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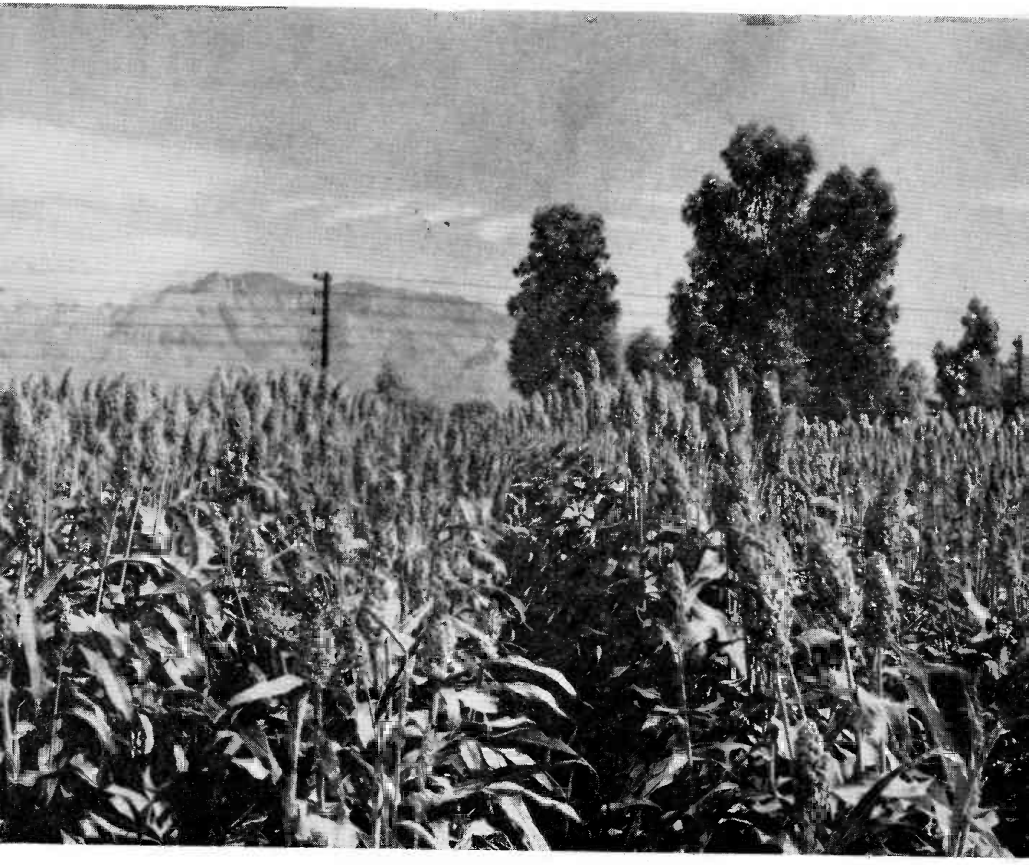
FACTORS THAT GIVE VALUE TO LAND OR BASIC LAND VALUES



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*In co-operation with U.S. Department of Agriculture, Soil Conservation Service.

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FOREWORD

The material presented in this publication should prove useful to land appraisers, landowners and prospective owners as a tool in establishing a reasonably definite value on a given piece of land. The proposed values, based upon years of experience with various soil types, are general averages worked out from numerous samplings.

It is not expected that the values given by the author will fit all situations. With usage, improvements and refinements should be effected which will enhance the worth of this method of land evaluation.

R. S. HAWKINS
Vice-Director

Arizona Agricultural Experiment Station

FACTORS THAT GIVE VALUE TO LAND OR BASIC LAND VALUES

By Karl Harris*

The ability to produce plant growth is the only thing that gives agricultural value to land. Of the factors that govern this growth, moisture, soil, and temperatures are probably the most important. Water must penetrate into the soil and be held there before the plant can use it. Climate has great influence on crop production. Air temperature determines to a large extent the rate that plants grow. When the air temperatures fall much below the freezing point the leaves of most of our economic plants are killed and growth ceases. Then too, if the soil is frozen, the soil moisture is unavailable and root activity is stopped.

The tree rings of the forest indicate by their width the years of the best soil moisture conditions. The historically good and bad years can be identified by the width of the annual growth rings. In the years of the best soil moisture the trees had the greatest growth, and this favorable moisture condition was recorded by the growth rings.

The amount of grass and browse produced on the range is directly proportional to the available water that is stored in the soil, and not necessarily to the amount of rain that falls on an area. This fact can easily be demonstrated by comparing the amount of feed produced in meadows to that on the adjacent side hills and slick spots. There is no question as to the relative amounts of feed produced during wet and dry years.

Probably no other factor influences the amount of crop produced in the Middle West so much as the amount of rain that falls at the right time. In many places where grain is produced from rainfall, forecasts are made at planting time on the basis of moisture penetration.

In the irrigated sections the growth of any plant is absolutely dependent on stored soil moisture. It is only the water which penetrates into the soil and is retained there that plants can use to make growth. Thus, in the West we are more conscious of the fact that water is probably the greatest factor that gives value to land. Those lands which have the most favorable water relations have the best opportunity for crop production and, therefore, the highest basic values. The water relations include:

1. Availability of water to the land, either rain or irrigation.
2. The ability of the soil to absorb this water.
3. The ability of the soil to retain this water.
4. The ability of the soil to give up this water.

*Irrigation Engineer, Division of Irrigation and Water Conservation, Soil Conservation Service and Arizona Agricultural Experiment Station.

In the extreme arid area are millions of acres of land which have little, if any, agricultural value because there is no water available with which to irrigate. The value of the land in many of the irrigated sections is not as great as it would be if it had more water. This is also true of vast areas that depend on rainfall.

Regardless of how fertile a soil may be, how level it lies, or how ideal it is in every way as to appearance and location, if it will not take in water it is useless so far as crop production is concerned. There are several general soil groups into which water enters with difficulty, such as heavy clay soils, dispersed soils, and compact soils.

Since water must get into the soil before the plants can use it, if the soil cannot absorb water, it will be unable to produce crops and will have little, if any, agricultural value.

It is only the water that is stored in the soil that the plants use. The water that passes through, or runs off, is wasted so far as that particular location is concerned. This wasted water may later come to the surface either by seepage or pumping or it may be picked up and used on lower lands. Coarse sands and gravels have such small water-holding capacities that to produce any growth, water must be added at such frequent intervals that their values are greatly reduced.

There are certain soils that have good water-holding capacity but because of excessive amounts of soluble salts, the plants are not able to use the water. There are other soils that are reclaimed with extreme difficulty. These are soils with poor drainage conditions and unfavorable sodium ratio. The value of these saline soils depends on the ease with which they may be reclaimed.

SOILS IN CROP PRODUCTION OR AS A FACTOR IN LAND VALUES

By far the greatest influence soils have on crop production, and therefore, on land values lies in their water relationships. Factors that have the greatest influence on the water relations are:

1. Texture of the surface soil.
2. The type of subsoil, which indicates the amount of water available to plants.
3. The depth of the soil that has water-absorbing and water-holding capacity.
4. The slope of the land which influences erosion and water absorption.

Each of these factors is discussed separately below.

TEXTURE OF THE SURFACE SOIL

The size of the particles making up a soil determines its texture. These particles range from fine gravel down to the clay which is so fine that its particles cannot be distinguished even with a powerful microscope. Most soils contain a mixture of all

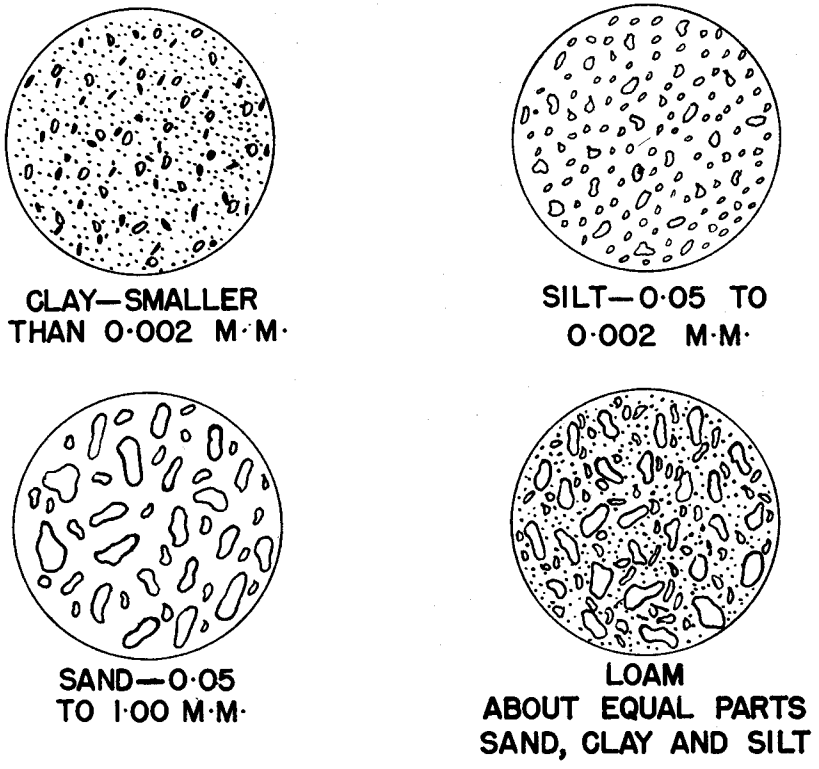

Figure 1.—Relative size of soil particles (texture).

the different sizes of particles. If the sand particles predominate, the soil is called a sand; if the clay predominates, it is called a clay. The silt falls between the clay and sands. The loams are medium-textured soils; that is, they have about equal amounts of clay, silt, and sand particles. (See Fig. 1.)

The relative values of soils are closely tied to their water relationships. The loams and fine sandy loams are given a higher rating than the silt loams because silt has a difficult penetration problem. Medium sandy loam is given a lower rating because of its lower water-holding capacity.

The silty clay loams, clays, and silty clays, are given a lower rating than the loams because of hazards connected with these heavy soils. If they are worked too wet or are compacted they become quite impervious to water and the roots of tap-rooted plants penetrate with difficulty. It is recognized that the best farmers produce more on the heavier soils than on the lighter, but heavy soils require special handling and if a mistake is made it may take several years to get the soils back into good condition. On the other hand, the coarse sandy loams, gravelly loams, or sands do not have high enough water-holding capacity, and

TABLE 1.—RELATIVE VALUES OF SOIL BASED ON TEXTURE

Loam	Fine sandy loam	Silt loam	Medium sandy loam	Clay loam	Silty clay loam	Clay	Silty clay	Coarse sandy loam	Gravelly loam	Sand
100	95	90	85	80	75	70	60	55	50	45

for the best irrigation practice must be irrigated at such frequent intervals that their value is greatly reduced.

Table 1 gives the relative value of soils in relation to texture. The arrangement is largely the author's opinion based on experience in the Salt River Valley. It is assumed that the land will be operated by typical farmers. It is the author's belief that management has a great influence on land values; that is, an operator who knows how to handle the heavier types of soil will produce more than he would on the lighter soils. Under typical operators these heavy soils have certain hazards so that the arrangement given is the author's best opinion. In this discussion the surface soil is considered the upper 2 feet and the subsoil that portion below this depth. Two feet is deeper than is generally considered surface soil. The author uses 2 feet, as the soil above this depth is influenced by tillage practices (Table 1).

THE SUBSOIL

The subsoil has a great influence on crop production and therefore on land values because it determines the total amount of water that can be stored in the soil and the extent of the root zone of the plants. The larger the root feeding zone the greater will be the crop yield. Unlike the surface soil, the subsoil is not affected by tillage implements. Normally, therefore, subsoils have a better water penetration rate than the surface soil of similar texture. Like the surface soils the best subsoils are those with the best water relations.

The best type subsoil is that which has good internal drainage and at the same time has good water-holding capacity. The very fine sandy loams, loams and clay loams generally have these characteristics. The objection to the light soils characterized by the coarse sandy loams is their low water-holding capacity.

The term "caliche" has a very indefinite meaning, but in Arizona and the Southwest it generally means the whitish material which is high in calcium carbonate. In the soil it has great variation as to degrees of hardness and permeability to water. Many caliches are quite soft and have a high water-holding capacity. There are other forms of caliche that are cemented together to form hard chunks. In this type the water and root activity is greatly retarded. In any of the caliche type subsoils which have been wetted and which have been penetrated by roots, carbon

dioxide is liberated into the soil. Calcium carbonate is relatively soluble in the presence of carbon dioxide. Because of this fact caliche type subsoil becomes better over a period of years.

The heavy silty clays and the salty clays are given the lowest ratings because they need special care in irrigation. In some of these heavy clays it is not uncommon for the soils to remain above the moisture equivalent for three weeks after an irrigation. This temporary perched water table often makes for a poor growth and in some instances causes dieback in orchards or restricted root development. On the other hand, with good irrigation practice, these heavy clay and salty clay subsoils may become very productive. They have certain limitations as to what crops may be grown. With a heavy irrigation given before the crops are planted and all subsequent irrigations light enough to just reach the heavy clay layer, these soils may be very productive. Extreme care must be exercised in the irrigation of crops on these soils or damage to the crops will result.

RELATIVE VALUE OF SUBSOILS

100 Uniform soil 1½ inches to 2 inches water-holding capacity per foot of soil.
95 Uniform soil 1 inch to 1½ inches water-holding capacity per foot of soil.
90 Soft caliche (Laveen type).
85 Caliche (Mohave type).
80 Light soil ¾ inch to 1 inch water-holding capacity per foot of soil.
75 Caliche in hard chunks, massive but fractured (roots still able to penetrate).
70 Caliche with granite rocks (Pinal type).
65 Sand with less than ¾ inch water-holding capacity per foot of soil.
55 Extremely heavy clay with slow internal drainage.
50 Salty clay.

DEPTHS OF SOILS WHICH HAVE WATER-ABSORBING AND WATER-HOLDING CAPACITY

The depth of soil determines to a large measure its crop producing potential. It has great influence on plant growth and, in turn, on land values. Most of the annual crops will develop a 6-foot root system by the end of the season if conditions in the soil are favorable. That is, if the soil contains:

1. Available moisture
2. Air
3. Plant food
4. No toxic material such as excessive amounts of soluble salts.

Alfalfa and many of the other perennials have root systems of 10 or more feet. The author has traced date roots to a depth of 32 feet on the University of Arizona Date Farm at Tempe, Arizona.

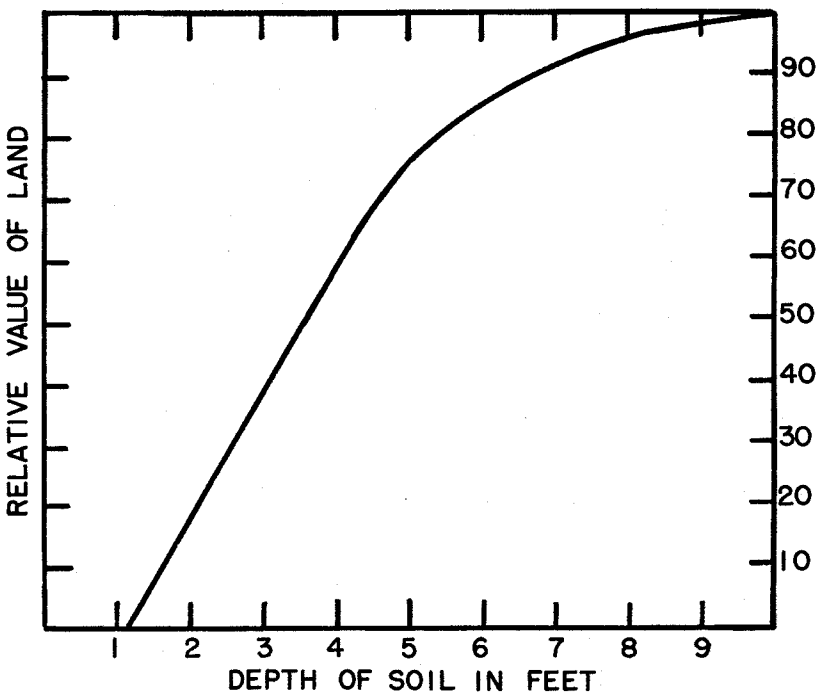

Figure 2.—Relation of depth of soil above impervious material, or coarse gravel, to value of land.

Almost everyone has seen some pretty fair crops grown on relatively shallow soil on the foothill areas of the western states but the soil is not as productive as it would be if it were deeper. The deeper soils have better water-holding capacities and will support a more extensive root system which makes for a more rapid and vigorous growth of plants. The deeper soils also are more economical to handle as they do not need to be irrigated at such frequent intervals.

Regardless of how often the shallow soils are irrigated in the hot, dry climate of southern Arizona, they will not produce as well as the deep soils.

Figure 2 is the author's opinion of the relative value of land as affected by depth of the soil. He realizes that in cooler climates or in areas with a different cropping system, a different set of relative values would be found. In any event, regardless of the climate or cropping system, the depth of the soil enters into the relative land values. (See Fig. 2.)

THE SLOPE OF THE LAND

The slope of the land has great influence on land values. It is probable that no two areas would be affected to the same degree. Where there is considerable organic matter in the soil and where

water moves through the soil readily, increased slopes would not affect the land values to the same degree as they would in areas such as in the Southwest. In Arizona, excessive slopes are not only subject to erosion but present a serious obstacle to proper moisture penetration, owing to the high water velocity.

In the Salt River Valley slopes up to 16 inches per 100 feet can be handled by using certain simple precautions. If the first irrigation after plowing is given while the land is still rough, it is possible to get good deep moisture penetration on this slope. For the subsequent irrigations, if care is used in selecting the right type of furrow and head of water, the velocity of water can be reduced to a point low enough to prevent erosion and to get a satisfactory moisture penetration. With slopes greater than 16 inches per 100 feet the penetration problem becomes so acute that it reduces the value of the land considerably.

Figure 3 is an attempt to show relative value of land with various slopes. The author makes no claim that it will fit conditions other than areas with soils that are easily eroded and have penetration problems. The slope is a factor in land values for every area but it would be impossible to make a curve to fit every condition. (See Fig. 3.)

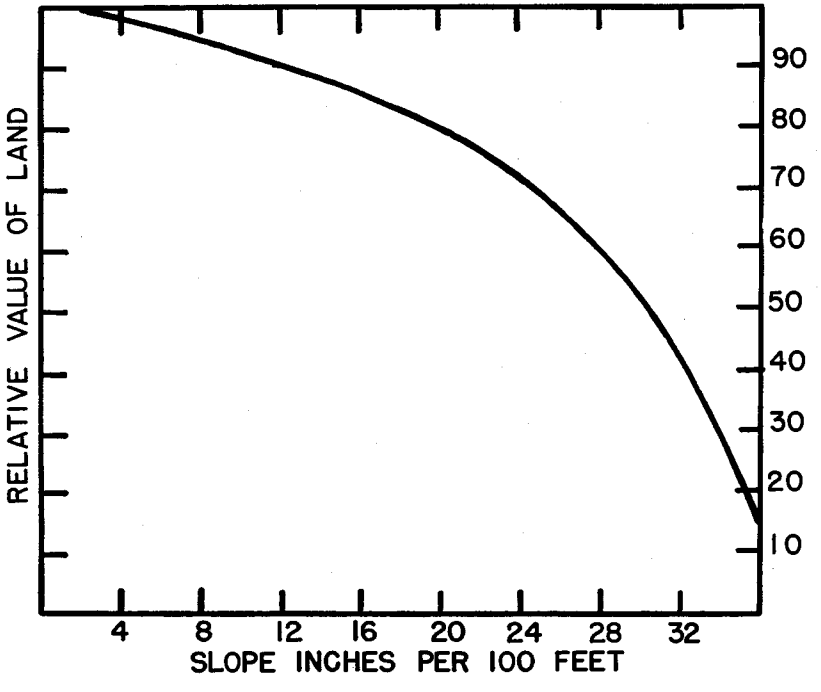

Figure 3.—Effect of slope on land values.

IRRIGATION WATER IN CROP PRODUCTION OR AS A FACTOR IN LAND VALUES

Water is the major factor that gives agricultural value to land. Without water, either irrigation or natural precipitation, no plant life could grow. Irrigation water has the greatest influence on land values in areas of low rainfall. As the rainfall decreases, the effect of irrigation water on crop production increases, as does its effect, on land values. The following are the chief factors that determine the effect of water on land values:

1. Quantity of water
2. Quality of water
3. The time of the year this water is available.

QUANTITY OF WATER

The amount of water needed for the maximum production is dependent upon the crop grown, the temperature, the relative humidity, the fertility of the soil, the quality of the water, and the efficiency of irrigation. The evaporation of water from a weather bureau pan is probably as good an indication of the water requirements as any other method. If there is precipitation or irrigation water equal to the evaporation, maximum yields of any combination of crops adapted to that area can be grown. If less water is available than the evaporation then the operator is limited to what combination of crops he can grow and obtain maximum yields.

In central Arizona the maximum production of alfalfa, or a winter crop followed by a summer crop, requires the application of about 7 acre-feet of water per year. If less than 7 acre-feet per acre is available not all the area can be double-cropped nor can the maximum production be obtained if seeded to alfalfa; hence, it would be advisable to plant part of the area to crops not requiring as much water as alfalfa or a double crop.

Figure 4 shows the cropping system suited to different amounts of water. Seven acre-feet is more water than is generally considered necessary for alfalfa but it appears that the point of diminishing returns is not reached until amounts greater than 7 acre-feet are used. The duty of water given for cotton and grain type crops is in line with published data of the University of Arizona Agricultural Extension Service in Circular No. 127, "Fitting Cropping Systems to Water Supplies in Central Arizona" by Hobart and Harris, and the Arizona Bulletin No. 181, "Irrigation Requirements of Cotton on a Clay Loam Soil in the Salt River Valley," by Harris and Hawkins.

Often in fields of the Southwest the best crops appear at the upper end of the field where the water has been on longest. It is always found that the best crops are in that part of the field which enjoys the best moisture penetration. (See Fig. 4.)

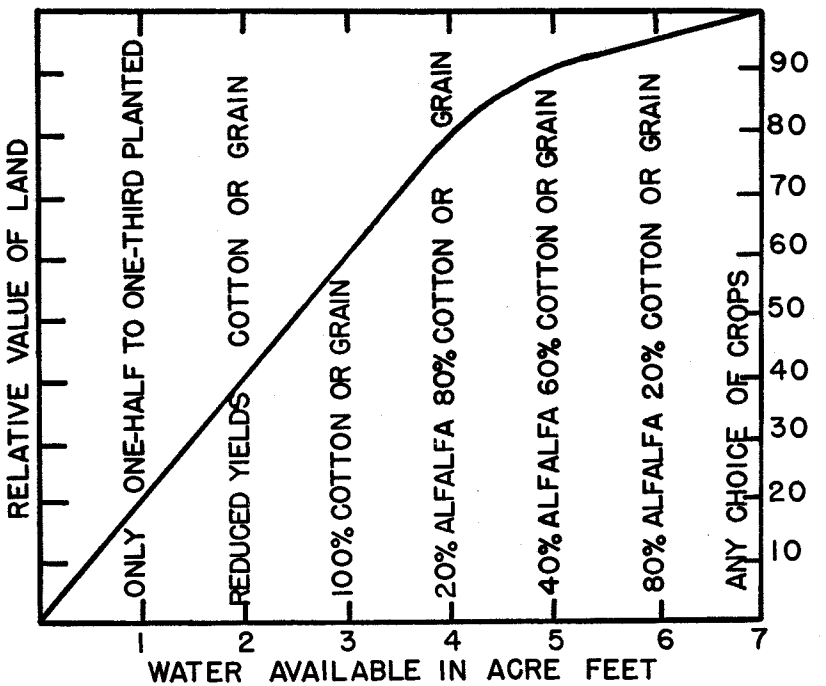

Figure 4.—Effect of water supply on land values.

Figure 5 is an idealized curve but it is very common in the Southwest regardless of crop grown. This condition demonstrates the beneficial effect of a deep moisture penetration. (See Fig. 5.)

QUALITY OF WATER

The quality of irrigation water has a great influence on crop production and consequent land values. Reduction in yields up to 25 or 30 per cent may occur before it is realized that the salt content of the irrigation water is the cause. The effect of salt in the water on the crop is probably subject to more modifying conditions than any of the other factors considered so far. These qualifying conditions include the following:

1. The kind of salt in the water—that is, the ratio of sodium to calcium and magnesium.
2. The type of surface soil—the more open soils would be less subject to damage over a long period of time than the heavier clay loam or clay types.
3. Soils that are well aggregated are less apt to damage than soils that are dispersed.
4. Soils that have an appreciable amount of calcium carbonate will probably be subject to less damage than soils that contain only a little calcium carbonate.

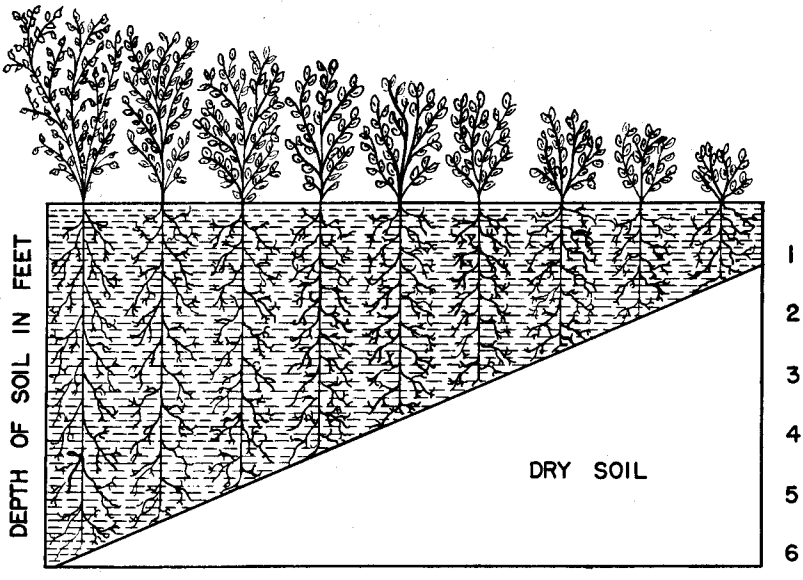

Figure 5.—Effect of depth of moisture penetration on size of plants.

5. Soils that have open permeable subsoils are less subject to damage than are subsoils which do not allow the movement of water through them easily.
6. The availability of certain soil amendments may be a factor.
7. In case the salt content is high, more water must be used in order to prevent accumulation of salt in the soil; hence, the quantity of water available is important.

Figure 6 is the best curve figured from available published data. It shows the relative value of lands irrigated with salty water if the above conditions are kept in mind. (See Fig. 6, page 13.)

THE TIME OF YEAR THE WATER IS AVAILABLE

For the best crop production there should be precipitation or irrigation water in sufficient quantities to saturate the soil to a depth of 8 or 10 feet before the crop is planted. This will ordinarily require about an acre-foot of water. From a theoretical standpoint this water could be applied after the crop is planted but it is much more difficult to get a deep penetration after the seedbed has been prepared.

For the best results, about an acre-foot of water should be stored in the soil prior to planting and water should be available to the plants either through application to the soil or storage in the soil in amounts equal to the evaporation during the growing season. If all the water comes with a flush in the spring it will not have the value it would have if it were more evenly distributed over the season. Neither will it have the value if it all comes

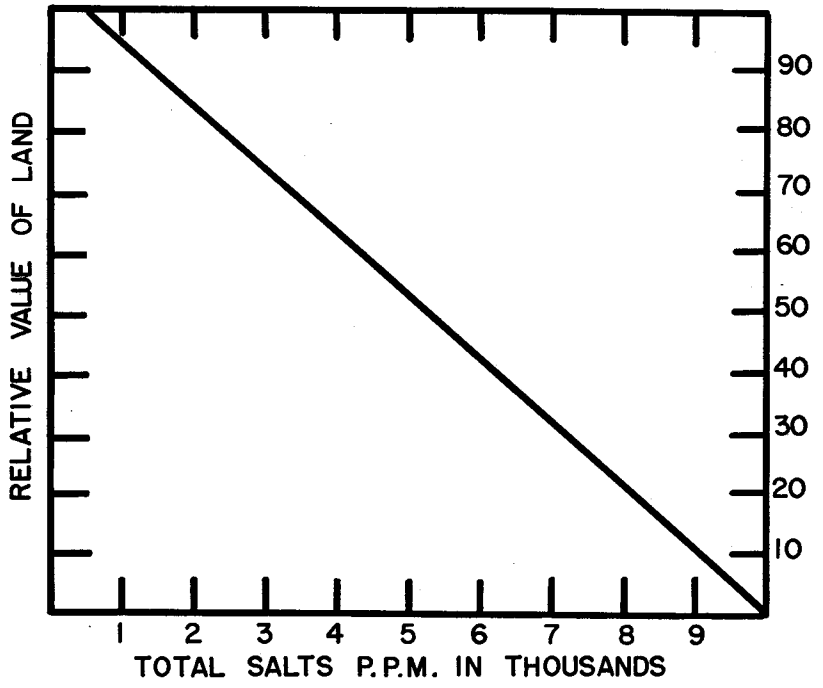

Figure 6.—Effect of salt content of water on land values.

after the crops are planted. The ideal distribution would be to have enough water to saturate the soil to the desired depth either in the fall, winter, or spring, before the crop is planted and to have water available in amounts equal to the evaporation during the growing season, either in stored soil moisture, irrigation water, or precipitation.

CLIMATE IN CROP PRODUCTION OR AS A FACTOR IN LAND VALUES

The length of the growing season has great influence on the productive capacity of land. In most of the western states great variation in the length of the growing season is encountered in a relatively short distance, due to changes in elevation. In Arizona, for example, Yuma Valley has over 300 frost-free days and Alpine less than 100. In determining relative value in which the length of the growing period is the variable there are several things that must be kept in mind:

1. If citrus can be grown, considerable feed and vegetables can also be grown during the winter months, which gives a wide choice of both summer and winter crops.
2. If the season is long enough to grow cotton, it will also be long enough to produce a great variety of crops and obtain high yields of crops like alfalfa.

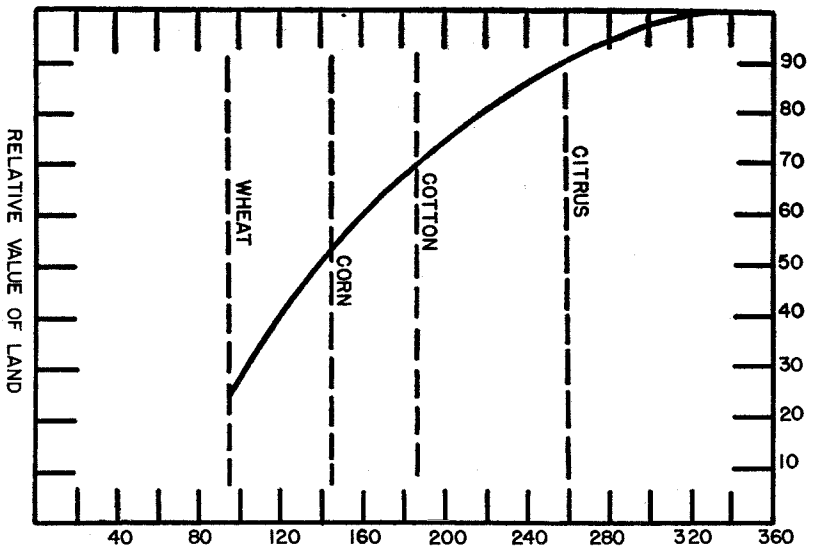

Figure 7.—Relative value of land which has a growing season in days between frost.

3. If the season is long enough to grow corn, it will also be possible to grow any of the grains and obtain a fair yield of alfalfa.
4. If the growing season is just long enough to grow the small grains, it will only produce low yields of alfalfa. It will take more acres to feed a given number of stock or people.

Figure 7 is an attempt to evaluate land when all other factors are equal and the length of the growing period is the variable.

It is realized that you cannot compare widely scattered areas with entirely different cropping systems. In general, the amount of plant growth is very greatly influenced by the length of the growing season. It is the author's belief that Figure 7 represents the relative value of land for Arizona and similar curves could be drawn for other states or locations.

FACTORS THAT INFLUENCE CROP PRODUCTION BUT ARE NONBASIC

The following factors greatly influence crop production:

1. Irrigation water distribution system
2. Soluble salt in the soil
3. Irregularities in contour
4. Soil-borne plant diseases and insect pests.
   (a) Texas root rot
   (b) Nematodes
   (c) Other
5. Noxious weeds
6. Plow sole.

These do not contribute to the basic value of the land as the adverse condition caused by these factors may be permanently remedied. If these adverse conditions were to go unchecked it would not change the potential productivity of the land.

A good system of distributing irrigation water is of major importance in crop production. The essentials of a good system are:

1. Water to be transported to all fields with minimum loss
2. Proper structures so that the operator may reduce labor and insure a more uniform distribution of irrigation water.

The farm irrigation ditch is the cause of considerable loss of water. Many ditches are wide and shallow so that a high percentage of the water is in direct contact with the soil. This makes a maximum seepage loss. The farm ditch provides a favorable environment for the growth of grass and weeds. As a result, many of the ditches become clogged with growth which considerably increases the seepage loss.

It would be difficult to set a figure as to the amount of water lost by seepage, but in many cases it is very high.

The aim of every operator should be to reduce excessive seepage losses. If this is done and the water saved is added to the land, in many cases the yield will be increased considerably.

With proper irrigation structures the irrigator is able to get a more uniform distribution of his water. Also, the water is under control and the amount into each furrow or border can be changed very easily. If the amount of water cannot be regulated easily it is almost impossible to get an irrigator to change it after it is once set. As a result, if too little water is turned into each set the upper end is over-penetrated before the water reaches the bottom of the field. Or, if too much water is turned on before the soil is wetted to the proper depth there will be considerable run-off at the lower end.

SOLUBLE SALTS IN THE SOIL

The effect of moderate amounts of alkali in the soil is often overlooked, and declines in yields of 10 to 20 per cent may result before a salt problem is recognized. It is difficult to give relative values to land with varying amounts of salt as many factors influence their removal. The following are factors that affect the values of land containing soluble salt:

1. Amount of salt
2. Kind of salt
3. Type of soil
   (a) Surface
   (b) Subsoil
4. Kind of drainage
5. Amount of irrigation water available
6. Quality of irrigation water.

IRREGULARITIES IN CONTOUR

Fields that have high or low spots or where the slope increases considerably usually have poor yields. An area in a field or border not over an inch higher than the surrounding area will often reduce the yield of the entire border by more than one-half. This is especially true of alfalfa and for the heavier soils. It is caused by decreased moisture penetration on such spots. The water has to fill up the lower areas before it covers the high spots, the water is on the high spots for a shorter time.

Where the slope suddenly increases there is usually found an area of smaller plant growth, because of poor moisture penetration. As the slope increases the velocity of the water increases, which reduces the rate of water intake into the soil.

If there are low spots in the field it is necessary to pond the water on them before it can be forced to the end of the field. This is not only a waste of valuable resource but often drowns the plants in the low spots. Irregularities of contour is one of the important causes of waste of this most valuable natural resource and, is one of the major causes of yields below that which the soil, water, and climate are capable of producing. As most of the land will be irrigated for many years there is probably nothing that will pay such big dividends as proper land leveling. It is believed that the value of land improperly prepared for irrigation should be reduced by the amount it would cost to properly prepare it for irrigation.

SOIL-BORNE PLANT DISEASES AND INSECT PESTS

There are a number of plant diseases such as Texas root rot, and nematodes and other insects which greatly reduce the yield of many of our crops grown and entirely eliminate the possibility of planting certain crops. These soil-borne organisms are an important factor in crop production but, with certain remedies and crop rotations, they may be eliminated.

NOXIOUS WEEDS

Weeds not only use water and plant food that should go into economic crops but often become so numerous that they eliminate all economic plants. With our present knowledge of chemicals and cultural methods, weeds may be eliminated and the land restored to its potential productivity.

PLOW SOLE

A compacted soil layer caused by tillage implements is called a plow sole. This layer is very common in Southwestern fields. This compacted layer in extreme cases may extend from the surface to more than 2 feet below but the most common condition is a compacted layer from 4 to 10 inches. This compaction greatly retards water penetration and may completely prohibit it and reduce crop yields considerably. This adverse condition may be eliminated by certain amendments and cultural methods.

FACTORS THAT GIVE VALUE TO LAND—NONBASIC BECAUSE THEY MAY BE PERMANENTLY REMEDIED BY EXPENDITURE OF WORK OR MONEY*

POOR SOIL STRUCTURE _____

DRAINAGE _____

IRRIGATION STRUCTURES _____

SOIL ALKALI _____

IRREGULARITIES OF SLOPE _____

SOIL-BORNE PLANT DISEASES:

ROOT ROT _____

NEMATODES _____

OTHER _____

NOXIOUS WEEDS _____

*It would be impossible to give values to these but the value of the land should be reduced the amount it would take to remedy these factors.

SUMMARY OF RATING LAND

In rating a tract of land there are many things to be considered. Many of these factors are not considered in this report. It is the author's belief that if one tract of land has 20 per cent greater productive capacity than another the value of that land is much greater than 20 per cent. This is true if both tracts have the same cost of production, that is, if it costs the same to bring the crop on each to harvest. The one which has the 20 per cent greater productive capacity may make a nice profit. On the other hand the land with less production may not pay operation costs.

An example:

Surface soil clay loam rating Table 1	= 80
Subsoil caliche with granite rock rating Table 2	= 70
Depth excess of 10 feet Figure 2 rating	= 100
Slope 20 inches per 100 foot one direction rating	= 80
Slope in other direction is 12 inches per 100 feet	= 90
Quantity of water, 3 acre-feet per acre total per year available rating Figure 4	= 60
Quality of water, the water contains 2,500 parts per million rating, Figure 6	= 80
Time available, water comes from pump and can supply water as needed up to a total of 3 acre-feet per year, rating	= 100

The following table takes the above figures and rates a piece of land considering only the productive capacity of the land under typical operators.

SUMMARY OF BASIC LAND VALUE FACTORS

SOILS

SURFACE SOIL	80	
		75
SUBSOIL	70	
DEPTH OF SOIL		100
SLOPE IN DIRECTION OF WATER RUN	80	
		85
SLOPE RIGHT ANGLES TO WATER RUN	90	
RATING SOILS, 75x100x85		64

WATER

QUANTITY	60	
		70
QUALITY	80	
TIME AVAILABLE		100
RATING WATER, 70x100		70

CLIMATE

LENGTH OF GROWING SEASON	90
RATING FOR LAND VALUES, 64x70x70	40

IF ANY OF THE ABOVE VALUES ARE ZERO THE BASIC VALUE OF THE LAND WILL BE ZERO.

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