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CONTENTS

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FACTORS AFFECTING SELLING PRICES OF LAND IN THE ELEVENTH FEDERAL FARM LOAN DISTRICT

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INTRODUCTION

Farm land valuation is a subject which is of interest to farmers; to other buyers and sellers of land; to the accountant who would apportion costs and income among the factors of production; to the mortgage holder; to the tax assessor; to the economist studying problems of land utilization, farm organization or agricultural relief; to the congressman who would improve our public land policies; to the chamber of commerce interested in regional planning; and to the farm real estate broker whose living depends upon his knowledge of values. "At the outset let it be understood that the subject of land valuation is little explored. Economists and real estate appraisers are still feeling their way toward guiding principles."[3] Before it is possible to place reliable principles and methods of appraisal in the hands of practical minded appraisers, farmers and real estate dealers, it is necessary to develop fundamental truths regarding land valuation. To make possible the proper interpretation of the great unorganized mass of knowledge pertaining to the subject, it is necessary to use methods which have been developed by economists and statisticians.

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[2] The author is indebted to Mrs. Ruth Howe (Née Ruth McChesney) for valuable assistance in making statistical analyses and in the preparation of the manuscript.

[3] Ely and Morehouse. Elements of land economics. p. 236. The Macmillan Co. 1924.

This discussion is prepared primarily for the use of economists and statisticians working on this complex problem. When the field has been more thoroughly covered, statements can be prepared of the findings which will be much more useful to those desiring to apply them directly to problems in the field. In the meantime, the material as here presented contains information which should clarify some of the difficulties of appraisal. It might be well to caution those unaccustomed to the terminology used in parts of this paper to be patient with the instruments employed while they are making use of such material as may be gleaned from the more readable portions.

Current Methods of Farm Land Valuation.—A certain bank president speaking to a group of bankers stated that, after all, farm land appraisal is a "good guess," with all the data before you. This same bank president is noted for his use of scientific knowledge when it can be demonstrated that it might increase the accuracy of the work of his appraisers. Taylor[4] uses the principle of capitalization as the basis of his discussion of land valuation calling attention to some of the limitations of this method. Ely and Morehouse[5] state that the income of land is the basis for arriving at its value and that the process of capitalizing land income into a capital value is the "heart of the problem of land valuation." Recognizing capitalization as the heart of the problem, however, does not deter these authors from stating their position in regard to the limited usefulness of this method as the basis of appraisal. "Having laid down the principle underlying land values," they state, "we are ready to depart from it! We have assumed several figures and regarded them as fixed, whereas, in reality they are highly variable in time and place."[6]

The general method used in land valuation by the Interstate Commerce Commission is summarized in the following paragraph:

"In determining the unit of value for the zone, the appraiser will generally be governed by the sale, assessment, and opinion data. He should not, however, fall into the habit of slavishly following the average of the information obtained. The object in procuring sales, assessments, and opinions is that the appraiser may be informed as to values. The end sought is the value of the land, not the average of the data. One particular sale, known to be characteristic, might outweigh three or four other sales or a mass of other data."[7]

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[4] Taylor, Henry C. Outlines of agricultural economics. pp. 250–263. The Macmillan Co. 1925.

[5] Ely and Morehouse. Elements of land economics. pp. 239, 242. The Macmillian Co. 1924.

[6] *Ibid.*, p. 244.

[7] Artuad, T. P. Instructions pertaining to land appraisals. Interstate Commerce Com. Bureau of Valuations. p. 7. Government Printing Office, Washington, D. C. 1922.

That those engaged in practical land valuation have had to depart from capitalizing land income as a basis of valuation is illustrated in the case of values placed on undeveloped railroad land by one of the large land-holding railroad companies. "We watch the land market," says the supervisor of land sales for this company, "and place values on our lands according to the demand, making allowances, of course, for differences in topography, location, etc." Foreclosures, delinquencies, complaints, loss of business, all play an important part in the appraisal policies of banking institutions. Trial and error are the basis of the "good guesses" of values placed upon farms by the practical appraisers of these institutions. Between a high rate of foreclosures and delinquencies, on the one hand, and complaints of applicants for loans and actual loss of business on the other, the land appraiser works, using his best judgement, in the placing of values. The man of experience with a knowledge of soils, crops, crop diseases, irrigation and drainage, will do a pretty good job of guessing. No amount of technical investigation will ever replace entirely the judgment of such a practical man of experience. If, however, we can add to his knowledge by the study of relationships between some of the important qualities of land and their effect upon value, we may in time be able to increase the efficiency and the accuracy of his work.

Value or Price?—Those who place all of their faith upon capitalization of net income as a basis of value are able to think in terms of value entirely apart from price. Those whose interest in land value is entirely an evaluation of the security for the purpose of a loan, insofar as they are concerned about the ability of the farmer to make payments on interest and principal when due, are also able to think of land value entirely apart from price. The real security value, however, of a farm is its most probable selling price, taking into consideration possible changes in economic conditions. A margin must also be allowed for costs of foreclosure. A farmer buying a piece of land thinks of the value in terms of the price he must pay for it, the price he might be able to sell it for, and also in terms of the income he expects to get from it. The dealer in land thinks wholly in terms of purchase and selling prices. The economist thinks of land value as capitalized rent and a result of the difference between cost and income rather than as one of the costs. The accountant thinks of land value as so much invested capital for which interest must be paid as one of the costs of operation. The present study is an analysis of prices at which farms have actually exchanged hands and it will be assumed by the writer that the price at which any particular farm changes hands is not necessarily its value but that the most probable price at which that farm would sell on the market is its market value, and that the "level," or line of trend, of prices about which this most probable value fluctuates over a period of time will be considered as the normal value, "the term normal being taken to refer to a long period of time."[8] This does not preclude the use of income data as an index of the normal or the market value. The problem is so complex that it will be necessary to approach it from many angles. This report necessarily covers only a portion of the entire field.

Income and Selling Prices of Land as Measures of Value.—There are many difficulties to be met in the appraisal of land, either on the basis of capitalizing net income or on the basis of measuring values by the use of established relationships between selling prices and land qualities. Appraisal by either method requires a study of those elements which cause different farms to have different values.

Although the research reported in this publication has not covered factors of net and gross income as affecting land value, it should not be assumed without further investigation that similar studies cannot be made of the relationships between net and gross income and the same land qualities which have been correlated in this analysis with selling prices. Difficult as income is to determine, careful correlation of net income and land qualities may result in measures which may be used as indexes of value. Productivity and income should enter into the problem, not so much in the form of complete estimates of net income to be capitalized, as in the form of indexes of those qualities of land which are the causal factors of that net income.

Disadvantage of Appraisal on the Basis of Net Income.—Income from land is practically inseparable from the income of other elements of production; namely, labor, equipment, and management. Changing proportions of equipment, labor and land result in changing proportions of the total product due directly to the product of the soil; therefore, the income due directly to the land may be an ever changing quantity and impossible to determine. Income from land is constantly changing because of climatic and crop conditions, changing prices, and changing costs of production. The changes in land income vary over different areas at different rates. It is difficult to determine yields. The experience of one year is not sufficient. Information for a number of years can seldom be secured with accuracy. Translation of yields into net income is a difficult accounting process. It is seldom done with accuracy on account of the amount of labor involved and

[8] Marshall, Alfred. Principles of economics. p. 371. The Macmillan Co., 1920.

the need of training in farm accounting methods. The limited accuracy of available data makes impossible accurate estimates of net income. In a new region prices are not established, productivity of land is not established, crop adaptation is uncertain and the whole basis of land valuation hangs upon the future development of the surrounding country. This difficulty is common to all methods of land valuation. In evaluating land which has not been developed, there is no means, except by comparison with other farms, to determine the potential producing power. A rational basis for doing this may have been developed by some appraisers, but in most cases guess work under the name of "judgment" is the only basis of making this important step in the process of appraisal. If income can be determined, its capitalization into value is dependent upon the selection of "the current rate of discount." The current rate of discount may vary between wide extremes according to the character of the security, the condition of the money market, and the personality of the borrower. In general, income from land tends to increase while income from capital tends to decrease. This would cause an ever increasing divergence between the rate used in capitalization and the actual land income.

Finally, income from land is not the only factor determining land value. Not even when all of the indirect sources of income are considered does the income necessarily indicate value, if we are to define value as the most probable selling price. Alternative opportunities in other business is often an important influence in determining the demand for land. There is a resulting effect upon land price.

Difficulties Encountered in Making Sales Price the Basis of Land Appraisal.—In the case of appraisal on the basis of sales price analysis, classification of land is difficult owing to the great variability in its character. Market price of land changes as do prices of other commodities. These changes take place in response to changes in demand, arising from varying demand for agricultural commodities; from business conditions which, at different times, cause men to seek employment in agriculture because of the difficulty in finding employment elsewhere; and, from changes in the money market and credit conditions, which may to some extent affect the rate of land purchase because of the varying degree to which money is available for such purchase. Standards set temporarily by land sales agencies combined with the general lack of knowledge on the part of many purchasers concerning the value of the land they are buying, and uncertainty as to actual net rates, may, for a time, upset the economic trend of land prices, as in the case of appraisal by capitalizing net income. In a newly developed region, sales prices are likely to be unstable because of uncertainty as to the future development of that region and the marketability of crops. The best adaptability of the crops to the various soil conditions must also be determined by experience, to a large extent. Soil surveys and climatological data are reducing the uncertainty which existed in early settlements. However, many do not avail themselves of these modern facilities for obtaining information. One of the most important difficulties in both the selling price and net income analyses for obtaining land values, is the inaccuracy of data and lack of reliable basic information.

Purpose of the Analysis.—The purpose of the present study has been to determine quantitative relationships between selling price of land and the factors that affect that selling price, with a view to working toward a basis of more rational farm appraisal, in which quantitative measurements of land qualities may, in part, take the place of rough estimates of the degree to which different land qualities affect value. The objective of the entire research has been to ascertain how certain land qualities, which are variables, are associated with sales prices, that is to determine what men are willing to pay for certain land qualities—those land qualities which can be measured in degree, or quantity. An endeavor has been made to find out how soils and temperature combinations may be measured in terms of relative productivity, how crop value per acre may be expressed upon a relative basis. Size of farm can be expressed in acres, value of buildings in dollars, productivity in yield per acre, etc. It is not expected that the results of this work will revolutionize appraisal methods, but that the first results will help research worker better to understand the relative importance of different land value elements. As progress is made in the years to come and more data become available which are applicable to such studies, it is believed that actual measurement can be made of the effect of certain elements upon value, which are at present determined by rough approximations. At such time as confidence is established in the results, the necessarily complex methods may be reduced to tables and simple methods for the use of appraisers and others.

The Scope of the Study.—The multitude of complications which would arise if all kinds and classes of farm land were included in the investigation, especially in the beginning, make it necessary to limit the scope of the study. Such an analysis naturally divides itself into two important divisions. The first of these is a consideration of the dynamic economic factors which influence the general level of land prices while the second phase of the research inquires into the factors which cause differentials in prices of different farms. In the first case, it is possible to include large numbers of farms of different kinds and sizes for the purpose of drawing general conclusions concerning the relationships between indexes of economic conditions and price of land. Even this study, however, must be made with the fact in mind that farms of different types react differently to given economic conditions. In the analysis of the second phase the scope of the work must be radically reduced, first to get a starting point for use as a basis of comparison, and second to reduce the amount of work to a volume within the limit of possible accomplishment. In the study of differentials in price, therefore, the work has been narrowed down to an inquiry into the causes of differences in prices of dairy farms with the expectation that the results obtained will be useful in extending the analysis to other types of agriculture. Not only has it been necessary to reduce this phase of the investigation to one type of agriculture, but it has also been necessary to exclude a large number of variables such as poor irrigation and drainage conditions, excessive alkali, hardpan, weeds, pests, and other characteristics which would make the number of variables so large that the analysis would be too cumbersome. As a starting point, therefore, farms of almost ideal physical conditions have been selected for the purpose of developing indexes to be applied later in the evaluation of some of these more difficult factors of a heterogeneous character. This process of elimination has reduced the number of cases available for correlation studies to a rather small figure. The present analysis leaves a number of questions unanswered which logically might have been included. The effect of community development upon land values for instance is a most important consideration but available data have not yet given the means to measure the effect of the general character of the community upon land prices.

Sources of Data.—Sales prices of farms may be secured from county offices where they are legally on record, from railroad companies, from banks, from farmers, and other agencies which have compiled sales prices from one of the above sources. The Federal Land Bank has within its files more than 30,000 cases where applications for loans have been made in which the applicant has declared the purchase price paid for his farm. More than 18,000 of these are in California, 9,000 in Utah, 700 in Nevada and 3,000 in Arizona. A large part of the records on file in the bank are for farms covered by active federal farm loans. In 1926, 854 loans were closed in California, 295 in Utah, 54 in Nevada, and 143 in Arizona. A little more than half the total are rejects where loans have not been approved or are cancellations of loans which have been paid up. Nearly 5,000 of these farms have changed hands since the loans have been in the bank. The sale of a farm on which a federal farm loan has been granted is called a resale. These resale prices, declared before a notary by the purchaser, are recorded in the bank at the time the transfer is made. In 1926, 261 resales were made in the Eleventh Federal Farm Loan District. Of these, 146 were in California.

This source of sales price data is especially interesting because of the fact that a more or less complete description of each farm accompanies the record of the sale price. This information is more complete for the later years because appraisal methods have gradually improved and basic information has been collected, making possible more reliable information concerning conditions throughout the Farm Loan District. While there are many limitations to the use of these data for research, because they were collected for another purpose, they furnish the basis for some very interesting analyses of the relation of sales prices of land to such factors as affect selling prices. These data form the principal basis of the study. While most of the available prices have been used in time series, only a small number of the total number of cases enter into the detailed correlations because of eliminations described later.

Data in Appraisers' Reports and Applications for Loans.—Appraisers' reports and applications for loans contain, among other information, a record of the purchase price of the land, estimates of gross income, net farm income, and a financial statement of the farmer. The utilization of the farm is given, showing the acreages of the different crops; and in the application blank, the yields of the important crops for the year the application was made are itemized, while in the appraiser's report the appraiser's estimate of the average yield is recorded. Notes as to topography are included, and the soil type is given by the appraiser where there has been a soil survey, or described in more or less detail where there has been no soil survey. The exact location of the farm is recorded and its distance from railroad station, church, school, and state roads. In later years, very adequate description of drainage and irrigation factors have been attached to the appraiser's report on a special blank. Information is available concerning costs of irrigation, including bonded indebtedness, interest on bonded debt, and operation and maintenance costs.

Where pumps are installed for irrigation, information is usually given to make possible an estimate of the cost of operatioin. Information is also included, though not always complete, concerning the value of improvements made on the farm between the time of purchase and the time of appraisal. Appraised values of land and buildings are recorded separately.

Purchase Price and Resales Price Data.—Purchase price and resales price data are subject to certain inaccuracies. It was expected that purchase price data would be subject to a bias due to the desire on the part of some applicants to secure as large a loan as possible. On the whole, however, it is believed that the applicants have been honest in their statements. Purchase price has the disadvantage of containing in many cases the price paid for stock, equipment, etc., which had not been mentioned in the applicant's report. Usually these cases can be detected and eliminated. Data on purchase price are also given by the applicant sometimes years after the transfer occurred, thus making the memory of the farmer giving the report a source of error. The purchase price as recorded applies, in each case, to a time prior to the time of application and appraisal. If this is several years, the descriptive matter concerning the farm, recorded by the applicant and the appraiser at the time of appraisal, applies to the farm some time later than the date of purchase. In the meantime, improvements may have been made and the descriptive information may have little significance in the analysis of the factors affecting purchase price. The resale price is of record usually some years later than the date at which description is available. No record of improvements during this intervening time is given. Studies of the effect of this lapse of time have been made by examining average sales price of farms by groups of different lengths of time between appraisal and resale. There seems to be little change where the farm is in a fair degree of development at the time of appraisal. By including in correlations of factors affecting sales price only such farms as are in a fair state of development and farms sold not more than two years subsequent to appraisal, error from this source is greatly reduced.

Income Data.—Estimates of net farm income and gross income are probably of very little value. The statement of the applicant is often very different from that of the appraiser in respect to income. Accurate estimates of income are extremely difficult to make and discrepancies are expected in such data.

Dynamic Economic Factors and their Significance with Relation to Land Price

Land prices are subject to both secular and cyclical changes. The relationship between industrial conditions, agricultural prices, and land prices is not a simple one. The effect of changes in demand for land, on cyclical deviations in land prices, depends upon two sets of variables. One of these is a composite of industrial activity, and the other pertains directly to agricultural income. These two influences upon demand for land and a group of factors which influence economic supply of land determine the general land price level.

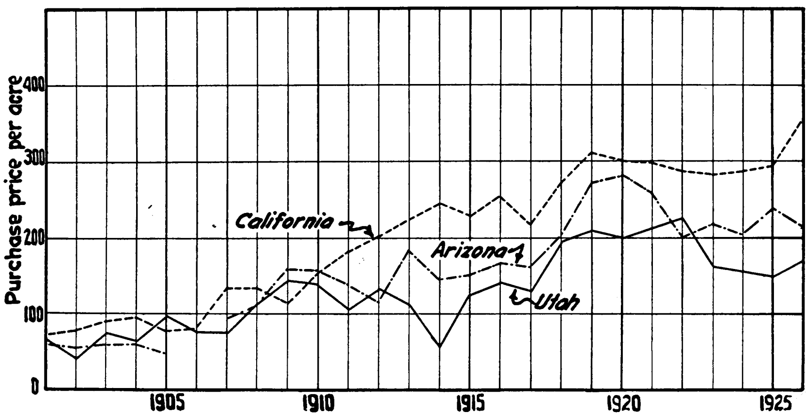

Fig. 1. Average purchase prices of land covered by Federal farm loans in California, Arizona, and Utah, 1901–1926.

Trends in Purchase Price of Farms Covered by Federal Farm Loans.—Purchase price of farms covered by Federal Farm Loans is useful within certain important limitations in studying the secular trend of land prices over a period of years. Time series of land price for different types of agriculture have important differences. Combining in a single land price series prices of farms of widely varying sizes, different types of agriculture, and varying improvement values is sure to result in misuse and wrong interpretation by the majority of those interested, if care is not taken in weighting the series according to the purpose intended.

Average annual purchase price of farm land in Arizona, Utah and California are shown in figure 1 and in tables 1 and 2. Figure 2 and table 2 show the average purchase prices of farm land covered by federal farm loans in California from 1901 to 1920 inclusive. Values of improved farms and unimproved farms published by the U. S. Department of Agriculture[9] from 1912–1926 inclusive are also shown. In California, the purchase prices have been sorted according to type of agriculture. The groups for individual crops contain so few cases in certain years that time series were impracticable. When combined into the general groups of permanent crop and field crops, some interesting comparisons have been made possible. Since 1918, purchase prices of permanent crop land in California have averaged about $400 per acre, while the purchase price of field crop and dairy land taken together has averaged about $230 per acre. Permanent crops and field

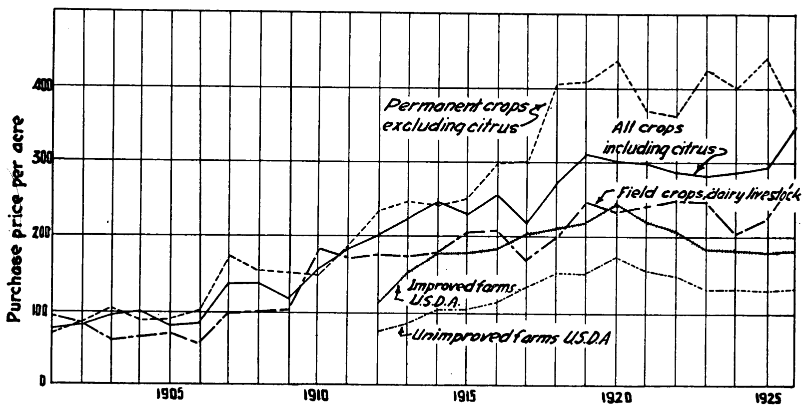

Fig. 2.—Average prices of land covered by Federal farm loans in California compared with prices of farm land compiled by the U. S. Department of Agriculture. The data are shown in table 2.

crops combined in the all-crop land price series have averaged a little less than $300 per acre. Prior to 1918, there was, as is well known through other land value studies, a gradual rise in land values, being most rapid during the period shown by these land price series. It must be borne in mind that these prices apply to land purchased prior to application for loans in the bank, and in a large number of cases include prices paid for practically undeveloped land. In this respect they differ materially from lands transferred since loans have been issued by the bank. The latter which have already been referred to as resale prices will be considered after certain characteristics of average purchase prices for the different years have been described.

[9] Bureau of Agricultural Economics, Prices of farm products received by producers. 4. Mountain and Pacific States. U. S. D. A. Stat. Bul. 17:152, table 77. Government Printing Office, Washington, D. C.

In making comparisons between the U. S. Department of Agriculture index for improved farms and unimproved farms in relation to the purchase prices of land covered by Federal Farm Loans, it will be noticed that the U. S. Department of Agriculture index is much lower than that of this research. An important cause for this difference is probably in the manner of computing the average prices represented. The usual custom in computing such an index is to calculate average prices by dividing total value by total area. Such an index is not representative of prices that the majority of farmers paid for their farms nor would it be representative of that area where greatest values are concentrated. The average is unduly weighted by the larger farms. The purchase price averages used in this study have been

TABLE 1

AVERAGE PURCHASE PRICE PER ACRE OF LAND COVERED BY FEDERAL FARM LOANS IN ARIZONA AND UTAH, 1901–1926

Year	Arizona		Utah	
	Frequency	Average price	Frequency	Average price
		Dollars		*Dollars*
1900	5	49	7	115
1901	2	62	5	68
1902	3	57	8	42
1903	5	67	10	76
1904	4	65	8	64
1905	2	50	15	99
1906	....	......	15	77
1907	7	94	8	76
1908	3	107	12	115
1909	11	158	11	144
1910	7	157	15	140
1911	11	139	13	106
1912	22	117	20	133
1913	10	184	17	188
1914	14	146	15	58
1915	15	152	14	125
1916	31	170	36	141
1917	77	163	37	130
1918	57	202	52	196
1919	54	275	63	209
1920	63	284	63	200
1921	37	261	22	214
1922	32	203	19	226
1923	47	218	28	161
1924	21	205	34	154
1925	9	239	18	148
1926	4	214	14	171

computed by adding together the average prices per acre for all of the farms in the sample for a given year and dividing by the total number of cases included. By this method more weight is given to the price per acre of that type of farm of most common frequency rather

TABLE 2

AVERAGE PURCHASE PRICE OF LAND COVERED BY FEDERAL FARM LOANS IN CALIFORNIA FOR THE PERIOD 1901–1926, INCLUSIVE, COMPARED WITH THE FARM LAND PRICE SERIES FOR CALIFORNIA COMPILED BY THE U. S. DEPARTMENT OF AGRICULTURE, 1912–1926

Date	Average purchase price per acre of land covered by federal farm loans			U. S. D. A.* farm land value	
	All crops, including citrus	Permanent crops, excluding citrus	Field crops, dairy, livestock	Improved farms	Unimproved farms
	Dollars	*Dollars*	*Dollars*	*Dollars*	*Dollars*
1901	72	68	91	......	......
1902	79	89	81	......	......
1903	91	102	59	......	......
1904	96	84	63	......	......
1905	77	85	68	......	......
1906	82	99	55	......	......
1907	135	172	93	......	......
1908	134	152	98	......	......
1909	114	149	98	......	......
1910	155	145	138	......	......
1911	183	186	131	......	......
1912	201	233	175	107	70
1913	225	245	173	150	85
1914	245	242	179	175	100
1915	229	250	205	175	100
1916	253	298	208	180	110
1917	218	300	170	200	130
1918	272	406	195	207	148
1919	310	408	246	218	150
1920	300	439	230	240	170
1921	298	369	241	218	155
1922	286	363	248	206	146
1923	281	425	247	182	129
1924	286	401	205	180	128
1925	293	443	223	178	126
1926	356	368	278	180	130

* Bureau of Agricultural Economics. Prices of farm products received by producers. Part 4. Mountain and Pacific states. U. S. D. A. Stat. Bul. **17**: 152. Washington, D. C., March, 1927.

than to total acreage. More weight is given to small farms where larger values are concentrated inasmuch as they are the most frequent sizes. More weight is given to that type of farm that the "average" farmer is thinking of buying or selling. A special study has been made to determine the difference between a time series derived by this method of frequency weighting and time series derived by two other methods in common use. The same data are used in the three types of averages, but one series is weighted by value, another series by acreage, while a third is in effect weighted according to the type of farm of greatest frequency. The average price per acre for each farm was computed by dividing its value by the number of acres in the individual farm. The averages for the year were computed by dividing the sum of the average prices per acre by the total number of farms in the group. As was expected, and in conformity with the variance between the U. S. Department of Agriculture index and the purchase price series of this analysis, the series weighted by acreage is much below that of the other two, while that weighted by value gives a series higher than that given by the other two methods. The results of these computations are shown in figure 3. The purchase price index weighted by the frequency is not representative of the average price per acre which was paid for large farms in the years indicated. In a state where land prices vary from a dollar or two an acre to thousands of dollars per acre and where sizes of farms vary from thousands of acres to a fraction of an acre, there is a question as to the real significance of any form of series of land prices which does not represent a specific class of farm. It seems that the one representing the farm of most frequent size would be more representative than the one giving weight more particularly to large areas of low-priced land.

It must be remembered that in addition to the method of computing averages, there may be another reason for the difference in the purchase price index and the U. S. Department of Agriculture series. The purchase price index is for farms which have for the most part been selected as suitable for federal farm loans. This is probably not an important cause of the difference. In many cases, however, the purchase price included in the average was for land which at the time of purchase would not have been considered sufficient security for the loan and that the development since purchase, in many cases, undoubtedly has been the basis of the security. Improved farm land values in California from 1918 to 1927, according to the U. S. Department of Agriculture index, have averaged $201 an acre. Land values during the earlier portion of this period were much higher than during the later years. From 1918 to 1922 inclusive the average value was $218 an acre while from 1923 to 1927 inclusive the average was $180 an acre.

Another source of misinterpretation of such series may arise from the fact that more small farms come into the average as time goes on. Census data and the records of the Federal Land Bank both show a gradual diminution in the size of farms and since small farms sell for higher prices per acre than large farms for many reasons, a time series of land prices which does not give consideration to size changes is subject to an exaggeration of an upward trend in land price.

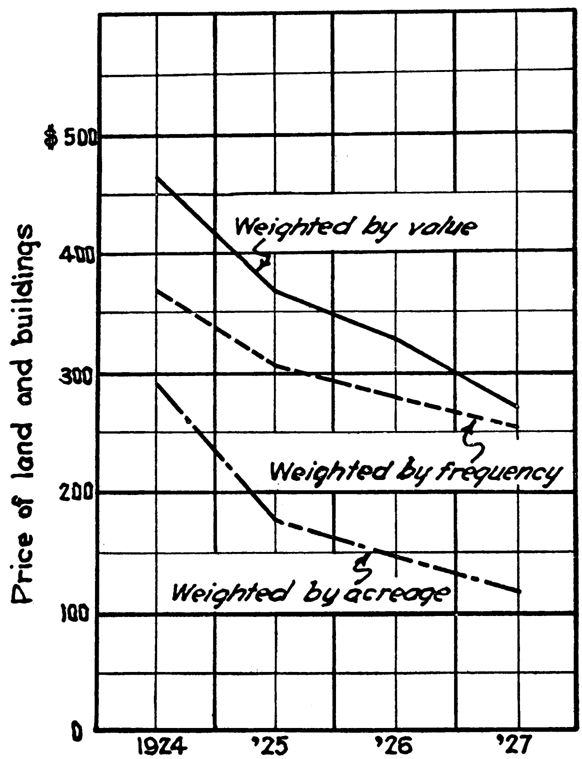

Fig. 3. The effect of methods of weighting upon time series of land prices.

When the purchase price series is compared with the resale price series, discussed later, it will be seen that the peak of land prices occurred at an earlier date in the former series. There is no doubt that such a difference actually occurred in the case of farms resold after the issuance of a loan because of a greater degree of development. There may have been, however, certain erratic discrepancies in each of the series in 1921 and 1922 when such small numbers of farms changed hands as to cause samples of comparatively small numbers of cases. Inasmuch as the resale prices are for more highly developed farms and farms which were probably in the process of development at the time deflation began, there is reason to believe that the increase in development resulted in a continuation of rising values due to added improvements. In the case of purchase prices, however, which in large numbers of cases were the sales of land in development projects, the slump was felt sooner.

The decline in purchase prices in 1917 is not shown in the Department of Agriculture series. This decline is probably significant for it occurred in several independent series. It is present in the California permanent crop land series, in the California field crop and dairy farm land series, and in the all-crop lands of Utah and Arizona. It is probably explained by the declining demand for land by mobilization of troops, and increased industrial activity.

Later discussions of the effect of size and other variables upon land price indicate the inadequacy of ordinary time series of land prices for most purposes. In fact they may be actually misleading. If a time series must be used for deflation purposes, relatives will serve that purpose. Such a series is not so susceptible to the effects of poor weighting.

Cyclical Analysis of Resale Prices of Farm Land.—There is a direct relationship between cycles in the price of improved land in the San Joaquin Valley, California, since 1921 and cycles of industrial and financial activities. The correlation between land price and daily pig iron production in the United States is a fair example of this relationship. Figure 4 and table 3 show monthly average resale prices per acre of land covered by federal farm loans in the San Joaquin Valley, California, which changed hands each month from September, 1918, until March, 1927. Because of a comparatively small number of cases in each month, there is considerable variation in these monthly averages. In order to smooth out these irregularities and to study the cyclical changes in land prices, twice iterated three-months moving averages have been applied to the raw monthly averages. The inflection points of the resulting series have been connected in smooth curves which we will call, following Frisch,[10] the originator of this method of time series analysis, the first trend. The first trend shows cyclical variations, with seasonal and erratic fluctuations eliminated.

[10] Dr. Ragnar Frisch, Lecturer of Economics and Mathematical Statistics in the University of Oslo, Norway, has through personal interview described the essentials of his method to the writer.

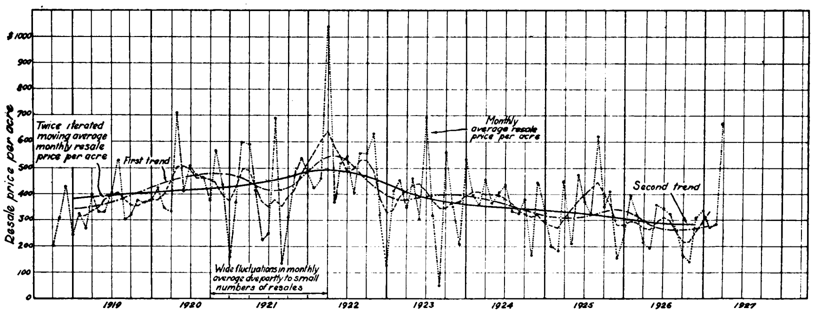

Fig. 4. Analysis of cyclical variation in resale prices of land covered by Federal farm loans in the San Joaquin Valley, California.

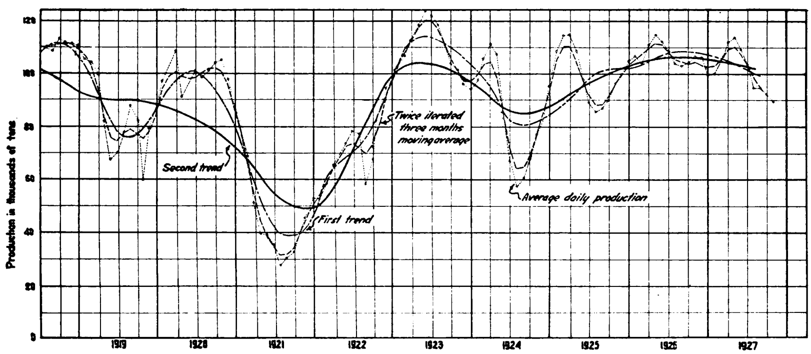

Fig. 5. Cyclical variations in average daily pig iron production in the United States, 1918–1927.

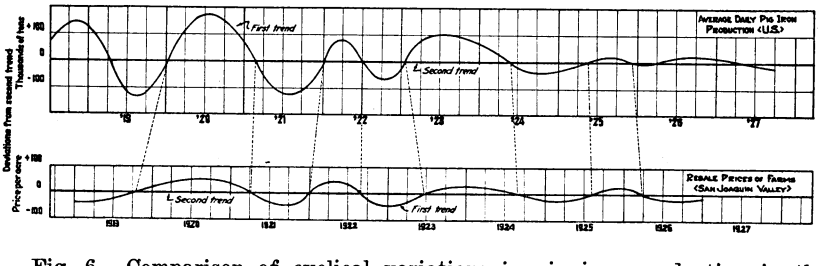

Fig. 6. Comparison of cyclical variations in pig iron production in the United States, and resale prices of farms covered by Federal farm loans in the San Joaquin Valley, California.

TABLE 3

AVERAGE MONTHLY SALES PRICES OF LAND COVERED BY FEDERAL FARM LOANS IN SAN JOAQUIN AND SACRAMENTO VALLEYS, CALIFORNIA, AND IN THE STATES OF UTAH AND ARIZONA

Year	Month	San Joaquin		Sacramento		Utah		Arizona	
		Frequency	Price	Frequency	Price	Frequency	Price	Frequency	Price
			Dollars		*Dollars*		*Dollars*		*Dollars*
1918	January	1	264						
	February								
	March					1	46		
	April								
	May								
	June			1	20				
	July	1	211	1	700				
	August								
	September	1	200	1	113	1	487		
	October					4	133	1	240
	November	1	425						
	December	2	238	1	187	2	190	2	75
1919	January	1	325			5	203	1	55
	February	4	265	1	187	1	31	1	44
	March	3	395	3	120	7	138	3	242
	April	5	327	1	89	9	80	2	102
	May	6	327	2	352	5	126		
	June	3	400	3	113	2	58	1	141
	July	7	527	3	75	4	263		
	August	11	299			4	94	2	130
	September	9	315			3	110		
	October	9	370	5	205	5	127		
	November	10	361	4	283	9	185		
	December	15	371	9	222	6	153	4	205
1920	January	19	418			8	236	3	181
	February	19	341	5	136	14	197		
	March	10	327	7	298	14	197	2	306
	April	9	702	2	142	3	199	3	188
	May	9	403	1	11	9	165	1	284
	June	9	504	2	65	3	122	3	41
	July	4	465	3	350	4	203		
	August	7	457			6	127	2	26
	September	2	369			4	284	3	438
	October	7	561	6	200	3	215	1	473
	November	4	421	3	451	4	144	1	750
	December	2	154	2	182	2	103	1	200
1921	January	8	360			4	140		
	February	4	591	2	145	5	142	1	181
	March	3	585	2	223	3	199	2	107
	April	4	432	1	19	8	96	3	98
	May	3	220	2	138	4	187	1	26
	June	4	246			2	182		
	July	3	683						
	August	1	134	1	255				
	September			2	217	1	103		
	October	5	468	1	37	3	170		
	November	8	535	1	141	13	77		
	December			2	212	6	142	1	75

TABLE 3 (continued)

Year	Month	San Joaquin		Sacramento		Utah		Arizona	
		Frequency	Price	Frequency	Price	Frequency	Price	Frequency	Price
			Dollars		*Dollars*		*Dollars*		*Dollars*
1922	January	4	416	1	400	5	140	3	86
	February	4	455	1	300	4	188	4	194
	March	2	1128	1	280	5	145	2	159
	April	4	364	1	26	5	215	2	168
	May	5	513	......	......	9	149	3	240
	June	5	540	1	580	6	151	1	94
	July	4	401	......	......	2	247	......	......
	August	5	553	1	26	2	168	2	88
	September	2	551	5	331	9	182	2	149
	October	4	627	......	......	7	121	4	161
	November	1	315	1	423	14	111	2	178
	December	4	126	3	158	5	113	2	231
1923	January	7	406	2	174	9	192	2	192
	February	3	455	2	339	7	51	2	211
	March	4	341	3	216	11	113	4	102
	April	3	455	3	248	6	152	4	210
	May	5	299	2	197	10	111	1	250
	June	2	688	1	12	4	106	......	......
	July	5	315	2	370	3	214	1	95
	August	1	52	1	533	4	106	3	39
	September	3	556	3	155	4	113	1	188
	October	1	347	2	220	5	209	3	179
	November	5	202	5	219	12	156	2	206
	December	6	532	1	200	11	118	2	244
1924	January	9	392	......	......	14	132	8	209
	February	8	254	2	312	14	152	1	275
	March	8	454	6	286	12	186	4	202
	April	4	359	3	540	11	154	3	182
	May	6	402	......	......	4	103	1	62
	June	7	434	2	538	5	129	3	138
	July	5	334	4	644	4	126	1	148
	August	5	323	2	295	5	129	2	134
	September	6	374	2	151	4	118	1	213
	October	6	162	2	374	5	150	......	......
	November	7	441	......	......	2	132	5	145
	December	7	324	2	95	6	119	5	226
1925	January	8	198	3	209	4	94	8	200
	February	7	180	2	255	7	86	3	181
	March	8	448	2	397	13	107	3	181
	April	7	208	2	348	4	97	1	116
	May	7	468	1	318	5	127	1	300
	June	5	370	3	204	5	92	2	226
	July	9	314	2	100	2	158	2	194
	August	3	617	3	386	3	135	1	62
	September	7	347	2	158	4	29	5	124
	October	5	408	3	468	5	153	4	213
	November	6	153	1	234	8	104	1	191
	December	7	238	2	422	11	170	6	118

TABLE 3 (continued)

Year	Month	San Joaquin		Sacramento		Utah		Arizona	
		Frequency	Price	Frequency	Price	Frequency	Price	Frequency	Price
			Dollars		*Dollars*		*Dollars*		*Dollars*
1926	January	8	389	2	358	12	127	7	235
	February	8	315	4	184	6	130	3	175
	March	9	214	3	356	17	169	3	262
	April	11	189	3	398	8	102	2	184
	May	10	354	3	99	5	61	2	98
	June	6	340	2	248	3	42	2	24
	July	4	320	3	241	3	88	1	185
	August	8	254	......	......	5	92	1	372
	September	3	167	3	248	7	99	3	199
	October	4	138	2	461	4	151	7	254
	November	4	304	4	233	7	175	......	......
	December	5	332	3	283	10	67	3	171
1927	January	16	269	......	......	......	......	......	......
	February	16	266	......	......	......	......	......	......
	March	13	307	......	......	......	......	......	......
	April	17	240	......	......	......	......	......	......
	May	23	425	......	......	......	......	......	......
	June	12	209	......	......	......	......	......	......
	July	6	220	......	......	......	......	......	......
	August	12	250	......	......	......	......	......	......
	September	17	293	......	......	......	......	......	......
	October	16	209	......	......	......	......	......	......
	November	9	204	......	......	......	......	......	......
	December	9	238	......	......	......	......	......	......

Seasonal variations in land price indicate that high-land prices tend to occur in the second quarter of the year, that is, from March to June. This, of course, is coincident with high seasonal demand and indicates that most farm land is exchanged at a time which gives an advantage to the seller. The inflection points of this first trend have been used in constructing a second trend. This second trend follows the general long-time tendency of land prices. The method is treated more fully in the discussion of "The Adequacy of the Frisch Method of Time Series Analysis," found in the section "Statistical Analysis" at the close of this bulletin. At present, the economic and not the statistical aspects of the problem are under consideration.

Figure 5 shows graphically the average daily pig iron production in the United States by months from 1918 to 1927. The Frisch method of analysis has been used as in the case of the land prices. The regional monthly averages were treated with a twice iterated three-months moving average. The inflection points of the resulting series were connected to form the first trend. The second trend is the line passing through the inflection points of the first trend. Deviations of the first trend from the second trend give us the cyclical variations which are comparable to the cycles of the same order in land prices.

Figure 6 shows the deviations of the first trends of each of these series from the second trends, land price being lagged two months behind pig iron production. While there is only a fair correlation, and the series cover only comparatively short periods of time in each case, there is considerable evidence of direct relationship between the two series. The lag of land prices behind pig iron production indicates that industrial activity is followed soon by corresponding changes in the price of improved high-priced land. That the relationship between industrial conditions and agricultural prices is not a simple one is emphasized by the occurrence of important exceptions to the direct relationship. As will be seen later, the demand for undeveloped low-priced land follows a different cyclical tendency. Resale prices are for land which is in a fairly complete state of development. Loans are not awarded where farms are unimproved.

In the discussion of purchase prices, certain precautions were found to be necessary in the use of time series of land prices. The same precautions should be followed in the use of time series based upon resale prices. Although the prices are more accurate, the series are subject to changes in the proportion of farms of different sizes.

If a series is a composite of land prices in different localities, not only may cyclical tendencies be different, but the long-time trends in the different regions may follow along entirely different lines. As a matter of fact, cyclical changes in the different regions are more nearly alike than are the trends. Figure 7 shows recent trends in resale prices of land in different sections of the Eleventh Federal Farm Loan District. Cyclical tendencies are similar but trends are not. Farm land prices rose higher in the San Joaquin Valley than in other parts of the district and retained their high level until 1922. Since 1922 the trend has been downward. For the rest of the State of California, the trend was similar to the San Joaquin Valley until the later part of 1923 when a decline set in after which there have been some signs of recovery. In the Sacramento Valley, excluding those speculative sections where the Federal Land Bank has not made a practice of extending credit, land prices followed a steadily increasing trend until late in the year 1924, after which there was a slight decline. In Arizona and Utah the high points came much earlier. The peak of land prices occurred in Arizona in 1920, while in Utah the higher values occurred earlier in 1919. Since that time, there has been a very slight decline in the general trend. These regional differences in land price trends give a feeling of insecurity in the use of a general price series for following land value changes in local areas. Even the trend for the San Joaquin Valley should be applied to local areas within the San Joaquin Valley with caution. General crop areas are likely to have

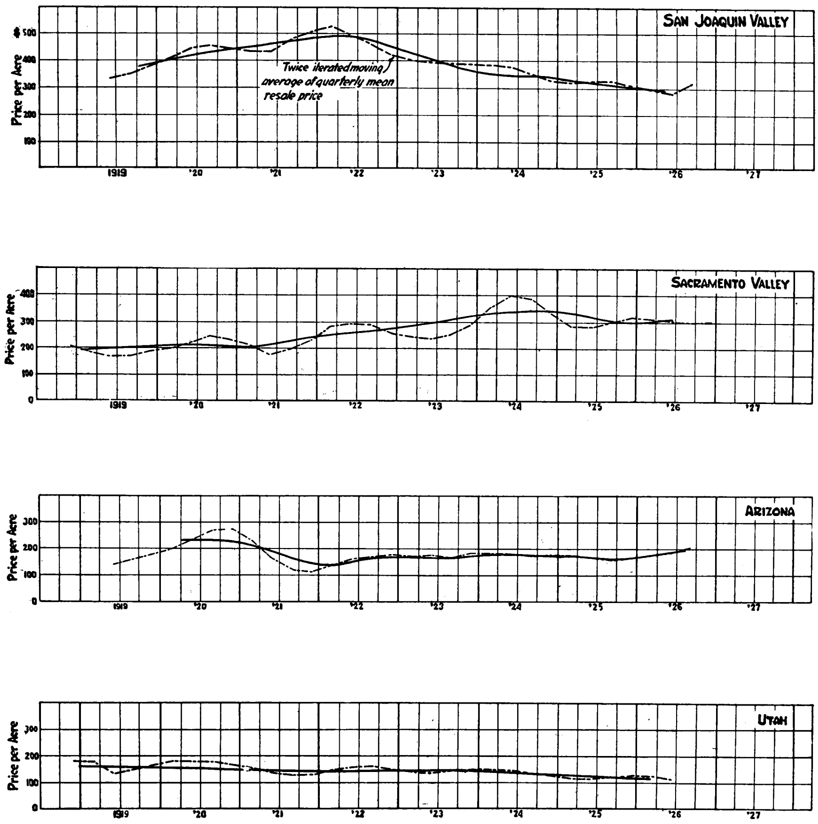

Fig. 7. Recent trends of resale prices of land in different sections of the Eleventh Federal Farm Loan District.

different land price trends from those of permanent crop lands. There is some indication, though not a persistent tendency, that cycles in purchase price of dairy and general crop farms are inverse to cycles in prices of permanent crop lands. The actual process of land price deflation is difficult and so far satisfactory methods are not available.

A more detailed analysis was made of some of the different counties in the San Joaquin Valley. Merced and Fresno counties seemed to follow similar land price changes, the difference being in the height of the price level. These county series are not shown graphically because of insufficient data to make them continuous. Sufficient data have not been available to create land price trends for small areas. Such trends would be necessary if an accurate determination were to be made of local changes in land value. Even if a time series for a local area were available, in light of what we have said about prices

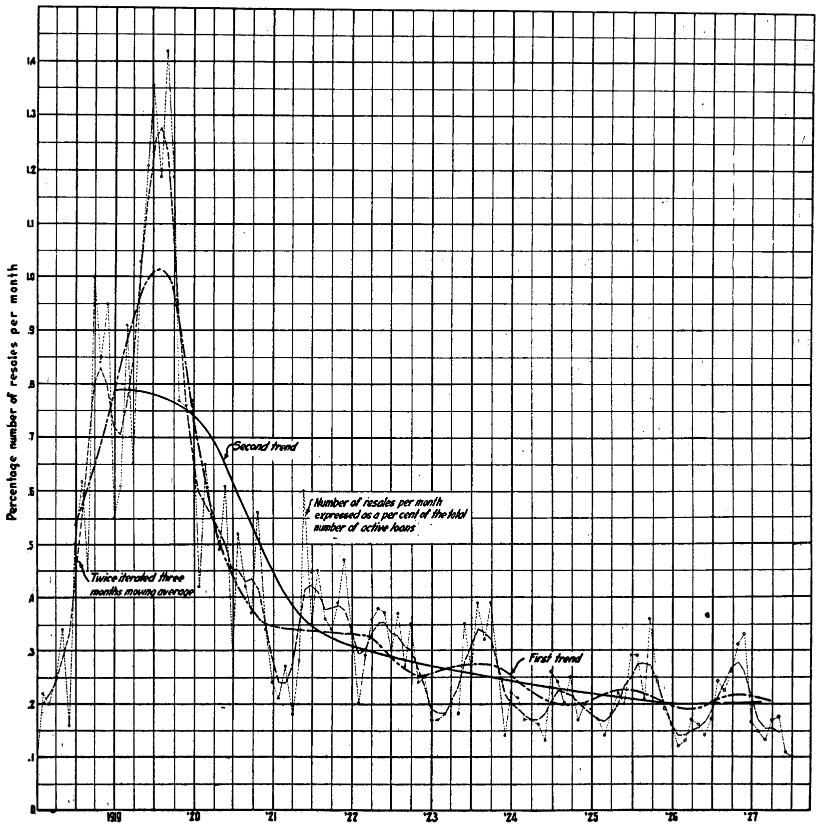

Fig. 8. Analysis of cyclical variation in the number of resales per month, expressed as a per cent of the total number of loans in the Eleventh Federal Farm Loan District.

of land utilized for different crops, prices of all farm lands would not necessarily follow this general trend. We must depend therefore on time series for larger areas and study the causes for regional differences. In this way corrections may be made on the basis of local characteristics. Dynamic factors must take their place with other variables in the complex process of ''unscrambling'' the interacting effects of the many elements affecting land price.

Factors Influencing Demand for Farm Land.—Demand for improved farms of high per-acre value seems to have different causes from those which produce the fluctuations in the demand for raw, undeveloped low-priced land. The number of resales per month among the farms covered by federal farm loans gives us an index of the rate of transfer with respect to the improved farms involving higher acreage values. Figure 8 and table 4 show graphically the rate at which farms in the Federal Land Bank changed ownership during the years 1918–1927 inclusive. The number of resales per month expressed as a per cent of the total number of loans in the Eleventh Federal Farm Loan District declined rapidly, with minor variations, from early in 1920 to 1921. Since 1921, there has been a further gradual decline up to the year 1927. There is some indication of a flattening out of the trend in the later post-war years. During the month of February, 1920, a little more than 1.4 per cent of the farms on record in the Federal Land Bank of Berkeley changed hands. In February, 1927, about 0.23 per cent of the total number of farms on record in the bank changed hands.

The declining trend in rate of transfer is accompanied by a decline in trend in the selling price of these same farms. There is no definite proof that there is any causal relationship between the decline in the trends of the price of land and rate of transfer. The decline in rate of transfer could be due to diminished demand for land by purchasers either because of decreased prospects of adequate returns or because of greater opportunity offered in other fields. The decline in rate of transfer could be due to the reluctance of the owners to part with their farms at available prices offered. There is probably no real difference in the fundamental causes for the decline in the rate of transfer whether it acts through its effect upon the willingness of the owners to sell or upon the demand by purchasers. When we consider short time fluctuations, however, we find a persistent inverse relationship between land prices in any year and the rate at which land sales take place the next. Figure 9 shows the relationship of prices of farm land to the number of sales per month with the resale transfer curve lagged one year. This chart is constructed from the first and second trends of resale prices shown previously in figure 4, and the cycles of rate of transfer of the same order taken from figure 8, the second trend in each case being represented by the line 00. The inverse relationship between land prices and rate of transfer seems to be more significant and the correlation seems to be higher than any relationship which may be found to exist between the cyclical variations in rate of land transfer and business conditions or wholesale prices. Although there is some indication of such a relationship, it is probably due to the indirect effect of industrial or financial conditions on rate of transfer through its effect upon land price.

A digression from the discussion of the results of the analysis of transfers of farms on file in the Federal Land Bank is necessary at this point to complete our understanding of the factors influencing demand for land. For the study of a clear-cut case of demand for undeveloped land, where the price of the land is not a retarding factor, operations under the Homestead Act give us the desired data.

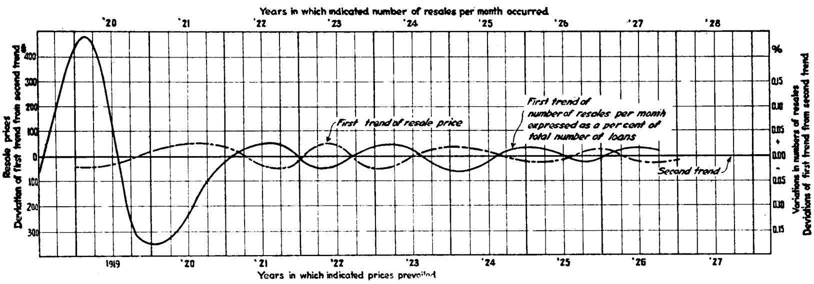

Fig. 9. Relation of prices of farm land to numbers of sales per month the following year. . This figure is derived from figures 4 and 8.

In considering the conclusions drawn, however, it must be remembered that many economic changes have occurred since the years covered by this series and that the immigration laws of the country may affect the tendencies observed. When homestead entries are analyzed from the standpoint of cyclical variations, the conclusion is that the demand for raw, low-priced land is much more subject to industrial conditions than is the case with higher priced developed farms. In the first instance, increased activity under the Homestead Law indicates a definite movement to the land by those who make permanent settlers. In the case of the rate of transfer of improved lands, each purchaser moving to his newly purchased farm displaces another farmer so that the movement is not one which is all in one direction. There is a movement away as well as a movement to the land. The farmer displaced by the purchaser may himself become a purchaser. Furthermore, the purchase of improved farms involves the expenditure of considerable amounts of capital by the purchaser even where extensive credit is given. The improved farm, therefore, is an outlet for a different class of labor from the unimproved farm which attracts large numbers of those formerly employed in industry seeking new employment when industry fails them.

TABLE 4

NUMBER OF RESALE TRANSFERS PER MONTH EXPRESSED AS A PER CENT OF TOTAL NUMBER OF LOANS IN THE ELEVENTH FEDERAL FARM LOAN DISTRICT

Year	Month	Number of resales	Number of active loans in bank*	Per cent of resales to number of loans	Year	Month	Number of resales	Number of active loans in bank*	Per cent of resales to number of loans
1918	Jan.	1	630	.16	1922	Jan.	22	4,930	.45
	Feb.	....	....	....		Feb.	18	5,050	.36
	Mar.	5	850	.59		March	18	5,240	.34
	April	3	960	.31		April	21	5,400	.39
	May	3	1,090	.28		May	26	5,550	.47
	June	1	1,230	.08		June	19	5,750	.33
	July	3	1,350	.22		July	12	5,900	.20
	Aug.	3	1,480	.20		Aug.	18	6,160	.29
	Sept.	4	1,600	.25		Sept.	23	6,450	.36
	Oct.	6	1,750	.34		Oct.	26	6,750	.38
	Nov.	3	1,860	.16		Nov.	26	7,050	.37
	Dec.	10	2,000	.50		Dec.	22	7,330	.30
1919	Jan.	13	2,120	.62	1923	Jan.	28	7,650	.37
	Feb.	10	2,250	.45		Feb.	21	7,920	.27
	March	24	2,400	1.00		March	29	8,200	.35
	April	21	2,500	.84		April	20	8,380	.24
	May	25	2,650	.95		May	21	8,560	.25
	June	15	2,750	.55		June	15	8,700	.17
	July	17	2,860	.61		July	15	8,850	.17
	Aug.	27	2,980	.91		Aug.	16	8,950	.18
	Sept.	20	3,080	.65		Sept.	18	9,020	.20
	Oct.	33	3,200	1.03		Oct.	16	9,150	.18
	Nov.	40	3,300	1.21		Nov.	32	9,250	.35
	Dec.	46	3,370	1.36		Dec.	24	9,350	.26
1920	Jan.	41	3,450	1.19	1924	Jan.	37	9,450	.39
	Feb.	50	3,520	1.42		Feb.	31	9,550	.32
	March	43	3,600	1.19		March	38	9,650	.39
	April	28	3,650	.77		April	26	9,750	.27
	May	28	3,700	.76		May	14	9,840	.14
	June	29	3,750	.77		June	22	9,930	.22
	July	16	3,800	.42		July	21	10,030	.21
	Aug.	25	3,830	.65		Aug.	17	10,130	.17
	Sept.	21	3,850	.55		Sept.	17	10,230	.17
	Oct.	19	3,900	.49		Oct.	17	10,300	.16
	Nov.	24	3,920	.61		Nov.	14	10,400	.13
	Dec.	12	3,950	.30		Dec.	27	10,500	.26
1921	Jan.	21	4,000	.52	1925	Jan.	25	10,560	.24
	Feb.	17	4,040	.42		Feb.	21	10,650	.20
	March	15	4,080	.37		March	27	10,750	.25
	April	23	4,110	.56		April	18	10,800	.17
	May	14	4,170	.34		May	22	10,900	.20
	June	10	4,250	.24		June	21	11,000	.19
	July	9	4,320	.21		July	19	11,080	.17
	Aug.	12	4,400	.27		Aug.	15	11,150	.14
	Sept.	8	4,500	.18		Sept.	23	11,250	.18
	Oct.	13	4,580	.28		Oct.	25	11,300	.22
	Nov.	28	4,700	.60		Nov.	23	11,400	.20
	Dec.	17	4,800	.35		Dec.	33	11,500	.29

TABLE 4 (continued)

Year	Month	Number of resales	Number of active loans in bank*	Per cent of resales to number of loans	Year	Month	Number of resales	Number of active loans in bank*	Per cent of resales to number of loans
1926	Jan.	34	11,600	.29	1927	Jan.	31	12,840	.24
	Feb.	24	11,700	.21		Feb.	29	12,940	.22
	March	42	11,790	.36		March	34	13,050	.26
	April	29	11,880	.24		April	41	13,170	.31
	May	23	11,950	.19		May	44	13,300	.33
	June	19	12,070	.16		June	22	13,400	.16
	July	15	12,160	.12		July	20	13,500	.15
	Aug.	16	12,260	.13		Aug.	18	13,600	.13
	Sept.	21	12,400	.17		Sept.	23	13,700	.17
	Oct.	20	12,500	.16		Oct.	24	13,800	.17
	Nov.	18	12,600	.14		Nov.	15	13,900	.11
	Dec.	21	12,750	.17		Dec.	14	14,000	.10

* Number of active loans in the bank for any month were estimated by reading values from a curve connecting the annual totals. While they are sufficiently accurate for the purpose for which they were used here they are not the exact numbers of active loans.

In a previous bulletin,[11] it has been shown that there is an inverse relationship between the all-commodities wholesale price index and final homestead entries lagged for the period between original and final entry. This tendency has been studied further in the present investigation. Effective demand for undeveloped land, where land price is not a dominant consideration, varies inversely with wholesale prices of all commodities. Figure 10 shows original and final homestead entries plotted for the years 1863 to 1923 inclusive.[12] The final entry graph is lagged for the period of three or five years required for proof. Many original entries did not become final entries. The final entries are the ones, therefore, which show effective demand for land. The percentage of original entries which became final, that is, the effective demand for land, is correlated with business conditions at time of entry, business conditions during the early period of settle-

[11] Weeks, David and Charles H. West. The problem of securing closer relationship between agricultural development and irrigation construction. California Agr. Exp. Bul. 435:99 p. 1927.

[12] Source of data:

1863–1880. Report of Public Land Commission. p. 351–355. 1881.
1881–1882. Report of Public Land Commission. p. 1016. 1884.
1882–1883. Public Domain. Report of Public Land Commission. p. 1284. 1884.
1884–1899. Report of Commission of General Lands.
1900–1906. Congressional Records. 1899—p. 3914. 1900—p. 4100. 1901—p. 4289. 1902—p. 4457. 1903—p. 4644. 1904—p. 4797. 1905—p. 4958. 1906—p. 5117.
1907–1926. Report of Commission of General Land Office in Dept. of Interior Reports.

ment, and with the total number of entries. Figure 11[13] is a cyclical analysis of wholesale prices and forms the basis together with figure 10 for figure 12 which shows graphically the inverse relationship between wholesale price of all commodities and final homestead entries lagged for the period between original and final entry. There was a tendency for a much larger percentage of original entries to become final when the total number of original entries was small. In other words, there was an inverse relationship between numbers of original homestead entries and the per cent of those which became final entries. This is shown in figure 13. Economic conditions at the time of entry and the total numbers making entry are not the only causes which influenced the percentage of the number of original entries which became final.

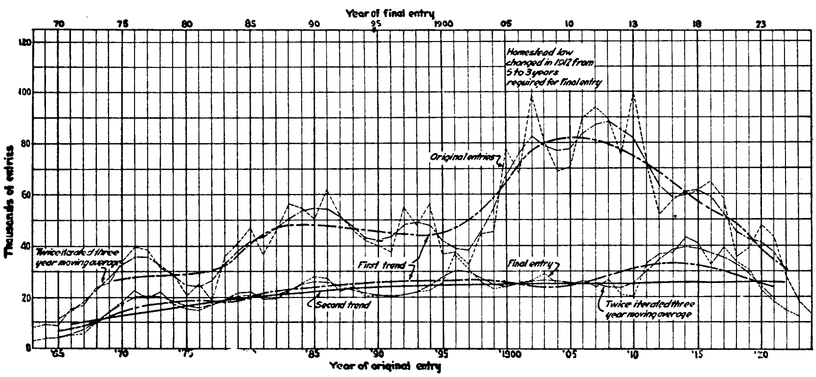

Fig. 10. Cyclical analysis of original and final homestead entries, 1863–1924.

Although obscured somewhat by the relationships already mentioned, there is an indication that economic conditions a year after entry have an important effect upon those remaining on their homesteads. It would be reasonable to suppose that this would be true with the wholesale prices lagged two and one-half years or one-half of the period between original and final entry, for it would seem that business conditions during the period of settlement might affect the numbers who stayed on the farms. The results of the analysis, however, indicate that probably a large number of those giving up did so during the early part of their period of proof and their tendency to leave their homesteads was retarded by poor business conditions which probably meant lack of opportunity for employment in other fields than agri-

13 Farm economics. Dept. of Agr. Econ. and Farm Man. New York State College of Agriculture, Cornell University, Ithaca, N. Y. 45:698. June, 1927.

culture. There is some tendency toward the same relationship without the lag. In other words, high price conditions at time of original entry indicates a small percentage making final proof. The complex nature of the problem is brought about by the fact that the composite economic situation prevailing through the five- and three-year period of proof affected not only the numbers taking up land, but also the number leaving the claims during the period of proof.

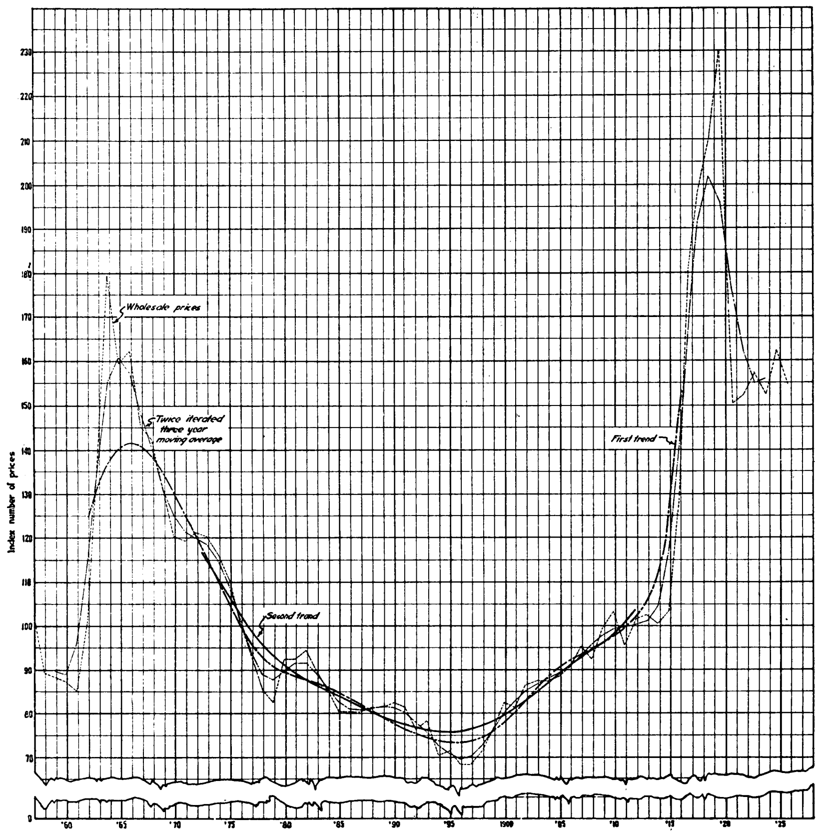

Fig. 11. Cyclical analysis of wholesale prices of all commodities, 1857–1927.

Factors Affecting the Economic Supply of Land.—Statistical analysis of economic supply of land have not been undertaken in the present study. Advertisements for farms, data on the character of reclamation projects and information concerning farms being purchased, furnish statistical measures of supply. There are at present about 22,000,000 acres in drainage enterprises in the United States provided with reclamation which are not being utilized for agricultural production. About 7,000,000 acres though undeveloped are provided with irrigation facilities. These lands are available, but at a price which is sufficient to cover costs of the raw land and of the reclamation construction. This price may, therefore, be a limitation to the economic supply inasmuch as costs of production when land costs are included may be so great as to eliminate the possibility of any net income. In addition, there is a large area capable of producing crops without reclamation. This land, however, is for the most part of poor quality. Though these figures indicate large supplies of land, the effective economic supply is limited by cost of development in rela-

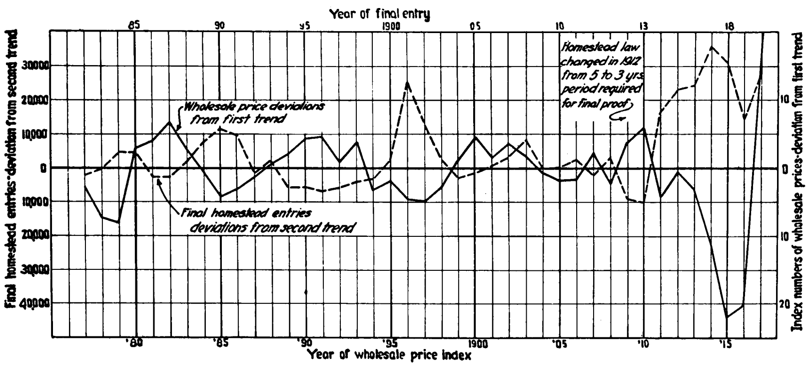

Fig. 12. There is an inverse relationship between wholesale prices of all commodities and final homestead entries when the latter are lagged for the period between original and final entry.

tion to expected income and available capital for development. Economic supply of raw land, unimproved, is, like the demand for undeveloped land, subject to different influences from the supply of improved land. Raw land is usually held by owners who are desirous of selling it at a price which will pay them for holding charges and development costs and usually an additional amount in the form of business profits. The growing scarcity of fertile soil in undeveloped lands tends to decrease this economic supply. Increasing costs of development, carrying charges, and overhead costs of agencies subdividing and selling undeveloped land tend further to decrease the effective economic supply. In irrigated areas, water supply is also an important influence upon the supply of irrigable land. Speculative irrigation enterprises spring up during times of business prosperity but are likely to be developed, if the price of land is low enough, during periods of poor industrial conditions. The recent war period introduced exceptional influences which require caution in drawing conclusions. The supply of improved land is indirectly influenced by many of the factors which affect the supply of undeveloped land. The situation of the seller, however, is entirely different. The owner of the improved farm may be more or less willing to sell his farm according to different conditions which may prevail. High prices for agricultural produce may induce him to hold his land at a higher price per acre, thus limiting the effective economic supply. Opportunity for part-time employment in nearby urban centers may have the same effect as increased agricultural prices. However, attractive opportunities for industrial employment or desire on the part of the family for

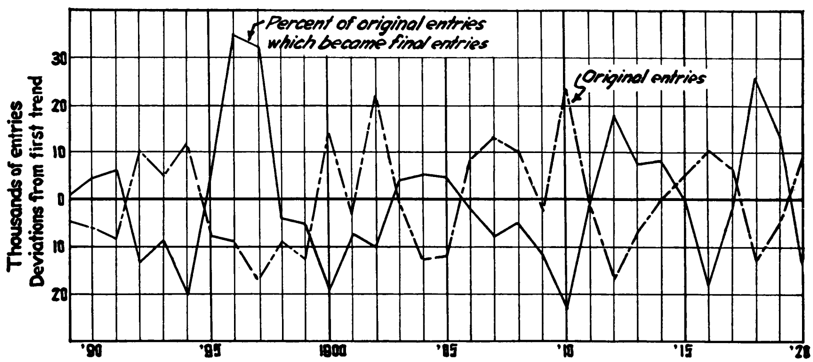

Fig. 13. There is an inverse relationship between numbers of original entries and the per cent of those which became final entries.

modern conveniences and attractions, may increase the economic supply of land by reducing the price at which farmers, who govern a given land market, are willing to sell their farms. The peculiar characteristic of supply in this case is that the same conditions that would tend to cause an increased supply would tend to cause a reduced demand. Either one alone would reduce land prices. The effect of land price on rate of buying and selling and the reverse, the effect of rate of buying and selling upon land price, is pointed out by Gray and Lloyd who in describing the land boom of 1919 stated that "the increase in value tended to stimulate actively in buying and selling while this activity in turn reacted upon values."[14]

The relationship between factors influencing supply of and demand for land are indicated in the time series which have been analyzed. Frequently exceptions may be noticed to the inverse relationship men-

[14] Gray, L. C., and O. G. Lloyd. Farm land values in Iowa. U. S. Dept. Agr. Dept. Bul. 874:37. August 23, 1920.

tioned above between business conditions and movement to undeveloped land. A direct relationship between an index of business conditions and the rate of movement to undeveloped land would indicate that during prosperous times agriculture was still more prosperous because of attractive price conditions or from other causes. This occurred during the early part of the war period. During industrial depressions, agriculture might be even more depressed than industry, for although employment conditions in industry might be very unsatisfactory, the opportunity for agricultural returns might still be sufficiently poor to prevent a general movement to the land. This was the condition in the years immediately following the war. Income alone, therefore, from agricultural land is not the sole determinant of the most probable price which that land would obtain in a sale.

Land Prices and Agricultural Prices.—Wiecking,[15] in discussing the complex factors which enter into changes in land values, states that, "year to year fluctuations in earnings may not be reflected in values, at least, not immediately. Land yields its services year after year. One year's increase or decrease in income, therefore, may or may not affect value. Many considerations enter. How great the increase or decrease is, what its relationship to the trend over preceding years is, the extent to which it is considered more or less temporary or as an indication of the future trend, the general future outlook for earnings—these and other factors have effect. It is probably the trend or average of income realized over a series of years which is the dominant influence on the earnings side. Even a reasonably stable trend in earnings, however, may be offset by other forces, of which a number are apparently still in operation." Black[16] in discussing the studies of income made by the National Bureau of Economic Research flays the method which was used in deflating inventory values to correspond to changes in prices. He states that "the preposterousness of this lies especially in the fact that land prices should not rise with the price level until it is clear that the new price level has come to stay." Chambers,[17] in discussing the effect of income on land value in the boom years of 1919 and 1920 states that land values "went up in these years in the main because land incomes went up, and because buyers of land did not discount the fact that these incomes were based upon

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15 Wiecking, E. H. The farm real estate situation, 1926–1927. U. S. Dept. Agr. Cir. 15:7. Washington, D. C.

16 Black, John D. Agriculture now. Journal of Farm Econ. 9(2):137–162. Bureau Agr. Econ., Washington, D. C. April, 1927.

17 Chambers, Clyde R. Relation of land income to land value. U. S. D. A. Bul. 1224:38. Washington, D. C., 1924.

abnormal conditions.'' He further illustrates the tendency of land purchasers and sellers to inaccurately anticipate the future, by the following statement: ''In the early part of this century, the farmers, who are the principal buyers and sellers of land, had fresh in their memories the long depression of the nineties. Furthermore, land incomes up to this period had not increased very much or very rapidly. Hence, very little was anticipated in the way of further increase in land income and the ratio of rent to value was therefore relatively high. But in the years following 1900 the average increase in land income was greater and greater, so that a constantly increasing percentage of the value was based upon anticipated increases in income, resulting in declining ratios of rent to value.''

The fact that land prices are based upon inaccurate estimates of future returns introduces much irregularity in the relationship between prices of farm commodities and land prices. Much more important than changes in prices of agricultural commodities alone is the relation of that change to changes in costs. Forster[18] has shown that the remarkable increase in land prices in Kentucky in 1919 and 1920 was due not alone to the increase in tobacco prices but also to the fact that tobacco prices increased so much more rapidly than costs. He states that ''while there was an increase of 269 per cent in the price of tobacco there was an increase of only 104 per cent in the cost of production.'' Gray and Lloyd[19] have emphasized this same cause of the 1919 land boom. In addition they mention the fact that ''during this period farmers used many kinds of equipment bought at the earlier prices of the pre-war period, such as machinery, work horses, harness, etc.'' All of these writers have given much attention to the phenomenal increase in land prices during the period of inflation during and following the war, but little attention has been paid to general economic influences upon land prices under less extraordinary conditions. Since the war, the trend of profits from agriculture has been reversed. The trend of agricultural prices has been downward. The trend of land prices has also been downward. The relationship is not necessarily a simple illustration of cause and effect, however. In most of our studies, we have found different causes and effects, in regard to land price changes, in evidence during more normal times than occurred during the war inflation and deflation period. We have already mentioned the complex relationships existing between indus-

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[18] Forster, G. W. Land prices and land speculation in the Bluegrass Region of Kentucky. Kentucky Agr. Exp. Sta. Bul. **240**:64. Lexington, Ky.

[19] Gray, L. C., and O. G. Lloyd. Farm land values in Iowa. U. S. D. A. Bul. **874**:3. August, 1920.

trial conditions, agricultural prices and land prices. The lag of agricultural costs behind agricultural prices during periods of increasing and decreasing prosperity adds to this complexity and diminishes our expectation of a close correlation between land prices and agricultural prices.

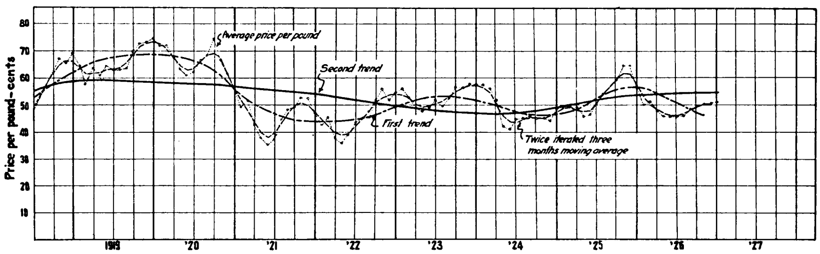

Fig. 14. Cyclical analysis of California butterfat prices, 1919–1926.

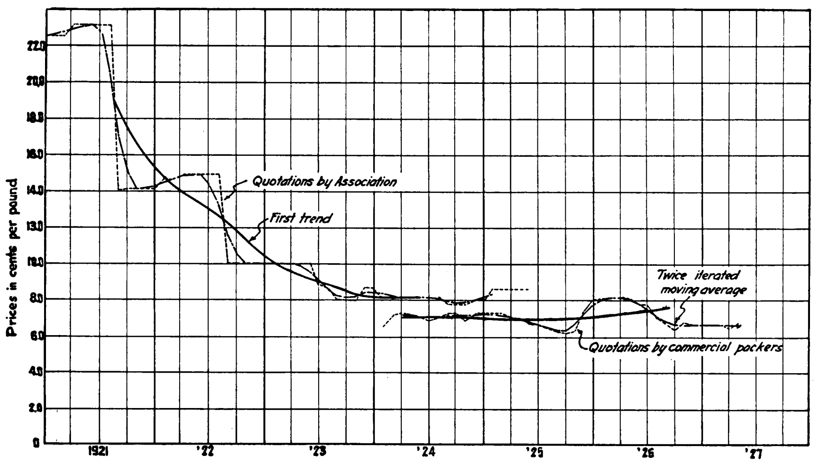

Fig. 15. California wholesale raisin prices.

There is some indication of a direct relationship between butterfat prices and price of land through the years 1923–1927, inclusive. A longer period would be necessary to verify this tendency. Through the years from 1919 to 1922, inclusive, however, there seems to be no relationship whatever between butterfat prices and land price. Figure 14 is a cyclical analysis of butterfat prices.[20] In the San Joaquin

[20] Source of data:

Voorhies, Edwin C. Economic aspects of the dairy industry. California Agr. Exp. Sta. Bul. 437:80. *Table 35.* 1927.

Valley where the price of raisins has been such a vital factor, there is little indication that fluctuations from year to year in land prices have been affected thereby. Figure 15 shows the wholesale price of raisins from 1921 to 1927.[21] It will be observed that control of prices upsets the cyclical tendency in the first trend. There are no cyclical relationships for short periods, at least, between raisin prices and land prices. There is, however, no question but that the secular trend of land prices in the San Joaquin Valley is greatly influenced by the raisin situation. This probably applies to lands other than vineyards. In the long run, crop prices undoubtedly are one of the important influences, but not the only one, governing land prices; but over short periods of time industrial or financial conditions seems to be much more important causes of variations than agricultural prices.

Principle of Relative Productive Value

Quantitative determination of the effect of different land qualities combined in different proportions is basic to scientific appraisal. Factors influencing land value or price of land are so numerous and complex that if we are to resort to relationships as a guide to variability of price or value, we must simplify our work by segregating the important factors into groups and by analyzing the relationships within each of these groups before attempting to study relationships between land value and the indexes of the groups themselves.

The combining of a number of related variables into a single index seems to be the only hope of reducing land valuation to a scientific basis. The variables are so numerous that if they are considered separately and independently, rational interpretation becomes hopeless. To illustrate this important point the productivity of a piece of land may be taken as an example. Productivity is usually considered the most important factor in land valuation. In fact, the Federal Farm Loan Act dictates that productivity shall be the *basis* of land valuation. Productivity itself, however, is determined by a large number of other factors such as rainfall, temperature, soils and many other elements. The measurement of productivity in terms of the many elements affecting it would result in an index which would represent the net effect of these elements in the final analysis of value. It would be used as a single factor instead of many variables in correlations, thus simplifying a complex problem.

[21] Raisin prices from which figure 15 was constructed were compiled by Dr. S. W. Shear, Division of Agricultural Economics, University of California.

Livingston[22] has done some work on the development of physiological indexes of productivity with special reference to climatic conditions and has given us a temperature index based upon the work of Lehenbauer.[23] The index developed by Livingston in his early work was merely intended to give the temperature efficiency for different parts of the United States. It is so general, however, that its value as a local index to be used in land valuation would be limited. Its chief value is to be found in general geographical studies. The work of Livingston and Lehenbauer, however, give us a suggestion of the possibility of combining the results of many variables into a single factor, thus simplifying a complicated study. Future work in this field should be coordinated with more recent researches of this character by these and other investigators.

A Corollary to the Principle of Proportionality.—The difficulty of such studies is increased by the fact that most of the factors affecting productivity have curvilinear relationships following the principle of proportionality. This principle has been stated in many different forms and is frequently called the principle of diminishing returns. Some economists believe that the use of the latter expression, "diminishing returns," applies only to the broader population problem; whereas when different combinations of elements of production are concerned the principle of proportionality is involved. Fetter in his *Economic Principles* states that, "a clear understanding of this most fundamental principle of proportionality is essential to the solution of the complex problems of valuation. Things are not valued in isolation from each other. The great mass of complementary agents act and react upon each other. The valuation put upon one agent is due in part to the presence in certain proportions of other agents."[24]

Beckett and Robertson[25] have shown that the yield of alfalfa under the application of additional amounts of irrigation water follows the principle of proportionality. We have only to extend this principle to apply it in the evaluation of lands having different quantities of water available for irrigation. Just as each additional unit of fertilizer increases productivity up to a certain point after which returns

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22 Livingston, Burton Edward. Physiological temperature indices for the study of plant growth in relation to climatic conditions. Physiological Researches. 1913–15 1(1):399–420. Physiological Researches, Station H, Baltimore, Maryland.

23 Lehenbauer, P. A. Growth related to temperature. Physiological Researches 1913–15 1(1)247–286. Station N, Baltimore, Maryland.

24 Fetter, Frank A. Economic principles. 1:134. The Century Co., New York, 1926.

25 Beckett, S. H., and R. D. Robertson. The economical irrigation of alfalfa in the Sacramento Valley. California Agr. Exp. Sta. Bul. 280:272–294. Berkeley. May, 1927.

per unit added decrease, land situated under different conditions of temperature vary in productivity according to the same principle.

Black has stated the principle of "diminishing physical outputs" as applied to several factors of production in combination, as follows: "*As increasing inputs of one or more elements of production are added to one or more fixed elements, a point is soon reached after which outputs per unit of the varying input elements decrease; and if more than two of either fixed or varying elements are involved, the points at which the decrease sets in, and the amount of all the outputs per unit of input, are affected by the inter-effects of the changes in the several varying elements, and also by the inter-effects between the several fixed and the several varying elements.*"[26]

The above carefully worded principle, is probably a good starting point from which to develop a corollary for application to land value studies. Designed primarily for the analysis of production problems, it is clearly inadequate for the purpose of describing the variations in value of different tracts of land composed of qualities combined in different proportions.

In considering the productivity of one piece of land relative to that of another we are not adding factors of production in different proportions. We are simply comparing two different sets of such combinations, many of the elements in each being capable of little change. The underlying principle is the same but previous statements of it are inadequate for this purpose. A corollary to the principle of proportionality which is fundamental to land valuation and which may be extended in its application in other fields might be stated as follows: *In considering the relative productive value of two or more parcels of farm land it must be taken into consideration that the productive value of a given element or group of elements is dependent upon the proportion which that element or group of elements bears to the other essential elements contributing to or detracting from the productive value of the whole and that up to a certain point each unit of any essential element of productivity will be relatively more valuable as it is found in larger proportions but that superabundance of any element of productivity may result in a lower value per unit of the contributing element or may actually detract from the total productive value of the parcel of land in question.* In applying this principle it must be borne in mind that changes in supply and demand are held in abeyance and that time does not enter as a factor.

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[26] Black, John D. Production economics. p. 309. Henry Holt & Co. New York, 1927.

Furthermore, it is not intended as a substitution for the theory of rent although it is the belief of the writer that it has greater significance and usefulness in the practical problems of land appraisal. In referring to this principle in the following pages, it will be called the *principle of relative productive value.*

The relative productive value of one piece of land as compared to another will be greater, other variables being constant, for that land situated under conditions of higher mean temperature. This is true only up to a certain degree of temperature after which the land so situated that its mean temperature is still higher will tend to have a lower productive value. This principle applies in general to other land qualities, not only those affecting physical productivity but many of the economic qualities as well.

An Index of Productivity

The construction of a productivity index is complicated by the many influences affecting crop adaptation; by the fact that many crops do not utilize, for economic and physical reasons, the entire climatic efficiency available; by the fact that productivity is often created by methods of culture rather than by inherent qualities in the soil; and, by the fact that for economic reasons we do not find crops distributed over a sufficiently large range of conditions to afford an opportunity for adequate sampling. Even when the problem is reduced to its simplest form, that of the yield of a single crop produced throughout a fairly wide range of conditions, relationships between yield and the factors causing that yield are curvilinear. Not only are these relationships curvilinear, but the curves in some cases cross one another indicating that positive correlations between certain variables in one region become negative in another. Added to these difficulties are the large numbers of influences affecting yield which, in order to be studied separately, require the grouping of available data on yield and value into such small groups that the question arises as to the representativeness of available data with respect to the group which it is supposed to represent. In the face of these disturbing variables too much in the way of results can not be expected at first.

In a previous section the need of simplifying the analysis by grouping the indexes of productivity, community values, and other similar attributes have been discussed. It has also been seen that land qualities occurring in different proportions follow a corollary to the principle of proportionality which corollary, for convenience, has been called the principle of relative productivity. Relationships following this principle are curvilinear and the variables are numerous. A large amount of data is necessary, therefore, for detailed analysis. An enumeration of only a few of the more important variables included in a study of yield as a measure of productivity indicates how large the number of groups becomes and how small the number of observations in each group must become. In such a study, farms must be sorted into groups according to soil characteristics, temperature, rainfall, several grades of quality of irrigation, a similar number of drainage conditions, varying degrees of alkali concentration, the presence of hardpan at various depths, the prevalence of weeds, pests, etc., with a view to studying yields in these respective groups. Average yields, therefore, due not only to soil conditions but to different degrees of personal efficiency, different amounts of capital invested in production and different seasonal conditions which vary from year to year are sure to have a high dispersion. Notwithstanding these wide variations, a definite tendency for different soil textures to have average yields which follow the corollary to the principle of diminishing returns has been established, and although a higher degree of accuracy may be expected as a result of future investigations, the present study gives a means of measuring productivity, under different general conditions, to a greater degree of certainty than has hitherto been possible in appraisal work.

In the Eleventh Federal Farm Loan District irrigation is of great importance in agriculture. Rainfall, except that it replenishes the irrigation supply, is therefore of less importance. Variations in rainfall may be expected to have little direct effect upon the productivity of farms having adequate water supply and depending almost entirely upon irrigation for moisture. Other factors, with the exception of temperature, which might be expected to affect productivity are capable of segregation. Even the effect of temperature may be studied by itself by grouping farms about a given temperature station. Yields of crops of different kinds may be studied in relation to the different factors affecting that productivity by eliminating as many variables as possible. When this is done and average yields determined, the principle of relative productivity has been found to hold. The present study has been greatly simplified by the elimination of all farms having accumulations of alkali, hardpan, less than first class irrigation or drainage conditions, weeds, pests or other unfavorable conditions. The elimination of these makes it possible to establish a standard for the measurement of the effect of such qualities in later studies. A number of difficulties still exist however which cause some trouble in analysis. Elimination of these unfavorable influences diminishes the range of productivity which would otherwise exist. Whole soil series are eliminated. The number of cases is reduced to such an extent that there is considerable dispersion even of averages from regression lines. Even if the range in productivity were not reduced in this manner it would be limited by the fact that crops tend to be produced under conditions of more favorable productivity. Observations of productivity values cannot be obtained for soils far below the limits of profitable cultivation. This brings up the complication of adaptation which is so involved that it has been reserved for future study.

The Combination of Productivity Indexes for Different Crops.—It would be desirable to develop a productivity index which is a composite of the yield of a number of important crops. The combination of productivity indexes for different crops is complicated by crop adaptation. It is necessary to approach this question cautiously. A measure of the comparative advantage of two areas cannot be made upon the basis of yield alone. The economic tendency for a piece of land to produce up to certain limits that crop for which it is best adapted introduces another important factor, second only to yield, in determining the relative economic productivity of two or more different areas.

An explanation has been made of the necessity of limiting the scope of this phase of the analysis. Some of the reasons given for limiting the scope of the study also apply to a discussion of the difficulties to be met in constructing a productivity index which will serve as a measure under different conditions of crop adaptation. The yield of fruit lands is complicated by the influence of the age of orchard or vineyard. Furthermore, many soils unfit for alfalfa or other crops are utilized for highly productive orchards. Labor may be an important element in deriving this productivity. The same degree of productivity might be physically possible but economically impracticable in the case of a lower priced crop. With the production of such a crop as oranges, fertility may be created at a great expense with profitable results. In such cases, the value of the soil may be simply the opportunity it affords to the crop for standing room as intensity of culture introduces the needed elements of productivity. Because of the multitude of complicated factors, it has been considered safer at the present time not to launch an attempt to combine indexes of productivity based upon yields of different crops until a number of individual studies have been completed with regard to special types of agriculture.

The study of differentials in productivity has for this reason and for reasons discussed elsewhere been limited to a single product, alfalfa, which is the basic crop in the dairying industry. Dairying is being conducted on the farms included in the analysis, because it is probably in most cases the best of the alternative purposes for which the land might be utilized. It has not been assumed, however, that the dairying industry alone has determined the value of the land utilized for dairying, but has competed with other crops in the purchase of land. Ultimately, when similar studies of values of land utilized for other purposes have been made, it may be possible to clarify our knowledge of alternative use and crop adaptation with respect to their effect upon land values.

Limiting the scope of the study in this way has its disadvantages and therefore it may be necessary later in the light of more detailed and extensive studies, to change some of the conclusions. It is expected that future work will result in changes and refinement. A beginning must be made, however, and it is with this understanding that the results of this preliminary analysis are being presented.

An Index Based Upon Alfalfa Yields.—The indexes of productivity in the present analysis are merely the average yields of alfalfa growing on irrigated land with adequate water supply under different conditions of soil texture, different mean temperatures and different annual ranges of mean temperature. The fitting of curvilinear regression lines to these averages increases the reliability of the index. Irregularities caused by inadequate data in certain groups, but supported by adjoining groups of large numbers of cases are smoothed out with a most interesting result showing the application of the basic principle of diminishing returns to the relative productivity of different lands.

Alfalfa has been used because it is a crop that utilizes the entire growing season, because it is grown in all parts of the district, and because it is the principal feed for dairy cattle throughout this district. It therefore lends itself to the study of dairy land price differentials used as an example of the application of the principles developed in this study. This index should be valuable in the extension of the analysis to other types of land but complications become numerous as soon as other crops, especially fruits, are brought into consideration. Grain crops harvested in early summer may or may not utilize the entire temperature efficiency of a region. There may be economic justification for growing a crop which does not make full use of the available source of energy. Economic and physical influences determine crop adaptation. It may be necessary to measure productivity with one or a few crops as with alfalfa, and introduce a new factor measuring adaptation when other types of agriculture are included in land price studies. Although grown generally throughout the district, alfalfa is not a universal crop. It is probable that it will be necessary to develop indexes by the use of crops which overlap in their soil adaptations. One of the difficulties in preparing the alfalfa index is that a given soil may in general be of low productivity, but under especially favorable conditions alfalfa may be found growing upon it, and yields obtained under these favorable conditions of growth may be represented in the correlations. For this reason, only soils have been included which are generally utilized for growing alfalfa.

Relation of Temperature to Productivity.—The study of effects of temperature upon plant growth in itself is not an economic problem. When we begin to consider the money value of different temperature conditions, however, we are well within the field of economics. There is a zone between the physiological and the economic phases of the subject which must be explored jointly by workers in both fields. If the writer has apparently gone beyond his depth in the physical aspects of the problem, it is only with a purpose of arriving at a point where it is possible to begin the economic analysis. Certain physical problems must be solved before the solution of the economic problems can be begun. Coordination of physical and economic studies will be necessary in future work in this field.

An attempt will not be made to review the literature on the effect of temperature upon plant growth. Lehenbauer[27] has given us some important findings in this respect which are very useful from the standpoint of economic analysis of factors affecting land price. Lehenbauer's curve showing the relationship between temperature and rate of growth has the typical characteristics of the principle of diminishing returns. Table 5 shows Lehenbauer's "mean average hourly growth rates (hundredths of a millimeter) for shoots of maize seedlings at temperature of from 12° to 43° C. The length of exposure in this case was 12 hours. The results of the work of Lehenbauer are used in the present study to give us the general shape of the temperature growth curve. That the factors determining the temperature of maximum growth rate and the magnitude of the maximum growth rate are variables is indicated by the results of Lehenbauer's experi-

[27] Lehenbauer, P. A. Growth of maize seedlings in relation to temperature. Physiological Researches 1(1):247–286. Station N, Baltimore, Maryland, 1913.

ments, using exposure periods other than twelve hours, which resulted in optimum temperatures occurring at different degrees of temperature with corresponding different rates of growth at the maximum. "Indeed," states Lehenbauer, "it appears that the term 'optimum temperature' for growth in this case at least is quite without meaning unless the length of the period of exposure is definitely stated." Temperature efficiency for most practical purposes may be considered as a function of mean temperature and annual range. Under ordinary growth conditions, temperature is constantly fluctuating hour by hour, day by day, and year by year. The length of exposure becomes an erratic variable. Furthermore, different plants have different growth rates. The remarkable thing is that the shape of the Lehenbauer curve is retained at all owing to the caprices of natural conditions. Such is the case, however, when average alfalfa yields are plotted against mean temperature; the characteristic shape of the Lehenbauer curve is reproduced and it requires only a change in the vertical and horizontal scales of the diagram to practically duplicate it.

Effects of Daily and Annual Variations in Temperatures.—This similarity in the curves showing growth-temperature relationships is quite striking when it is taken into consideration that the mean annual temperature has within it all of the daily and annual variations which have different characteristics from region to region. The analyses show that daily range of temperature has little effect upon the alfalfa yield. This is possibly due to the observation noted by Lehenbauer that growth rates decline after a certain length of exposure and the effectiveness of the temperature of the day may be almost as great through a portion of the twenty-four hours as if it were continuous. Annual range, on the other hand, has a marked effect upon the yield of alfalfa. This would naturally be expected. A region having great range of temperature throughout the year is subject to shorter growing seasons and cooler winters. Coefficients of correlation of $+.879$ have been found between annual mean temperature and frost free period; of $+.006$ between annual mean temperature and daily range, and of $-.539$ between annual range in monthly mean temperature and frost free period. It seems that daily range in temperature has very little relationship with length of growing season. The correlations, among the three variables, mean temperature, annual range in mean temperature, and frost free period, indicate that it is not a serious omission to leave length of growing season out of the correlations. The coefficient of multiple correlation for these three variables was $+.887$.

Harmonic Characteristics of the Annual and Daily March in Temperature.—Daily and annual temperature variations follow very closely a modified form of the cosine curve. Figure 16 shows the mean monthly maximum and the mean monthly minimum temperatures of Phoenix, Arizona, with the curve fitted to the maximum series.

$$Y = 83.5 + 19.2 \cos. 30M$$

In this equation, Y is the mean maximum temperature, M is the number of the month of the year expressed in degrees numbering from July. One month is one-twelfth of 360° or 30°. July is 0° or 360°.

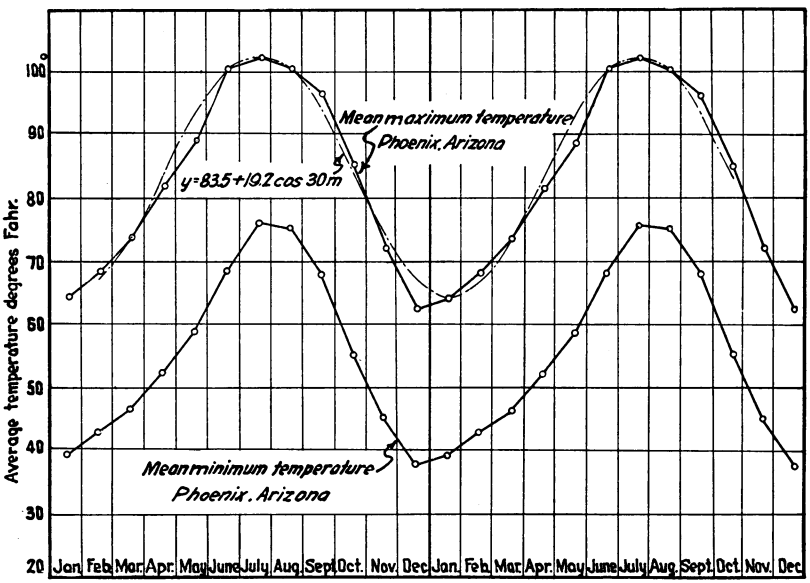

Fig. 16. Tendency of temperature variations to follow the cosine curve.

Marvin[28] has found that for a section of the Northeastern United States, the annual curve of temperature may be represented by a single cosine curve. West[29] has given a formula

$$T = (\frac{Ma}{2} + Va \cos. t) + \frac{My}{2} \cos. t$$

"The constants are the mean annual temperature (Ma), the range of the annual march (Va), and the range of the daily march (My)."

[28] Marvin, C. F. Are irregularities in the annual range of temperature persistent? Monthly Weather Review 47(8):544. 1919.

[29] West, Frank L. A simple equation of general application for the normal temperature in terms of the time of day and the day of the year. Monthly Weather Review 48(7):394–396. 1920.

For a given station, however, the mean temperature for any day in the year can very closely be approximated by the simple cosine relationship

$$T = M + \frac{R}{2} \cos. \theta$$

where M equals mean daily temperature, R equals annual range in temperature, and θ equals time in degrees counted from the maximum.

Application of Results of Maize Growth Experiments and Harmonic Characteristics of Temperature Variations in Constructing a Productivity Index.—Because of the large number of possible combinations of mean temperature and range in temperature, the small number of cases of yield data in some of the groups makes it difficult to construct these curvilinear correlations without the aid of the results of Lehenbauer's studies and calculations based on the harmonic characteristics of the annual march of mean temperature. The annual temperature efficiency of a given climatological station may be considered as the sum of the temperature efficiencies for the different periods of the year. This is not exactly true because a given temperature is probably more effective for plant growth at one time in the year than at another. We can proceed with the assumption, however, that there will be a fairly high correlation between temperature growth efficiencies for a whole year integrated from the temperature growth efficiencies for the different parts of the year, and yield.

On the basis of the simple cosine formula given above, mean daily temperatures have been computed for 24 intervals of time throughout the year for annual ranges of temperature from 0° to 45° F and for annual mean temperatures from 25° F to 100° F. For each of these computed values of temperature, the corresponding growth rate found by Lehenbauer has been taken from table 5. Averaging these 24 bi-monthly values for a given mean temperature, it has been possible to obtain indexes of temperature efficiency for the year based upon mean hourly growth rates of maize seedlings for ranges of temperatures from 0° to 45° F. Figure 17 and table 6 are based upon the Lehenbauer experiments and upon the corrections for range in temperature described above. The curve having a range equal to zero is based upon the original Lehenbauer twelve-hour exposure experiment. In the cooler regions, for a number of months, the temperature efficiency is 0. Temperature efficiency is greater during the winter months for those stations having the longer growing seasons. Average temperature efficiency for the year is therefore greater for those stations having the longer growing season.

TABLE 5

MEAN AVERAGE HOURLY GROWTH RATES—HUNDREDTHS OF A MILLIMETER—FOR SHOOTS OF MAIZE SEEDLINGS FOR A TWELVE-HOUR PERIOD OF EXPOSURE

(1) Temperature, deg. C.	(2) Growth rate*	(3) Temperature, deg. F.	(4) Growth rate†	(Col. 3, cont.) Temperature, deg. F.	(Col. 4, cont.) Growth rate†
12	9	40	0.0	76	72.896
13	10	41	0.3	77	76.601
14	16	42	0.6	78	80.446
15	20	43	0.9	79	84.439
18	28	44	1.3	80	88.561
20	45	45	1.6	81	92.753
21	53	46	2.2	82	96.924
22	59	47	2.7	83	100.927
23	64	48	3.4	84	104.554
24	69	49	4.2	85	107.241
25	75	50	5.1	86	108.630
26	82	51	6.0	87	109.455
27	90	52	7.1	88	109.804
28	98	53	8.2	89	109.338
29	105	54	9.586	90	107.916
30	108	55	10.916	91	105.564
31	109	56	12.546	92	102.361
32	111	57	14.376	93	98.380
33	101	58	16.501	94	93.752
34	97	59	18.879	95	88.637
35	86	60	21.430	96	83.084
36	74	61	24.127	97	77.183
37	70	62	26.947	98	71.010
38	58	63	29.872	99	64.618
39	46	64	32.887	100	58.059
40	31	65	35.979	101	51.400
41	20	66	39.136	102	44.706
42	11	67	42.346	103	38.063
43	6	68	45.606	104	31.573
		69	48.915	105	25.352
		70	52.251	106	19.535
		71	55.604	107	14.316
		72	58.969	108	10.009
		73	62.349	109	6.890
		74	65.853		
		75	69.321		

* Marvin, C. F. Are irregularities in the annual range of temperature persistent? Monthly Weather Review. **47** (8): 276. 1919.

† Growth rates are calculated from adjusted second differences taken from a smoothed curve fitted to the original data of column (2). Values in column (4) are given to three decimal places to make possible the reproduction of the smoothed second difference curves from which they were derived without cumulative error. In much work of this kind, differences in growth or rates of change are more important than absolute rates. Rates of change (first differences) and acceleration (second differences) may be computed from column (4). The number of decimal places should not be taken as an indication of the accuracy of any individual observation although an estimate from column (4) should be a closer approximation to the probable growth rate than any individual observation taken from column 2.

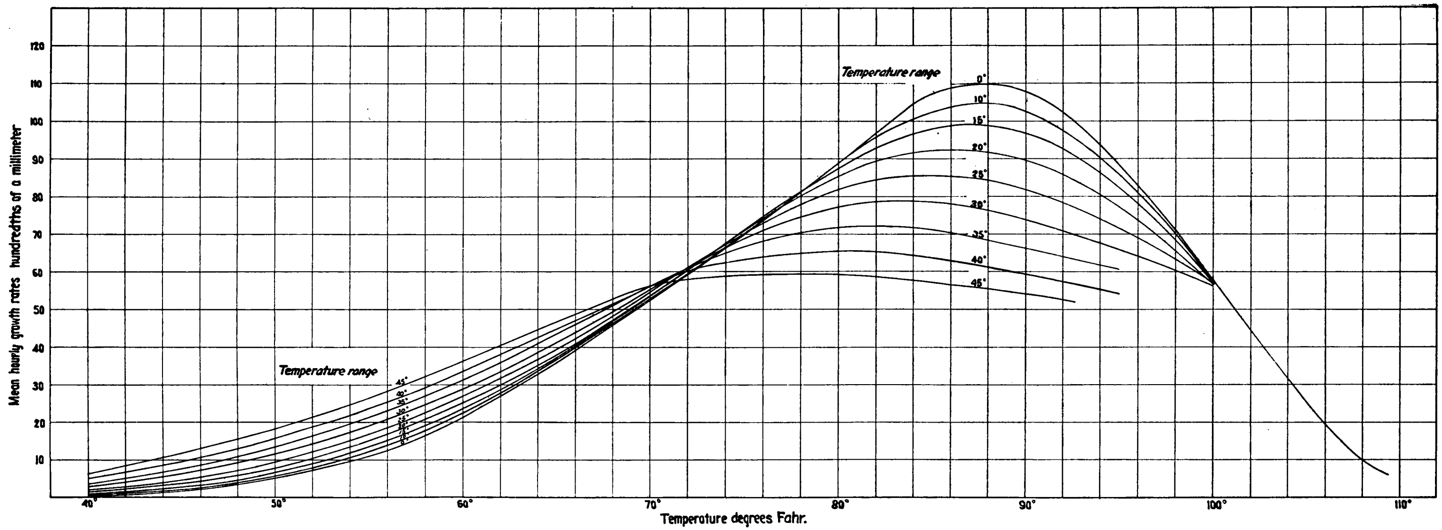

Fig. 17. Lehenbauer has derived mean hourly growth rates of maize seedlings under constant temperature conditions. The results of his experiments under conditions of 12-hour exposures are shown above in the curve for temperature range of 0°. This curve is a smooth curve fitted to his data. The data of Lehenbauer have been applied here to measure the growth efficiency of a given mean annual temperature associated with a given range in mean temperature throughout the year. The range as actually used is the difference between the highest monthly mean temperature and the lowest monthly mean temperature. The ordinates of the other curves of the illustration were obtained as follows: The ranges in the mean annual temperature, M, from 0° to 45° F were used to establish the constant R in the cosine curve $T = M + \frac{R}{2} \cos \Theta$, which expresses the annual march in daily mean temperature, T. Time is measured by Θ. By means of this formula, mean daily temperatures were computed for 24 equal intervals of time during the year. Maize growth rates corresponding to these temperatures were averaged to obtain the ordinates of curves for different ranges in temperature. With the exception of the original Lehenbauer curve, these should not be considered as results of observations but as purely abstract indexes of the growth efficiency corresponding to mean temperatures for given ranges in monthly mean temperature. The complex variations in the growth of plants under the cumulative effects of changing temperatures are, of course, not exactly indicated by these indexes. Correlations, however, indicate fair approximation to growth conditions and therefore justify their use.

TABLE 6

TEMPERATURE INDEXES FOR USE IN CALIBRATING THE RELATIVE PLANT GROWTH EFFICIENCY FOR WEATHER BUREAU STATIONS IN THE ELEVENTH FEDERAL FARM LOAN DISTRICT

Range in temp., deg. F.	10°	15°	20°	25°	30°	35°	40°	45°
Mean temp., deg. F.								
25						.1	.2	.5
30				.1	.3	.6	.9	1.5
35		.1	.3	.6	1.1	1.7	2.4	3.3
40	.5	.9	1.4	2.0	2.8	3.8	5.1	6.2
45	2.1	2.7	3.6	4.6	6.1	7.8	9.7	11.8
50	5.6	6.5	7.8	9.5	11.5	13.7	16.0	18.4
55	12.1	13.4	15.1	17.0	19.1	21.4	23.9	26.5
60	22.4	23.6	25.2	27.1	28.9	31.1	33.6	36.3
65	36.6	37.1	38.0	34.3	41.1	43.3	44.8	46.9
70	52.4	52.7	53.5	54.5	55.2	56.2	56.1	55.2
75	69.9	70.8	70.9	70.4	69.0	66.5	63.2	59.0
80	88.7	87.4	85.2	81.8	77.1	71.6	65.6	59.2
85	102.3	97.8	92.0	85.4	78.5	71.1	63.8	56.7
87.5	104.9	99.0						
90	102.8	96.9	89.6	81.8	73.9	66.2	59.7	54.3
95	85.8	82.2	77.2	71.5	65.7	60.7		
100	57.4	57.0	56.7	56.8	56.2			
105								

From this point, the fact that the curve is based upon growth rates of maize seedlings ceases to be significant. The objective is to obtain a chart which will express the relationship between mean temperature and probable alfalfa yield for different ranges in mean temperature. Such a chart will obviously have the same characteristics as figure 17, but since the growing conditions of alfalfa are different and the units and basis of measurement are different, the vertical and horizontal scales will be different. If it were not for the variability introduced by range in temperature we should be able to construct the desired chart from the alfalfa yield data alone. It is a measurement of the effect of range in temperature which compels us to use the following method of calculation. By changing the vertical and horizontal scales, the curve showing the relationship between the average yield of alfalfa on sandy loam under different conditions of mean temperature can be made to conform to the 30° range line of the maize-growth curve in figure 17, 30° being approximately the average range in temperature for the cases of alfalfa yield included in the correlation. This was accomplished by the following procedure. The horizontal scale of the 30° range line of the maize-growth curve was changed to bring the maximum of that curve into the same vertical line, as the maximum of the curve of sandy loam alfalfa average, 40° mean temperature being considered identical in both curves. This was approximated at first by observation of the points of maxima. The adjustment was refined finally by adopting that horizontal scale which would give the highest correlation between alfalfa yield averages and maize-growth corresponding to mean temperature on the adjusted horizontal scale. By considering both scales coincident at 40° mean temperature, the temperature of maximum efficiency for corn of 84° was reduced to 68° for alfalfa. By such adjustment of the horizontal scale it was possible to obtain a correlation of + .67. It must be remembered, however, that temperature range is still a cause of dispersion. By means of the regression line of this correlation a new vertical scale was derived. This regression line is an expression of the relation between the values on the vertical scale of the maize-growth curve and the values on the vertical scale of the alfalfa yield curve. The resulting curve shows mean temperature-alfalfa yield relationships, average temperature range being 30°. By means of the new vertical and horizontal scale adjustments, the temperature-range corrections of figure 17 were plotted, as deviations from the 30° range line. In the original form this gave us a chart quite similar to figure 17, but for use in computations it was changed to the form shown in figure 19 in which the sandy loam alfalfa yield curve for a mean temperature range of 30° was reduced to a horizontal position. The other curves of this figure give deviations in the yield of alfalfa for different ranges in mean temperature corresponding to different mean temperatures.

Having obtained the basic sandy loam yield curve, the next step was to compute the respective deviations for the several soil textures from the sandy loam estimates. This was done by making an estimate of yield for each temperature station on the basis of the sandy loam alfalfa yield curve. These estimated values were subtracted from the observed yields for the different soil textures corrected for range in mean temperature by values read from figure 19. These deviations for each soil texture were sorted into groups according to class intervals of mean temperature. Average deviations were plotted for each mean temperature class and a smooth curve was drawn through these averages. These curves gave a basis for estimating corrections in yield for soil texture to be applied to estimates based on the standard sandy loam mean temperature yield curve. These estimated deviations measured in the proper direction above and below the sandy loam curve gave a set of curves similar to those shown in figure 18. Even

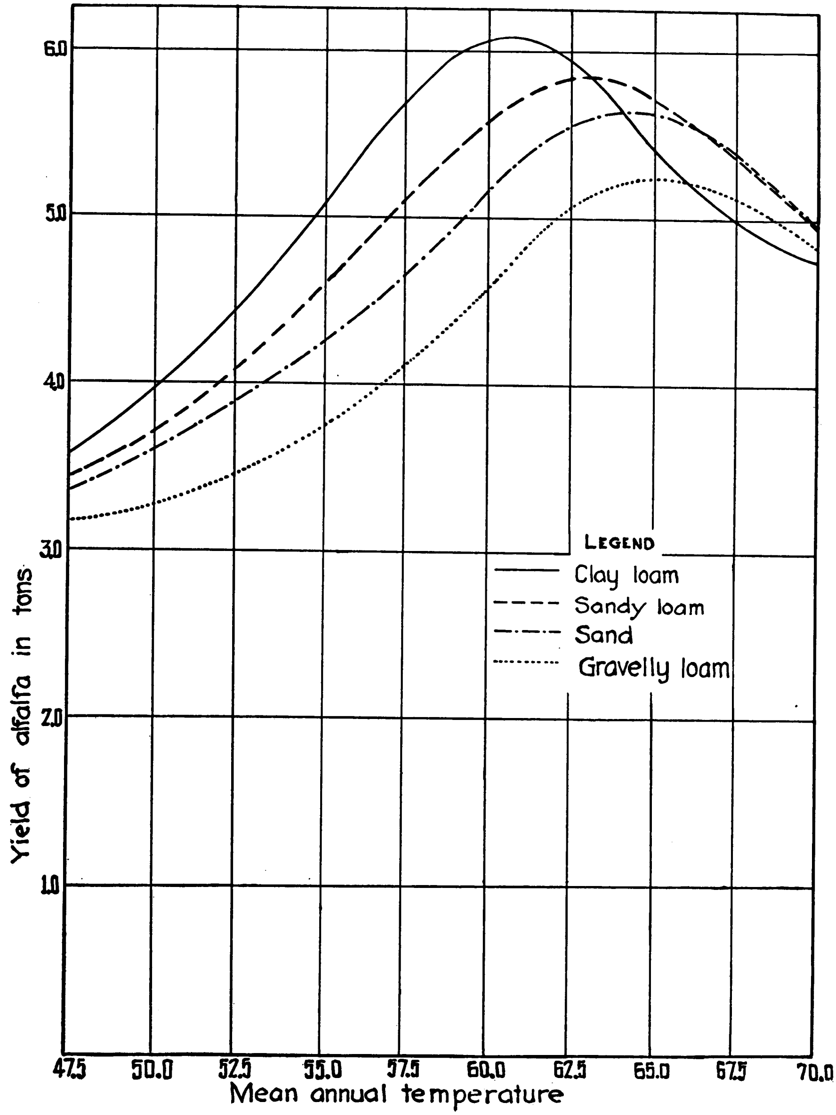

Fig. 18. Average yield of alfalfa for mean annual temperatures from 47.5° to 70° F for a range of 30° between the lowest monthly mean and the highest monthly mean temperatures.

the basic sandy loam curve itself was refined when studied in connection with deviations due to range. Having individual characteristic curves for a number of the important textures, it only remained to take out the irregularities which were obviously erratic. The curves were smoothed with the objective of obtaining continunity not only with respect to a single texture but from one texture to another. The resulting curves for four important textures are shown in figure 18.[30]

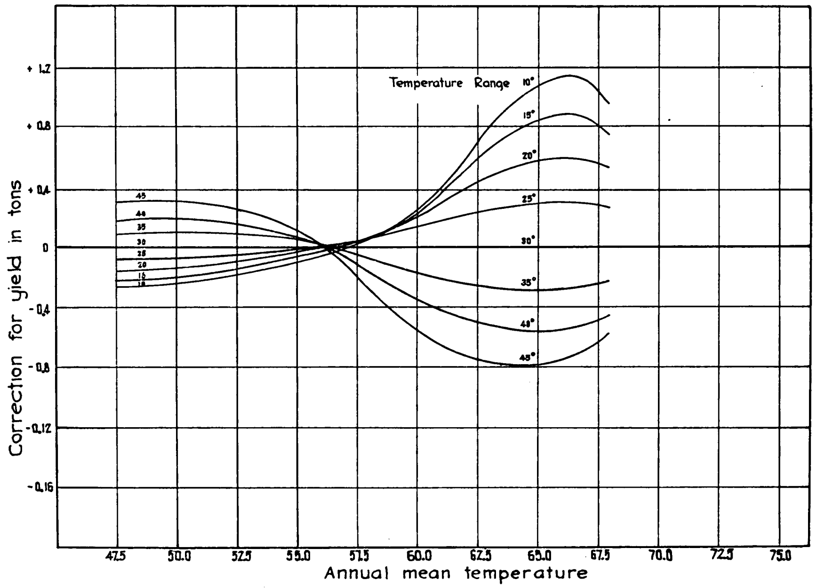

Fig. 19. Corrections for annual range in temperature degrees Fahrenheit to be applied to alfalfa yields estimated on the basis of relationships of mean temperature to yield shown in figure 18.

It must be understood that these observations take into consideration only the average resultant effects of soil textures which in natural conditions are subject to many interacting effects of temperature, moisture and of aeration. The subdivision of these into their components is truly the work of the soil physicist, while the difficult problem of ever-changing chemical conditions must be the subject of

[30] The test as to the reliability of the method of analysis was made by correlating estimated yields of alfalfa with observed yields. Estimated yields on sandy loam for the mean temperature prevailing at a given climatological station but for a mean temperature range of 30° F were paired with average observed yields at the same station corrected for range in mean temperature and for soil texture. This correction was made to bring the estimated yields and the observed yields to the comparable basis of 30° F range in mean temperature and sandy loam soil before correlations were made. The success of the method was established by a correlation coefficient of + .886.

detailed research by the agricultural chemist and plant physiologist. Estimated yields of alfalfa based upon figures 17, 18, and 19 are the productivity indexes used later in the land price analyses.

The Importance of Rainfall.—Inasmuch as this study does not include farms depending entirely upon rainfall for their productivity, later studies should include such analyses at which time much light may be thrown upon the effect of rainfall upon unirrigated portions of irrigated farms.

Price of Land in Relation to Size of Farm and Value of Buildings

Small farms sell for higher prices per acre than large farms. Cost of subdivision and sale, characteristics of demand for and supply of land, productivity, opportunity for employment off the farm, residence value, psychic values, including attractiveness of urban centers, and type of agriculture are elements in the size price relationship. Other elements are cost of farm development, scarcity of land of suitable location, building values, and total capital required for purchase. Some of these are causes of higher prices per acre. Others are effects. Some are both cause and effect indirectly reacting one upon the other coming into equilibrium with a resultant price which is higher in the case of smaller farms. Cost of subdivision and sale is greater for the small farm. Surveys, the making of records, and salesmen's fees are all practically as great for the small farm as for the large one, making the cost per acre greater. Can it be said that higher cost of subdivision and other selling costs are a cause of higher price or the result of a higher price? An answer to this question would involve a discussion of the theory of value as applied to land and improvements. This would require an analysis similar to other price and cost of production studies. Certainly higher costs of subdivision and sale are made possible by a demand at a price sufficient to cover costs. If it were not for these costs, however, the supply of small farms at a given price would be greater and the price would fall. High-valued lands tend to be cut up into smaller parcels. The soils in any large tract of land are likely to be poorer, on the average, than on a small farm. There is an economic as well as a physical reason for this fact. If small farms were carved at random out of large tracts of land, the average quality of the soil would probably be the same. A small farm, however, must have good soil or it will cease to be cultivated as a small farm. Five acres of poor land will have much greater influence upon the buyer of the 15-acre farm than upon the

160-acre farm. It is quite difficult to find a large tract of uniformly high quality land whereas land of very high degree of productivity may be found in small areas.

Although the price per acre is greater, the total amount paid for the small farm is less than for the large farm. The demand, therefore, is influenced by the amount of money possessed by purchasers, in relation to the total amount asked for the land. The total amount of capital required therefore being smaller for small farms is a factor determining a higher price per acre.

By the application of more labor per acre, though less might be received per unit for the labor, land will be made to yield more and a certain amount of the labor income is likely to be capitalized into the price of the land. So long as a living can be produced, a possibility of success will induce the seller of the land to demand "what the traffic will bear." This is true of farms large and small but in the case of small farms, the amount of such labor income so capitalized may be much more per acre for such labor is spread over a smaller number of acres. The capitalization of labor income into land price, then, is another element making small farms sell for a greater price per acre.

Small farms frequently are not the only source of income. If there is an outside source of income, a higher price can be asked for the land not only because of its residence value but because there is a joint source of income from the farm and from the outside source. The price per acre is thus determined by the advantage gained by these combined sources of income.

Small farms are frequently near urban centers, and the value of the small farm is increased not only because of its residence value and speculative value, resulting from anticipation of future urban expansion, but because of many economic advantages such as demand and marketing facilities for high-priced crops. High-priced crops make possible a living on small acreages. Intensity of culture is increased because of the higher value, and higher values result from intensive culture.

Figure 20 shows the relation of size of farm to appraised value of land and of buildings and also shows the relation between size of farm and the combined value of land and buildings. The average values from which this figure has been constructed are given in table 7. Figure 21 gives the same relationships between size of farm and resale prices of land and buildings in the San Joaquin Valley, California.

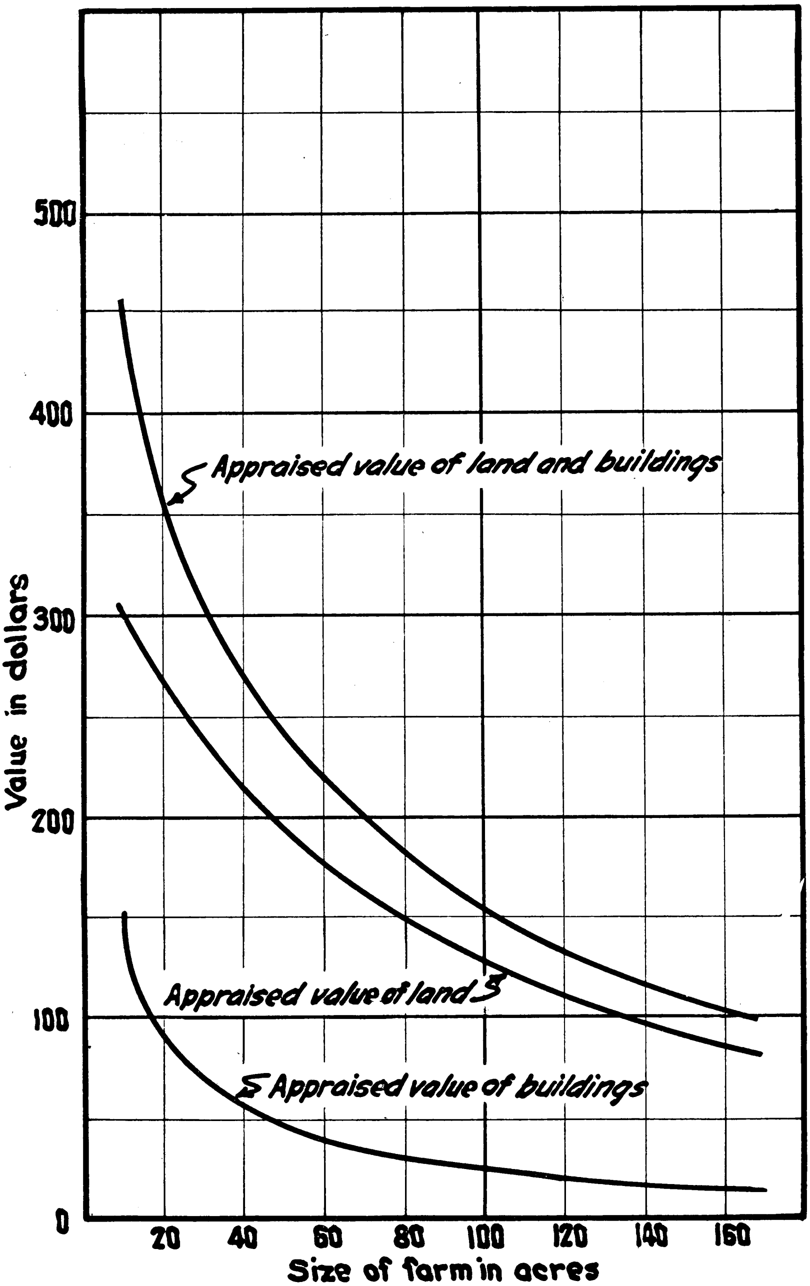

Fig. 20. Relation of size of farm to appraised value of land and buildings.

The average resale prices are computed from all available resale prices for farms on record in the bank for the sizes given. These average resale prices are given in table 8. Prices from which figure 21 was constructed were not deflated. The curve as shown, however, follows very closely the curve which would have resulted had deflated prices been used.

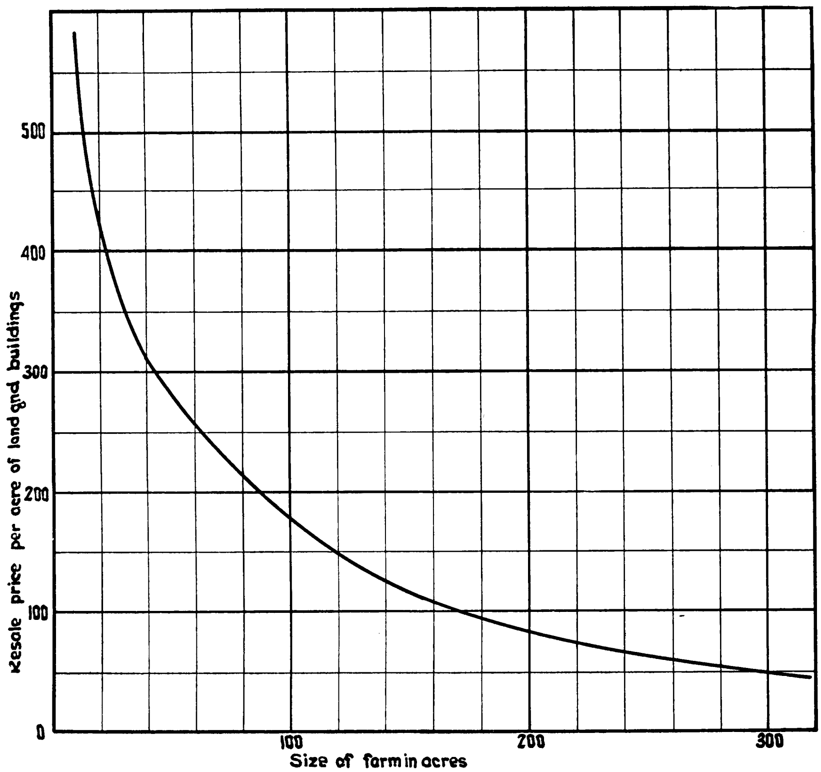

Fig. 21. Relation of size of farm to resale price per acre of land and buildings.

Figure 22 shows the changes which have taken place in the relationship of farm size to building value over the period of years from 1918 to 1927. Figure 23 shows the trend in appraised value of land for 10-, 20-, 40- and 80-acre farms from 1918 to 1927. Building values per acre have increased due probably to added volume of building. Land value trends for the various size of groups shows a consistent maintenance of a fairly constant general level.

TABLE 7

AVERAGE APPRAISED VALUES PER ACRE FOR LAND AND BUILDINGS ON FARMS OF DIFFERENT SIZES COVERED BY FEDERAL FARM LOANS IN THE ELEVENTH FEDERAL FARM LOAN DISTRICT, 1918–1926

Size*	Frequency	Average building value per acre	Average land value per acre
Acres		*Dollars*	*Dollars*
10	549	152	302
20	1601	90	245
40	1276	56	212
80	477	31	161
120	161	20	109
160	328	16	90

* A few farms slightly larger and smaller than the indicated size were included in the averages in each group. Since most of the farms in each group are exactly the size indicated the average is highly representative of the size group in each case.

TABLE 8

AVERAGE RESALE PRICES PER ACRE FOR FARMS OF DIFFERENT SIZES COVERED BY FEDERAL FARM LOANS IN THE SAN JOAQUIN VALLEY, CALIFORNIA

Size*	Frequency	Average
Acres		*Dollars*
10	49	582
20	190	436
40	128	311
80	25	216
160	16	108
280	5	61
300	9	34

* Farms slightly larger and smaller than the indicated size are included in the averages of each size group.

Building Value per Acre in Relation to Size of Farm.—The mathematical relationship between size of farm and value of building becomes a most confusing element in the interpretation of the purely economic relationships between these same elements. The mathematical relation between building value per acre and size of farm can be postulated by holding land value per acre constant and total building value constant. If we denote total building value as K, building value per acre as B, the size of farm in acres as S, the per acre value of buildings may be expressed as follows:

$$B = \frac{K}{S} = K\left(\frac{1}{S}\right)$$

Building value per acre, economic and other physical forces being held constant, varies with the reciprocal of the size of farm. The reciprocal curve has the characteristic form of the rectangular hyperbola. Table 9 gives values of $\frac{1}{S}$ for sizes of farms, ranging from 10 to 160 acres. In the same table are given building values per acre corresponding to total building values ranging from \$1000 to \$3000. For each total building value the size intervals range from 10 to 160 acres. This table is designed to show the purely mathematical relationships between size and building value per acre.

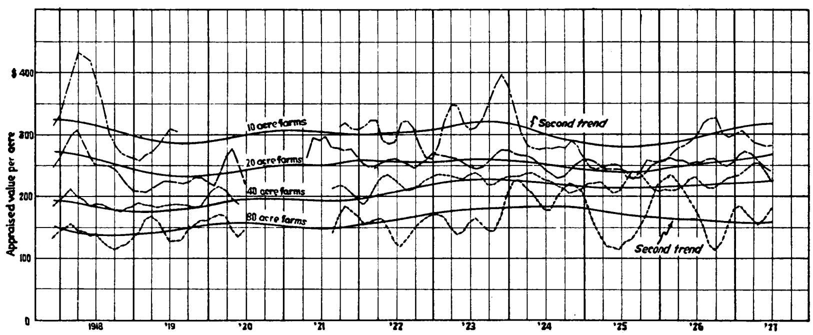

Fig. 22. Appraised value of buildings per acre on 10-, 20-, 40-, and 80-acre farms covered by loans in the Eleventh Federal Farm Loan District.

TABLE 9

RECIPROCALS OF FARM ACREAGE AND VALUES OF BUILDINGS PER ACRE, TOTAL BUILDING VALUES AND FARM ACREAGES VARYING

S*	$\frac{1}{S}$	B when K=1000	B when K=1500	B when K=2000	B when K=2500	B when K=3000
10	.10000	100.00	150.00	200.00	250.00	300.00
20	.05000	50.00	75.00	100.00	125.00	150.00
40	.02500	25.00	37.50	50.00	62.50	75.00
60	.01667	16.67	25.00	33.33	41.67	50.00
80	.01250	12.50	18.75	25.00	31.25	37.50
120	.00833	8.33	12.49	16.67	20.82	25.00
160	.00625	6.25	9.37	12.50	15.62	18.67

* S=Size of farm.
B=Building value per acre.
K=Total building value.

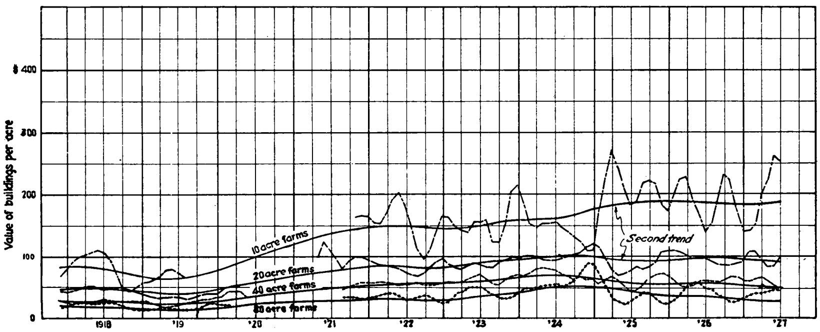

Fig. 23. Appraised value of land exclusive of buildings in 10-, 20-, 40-, and 80-acre farms covered by loans in the Eleventh Federal Farm Loan District.

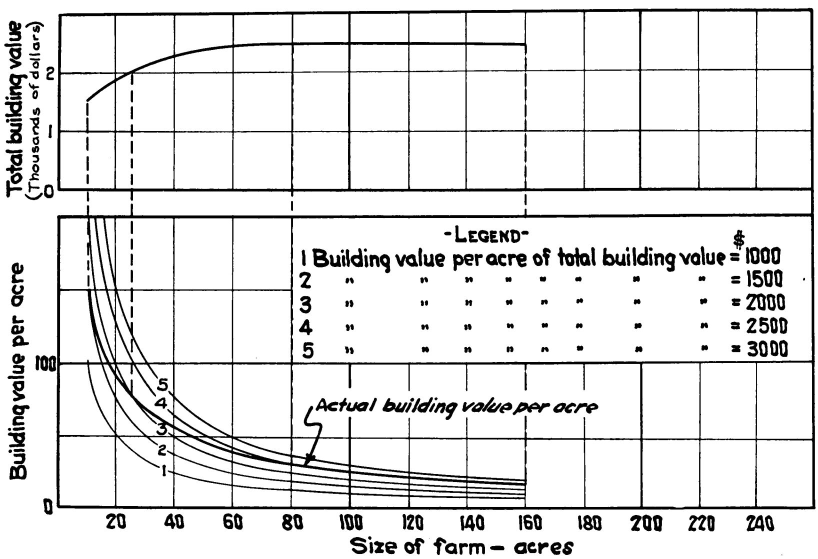

Fig. 24. Mathematical and economic causes for characteristic shape of the curve of relationship between size of farm and building value per acre.

In figure 24, the total value of buildings for different sized farms is introduced as a variable. This variability is due to economic causes. Small farms tend to have smaller total building values. This may be due to the fact that less building equipment is necessary to carry on the farm operations on the small farm; it may be due to the fact that the earning power on small farms is not sufficient to provide such expensive buildings as on the larger farms; or it may be a combination of both of these. In the illustration referred to, the mathematical and economic aspects are clearly distinct. The light lines in the lower part of the drawing give the mathematical relationships between building value per acre and size of farm for total building values varying from $1000 to $3000. The curve in the upper part of the chart shows the average total appraised value of buildings on farms of different sizes.[31] Curvilinearity in this graph is due to economic causes. For the size of farm where this curve crosses the line of $2000 total building value, the heavy line in the lower portion of the chart crosses the mathematical curve of relationship between building value per acre and size of farm, total building value per acre being held constant at $2000. This heavy line is the curve of relationship between building value per acre and size of farm where both mathematical and economic influences enter. It is based upon average building values given in table 7. It is identical to the building value curve of figure 20.

Building Value per Acre in Relation to Value of Land and Buildings per Acre.—In the ordinary application of the principle of proportionality, we are familiar with the fact that as additional amounts are expended for buildings on a given farm, the return per unit of farm building value added increases up to a certain point after which the returns per additional unit decrease. The addition of buildings to a single farm may increase the per acre value of that farm in a greater proportion than the added building value per acre. After a time, successive additions will result in increased value of land and buildings per acre, but the increase in value of land and buildings will not be so great as the additional building value per acre. Finally a point is reached where over-development of buildings actually reduces the value per acre of land and buildings. A hypothetical case will illustrate this point. There are two unimproved 40-acre farms exactly alike in soil, topography, irrigation and drainage conditions, etc., lying on opposite sides of the highway so that they are the same distance

[31] Averages of appraised values of all farms of indicated size covered by active loans in the Federal Land Bank of Berkeley, 1927.

from market, and situated in an excellent dairy section. They are held at the same price, namely, $250 an acre. Brown buys one of them and Smith the other, and both proceed to build and make their farms into ideal dairy farms. Brown builds an $8000 or $10,000 house and expends about $20,000 in barns and other buildings, so he has all the necessities and modern conveniences found on the best dairy farms. Yet his building is not "over-developed." Brown's farm now stands him $40,000.

Smith has plenty of money and likes fine buildings, so he builds a $120,000 mansion, and puts about $70,000 into barns, etc., making his farm stand him $200,000. Now Smith's building would probably be regarded as over-developed.

In the course of three or four years, Mr. Jones decides to buy a dairy farm and learns that these two farms are for sale. Brown is ready to quit dairying and offers his place for $42,000. Smith has died and his heirs do not care for farming of any kind so they offer their farm for $45,000 or even $43,000. Which, farm, if either, will Mr. Jones buy?

The net income from Smith's farm will be less, because of higher taxes, greater depreciation and other operation costs. The number of prospective purchasers for such an estate are few, and unless the location is such as to give the farm an especially attractive residence value, it is likely to be sold for the value of the old lumber in its buildings after the cost of salvaging the same has been deducted. This subject is discussed again on pages 519 and 524 in connection with figures 25 and 26. In the valuation of farm real estate, comparisons must be made of the relative values of different farms each having building values which may exist in widely different proportions to the total value.

Taking the farms as they are found with the buildings already constructed, the relative values of these farms vary with respect to each other according to the principle of relative productive value stated above. In other words, as applied to building values, if one considers farms which are similar in every respect except for building value, those farms which have the higher expenditure per acre for buildings have a more than proportionally higher value per acre for land and buildings combined, but this is true only up to a certain degree of development after which a piece of land may have less than a proportionally greater value per acre, while the farm greatly over-developed in buildings may actually have a value per acre less than that of a farm having a smaller expenditure per acre for buildings.

Figure 25 shows the relation of appraised value of buildings to appraised value of land and buildings on 20-acre farms covered by loans in the Federal Land Bank of Berkeley. When the size variable is held constant, the characteristic curve of the principle of diminishing returns is in evidence. Table 10 gives the average values upon which the curves in figure 25 are based. On farms having build-

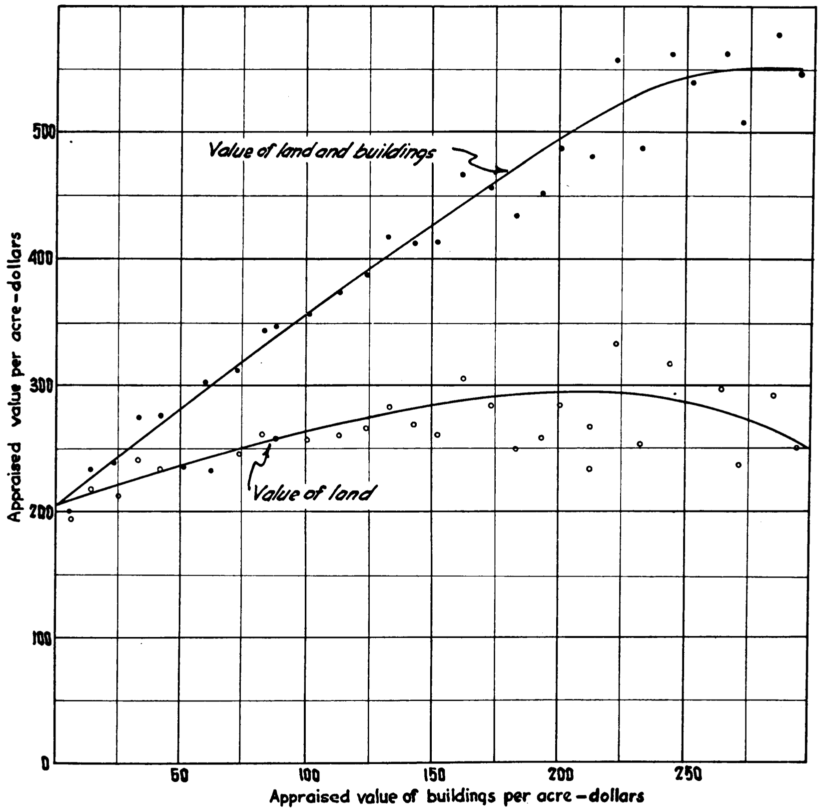

Fig. 25. Relation of appraised value of buildings to appraised value of land and buildings on 20-acre farms covered by Federal farm loans in the Eleventh Federal Farm Loan District. Average for the period 1918–1926.

ing values ranging from $50 to $100 an acre, the average increment in land value, exclusive of buildings per dollar increment in building value amounts to $0.56. On farms having building values ranging from $150 to $200 an acre, the average increment in land value amounts to $0.18 per dollar increment in building value while farms having building values ranging from $250 to $300 per acre have a decrement of $0.74 per dollar increment in building value.

These increments and decrements, it should be borne in mind, are differences in value, exclusive of building value and therefore represent the net difference after allowing for the cost of the additional building value. The curves in figure 25 are subject to changes over a period of time. It has been seen in figures 22 and 23 that the trend of appraised building values has been upward while appraised land values have not increased so rapidly. The ratio between land value and building value is therefore not constant. The ratios between land value and building value on 20-acre farms having $1000 to $1199 total building value are given in table 11. The trend in the ratio of land value to building value has decreased over the nine-year period, 1918 to 1926, from 4.68 to 4.06.

TABLE 10

AVERAGE APPRAISED VALUES OF LAND AND BUILDINGS FOR TWENTY-ACRE FARMS COVERED BY FEDERAL FARM LOANS FOR DIFFERENT BUILDING VALUES, 1918–1926

Building value class interval groups	Frequency	Building value, average	Land value, average	Value of buildings and land
		Dollars	*Dollars*	*Dollars*
1– 199	26*	112	3,897	4,010
200– 399	68	286	4,373	4,659
400– 599	104	479	4,297	4,776
600– 799	94	667	4,818	5,486
800– 999	90	848	4,686	5,535
1,000–1,199	134	1,031	4,688	5,719
1,200–1,399	71	1,251	4,634	5,885
1,400–1,599	76	1,473	4,912	6,385
1,600–1,799	46	1,658	5,216	6,874
1,800–1,999	36	1,763	5,164	6,927
2,000–2,199	93	2,023	5,144	7,167
2,200–2,399	31	2,270	5,207	7,477
2,400–2,599	46	2,486	5,267	7,753
2,600–2,799	28	2,654	5,671	8,325
2,800–2,999	19	2,867	5,389	8,256
3,000–3,199	41	3,041	5,236	8,277
3,200–3,399	13	3,231	6,124	9,355
3,400–3,599	30	3,472	5,683	9,155
3,600–3,799	15	3,667	5,015	8,682
3,800–3,999	13	3,870	5,168	9,038
4,000–4,199	23	4,023	5,702	9,725
4,200–4,399	12	4,258	5,355	9,613
4,400–4,599	9	4,469	6,673	11,142
4,600–4,799	9	4,667	5,072	9,739
4,800–4,999	4	4,900	6,336	11,236
5,000–5,199	15	5,043	5,757	10,800
5,200–5,399	6	5,308	5,941	11,249
5,400–5,599	3	5,433	4,722	10,155
5,600–5,799	4	5,712	5,832	11,544
5,800–5,999	3	5,900	5,026	10,926

* Farms of zero building value are not included. This is to avoid confusion with farms for which building values are not given.

TABLE 11

RATIO OF APPRAISED LAND VALUE TO BUILDING VALUE, 1918–1926, FOR TWENTY-ACRE FARMS HAVING BUILDING VALUE RANGING FROM $1,000 TO $1,199

Year	Frequency	Total building value, average	Total land value, average	Ratio of land to buildings
		Dollars	*Dollars*	
1918	32	1040	4860	4.68
1919	23	1005	4780	4.20
1920	4	1000	4290	4.79
1921	4	1038	5280	5.1
1922	20	1031	5350	5.18
1923	12	1041	4170	4.0
1924	13	1060	4500	4.25
1925	10	1060	4113	3.88
1926	16	1045	4260	4.06

SALES PRICES OF DAIRY FARM LANDS

Variables of the Problem.—The important variables causing differences in prices at which dairy farms are sold include productivity, value of buildings, size of farm, percentage of the farm irrigated, percentage of the farm in pasture and the character of community development. Many other causes of differences exist but either have a minor degree of importance or have not come within the scope of this study because of insufficient information. Effects of topography, poor drainage and irrigation, weeds, pests, alkali, hardpan and other physical defects have been excluded from this phase of the study also. Character of community development has been in evidence throughout as an important factor but field studies will be required to supplement the present analysis before proper evaluation can be made of this element of value. Irrigation costs, taxation and bonded indebtedness on lands come within the scope of this community factor. Although many of these disturbing elements are important, they have been excluded merely to provide a starting point.

The Heterogeneous Character of Dairy Farms.—Diverse methods of land utilization, diversity in sizes of farms, variations in the number of cows found on these farms, differences in the percentage of the total area irrigated and variable proportions in which different enterprises are combined are characteristics not only of farms in general but of dairy farms in particular. The dispersion is not so great, however, within such a group that we cannot discover general tendencies. We are continually compelled to decide whether accuracy will be increased or decreased by further limiting the scope because each limitation in scope reduces the number of observations and increases the disturbing effect of erratic measurements.

Deflation of Land Prices and Building Values.—Prices of land and buildings used are the total values declared by the purchaser before a notary when the resale was made divided by the farm acreage. This price per acre was divided by a deflation index calculated from our land resale price series described in the earlier pages. In computing this index, irregularities were removed by the use of a three times iterated three months moving average. The monthly averages thus computed were reduced to relatives using the average of the entire period, 1918–1926 inclusive, as a base. This index series includes the seasonal variations. At least one serious question arises in the use of such an index. The trends of land prices for different regions have been shown to be different. A series for each region can readily be calculated but within a region there is no certainty that a land price series for all kinds of farms is applicable to dairy farms and there are not sufficient dairy farms in the data used to make possible a dairy land price series for different regions. The only recourse was to use the relative index based upon price of all farms and test its effectiveness by results in correlation with and without the index. Coefficients of correlation were much improved by the use of the index. Most of the cases used in the constant productivity study were in the San Joaquin Valley. The land price deflation index for San Joaquin Valley is given in table 12.

In considering the deflation of building values, an attempt was made to study trends in building values. These have already been shown and discussed in connection with figure 22 on page 515. Although there have been quite radical changes in building prices since 1918, appraised values of buildings have certainly not followed these changes. The trend of building values per acre has been upward since 1918 probably due to added volume of buildings per acre. Appraisers and farmers have undoubtedly deflated costs to some extent but original costs have probably dominated appraisals. In the light of uncertainty as to what kind of index to use, building values have not been deflated in this study.

TABLE 12

LAND PRICE DEFLATION INDEX* BASED UPON A THREE-TIMES ITERATED THREE-MONTHS MOVING AVERAGE OF SAN JOAQUIN VALLEY RESALE PRICES, 1919–1927

Year	Month	Three-times iterated three months moving average	Index	Year	Month	Three-times iterated three months moving average	Index
1919	Jan.	310	83.3	1923	Jan.	345	92.7
	Feb.	320	86.0		Feb.	380	102.1
	March	330	88.6		March	410	110.1
	April	348	93.5		April	425	114.2
	May	370	99.4		May	425	114.2
	June	390	104.8		June	405	108.8
	July	390	104.8		July	370	99.4
	Aug.	375	100.7		Aug.	355	95.4
	Sept.	360	96.7		Sept.	350	94.0
	Oct.	356	95.6		Oct.	360	96.7
	Nov.	362	97.2		Nov.	375	100.7
	Dec.	375	100.7		Dec.	390	104.8
1920	Jan.	380	102.1	1924	Jan.	400	107.4
	Feb.	400	107.4		Feb.	405	108.8
	March	438	117.7		March	400	107.4
	April	480	128.9		April	395	106.1
	May	500	134.3		May	390	104.8
	June	485	130.3		June	380	102.1
	July	465	124.9		July	360	96.7
	Aug.	455	122.2		Aug.	335	90.0
	Sept.	448	120.3		Sept.	320	86.0
	Oct.	425	114.2		Oct.	315	84.6
	Nov.	400	107.4		Nov.	305	81.9
	Dec.	388	104.2		Dec.	290	77.9
1921	Jan.	415	111.5	1925	Jan.	275	73.9
	Feb.	470	126.3		Feb.	285	76.6
	March	470	126.3		March	305	81.9
	April	430	115.5		April	340	91.3
	May	374	100.5		May	375	100.7
	June	360	96.7		June	395	104.8
	July	360	96.7		July	415	111.5
	Aug.	370	99.4		Aug.	420	112.8
	Sept.	380	102.1		Sept.	395	104.8
	Oct.	423	113.6		Oct.	340	91.3
	Nov.	475	127.6		Nov.	300	80.6
	Dec.	500	134.3		Dec.	285	76.6
1922	Jan.	535	143.7	1926	Jan.	285	76.6
	Feb.	574	174.2		Feb.	285	76.6
	March	595	159.8		March	275	73.9
	April	580	155.8		April	275	73.9
	May	532	142.9		May	290	77.9
	June	500	134.3		June	300	80.6
	July	500	134.3		July	285	76.6
	Aug.	515	138.3		Aug.	255	68.5
	Sept.	515	138.3		Sept.	230	61.8
	Oct.	470	126.3		Oct.	230	61.8
	Nov.	395	106.1		Nov.	260	69.8
	Dec.	345	92.7		Dec.	285	76.6

* Index computed as relatives having a base period 1922–1926.

TABLE 12 (continued)

Year	Month	Three-times iterated three months moving average	Index
1927	Jan.	290	77.9
	Feb.	285	76.6
	March	290	77.9
	April	295	79.2
	May	290	77.9
	June	275	73.9
	July	255	68.5
	Aug.	250	67.2
	Sept.	245	65.8
	Oct.	240	64.5

Limiting the Problem to Three Variables—Size of Farm, Value of Buildings, and Price of Land and Buildings.—Economic and mathematical relationships between building value, size of farm, and land price introduce difficulties of analysis which must be clarified before broader studies of other land price elements can be made. Figures 26, 27, and 28 show relationships between size, appraised values of buildings and values of land and buildings on irrigated dairy farms having no pasture, having approximately equal productivity and having practically the entire area under irrigation. Although the productivity index does not enter here as a variable, it has served the very useful purpose of holding that factor constant. The farms have also been selected so as to be free from conditions of alkali, hardpan, poor drainage, or less than first class irrigation in order to reduce the number of variables and the amount of the dispersion. It is believed that the data so secured are valuable for the purpose of giving the characteristics of certain important relationships although actual quantitative measurement may be subject to slight change when more data have been collected for further analysis. Owing to the constant improvement of farms, the relationships between building values and land values are constantly changing, greater building values being associated with given land values as time goes on. This change, however, should not interfere with the fundamental characteristics shown in these charts.

We have already seen that as buildings are added to land, eventually a point is reached where the added building value ceases to add value to the land. The same tendency is in evidence in this analysis although the higher points on the curves are supported by meagre data. It is not frequently the case that a farm is over-developed in regard to buildings, but among the data available many instances support the conclusion that the principle of proportionality operates with respect to the actual prices at which land changes hands. This characteristic is responsible for the shape of the curves in figure 26. For building values higher than those shown in figure 26, the plotted values became so scattered, curve fitting was impracticable.

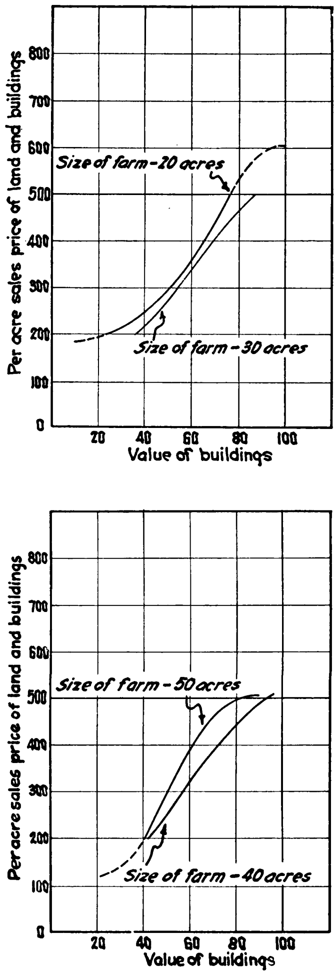

Fig. 26

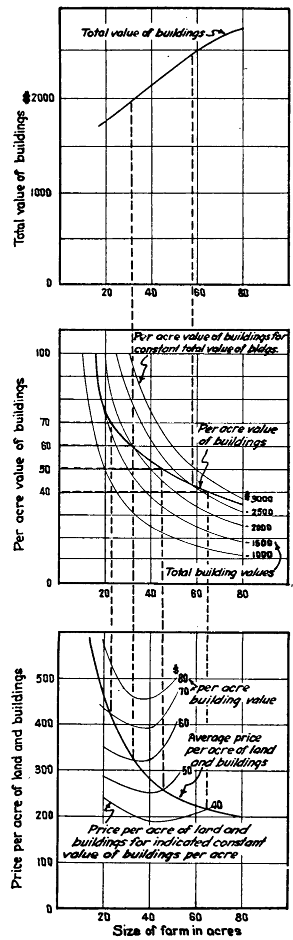

Fig. 27

Fig. 26. Relationship between value of buildings and price of land and buildings for 20-, 30-, 40-, and 50-acre farms.

Fig. 27. Inter-relation between total and per acre building values, and price per acre of dairy farm lands for farms of different sizes.

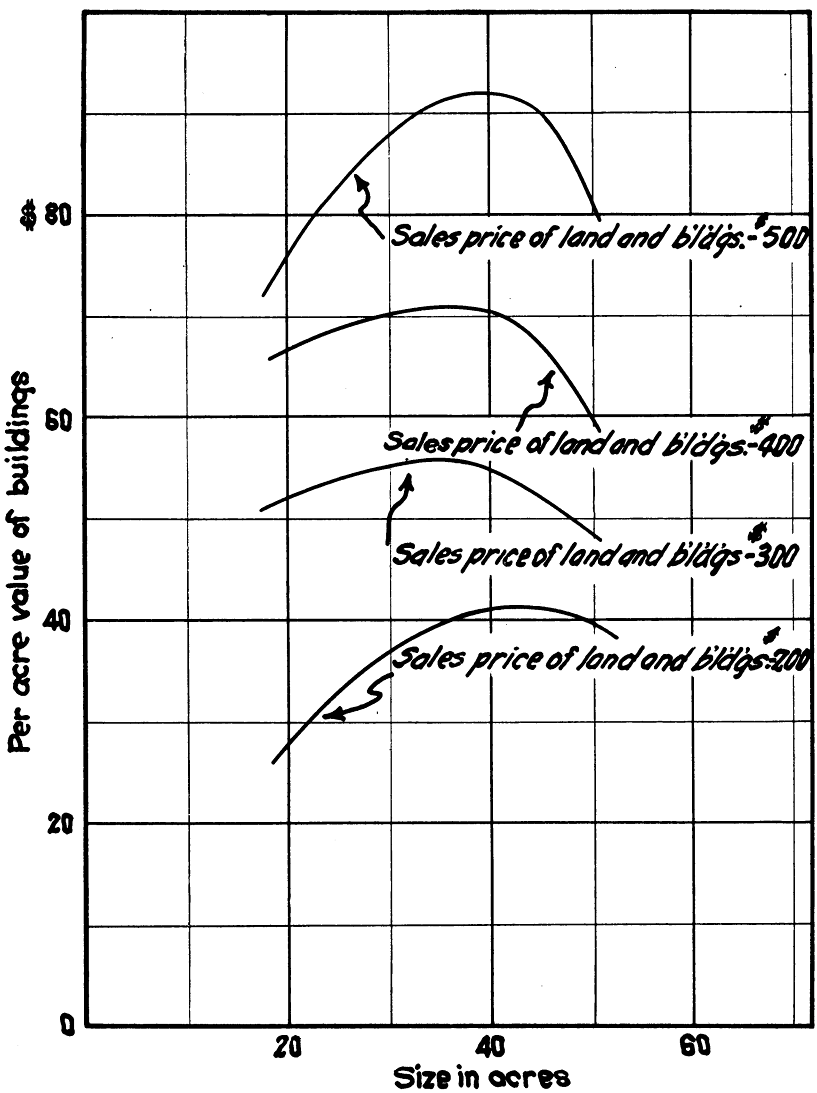

Fig. 28. When sales price per acre of land and buildings is held constant, the relation between per acre value of buildings and size of dairy farm in acres is expressed by a curve which, for size of farm between 20 and 50 acres, is convex upward. A given increment in the value of buildings is not accompanied by the same nor a proportional increment in value of land and buildings.

However, the scattered points indicate a downward tendency in the relationship between value of buildings and per acre sales price of land and buildings. It is natural that a few cases only could be obtained to illustrate this inefficient condition of farm improvement especially when the source of data is considered. Two 20-acre farms in the San Joaquin Valley will illustrate the tendency. Each of these farms is within three and one-half miles from town. Each is devoted to the production of field crops and dairy. The soils of these farms are sandy loam and fine sandy loam which have been shown in the preceding analysis to have approximately equal yield values. Temperature conditions are uniform with respect to each farm. Each has first class irrigation facilities. One of them has somewhat greater livestock development and has 18 acres in alfalfa while the other has 12 acres of alfalfa. The first of these farms has a per-acre building value amounting to $75, whereas the second has a building value of $217 per acre, a difference of $142 per acre in building value. The difference in deflated sales prices of these farms was $45, the farm having the higher building value corresponding to the lower sales price. We should guard, however, against drawing conclusions from individual sales of this kind. It is the general position of the scattered points in the different size groups studied which has lead to the conclusion that it is possible for value of land and buildings to be reduced by excessive addition to buildings. For most practical purposes land value studies will fall within the range of increasing value per acre of land and building for each increment in added building value, but the point may often be reached where increased building values ceases to add to the value of the land exclusive of buildings. The shape of the curve of relationship between value of buildings and sales price of land and buildings for 20-acre farms is quite different from the curve showing the same relationship on 50-acre farms. There are two reasons for this difference. In the first place, for economic reasons, diminishing returns to investment in buildings begin at a different point on 50-acre farms from that on 20-acre farms. In the second place, the purely arithmetical relation between total building values, size of farms, and building value per acre introduces the same difficulty of isolating the economic from the mathematical elements as was seen in the case where value of land and buildings in relation to size of farms was affected by these two different factors.

Inter-Relations Between Total and per Acre Building Values and Price per Acre of Dairy Farm Land for Different Farm Sizes.— Figure 27 is composed of three different sections each of which is designed to bring out a special phase of the inter-relationship among these three variables. The upper section shows the simple relationship between average total appraised building value and farm size. The next section below this is identical with figure 24 previously described except it applies to dairy farms of the particular homogeneous group under discussion. This portion of the figure, together with the upper portion of the chart differentiates between the economic and mathematical variables, size of farm and value of buildings. The light curved lines are, as in figure 24, the rectangular hyperbolae giving the mathematical relation between size of farm and value of buildings per acre. The heavy curve in this central portion of the figure is the curve of relationship between size of farm and average value of buildings per acre. This curve is based upon the average building values given in table 13. This curve crosses each hyperbola at points vertically below the point on the total building value curve corresponding to the total building value represented by that hyperbola.

TABLE 13

AVERAGE PER ACRE SALES PRICES OF LAND AND BUILDINGS; APPRAISED VALUES OF BUILDINGS AND AVERAGE SIZES OF FARMS FOR IRRIGATED DAIRY FARMS NOT HAVING ORCHARDS NOR PASTURE FALLING WITHIN DIFFERENT CLASS INTERVALS OF SIZE

Size class interval	Average size	Average appraised value of buildings	Average sales price of land
Acres	*Acres*	*Dollars*	*Dollars*
10–29	18.3	93	421
30–49	39.2	58	318
50–69	57.0	31	216
70–89	79.3	36	204

In the lower portion of the figure is a set of curves concave upwards showing the relation between size of farm and price of land and buildings for constant per acre building values. These curves in figure 27 have been derived from a set of curves similar to those in figure 26, and, together with them, have been derived from a smoothing of the raw data into a surface describing the relationship between the three variables under discussion. In this lower portion of the same figure is another curve showing the relation between size of farm and average price of land and buildings for average building values corresponding to the prices and sizes in each case. This curve is based upon average prices of land and buildings given in table 13. In this curve, building value is a variable element and each point on the curve is the result of the average combination of size-building value and land price. The inter-relations of the different variables and the significance of the different portions of the illustrations are emphasized by the dotted lines connecting the different parts of the diagram. The point where the curve of total building value in the upper portion of the figure crosses the $2000 building value line is vertically above the point where the curve showing the average relationship between building value and size of farm crosses the curve of $2000 constant total building value. The point where the average building value curve in the central part of the figure crosses the line of $50 per acre building value is vertically above the points where the curve expressing the relationship between size of farm and average price per acre for land and buildings crosses the curve of relationship between size of farm and price of land and buildings for a constant building value of $50. Referring again to figure 26 with the new relationships revealed in figure 27 still in mind, the inter-relationships of size-building value and price of land and buildings may be better understood. Between price for land and buildings of $200 to $500 per acre, 30- and 40-acre farms have approximately $6 difference in price of land and buildings associated with each $1 difference in value of buildings. The 20-acre farms and 50-acre farms are more curvilinear between these prices and have differences in price of land and buildings, ranging for the price range given, from $3.50 to $10 for a difference of $1 in building value, the lower increments in price being for lower priced farms in the case of the 20-acre size and for the higher priced land in the case of the 50-acre farms. For a constant per acre building value, farms smaller than 35 acres generally have increments in price of land and buildings, for each acre difference in size, which are rapidly increasing as the size of farm decreases. For farms greater than 40 acres, increments in price of land and buildings for each acre difference in size rapidly increase up to certain limits, as size increases. But this latter tendency is due largely to the increasing importance of a given constant building value per acre as the size of the farm increases. The lower portion of figure 27 illustrates these tendencies.

Similar reasoning may be brought to bear in explaining the curves in figure 28 which show the relations existing between size of farm and per acre value of buildings for constant values of land and buildings. This figure is also a result of the same surface of relationship among the three variables. The curve showing the average relationship between size of farm and price per acre of land and buildings now has greater significance. It owes its shape to the mathematical hyperbolae first shown in figure 24, to the economic factors which cause lower per acre building values to be associated with larger farms and to the many reasons enumerated above for large farm sizes to be associated with lower per acre values of land exclusive of buildings.

TABLE 14

ESTIMATED VALUE OF BUILDINGS AND ESTIMATED SALES PRICES OF LAND AND BUILDING COMPRISING IRRIGATED DAIRY FARMS NOT HAVING ORCHARDS NOR PASTURE AND HAVING APPROXIMATELY EQUAL PRODUCTIVITY*

Size	Estimated average per acre value of buildings	Estimated average per acre price of land and buildings
	Dollars	*Dollars*
20	74	470
30	62	340
40	54	280
50	47	245
60	42	225
70	38	205
80	34	195

* Table 14 has been compiled from figure 27.

The Effect of Introducing Other Variables.—The foregoing analysis indicates that the introduction of additional variables will make necessary extreme caution if reliable results are to be obtained. No attempt will be made in the present discussion therefore to set up the partial correlations for additional variables. The simple correlations between land price as a dependent variable and productivity, per cent of farm irrigated, per cent of farm in pasture, building values, and size of farm as independent variables when all of these are present with interacting influences upon each other are shown in figures 29 to 33 inclusive. The correlations are between median values of class interval groups given in table 15. These graphs should be used with careful judgment. The size-land price curve, figure 29, is distorted especially in the case of larger farms by the presence of the other variables. Building values bear a different relation to price of land and buildings. The lower building values in figure 30 are for the larger farms having more or less pasture. In the case of higher building values and higher land values there is closer correspondence between the curves constructed under the two different sets of conditions. This is because the farms in this portion of the curve are predominantly those comprising the data from which the other curves were drawn. In other words, high building values and high land values are associated with irrigated farms without pasture. The other relationships shown in figures 31, 32 and 33 are subject to the same complications.

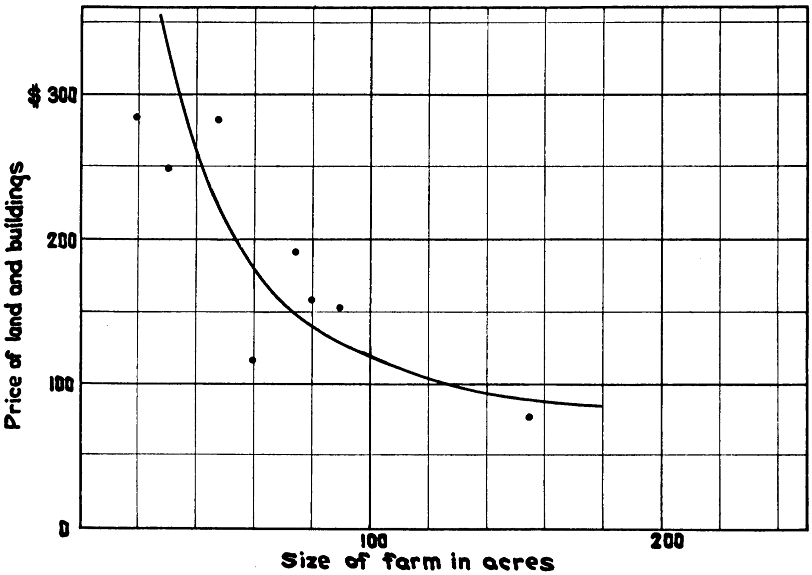

Fig. 29. Figures 29 to 33 inclusive show correlations between price of dairy farm lands and various other factors. Figure 29 shows the relation between size of dairy farm and price per acre. It should be borne in mind that these are not partial correlations and each scatter diagram is influenced by the interactions of all of the factors. Each of the points plotted in these illustrations is the median value of a class interval group. The number of cases in each group, however, is small, and the curves are presented as approximations only.

An important use which this set of charts may serve is that from them a typical farm may be set up showing the average conditions which may be expected to prevail with regard to any particular price of land and buildings. This may be used as an approximate guide when proceeding according to ordinary methods of appraisal. Such a guide would be much more satisfactory than the usual scattered and unorganized sales price data. For this purpose, table 16 has been prepared showing such typical combinations of conditions for different prices of land and buildings. It must still be borne in mind that there is a much larger group of farms subject to variable conditions of drainage, irrigation, hardpan, etc., which has not been represented.

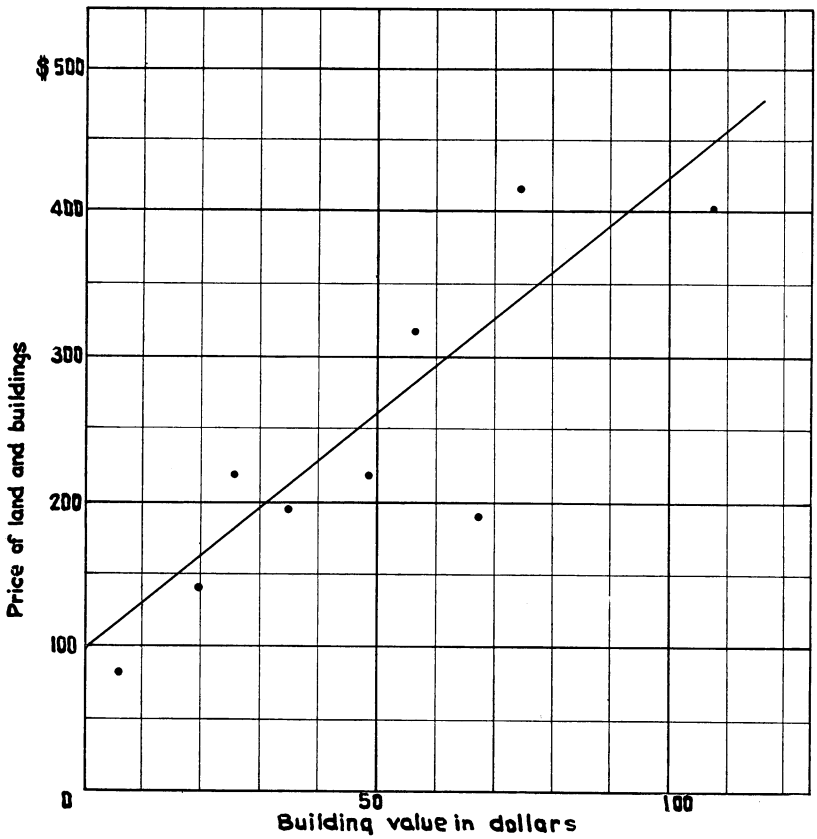

Fig. 30. Relation of building value to price per acre of dairy farm land. The method of construction and precautions to be taken in the interpretation of this illustration are the same as for figure 29.

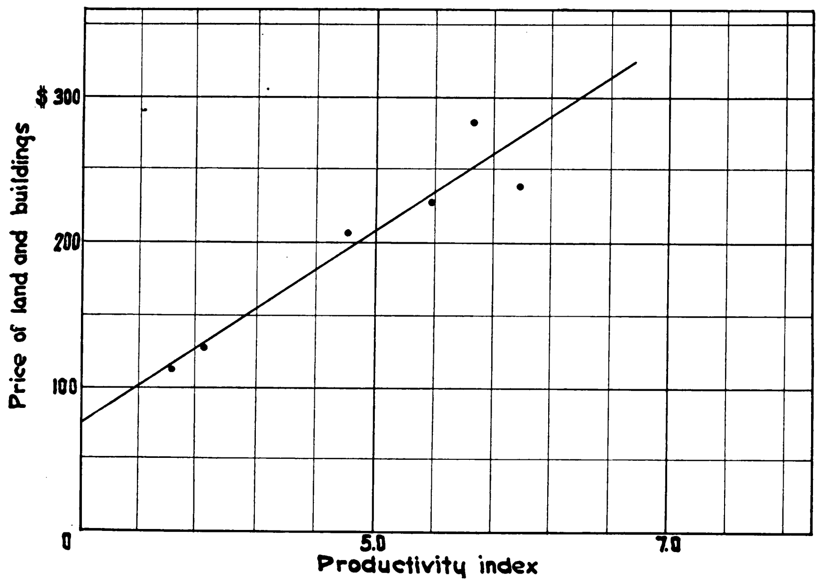

Fig. 31. Relation of productivity index to price per acre of dairy farm lands. The method of construction and precautions to be taken in the interpretation of this illustration are the same as for figure 29.

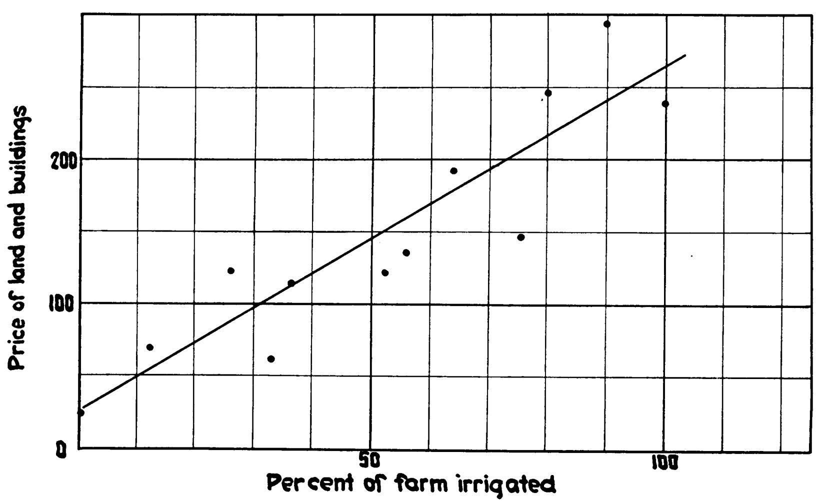

Fig. 32. Relation of per cent of irrigated land on each farm to dairy farm land price. The method of construction and precautions to be taken in the interpretation of this illustration are the same as for figure 29.

The well-defined correlation between price of land and buildings and productivity is gratifying after the tedious process of constructing this index. Although its significance is mingled with the effect of other variables, in figure 31, the very important fact is brought out that a given average productivity is associated quite definitely with a given average price of land and buildings not withstanding that there are many elements contributing to the value represented in that price.

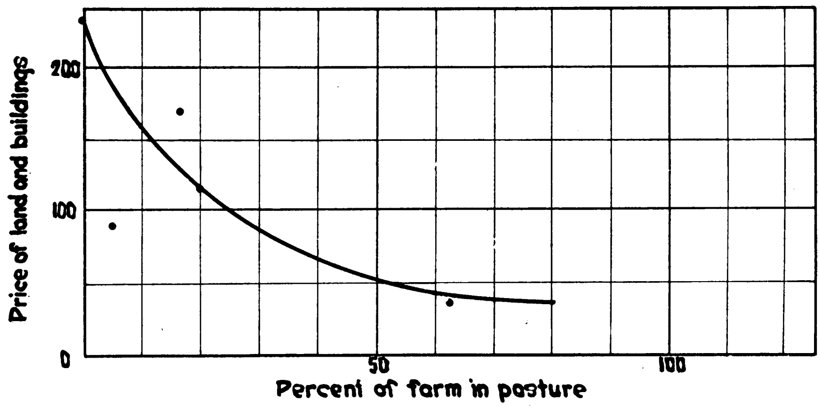

Fig. 33. Relation of per cent of farm in pasture to price of dairy farm land. The method of construction and precautions to be taken in the interpretation of this illustration are the same as for figure 29.

TABLE 15

MEDIAN DEFLATED PER ACRE PRICES OF FARM REAL ESTATE FOR DIFFERENT CLASS INTERVALS OF BUILDING VALUE, SIZE, PER CENT OF FARM IRRIGATED, PRODUCTIVITY AND PER CENT OF FARM IN PASTURE

Building value		Size		Per cent irrigated		Productivity index		Per cent of pasture	
Class interval	Corresponding median price	Class interval	Corresponding median price	Class interval	Corresponding median price	Class interval	Corresponding median price	Class interval	Corresponding median price
0–9	80	10–19	412	0–9	24	3.4–3.79	112	0	243
10–19	139	20–29	284	10–19	68	3.8–4.19	127	1–9	95
20–29	218	30–39	246	20–29	123	4.2–4.59	315	10–19	170
30–39	193	40–49	281	30–39	61	4.6–4.99	206	20–29	118
40–49	217	50–59	——	40–49	114	5.0–5.39	226	over 29	39
50–59	313	60–69	125	50–59	122	5.4–5.79	282		
60–69	190	70–79	191	60–69	192	5.8–6.19	248		
70–79	440	80–89	157	70–79	150				
80–109	394	90–99	150	80–89	246				
over 109	492	100–169	76	90–99	294				
		over 169	32	100–	238				

Statistical Method

The results of this research have not been reached without trial and error in the use of a number of different methods of statistical analysis. The machine sorting process and mechanical tabulation which served so admirably in the development of the productivity index and in orienting the research had to give way to a detailed analysis of individual farms in the final land price study. More than 15,000 cards were punched in code giving scores of descriptive items for each farm studied. The rapid sorting of these into classified groups and the tabulation and totaling of yield data gave the basis of the averages used in estimating alfalfa yields for the different temperature stations and for the different soil textures.

TABLE 16

Average Combinations of Estimated Price per Acre, Size, Productivity Index, Per Cent of Farm Irrigated, Per Cent in Pasture, and Building Value per Acre for Dairy Farms in the Eleventh Federal Farm Loan District

Price per acre	$100	$125	$150	$175	$200	$225	$250	$275	$300
Size, acres	127	95	72	60	52	46	41	36	35
Productivity	3.4	3.8	4.2	4.5	4.9	5.3	5.6	6.0	6.4
Per cent irrigated	31	42	52	63	73	84	94	100	100
Per cent pasture	26	18	11	6	3	1	0	0	0
Building value, dollars	0	8	16	23	31	39	48	54	62

In making the detailed study of resale prices, the description of each farm was recorded on strip cards and the process became one of careful manual sorting and tabulating in place of the machine sorting and tabulation in the earlier period of the investigation. This was made possible by the smaller numbers of cases handled. Not only has it been necessary to give much attention to the method used in selecting and tabulating the data but methods of analysis of time series and of price differentials have required much time and laborious effort.

Inadequacy of Multiple Correlation in Land Price Analysis.—This study as well as many previous studies indicates that economic relationships are not simple straight line correlations, but rather of a complicated and varied curvilinear character. The ordinary curvilinear multiple correlation carried out by the solution of normal equations adjusted for curvilinearity by successive approximations is limited in its application to the complex problems of land valuation.

Curvilinear multiple correlation, as ordinarily carried out, does not give proper significance to the effect of combinations of other factors. This is probably its chief limitation. The effect of a given independent variable upon the dependent variable shows a different curve under changed conditions of other variables. In fact it has very definitely been found that any given regression line changes in shape, if curvilinear, and slope for changing conditions of other variables. When one conceives the problem to be of such a nature, it no longer is a study of parallel curves in a plane which is the assumption of curvilinear multiple correlation, but rather a warped surface. In fact the problem must be set up as a group of such surfaces. Such studies require more sampling technique than is usually applied. Enough data must be collected to properly represent different portions of the various surfaces. If this is done completely, multiple correlation gives way to a number of related simple correlations followed by the determination of relationships between the various simple regression lines or surfaces. There is a limit to the extent to which this can be carried out, not only because of the cost involved but because of the non-existence of farms in certain classifications. Increase in numbers of cases is sure to introduce new variables.

The importance of this method of analysis was emphasized in the soil-temperature analysis. It may be noticed by referring to figure 17 and the discussion thereabouts that for different mean temperatures, variations in range of temperature have entirely different effects—in fact opposite effects. An increase in range of temperature shows a positive increase in yield for the lower mean temperatures and a negative relationship for the higher temperatures. Had the ordinary method of multiple correlation been applied, the average effect of differential in temperature range upon yield would have appeared unchanged irrespective of the mean temperature, whereas the chart shows that the relationship is very different under different temperature conditions.

Another example indicating the inadequacies of multiple correlation in such studies is illustrated by the study of the interrelations of resale price, building value and size of farm. In fact, as we have seen, most of the elements of land value have curvilinear relationships which follow the characteristic curve of diminishing returns. These curves for different sizes of farms cross and recross each other.

Methods Used.—The only possibility of following and isolating such curvilinear relationships is to study each group separately by selecting samples and eliminating many of the variables by sorting.

The present study, employed with some success, the use of mathematical formulae in bridging gaps and in fitting surfaces to some of the grouped data. The three variables just mentioned, size of farm, building value, and price of land and buildings yield to manipulation with the formula $y = a + b \frac{2}{(e^{K(x-c)} + e^{-K(x-c)})}$ in which y is the price of land and buildings, x is the value of buildings, while a, b and c are functions of the size factor and K is a constant which gives flexibility to the shape of the curve. Any section of the surface obtained by constant values of a, b, and c is similar in shape to the normal curve of error. This shape is also characteristic of many of the curves following the principle of diminishing returns. Where the data do not follow a bisymmetrical curve, a "skew" can be obtained in the above formula by the use of $f(x)$ in place of x. The actual curves shown in figures 26, 27, and 28, however have been developed by reducing the problem to three variables by sorting into groups and by plotting curves between two of these variables holding the third constant. Overlapping class interval groups were used, making possible a large number of such curves for different average values of the third variable. When these curves were completed, the variable which was held constant in the first place was used as a variable in relation with one of the others and cross section curves were constructed using values estimated from the previously constructed set of curves. Smoothing was thus carried out in two directions at right angles to each other and a curved surface was thus constructed.

Complications of Additional Variables.—The simple correlations presented in figures 29, 30, 31, 32 and 33 represent a work only partially completed, it is true, but useful if the limitations are kept clearly in mind. It would not be difficult to set up a multiple correlation equation of regression for estimating land price from these variables. It is believed, however, that more careful study should be given to correlation methods to be used in completing this analysis before it is safe to present such an equation.

The Adequacy of the Frisch Method of Time Series Analysis.—The method of time series correlations used in this investigation has been somewhat of an experiment in which the adequacy of the Frisch method of handling cyclical problems has been tested. This method has been studied having in mind the following prerequisites of an adequate time series analysis. The method should have inherent within it the possibility of studying (1) cycles and trends of various orders; (2) changing slopes in trend; (3) changing lengths of the several cycle periods; and (4) changing amplitude of oscillations. It has been with the desire to observe these four aspects of the problem that this comparatively new treatment of time series has been applied in the present study.

Lack of flexibility due to mathematical assumptions and formulae has characterized most of the current methods. In the present and previous studies, it has been found that even long time trend analyses are not adequately handled by the straight line or parabolic methods. The concept although quite different from other methods is simple. Instead of fitting a secular trend line and then removing seasonal variations, seasonal and erratic variations are removed in the process of fitting the first trend. The raw data are smoothed, and points of inflection in the series are located and connected by a smooth curve. The inflection points of the resulting graphs are located and connected by a second smooth curve and so on indefinitely. Cycles of various orders are thus isolated and their deviations from trends of succeeding orders form the basis of the analysis. Although it is not without limitations and difficulties of application, the advantages of the Frisch method are numerous. Flexibility in meeting the complicated cyclical combinations of a series has proved to be an advantage in its favor. Comparison with results obtained by the use of a trend line fitted by the method of least squares and ordinary means of removing seasonal variation shows that although the cyclical characteristics described by the older methods were different, the long time trends were similar. Relationships between different time series has been discovered by this method which would have passed unnoticed in the use of former methods. It more adequately meets the problem of changing seasonal variation and more completely removes erratic influences leaving a well defined cycle from which disturbing elements have been removed. The result is that the coefficient of correlation more nearly describes the true relationship between the cycles of the different series.

The trend developed is not an "average" trend in the sense that the sum of the deviations from it is zero. In fact, when applied to pig iron production in the United States it has been found that more of the values fall above the line of trend than below it, indicating that prosperous years have been more numerous than years of depression. This tendency cannot be said to be a defect. It is merely a characteristic that must be recognized. A very important advantage of the method is that it yields to graphical analysis and much time is saved in making trial correlations when search is being made for related series. The method is subject to two defects which can be eliminated by the acquirement of practical judgment in its use and by the maintenance of strict honesty on the part of the analyst. Certain erratic fluctuations in the data may introduce minor cycles which if adherence to the method were maintained would make it possible for these erratic variations to take the place of seasonal or other cyclical variations. As will be seen when the method is explained more fully, this may result in the confusion of cycles of one order with those of another.

The second difficulty arises in drawing in the trend lines established by the location of the inflection points. These points falling at some distance from each other are connected by smooth curves. The curvature between inflection points allows the judgment of the analyst to enter and introduces a personal element in the exact location. The general position and shape of the line, however, is fixed by the statistics. Balancing the advantages against the disadvantages it seems safe to conclude that the method deserves more general use by American analysts.

Description of the Method.—The underlying assumption in this method is that an economic time series is a composite curve of many components, or trends of several orders, each cyclical in nature and fluctuating about a trend of higher order. In the process of isolating these several trends, this method first eliminates trends of the lower orders (usually the seasonal variation) leaving to be isolated the trends of higher orders. Dr. Frisch has developed two methods for the solution of the complex problem of isolating the different cyclical trends of a series. One of these he calls "the method of normal points," the other, "the method of moving differences." Each is based upon the construction of a curve of second differences. The first of these methods, that is, the normal point method, is based upon the fact that the cyclical fluctuation of the curve obtained by plotting the original data passes its "normal" at the same point where the second difference curve becomes zero. The second method, that is, the method of moving differences, depends upon the fact that within certain limiting conditions the cyclical fluctuation of the composite curve formed by plotting the original data is proportional to the ordinates of the second difference curve, the constant required to reduce the ordinates of the second difference curve to those of the curve showing cyclical fluctuations being a function of the distance between zero points, that is, between the normal points determined by the first method. The method of moving differences has not been tested in the present study. The analyses of this investigation have been based entirely upon the normal point method. There are certain limiting conditions which must be observed in connection with this method. One of these limiting conditions is that, for accuracy, the ratio between the number of cycles in a trend of a given order to the number of cycles in the same length of time in the trend of the next higher order should be fairly high. If the period length in any given trend is approximately the same or only slightly less than that of the next succeeding higher order, an error is introduced due to the curvature in the trend of high order.

In the discussion which follows, no attempt is made to go into the intricacies of the two methods mentioned above. Only a brief description of the method of normal points is given. The application of the method is very simple. Observance of the limiting conditions, a discussion of which must necessarily be too elaborate for inclusion here, involves certain tests which are based upon difficult mathematical calculations but which in themselves are not elaborate.

In order to explain the differential aspect of the method, it may be well to bear in mind a simple concept of a smoothly fluctuating series. Zero points of the second difference curve are points of inflection on the original curve. These points of inflection determine the position of the first trend line from which deviations of the points on the original curve constitute the cycle of the lowest order. It is upon this basic analysis that the entire system of trend eliminations is based. Having obtained trends of successive orders, points of inflection are spotted, and new trend lines drawn through the cyclical deviations studied from these higher trends.

The actual procedure followed in the case of the study of cycles in land prices was first to plot the monthly average prices against time as is shown by the dotted line in figure 4. Because of the irregular fluctuations of the curve, it was necessary to compute a twice iterated three-months moving average (the moving average of the moving average). This smoothed curve was obtained readily by means of graphically locating the points rather than working out the averages by arithmetic calculations. The method of graphical construction of moving average as used in this study is that developed by Ruth McChesney.[32] Upon the completion of the twice iterated three-months moving average, the points of inflection were located by graphical analysis at a point where a three-times iterated average crossed the

[32] McChesney, Ruth. Graphical construction of moving averages. Jour. American Stat. Assoc. 23(162):164–172. June, 1928.

twice iterated moving average. Through these inflection points was drawn a smooth line, designated as the *trend of first order,* to form the basis of measuring the fluctuations of the cycles of first order, which in this case were usually those of seasonal variations.

The inflection points of the trend of first order were located and connected by means of the smoothest line possible. This line is called the *trend of second order.* The difference between the trend of first order and the trend of second order brings out the cyclical variations of the second order. If these second trends be reduced to a horizontal base, cycles of different series may be compared as is common in studies based upon other methods of analysis. The above procedure may be carried on indefinitely, limited only by the length of period for which data are available, resulting in trends and variations of several orders. Most of the comparisons in the land price study were made with respect to the deviations of the first from the second trend; i.e., the cycles of the second order, the cycles of the first order being eratic and seasonal variations.

Conclusion

A conclusion to such a study must necessarily be brief, for to present the findings in any detail would lead at once into the intricate complications which have already been presented. If a step forward has been made, it is in the the direction of method of approach to this most difficult problem. The relation of the principle of proportionality to scientific appraisal has probably been more definitely established. The classification of productive elements together with determinations of the effect of these elements combined in different proportions may replace, for many purposes, the classification of land itself. The numbers of possible classes of farms is almost infinite while the important elements are capable of finite description. The dynamic factors affecting land price through their effect upon economic supply of and demand for land gives us an insight into the changing importance of income in relation to land valuation, and may be a convincing argument that income, while it is the basis of value, does not have a constant relationship to value. This does not mean that sales price analyses should entirely replace income as a measure of value. We need all the information possible regarding income and sales prices. Finally, by the analysis of different elements of value in different combinations the way has been suggested, in fact demonstrated, by means of which we may be able to construct methods of measuring probable producing power—not on the basis alone of what the land is producing but on the basis of what it is capable of producing. In light of its being more or less a pioneering effort, the findings so far presented, though meagre have justified the tedious process of isolating these few facts and principles from the great mass of data in which they were found.

The titles of the Technical Papers of the California Agricultural Experiment Station, Nos. 1 to 20, which HILGARDIA replaces, and copies of which may be had on application to the Publication Secretary, Agricultural Experiment Station, Berkeley, are as follows:

1. The Removal of Sodium Carbonate from Soils, by Walter P. Kelley and Edward E. Thomas. January, 1923.
3. The Formation of Sodium Carbonate in Soils, by Arthur B. Cummins and Walter P. Kelley. March, 1923.
4. Effect of Sodium Chlorid and Calcium Chlorid upon the Growth and Composition of Young Orange Trees, by H. S. Reed and A. R. C. Haas. April, 1923.
5. Citrus Blast and Black Pit, by H. S. Fawcett, W. T. Horne, and A. F. Camp. May, 1923.
6. A Study of Deciduous Fruit Tree Rootstocks with Special Reference to Their Identification, by Myer J. Heppner. June, 1923.
7. A Study of the Darkening of Apple Tissue, by E. L. Overholser and W. V. Cruess. June, 1923.
8. Effect of Salts on the Intake of Inorganic Elements and on the Buffer System of the Plant, by D. R. Hoagland and J. C. Martin. July, 1923.
9. Experiments on the Reclamation of Alkali Soils by Leaching with Water and Gypsum, by P. L. Hibbard. August, 1923.
10. The Seasonal Variation of the Soil Moisture in a Walnut Grove in Relation to Hygroscopic Coefficient, by L. D. Batchelor and H. S. Reed. September, 1923.
11. Studies on the Effects of Sodium, Potassium, and Calcium on Young Orange Trees, by H. S. Reed and A. R. C. Haas. October, 1923.
12. The Effect of the Plant on the Reaction of the Culture Solution, by D. R. Hoagland. November, 1923.
13. Some Mutual Effects on Soil and Plant Induced by Added Solutes, by John S. Burd and J. C. Martin. December, 1923.
14. The Respiration of Potato Tubers in Relation to the Occurrence of Blackheart, by J. P. Bennett and E. T. Bartholomew. January, 1924.
15. Replaceable Bases in Soils, by Walter P. Kelley and S. Melvin Brown. February, 1924.
16. The Moisture Equivalent as Influenced by the Amount of Soil Used in its Determination, by F. J. Veihmeyer, O. W. Israelsen and J. P. Conrad. September, 1924.
17. Nutrient and Toxic Effects of Certain Ions on Citrus and Walnut Trees with Especial Reference to the Concentration and Ph of the Medium, by H. S. Reed and A. R. C. Haas. October, 1924.
18. Factors Influencing the Rate of Germination of Seed of Asparagus officinalis, by H. A. Borthwick. March, 1925.
19. The Relation of the Subcutaneous Administration of Living Bacterium abortum to the Immunity and Carrier Problem of Bovine Infectious Abortion, by George H. Hart and Jacob Traum. April, 1925.
20. A Study of the Conductive Tissues in Shoots of the Bartlett Pear and the Relationship of Food Movement to Dominance of the Apical Buds, by Frank E. Gardner. April, 1925.