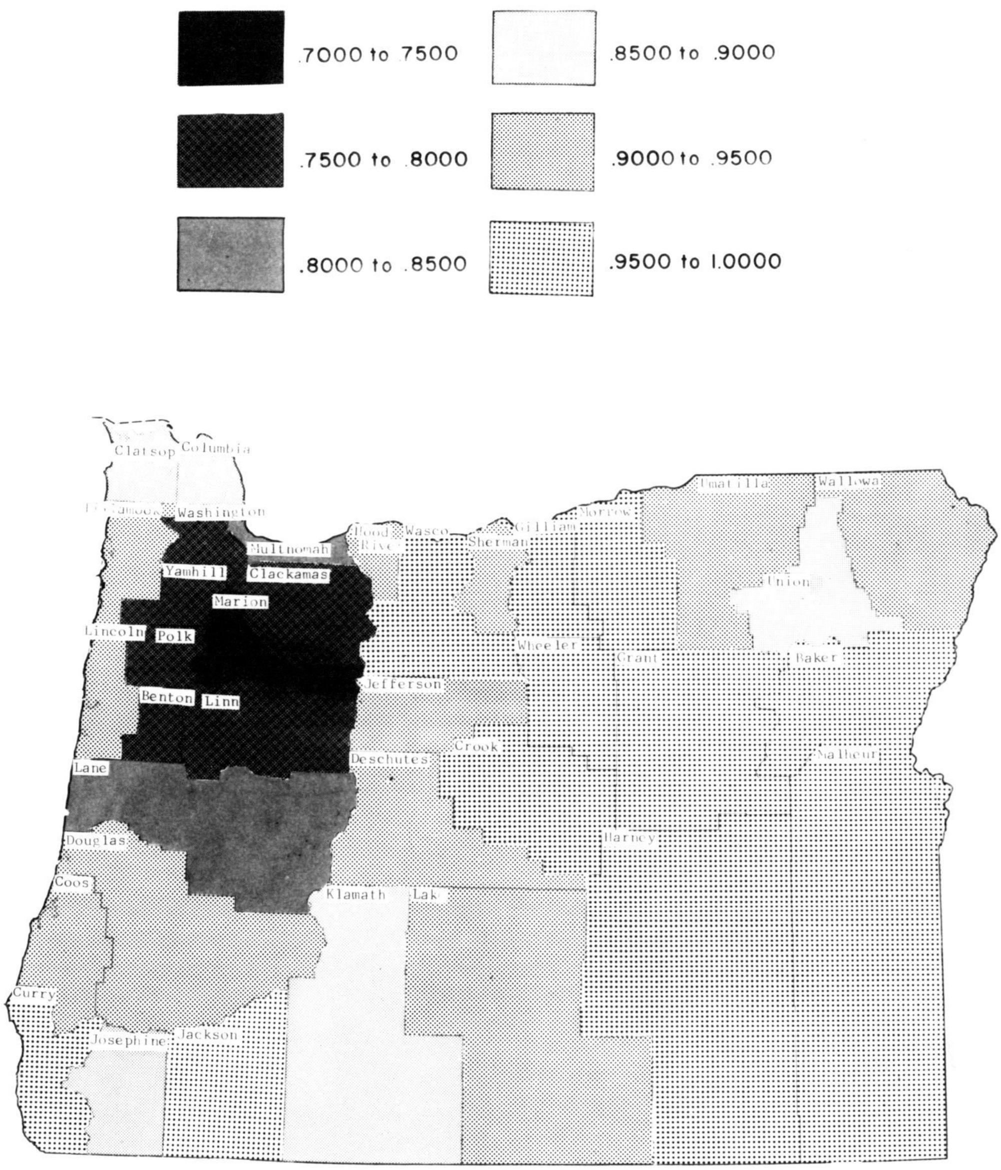
The level of diversity varies in the three southern Oregon counties. Diversity in southern Oregon is highest in Josephine county where improved pasture and hay are the largest land use categories. Unimproved pasture and improved pasture lead in less-diverse Douglas and Jackson counties.

Hood River county is strongly specialized in orchard crops. Sixty-seven per cent of this county's land is in this category. Improved pasture and hay crops occupy most of the remainder.

Diversity is low in the Columbia Basin counties where unimproved pasture and small grains are the largest land use categories. The index is somewhat lower in Sherman and Umatilla counties where the proportion of land in small grains is higher.

The level of diversity also is low in central and eastern Oregon. This area is strongly specialized in unimproved pasture with some land in hay and improved

Map 2- Refined Diversity Indexes



pasture. Higher proportions of the latter two categories, along with some production of small grains and potatoes raises the level of diversity somewhat in central Oregon.

Northeastern Oregon is also strongly specialized in unimproved pasture with some hay and improved pasture. Union county, the most diverse county in eastern Oregon, has unimproved pasture as its leading category but also includes appreciable proportions of small grains, hay and improved pasture.

SPECIALIZATION

The diversity index alone provides no indication of important elements in the agricultural economy of a county. Particular agricultural specialties may be associated with diversity, or lack of diversity. Even if consistent associations do not exist, knowledge of the important specialties in a county may be important in an analysis of diversity.

An index for indicating land use specialization in a county, compared to the nation as a whole, may be obtained by comparing the proportion of the county's agricultural land in each category with the proportion of national agricultural land in the same category. The formula for this comparison is given below.

Specialization Index for category X, county A =

$$\frac{\text{\% of county A land in category X}}{\text{\% of national land in category X}}$$

Values in excess of one indicate some degree of specialization.[20]

The base values, percentages of national land in the various categories, have been modified for the measurement of specialization in Oregon. Four of the fifteen categories, annual legumes, cotton, sorghums, and tobacco, do not occur in Oregon. Together they account for about seven per cent of the nation's agricultural land. These categories have been eliminated from the national total used to calculate the national percentage values. If they were included in the calculation of national percentages the percentages would be lower and some degree of specialization would be indicated in Oregon on the basis of crops that do not occur in Oregon rather than solely on the basis of crops that do occur.

The specialties that appear to be most strongly associated with diversity in Oregon counties are vegetables; orchard, vine, and berry crops; and field seed crops. Eleven counties have specialties in vegetable crops. None has a diversity index above .9107 (Umatilla county) and all but two have indexes below .8200. There are fourteen counties with specialties in orchard, vine and berry crops. Eight of them have indexes below .8500. Specialties in field seed crops occur only in the Willamette Valley.

PHYSICAL VARIABLES

Three physical variables were tested for association with diversity. No attempt is made here to identify causal relationships, only associations. Two hypotheses are at least partially tested. One hypothesis is that diversity is associated with a varied or diverse resource base with farmers responding by choosing a diversity of operations fitted to such a resource base. The second hypothesis is that diversity is associated with a land resource base that allows operators a broad choice of alternatives. The two hypotheses are separate and acceptance of one does not imply rejection of the other.

Diversity of the Resource Base

An index value for the diversity of the resource base in each county was obtained by a method identical to that used for the land use diversity index. The land capability classes developed by the U.S.D.A. Soil Conservation Service were used as categories.[21] Classes of land suitable only for grazing were grouped together in one category.

The amount of land in each category in each county was measured with a planimeter on a map of capability classes in Oregon.[22] Diversity indexes of land capability were developed for each county and correlated with the land use indexes by means of Pearson's product moment coefficient of correlation. The resulting correlation coefficient of -.16 indicates no association between the diversity of land capability classes and the diversity of land use in Oregon counties.

Proportion of High Quality Land

The second hypothesis is that diversity is associated with a resource base that allows farmers a broad choice of alternatives. The proportion of Class I and Class II land in each county was taken as a measure of the amount of land on which farmer's choices were not severely restricted by the physical environment.

According to the Soil Conservation Service, Class I land has "few limitations that restrict use" and Class II land has "some limitations that reduce the choice of plants or require moderate conservation practices."[23] The other classes have severe limitations for cultivation or are unsuitable for cultivation.

The proportion of land in Classes I and II in each county was correlated with the diversity indexes. The correlation coefficient of -.68 indicates a significant correlation at the one per cent level of confidence. Note that, since the diversity index is inversely proportional to diversity, a negative correlation with the index indicates a positive correlation with diversity.

Precipitation

Moisture supplies are as important as the soil and physical conditions considered in the S.C.S. capability classes in restricting the range of choice available to farmers. Therefore, a measure of precipitation in each county was correlated with the diversity indexes. The measure of average precipitation for each county was obtained by averaging the mean annual precipitation for three stations in each county. The stations chosen are located in agricultural areas. Data were obtained from publications of the U.S. Weather Bureau.[24] The correlation coefficient of -.82 between average precipitation and the diversity index indicates a strong positive association between precipitation and the level of diversity in Oregon counties.

CULTURAL VARIABLES

The association of diversity with five cultural variables was also investigated. Again, no attempt is made to identify causal relationships, only associations. The cultural variables include two measurements of land-use practices; the proportion of irrigated land and livestock as a proportion of the value of farm products sold. There is also one measurement of scale, the average size of farm; one of value of production per acre; and one of level of living of farm operators. All figures, with the exception of those for level of living, were obtained from the 1964 Census of Agriculture.

Land-Use Practices

Irrigation may affect the diversity of agriculture in a county since a broader range of enterprises is possible when moisture is adequate. To test this hypothesis the proportion of irrigated land in all farm land was correlated with the diversity indexes. The resulting correlation coefficient, .0003, indicates that no association exists.

Livestock operations may add to the diversity of an individual farm. They are often carried out on land unsuitable for other purposes and utilize the farmer's time during off seasons. Large scale livestock operations, however, usually occur in areas where other enterprises are restricted by rugged topography or low rainfall and diversity is low. The correlation between the diversity indexes and the value of livestock and livestock products as a proportion of the value of all products sold is .37. This indicates, at the five per cent confidence level, that diversity tends to become lower as the importance of livestock increases in Oregon counties.

Value of Production

An association also may exist between the value of farm production per acre and the diversity indexes. If diversity is an objective of the farmer he may substitute a lower value crop, hence lowering the value per acre, in order to diversify. On the other hand, diversity has been shown to be associated with areas of high land quality where the value of production per acre is likely to be high. The correlation coefficient, -.43, indicates that the value per acre of farm products tends to be higher where diversity is high. The diversity index was also correlated with the average value per acre of land and buildings per acre which is a human appraisal in which the potential production is probably the major factor.[25] The correlation coefficient in this case was the same, -.43.

Level of Living

Farm operator level of living indexes, published by the U.S.D.A. Economic Research Service provide a measure of the living standards of farm operators by counties in the United States.[26] The level of living indexes are derived from *Census of Agriculture* data. They are based on five factors; average value of sales per farm, average value of land and buildings per farm, and the percentage of farms with telephones, home freezers, and automobiles. A statistical technique, factor analysis, is applied to these figures to derive an index such that a county with a value of zero in each factor would have an index of zero and a county with the national average in each factor would have an index of 100.

Farm operator level of living indexes for Oregon counties were correlated with the diversity indexes. The resulting coefficient, .36, is significant at the five per cent level of confidence and indicates that levels of living tend to be higher in the less diverse counties.

CONCLUSIONS

The index used here yields a useful measure of agricultural diversity. It takes account of all types of agricultural land use and is applicable anywhere in the United States. The index values fall within a rather narrow range, however. The values for Oregon counties range only from .7107 to .9867 within a possible range of zero to one. This occurs because a large proportion of land in most counties is in unimproved pasture. On the other hand, some categories, such as vegetables and orchard, vine, and berry crops, commonly occupy small proportions of a county's land, even in counties where they are a major element in the agricultural economy. Categories that commonly occupy small acreages do not exert a large influence on the index.

Diversity in Oregon counties, as measured by the index, is associated with several physical and cultural variables. Counties with diverse agriculture are likely to have specialties in vegetables or orchard, vine and berry crops. Diversity is more likely to occur in counties with generous proportions of high quality land and abundant precipitation. The value of production per acre is likely to be higher in diverse counties. Livestock operations tend to be less important in the more diverse counties. The level of living of farm operators tends to be higher in the less diverse counties of Oregon. Identification of the exact nature of the relationships between diversity and any of these factors would require further study, however.

FOOTNOTES

1 Merle Prunty, "Land Occupance in the Southeast," Geographical Review, Vol. 42 (1952) p. 461.

2 Rayfred L. Stevens and Paulo Rebouças Brandão, "Diversification of the Economy of the Cacao Coast of Bahia, Brazil," Economic Geography, Vol. 37 (1961) pp. 231-52.

3 Stevens and Brandão, op. cit., p. 231.

4 Yu Hsuen Mo and Emery Castle, "Diversification - does it reduce Price Variation" (Corvallis, Oregon: Oregon State College Agricultural Experiment Station, Station Bulletin 569, 1959) 15 pp.

5 Lester R. Brown, "Agricultural Diversification and Economic Development in Thailand, A Case Study" (Washington: U. S. Department of Agriculture, Foreign Agricultural Economic Report no. 8, 1963) 34 pp.

6 Brown, op. cit., p. 31.

7 Brown, op. cit., p. 32.

8 Edward Higbee, American Agriculture: Geography, Resources, Conservation (New York, John Wiley and Sons, 1958) p. 163.

9 Higbee, op. cit., p. 170.

10 Allan Rodgers, "Some Aspects of Industrial Diversification in the United States," *Economic Geography*, Vol. 33 (1957) p. 16. See also Edger C. Conkling, *A Geographical Analysis of Diversification in South Wales* (Evanston Ill., Dept. of Geography, Northwestern University, 1962) p. 18 for a discussion of several senses of the term "diversity."

11 Glenn E. McLaughlin, "Industrial Diversification in American Cities," *Quarterly Journal of Economics*, Vol. 45 (1930) pp. 131-49.

12 R. C. Tress, "Unemployment and the Diversification of Industry," *The Manchester School of Economic and Social Studies*, Vol. 9 (1938) pp. 140-52.

13 Tress' terms "greatest diversity" and "least diversity" have been changed to "complete diversity" and "no diversity."

14 Conkling, *op. cit.* See also, Edger C. Conkling, "South Wales: A Case Study in Industrial Diversification," *Economic Geography*, Vol. 39 (1963) pp. 258-272.

15 Rodgers, *op. cit.* pp. 16-30.

16 Shyam S. Bhatia, "An Index of Crop Diversification," *The Professional Geographer*, Vol. 12 (1960) pp. 3-4. See also Shyam S. Bhatia, "Patterns of Crop Diversi-

fication in India," Economic Geography, Vol. 41 (1965) p. 15.

17 These difficulties have been pointed out by James Shear. See James Shear, "A General Measure of Diversity," The Professional Geographer, Vol. 17 (1965) p. 15.

18 Shear, op. cit., pp. 14-17.

19 Irene Johnson, Agricultural Diversification in Georgia (Columbus, Ohio: Ph.D. dissertation, Dept. of Geography, The Ohio State University, 1965) 164 pp.

20 This index is essentially the same as the location quotient developed by Florence, Fritz, and Gilles for the National Resources Planning Board. See P. Sargent Florence, W. G. Fritz, and R. C. Gilles, "Measurement of Industrial Distribution," in Industrial Location and Natural Resources (Washington: U.S. National Resources Planning Board, 1943) pp. 105-124. See also, Walter Isard, Methods of Regional Analysis (Cambridge, Mass.: The M.I.T. Press, 1960) p. 251.

21 See A. A. Klingebiel and P. H. Montgomery, "Land Capability Classification," Agriculture Handbook no. 210 (Washington: U.S. Department of Agriculture, Soil Conservation Service, 1961) 21 pp.

22 This map was included with: William Hill and W. L. Powers, "Land Capability for Soil and Water Conservation in Oregon," Station Bulletin no. 530 (Corvallis, Oregon: Oregon Agricultural Experiment Station and U.S. Department of Agriculture cooperating, 1953) 31 pp.

23 Klingebiel and Montgomery, op. cit. p. 6.

24 U.S. Weather Bureau, "Climatic Summary of the U.S. Supplement for 1951 through 1960" (Washington: U.S. Govt. Print. Off., 1965).

25 The agricultural census obtains this figure by asking farmers for their own appraisal of the worth of their property. It is not an appraisal for tax purposes.

26 James D. Cowhig, "Farm Operator Level of Living Indexes for Counties of the United States, 1950 and 1959," Statistical Bulletin no. 321 (Washington: U.S. Department of Agriculture, Economic Research Service, 1962) 64 pp. Level of living indexes for 1959 were used in this study because indexes have not yet been calculated from the 1964 Census data.