PROJECTIONS RELATING TO KANSAS LIVESTOCK FEED PRODUCTION, 1975

by

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INTRODUCTION

A dynamic evolvement has characterized the growth and development of Kansas agriculture since Kansas territory was first opened to settlement in May, 1854. The dynamic qualities of this evolution have been due, in no small part to the role which the livestock industry has played in Kansas agriculture.

It has been said "the grass grows green in Kansas" and certainly the grasses which flourished so abundantly throughout the state formed the backbone of the first and most colorful chapter written in the history of Kansas livestock agriculture.[1] Thus in the two decades between 1865 and 1885 as the railroads made their meandering penetration across the Kansas prairie the great cattle trade was born, grew to dazzling proportions and waned into a romantic legend. And although the kind of agriculture typified by the great cattle drives, the dusty trail, the bawling cattle, gigantic cattle empires, dashing cowboys, quick riches, and even faster death was almost pre-destined to early extinction, it serves as a poignant reminder that the Kansas prairies were potent producers of livestock even from the beginning of the state's history.

By 1885 the passage of quarantine laws effectively stopped the influx of Texas cattle to Kansas shipping points and the abuse of grasslands through overgrazing combined with the rapid migration of homesteaders had almost as thoroughly broken up the great cattle empires.[2] The continued rapid settlement of farmers during the remainder of the 19th century, followed at discrete intervals in the 20th century by two world wars with their well known price structures so favorable to crop production, unquestionably completed the transformation of Kansas from a range state to a farm state.

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1. Charles C. Howes, <u>This Place Called Kansas</u>, p. 128.
2. Leo M. Hoover, "Kansas Agriculture After 100 Years," Kansas State University, Agr. Expt. Sta. Bul. 392, p. 12.

However, this gradual transformation which has almost eliminated extensive expanses of grassland in Kansas, with the exception of the Flint Hills and other smaller areas, has by no means resulted in a comparable reduction in the importance of livestock to Kansas agriculture. Indeed, the Kansas State Board of Agriculture reported in 1961 that farmers in the state were receiving over half their cash receipts from the sale of livestock and livestock products, 55 percent as compared to 45 percent from sale of crops.[1] Also, cash receipts from the sale of cattle exceeded by 1 percent (35 percent as compared to 34 percent) those received from the sale of King Wheat. Not only does livestock production hold a position of high relative importance in Kansas agriculture, but it also ranks very favorably in relation to other states. As of January 1, 1961, Kansas stood fourth among the states in numbers of all cattle and calves on farms, fifth in numbers of sheep and lambs on feed, and fourteenth in numbers of all hogs and all sheep and lambs.[2] In 1960 Kansas was fourth in total production of cattle and calves, and fourteenth in total production of sheep and lambs, and hogs.[3]

A number of developments and circumstances in the past half decade seem to indicate a potentially favorable extension of the Kansas livestock industry into the future. Recent attempts to limit wheat output through acreage controls has forced a large acreage into feed grain (mostly grain sorghum) production. This acreage shift has been in part responsible for the approximately five-fold increase in 1960 Kansas grain sorghum production over that of 1955. During the past decade (1950-60) the Southwest (United States) increased its population 33 percent. This was more than twice the rate of growth for the remainder of the

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1. Farm Facts, Annual Report of the Kansas State Board of Agriculture, 1960-61.
2. Livestock and Poultry Inventory, January 1, 1961, Number Value and Classes, USDA.
3. Farm Facts, loc. cit.

United States.[1] This area of rapidly increasing population and low per capita livestock production offers a potentially lucrative market for other regions of the country which are normally livestock surplus areas. It has been indicated that Kansas is in a geographically favorable competitive position for marketing hogs in the above area.[2] A similar study for beef cattle concludes that although Kansas farmers do not enjoy a competitive advantage in marketing beef in terms of geographical location, they may profitably enjoy the advantages of expanding beef output through low cost production made available by an expanded supply of feed grains and a localized stocker-feeder market.[3]

Considering these diverse factors and assuming for the moment that Kansas will be able to compete economically with other areas for potential livestock consuming markets, the question arises, what will the Kansas livestock industry be geared to produce in the future, say 1975? Will it be able to adequately help fulfill the demands for livestock in pork, beef, and mutton deficit areas? Assuming further, that Kansas production of beef, pork, and lamb is dependent upon the production of feed grains in the state, then immediately the question becomes relevant, what can reasonably be expected to occur, considering all influencing factors, in the way of expansion of potential average livestock feed production in Kansas by 1975? It is toward the derivation of an answer to this latter question that the remainder of this paper is devoted. The answers are presented in the form of projections of expected potential production of the various feed grain and forage crops in Kansas by 1975, under various assumed conditions.

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1. James D. Goetzinger, The Competitive Position of Kansas in Marketing Beef, p. 4, Unpublished Master's Thesis, Kansas State University, 1960.
2. Paul Kelley, John McCoy, and Milton Manuel, The Competitive Position of Kansas in Marketing Hogs, Kans. Agr. Expt. Sta. Tech. Bul. 118.
3. Goetzinger, op. cit., p. 114.

An attempt has been made to remain as objective as possible in this analysis. However, the lack of reliable data concerning many of the factors which will influence future trends in livestock feed production has rendered untenable to a certain extent some of the more rigidly objective tools commonly used in economic analysis. This has necessitated the rather liberal use of informed and calculated judgements in supplementing and qualifying the conclusions of this paper.

However, despite this necessary and deliberate deviation from a purer form of the scientific method it is hoped that the projections contained herein will bear a closer semblance to reality and prove somewhat more palatable to the scientific mind than the simple extension of trends which Mark Twain found so fascinating in LIFE ON THE MISSISSIPPI.

> In the space of one hundred and seventy-six years the lower Mississippi has shortened itself two hundred and forty-two miles. This is an average of a trifle over one mile and a third per year. Therefore, any calm person, who is not blind or idiotic, can see that in the old Oolitic Silurian period, just a million years ago next November, the lower Mississippi River was upwards of one million three hundred thousand miles long, and stuck out over the Gulf of Mexico like a fishing rod. And by the same token any person can see that seven hundred and forty-two years from now the lower Mississippi will be only a mile and three-quarters long, and Cairo and New Orleans will have joined their streets together and will be plodding comfortably along under a single major and a mutual board of alderman. There is something fascinating about science. One gets such wholesale returns of conjecture out of such a trifling investment of fact.[1]

THE PROBLEM

Theoretical Problem and General Model

As implied in the introduction, the purpose of this paper relates to the determination or estimation of probable livestock feed production in the state

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1. G. T. Barton and R. F. Daly, "Prospects for Agriculture in a Growing Economy," p. 1, Address, Conference on Problems and Policies of American Agriculture, Iowa State College, October 27-31, 1958.

of Kansas for the year 1975. The theoretical problem involved may thus be stated as the determination of those independent variables functionally related to a dependent variable, the probable production of livestock feeds in Kansas in a defined future time period, 1975. Stated in other terms, given the general model $Y = f(X_1, X_2, X_3, \ldots X_n)$, in which the dependent variable, Y, is probable livestock feed production in Kansas in 1975, and the X independent variables represent those functional factors determining the value of Y, then the theoretical problem becomes that of identifying those independent variables and analytically determining the magnitude and scope of the functional impact which each exerts upon the final value of Y under the assumptions and conditions of the model.

Practical Problem

This paper is empirically rather than theoretically oriented and being such the practical problem assumes a greater magnitude than does the theoretical problem. After little more than a casual investigation it will become almost intuitively obvious that the most basic two factors affecting the size of any crop production are number of acres harvested and the yield per acre. This simple dichotomy forms a first and very natural breakdown of the problem for analysis in this study.

Proceeding with the twin problems of yield and acreage determination, and assuming for the moment that the various independent variables affecting each of these have been identified, it becomes possible once more to abstract from the general problem a symmetrical dualism. This may be expressed as (1) the difficulties of projecting into the future associated with the great variability in and lack of adequate information about historical data concerning the independent variables and (2) the difficulties of projecting into the future associated with anticipating the uncertainty and the unknown and unknowable qualities of the future time period in question.

Year to year variability in production of crops in Kansas is a well-known phenomenon to layman and researcher alike. Fluctuation in weather is the most important factor involved although alterations in the number of insect pests and frequency of occurrence of crop diseases also exert a causative influence. This variation in historical trends, coupled with an inadequate source of information concerning certain of the factors functionally related to crop yields and acreage harvested, relates to the problem of this study through its impact upon an objective analysis. This is to say that any formulation of a rigidly objective mathematical model implies a reasonable knowledge of the relationship among the independent variables and their functional impact upon the Y value. Because of this, in any situation in which a precise and formal relationship cannot be adequately established, for one reason or another, the researcher is faced with two alternative courses of action. Either arbitrary assumptions must be imposed upon the model, with an almost inevitable resulting departure from realistic conditions, or the objective analysis must be extended and qualified through the use of subjective judgements and evaluations. By and large the second alternative has been used in this study.

Any attempt to estimate or predict values pertaining to some future time period will be beset with difficulties relating to the uncertainty, or unknowable quality of the future. In this study these uncertainties are relevant particularly in relation to subjective evaluations and judgements used in estimating potential 1975 livestock feed production. It is recognized that any subjective estimation of future unknowns, no matter how well based it may be, will remain valid only to the extent that the pre-suppositions about which it is oriented remain valid.

In view of the above considerations it was determined that the desired result of a realistic estimation of expected output of livestock feeds in Kansas in 1975 could best be obtained by using a "synthetic" method of analysis.[1] This implies the integration of quantitative and qualitative measures, qualified by necessary assumptions, in determining the unknowns of the problem.

It is to be pointed out that even though an attempt has been made to foresee probable conditions in a specified future time period, the results arrived at in this study are in no way forecasts of what will happen. They are rather "prediction estimates" of the expected 1975 production of livestock feeds in Kansas, based upon an examination of the independent variables influencing production in the past, and an attempted anticipation of changes which will occur in these variables during the next 15 years.

The relevant unknowns pertaining to 1975 livestock feed production were defined as yield per acre for each crop under both irrigated and dryland conditions, and harvested acres of each crop under both dryland and irrigated conditions. Thus based upon the foregoing discussion, the basic practical problem of this study was one of determining a projected 1975 probable irrigated and dryland yield for each relevant feed crop, and a projected 1975 cropping pattern under irrigated and dryland conditions, taking into consideration past trends, present conditions, and changes which may reasonably be expected to occur by 1975.

OBJECTIVES

Having defined and discussed the nature of the problem concerning this study, the following objectives were established as goals by which the validity

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1. For more detailed discussion of "synthetic" methodology see, Gerald W. Dean and Chester O. McCorkle, Jr. Projections Relating to California Agriculture in 1975. Calif. Agr. Expt. Sta. Mimeographed Report No. 234, p. 3. Also see: Gerald W. Dean and Chester O. McCorkle, Jr., "Limitations of Alternative Approaches to Agricultural Adjustment." Proceedings of the Western Farm Economics Assoc,, 31st Annual Meeting, August 13-15, 1958, pp. 97-101.

of the projected probable production models could be measured. They are:

1. To examine past and present data concerning actual and potential feed grain and forage crop yields in Kansas.

2. To examine past acreage trends and present cropping patterns concerning feed grain and forage crop acres in Kansas.

3. To determine those factors which can be anticipated to cause a change in feed crop yields by 1975 and/or those factors which can be expected to cause a shift in feed crop acres by 1975.

4. To estimate the probable level of magnitude of those anticipated changes in 3.

5. To integrate the estimates of expected 1975 crop yields with the estimates of expected land use for 1975 in formulating general probable production models of Kansas livestock feed production in 1975.

SCOPE

The scope of this study in general encompassed that area of Kansas agricultural crop production which contributes substantially to the annual supply of livestock feeds. This included the four major feed grains, corn, grain sorghum, barley, and oats. Consideration was also given to wheat, both because of the implications of future wheat acreages upon feed grain acreage and because of the potential livestock feed value in surplus supplies of this grain.[1] In terms of forage crops, consideration was given to sorghum silage, sorghum forage, alfalfa hay, wild hay, and permanent pasture. Other feed crops, generally occupying less than 300,000 to 400,000 acres in the state, were considered minor and either assumed to be insignificant in total livestock feed production or else

1. However, in making final estimates of 1975 livestock feed production, wheat was not included.

were combined as "other" crops. Examples of these crops include rye, miscellaneous tame hays other than alfalfa, and temporary pasture crops. Minor non-feed crops were considered only to the extent that a potential acreage expansion in some area might in the future compete with feed crops for land use. Examples of these crops would be soybeans, sugar beets, vegetables, and fruits.

For purposes of analysis the nine crop reporting districts were used as delineated by the Kansas State Board of Agriculture in their annual reports. This breakdown was used mainly because (1) it provided a readily accessible source of crop yield and acreage data from State Board of Agriculture Reports and (2) the smaller number of areas as compared to certain other classifications was desirable from the standpoint of time necessary for computations. It was felt that potential production differences among various areas of the state were significant enough to justify an area analysis. Although the crop reporting districts adhere to no topographical or type of farming area distinctions such as the area classifications used by the Kansas Water Resources Board or Kansas State University farm management specialists, it was felt they adequately fulfilled the purpose for which they were used in this study.[1]

Regarding the variables considered to affect crop yields and acreages, an attempt was made to evaluate all those factors which directly or indirectly might influence trends in expected production of livestock feed under normal or average conditions between the present and 1975. These factors will be identified and discussed in later sections of this paper.

REVIEW OF LITERATURE

The vast complex of problems which today beset the agricultural economy of the United States offer a fertile field of investigation for those research

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1. "Developing a State Water Plan," Bul. No. 1, Kansas Water Resources Board, Topeka, October, 1956; Hoover, op. cit., p. 15.

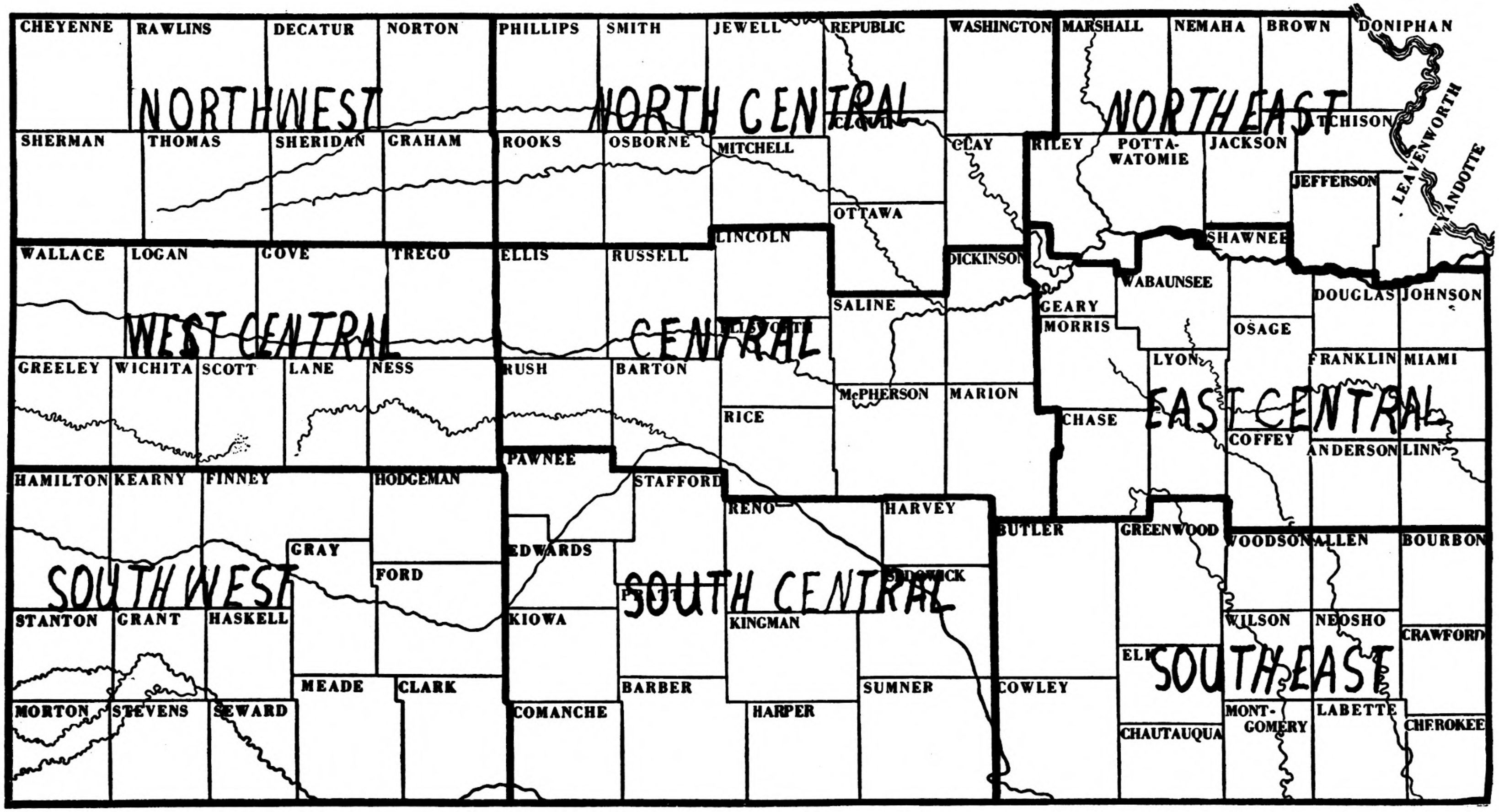

Fig. 1. Crop reporting districts, state of Kansas.

workers who, for one reason or another, wish to stake their future academic integrity upon the science (or art?) of predicting crop and livestock production potentials. Indeed the perennial twin and seemingly antithetical agricultural problems of chronic overproduction on a macro level (e.g. physical overproduction on an industry basis) and chronic underproduction on a micro level (e.g. net economic underproduction on a firm basis) along with the ever increasing cries of the population explosion alarmists, hurling their skepticism at Agriculture's ability to keep pace with the hungry mouths of the mushroom crowd have made it almost imperative that agriculture's potential to produce be investigated.[1] Research workers have responded well to the call, coming forth with an array of studies ranging from the potential for expanding micro (firm) production in terms of net income for a small homogenous area within a state, to more aggregative models of the potential agricultural production for the United States as a whole in a future time period as related to expected demand.

Schmidt and Christiansen, working with a nine county area in Northwest Wisconsin, analyzed the potential production of dominant soils in this area under recommended cropping practices, compared to the production currently being obtained on some of the "better managed" farms in the area.[2] The Wisconsin investigation listed two general objectives.[3]

1. To determine yields of principal crops by major or dominant soil types in Northwest Wisconsin.
   a. Under actual cropland practices, and
   b. Under recommended cropland practices.

2. To evaluate the effect on livestock programs and net farm income of changing from actual to recommended cropping practices.

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1. William Vogt, People, Challenge to Survival.
2. John R. Schmidt and Rudolph A. Christiansen, Potential Crop and Livestock Production and Net Farm Income on Dominant Soils in Northwest Wisconsin, University of Wisconsin, Agr. Expt. Sta. Res. Bul. 219. May, 1960.
3. Ibid., p. 4.

The study area was described as one high in feed production with the main livestock enterprises being dairy animals, hogs, and poultry. Approximately nine tenths of the farm income was derived from the sale of livestock and livestock products. Field crops most commonly grown were corn, oats, and hay.

Present cropping practices and livestock programs were determined by analyzing the 1953 to 1955 business records from 195 farmers belonging to the Northwest Wisconsin Farm Management Association.[1] The determination of present crop rotations and crop yields for a "typical" size farm on each dominant soil type provided the basis for computing present crop production.[2]

Potential crop production in the Wisconsin study was calculated by combining acreage for land use under recommended crop rotation practices with estimated potential crop yields on each dominant soil type under recommended levels of management. The recommended crop rotations were provided by the SCS. They were based on available knowledge of the designated dominant soil types in the area including allowable soil loss, typical length and gradient of the slope, and land use capabilities. Rotations were selected which it was felt would provide the greatest return to the farmer and still protect the land. The establishment of potential crop yields was based upon measured yield data obtained from Wisconsin branch experiment stations, experimental fields on various soil types, and yields obtained by farmers participating in the Wisconsin Pacemakers Corn Club Program. Potential crop yields with recommended cropping practices were found to be substantially higher than yields with past cropping practices. Also potential yields differed more between individual soils. This was explained on the basis that poorer soils were producing nearer full capacity under present management than were potentially more productive soils. Total potential feed

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1. Ibid., p. 10.
2. Ibid., p. 11.

production calculated on the basis of land use under recommended crop rotations and potential yields with recommended management levels was significantly increased in most instances.

After present and potential feed production for the typical size farm by dominant soil type was determined, the optimum (most profitable) livestock organization was budgeted for each farm under both past and recommended cropping practices.[1] Livestock enterprises commonly found on sample farms were dairy cattle, hogs, and poultry. A 200-hen poultry flock was arbitrarily included in each organization in this study. Optimum allocation of the remaining feed and labor between dairy cows and hogs was determined by linear programming analysis. Alternative livestock enterprises such as beef cattle, sheep, and feeder pigs were not considered.

Relative profitability of livestock organizations was computed for three different livestock production situations, A, B, and C. "Livestock alternatives under situation A were dairy cows producing '7,000#' of milk per year and 'average' hogs (6.5 pigs/litter). In situation B alternatives were '9,000#' cows and 'average' hogs. In situation C alternatives were '11,000#' cows and 'good' hogs (8.0 pigs/litter)."[2]

The major conclusions reached in regard to livestock enterprise selection indicated that lower production dairy cows (7,000 and 9,000 pound producers) did not figure dominantly in livestock organization.[3] However, under situation C, cows constituted the major livestock enterprise on all soil types with recommended cropping practices.

The development of the Columbia Basin Project in South Central Washington, and in particular the land to be irrigated from water impounded in Lake Roosevelt

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1. Ibid., p. 2.
2. Ibid., p. 2.
3. Ibid., p. 3.

behind the Grand Coulee Dam, led to the publication of a series of studies by the Washington Agricultural Experiment Station in cooperation with the Bureau of Reclamation in which estimates were made of the future potential crop and livestock production in the basin under conditions of mature development. These studies aimed at presenting information on anticipated crop and livestock production, crop concentration in different areas of the basin, and estimates of the volume of crops, livestock, and livestock products which would be available for sale.[1]

To determine physical production potentials of project land, a system of land types was developed based on physical characteristics which would influence crop yields, crop adaptation and costs of production.[2]

These land types were developed by integrating soil series with Bureau of Reclamation land classes. The result was 22 "land types" defined as "bodies of land with relatively homogenous inherent fertility, use capability, and management requirements under irrigation."[3] The purpose of the land types was to provide a reasonably precise, valid comparison between soils in the project and those in other projects actually under irrigation. By studying data from comparable project type irrigation developments with similar soil types, and supplementing with experiment station results and judgements of the group studying the problem, it was possible to estimate for each land type in the project, the most probable pattern of land use and the average yields to be expected. The expected cropping patterns for each type were then applied to the acreage of each land type mapped in an area. Expected production for each area in the project

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1. O. L. Brough, Jr. and Al Walker, Crop and Livestock Production Possibilities, Columbia Basin Project, Washington, Wash. Agr. Expt. Sta. Circular 239, p. 1.

2. O. L. Brough, Jr. and others, Columbia Basin Project, Relative Land Productivity and Income, Wash. Agr. Expt. Sta. Bul. 570, p. 2.

3. Loc. cit.

was then determined by multiplying the expected yield times the acreage of each crop for each land type. Summation of area production totals provided estimates of potential crop production for the whole project.

In developing estimates of potential livestock production in the unit, it was expected that relative concentration of forage crop production would largely influence the location of livestock enterprises.[1]

A number of assumptions were set forth as the basis of projecting production of livestock and livestock products. The assumptions were:[2]

1. Fifteen percent of the total project area hay production would be sold and transported outside the project area.

2. The balance of the hay produced plus all pasture and grains produced in the area would be utilized by livestock.

3. Dairy or beef cattle would be important livestock enterprises with dairy herd size depending upon the land type and size of farm. Relative numbers of beef and dairy cattle would be a function of relative price relationships.

4. Forage crops not utilized by dairy cattle and sheep flocks would be consumed by beef cattle shipped in from range areas.

Areas important in grain production were expected to be most favorable to hog numbers. Poultry flocks were not expected to be large.

In a refinement of the analysis concerning potential livestock production, Quann and Wyckoff investigated the potential for beef production in the Columbia Basin.[3] The purpose of the beef study was to determine the feasibility of extensive cattle feeding operations, the adequacy of the potential feeder cattle supply in relation to demand, and the potential market outlet for fed beef, in and for the basin project area. It was assumed that the limiting factor in beef production would be the supply of roughage, e.g. pasture, hay, and silage. This assumption was made on the belief that grains would be available and could be

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1. Brough, Bul. 570, op. cit., p. 15.
2. Loc. cit.
3. C. J. Quann and J. B. Wyckoff, Potential Beef Production in the Columbia Basin, Wash. Agr. Expt. Sta. Bul. 622, November, 1960.

imported from surrounding areas to complement the supply produced in the project area. Allocation of the forage crop supplies among various livestock enterprises was made on the basis of several assumptions. It was assumed that dairy cattle numbers would be sufficient to provide the dairy product needs of the area. Poultry numbers were considered to be of little importance as competitors for livestock feeds. Sheep numbers were assumed to slowly increase in keeping with past trends and expected relative profitability. Hog numbers were anticipated to increase. However, since hogs were not large consumers of roughages, and because of the assumption that grains would be imported to meet area needs, it was felt that swine production would not seriously compete with beef cattle for basin feed supplies. Having arrived at a projected number of animal units for the various livestock enterprises other than beef, an estimation of their needs in terms of roughages was determined based on feed conversion ratios supplied by animal scientists. The total of roughages thus determined to be needed was subtracted from the total supply estimated to be available from project area production. This remainder was considered the potential supply available for beef production. This gave a basis for the estimation of the number of mature beef animals which could be fed out in the basin area each year.

Dean and McCorkle in a recent comprehensive study have made projections of California agriculture to 1975.[1] Their stated objectives were to determine average yield and total production of major crops, numbers and projections of major types of livestock, general shifts in the location of crop and livestock production within California, and changes likely to occur on individual farms.[2]

The methodology used in their approach involved the use of conventional economic analysis tools such as linear programming, demand-supply analysis, and input-output analysis in conjunction with qualitative judgements. This "synthetic"

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1. Gerald W. Dean and Chester O. McCorkle, Jr., Projections Relating to California Agriculture in 1975, op. cit.
2. Ibid., p. 3.

method was employed because it was felt the quantitative tools taken alone were not adequate devices for handling the long run analysis involved in much of the study.

In the California study projections were developed separately for crops and for livestock. This was done since it was felt livestock, forage and feed grain crops could not compete with high value human food crops for the use of irrigated land in California. This reduced hay and feed grains to the role of becoming little more than "residual claimants" to the land and implied a greater dependence of livestock production on crop production than vice-versa.[1] Also "the basis for projecting crop production differs from that used for livestock. California crop production is assumed to be largely dependent on U.S. demand, while livestock production (particularly dairy and poultry production) is assumed to be primarily dependent on California demand."[2]

The assumption that California crop production was dependent upon U.S. demand made it necessary to obtain projections of the U.S. output which would be required to meet estimated 1975 demands. "U.S. crop projections by Daley were taken as a point of departure in making California crop projections."[3] In translating this required U.S. output into terms of required California output, two alternative assumptions were made.

a. That California will produce the same share of total U.S. crop production in 1975 as its average annual share from 1954-1957;

b. That California will produce a changing share of total United States crop production over time, based on a projection of California's historical share of U.S. production.[4]

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1. Ibid., p. 5.
2. Loc. cit.
3. Ibid., p. 7.
4. Ibid., p. 10.

After establishing the necessary total California production of various crops needed to meet projected demands, this total production was combined with projected 1975 crop yields as estimated by crop production specialists to determine the needed acreage of individual crops. Past and current trends were analyzed to anticipate probable future shifts in location of crop production within the state.

Estimates of California livestock production in 1975 were derived on the basis of the output needed to meet projected 1975 state demand. It was assumed that the demand for fluid milk and eggs would be met by state production. An estimation of the total state output of turkeys, broilers, beef cattle, sheep, and hogs was made on the basis of past trends and future prospects. Per unit production of these livestock and poultry classes was projected to 1975 by livestock production specialists. A combination of per unit and total production figures provided an estimate of the 1975 livestock and poultry numbers needed to supply the projected demand. Aggregate livestock feed needs for California in 1975 were estimated from projections of per unit feed requirements. Integration of the crop and livestock projections thus derived provides an estimate of the 1975 California feed-livestock balance and gives a basis of comparison between the implied resource requirements and California's projected 1975 land and water resource base.[1]

Bonnen and Witt, discussing the production potential of American Agriculture, project an agricultural production model to 1965.[2] The determination of 1965 crop yields and livestock efficiency was based on a subjective analysis of factors which were expected to contribute to yield and efficiency increases for each crop and livestock class. Using 1955 as a base year, the percent increase in crop

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1. Ibid., p. 11.

2. James Bonnen and Lawrence Witt, "What is American Agriculture Geared to Produce," Proceedings, Sixth National Institute of Animal Agriculture, Purdue University, April 19-20, 1956. pp. 49-63.

and livestock per unit yields by 1965 was estimated on the basis of the expected contributing factors. The 1965 crop yields thus derived were applied to the 1955 land use pattern to establish an estimated 1965 crop and forage production figure.

Given the estimated 1965 crop production, the next step was to estimate livestock production. Two alternative assumptions were used. The first estimation was based on the assumption that excess acreage[1] would be limited, by effective production controls, to non-livestock uses. Under this assumption, estimates of livestock production were made with 1955 and probable 1965 levels of feed utilization efficiency.

The second estimation by Bonnen and Witt involved the assumption of no production controls. This meant that production from excess feed grain acreage (estimated at 20 million acres) would be channeled into the livestock industry. In this projection livestock production estimates were calculated at both a "probable" level of 1965 feeding efficiency and also at a "maximum" feeding efficiency level, thought to be possible under conditions of optimum management.

In a U.S.D.A. study appraising the production potential for wheat, feed, and livestock in 1965, recent changes and trends are considered a guide for estimating production prospects "because the forces that have been responsible for the recent increases in these products still seem to have unexpended power."[2]

Year by year yield projections were made for the period 1960-65 on the basis of specific assumptions concerning cost-price relationships, agricultural programs,

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1. Op. cit., p. 57. Excess acreage was derived as the difference between the crop acreages on the basis of the 1955 land use pattern and the acreage necessary to provide for normal 1965 consumption given expected yield increases. Normal 1965 consumption was defined as "1953 per capita consumption, plus or minus evident trends, multiplied by the 1965 Census estimate of population."

2. Raymond P. Christensen, Sherman E. Johnson, and Ross V. Bauman, Production Prospects for Wheat, Feed, and Livestock 1960-65, ARS 43-115, p. 10.

cropping pattern, weather, and management and cultural practices. Wheat yields were projected to continue increasing at the long term rate of 0.3 bushel per year. Feed grain yields were expected to continue increasing under the influence of heavier fertilization, continued improvement in hybrids and varieties, and use of better practices in weed control, planting rates, and tillage.[1]

Consideration of roughage production indicated a gradual upward trend in yields over the past few years for both hay and pasture which was expected to continue through 1965.

Projections of livestock production trends were made under two alternative assumptions.[2] An "A" projection served to indicate the livestock numbers which would provide animal products at the 1959 level of per capita consumption, thus being geared to the anticipated population expansion.

The "B" projection was designed to reflect the number of livestock that could be maintained if total 1960-65 feed production were utilized by livestock and poultry. Wheat supplies in excess of exports and human domestic consumption were assumed to enter the feed supply. An expansion of cow and calf numbers to 110 million with dairy cattle and poultry numbers remaining at the same level as in the "A" projection was also assumed. The specific utilization of feed production under the "B" projection was outlined as follows:

1. Dairy cattle and poultry would use sufficient feed to produce enough dairy products, eggs, and poultry meats to maintain 1959 per capita consumption levels;

2. Sufficient feed would be provided to increase total cattle numbers to 110 million through 1965;

3. The residual quantity of concentrates would be fed to hogs.[3]

It is interesting to note that this projection would increase the per capita U.S. supply of red meats 23.5 pounds by 1965.

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1. Ibid., p. 26.
2. Ibid., p. 35.
3. Ibid., p. 39.

In another U.S.D.A. report Rogers and Barton made estimates of potential per acre yield increases of specific crops by 1975 taking into consideration contributions to yield increases brought about by such factors as improved varieties, "better use of more efficient insect controls, increased inputs of fertilizer and irrigation water, and fuller utilization of presently known good management practices."[1] The projections were made within the framework of the following specific assumptions.[2]

1. Yield estimates for 1975 are based on technology presently known by researchers or almost certainly expected to be available to farmers by 1975.

2. The 1951-53 price level and price relationships between agricultural and other commodities.

3. Average weather.

4. The 1951-53 cropping patterns for distribution of crops by land class and between states, geographic regions and so on.

The 1975 yield projections were made in a series of meetings held with natural scientists of the ARS. Supporting tabulations such as "historical yields, yield potentials developed in other studies, the extent of irrigation of crops, and the geographic distribution of crop acreage and production" were discussed and evaluated as background material.[3]

The yield estimates were originally developed from state estimates. These were later reappraised on a national basis only.[4] It was felt the major assumption made was that assuming yield increases on the basis of known technology only. No formal mathematical estimating equation was used.[5]

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1. Robert O. Rogers and Glen T. Barton, <u>Our Farm Production Potential, 1975</u>, Agricultural Information Bul. No. 233.
2. <u>Ibid</u>., p. 4.
3. <u>Loc. cit</u>.
4. Donald D. Durost, letter to author, March 6, 1961.
5. <u>Loc. cit</u>.

PROCEDURE AND METHODOLOGY

In order to present a more comprehensive picture of probable 1975 livestock feed production it was originally decided to develop four probable production models. These were conceived to be based upon various combinations of alternative yield estimates and acreage projections. The alternative 1975 yield estimates were stated as (1) a "probable projected" yield which was defined as that yield level which might, on the average, reasonably be obtained by farmers in any given crop reporting district in an average year, 1975, assuming a "normal" development of those factors affecting crop yields; and (2) an "optimum projected" yield, defined as that yield level which might, on the average, reasonably be obtained by farmers in any given crop reporting district in an average year, 1975, assuming an "optimum" development of those factors affecting crop yields. The alternative 1975 harvested acreage estimates were defined as (1) 1975 harvested crop acreage assumed to remain at its "present" level,[1] and (2) "projected" 1975 harvested crop acreage assumed to reflect those shifts which could be anticipated to occur under the impact of relative cost-price relationships, demand, farmer preference, crop adaptability, government programs, and other influencing factors.

Thus the estimates of 1975 Kansas livestock feed production were outlined as follows.

Model I - "Probable projected" yield and "present" acreage.

Model II - "Optimum projected" yield and "present" acreage.

Model III - "Probable projected" yield and "projected" acreage.

Model IV - "Optimum projected" yield and "projected" acreage.

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1. Defined as an average of the years 1957, 1958, and 1959.

Due to the limitations of inadequate data and insufficient time, it was impossible to develop the latter two models in this thesis.

Yield Estimates

Dryland Yields. The procedure followed in developing estimates of probable 1975 dryland yields combined the use of quantitative and qualitative methods.[1] The basic yield information was obtained from State Board of Agriculture data.[2]

It was necessary to effect minor revisions in the crop reporting district yield data for certain years.[3] These revised yields were then plotted on a graph showing yield on the Y axis and time on the X axis. This process was followed for the four feed grains, wheat, and the four forage crops in each crop reporting district. The time period used was 1941-1959. After plotting historical yields a linear regression trend line of yield on time was computed to detect any observable trend in yields. A projection of the trend lines to 1975 gave an estimated 1975 yield for each crop in each crop reporting district.

Next a "probable present" yield for each crop was computed based upon an average of current empirical data designed to reflect yields presently attainable by farmers in a given crop reporting district utilizing average methods and with normal weather.[4] In order to provide "guide lines" in determining 1975 yield levels flat increases of 10 and 25 percent above the hypothetical present yields were computed.

The last step in the determination of probable 1975 crop yields based on "normal" and "optimum" developments consisted of a series of interviews by the author with crop scientists. A total of 20 interviews were held with 17 crop

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1. See Dean, op. cit., p. 3.
2. Farm Facts, 1941-1959, op. cit.
3. See Appendix I.
4. Farm Facts, 1955-1958, op. cit.

scientists and agricultural research workers. These included eight crop scientists, one soil scientist, one plant pathologist, three entomologists, one irrigation engineer, and three agricultural economists. In these interviews consideration was given to historical trends, projections, and those factors which each individual felt would exert an influence upon the probable level of 1975 crop yields. In addition, letters were sent to 19 crop scientists and plant breeders at branch experiment stations and experimental fields in every crop reporting district in the state except the east central. These letters requested information regarding prospects for crop yield increases in their particular area by 1975. Replies from these sources provided additional data for estimating yields in each crop reporting district. Final estimates were based upon a combination and integration of information from all the above sources.

Irrigated Yields. Historical data on irrigated yields was obtained from a number of sources.[1] Where possible comparable irrigated and dryland data was obtained. These comparable yields were compiled from each available source, and the irrigated yield was divided by the dryland yield for each year. The resulting yearly irrigated yield "factors" were then averaged together for each source of data to give an "average factor" for each location based upon the

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1. "Kansas Corn Tests, 1957-1960," Kans. Agr. Expt. Sta. Buls. 397, 404, 419, 432. "Kansas Grain Sorghum Performance Tests, 1957-1960," Kans. Agr. Expt. Sta. Buls. 398, 403, 420, 435. Farm Facts, 1958-1960, op. cit. Merton L. Otto and Wilfred H. Pine, Sprinkler Irrigation Costs and Returns, South Central Kansas, Kans. Agr. Expt. Sta. Bul. 381, August, 1956. Annual Reports on Irrigation Development Farms, Kansas, 1952-1960, Kansas State University, Extension Service. "Experiment Station Results with Fall-Seeded Wheat, Barley, Oats, 1954-1960," Kans. Agr. Expt. Sta. Circulars 314, 329, 343, 354, 366, 373, 379. Robert J. Raney and Harry Manges, Results from the Concordia, Kansas, Irrigation Experiment Field, 1953-1957, Kans. Agr. Expt. Sta. Bul. 421, April, 1960. A. L. Clapp, Experiment Station Results with Varieties of Sorghums, Sudangrass, Soybeans, 1954-1958, Kans. Agr. Expt. Sta. Reports of Progress 14, 17, 20, 23, 31. Andrew B. Erhart, Walter R. Meyer, and Ben L. Grover, Irrigation in Western Kansas, Kans. Agr. Expt. Sta. Circular 324, May, 1958. Kansas Farm Management Summary and Analysis Reports, 1955-1960, Kansas State University, Extension Service.

number of years for which comparable data was available from that source. Next "average factors" from each source of data within a given crop reporting district were averaged together to give an "aggregate average factor" for that crop reporting district. These "aggregate average factors" then were multiplied times the "probable present" dryland yields to compute a "probable present" irrigated yield for each crop reporting district. Computed "present" irrigated yields were compared with actual yields being obtained under farm conditions to check their validity.

Beyond this point the procedure in determining irrigated yields followed the same pattern as for dryland yields. Ten percent and 25 percent increases over "present" yields were computed as guide lines. Final estimates of 1975 irrigated yields under "normal" and "optimum" levels of development were made in cooperation with crop scientists.

Acreage Estimates

Dryland Acreage. Historical dryland acreage was obtained from State Board of Agriculture Reports and revised when necessary.[1] An assumed 1975 harvested acreage pattern based upon an average of 1957-59 acreages was computed. A "projected" 1975 acreage was not determined due to lack of time and inadequate data.

Irrigated Acreage. A projected 1975 irrigated acreage for Kansas was obtained from the Kansas Water Resources Board.[2] This projection was made on an area basis of 12 watershed units in the state. To derive the projected acreages in terms of crop reporting districts the following steps were taken. First, counties totally or partially within each watershed unit were arrayed. The acreage of each county which was located in a particular watershed was then entered in a column headed by the crop reporting district in which the county was also located. The summation of the various county acreages falling in each crop

1. Farm Facts, op. cit. Also, see Appendix I and Appendix Tables 21 - 38.
2. W. E. Steps, Personal Communication, April 6, 1961.

reporting district column gave the acreage of each watershed which was located within each crop reporting district. Dividing these acreages by the total watershed unit acreage gave the proportion or percent of each watershed district which lay within a particular crop reporting district. Multiplying these percentage figures times the 1975 projected irrigated acreage for each watershed unit gave the proportion of that watershed's projected 1975 irrigated acreage which lay within a particular crop reporting district. Summation of these proportions from each watershed which lay partially or completely within a crop reporting district gave a 1975 projected irrigated acreage figure for each crop reporting district.

Determination of irrigated cropping patterns was based on data supplied by County Agents Annual Reports, in which estimates of irrigated acreages were given, by crop, for each county.[1] The percent of the total irrigated acreage occupied by each crop in each crop reporting district was computed. An average of the percentage for the period 1958-1960 was used as the basis for determining the assumed 1975 irrigated cropping pattern. As in the case of dryland acres, limitations of time and data prevented determination of "projected" 1975 irrigated cropping pattern.

Statistical Methods

Statistical analysis related mainly to the linear regression trend line projections of crop yields.

Simple regression and correlation analysis involving the standard estimating equation of $Y = a + bX$ was used.[2] Coefficients of determination (r^2) and

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1. County Agents Annual Reports, Unpublished, Kansas State University, Manhattan, 1954-1960.
2. Morris M. Blaird, Elementary Statistics, p. 176.

correlation (r) were computed. Level of significance of b and r values was determined by use of standard t-tests.[1]

GENERAL ASSUMPTIONS

In any scientific study there are always those factors which, although related and relevant, cannot profitably be given a detailed consideration. These may be broad general classifications, of political, economic, or climatic nature, falling outside the scope of the study but which must be held in some constant or known framework in relation to the study in order that the results will be valid. Or they may be more specific classifications, well within the scope of the study, which are of such an indeterminate nature as to render analysis ineffective or which it is desired to hold constant under an assumption for purposes of comparison. In this study, the following framework of general assumptions was established in order that various relationships of the above nature might be set forth in more incisive terms.

(1) The world political situation will continue in various temperature stages of the cold war. There will be no widespread armed conflict and the state of U.S. military preparedness will remain at a same or moderately higher relative position.

(2) The general economic tone of the nation was assumed to be healthy with no dangerous deflationary or inflationary trend in progress.

(3) Employment was expected to be at a level in keeping with a healthy economy, with consumption consistent with present population and per capita consumption trends.

(4) Strong private and government action will continue in disposing of farm commodities produced in excess of domestic consumption needs.

(5) Average weather conditions were assumed. The concept of average weather is less meaningful in Kansas than in areas of more stable weather patterns. However, it may be thought of as a "normal" level of rainfall, soil moisture, temperature, and related factors, i.e., no severe drouth or unusually abundant moisture.

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1. George W. Snedecor, Statistical Methods.

(6) It was assumed that price-cost relationships will remain at approximately their 1960 level.

(7) Attainment of the projected physical production levels will remain consistent with marginal analysis.

(8) Ground and surface supplies of irrigation water will be adequate to fulfill requirements of the 1975 projected irrigated crop acreage.

(9) A continued gradual reduction in the number of farms and farm workers with resulting larger units was assumed.

(10) In Models I and II it was assumed that harvested crop acreage and cropping patterns would remain consistent with 1957-1959 average levels. This reflects a period of restricted wheat production and expanded feed grain production.

(11) In Models III and IV (not developed) it was assumed conservation reserve land would remain out of production through 1975, wheat acreage would be restricted to that needed to produce Kansas' share of projected domestic and export wheat needs, and remaining crops would be allocated according to relative profitability, adaptability, preference, past trends, and expected shifts.

POTENTIAL IRRIGATION DEVELOPMENT IN KANSAS

Preface

Perhaps the most important one factor in the procreation and prolongation of life, both plant and animal, is water. Not only is it the largest single constituent of nearly all living plant or animal tissues, but it also performs exceedingly important functions.[1] The recognition by early peoples of their dependance upon water is clearly reflected in development patterns of young civilizations. These settlements first were established in river valleys and later extended primarily along coast lines and river banks.[2]

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1. Frank B. Morrison, Feeds and Feeding: a Handbook for the Student and Stockman, 22nd ed., Unabridged, p. 2.
2. Richard Pfister, "Water Resources and Irrigation," Economic Development in Southwestern Kansas, Part IV, p. 1.

Wherever man has attempted a transition from a wandering or nomadic type of existence to a settled culture he has been confronted with the problem of deriving a sustained food supply for himself and his livestock from a static land area. This problem has been particularly acute in regions of limited rainfall, the sub-humid, semi-arid, and arid areas of the world.[1] Indeed this factor has oft-times precluded or at best grossly delayed the establishment of a settled culture as attested by present day nomadic tribes in arid regions of northern Africa and the wandering Indians of the early North American plains. Historically the agricultural development of such regions has taken place commensurate with and dependent upon the discovery and development of satisfactory methods of artificially applying water to the land, i.e., irrigation. The centuries old establishment of this practice in such places as the Nile and Tigris-Euphrates Valleys is well known.[2] Nor has interest in irrigation been lacking in more humid regions of the world, as evidenced by Boswell writing in England in 1790: "Flooding is truly the best of all improvements where it can be effected; and there ought not to be a single acre of land neglected which is capable of it."[3]

The advent of irrigation development in North America long preceded the coming of the white man. Mead indicates that:

> Irrigation on the American continent is older than historical records. In various parts of the southwest, notably in the Salt River Valley of Arizona, in northern New Mexico, and in southwestern Colorado, are well-defined remains of irrigation works which have outlived by many centuries the civilization to which they belonged. Even modern irrigation is comparatively old. It began seventy years before the English colony landed at Jamestown, when Spanish missionaries gained an enduring foothold in the valley of the Rio Grande. They built churches which still stand and planted gardens which still flourish; but in watering these gardens they taught nothing new to the native inhabitants. The Spanish explorers, who rode up the valley of this river in the first

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1. See Walter Prescott Webb, The Great Plains, p. 323.
2. Webb, op. cit., p. 332.
3. George Boswell, A Treatise on Watering Meadows, p. i.

half of the sixteenth century, found Pueblo Indians irrigating the thirsty soil as their forefathers had done for centuries before them, and as their descendants are still doing.[1]

The beginnings of Anglo-Saxon irrigation in the United States are to be found in the Salt Lake Valley of Utah, where, in July, 1847, the Mormon pioneers first turned the clear waters of City Creek upon the sun-baked and alkaline soil.[2] Some 20 years later the establishment of a New England settlement of what is now Greeley, Colorado, introduced the institution of irrigation to the Colorado plains. The success of this undertaking was instrumental in inspiring an impulse which resulted in the reclamation and settlement of northern Colorado.[3] Subsequently, through the years the development of irrigation throughout the arid plains and west has progressed. In the high plains from Texas to the Dakotas, in the range states, the Northwest, the Southwest, California, all have searched for the life giving water. And where it has been found, whether from a privately developed well or a government sponsored reservoir, it has brought a promise of a brighter future, a better life.

But the water problem of the Great Plains was and is painfully simple. There is not enough to go around. As Walter Prescott Webb so aptly expressed it:

> In the Scriptures we read that Jesus went into a 'desert place' and was followed by a multitude. There was no food save five loaves and two fishes. The amount was sufficient for the first few, but it took a miracle to make it go around. So it is with water in the Great Plains: there is a little water, which is very profitable to the first few; but there is not enough to go round, not enough for the multitude, and as yet science has not been able to perform the miracle that was performed with the loaves and fishes. Nor does science promise to do so.[4]

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1. Elwood Mead, Irrigation Institutions, p. 41.
2. Ibid., p. 42.
3. Ibid., p. 45.
4. Webb, op. cit., p. 323.

So wrote Webb of irrigation development in the Great Plains in 1931. The intervening three decades have seen developments and expansion in irrigation which, while perhaps not miraculous, have far outreached the expectations for them. Be that as it may, the purpose of this section on irrigation is to (1) examine the past development and present status of irrigation in a particular segment of the Great Plains, semiarid to sub-humid Kansas, and (2) investigate the potential for further expansion in the application of fixed and limited water resources to land, in Kansas over the next decade and a half, be this expansion miraculous or otherwise.

The most important variant in the climate of Kansas is rainfall. In terms of long-time averages, annual precipitation in the state increases quite uniformly from west to east. The three western crop reporting districts range in annual precipitation from 16 inches along the western edges of Wallace, Greeley, and Hamilton counties to 22 inches along their eastern edges. The range for the crop reporting districts in the central portion of the state varies from 22 inches at their western boundaries to 28, 30, and 32 inches along the eastern borders of the north central, central, and south central crop reporting districts respectively. For the eastern third of the state rainfall amounts along its west side correspond to amounts for the eastern edge of central Kansas while precipitation along the eastern border of Kansas varies from 32 inches at the northeast corner through 38 inches in Miami county midway along the east side to 42 inches at the eastmost periphery of Crawford county near the southeast corner of the state.

In addition to the gradual gradations in long-time average annual precipitation which transverse the state from west to east, rainfall patterns are characterized by yearly fluctuation above and below the mean, for any given area or location. Historically these deviations have followed more or less definable patterns of fluctuation. That is, generally speaking precipitation patterns tend to follow approximately an 11-year pattern between the high and low rainfall points of a 22-23 year weather cycle.[1] It is important to point out, however, that many exceptions to this generalization exist, with a below normal rainfall year likely to occur during a wet phase of the cycle and vice versa. Also there is considerable variation as to length and intensity of cycles.

Consideration of the long time precipitation averages for various regions of the state indicate that in general the western one-third falls in a semiarid rainfall belt of 10-20 inches per year.[2] The central portion of the state may be broadly classified as sub-humid with a 20-30 inch rainfall range, while the eastern one-third of the state may be considered as humid with generally above 30 inches average annual rainfall. These facts coupled with the previously mentioned cyclical nature of year to year moisture supplies points up the role which, given a suitable supply of water and irrigable land, irrigation might play in increasing livestock feed production in Kansas.

Early beginnings of irrigation in Kansas, of any significant proportions, appear to have occurred around 1880. An irrigation company was organized in 1879 at Garden City for the purpose of constructing an irrigation canal which would divert water from the Arkansas River onto nearby farm lands. A four-mile canal constructed in 1880 served water to about 100 acres with good results. This project initiated a boom period in the construction of irrigation ditches with which to appropriate water from the Arkansas River for irrigation purposes. This activity lasted until after the turn of the century and saw as many as 12 to 15 or more large irrigation ditches constructed at various times. This early "splurge" of development, proceeding without regulation or systematic allocation

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1. See: "Droughts Don't Last Forever," Scientific American, 156:135-136, February, 1937. Also see: "Four Years of Drought and More to Come," U.S. News and World Report, 37:68-70, August, 1954.
2. Webb, op. cit., p. 323.

of available water, could only culminate in one thing, over-expansion. As a result the projects generally were dismal failures, both financially and agronomically.[1]

At the same time similar type developments were occurring in northwestern Kansas. As early as 1880, plans were made for construction of a 25-mile long irrigation ditch designed to service 25,000 acres with water diverted from the South Fork Republican River near the Colorado-Kansas state line. This project was never completed although irrigation water was provided to 3,000 acres in 1894. By 1908 Cheyenne county alone had eight irrigation ditches in use. However, problems and difficulties concerned with lack of dependable surface water supplies and inadequate pump and power units for securing ground water largely limited these early projects to small acreages and often short durations.[2]

Beginning in 1889 census data was collected pertaining to irrigation in Kansas. Figures for that year indicate a total of 20,818 acres watered in the state, over 90 percent of which was located in the southwest crop reporting district. A slow but persistent expansion in irrigation has occurred since the turn of the century with census data reporting 23,620 acres in 1899, 37,479 acres in 1909, 47,312 acres in 1919, 71,290 acres in 1929, 99,980 acres in 1939, and 140,992 acres in 1949.[3] During this period the highest proportion of acreage remained in the southwest crop reporting district. The percentage figure ranged from 93 in 1909 down to 69 by 1949.[4] Of lesser importance in western Kansas in terms of acres irrigated has been the west central crop reporting district. Its proportionate share of the state total has grown, however, from 6.5 percent in 1919 to over 20 percent in 1949, most of which was located in Scott county.

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1. See Pfister, op. cit., pp. 48-61.
2. See State Water Plan Studies, Part A: Preliminary Appraisal of Kansas Water Problems. Section 6. Upper Republican Unit. Kansas Water Resources Board, Kansas, June, 1960.
3. Pfister, op. cit., p. 63.
4. Ibid.

Since 1939, somewhat significant developments in irrigation have occurred in the south central crop reporting district, with 4,174 irrigated acres reported in 1949, or 3 percent of the state total.[1] The 10 to 15 percent remaining balance of irrigated acres in Kansas has historically been distributed mainly throughout the northwest, north central, and central crop reporting districts.

As implied in the foregoing discussion, embryonic beginnings of irrigation in Kansas were concentrated along the "big ditches" in southwestern Kansas. Census data in 1909 indicated 95 percent of irrigation water in the state was obtained from surface supplies.[2] Realization of the unreliable nature of stream flows in the state (particularly in the west) coupled with improved techniques in well drilling and efficiency of pumps and power units provided the setting for expansion in ground water irrigation development. This occurred at first in shallow water areas such as river plain alluvium and the Scott-Finney depression. Later the expansion was extended to upland deep water areas. By 1957, it was estimated that 80 percent of irrigation water used in Kansas was obtained from irrigation wells.[3]

The preceding review of irrigation development in Kansas has focused mainly on the time between 1889 and 1949. In this 60-year period, the state witnessed a seven-fold expansion in irrigated acreage. A gradual advancement had been made from the river valleys of western Kansas, onto the uplands of the same region, thence penetrating into the humid eastern third of the state, as periodic dry spells stimulated interest in supplemental irrigation. Then suddenly, like a sleeping giant wakened from long hibernation, the expansion in irrigation began to snowball during the decade of the fifties. By 1954 every county in the

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1. Glenn H. Miller, Jr., Mineral and Water Resources, The University of Kansas, Center for Research in Business, June, 1959.

2. Pfister, op. cit., p. 69.

3. Russel Herpich and R. D. McKinney, Irrigation Farming for Profit. Kans. Agr. Expt. Sta. Circular 372, p. 6.

state reported cropland watered.[1] From 1949 to 1959 irrigated acres expanded from 140,992 to 1,017,000. That grain sorghums, forage sorghums, alfalfa, and corn hold the number 1, 3, 4, and 5 positions respectively, in crop acres irrigated, occupying nearly 75 percent of irrigated cropland in the state is precisely indicative of the great impact which recent expansions in irrigation have had upon livestock feed production.[2] In 1960 over half the 30,400,000 bushels of grain sorghums produced in the southwest crop reporting district were grown on irrigated land.[3]

Allusion to an earlier illustration pertaining to the limited extent of available irrigation water resources in the Great Plains area raises the question, to what extent are ground and surface water resources in Kansas adequate to meet continued expansion in acres watered and/or maintain the present level of irrigation development? Since water resources without land on which to apply them are next to worthless in terms of irrigation usage, a further question is raised. Given a supply of water, will it be geographically and geologically situated so as to permit economically rewarding application to a land area which is suitable in terms of structure, topography, and capability? And even granting an optimal or at least satisfactory water-land supply and relationship the further question arises relevant to the problem of future production potentials of livestock feed supplies with which this paper is concerned, just what is the probability that a given irrigation potential will be developed by 1975?

These questions point out the three-fold nature of the problem confronted in this section. That is (1) to examine the extent and nature of available ground and surface water supplies, (2) to examine the geographical relationship between suitable water and land irrigation resources, and (3) to investigate the

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1. Ibid., p. 4.
2. Herpich, op. cit., p. 25.
3. Farm Facts, 1961, op. cit., p. 39.

probability for development and utilization of these existing resources by 1975, particularly in terms of the impact which such development would exert upon livestock feed production. The problem thus defined will form the basis of discussion in the following pages where attention will be directed toward the development potential of ground water, surface water, and land resources for irrigation purposes in each crop reporting district.

The analysis will be in terms of a review and assimilation of available published and unpublished data and reports rather than the development of original research. The reason for this is two-fold. First, this study is basically oriented toward problems of livestock marketing as they might be affected by increased livestock feed production, rather than toward a production economics, land economics, or farm management study. Therefore, it was felt justifiable and advisable to fully utilize the results of previous work rather than to develop new research. Second, a vast array of widely variant studies have been made by various agencies related or pertaining to irrigation development in Kansas. Unfortunately, however, many of the projects have covered only a limited area of the state. Others, more comprehensive in nature, have either been developed over extended periods of time or else have buried a few short paragraphs on irrigation within a mass of other material. Still other relevant data has received practically no dissemination. Thus, it is felt the current situation justifies the development of a concise and systematic presentation of potential irrigation water and land resource uses in Kansas, by crop reporting districts, for the next decade and a half. If this purpose is realized, it is felt the efforts involved will not have been in vain, thus justifying this section on the basis of its own merit, above and apart from the obviously important role which it fulfills within the structural framework of the total paper.

Northwest Crop Reporting District

Physical Soil Characteristics.[1] The soils of this district are more uniform than for other areas of the state. Three broad soil associations have been defined by Bidwell, in addition to a group of alluvial soils which occur in narrow belts on the bottom and terrace lands of the stream valleys. Approximately the western three-fourths of the district consists of Keith and Colby soils. These grayish brown and dark grayish brown silt loam soils occur on undulating to nearly level relief. The Keith soil is considered to be well adapted to irrigation.

The eastern end of the district, mainly in Norton and Graham counties, consists largely of Hastings and Holdrege silt loam soils. These soils, occurring on undulating to nearly level relief, are similar to those to the west except for generally darker color and greater depth of development. More sloping lands in this area are occupied by the shallower Colby silt loam soil. This soil, with moderately permeable surface and subsoil layers, is quite subject to runoff and water erosion.

The third major soil area in this district consists of Canyon soils. These light grayish brown stony and gravelly loam and silt loam soils occur on moderately steep to very steep relief. Except for minor level divides, they should be devoted to native grasses. The occurrence of this soil area in the northwest district is limited to the southern edge of Sherman county.

The bottom and terrace soils are quite variable in characteristics. Some are sandy while others are clayey and impermeable. However, generally they are deep, friable, silt loam soils of high productivity.

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1. Based on O. W. Bidwell, Major Soils of Kansas, Kans. Agr. Expt. Sta. Circular 336, July, 1956.

In terms of irrigable lands it has been estimated that 2,422,000 acres in the northwest crop reporting district are physically suited to irrigation (see Table 1, Fig. 2). This estimate is based on physical characteristics such as texture, slope, depth, and structure. Approximately 239,600 acres of bottom and terrace land and 859,000 acres of upland, all with less than 2 percent slope are considered irrigable. The remaining 1,323,300 acres, mostly upland, are suitable for irrigation but have slopes of 2 to 5 percent.

Potential Water Supplies. Surface water. Three potential Bureau of Reclamation irrigation projects utilizing surface water supplies are located within the Northwest crop reporting district. The first of these is the Nelson Buck unit located on Beaver Creek in Decatur county.[1] This multipurpose project is designed to provide flood control and irrigation in Kansas and Nebraska. Construction of a Herdon reservoir as illustrated in Fig. 3 is tentatively planned for one mile west of Cedar Bluffs, Kansas. Preliminary reports indicate approximately 2,000 acres of valley land may be irrigated below the dam site.[2] Of this acreage, one-half would be in Kansas and one-half in Nebraska. Most of the acreage lies on the north side of the stream. Indicated storage capacity includes 12,000 acre feet for irrigation purposes. Additional information is indicated in Table 2.

A second potential surface water irrigation development in this district is the Oberlin unit. This is a multipurpose project designed for irrigation and flood control. Plans presented in this paper are based on reconnaissance data.[3] The location for construction is tentatively planned for three miles southwest of Oberlin, Kansas, on Sappa Creek. Irrigation facilities for this project would

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1. Kansas River Basin, Colorado-Nebraska-Kansas, U.S. Dept. of the Interior, Bureau of Reclamation, Region 7, Denver. Missouri River Basin Project Report, p. 67.
2. Ibid., p. 68.
3. Loc. cit.

Table 1. Location of physically irrigable lands (according to texture, slope, depth, and structure) in relation to underground water supplies, by crop reporting district.[a]

Crop reporting district	Land with suitable texture, structure, depth and slope, less than 2 percent		Suitable for irrigation except 2-5 % slope mostly upland	Total land with physical characteristics suitable for irrigation	Physically irrigable lands overlying saturated tertiary & quarternary sands and gravels over 60 ft. thick	Projected irrigated acreage 1975[e]
	Bottom and terrace land	Upland				
Northwest	239,600	859,000	1,323,300	2,422,000	1,298,750	95,700
West Central	287,000	847,100	732,500	1,866,750	602,900	226,900
Southwest	243,100	2,660,700	1,274,300	4,178,100	2,457,500	874,000
North Central	551,050	525,900	1,177,400	2,254,300	324,250	157,000
Central	423,200	669,400	631,700	1,724,200	522,600	134,400
South Central	794,400	777,600	156,500	1,728,400	1,163,100	191,700
Northeast	593,700	19,600	972,800	1,586,200	152,100[d]	77,800
East Central	627,050	13,800[b]	359,500	1,000,250	53,500[c]	54,600
Southeast	714,700	7,200[b]	-	721,900	13,300[c]	20,300
State totals	4,473,800	6,380,300	6,628,000	17,482,100	6,588,000	1,832,400

a. Acreage figures for crop reporting districts derived from similar data for Kansas watershed units, provided by Kansas Water Resources Board, Topeka, Kansas, personal communication.

b. Reconnaissance surveys indicate only a few small tracts of upland suitable for irrigation.

c. Due to limited extent of occurrence of water-bearing aquifers, ground water irrigation development will be negligible.

d. Although the aquifer is not always 60 or more feet thick, the interchange between surface and ground water allows development on aquifer of less than 60 feet.

e. See Table 4.

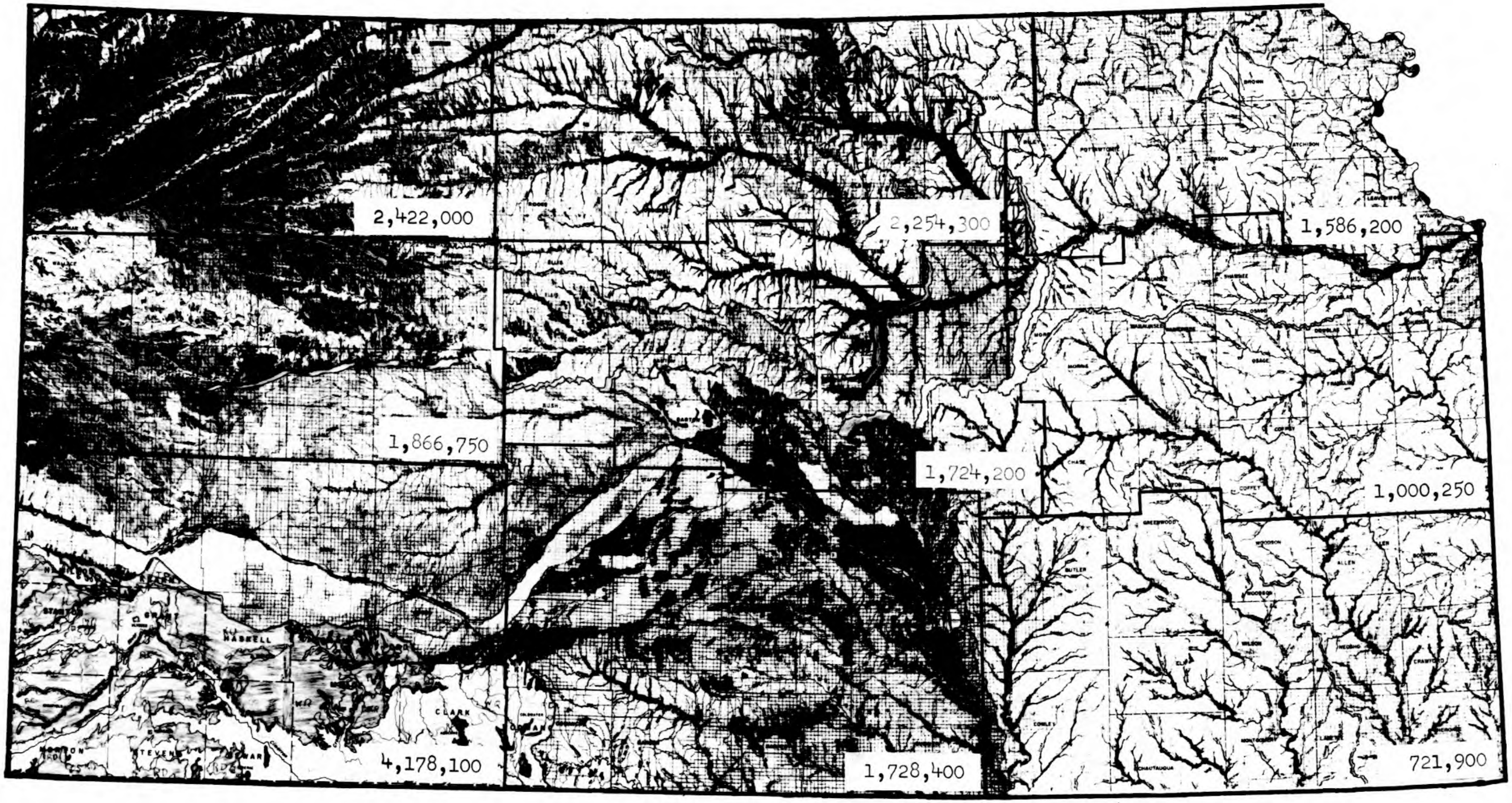

Fig. 2. Potentially irrigable lands, state of Kansas. Shaded areas indicate lands suitable for irrigation on basis of soil characteristics. Numbers indicate irrigable acreage within each crop reporting district. Source: KSU water resources committee.

serve approximately 1,500 acres of land below the dam although flood control would be the predominate feature. The general location of the project is indicated on Fig. 3. Allocation of 15,000 acre feet for irrigation storage out of a total probable storage capacity of 166,000 acre feet is indicated in Table 2.

The Almena unit is located on Prairie Dog Creek, in Norton county. This project was originally considered primarily for irrigation. However, the high relative cost of a single purpose unit coupled with the recent high frequency of flash floods led to the inclusion of flood control facilities. As generally indicated on Fig. 3, construction of Norton dam and reservoir is proposed for a site three miles above Norton, Kansas. Irrigation facilities would feature a diversion dam located approximately three miles southwest of Almena, Kansas. A canal and distribution system would originate at that point and extend to the vicinity of Long Island, Kansas. The 5,000 acres of arable land are located along both sides of the creek in a fairly narrow strip about ten miles long. Table 2 indicates a reservoir irrigation storage capacity of 24,000 acre feet.

Ground Water. A fairly substantial supply of ground water is available over most of this district. There are two major sources of occurrence. The more extensive of these is the Ogallala geological formation underlying much of the western two-thirds of the district. The other primary source of occurrence is the more shallow alluvium and terrace deposits in the stream valleys. At the present time about one-half of the total ground water pumped in this area is obtained from terrace and alluvium deposits and the other half from the Ogallala formation.[1]

In a study of the Upper Republican watershed unit, which covers approximately the northwest one-half of this district, there was estimated to be

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1. State Water Plan Studies, Section 6. Upper Republican Unit. p. 10, op. cit.

Table 2. Plan of development of surface water resources, state of Kansas, by crop reporting districts, which will contribute to irrigation development.[a]

Crop Reporting District, basin & division of unit	Location	Purpose[b]	Status	Acres to be irrigated			Reservoirs and allocated capacities (acre-feet)						
				New land	Supplemental	Total	Name	Stream	Total	Dead and inactive	Sediment	Irrigation	Flood control
							Kansas River Basin Projects						
Northwest Crop Reporting District													
Republican River Basin													
Nelson Buck Unit	Kan-Nebr	I.F.W.R.	Investigation	2,000	0	2,000	Herndon	Beaver Creek	247,000	-	15,000	12,000	220,000
Oberlin Unit	Kansas	I.F.W.R.	Investigation	1,500	0	1,500	Oberlin	Sappa Creek	166,000	-	16,000	15,000	135,000
Almena Unit	Kansas	I.F.W.R.	Authorized	5,000	0	5,000	Norton	Prairie Dog Creek	129,700	200	5,500	24,000	100,000
Sub-total Northwest Crop Reporting District				8,500	0	8,500			542,700	200	36,500	51,000	455,000
West Central Crop Reporting District													
Smoky Hill River Basin													
Cedar Bluff Unit[c]	Kansas	I.F.W.R.	Under const.	11,300	0	11,300	Cedar Bluff[d]	Smoky Hill River	377,000	12,200	13,000	159,900	191,900
Ellis Unit[c]	Kansas	I.F.W.R.	Investigation	5,000	0	5,000	Ellis	Big Creek	118,000	-	4,000	20,000	94,000
Sub-total West Central Crop Reporting District				16,300	0	16,300			495,000	12,200	17,000	179,900	285,900
North Central Crop Reporting District													
Smoky Hill River Basin													
Webster Unit	Kansas	I.F.W.R.	Under const.	8,500	0	8,500	Webster	So. Fk. Solomon River	271,700	3,200	8,000	60,500	200,000
Kirwin Unit	Kansas	I.F.W.R.	Under const.	11,500	0	11,500	Kirwin[d]	No. Fk. Solomon River	314,600	6,300	12,500	76,400	219,400
Glen Elder Unit	Kansas	I.F.W.R.	Authorized	10,000	0	10,000	Glen Elder	Solomon River	842,000	-	40,000	80,000	722,000
Republican River Basin													
Kansas Bosturick Division	Kansas	I.F.W.R.	Under const.	62,000	0	62,000	Lovewell	White Rock Creek	94,200	13,200	8,000	225,000	50,100
Sub-total North Central Crop Reporting District				92,000	0	92,000			1,522,500	22,700	68,500	239,800	1,191,500
Central Crop Reporting District													
Smoky Hill River Basin													
Wilson Unit	Kansas	I.F.W.R.	Authorized	2,200	0	2,200	Wilson[e]	Saline River	555,000	-	20,000	225,000	310,000
Kanopolis Unit	Kansas	I.F.W.R.	Authorized	41,000	0	41,000	Kanopolis[f]	Smoky Hill River	450,000	-	53,000	162,500	234,500
Gypsum Creek Unit	Kansas	I.F.W.R.	Investigation	10,000	0	10,000	Gypsum Ck.	Smoky Hill River	Not determined				
Sub-total Central Crop Reporting District				53,200	0	53,200			1,005,000		73,000	387,500	544,500
Northeast Crop Reporting District													
Kaw and Blue River Basins													
St. George Unit	Kansas	I.	Investigation	50,000	0	50,000	None	Kaw River	None				
Sub-total Northeast Crop Reporting District				50,000	0	50,000			-	-	-	-	-
Total Kansas River Basin Projects in Kansas				220,000	0	220,000			3,565,200	35,100	195,000	858,200	2,476,900

Table 2. (Continued)

Crop Reporting District, basin & division of unit	Location	Purpose[b]	Status	Acres to be irrigated: New land	Acres to be irrigated: Supplemental	Acres to be irrigated: Total	Reservoirs and allocated capacities (acre-feet): Name	Stream	Total	Dead and inactive	Sediment	Irrigation	Flood control
Arkansas-White-Red River Basin Projects													
Southwest Crop Reporting District													
Arkansas River Basin (Above Great Bend)													
Granada Irrigation Proj.	Colo-Kan	I.W.	Investigation	0	62,100	62,100	Granada	Arkansas River	30,000	3,000	-	-	-
Saracuse Reservoir	Hamilton Co.	I.F.	Investigation				Saracuse	Arkansas River	370,000			60,000	310,000
Ingalls Irrigation Pumping Project	Gray Finney Ford Co.	I.	Investigation	58,000	0	58,000[h]	--	--	24,000			24,000	
Cimarron River Basin													
Englewood Irrigation Project	Beaver Co. Oklahoma	I.F.	Investigation	6,500	0	6,500		Cimarron River	250,000	-	90,000	80,000	80,000
Sub-total Southwest Crop Reporting District				64,500	62,100	126,600			674,000	3,000	90,000	164,000	390,000
Central Crop Reporting District													
Grand (Neosho) River Basin													
Marion Reservoir		F.	Authorized	7,000	0	7,000		Cottonwood River	153,000	25,300	47,000	21,000	60,000
Cedar Point Reservoir		F.	Authorized	4,000	0	4,000		Cedar Creek	67,000	15,800	3,000	12,000	36,200
Sub-total Central Crop Reporting District				11,000	0	11,000			220,000	41,100	50,000	33,000	96,200
South Central Crop Reporting District													
Arkansas River Basin (Below Great Bend)													
Chikaskia Multiple-Purpose Plan:													
Corbin Reservoir	Sumner Co.	F.	Investigation	4,000	0	4,000	Corbin	Chikaskia River	132,000	44,600	87,400	-	-
Caldwell Reservoir	Sumner Co.	F.	Investigation			[g]	Caldwell	Bluff Creek	103,800	-	15,800	87,000	88,000
Kiowa Reservoir	Barber Co.	I.F.	Investigation	20,000	0	20,000[i]		Medicine Lodge R	307,000	-	82,000	87,000	138,000
Wichita Project:				11,000	0	11,000							
Cheney Reservoir	Sedgwick Co.	F.	Investigation				Cheney	No Fork Ninnescah R	242,800	162,300	-	-	80,500
Murdock Reservoir	Kingman Co.	F.	Investigation			[g]	Murdock	So Fork Ninnescah R	120,000	30,500	15,000	-	74,500
Conway Springs Reservoir	Sumner Co.	F.	Investigation				Conway Springs	Slate Creek	49,000	-	13,000	-	36,000
Sub-total South Central Crop Reporting District				35,000	0	35,000			954,600	237,400	213,200	87,000	417,000
East Central Crop Reporting District													
Grand (Neosho) River Basin													
Council Grove Reservoir	Morris Co.	F.	Authorized	4,900	0	4,900	Council Grove	Grand(Neosho) R	100,000	14,600	10,400	15,000	60,000
Straw Reservoir	Coffey Co.	F.	Authorized	10,500	0	10,500	Straw	Grand(Neosho) R	406,900	17,300	50,000	19,000	320,600
Sub-total East Central Crop Reporting District				15,400	0	15,400			506,900	31,900	60,400	34,000	380,600
Southeast Crop Reporting District													
Arkansas River Basin (Below Great Bend)													
Silverdale Reservoir	Cowley Co.	F.	Investigation				Silverdale	Silver Creek	33,000	-	8,000	-	25,000
Walnut River System:				11,400	0	11,400[g]							

Table 2. (Continued)

Crop Reporting District, basin & division of unit	Location	Purpose[b]	Status	Acres to be irrigated: New land	Acres to be irrigated: Supplemental	Acres to be irrigated: Total	Reservoirs and allocated capacities (acre-feet): Name	Stream	Total	Dead and inactive	Sediment	Irrigation	Flood control
						Arkansas-White-Red River Basin Projects							
El Dorado Reservoir	Butler Co.	I.F.	Investigation				El Dorado	Walnut River	108,000	-	4,000	15,000	89,000
Augusta Reservoir	Butler Co.	I.F.	Investigation				Augusta	Whitewater River	195,000	-	33,000	15,000	147,000
Wingate Reservoir	Cowley Co.	F.	Investigation				Wingate	Rock Creek	44,000	-	10,000	-	34,000
Douglas Reservoir	Butler Co.	F.	Investigation				Douglas	Little Walnut River	113,000	-	24,000	-	89,000
Verdigris River Basin													
Toronto Reservoir	Greenwood Co.	F.	Under constr.	600	0	600	Toronto[f]	Verdigris River	197,000	10,000	14,000	2,000	171,000
Neodesha Reservoir	Montgomery Co.	F.	Authorized	7,750	0	7,750	Neodesha	Verdigris River	93,000	-	10,000	3,000	80,000
Fall River Reservoir	Greenwood Co.	F.	Existing			[g]	Fall River[f]	Fall River	267,500	17,000	10,000	4,500	236,000
Elk City (Table Mound) Reservoir	Montgomery Co.	F.	Authorized			[g]	Elk City	Elk River	293,500	12,000	14,000	4,500	263,000
Sub-total Southeast Crop Reporting District				19,750	0	19,750			1,344,000	39,000	127,000	44,000	1,134,000
Total Arkansas-White-Red River Basin Projects in Kansas				145,650	62,100	207,750			3,699,500	352,400	540,600	362,000	2,417,800
Grand Total River Basin Projects in Kansas				365,650	62,100	427,750			7,264,700	387,500	735,600	1,220,200	4,894,700

a. Compiled from: Kansas River Basin, Colorado-Nebraska-Kansas, Missouri River Project, September 1956, p. 24; United States Department of the Interior, Bureau of Reclamation, Region 7, Denver, Colorado.

Development of Water and Land Resources of the Arkansas-White and Red River Basins, Senate Document No. 13, 85th Congress, 1957.

Personal communication M. G. Barclay, Area Engineer, Bureau of Reclamation, Oklahoma City, Oklahoma, February 17, 1961.

b. Code for purposes: I--Irrigation
F--Flood control
W--Fish and wildlife
R--Recreation

c. Storage structures located in West Central Crop Reporting District, but majority of irrigable lands located in Central Crop Reporting District.

d. Constructed by Bureau of Reclamation.

e. Authority for construction of Wilson Reservoir transferred to the Corps of Engineers from the Bureau of Reclamation on May 2, 1956.

f. Constructed by Corps of Engineers.

g. These projects have no planned irrigation development but flood control protection provided to agricultural lands downstream is expected to encourage private irrigation.

h. Part of Granada acreage.

i. Some of land is in Oklahoma.

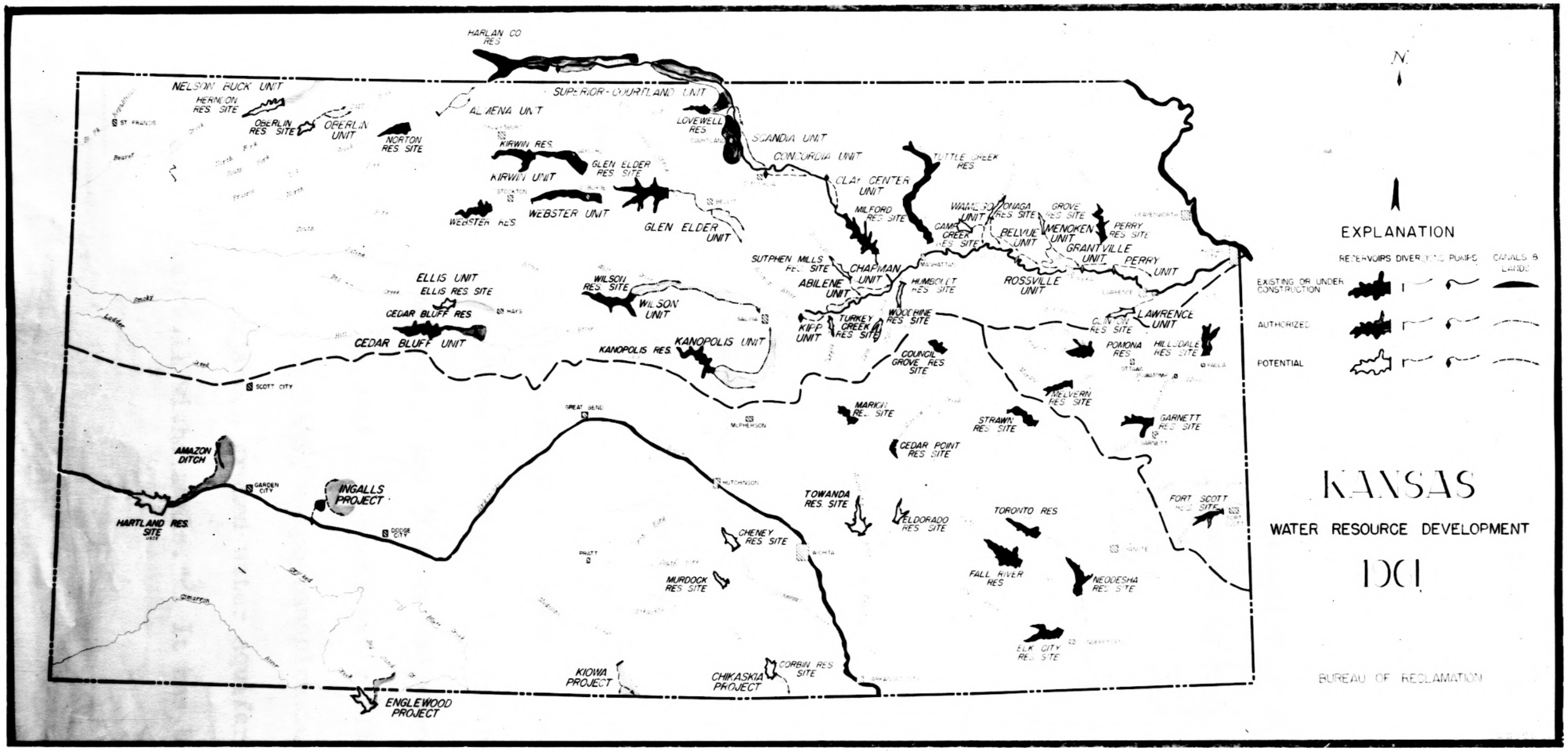

Fig. 3. Existing and potential surface water storage structure and irrigation unit development, state of Kansas. Source: Bureau of Reclamation, 1961.

approximately 22,000,000 acre feet of water in storage.[1] The total for the district would be expected to be considerably less than double this figure as aquifers underlying the Upper Republican Unit are generally more extensive in occurrence and of higher yielding capacity than those in the more southern and eastern portions of the district.

Location of water in the Ogallala formation ranges in depth from 50 to 200 feet, with an average of about 150 feet. As indicated by Fig. 4 yields in excess of 500 gallons per minute are generally obtained in the western part of the district although local exceptions may occur. This formation decreases in thickness from west to east and outcrops generally along the west edge of Norton and Graham counties. Thus the potential ground water yield generally is less toward the eastern edge of the district with much of Norton and Graham counties having little ground water available except along stream valleys (see Fig. 4).

Water supplies in the alluvium and terrace deposits of the major stream valleys are generally available at average depths of 20 to 40 feet. Generally, because of the shallowness of these formations, well capacities are limited to a few hundred gallons per minute.[2]

The supply of water moving into ground water storage is derived primarily from precipitation falling on the land surface within the district (estimated at an average of one-fourth inch per year) and from ground water movement into the area from adjacent aquifers to the west. "Ground water leaves the area through natural processes (seeps and springs, evapotranspiration in areas close to the surface, and movement into adjacent ground water aquifers to the east and northeast) and through artificial well withdrawals."[3] It has been estimated that

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1. _Loc. cit._
2. _Ibid._
3. Ibid.

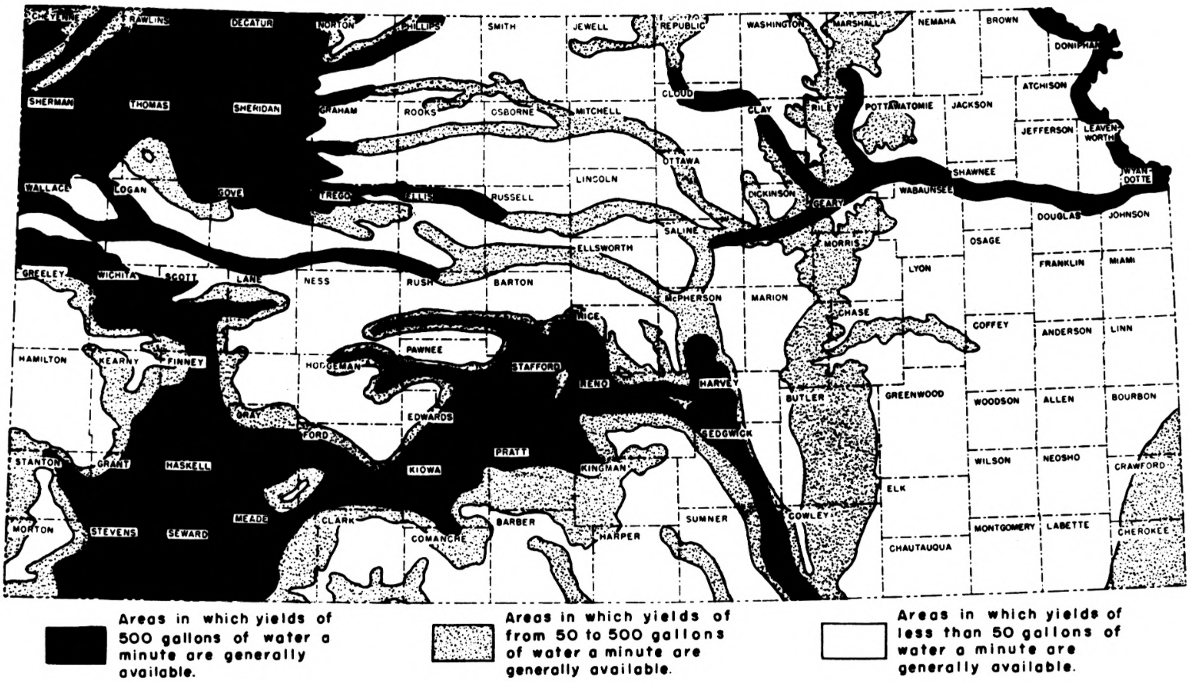

Fig. 4. General location and extent of ground water reservoirs, state of Kansas.

current annual ground water recharge levels for the Upper Republican Unit exceed annual withdrawals by some 29,000 acre feet.[1] Although similar figures were not calculated for the crop reporting district as a whole but it would seem safe to assume that no serious depletion or mining of ground water reserves is occurring at the present time on a total area basis. However, it must be recognized that local situations may exist which are contrary to the general case.

Expected Irrigation Development, 1975. The acreage projections of 1975 irrigation development in Kansas presented in this study were developed by Kansas State University personnel for use by the Kansas Water Resources Board. The projected estimates, on the basis of watershed units, were made available for this study by the Water Resources Board. In deriving the projections, attention was given to past trends in irrigated acreage and to the factors of land, surface, and ground water supplies previously discussed. An effort was made to ascertain that realization of projected expansion would be consistent with available and relative supplies of physically irrigable lands and ground and/or surface water supplies with which to irrigate these lands. Land characteristics considered pertained to soil structure, texture, and depth, and to slope. Ground water supplies were investigated to estimate geological and areal extent and location, yield characteristics of relevant aquifers, extent of present development, and future development potentials in terms of physically and economically derivable supplies. Consideration of surface water supplies was directed toward stream flow characteristics, present, planned, and potential reservoir development, and the possibilities for project type irrigation development below these reservoirs.

The 1975 irrigation acreage projection for the northwest crop reporting district was 95,700 acres as indicated by Table 4. This compares with 50,600 acres watered in 1960. A total of 2,422,000 acres in this district are considered

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1. Ibid.

Table 3. Status of surface water irrigation development, Kansas River Projects, state of Kansas, by Crop Reporting Districts.

Division and irrigation district	Repayment years of: D.P.R. Acreage	Contract acreage	Initial service	Development period	1958: Acreage for service	Acreage irrigated	%	1959: Acreage for service	Acreage irrigated	%	1960 (estimate): Acreage for service	Acreage irrigated	%	1961 (estimate): Acreage for service	Acreage irrigated	%	1962 (estimate): Acreage for service	Acreage irrigated	%	1963 (estimate): Acreage for service	Acreage irrigated	%	1964 (estimate): Acreage for service	Acreage irrigated	%	Acres balance to complete
Full irrigation service																										
West Central Crop Reporting District																										
Cedar Bluff District[c]	6,200	6,200	-	-	-	-	-	-	-	-	-	-	-	-	-	-	663	300	-	6,200	3,100	-	6,200	3,700	-	None
Total West Central Crop Reporting District	6,200	6,200															663	300		6,200	3,100		6,200	3,700		
Northwest Crop Reporting District																										
Almena District	5,350	5,350	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5,350[b]
Total Northwest Crop Reporting District	5,350	5,350																								5,350[b]
North Central Crop Reporting District																										
Kirwin District	11,500	11,500	1957-58	1960-64	11,500	4,127	35	11,500	6,470	56	11,500	8,500	74	11,500	9,500		11,500	10,500		11,500	11,000		11,500	11,200		None
Webster District	8,500	8,500	1960-	-	-	-	-	-	-	-	4,800	2,200	55	8,500	4,000		8,500	6,000		8,500	7,000		8,500	7,500		None
Kansas-Bostwick District																										
Block 1 (Above Lovewell Reservoir)	13,030	-	1955-56	1957-61	10,335	5,829	60	9,782	7,159	73	9,780	7,500	77	9,780	7,700		9,780	7,900		9,780	8,000		9,780	8,000		2,587[a]
Block 2	26,760	-	1958-59	1960-64	10,092	2,878	28	21,784	9,081	42	21,978	12,500	59	21,978	14,100		21,978	15,600		21,978	16,000		21,978	16,400		5,375[a]
Block 3 (White Rock Canal & Pump 4)	1,570	-	1960	1961-65	-	-	-	-	-	-	-	-	-	954	600		954	650		954	700		954	750		269[a]
White Rock Canal Extension	2,700	-	-	-	-	-	-	-	-	-	-	-	-	2,761	1,100		2,761	1,400		2,761	1,650		2,761	1,600		356[a]
Pump 1	2,240	-	-	-	-	-	-	-	-	-	-	-	-	1,859	900		1,859	1,100		1,859	1,250		1,859	1,400		381[a]
Pump 2	1,800	-	-	-	-	-	-	-	-	-	-	-	-	-	-		801	360		801	450		801	520		999[a]
Pump 3	900	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-		560	250		560	310		340[a]
Sub-total Kans-Bost. Dist.	49,000	49,000			20,427	8,707	43	31,566	16,240	51	32,712	20,500	63	37,332	24,400		38,133	27,010		38,693	38,300		38,693	29,380		10,307[a]
Total N. C. Crop Reporting District	69,000	69,000			31,927	12,834		43,066	22,710		49,012	31,200		57,332	37,900		58,133	43,510		58,693	46,300		58,693	48,080		10,307
Grand Total, full irrigation service, State of Kansas	80,550	80,550			31,927	12,834		43,066	22,710		49,012	31,200		57,332	37,900		58,796	43,810		64,893	49,400		64,893	51,780		15,657

a. Lands in less than 40-acre tracts, requiring pump turnouts, flood protection, or inclusion in district, some of which to be deleted from plan of development.
b. Initial service available to full acreage in 1965.
c. Storage structure located in W. C. Crop Reporting District but majority of irrigatable lands located in C. Crop Reporting District.
Source: Annual Irrigation Progress Report, Kansas River Projects, Bureau of Reclamation, 1960, p. 8.

irrigable on the basis of physical land characteristics with some 1,208,750 of these acres overlying an aquifer with water-bearing potential capable of irrigation development. By comparison some 8,500 acres in this district have been indicated for possible project type surface water development (see Table 2). Of this amount, only some 5,000 acres are expected to be developed in the district by 1975 (see Table 3). This would indicate that of the 95,700 district acres projected for irrigation development by 1975, somewhat over 90,000 would be private development utilizing ground water, except for a very insignificant amount of private stream bank pumping.

West Central Crop Reporting District

Physical Soil Characteristics.[1] Bidwell has delineated six soil associations within the west central crop reporting district. The largest area is the Keith, Colby silt loam soil association referred to in the northwest district. This association occurs in three areas. The northmost lies along the northern side of Logan, Gove, and part of Trego counties. The association also occurs in Wallace county extending southeastward across the corners of Logan and Wichita counties, and then eastward to cover most of Scott and Lane counties. These soils were developed from loess. The Keith soil is commonly found on the more level uplands with the Colby soil occupying the steeper slopes. The third, smaller area of this association is located in Trego and Ness counties near the east central portion of the district.

A second soil association falls along the Smoky Hill River and its tributary streams within the district. These steeply sloping lands are occupied by shallow, unproductive Canyon soils. Unsuited for cultivation, these soils need special management even for grazing use.

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1. Based on Bidwell, op. cit.

Table 4. Irrigated acreage[a] in Kansas, by crop reporting districts, with projection[b] to 1975.

Year	Northwest	West Central	Southwest	North Central	Central	South Central	Northeast	East Central	Southeast	State of Kansas
	Crop Reporting District									
	(Acres irrigated)									
1954	8,200	64,600	272,600	15,100	16,000	23,400	9,100	6,100	2,900	418,000
1955	16,800	115,900	311,500	22,600	20,000	34,300	16,900	8,800	3,600	550,400
1956	28,400	140,300	406,700	31,200	30,600	56,400	12,500	11,700	6,600	724,400
1957	38,400	157,100	469,200	41,100	41,200	67,000	5,800	13,800	6,400	840,000
1958	42,700	161,700	481,800	65,300	47,900	69,300	15,100	14,100	5,700	903,600
1959	47,000	200,200	526,700	86,500	47,100	73,800	15,800	14,200	6,400	1,003,800
1960	50,600	212,100	520,800	78,800	35,600	79,000	11,000	14,400	6,700	1,017,700
1975	95,700	226,900	874,000	157,000	134,400	191,700	77,800	54,600	20,300	1,832,400

a. Acreages compiled from County Agents Annual Reports.

b. Projected 1975 acreage derived from irrigated acreage projections for Kansas watershed units provided by Kansas Water Resources Board, Topeka, Kansas, personal communication.

In the southwest corner of the district is located a Richfield, Colby, association. The Richfield and similar soils are relatively permeable, relatively level, productive soils. The Colby silt loam falling on more sloping land, is shallower, with a less well developed and less durable structure in its sub-soil than is found with the Richfield soil.

The Keith, Hoisington association is situated in the south central part of Scott county, in the Scott-Finney Depression. This is an extended level, slightly depressed area between Garden City and Scott City. The better drained sites contain the Keith silt loam and associated soils while less well drained sites are characterized by the Hoisington silty clay loam and similar soils.

The Hastings-Holdrege, Colby association described in the northwest district extends across the eastern side of the west central district. Characteristics are similar to those already described.

The final association in this district consists of the variable alluvial soils. These range from sands to clays, from permeable, friable soils with high productivity to tight, intractable soils that are difficult to manage. As a group, these bottomland and terrace soils are probably the most productive soils of the district.

Physically irrigable lands in this district have been estimated to cover some 1,866,750 acres. This includes 287,000 acres of bottomland and 847,000 acres of upland with less than two percent slope. An additional 732,500 acres of upland with somewhat steeper, 2 to 5 percent slopes, would be irrigable with more intensive land preparation.

Potential Water Supplies. Surface water. Substantial surface water supplies in this crop reporting district are largely restricted in occurrence to the Smoky Hill river and its tributaries. Two Bureau of Reclamation projects are located in this area. One is a reality; the other, proposed. However, as both of these developments are situated near the eastern side of the district, most of the land which could potentially be watered from them is in the central crop reporting district.

The Cedar Bluff unit is located on the Smoky Hill River in the southern portion of Trego and Ellis counties.[1] The relative location is indicated on Fig. 3. The Cedar Bluff dam and reservoir is a multipurpose project which was completed in 1951. It provides flood control and will furnish irrigation water for 11,300 acres and municipal water for the city of Russell. The proposed irrigable lands lay along the north side of the Smoky Hill river valley downstream from the dam for about 23 miles to just south of Antonino. Irrigation facilities to deliver water to these lands will include the Cedar Bluff canal, originating at the dam, along with necessary laterals and drains. Overwhelming local opposition to project development in the lower reaches of the unit has given rise to an alternative plan now under consideration. This plan involves reducing the scale of irrigation to serve 6,000 acres in the upper reaches of the unit. Reference to Table 2 indicates allocation of 159,000 acre feet of storage capacity for irrigation purposes.

The Ellis unit is located on both sides of Big Creek valley near Ellis and Hays in Trego and Ellis counties.[2] Investigations in this unit are of a very preliminary nature only. They indicate that 11,500 acres may be arable, extending on both sides of Big Creek from six miles west of Ellis to near Hays. Present development plans call for irrigation of about 5,000 acres as indicated in Table 2. Investigations of this unit originated as a possible alternative area for utilization of available water supplies in the Cedar Bluff reservoir. The location of this proposed project is indicated on Fig. 3.

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1. Kansas River Basin, Colorado-Nebraska-Kansas, op. cit., p. 88.
2. Ibid., p. 92.

Ground Water. Ground water supplies in the west central crop reporting district are obtained from primarily the same sources as in the case of the northwest district. That is, upland wells derive their water supply mainly from the Ogallala formation, while terrace and alluvium deposits provide well water at relatively shallow depths in the main stream valleys (in the west central district, the Smoky Hill and its major tributaries).

However, as may be ascertained in observing Fig. 4 the areal extent of occurrence of ground water reservoirs in the west central district is considerably less extensive than was the case of the northwest district. Yields of 500 gallons of water a minute are generally obtainable only in the southern part of Wallace county and in most of Wichita and Scott counties. As indicated by Fig. 4 the other major area of occurrence is along the Smoky Hill river valley.

Expected Irrigation Development, 1975. The acreage projections of 1975 irrigation development in Kansas presented in this study were developed by Kansas State University personnel for use by the Kansas Water Resources Board. The projections, on the basis of watershed units, were made available for this study by the Water Resources Board. In deriving the projections, attention was given to past trends in irrigated acreage, and to the factors of land, surface, and ground water supplies previously discussed. An effort was made to ascertain that realization of projected expansion would be consistent with available and relative supplies of physically irrigable lands and ground and/or surface water supplies with which to irrigate these lands. Land characteristics considered pertained to soil structure, texture, and depth, and to slope. Ground water supplies were investigated to estimate geological and areal extent and location, yield characteristics of relevant aquifers, extent of present development and future development potentials in terms of physically and economically derivable supplies. Consideration of surface water supplies was directed toward stream flow characteristics, present, planned, and potential reservoir development, and the possibilities for project type irrigation development below these reservoirs.

The 1975 irrigation acreage projection for the west central crop reporting district was 226,900 acres as indicated in Table 4. This compares with 212,100 acres watered in 1960. Some 1,866,750 acres in this district are considered irrigable on the basis of physical land characteristics, with 602,900 of these acres overlying an aquifer with water-bearing potential capable of irrigation development. By comparison 16,300 acres in this district have been indicated for possible project type surface water development (see Table 2). Of this amount, only some 6,000 acres are expected to be developed by 1975 (see Table 3). This would indicate that of the 226,900 acres projected for irrigation development by 1975, over 220,000 would be private development utilizing ground water supplies except for very limited amounts of private stream bank pumping.

Southwest Crop Reporting District

<u>Physical Soil Characteristics.</u>[1] The southwest district presents a wide diversity in terms of soil associations. Ten associations have been described in this area by Bidwell. Three areas of the Richfield, Colby association, described in the west central district, occur in the southwest district. One of these is situated in the northwest corner, in the north half of Hamilton and Kearney counties. Another occurs in the west central portion of the district extending across Stanton and into Grant county. The third falls mainly in the northern half of Morton county. These silt loam soils are generally quite productive when favorable climatic conditions prevail.

The Keith, Colby association, so prominent in the northwest district, appears again in this area. The largest tract of this association is located mainly in Finney, Gray, and Hodgeman counties. Another location in which this association is found covers most of Haskell county.

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1. Based on Bidwell, <u>op</u>. <u>cit</u>.

The shallow Canyon soils extend from the west central district down into the eastern end of Finney county and a corner of Hodgeman county. Even grasses do poorly on these unproductive slopes.

A fourth association in the southwest district is composed of the Mansker, Canyon soils. These occur in two areas. One is located in the southern part of Hodgeman county, and extends into Ford county. The second area lies along the southern edge of Meade county with three narrow finger-like protrusions extending upward, one northwestward across Seward county, a second northward across Meade county and the third northeastward across Clark county. The soils in this association are droughty and limy in character, occurring on steeply sloping, highly eroded terrain. As with the Canyon soils this association should remain in carefully managed native grass.

A second Richfield, Colby association is found in the eastern part of the district, both north and south of the Arkansas river. These are fine textured soils, similar to the Richfield, Colby association previously described except for receiving higher rainfall. A considerable water erosion hazard is present on these soils.

In a band directly south of the Arkansas river valley alluvium extending across most of the crop reporting district occurs the Dune Sand, Tivoli soil association. This group of undulating to rolling soils is best suited to native grasses. Proper management can produce good grazing.

A Dalhart, Richfield, Mansker association covers Stevens county and extends into parts of Morton, Stanton, Grant, and Seward counties. These are brown and and grayish brown fine sandy loams (Dalhart), silt loams (Richfield), and clay loam (Mansker) soils. These predominantly sandy lands are subject to serious wind erosion unless protected by native vegetation.

Approximately the center third of Clark county is covered by an eighth soil association, the Grant, Albion, Vernon, and Renfrow group. These reddish brown and brown silt loam, loam, and clay (Vernon) soils occur on undulating, rolling, and occasionally hilly relief. Areas of maximum soil development and minimum erosion are suitably adapted to crop production.

A ninth association, the Keith, Hoisington, previously described in the west central district occupies the portion of the Scott-Finney depression which extends into the southwest district. The extent of these soils is limited to a strip through Finney county northward from the Arkansas river.

Finally, in this area, occurs the widely varying Alluvial soils of the bottom and terrace lands. These water deposited soils are generally highly productive. Irrigation often permits intensive cropping practices on these lands.

In terms of irrigation potential, it has been estimated that some 4,178,000 acres in this unit are suitable for irrigation development on the basis of physical characteristics.[1] Those characteristics considered were texture, structure, depth, and slope. As indicated in Table 1, approximately 243,100 acres of the above total is located on bottom and terrace lands with less than 2 percent slope. An additional 2,660,000 acres is upland with less than 2 percent slope. The remaining 1,274,000 acres are mostly uplands, suitable for irrigation except for slopes of 2 to 5 percent. These latter lands generally require more intensive development for successful watering.

Potential Water Supplies. Surface water. Two Bureau of Reclamation project type surface water irrigation developments are under consideration in this crop reporting district. Fig. 3 indicates the location of the Hartland reservoir site

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1. See Table 1; Fig. 2.

in Kearney county. Irrigation service would be provided to Arkansas river valley lands above Garden City on the north side of the river. As this project represents a very recent change in development plans for this area, more detailed information concerning it was not available at the time of this writing.

The Englewood irrigation project is located on the Cimarron river in Beaver county, Oklahoma.[1] This multipurpose unit is designed to provide flood control and irrigation. As indicated on Fig. 3, irrigable lands to be benefitted from this project are located in Oklahoma and Kansas. Bureau of Reclamation information indicates a total of 12,000 irrigable acres of which 6,500 are located in Kansas.[2] As indicated in Table 2, 80,000 acre feet of storage capacity would be allocated to irrigation uses. Two canals originating at the dam, together with appurtenant laterals and drains, comprise the irrigation works. "The south canal would be about 10.8 miles in length with an initial capacity of 127 cubic feet per second and would serve 7,500 acres. The north canal would be about 7.4 miles in length with an initial capacity of 80 cubic feet per second and would serve 4,500 acres."[3]

<u>Ground Water</u>. The major ground water storage area in the state is found in the southwest crop reporting district. "The saturated thickness of the water-bearing material in the district varies from zero in some areas to as much as 700 feet in others."[4] As is the case throughout the western portion of the state, the Ogallala formation is the major aquifer, occurring in the Pliocene and Pleistocene rock deposits which constitute the surface rocks over most of the district.

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1. <u>Development of Water and Land Resources of the Arkansas-White and Red River Basins</u>, 85th Congress, Senate Document No. 13. January 17, 1957.

2. M. G. Barclay, Area Engineer, Bureau of Reclamation, Oklahoma City Development Office, personal communication, February 17, 1961.

3. <u>Development of Water and Land Resources of the Arkansas-White and Red River Basins</u>, <u>loc. cit</u>.

4. State Water Plan Studies, Part A: Preliminary Appraisal of Kansas Water Problems. <u>Section 2</u>. <u>Cimarron Unit</u>. Kansas Water Resources Board, p. 84.

It has been estimated that some 85,000,000 acre feet of water is in storage in the aquifers underlying the Cimarron watershed unit.[1] This unit covers approximately the south half of the southwest district thus providing a very rough indication of total storage in the district. However, it is important to emphasize that total storage is by no means usable storage. "Under favorable conditions, usable storage can probably be expected to approximate 50 percent of total storage."[2]

Natural recharge and discharge of aquifers in this district is essentially the same as that described for the northwest district with additions to storage coming mainly by seepage from surface streams and depressions, subsurface flow from surrounding areas, and local precipitation. Likewise, movement from storage is accomplished through movement to adjacent areas, evapotranspiration in areas near the surface, and seepage through springs and into adjacent stream channels. "Under natural conditions, a ground water reservoir is in a state of approximate dynamic equilibrium, with long run water discharge by natural processes off-set by water added to the reservoir by natural recharge."[3] However, any significant amount of "unnatural" withdrawal over a long period of time can upset this balance resulting in mining or using up of storage supplies. Indications are that this mining problem either exists or is impending over a considerable portion of the southwest district and that depletion of economically attainable supplies for irrigation may occur in certain areas within a relatively short period of years.

Water supplies in alluvium and terrace deposits occur primarily along the Arkansas and Cimarron rivers and their main tributaries. As these supplies are

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1. Loc. cit.
2. Loc. cit.
3. Ibid., p. 51.

generally shallow in occurrence they may often be depleted quite easily under heavy pumping conditions. In some areas recharge may be realized through the alluvium forming a stream bed. However, due to the relatively small surface area of a stream bed and oft-times intermittent stream flow during drought periods, this means of aquifer recharge is generally inadequate, even though the stream bed may lie above the water table level.

Expected Irrigation Development, 1975. The acreage projections of 1975 irrigation development in Kansas presented in this study were developed by Kansas State University personnel for use by the Kansas Water Resources Board. The projections, on the basis of watershed units, were made available for this study by the Water Resources Board. In deriving the projections, attention was given to past trends in irrigated acreage, and to the factors of land, surface, and ground water supplies previously discussed. An effort was made to ascertain that realization of projected expansion would be consistent with available and relative supplies of physically irrigable lands and ground and/or surface water supplies with which to irrigate these lands. Land characteristics considered pertained to soil structure, texture, and depth, and to slope. Ground water supplies were investigated to estimate geological and areal extent and location, yield characteristics of relevant aquifers, extent of present development and future development potentials in terms of physically and economically derivable supplies. Consideration of surface water supplies was directed toward stream flow characteristics, present, planned, and potential reservoir development, and the possibilities for project type irrigation development below these reservoirs.

The 1975 irrigation acreage projection for the southwest crop reporting district was 874,000 acres as indicated by Table 4. This compares with 520,800 acres irrigated in 1960. Some 4,178,100 acres in this district are considered irrigable on the basis of physical land characteristics, with 2,457,500 of these acres overlying an aquifer with water-bearing potential capable of irrigation development. By comparison 126,600 acres in this district have been indicated for possible project type surface water development (see Table 2), none of which is expected to be developed by 1975.[1] This would indicate that, except for limited amounts of stream bank pumping, all of the projected 874,000 acres would be private ground water irrigation development.

North Central Crop Reporting District

Physical Soil Characteristics.[2] Six soil areas have been defined in this crop reporting district by Bidwell. The most extensive of these is the Hastings, Holdrege, Colby association located in approximately the western third of the district. These dark grayish brown and grayish brown silt loam soils occupy undulating to nearly level topography.

Directly to the east of this association occurs a wide band of the Crete, Hastings, Nuckolls association. The very dark grayish brown (Crete and Hastings) and dark brown or reddish brown (Nuckolls) silty clay loams occur on nearly level to rolling relief. The Nuckolls soil, because of its older age and position on more steeply sloping topography, is generally less productive than the other soils in this association.

A third association in this district is composed of the Lancaster, Hedville, Longford soils. Developed from Dakota sandstone and interbedded shales, these dark brown and dark grayish brown loams and silt loams occur on undulating to rolling relief. Best adapted to permanent pasture, more level areas of this association can be successfully cropped under good management and high moisture conditions.

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1. M. G. Barclay, loc. cit.
2. Based on Bidwell, op. cit.

The eastern parts of Washington and Clay counties in this crop reporting district are occupied by the Crete, Ladysmith, Kipp, Idana soil association. These are very dark grayish brown and dark grayish brown, silty clay loam soils with a silty clay to clay subsoil. Relief is generally nearly level to undulating.

A fifth soil association in this district occurs in a narrow strip along the eastern edge of Washington county. This Sogn, Summit, Florence, Idana association comprises the Flint Hills region of Kansas. Its soil characteristics are described under the south central district.

The Republican and Solomon river valleys which both cross this district provide rather extensive areas of Alluvial soils. This association in the north central district has soil characteristics similar to those previously described for water deposited alluvial soils.[1]

Physically irrigable lands, the location and acreage of which is indicated by Table 1 and Fig. 2, total 2,254,300 acres in this district. Approximately one fourth (551,050 acres) of this acreage occurs as bottom and terrace land. An additional one fourth (525,900 acres) occurs as upland with less than 2 percent slope. The remaining one half of the physically irrigable lands in this district are located on upland areas with 2 to 5 percent slope. As indicated on Table 1, the physical characteristics considered in defining irrigable lands were texture, structure, depth, and slope.

Potential Water Supplies. Surface water. A number of potential and established Bureau of Reclamation surface water irrigation projects exist in the North Central crop reporting district. The first three discussed are located in the

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1. See Physical Soil Characteristics, Northwest, West Central, and Southwest crop reporting districts.

Smoky Hill River Basin. The Kirwin unit occurs along the north fork of the Solomon river in Phillips, Smith, and Osborn counties, as illustrated in Fig. 3. This multipurpose development serves primarily for flood control and irrigation. Other benefits include recreation, wildlife and fish conservation. Provision has been made for the irrigation of 11,500 acres of valley lands below the dam.[1] These are served by a system of laterals, canals, and necessary drains. The origin of the main canal occurs at the outlet to the north side of the dam and continues downstream to the village of Cedar. At this location, it divides to serve land on both sides of the river. Terminal point of the canal system is near the town of Portis. As indicated in Table 2, storage capacity of 76,400 acre feet has been allocated for irrigation purposes.

The Webster dam and reservoir, a multipurpose unit, was essentially complete in the spring of 1954. Reference to Fig. 3 illustrates its location along the valley of the South Fork Solomon river in Rooks and Osborn counties. This unit provides irrigation for 8,500 acres of irrigable land located in the valley and on adjacent terraces extending from the village of Woodston to a point approximately four miles east of Osborne.[2] Irrigation works include the Woodston diversion dam located 1½ miles west of Woodston and the 31-mile Osborne canal on the north side of the river. Three small project pumps will provide service to 1,190 acres along the first seven miles of the canal. The remaining 7,310 acres will be served by gravity. As indicated in Table 2, storage capacity in the reservoir which has been allocated to irrigation use is 60,500 acre feet. The reservoir is located 11 miles upstream from Stockton.

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1. See Table 2.
2. Kansas River Basin, Colorado-Nebraska-Kansas. Op. cit., p. 83.

The Glen Elder Unit, a potential multipurpose project, would provide flood control and irrigation benefits, fish and wildlife habitat, and recreation facilities.[1] It is situated on the Solomon river in Mitchell, Cloud, and Ottawa counties. This location is indicated by Fig. 3. "The Glen Elder dam site is located immediately upstream and adjacent to the western boundary of the town of Glen Elder."[2] Potentially irrigable lands extend from Glen Elder downstream approximately 40 miles to Minneapolis. Reconnaissance land classification surveys indicate 14,000 arable acres within the unit. It appears that some 10,000 of these acres could be served from the proposed gravity canal.[3] A main canal would extend 22 miles downstream from the outlet works on the north side of the valley. Below this point, two canals would continue east, one on each side of the river. The combined length of these main canals would be 48 miles.[4] As indicated on Table 2 irrigation use storage capacity in the Glen Elder reservoir totals 80,000 acre feet.

All remaining Bureau of Reclamation surface water irrigation projects in this district are located in the Republican river basin. The multiple purpose Kansas-Bostwick irrigation division comprises the largest irrigation development in the Kansas river basin.[5] Located in south central Nebraska and Jewell, Republic, and Cloud counties in north central Kansas, the project development plan calls for full irrigation of 86,240 acres. Of this total, 62,000 would be in Kansas. Lovewell reservoir, on White Rock Creek in Kansas, provides the major storage facility on the Kansas side. Two irrigation units were planned for this project. The existing Courtland unit will ultimately distribute water to 49,000 acres through the Courtland canal system.[6] This begins at the state

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1. Ibid., p. 86.
2. Loc. cit.
3. Loc. cit.
4. Loc. cit.
5. Ibid., p. 72.
6. Ibid., p. 73.

line and includes several sub-canals. Four project pumps would service a 6,130 acre area too high for gravity flow. Some 2,000 acres are expected to be developed by small private pump lifts. Lovewell reservoir (see Fig. 3) will provide important regulation and storage for unit lands. As indicated in Table 2, 225,000 acre feet of storage are allocated for irrigation uses in Lovewell reservoir. The Scandia unit would be comprised of the potential Scandia diversion dam across the Republican river and the Scandia Canal which would deliver water for use on 13,000 acres of land. Indifference on the part of potential irrigators has delayed finalization of plans.[1]

Fig. 3 indicates the Concordia unit situated along the Republican river directly below the town of Concordia. The inclusion of this project in Bureau of Reclamation plans is a fairly recent development. Detailed information concerning its plan of development was not available at the time of this writing.

The Clay Center Unit is situated on both sides of the Republican river between Concordia and Clay Center.[2] As indicated on Fig. 3, it originates immediately below the potential Concordia unit. It would be a single purpose irrigation development, without storage reservoir, servicing some 14,500 acres of arable lands. Incomplete water supply studies indicate the possible necessity of supplementing the surface water supply by pumping ground water. Irrigation works would include a diversion dam on the Republican river near Concordia, two canals, and a distribution and drainage system.[3] The canals would originate at the diversion dam with one extending downstream on the north side approximately 41 miles. It would service 8,500 acres. The south side canal would be about 12 miles in length and service 6,000 acres.

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1. Loc. cit.
2. Ibid., p. 77.
3. Loc. cit.

The Milford reservoir is the only other surface water development project planned for this crop reporting district. It is a flood control project authorized for construction by the Corps of Engineers.[1] No irrigation development is contemplated for this project under present plans.

Ground Water. The situation existing in the north central crop reporting district relative to ground water supplies is considerably changed from that of the western tier of crop reporting districts. As indicated by Fig. 4 very few areas in this district are underlain by aquifers capable of producing in excess of 500 gallons of water per minute. This situation is brought about by the fact that the Ogallala formation, principle aquifer in western Kansas, does not extend into the central portions of the state, and no other water-bearing structure of similar yield potential is available to take its place in the north central district, with the exception of a few local areas.

The main source of ground water in this district in terms of yield potential occurs in the alluvium and terrace deposits of the stream valleys, in this case the North and South Fork Solomon and the Republican rivers and their major tributaries. Fig. 4 indicates yields ranging between 50 and 500 gallons per minute may generally be obtained from these locations. A bedrock aquifer which occurs in this district is the Dakota formation in parts of Washington and Clay counties. "Locally, yields as large as 300 gallons per minute probably can be obtained."[2] This formation, in the Cretaceous system, consists of beds of sandstone, shale, clay, and siltstone. Other formations occurring in this district generally may be expected to yield less than 50 gallons per minute, and while they may provide adequate local supplies of livestock and domestic water, may not be considered important from the standpoint of irrigation needs.

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1. Ibid., p. 78.
2. State Water Plan Studies, Part A: Preliminary Appraisal of Kansas Water Problems. Section 3. Kansas Unit. Kansas Water Resources Board. June, 1959.

Expected Irrigation Development, 1975. The acreage projections of 1975 irrigation development in Kansas presented in this study were developed by Kansas State University personnel for use by the Kansas Water Resources Board. The projections, on the basis of watershed units, were made available for this study by the Water Resources Board. In deriving the projections, attention was given to past trends in irrigated acreage, and to the factors of land, surface, and ground water supplies previously discussed. An effort was made to ascertain that realization of projected expansion would be consistent with available and relative supplies of physically irrigable lands and ground and/or surface water supplies with which to irrigate these lands. Land characteristics considered pertained to soil structure, texture, and depth, and to slope. Ground water supplies were investigated to estimate geological and areal extent and location, yield characteristics of relevant aquifers, extent of present development and future development potentials in terms of physically and economically derivable supplies. Consideration of surface water supplies was directed toward stream flow characteristics, present, planned, and potential reservoir development, and the possibilities for project type irrigation development below these reservoirs.

The 1975 irrigation acreage projection for the north central district was 157,000 acres as indicated by Table 4. This compares with 78,800 acres irrigated in 1960. Some 2,254,300 acres in this district are considered irrigable on the basis of physical land characteristics, with 324,250 of these acres overlying an aquifer with water-bearing potential capable of irrigation development. By comparison 92,000 acres in this district have been indicated for possible project type surface water development (see Table 2). Of this amount, some 60,000 acres are expected to be developed by 1975 (see Table 3). This would indicate that of the 157,000 acres projected for irrigation development by 1975, some 35 to

40 percent might be project type development utilizing surface water, while the remaining 60 to 65 percent would be private development utilizing ground water supplies, except for limited amounts of private stream bank pumping.

Central Crop Reporting District

Physical Soil Characteristics.[1] By and large the soil associations described in the North Central crop reporting district extend over most of the central district as well. With the exception of river valleys covered by Alluvium deposits, Ellis, Rush, Barton, and part of Russell counties are characterized by the Hastings, Holdrege, Colby association. Parts of Russell, Lincoln, and a corner of Ellsworth counties have the Crete, Hastings, Nuckolls association predominating. The Lancaster, Hedville, Longford association extends across Ottawa and parts of Clay, Cloud, and Washington counties. The soils of the two eastern counties in the district, Dickinson and Marion, largely fall into the fine textured Crete, Ladysmith, Kipp, Idana association. A smaller area of this association also protrudes into the eastern part of Saline county. Also in Dickinson and Marion counties, along their eastern borders occur small areas of the Sogn, Summit, Florence, Idana association. Substantial areas of Alluvial soils are found in the valleys of the Saline, Smoky Hill, and Arkansas rivers in this district.

In addition to the above six soil associations which have been discussed under previously considered districts, Bidwell defines two additional associations not found in heretofore discussed districts. The most extensive of these is the Crete, Goessel association. These nearly level claypan soils occur most widely in Rice and McPherson counties with smaller areas present in Barton,

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1. Based on Bidwell, op. cit.

Ellsworth, and Marion counties. Composed of dark grayish brown silty clay loam soils this association generally is found on nearly level to undulating relief.

The southern edge of Barton county and corners of Rice and McPherson counties are occupied by the Pratt, Albion, Derby association. These soils will be described in the south central crop reporting district where their occurrence is quite extensive.

Reference to Table 1 shows 1,724,200 acres of land in the central crop reporting district as being suitable for irrigation on the basis of physical characteristics alone. The general location of these lands is indicated in Fig. 2. Of the total irrigable lands, some 631,700 acres have slopes of 2 to 5 percent. These are mostly uplands. Irrigable areas defined with less than 2 percent slope are divided between uplands (669,400 acres) and bottom and terrace lands (423,200 acres). Characteristics of slope, depth, structure, and texture were considered in determining irrigability of soils.

Potential Water Supplies. Surface water. As indicated by Fig. 3, a number of potential and existing dams and reservoirs and project type irrigation development units are located in the central crop reporting district. The Wilson Unit is situated on the Saline river in Russell and Lincoln counties.[1] The dam is located approximately nine miles north of Wilson. Original plans called for irrigation development of 18,000 acres. Subsequent investigations revealed that drainage problems caused by an impermeable, fine textured sub-strata, coupled with a high salt content in the water effectively limited arable land to about 2,200 acres immediately below the dam. A canal system to service arable lands extending downstream from the damsite for about six miles would include two components. The Wilson north canal and the Wilson south canal would serve the

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1. Kansas River Basin, Colorado-Nebraska-Kansas. Op. cit., p. 92.

2,200 acres. Water resources information indicates the basic water supply of the Saline river would provide irrigation for 23,000 acres.[1] Thus as indicated in Table 2, 225,000 acre feet of storage capacity has been alloted for that purpose. Further investigations have been conducted to locate other land areas for feasible development.

The Kanopolis unit on the Smoky Hill river is located in Ellsworth, McPherson, and Saline counties (see Fig. 3). A multipurpose structure, Kanopolis dam and reservoir is situated about 35 miles upstream and southwest from Salina.[2] Potentially irrigable lands occur downstream from the dam on both sides of the river, extending to Salina. Use will be made of the existing Kanopolis Dam and Reservoir to inundate water flows of the Smoky Hill river. Construction of outlet works and other modifications will provide a water supply to an 86-mile system of canals, necessary laterals and drains. Service and water supply are planned for a maximum of 41,000 acres extending downstream to the outskirts of Salina. Final irrigable acres may be somewhat more limited based on more detailed land classification, canal layout and drainage system. As indicated by Table 2, a reservoir storage capacity of 162,500 acre feet has been allocated to irrigation use.

Reference to Fig. 3 indicates that the lower reaches of the Smoky Hill river basin in the northeast portion of the central crop reporting district is the location of several potential Bureau of Reclamation reservoirs and irrigation units. These projects include Turkey Creek reservoir on Turkey Creek, Woodbine reservoir on Lyon Creek, and Sutphen Mills reservoir on Chapman Creek. Potential irrigation units, generally situated along the Smoky Hill river valley between the terminal points of the Solomon and Republican rivers, include the Kipp unit,

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1. Loc. cit.
2. Ibid., p. 95.

Abilene unit, and Chapman unit. These projects are relatively recent additions to the Bureau of Reclamation plan of development. As detailed information regarding their size of potential development was not available at the time of this study, further discussion is impossible at this point.

Marion reservoir is located on a tributary of the Cottonwood river, part of the Neosho river basin, in Marion county. Although this structure is designed primarily for flood control, it is estimated some 7,000 acres below the reservoir could be irrigated through the use of stream bank pumping plants.[1] Modification of storage allocations in Marion reservoir to include 21,000 acre feet for irrigation would permit irrigation development of arable lands below the reservoir. Lowhead pumps would directly divert reservoir releases from the streams to nearby lands. Distribution of water could in most instances be made directly by gravity flow over the lands through field ditches. Certain circumstances might warrant distribution by sprinkler system or pipeline, however.

As indicated by Fig. 3, Cedar Point reservoir is situated on another tributary of the Cottonwood river, also in Marion county. It is estimated stream bank pumping plants might serve about 4,000 acres below the dam.[2] Development of irrigation facilities would require modification of storage allocations in Cedar Point reservoir to include 10,000 acre feet of irrigation capacity. Diversion and distribution systems would be similar to those discussed for the Marion reservoir.

Ground Water. Occurrence of ground water in the central crop reporting district with yield potential in excess of 50 gallons per minute is limited mainly to three belts across the district as illustrated in Fig. 4. A few generally local areas have aquifers capable of yielding water flows in excess of 500 gallons per minute.

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1. Development of Water and Land Resources of the A-R-W River Basins, op. cit., p. 567.
2. Loc. cit.

The two northern belts of aquifers capable of yielding in the 50 to 500 gallons per minute category generally occur in the Saline and Smoky Hill river valleys. The alluvium and terrace deposits in these stream valleys are the primary source of water availability. Yields of a few hundred gallons per minute can usually be obtained at relatively shallow depths.

The third and major area of ground water occurrence in terms of yield potential is situated along the southern edge of this district in parts of Rush, Barton, Rice, and McPherson counties. As indicated by Fig. 4, a considerable portion of this area has water yielding formations with yield capacities in excess of 500 gallons per minute. It is estimated the quantity of available ground water in storage in Barton, Rice, and McPherson counties to be in excess of 7,750,000 acre feet.[1] In the southern portion of McPherson county is situated part of the Equus Beds formation, a major ground water aquifer extending into the south central district. Aquifers in the above three county area range up to 160 feet in saturated thickness with very high rate yield potentials.[2]

The remainder of the central district generally has water producing capabilities of less than 50 gallons per minute, except for local situations. Although wells capable of supplying livestock and domestic needs may be obtained in these areas, no general irrigation development potential exists.

Expected Irrigation Development, 1975. The acreage projections of 1975 irrigation development in Kansas presented in this study were developed by Kansas State University personnel for use by the Kansas Water Resources Board. The projections, on the basis of watershed units, were made available for this study by the Water Resources Board. In deriving the projections, attention was

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1. State Water Plan Studies, Part A: Preliminary Appraisal of Kansas Water Problems. Section 4. Lower Arkansas Unit. Kansas Water Resources Board, p. 54.
2. Ibid., p. 80.

given to past trends in irrigated acreage, and to the factors of land, surface, and ground water supplies previously discussed. An effort was made to ascertain that realization of projected expansion would be consistent with available and relative supplies of physically irrigable lands and ground and/or surface water supplies with which to irrigate these lands. Land characteristics considered pertained to soil structure, texture, depth, and to slope. Ground water supplies were investigated to estimate geological and areal extent and location, yield characteristics of relevant aquifers, extent of present development and future development potentials in terms of physically and economically derivable supplies. Consideration of surface water supplies was directed toward stream flow characteristics, present, planned, and potential reservoir development, and the possibilities for project type irrigation development below these reservoirs.

The 1975 irrigation acreage projection for the central crop reporting district was 134,400 acres as indicated by Table 4. This compares with 35,600 acres irrigated in 1960. Some 1,724,200 acres in this district are considered irrigable on the basis of physical land characteristics, with 522,600 of these acres overlying an aquifer with water-bearing potential capable of irrigation development. By comparison, 64,200 acres in this district have been indicated for possible project type surface water development (see Table 2). It would appear that the Kanopolis Unit is the only project type irrigation development in this district likely to be in service by 1975. Development of this project would probably provide surface water supplies to somewhat less than 40,000 acres. Thus, it would appear that between 90,000 and 100,000 acres of the 1975 projected 134,400 acre irrigation development would be private development of ground and and to a lesser extent surface water supplies.

South Central Crop Reporting District

Physical Soil Characteristics.[1] Bidwell has identified 10 soil associations occurring in the south central crop reporting district. In the northwest corner covering parts of Pawnee and Edwards counties is the previously described Hastings, Holdrege, Colby association. Across the northeast corner of the district extends a band of Crete, Goessel association soils, discussed in the central district. Harvey, the northeast county in the district, also contains a small area of the Crete, Ladysmith, Kipp, Idana association. A thin band of the Sogn, Summit, Florence, Idana association, discussed in the northeast district, occurs along the eastern edge of Harvey and Sedgwick counties. A wide belt of Alluvial soils extend along the Arkansas river valley as it crosses Reno, Sedgwick, and Sumner counties. As in other parts of the state, these water deposited soils are characterized by their variability and generally high productivity.

The most widely dispersed soils area in this district is comprised of the Pratt, Albion, Derby association. These brown and dark brown sandy loam and loam soils occur mainly on undulating to hummocky relief. The Pratt and Derby soils are derived from aeolian and outwash sand material while parent material for the Albion soil is old alluvium. Soils in this association are generally characterized by moderate to rapid permeability. Parts or all of Edwards, Kiowa, Stafford, Pratt, and Reno counties, comprise the area in which this association occurs.

Much of the south half of Kiowa county is covered by the Canyon, Mansker association. As indicated previously, these steeply sloping, highly eroded soils are not suitable for cultivation.[2]

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1. Based on Bidwell, op. cit.
2. See Physical Soil Characteristics, southwest district.

In the northwest portion of Comanche county is situated the Grant, Albion, Vernon, Renfrow association. A larger area of these soils exists in the south central part of the district extending from Reno county over most of Kingman and Harper counties. These reddish brown and brown silt loam, loam, and clay (Vernon) soils occur on undulating rolling, and occasionally hilly relief. The Grant silt loam comes from red clay and loess parent material and has moderate permeability. Albion loam formed from old alluvium has moderate to rapid permeability. The Vernon silty clay and Renfrow silt loam were developed from red calcareous clay and red clay respectively. Both have very slow permeability.

The southwest corner of Comanche county has an area of Dune Sand, Tivoli soils. A descriptive account of these soils is given under the southwest crop reporting district, where this association occurs more widely.

A ninth soil association found in the south central district is the Vernon, Quinlan, Albion. These soils, located mainly in Barber and Comanche counties and adjacent Kiowa, Pratt, and Harper counties, occur mostly on hilly relief. The reddish brown and brown Albion silt clay loam is formed from red calcareous clay and has very slow permeability. Quinlan very fine silt loam with red calcareous packsand as parent material exhibits rapid permeability. Old alluvium is the parent material from which is formed the Albion loam soil. This soil has moderate to rapid permeability.

An association composed of Idana, Renfrow, and Kipson soils is located in the southeast area of this district. The dark clay and claypan residual soils of this region occur predominately in Sumner county, with smaller areas in Harper, Kingman, and Sedgwick counties. These dark grayish brown and brown silt loam and silty clay loam soils occur on nearly level to gently rolling relief. The Idana silty clay loam is formed from shales and loess and has slow to very slow permeability. The Renfrow silt loam, formed from red clay, shows very slow permeability. Kipson silt loam with moderate permeability is formed from parent material of shales and limestone.

Figure 2 indicates the general location of lands in this district suitable for irrigation on the basis of slope, structure, texture, and depth. On Table 1, 1,728,400 acres are listed as being physically suited to irrigation. Lands with less than 2 percent slope include 794,400 acres of bottom and terrace land and 777,600 acres of upland. An additional 156,500 acre, predominately upland, is physically suited to irrigation except for somewhat greater slopes of 2 to 5 percent.

Potential Water Supplies. Surface water. The Wichita irrigation project is a proposed multipurpose development in the Arkansas river basin southwest of Wichita. It consists of two divisions designed to provide flood control for the area and a municipal water supply for the city of Wichita.[1] The Cheney division, located on the North Fork Ninnescah river about 25 miles west of Wichita, consists of the Cheney dam and reservoir. The dam, a rolled earth structure, will provide a total storage capacity of 208,500 acre feet as indicated by Table 2. The Murdock division, with the Murdock dam and reservoir, is situated on the South Fork Ninnescah river about 32 miles southwest of Wichita. Table 2 indicates a total storage capacity of 120,000 acre feet. Although no irrigation storage is allocated for either of these divisions, the flood control provided by each of them would permit irrigation development by groups or individuals of some 11,000 acres downstream from the dams. These lands, presently subject to inundation, occur in small scattered tracts and are adaptable to private development. It is expected that reservoir seepage and inflow below the dams would provide these lands with an adequate water supply.

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1. Development of Water and Land Resources in the A-W-R River Basins, op. cit., p. 240.

The Kiowa irrigation project is located in Barber county, Kansas, and Alfalfa county, Oklahoma. Kiowa dam would be located on the Medicine Lodge river approximately 10 miles north of Kiowa, Kansas. This is a multipurpose project designed to provide flood protection and irrigation service.[1] Storage facilities would be provided by a rolled earth fill dam having a crest length of 15,490 feet. An allocation of 87,000 acre feet has been designated for irrigation purposes. "Irrigation facilities would consist of a main canal 11.8 miles long with a capacity of 335 cubic feet per second; a west branch 6.6 miles in length with a capacity of 165 cubic feet per second; and an east branch 2.2 miles long with a capacity of 45 cubic feet per second."[2] A water supply and distribution works to service 20,000 acres of arable land would be provided by this project. Some 2,000 acres would be served directly from the main canal, with the east and west branches serving 8,500 acres and 9,500 acres respectively.

The Chikaskia multiple-purpose project is located on the Chikaskia river, part of the Arkansas river basin, in Sumner county. It is designed to provide flood control, water supply, and limited irrigation development.[3] Some 10,000 acres in Kansas and Oklahoma are considered irrigable under the project.[4] It is estimated that 1.83 acre feet per irrigated acre would annually be required for irrigation purposes.[5] Tracts near the Corbin dam (see Fig. 3) would be served by gravity canal diverting directly from the dam. Areas further downstream would be served by pumping reservoir releases directly from the stream, into a gravity canal which would carry the water supply to the lands.

<u>Ground Water</u>. As indicated by Fig. 4, portions of the south central crop reporting district are characterized by very abundant ground water supplies.

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1. <u>Ibid</u>., p. 264.
2. <u>Loc. cit</u>.
3. <u>Ibid</u>., p. 267.
4. Barclay, <u>loc. cit</u>.
5. <u>Development of Water and Land Resources in the A-W-R River Basins</u>, <u>loc. cit</u>.

"The best sources of ground water in the district are the sands and gravels of the Quaternary system."[1] A very important ground water area, in terms of present use, exists in the northern portion of the district in parts of Harvey, Sedgwick, and Reno counties and extends into McPherson county in the central district. This area is known as the Equus Beds. "Large quantities of ground water are also available in an area encompassing northern Pratt, southern Stafford, and southeastern Edwards counties."[2] Dune-sand areas in the northwest portion of the district provide important avenues of recharge to the underlying aquifers, although they are not particularly good sources of ground water themselves.

In a recent study of the Lower Arkansas watershed unit which includes part or all of each county in the south central district, estimates were presented of total available ground water in storage in each county or part of county in the unit.[3] Converted to a crop reporting district basis these estimates would indicate a total in excess of 50 million acre feet of available ground water stored in unconsolidated deposits in the south central crop reporting district. The above yield estimates were derived through determinations of the porosity, specific yield, and saturated thickness of ground water aquifers underlying the area. "The porosity and thickness of saturated rocks determine the gross amount of water in storage in the aquifer. The specific yield essentially represents the net amount of water it is physically possible to withdraw after deducting the quantity of water in storage that the aquifer will retain against the pull of gravity."[4] A figure of 15 percent has been selected by the U.S. Geological Survey as being a reasonable average specific yield for this area.[5]

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1. State Water Plan Studies. Section 4. Lower Arkansas Unit. Op. cit., p. 29.
2. Loc. cit.
3. Ibid., p. 81.
4. Loc. cit.
5. Loc. cit.

The above estimates of available ground water are believed to be reasonably indicative of the amount it would be physically possible to withdraw from storage through well pumpage. "The economics of pumping would probably preclude actual withdrawal of this much of the water." It is suggested, however, that if no more than 50 percent of the foregoing estimate be taken as usable ground water in storage, a very sizable supply would still be in existence.[1]

Expected Irrigation Development, 1975. The acreage projections of 1975 irrigation development in Kansas presented in this study were developed by Kansas State University personnel for use by the Kansas Water Resources Board. The projections, on the basis of watershed units, were made available for this study by the Water Resources Board. In deriving the projections, attention was given to past trends in irrigated acreage, and to the factors of land, surface and ground water supplies previously discussed. An effort was made to ascertain that realization of projected expansion would be consistent with available and relative supplies of physically irrigable lands and ground and/or surface water supplies with which to irrigate these lands. Land characteristics considered pertained to soil structure, texture, and depth, and to slope. Ground water supplies were investigated to estimate geological and areal extent and location, yield characteristics of relevant aquifers, extent of present development and future development potentials in terms of physically and economically derivable supplies. Consideration of surface water supplies was directed toward stream flow characteristics, present, planned, and potential reservoir development, and the possibilities for project type irrigation development below these reservoirs.

The 1975 irrigation acreage projections for the south central crop reporting district was 191,700 acres as indicated by Table 4. This compares with 35,600 acres irrigated in 1960. Some 1,728,400 acres in this district are considered irrigable on the basis of physical land characteristics, with 1,163,100 of these acres over-

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1. Ibid., p. 83.

lying an aquifer with water-bearing potential capable of irrigation development. By comparison some 35,000 acres in this district have been indicated for possible project type surface water development (see Table 2). It is not expected that any of this acreage will be developed by 1975.[1] This would indicate that the major part of the 191,700 acres projected for 1975 irrigation development would be irrigated with privately developed ground water supplies with some generally minor and probably variable private development of stream bank pumping units.

Northeast Crop Reporting District

<u>Physical Soil Characteristics</u>.[2] Six soil associations described by Bidwell fall within the northeast crop reporting district. Portions of Marshall and Riley counties in the west end of this district contain the Crete, Ladysmith, Kipp, Idana association. These soils have been described in the north central crop reporting district. The Blue and Kansas river valleys are characterized by Alluvial soils. These water deposited soils are highly variable but usually of high productivity.

The Sogn, Summit, Florence, Idana association extends across Marshall, Riley, and Pottawatomie counties on both sides of the Blue river. Sogn and Summit silty clay loams are derived from limestone and calcareous shales. They have moderate and moderately slow permeability respectively. The Florence cherty silty clay loam has moderate permeability. Its parent material is cherty limestone. Idana silty clay loam, formed from shales and loess, has slow to very slow permeability. These mostly thin, rocky soils are best adapted to permanent grasses. This group of soils characterizes the entire region known as the Flint Hill-Bluestem pasture area of Kansas.

Well over half the land area in this district is covered by the Grundy, Crete, Pawnee, Burchard, Shelby soil association. These are very dark brown and dark

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1. Barclay, <u>loc</u>. <u>cit</u>.
2. Based on Bidwell, <u>op</u>. <u>cit</u>.

grayish brown silty clay loam soils. Grundy and Crete are loessial soils occurring on the nearly level divides. These silty clay loam soils are slow to very slow in permeability. The latter three soils are of glacial till origin and are found mostly on undulating to rolling relief. They have very slow, moderate, and moderately slow permeability respectively.

The remaining two associations in the district lay in two relatively narrow belts which border along the Missouri river. Immediately adjacent to the river is the Monoma, Marshall association. These are grayish brown and dark brown silt loams and light silty clay loams. The Monoma silt loam, a loess soil with moderately rapid permeability, occurs on rolling to hilly relief. The Marshall, a silt loam loess soil is found on undulating to rolling relief. It is of moderate permeability.

Along the Monoma, Marshall association is the Sharpsburg, Shelby, Marshall association. These dark grayish brown silty clay loam soils are generally found on undulating relief. The Sharpsburg and Marshall soils are of loess origin while the Shelby is derived from glacial till. They range from moderate to moderately slow in permeability.

Irrigation in this district is considered possible for a total of 1,586,200 acres on the basis of physical characteristics. Table 1 lists a general breakdown of these lands according to slope and topographic location. Over half the total is comprised of upland with 2 to 5 percent slope. The 19,600 irrigable acres of upland have less than 2 percent slope while 593,700 acres of irrigable bottom and terrace land with less than 2 percent slope are indicated. The general location of these lands is indicated in Fig. 2.

Potential Water Supplies. Surface water. A number of proposed surface water development projects are located in the northeast crop reporting district. Tuttle Creek dam and reservoir is located on the Blue river directly north of

Manhattan. This Corps of Engineers project, now nearly completed, has no provision for irrigation development. Four other reservoirs in this district are currently being investigated by the Corps of Engineers. As indicated by Fig. 3, only one of them, Perry reservoir on the Delaware river, has been authorized. Present storage allocations for this project, as in the case of Tuttle Creek, include no irrigation storage.[1] The three additional reservoirs currently under investigation by the Corps of Engineers are the Camp Creek reservoir on Camp Creek, the Onaga reservoir on Vermillion Creek, and the Grove reservoir on Soldier Creek. Present irrigation storage allocations for these projects are 67,000, 90,000, and 88,000 acre feet respectively. Bureau of Reclamation irrigation projects designed to utilize the flows from these reservoirs are located on the fertile bottomlands of the Kansas river valley between Manhattan and Lawrence. As indicated on Fig. 3, six irrigation development units falling partially or wholly within the northeast crop reporting district, are currently planned for this area. They are the Wamego unit, Belvue unit, Rossville unit, Menoken unit, Grantville unit, and Perry unit. Current potential irrigation acreage figures for each of these units were not available at the time of this writing.

<u>Ground Water</u>. Aquifers in the northeast crop reporting district with yield capacities in excess of 500 gallons per minute are limited to the Blue, Kansas, and Missouri river valleys as indicated by Fig. 4. Areas in which yields of 50 to 500 gallons per minute are generally available may be found in parts of Marshall, Riley, and Pottawatomie counties in the western portion of the district. Formations capable of yielding large quantities of good quality water are generally lacking over the rest of the district.[2]

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1. State Water Plan Studies, <u>Section 3. Kansas Unit</u>, <u>op. cit</u>., p. 161.
2. <u>Ibid</u>., p. 74.

The Pennsylvanian, Permian, Cretaceous, and Quaternary systems of rocks all figure in the geological ground water picture of this district. Of the first three systems only the Chase formation in the Permian system and the Dakota formation in the Cretaceous system yield sizable amounts. These two groups may produce up to 400 and 300 gallons per minute respectively in local areas with properly developed wells. The Dakota formation is the most important aquifer in the western portion of the district.[1] Other groups in the above mentioned three systems generally produce only limited outputs of water except in isolated cases.

Much of the ground water used in this district is derived from rocks of the Quaternary system. The origin of these deposits is closely associated with the occurrence of glacial ice sheets in this area. Deposits from the Kansas and other ice sheets were dumped in then existing low areas and stream beds. Where these unconsolidated deposits today lie below the water table in considerable thickness they may provide quite high well yields.[2]

The most important ground water reservoir in this district is the deposits of silt, clay, sand, and gravel underlying the valley floor of the major rivers and their main tributaries.[3] At points of maximum saturated thickness of the sands and gravels penetrated, wells yielding up to 2,000 gallons per minute can be constructed in these areas.

While more information is needed about the ground water situation in the river valley alluvium of this district before definite conclusions might be drawn, preliminary studies and investigations imply no over-all threat of a continually declining water table and no substantial depletion of ground water supplies.[4]

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1. Ibid., p. 77.
2. Ibid., p. 78.
3. Ibid., p. 79.
4. Ibid., p. 173.

<u>Expected Irrigation Development, 1975</u>. The acreage projections of 1975 irrigation development in Kansas presented in this study were developed by Kansas State University personnel for use by the Kansas Water Resources Board. The projected estimates, on the basis of watershed units, were made available for this study by the Water Resources Board. In deriving the projections, attention was given to past trends in irrigated acreage, and to the factors of land, surface and ground water supplies previously discussed. An effort was made to ascertain that realization of projected expansion would be consistent with available and relative supplies of physically irrigable lands and ground and/or surface water supplies with which to irrigate these lands. Land characteristics considered pertained to soil structure, texture, and depth, and to slope. Ground water supplies were investigated to estimate geological and areal extent and location, yield characteristics of relevant aquifers, extent of present development and future development potentials in terms of physically and economically derivable supplies. Consideration of surface water supplies was directed toward stream flow characteristics, present, planned, and potential reservoir development, and the possibilities for project type irrigation development below these reservoirs.

The 1975 irrigation acreage projection for the northeast crop reporting district was 77,800 acres as indicated by Table 4. This compares with 11,000 acres irrigated in 1960. Some 1,586,200 acres in this district are considered irrigable on the basis of physical land characteristics, with 152,100 of these acres overlying an aquifer with water-bearing potential capable of irrigation development. By comparison some 50,000 acres in this district have been indicated for possible project type surface water development (see Table 2). It is not expected that any of this acreage will be developed by 1975 (see Table 3). This would indicate the 77,800 acres expected to be irrigated in this district would be private development of ground and surface water supplies.

East Central Crop Reporting District

Physical Soil Characteristics.[1] The east central district, a 14-county area, includes nine of the soil associations which have been defined by Bidwell. A number of these associations have been described in previous crop reporting districts. The northern "panhandle" area of Geary county and parts of Morris county are covered with the Crete, Ladysmith, Kipp, Idana association, discussed under the north central crop reporting district. An area along the north side of the district including parts of Wabaunsee, Shawnee, Douglas, and Johnson counties is characterized by the Grundy, Crete, Pawnee, Burchard, Shelby association described in the northeast district. The Monoma, Marshall and Sharpsburg, Shelby, Marshall associations, also described in the northeast crop reporting district, occur over the northeast one fourth of Johnson county. The flood plains and terraces in the valleys of the Kansas, Marais des Cygnes, Neosho rivers and their tributaries are typically characterized by Alluvial soils. Much of the five eastern counties in this district fall within the Flint Hills-Blue Stem pasture area of Kansas. As indicated in the Northeast district, the soil association of this area includes the Sogn, Summit, Florence, and Idana soils.

Of the three remaining associations in this area, the Summit, Woodson, Labette, Bates is the most extensive in occurrence. These very dark grayish and dark brown silt loam soils occur on undulating to nearly level relief. The Summit silty clay loam and Labette silt loam are formed from limestone and calcareous shales. The former has moderately slow permeability while the latter is moderate in this respect. Parent material for Woodson silt loam were the calcareous shales. This soil exhibits very slow permeability. The Bates loam, formed from sandstone and sandy shales, has moderate permeability.

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1. Based on Bidwell, op. cit.

An area extending north and south through the center of Anderson county and the eastern third of Linn county is occupied by the Woodson, Parsons, Labette, Bates association. These are very dark grayish brown and dark brown silt loams and loams (Bates) occurring on level to undulating relief. The Woodson and Parsons silt loam soils are formed from calcareous shales and acid shales respectively and have very slow permeability. The Labette silt loam is formed from limestone and calcareous clays. Bates loam comes from sandstone and sandy shales. Both these latter soils have moderate permeability.

Lastly in this district is the Darnell, Stephenville, Dennis, Boone association extending across the southeast corner of Coffey county, along the eastern edge of Anderson county, and into the southwest corner of Franklin county. Composed of grayish brown and brown sandy loams and loams, this association is found on undulating to rolling topography. The Darnell and Stephenville fine silt loams are derived from sandstone and have rapid and moderate permeability respectively. Dennis silt loam with sandy, silty, and clayey shales as parent material has moderately slow permeability. Boone fine silt loam is moderately permeable soil derived from sandstone or sandy shales.

Physically irrigable lands in this district stand at 1,000,250 acres as indicated in Table 1. Observation of Fig. 2 reveals that much of this acreage occurs along the river valleys. Some 627,050 acres of bottom and terrace land with less than 2 percent slope are considered irrigable on the basis of slope, depth, texture, and structure. There are only 13,800 acres of irrigable upland with slopes of less than 2 percent. The balance of the irrigable acres is predominately uplands with 2 to 5 percent slope.

Potential Water Supplies. Surface water. Two of the potential reservoir sites in the east central crop reporting district are located in the Kansas river basin. Humboldt reservoir is situated in the northwest corner of the district on Clark Creek. Under investigation by the Corps of Engineers, this project is presently allocated 5,000 acre feet of irrigation storage.[1] No irrigation development unit is immediately associated with it. The Clinton reservoir is located on the Wakarusa river southwest of Lawrence. Also under investigation by the Corps of Engineers, this multipurpose flood control, irrigation project has a present allocation of 85,000 acre feet for irrigation storage purposes.[2] It would provide irrigation service to the Lawrence irrigation unit, extending from below the dam to the city of Lawrence.

Two additional reservoirs in this district are part of the Grand (Neosho) river basin irrigation project. The Council Grove and Strawn reservoirs are both authorized as indicated by Fig. 3. Irrigation development in this area would involve stream bank pumping plants serving discontinuous tracts along the main streams below the dam sites.[3] Modification of Council Grove reservoir to provide 15,000 acre feet of irrigation storage capacity would provide for the irrigation development of 4,900 acres below the dam. Irrigation works would consist of low head pumps diverting reservoir releases directly from the streams to nearby lands. Generally distribution could be effected by gravity systems although in certain cases, pipelines and sprinklers would be required. "Strawn reservoir would require modification so as to provide 19,000 acre feet of storage capacity for irrigation in order to provide water for irrigation development of 10,500 acres below the dam."[4] Water supply and distribution would be based on the same pattern as for Council Grove reservoir above.

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1. State Water Plan Studies. <u>Section 3</u>. <u>Kansas Unit</u>, <u>op</u>. <u>cit</u>., p. 163.
2. <u>Loc</u>. <u>cit</u>.
3. <u>Development of Water and Land Resources of the A-W-R River Basins</u>, <u>op</u>. <u>cit</u>., p. 567.
4. <u>Loc</u>. <u>cit</u>.

The four remaining reservoir sites in the east central crop reporting district are all located in the Marais des Cygnes river basin. Pomona reservoir on 110 Mile Creek is under construction. The other three, Melvern reservoir on the Marais des Cygnes river, Garnett reservoir on Pottawatomie Creek, and Hillsdale reservoir on Big Bull Creek have each been authorized.[1] Relative locations of these projects is indicated on Fig. 3. The above structures are under development by the Corps of Engineers. They are designed primarily to provide flood protection to downstream areas. No project type irrigation development is presently planned for these reservoirs.

Ground Water. Much of the east central crop reporting district is lacking in ground water reservoirs capable of yielding large quantities of good water. As indicated by Fig. 4, areas in which yields of 50 to 500 gallons of water a minute are generally available are limited mainly to parts of the western tier of counties in the district. Yield potentials in excess of 500 gallons per minute are not found outside the vicinity of the Kansas river valley along the north edge of the district.

The Douglas group of the Pennsylvanian system consisting of the Lawrence shale and underlying Stranger formation extends across parts of Douglas, Franklin, and Anderson counties. Yields of 25 to 150 gallons per minute may be obtained in very local areas from these formations, but in many of the upland areas yields are limited to less than one gallon per minute.[2] Wisconsinan and Recent Alluvium aquifers consisting of deposits of streamlaid gravel, sand, silt, and clay of Wisconsinan and Recent Age provide wells yielding up to 50 gallons per minute in the Upper Marais des Cygne valley under favorable conditions.[3] Well yields

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1. State Water Plan Studies. Part A: Preliminary Appraisal of Kansas Water Problems. Section 1. Marais des Cygnes Unit. Kansas Water Resources Board, June, 1958, p. 131.

2. State Water Plan Studies. Section 1. Marais des Cygnes Unit, op. cit., p. 65.

3. Ibid., p. 67.

obtainable in the alluvium and terrace deposits of the portions of the Kansas river valley in this district are similar to those discussed for the northeast district. Cherty limestone aquifers belonging to the Chase and Council Grove groups of Permian extend across the western end of the district. Although some water can usually be obtained from these formations, yields are variable and generally not of sufficient volume to be considered potential sources of irrigation water. Over much of the district the above discussed aquifers yield no water. In many locations in this district dependable supplies of domestic and stock water are difficult to obtain, and supplies adequate for municipal, industrial, or irrigation use are not obtainable.[1]

Expected Irrigation Development, 1975. The acreage projections of 1975 irrigation development in Kansas presented in this study were developed by Kansas State University personnel for use by the Kansas Water Resources Board. The projected estimates, on the basis of watershed units, were made available for this study by the Water Resources Board. In deriving the projections, attention was given to past trends in irrigated acreage, and to the factors of land, surface and ground water supplies previously discussed. An effort was made to ascertain that realization of projected expansion would be consistent with available and relative supplies of physically irrigable lands and ground and/or surface water supplies with which to irrigate these lands. Land characteristics considered pertained to soil structure, texture, and depth, and to slope. Ground water supplies were investigated to estimate geological and areal extent and location, yield characteristics of relevant aquifers, extent of present development and future development potentials in terms of physically and economically

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1. Ibid., p. 68.

derivable supplies. Consideration of surface water supplies was directed toward stream flow characteristics, present, planned, and potential reservoir development, and the possibilities for project type irrigation development below these reservoirs.

The 1975 irrigation acreage projection for the east central crop reporting district was 54,600 acres as indicated by Table 4. This compares with 14,400 acres irrigated in 1960. Some 1,000,250 acres in this district are considered irrigable on the basis of physical land characteristics with 53,500 of these acres overlying an aquifer with water-bearing potential capable of irrigation development. By comparison some 15,400 acres in this district have been indicated for possible project type surface water development (see Table 2). It is not anticipated at this time that any of this project development will have been completed by 1975.[1] Thus it would appear the projected 1975 irrigated acreage of 54,600 acres would be private development utilizing ground and surface water supplies. The limited availability of ground water supplies in this district would imply that a considerable proportion of irrigation expansion would rely on surface water sources, i.e. stream bank pumping, etc.

Southeast Crop Reporting District

Physical Soil Characteristics.[2] Of the eleven soil associations as defined by Bidwell which are found in this district, eight occur and have been described in other crop reporting districts. The Crete, Ladysmith, Kipp, Idana association is found in a small area in the northwest corner of Butler county. These claypan

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1. Barclay, *loc. cit.*
2. Based on Bidwell, *op. cit.*

soils are discussed in the north central district. The west central portion of Cowley county is occupied by another claypan association, the Crete, Goessel. It is described in the central district. The Flint Hills Sogn, Summit, Florence, Idana association, described in the northeast district, covers much of the western half of the southeast district including Butler, Cowley, Greenwood, Elk, and Chautauqua counties. Immediately to the east of this lies a belt of the Darnell, Stephenville, Dennis, Boone association described in the east central district. Most of Allen and parts of Woodson and Wilson counties are occupied by the Woodson, Parsons, Labette, Bates association. In the northeast part of the district, including most of Bourbon and part of Anderson and Neosho counties, occurs the Summit, Woodson, Labette, Bates association. The soils of each of these latter two associations are discussed in the central crop reporting district. Alluvial soils occur in the valleys of main streams and tributaries of the Neosho, Walnut, and Verdigris rivers.

The area occupied by Labette, Neosho, and Crawford and small parts of adjacent counties is covered by the Parsons, Dennis, Bates soil association. These grayish brown and dark brown silt loam and loam soils are found primarily on nearly level to undulating relief. The Parsons silt loam, formed from acid shales has very slow permeability. Sandy, silty, and clayey shales are the parent material from which the Dennis silt loam has been formed. This soil has moderately slow permeability. Bates loam is a moderately permeable soil formed from sandstone and sandy shales.

Cherokee county in the southeast corner of the state and the edge of Crawford county directly to the north are characterized by the Cherokee, Taloka, Parsons, Dennis, Bates association. The first three of these silt loam soils have a distinct claypan which reduces moisture penetration resulting in very slow permeability. These are grayish brown silt loam soils, which occur on nearly level areas. The Dennis and Bates dark grayish brown to dark brown silt loams and loams normally occur on well drained undulating relief. Parent material is sandy, silty, and clayey shales and sandstone and sandy shales for the Dennis silt loam and Bates loam respectively. They are moderately slow to moderate in permeability.

In the extreme southeast corner of Cherokee county is an area of the Bodine soil association. These grayish brown and brown sandy loams and loams occur on undulating to rolling topography. The Bodine cherty silt loam is formed from cherty limestone and has moderate permeability.

Very little upland in this district is suited to irrigation on the basis of physical characteristics such as slope, depth, structure, and texture. Table 1 shows a total of 721,900 acres physically adapted to irrigation. Of these 714,700 acres are found on bottom and terrace land locations. The remaining 7,200 acres are situated on uplands with less than 2 percent slope.

Potential Water Development. Surface water. The Walnut river system located on the mainstem and tributaries of the Walnut river would provide flood control, water supply, and irrigation along valley lands below proposed dams.[1] Preliminary investigations by the Corps of Engineers on potential storage structures in the Walnut basin were completed in the spring of 1960.[2] These studies indicated the possible justification of the Towanda and El Dorado reservoirs illustrated on Fig. 3. Towanda reservoir on Whitewater river has a preliminary total storage allocation of 240,000 acre feet. El Dorado reservoir on the East Branch Walnut river has a preliminary total storage allocation of

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1. Development of Water and Land Resources of the A-W-R River Basins, op. cit., p. 248.
2. State Water Plan Studies. Part A: Preliminary Appraisal of Kansas Water Problems. Section 5. Walnut-Verdigris Unit. Kansas Water Resources Board, June, 1960, p. 96.

224,700 acre feet.[1] Potential irrigation development of arable lands in the Walnut river valley depends upon future development and regulation of the above potential reservoirs, plus abatement of prevalent pollution problems in the watershed. Discontinuous tracts of irrigable lands occur mainly in the valley alluvium of the main stream. It is estimated some 11,400 acres could be served by stream bank pumping units.[2] Regulated releases from Towanda and El Dorado reservoirs together with return flow and tributary inflow would provide an adequate irrigation water supply.

The authorized Fort Scott reservoir in the northeast part of this crop reporting district is located on the Marmaton river. A Corps of Engineers project designed primarily for flood control, the Fort Scott development has no currently planned irrigation development. Total allocated storage capacity is 137,000 acre feet for this reservoir.

Extensive irrigation development in the Verdigris river basin is closely keyed to the development of the four remaining reservoirs in the southeast crop reporting district, Fall River, Toronto, Neodesha, and Elk City (see Fig. 3). Although these are Corps of Engineers projects designed primarily for flood control, modification of storage allocations to provide irrigation releases could provide water for the development of some 19,800 acres in this river valley.[3] The irrigable lands are situated in discontinuous tracts along main streams and tributaries below potential reservoirs. About 200 stream bank pumping plants would be required to serve individual bodies of land ranging in size from 10 to 750 acres. Water distribution generally could be accomplished through gravity flow field ditches although in some situations, pipelines or

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1. *Loc. cit.*
2. *Loc. cit.*
3. *Development of Water and Land Resources of the A-W-R River Basins*, *op. cit.*, p. 568.

sprinkler systems would be necessary. As previously indicated, certain modifications in storage allocations to permit retainment of water for irrigation purposes would be necessary. Toronto reservoir on the Verdigris river would require impoundment of 2,000 acre feet for irrigation purposes. Neodesha reservoir, also on the Verdigris river would receive a 3,000 acre foot allocation for irrigation purposes. Fall River reservoir on the Fall river and Elk City reservoir on the Elk river would each be allocated 4,500 acre feet for irrigation storage. As indicated on Fig. 3, the Toronto and Fall River structures are completed, while the Neodesha and Elk City developments have been authorized.

Ground Water. As implied by the ground water map on Fig. 4, ground water supplies in the southeast district are quite limited. "Accordingly, detailed ground water investigations have also been limited."[1] In only a small area of Cowley county in the Arkansas river valley are yields over 500 gallons per minute of water generally available in this district. Areas of the district in which yields of from 50 to 500 gallons per minute of water are generally available include most of Butler and Cowley counties in the west end of the district and parts of Bourbon, Crawford, and Cherokee counties in the southeast corner of the district.

Alluvial aquifers, streamlaid deposits of sand, gravel, silt, and clay of Pleistocene age occur locally in the uplands and more extensively in the major stream valleys. Although the aquifers are not extensive in occurrence, they are one of the largest yielders in the district in favorable formations. "Yields range from only one-fourth gallon per minute in areas where silt and clay form a large part of the saturated deposits to as much as 300 gallons per minute

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1. State Water Plan Studies. Section 5. Walnut-Verdigris Unit, op. cit., p. 67.

where saturated, permeable gravel predominates."[1] The Chase group of Cherty limestone aquifers provide water locally across much of Cowley and Butler counties. A number of municipal users and many farm and livestock needs are provided from these formations. The yield ranges of generally up to 150 gallons per minute are not adequate for field irrigation operations.[2] Wells from 850 to 1,100 feet deep in the Cambro-Ordovician rocks produce yields of fresh to brackish water up to 1,000 gallons per minute over the Bourbon, Crawford, and Cherokee county area.[3]

In other parts of the unit, formations capable of supplying limited to moderate domestic and livestock water needs exist locally. However, in general ground water supplies in this district are inadequate for more than very local and probably quite restricted irrigation development.

Expected Irrigation Development, 1975. The acreage projections of 1975 irrigation development in Kansas presented in this study were developed by Kansas State University personnel for use by the Kansas Water Resources Board. The projected estimates, on the basis of watershed units, were made available for this study by the Water Resources Board. In deriving the projections, attention was given to past trends in irrigated acreage, and to the factors of land, surface and ground water supplies previously discussed. An effort was made to ascertain that realization of projected expansion would be consistent with available and relative supplies of physically irrigable lands and ground and/or surface water supplies with which to irrigate these lands. Land characteristics considered pertained to soil structure, texture, and depth, and to slope. Ground water supplies were investigated to estimate geological and areal

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1. Ibid., p. 69.
2. Ibid., p. 70.
3. State Water Plan Studies. Section 1. Marais des Cygnes Unit, op. cit., p. 67.

extent and location, yield characteristics of relevant aquifers, extent of present development and future development potentials in terms of physically and economically derivable supplies. Consideration of surface water supplies was directed toward stream flow characteristics, present, planned, and potential reservoir development, and the possibility for project type irrigation development below these reservoirs.

The 1975 irrigation acreage projection for the southeast crop reporting district was 20,300 acres as indicated by Table 4. This compares with 6,700 acres irrigated in 1960. Some 721,900 acres in this district are considered irrigable on the basis of physical land characteristics with 13,300 of these acres overlying an aquifer with water-bearing potential capable of irrigation development (see Table 1). By comparison some 19,750 acres in this district have been indicated for possible project type surface water development (see Table 2). It is not anticipated at this time that any of this project development will have been completed by 1975.[1] Thus it would appear the projected 1975 irrigated acreage of 20,300 acres would be private development utilizing ground and surface water supplies. The limited availability of ground water supplies in this district would imply that a considerable proportion of irrigation expansion will rely on surface water sources, i.e. stream bank pumping, etc.

Prospects for Ground Water Depletion

"Ground water is the water which occurs in the saturated zone of an aquifer (the water-bearing formation often referred to as the ground water reservoir)

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1. Barclay, loc. cit.

and is the source of supply for wells and springs."[1] "The capacity of rocks to absorb, store, and yield ground water depends on many factors, including the number, size, and shape of the pores or openings. There are wide variations in the capacity of different rocks to yield water. The occurrence of ground water depends also on such factors as the position of the rock formations with respect to the land surface, the structure of the formations, the way they dip or are folded or faulted, the extent to which they are exposed to recharge, and the availability of water for recharge."[2]

"The quantity of water in storage in an aquifer depends on the saturated thickness of the water-bearing material and the average porosity. Many physical and economic factors combine to limit the amount of water in storage that can be ultimately withdrawn from an aquifer. Under favorable conditions, usable storage can probably be expected to approximate 50 percent of total storage."[3]

"The ground water table is not static but fluctuates upward and downward much as the water level of a surface reservoir. Under natural conditions and over a long period of time, most ground water aquifers maintain a state of approximate equilibrium in that natural discharge of water from the aquifer approximately equals natural recharge of the aquifer."[4]

> However, whenever a well withdraws water, there is a resulting drawdown, or lowering of the water table at the well and in the surrounding material. Drawdowns become greater as the rate of pumping increases. In an area of relatively large and continuous well withdrawals from an aquifer, a substantial lowering of the water table may take place, perhaps to the extent that most of the existing well installations will eventually have to be deepened or replaced. However, this situation does not result automatically, since the lowering of the water table by pumping increases the opportunity for recharge of the aquifer and tends to decrease the quantity of water discharged naturally from the aquifer. For instance, a material lowering of the water table as a result of well

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1. State Water Plan Studies. Section 6. Upper Republican Unit, op. cit., p. 54.
2. State Water Plan Studies. Section 2. Cimarron Unit, op. cit., p. 45.
3. Ibid., p. 84.
4. State Water Plan Studies. Section 4. Lower Arkansas Unit, op. cit., p. 87.

withdrawals could make more nonsaturated material available in the aquifer to receive recharge from the surface and from adjacent ground water areas. At the same time, this could result in a decrease in quantity of water formerly lost from the aquifer via natural discharge to streams, evapotranspiration near the surface, and movement into adjacent ground water areas. This situation could result in establishment of a new, relatively stable water table at a lower elevation than the original one. The necessity of replacing or deepening the wells would depend on the depth of the newly established water table. If, on the other hand, well development in an area becomes so concentrated and intensive that well withdrawals plus natural discharge exceed the recharge over an extended period of time, the water table will continue to lower as water is taken from storage in the aquifer, and a critical water shortage will result.[1]

"The principal short-run physical effects of a decline in water levels are reflected by a reduction in well capacities. The long-run effect is a depleted water supply. The types of special practices or adjustments induced by or associated with the decline in water supplies include: (1) increasing the number of hours of pump operation, (2) lowering pumps, (3) installing additional wells, (4) installing closed water-distribution systems, (5) installing smaller pumps in old wells, (6) decreasing the acreage of summer irrigated crops and increasing the acreage of crops irrigated in fall and winter, (7) staggering grain sorghum planting dates, (8) concentrating the available water supply on the highest value crop, (9) irrigating alternate rows, and (10) reducing the number of acres of cropland per irrigated farm."[2]

The preceeding paragraphs present a concentrated extraction from several sources of the general principles involved in the occurrence, characteristics, and conditions for depletion of ground water reservoirs. As to specific areas of Kansas, the west central, southwest, and parts of the south central crop reporting districts are heaviest users of ground water relative to total supplies. Present rates of withdrawal are certainly higher than rates of recharge in these

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1. Ibid., p. 96.
2. William F. Hughes and A. C. Magee, Some Economic Effects of Adjusting to a Changing Water Supply, Texas High Plains. Tex. Agr. Expt. Sta. Bul. 966. October, 1960, p. 2.

areas and if continued or increased point to critically diminishing supplies in storage at some time in the future. In general however, it is not felt that serious depletion has occurred to date, or that serious mining will have taken place by 1975. This is not to say that local areas will not have suffered substantial lowering of their water table or that increased investment and pumping costs will not be incurred. But rather it is suggested that present ground water reservoirs in the state will be sufficient to supply anticipated expansion in irrigation development by 1975 without there arising serious physical or economic consequences over any extended areas in the state.

ESTIMATION OF YIELD

Factors Affecting Crop Yields

Theoretical Conception. As in the case of the General Model of livestock feed production previously discussed, so also may the concept of crop yields be hypothetically expressed in terms of functional relationships.[1] Even though certain of the factors expressing a very direct relationship upon crop yields are of a qualitative and even nebulous nature, it is nevertheless useful in determining a theoretical approach to state these terms in a quantitative or simple mathematical form. The derivation of a theoretical functional expression involving the determination of crop yields, or more specifically increases in crop yields above a present normal or average level, requires the identification of those independent variables functionally associated with a dependent variable Y_1, increase in crop yields. For the purpose of this study the identification of those independent variables was accomplished by (1) a review of the causative

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1. See, Theoretical Problem and General Model, p. 4.

factors associated with yield increases as stated by previous studies, (2) an empirical examination of those factors which appear to exert a functional relationship upon crop yield increases under the specific conditions of Kansas agriculture, and (3) an extension, modification, and corroboration of the results suggested in steps 1 and 2 above through a series of interviews with crop scientists and research workers associated with the Kansas Agricultural Experiment Station.[1]

On this basis the following general functional equation was established,

$$Y_1 = f(X_B, X_C, X_F, X_I, X_O) \tag{1}$$

in which Y_1 is the increase in crop yields above a present normal or average yield, which may be expected to occur by a specified future time period. The functionally related independent variables are identified as: X_B, yield increases brought about through development of new varieties and/or hybrids, either by virtue of an inherently greater potential yield or through an increased hazard resistance, (e.g., greater insect and disease resistance, stiffer straw, earlier maturity, etc.) thus allowing a fuller and more consistent realization of an existing yield potential; X_I, yield increases brought about by a continued expansion in irrigation development; X_F, yield increases brought about by increased use of fertilizers by farmers; X_C, yield increases due to the development and practice of more optimal cultural methods, other than fertilization and irrigation, such as better mechanical and chemical weed and insect control, expanded use of summer fallow in areas of adaptation, improvement in timeliness and methods of seeding, tilling, and harvesting, and

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1. See, Procedure and Methodology, p. 22.

continued improvement in methods for establishment of optimum plant populations; and X_O, unidentified yield increases, of a generally insignificant nature, brought about by factors other than those listed above.

To further expand this hypothetical approach an additional series of four formal functional relationships were developed which were designed to depict the above independent variables in their effluence from and relationship to certain general principles. These general principles were defined as research (X_R), management (X_M), political restraints (X_P), and economic considerations (X_E). They may be conceived, in this theoretical scheme, as being abstract constituents out of which flow, or are generated, the more concrete entities defined as the independent variables in equation (1). In the following four equations, each independent variable of equation (1) becomes a dependent variable in its respective equation below, being functionally derived from various combinations of the general principles, which are the independent variables in these equations.

$$X_B = f(X_R + X_M) \tag{2}$$

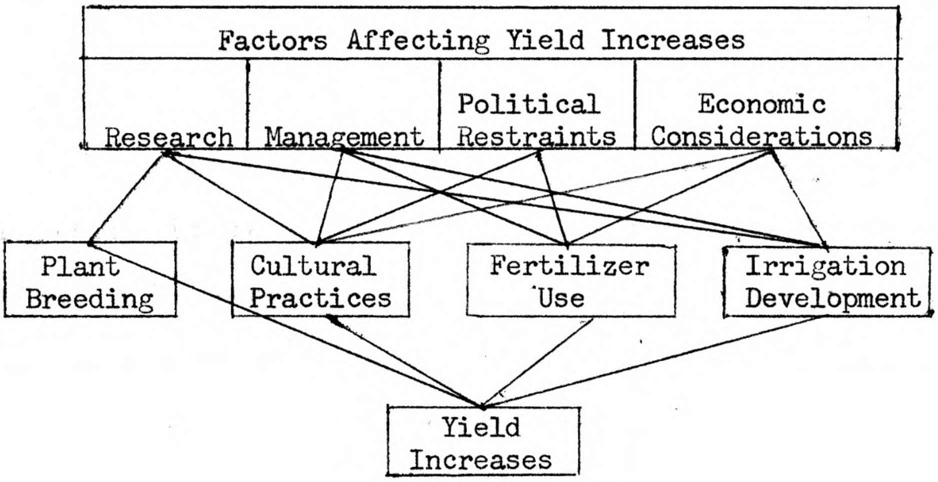
$$X_C = f(X_R + X_M + X_P + X_E) \tag{3}$$

$$X_F = f(X_R + X_M + X_P + X_E) \tag{4}$$

$$X_I = f(X_R + X_M + X_E) \tag{5}$$

At this point a word of explanation is in order regarding the principles. The research principle may be considered as embodying the creation, development, and dissemination of new ideas and techniques, by individuals and institutions, public or private, which can and do contribute directly and/or indirectly to a realized increase in average crop yields over a period of time. It was felt that research made a significant theoretical contribution to each of the independent variables of equation (1). The principle of management was conceived, in this theoretical context, to be that factor or element, which, when exercised to a more optimum degree by the individual entrepreneur, relative to a more appropriate combination of the independent variables of equation (1), might provide a fuller realization of potential increases in crop yields over a period of time. As in the case of research, it was felt that management had a significant theoretical relationship to each of the independent variables of equation (1). The principle of political restraints pertains to the theoretical influence of government farm programs upon the factors affecting crop yield increases. For the purpose of this paper this concept was confined primarily to the aspect of farm programs relating to supply control. The manifestation of this principle is revealed in its influence upon cultural practices through shifts in land use, retirement of less productive lands, and a tendency to stimulate more intensive cultivation, fertilization, etc. It might be well, at this point, to indicate that a considerable amount of interrelationship or interaction (analogous to the statistical sense of the word) exists among the principles. This can be particularly well illustrated in the case of political restraints. For example government programs of financial assistance to agricultural research can influence and stimulate the research principle. Also government participation in farmer educational programs can exert influences upon the management principle. Likewise, interactions between other principles might be pointed out. However, for the purpose of this theoretical discussion any affect which one principle may have upon another is assumed to be an integral part of that principle upon which the effect is made. This simplification is for the purpose of achieving less complexity of presentation. Finally, the principle of economic consideration was conceived, to give recognition to the influence of such factors as rational production, capital limitations, and economic uncertainty upon increases in crop yields. This principle may be considered as influencing primarily the independent variables of cultural practices, fertilization, and irrigation, as it relates to the economically necessary and sufficient conditions required for optimal use of these factors.

To conclude this theoretical schema it will perhaps be helpful to summarize the above algebraically stated functional relationships with a diagram. Here is depicted the origin of the yield increasing factors with the four principles, which flowing out, and, coming together in various combinations within the independent variables of equation (1) are thus translated into actual yield increases through the application of these specific practices.



It may be noted that the principle of research applied to the development of improved varieties together with the principle of management applies to the use of improved varieties, translated through the variable of plant breeding, results in yield increases. Likewise, the principle of research applied to the development of improved cultural practices, plus the principle of political restraints applied to the intensification of cultural practices brought about by reduction in acreages, plus the principle of economic considerations applied to the rational combination and application of cultural practices, all translated through the variable of cultural practices, results in another segment of the dependent Y_1 variable of yield increases. The remainder of the diagram may be interpreted in a similar manner.

The preceding was an effort to develop a formal context within which the following empirically grounded yield projections might be discussed. It is recognized that many shortcomings limit the foregoing theoretical schema and an effort was made to point out the more considerable of these within the text. However, despite this, it is suggested that the following empirical presentation can be more adequately understood if contemplated within the context of the general theoretical relationships and framework set forth above.

Empirical Relationships. Research. Present trends indicate that up to 1975 new research developments will, in most instances, provide a relatively small but steady contribution toward a higher average level of crop yields. A significant change in the research aspect will be an orientation of experiment station efforts more toward basic research with commercial firms becoming increasingly active in providing farmers with new developments through applied research, particularly in the area of crop breeding.[1] Other areas where significant research developments may be expected are in the application of fertilizers, optimum plant populations, machinery and techniques for minimum tillage operations under Kansas conditions, and insect and weed control. These potential developments will be discussed more fully in following sections.

Management. A two-fold area appears to hold forth whereby the management factor can contribute to increased crop yields by 1975. First, farmers could

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1. Fred C. Stickler, "Crop Production," The Kansas Agricultural Situation, Kansas State University, October, 1960, p. 15.

significantly increase present yields through a more optimum application of presently known and recommended practices. Second, the realization of yield increases which will be inherent in new research developments over the next 15 years can occur only to the extent that these developments are put into practice under optimum and recommended methods of management.

One source indicated estimates have been made that a 25 percent to 30 percent increase in grain sorghum yields might be realized through better management, although it was stressed that a lower figure might be considered much more reliable.[1] It was further suggested that higher yields due to improved management might be brought about, in part, through closer adherence to recommended planting rates, improved timeliness, and fuller application of realized and potential technological improvements within the limits of cost-price relationships.[2] It may be expected that these developments will be favored by an exit from farming of individuals with marginal management capacities under the pressure of small profit margins, along with a resultant increase in size and efficiency of farm units.[3] It is estimated that to bring "agricultural opportunities and rural man power into real balance, the farm population may be reduced up to 50 percent. It is doubtful that the bulk of today's marginal farmers can survive in an increasingly technical agricultural world."[4] These factors would seem to indicate at least a tentative tendency for a gradual improvement over the next 15 years in the level of management ability found among Kansas farmers, with a resulting contribution from this factor to an increased crop yield level.

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1. Ted Walter, Interview, June 17, 1961.
2. A. J. Casady, Interview, July 10, 1961.
3. *Loc. cit.*
4. Frank Orazem and Wayne Rohrer, "Farm Management and Sociology," *The Kansas Agricultural Situation*, Kansas State University, October, 1960, p. 6.

Government farm programs. Because of the instability associated with the political determination of farm programs it is impossible to indicate with satisfactory accuracy any probable trends which might occur by 1975 concerning the influence of farm programs upon crop yield levels. However, it will be worth while to examine briefly the present situation and explore some of the possibilities which do exist. Farm programs over the past half decade, particularly in the case of wheat, and more currently for feed grains, have been designed to reduce total production by a mandatory reduction in harvested acres. Although supporting data is not readily available, it seems to be generally agreed that these acreage reductions have contributed toward a higher average level of crop yields per acre. This has been due to the shifting of crops away from less productive soils as acreages were reduced and also due to more intensive farming methods stimulated by fewer acres and higher marginal revenues resulting from price supports associated with acreage controls.

Other government agricultural programs which tend to contribute toward higher yield levels are cost share agreements for the establishment of recommended conservation practices and such activities as technical and financial assistance in the establishment of irrigation and land drainage systems.

It would thus appear as if the tendency of present government farm programs is to contribute toward higher crop yield levels. It would seem reasonable therefore to assume that a continuation of present farm programs to 1975 would serve to maintain this tendency in force. Should, however, a reversal of policy occur, either toward expanded crop acres or toward less financial assistance for establishment of conservation practices, it is conceivable that a downward pressure on crop yield levels might be exerted.

Economic considerations. Economic considerations which are relevant to the determination of potential crop yield increases pertain primarily to marginal analysis, capital limitations, and uncertainty. A formal assumption of this study, stating that attainment of the projected physical production levels would be consistent with marginal analysis, places an upper limit on yield levels, given a production function and price relationships. However, there may be, for various reasons, a more or less general tendency for individual entrepreneurs to operate their physical plant at a level below that which would be consistent with maximization of profits. To the extent that this situation exists without a rational justification on the part of the individual concerned, and so long as it is not being enforced by arbitrary conditions outside of his control, there will exist an inherent bias toward a higher level of total physical production and also a higher level of production per unit of land, assuming acreage remains constant. This assumes the maximization of profits to be the production motive.

Aside from the above situation, there may exist conditions whereby capital limitations force an entrepreneur to operate at a level of physical output below the point of profit maximization where he would operate if he were producing with unlimited capital. Should any general tendency occur by 1975 which would serve to alleviate capital limitations which may presently be imposed upon Kansas farmers, allowing them to operate at a higher level of physical output relative to their land area, there would be a corresponding upward influence on per acre yields, assuming other factors remained constant.

Finally, to the extent that uncertainty regarding future income might cause the use of an abnormally high discount rate in planning the level of input investment, there may exist a tendency to produce at levels below those consistent with profit maximization. Here again, should future developments occur, such as more hazard resistance in plants or a greater degree of guaranteed price protection, which would result in a reduction in uncertainty this could bring about a tendency toward higher total and per acre crop production assuming that land acreage did not increase.

Plant breeding. A considerable amount of activity may be expected to continue in the field of plant breeding over the next 15 years. Developments regarding increased yield potentials for Kansas crops, however, will be of a slow nature, with the exception of certain possibilities to be mentioned later. It seems probable that a top level in terms of yield potential has pretty well been reached for most crops commonly grown in western Kansas under dryland conditions.[1] In other words, it would appear that an upper limit has just about been reached in terms of improving water uptake efficiency _on the amount of moisture which is generally available_. This adds up to the conclusion that, in general, future increases in average yield levels due to plant breeding will be relatively small, with gains being realized in the form of greater hazard resistance bred into the plants, thus permitting greater realized yields, rather than an actual genetically determined increase in yield potential.[2]

More specifically, in the case of small grains, breeding programs may be expected to produce greater winter hardiness, particularly in the case of barley and oats, but also with wheat.[3] A continued development of small grains with earlier maturity, stiffer, shorter straws, and improved resistance to diseases and insects may be expected to contribute toward a rate of increase in yields up to 1975 similar to that realized in the past 10 to 15 years.[4] The most exciting possibility in small grain breeding work is some promising research now under way in the development of both wheat and barley hybrids.[5] Although the time at which

1. C. O. Johnson, Interview, July 10, 1961.
2. _Loc. cit._
3. E. G. Hyene, Interview, August 4, 1961.
4. Ted Walter, _op. cit._
5. _Loc. cit._

these might become a reality to farmers is at present moot, it seems unlikely they will be a contributing factor to production in Kansas by 1975.[1] However, should a breakthrough occur in this area, an across the board increase in yield levels of a magnitude similar to those experienced by farmers in the case of hybrid corn and sorghum development may be expected.

In the case of sorghums, both grain and forage, a significant increase in yield may be expected over the next several years through continued improvement in hybrids.[2] This development will be in the direction of stronger stalks, insect and disease resistance, and more efficient utilization of a given land area. By 1975, grain sorghum yields of 200 bushels per acre will be commonly attained under hybrid test plot conditions.[3]

Any improvement, through breeding, in corn yields under Kansas conditions will be modest, although some gains in insect and disease resistance through development of better hybrids may be expected.[4] Another potential development in corn is that of "intermediate" height hybrids. These would come from crosses between present dwarfs and present tall types and would combine the better lodging resistance of the former with the higher yield potentials of the latter.[5]

In the case of alfalfa, there are three main areas for yield improvement through plant breeding. By breeding for more or less winter hardiness, it is possible to regulate the length of time the alfalfa plant will grow before going into its dormant stage. By thus increasing the length of the growing season higher yields may be obtained. However, if the growing season is extended too long, adequate preparation will not be made by the plants for winter, resulting in severe winter killing in areas as far north as Kansas. Alfalfa breeding work

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1. Fred Stickler, Interview, July 14, 1961.
2. Walter, op. cit.
3. A. J. Casady, op. cit.
4. Walter, op. cit.
5. Fred Stickler, "Crop Production," loc. cit.

is now going on in Kansas to produce the optimum balance between winter hardiness and total production for climatic conditions in the state.[1] A second potential area for increases in alfalfa yields through plant breeding is that of disease and insect resistance. A prime recent example of the ability of crop scientists to react quickly in this area was the development and release of Cody alfalfa, a variety resistant to the spotted alfalfa aphid.[2] It may be expected that work in this area will continue at a rate similar to that occurring in the past. The third and almost certainly the most productive area in alfalfa breeding in terms of yield increases likely to be realized by 1975, is that of hybrid development. Hybrid plants are now in the experimental stage and it would appear highly probable that they will be available for commercial production by 1975. Preliminary tests indicate yield increases over conventional varieties ranging in the magnitude of 20 to 25 percent. It seems likely that the big push in development of hybrid alfalfas will come from commercial seed companies.[3]

Long time records indicate that yields from native pastures have remained highly constant within a yield fluctuation pattern which is correlated closely with available moisture conditions.[4] At the present time it appears very unlikely that any plant breeding developments in native grasses will occur by 1975 which will cause an alteration in the above situation.[5]

Cultural practices. Perhaps one of the most significant potential developments which will likely occur in cultural practices within the next 15 years will be a greater emphasis upon control of plant populations and spacing in row crops. Row widths in corn and sorghum will tend to become narrower with resulting

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1. E. L. Sorenson, Interview, July 19, 1961.
2. See: E. L. Sorenson and others, <u>Cody Alfalfa</u>, Kans. Agr. Expt. Sta. Circular 381, April, 1961.
3. <u>Loc. cit.</u>
4. Jack R. Hartland, <u>Native Range</u>, Okla. State University Bul. 545, p. 7.
5. Kling Anderson, Interview, July 17, 1961.

wider spacing in the rows.[1] It has been found in eastern Kansas tests that grain sorghum yields can be increased by about 20 percent through the use of narrow rather than wide row spacings. However, the present inadequacy of pre-planting methods of weed control prevent this from being a recommended practice. Should the development of a usable pre-emergence spray be realized, this practice could provide a substantial increase in sorghum yields.[2] Machinery to accomplish more accurate and uniform seed spacing will be available within the next decade.[3]

"Present investigations suggest that in the next ten years there will be increased use of insect predators, parasites, fungi, bacteria, and viruses which attack economically important pests. There will be increased use of repellents which drive the insects away from crops. And there will be poisoned attractants, not applied to the edible products which will attract the insects to a bait which kills them. The trend toward increased irrigation of corn, sorghum, and other crops will increase yields and therefore further justify expenditures for insecticides."[4]

"Less but more effective tillage will be the keynote of land cultivation in the future. More effective weed control, better spacings of intertilled crops, effective use of starter fertilizers and more timely plantings will enable the farmer to eliminate some entire cultivations."[5]

A continuation of present acreage restricting farm programs will cause a continued shift of cultivated crops away from less productive lands. Expanded acceptance of stubble mulch farming will permit wider use of summer fallow

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1. Stickler, "Crop Production," loc. cit.
2. Casady, op. cit.
3. Stickler, "Crop Production," loc. cit.
4. Herbert Knutson, "Insect Control," Kansas Agricultural Situation, October, 1960.
5. F. W. Smith, "Soil Management," Kansas Agricultural Situation, October, 1960, p. 11.

methods for spring planted crops. A continued intensive program of establishing soil conservation practices will assist in the long-run maintenance of soil fertility levels.

In short, it would appear that new developments plus continued expansion in the use of presently recommended cultural practices will provide substantial support to an upward trend in average crop yield levels up to 1975.

Fertilization. Perhaps as much as 75 percent of an increase in the level of average crop yields in Kansas by 1975 may be due to increased use of fertilizers.[1] This will apply more nearly to the eastern two thirds than to the western one third of the state where moisture, as a limiting factor, except under irrigation, prevents a consistent realization of production increases from fertilizers. Use of fertilizers in Kansas has expanded from 32 thousand tons in 1940 to over 320 thousand tons today (1960). At the present rate of expansion, it seems likely that Kansas farmers will be applying between 500 thousand and 1 million tons of fertilizers by 1975.[2]

Virtually all yield increases from fertilizers will be due to heavier and wider applications. Higher yields from more efficient or easier to use plant nutrients will be small. Improvements in the fertilizer field are of a gradual nature with "breakthrough" type developments seldom if ever occurring.[3] Nevertheless, improvements in the physical condition and physical forms of fertilizers will take place. "Granulation will improve and concentration of nutrients will continue to rise."[4]

Nitrogen consumption will reflect higher fertilizer rates most. Phosphate needs will increase as soils become depleted with heavy cropping. Potash needs

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1. F. W. Smith, Interview, July 12, 1961.
2. Loc. cit.
3. Loc. cit.
4. Smith, "Soil Management," op. cit.

will become better understood over the next 15 years. In addition the trace and secondary plant nutrient elements are likely to receive more attention. Boron and zinc-containing fertilizers may be used in greater quantities. "Preparation of new iron compounds may make soil applications of this element more practical."[1]

It appears that Kansas farmers are today applying an average level of plant nutrients far below that consistent with maximization of profits. Part of this is due to capital limitations and uncertainty. Much is due to misunderstanding and poor management. It has been estimated that by 1970 "the Kansas fertilizer industry may well be a $35 million enterprise," and that, "properly applied these nutrients should add more than $80 million to farmer income by that year."[2]

Irrigation. Present and future irrigation development in Kansas is discussed in the section Potential Irrigation Development in Kansas.[3]

Existing Crop Yield Projections for Kansas

No previous study is available dealing with projected future crop yields in Kansas, for the state as a whole. However, two studies have been made dealing with potential crop yields for various areas of the state. The first of these is a potential yield map for approximately the eastern three fifths of the state based on the productive potential of various soil groups.[4] Yield potentials are given for wheat, corn, oats, grain sorghum, soybeans, and alfalfa, for each of 11 soil areas. The yield potentials are estimates based on the productive ability of the soils in each area. The yield figures represent averages which individual farmers should be able to attain over a period of 10 to 15 years.

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1. *Loc. cit.*
2. *Loc. cit.*
3. See pp. 28-99.
4. "Higher Farming Profits," prepared and distributed by National Plant Food Institute, Midwest Regional Office, 228 N. LaSalle St., Chicago, Illinois, in cooperation with Kansas State University.

Consideration is given to variations in temperature, moisture, and other growing conditions. To attain these yield potentials requires the following of recommended practices such as fertilization, planting recommended varieties, soil and water conservation, minimum tillage, weed, insect, and disease control, and careful harvesting.

The primary distinction between the above yield potentials and the yield estimates developed in this study is that the former is an estimate of what an individual farmer with a given quality of land <u>can</u> achieve using optimum methods, whereas the present study deals with estimates of yields which actually are expected to be achieved, based on an average of all farmers. The above study was found helpful, however, in establishing relative differences in yields among various areas of the state.

The second study available dealt with crop yields in the western third of the state.[1] In it was given a present normal yield and a projected normal yield for seven locations in the western part of the state. Yield figures were given for the following crops: wheat after fallow; wheat after wheat; grain sorghum after fallow, after wheat, after abandoned wheat fallow, after abandoned continuous wheat and after sorghum; forage sorghum after fallow, after sorghum and after wheat; silage sorghum after fallow, after sorghum, and after wheat; spring barley after fallow, after wheat, and after abandoned wheat fallow; and oats after fallow and after wheat. The "present normal" yield was defined as "that which may be attained currently by a typical farm operator with normal weather over time, using prevailing cropping practices and varieties."[2] The "projected normal" yields were defined as those which "may be attained in the near future

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1. Economic Research Service, U.S.D.A., Farm Economics Division, Waters Hall, Department of Agricultural Economics, Kansas State University, unpublished report.

2. <u>Loc</u>. <u>cit</u>.

(1965-70) by a typical farm operator with normal weather over time, using improved farming practices and better varieties and hybrids which are likely to be adopted within the next ten years."[1] The yield figures were based on data reported by the Kansas Experiment Station, Branch Stations, Experimental Fields, Crop Reporting Service, and Farm Management Association, together with the considered judgement of a group of crop scientists associated with the Kansas Experiment Station.[2]

Comparison of the "probable present" yields of the current study with the "present normal" yields of the above study for comparable crops and locations revealed no significant discrepancies. Likewise, a similar comparison revealed the "probable projected" 1975 yields of the current study to be consistent with the 1965-70 "projected normal" yields of the above study.

Yield Projections

Dryland. "Probable present" Yield. This yield figure is intended to be a reliable representation of the per acre output which might, on the average, reasonably be obtained by farmers in any given crop reporting district in an average "present" year, assuming utilization of currently prevalent management, cultural methods, etc. The "probable present" yields were established (1) to provide a "base point" from which to begin making estimates of 1975 yields, and (2) to secure a reliable "current measuring stick" with which the 1975 yield estimates might be compared. After due deliberation, it was decided that such a present yield should be established so as to fulfill three qualifications. First, so far as possible, it should be based on empirical data. Second, it

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1. *Loc. cit.*
2. *Loc. cit.*

should be established in a way that would reflect, as much as possible, a normal weather condition. That is, it should not be biased toward an above or below average part of the rainfall cycle. And third, it should be based on a fairly recent time period so that currently prevalent management, cultural practices, and other influencing factors would be reflected.

In selecting a source of data it was decided to use the crop yield data reported annually by the Kansas State Board of Agriculture, as these were the most comprehensive figures available.[1] Also, being derived from actual farm production, this data reflected the conditions with which this study was concerned.

The second qualification was met by making a considered examination of the data being used, in relation to long time average yields, patterns of fluctuation in weather, and present yield potentials under average weather conditions. On this basis it was decided, in consultation with crop scientists, that the four year period 1955-1958 would adequately fulfill the second qualification. Included in this period was a very low rainfall year 1955, two years of more nearly average precipitation, 1956 and 1957, and a high rainfall year, 1958.

It was felt that the selected period 1955-1958 was recent enough to also meet the third qualification.

Two exceptions were made in using the 1955-1958 yield data for establishing a "probable present" yield. One was in the case of grain sorghum. Here it was decided, after deliberation with a sorghum specialist, that the somewhat higher average grain sorghum yields obtained over the three year period 1957-1959 would more adequately reflect current use of grain sorghum hybrids than would the lower averages obtained in the 1955-1958 period. The second exception was in the case of pasture production.[2] Because no pasture forage yields are reported

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1. <u>Farm Facts</u>, <u>op</u>. <u>cit</u>.
2. Pasture production refers to forage available to livestock from tame and prairie grassland used primarily for pasture purposes.

by the Kansas State Board of Agriculture, it was necessary to obtain an alternative source of information for this data. Fortunately, a comprehensive recent study was available which presented the results of investigations into the production of native forages in the Great Plains over a long period of years.[1] Specific information was presented for several locations and types of native forage in Kansas so that fairly reliable estimates of native forage yields in various parts of the state could be made.

In averaging the State Board of Agriculture yield data for the appropriate periods in determining the "probable present" crop yields it was recognized that the original figures as presented by the State Board of Agriculture included production of both dryland and irrigated crops. Since it was desired to develop separate yield estimates for these two production methods in this study it was necessary to make adjustments in dryland estimates in some crop reporting districts where a significant proportion of some crops is produced under irrigation. This significant proportion was arbitrarily set at 10 percent. After "probable present" irrigated yields were estimated as set forth on page 25, they were multiplied times "present" irrigated acres for each crop to estimate present irrigated production. This production figure was divided by the total State Board of Agriculture production figure to determine whether it exceeded 10 percent. If so, the difference between total and irrigated production was divided by the "present" dryland acreage of the appropriate crop to derive a dryland yield estimate. Crops for which this adjustment was made were: wheat, SW crop reporting district; corn, NW, WC, SW, NC, and SC crop reporting districts; grain sorghum, WC, SW, and SC crop reporting districts; silage sorghum, NW, WC, SW, C, and SC crop reporting districts; and alfalfa hay, NW, WC, and SW crop reporting districts.

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1. Hartland, _op_. _cit_.

The "probable present" dryland yields for ten grain and forage livestock feeds are presented in column 2 of table 5, by crop reporting district, as they were finally established. As would be expected there is a general increase in yield level moving from west to east across the state, reflecting the rainfall pattern found in Kansas. Generally lowest yields are found in the WC and SW districts with the highest yields being in the NE and EC districts.

Linear trend line projection. To provide some quantitative indication of trend in average yields which might have been taking place over the past, a least squares linear regression was calculated for wheat, the four main feed grains, and the four main forage crops, by crop reporting districts. Crop Reporting Board yield data for 1941 through 1959 were used. Projection of these trend lines to 1975 gave estimates of 1975 crop yields, with the built in assumption that current yield trends would continue unaltered until that time. The yield figures derived in this manner are presented in column 4, Table 6, by crop and crop reporting district.

To estimate the significance of the various trend lines, conventional t-tests were statistically applied to the regression equation b and r values. The b and r values which were calculated for each crop in each crop reporting district are presented in Table 6 along with an indication of the level of statistical significance for each value.

The regression or b values measure the average change which occurs in a dependent variable for each unit of change which is made in an independent variable. In this case, the b values measure the change in average yield in bushels which on the average occurs with each unit (one year) change in time. A b value of zero indicates no change, a positive b indicates an upward change while a negative b indicates a downward change. Thus a b value of 0.75 would

Table 5. Crop yields, present and projected, by crop reporting districts.

Crop reporting district and crop		Actual: 1960 yield[a]	"Probable present" yield: Dryland[b]	"Probable present" yield: Irrigated[c]	Linear trend line projection: 1975[d]	Calculated 10% increase over "present" yields[e]: Dryland	Calculated 10% increase over "present" yields[e]: Irrigated	Calculated 25% increase over "present" yields[f]: Dryland	Calculated 25% increase over "present" yields[f]: Irrigated	"Probable projected" 1975 yield: Dryland[g]	"Probable projected" 1975 yield: Irrigated[h]	"Optimum projected" 1975 yield: Dryland[i]	"Optimum projected" 1975 yield: Irrigated[j]
Northwest													
wheat	bu.	38.1	20.5	32.5	22.0	22.4	35.7	25.6	40.6	22.3	38.4	25.6	43.9
corn	bu.	29.9	18.0	75.0	27.5	19.8	82.5	22.5	93.8	19.6	88.5	22.5	101.2
grain sorghum	bu.	24.8	24.0	72.0	25.1	26.4	79.2	30.0	90.0	26.9	85.0	30.0	97.2
barley	bu.	33.9	20.0	-	23.8	22.0	-	25.0	-	21.8	-	25.0	-
oats	bu.	39.9	19.6	-	12.5	21.6	-	24.5	-	21.4	-	24.5	-
forage sorghum	ton	1.9	1.5	-	1.8	1.6	-	1.9	-	1.6	-	1.9	-
silage sorghum	ton	5.9	5.4	18.0	8.8	5.9	19.8	6.8	22.5	6.0	21.2	6.8	24.3
alfalfa hay	ton	2.5	2.1	4.8	2.4	2.3	5.3	2.6	6.0	2.5	6.0	2.7	6.5
wild hay	ton	1.3	1.0	-	1.0	1.1	-	1.2	-	1.0	-	1.2	-
permanent pasture	ton	-	.27	1.30	-	.30	1.43	.34	1.62	.28	1.43	.32	1.62
West Central													
wheat	bu.	36.1	16.5	32.5	14.8	18.2	35.8	20.6	40.6	18.0	38.4	20.6	43.9
corn	bu.	58.8	15.0	75.0	-	-	82.7	-	93.8	-	88.5	-	101.2
grain sorghum	bu.	33.5	22.0	72.0	31.6	24.2	79.2	27.5	90.0	24.6	85.0	27.5	97.2
barley	bu.	28.8	15.0	-	16.1	16.5	-	18.8	-	16.4	-	18.8	-
oats	bu.	36.6	15.8	-	10.2	17.4	-	19.8	-	17.2	-	19.8	-
forage sorghum	ton	2.0	1.4	-	1.6	1.5	-	1.8	-	1.5	-	1.8	-
silage sorghum	ton	7.3	5.4	18.0	9.7	5.9	19.8	6.8	22.5	6.0	21.2	6.8	24.3
alfalfa hay	ton	3.2	2.0	4.8	3.4	2.2	5.3	2.5	6.0	2.4	6.0	2.6	6.5
wild hay	ton	1.3	1.1	-	0.9	1.2	-	1.4	-	1.1	-	1.3	-
permanent pasture	ton	-	.27	1.30	-	.30	1.43	.34	1.62	.28	1.43	.32	1.62

Table 5 (cont.)

Crop reporting district and crop		Actual 1960 yield[a]	"Probable present" yield: Dryland[b]	"Probable present" yield: Irrigated[c]	Linear trend line projection 1975[d]	Calculated 10% increase over "present" yields[e]: Dryland	Calculated 10% increase over "present" yields[e]: Irrigated	Calculated 25% increase over "present" yields[f]: Dryland	Calculated 25% increase over "present" yields[f]: Irrigated	"Probable projected" 1975 yield: Dryland[g]	"Probable projected" 1975 yield: Irrigated[h]	"Optimum projected" 1975 yield: Dryland[i]	"Optimum projected" 1975 yield: Irrigated[j]
Southwest													
wheat	bu.	31.1	16.1	32.5	14.4	17.7	35.7	20.1	40.6	17.5	38.4	20.1	43.9
corn	bu.	70.9	15.0	75.0	-	-	82.5	-	93.8	-	88.5	-	101.2
grain sorghum	bu.	36.5	22.0	72.0	30.8	24.2	79.2	27.5	90.0	24.6	85.0	27.5	97.2
barley	bu.	25.0	15.0	-	16.3	16.5	-	18.8	-	16.4	-	18.8	-
oats	bu.	32.1	14.3	-	6.0	15.7	-	17.9	-	15.6	-	17.9	-
forage sorghum	ton	2.1	1.6	-	1.6	1.8	-	2.0	-	1.7	-	2.0	-
silage sorghum	ton	7.9	5.4	18.0	11.1	5.9	19.8	6.8	22.5	6.0	21.2	6.8	24.3
alfalfa hay	ton	3.2	2.0	4.8	3.8	2.2	5.3	2.5	6.0	2.4	6.0	2.6	6.5
wild hay	ton	1.2	1.0	-	0.8	1.1	-	1.2	-	1.0	-	1.2	-
permanent pasture	ton	-	.27	1.30	-	.30	1.43	.34	1.62	.28	1.43	.32	1.62
North Central													
wheat	bu.	22.8	17.8	35.0	21.4	19.6	38.5	22.2	43.8	19.9	41.3	23.1	47.2
corn	bu.	42.2	22.2	82.0	24.8	24.4	90.2	27.8	102.5	24.9	96.8	28.9	110.7
grain sorghum	bu.	43.8	28.0	80.0	28.6	30.8	88.0	35.0	100.0	32.2	94.4	36.4	108.0
barley	bu.	22.1	17.0	-	23.6	18.7	-	21.2	-	19.0	-	22.1	-
oats	bu.	38.1	22.3	-	18.4	24.5	-	27.9	-	25.0	-	29.0	-
forage sorghum	ton	2.6	2.1	-	2.1	2.3	-	2.6	-	2.4	-	2.7	-
silage sorghum	ton	9.5	6.1	21.0	9.3	6.7	23.1	7.6	26.0	7.0	24.8	7.9	28.4
alfalfa hay	ton	2.8	1.6	5.0	1.8	1.8	5.5	2.0	6.2	1.9	6.2	2.2	6.8
wild hay	ton	1.4	.9	-	0.8	1.0	-	1.1	-	.9	-	1.0	-
permanent pasture	ton	-	0.30	1.30	-	.33	1.43	.38	1.62	.31	1.43	.36	1.62

Table 5 (cont.)

Crop reporting district and crop		Actual: 1960 yield[a]	"Probable present" yield: Dryland[b]	"Probable present" yield: Irrigated[c]	Linear trend line projection 1975[d]	Calculated 10% increase over "present" yields[e]: Dryland	Calculated 10% increase over "present" yields[e]: Irrigated	Calculated 25% increase over "present" yields[f]: Dryland	Calculated 25% increase over "present" yields[f]: Irrigated	"Probable projected" 1975 yield: Dryland[g]	"Probable projected" 1975 yield: Irrigated[h]	"Optimum projected" 1975 yield: Dryland[i]	"Optimum projected" 1975 yield: Irrigated[j]
Central													
wheat	bu.	21.6	18.9	35.0	22.1	20.8	38.5	23.6	43.8	21.2	41.3	24.6	47.2
corn	bu.	35.6	21.5	82.0	21.3	23.6	90.2	26.9	102.5	24.1	96.8	46.2	110.7
grain sorghum	bu.	39.7	28.0	80.0	25.9	30.8	88.0	35.0	100.0	32.2	94.4	36.4	108.0
barley	bu.	21.0	19.5	-	23.4	21.4	-	24.4	-	21.8	-	25.4	-
oats	bu.	31.1	22.0	-	17.5	24.2	-	27.5	-	24.6	-	28.6	-
forage sorghum	ton	3.2	2.0	-	2.0	2.2	-	2.5	-	2.2	-	2.6	-
silage sorghum	ton	9.0	6.3	21.0	8.2	6.9	23.1	7.9	26.0	7.2	24.8	8.2	28.4
alfalfa hay	ton	2.5	1.8	5.0	1.6	2.0	5.5	2.2	6.2	2.2	6.2	2.4	6.8
wild hay	ton	1.4	1.0	-	1.0	1.1	-	1.2	-	1.0	-	1.2	-
permanent pasture	ton	-	0.30	1.30	-	.33	1.43	.38	1.62	.31	1.43	.36	1.62
South Central													
wheat	bu.	24.8	17.2	35.0	21.3	18.9	38.5	21.5	43.8	19.3	41.3	22.4	47.2
corn	bu.	37.8	21.0	82.0	23.3	19.8	90.2	26.2	102.5	22.9	96.8	27.3	110.7
grain sorghum	bu.	38.9	23.0	80.0	26.6	25.3	88.0	28.8	100.0	26.4	94.4	29.9	108.0
barley	bu.	23.0	18.0	-	21.5	19.8	-	22.5	-	20.2	-	23.4	-
oats	bu.	27.9	19.8	-	15.6	21.8	-	28.8	-	22.2	-	25.7	-
forage sorghum	ton	2.4	1.7	-	1.6	1.9	-	2.1	-	1.9	-	2.2	-
silage sorghum	ton	8.5	5.7	21.0	7.6	6.3	23.1	7.1	26.0	6.5	21.0	7.4	28.4
alfalfa hay	ton	2.5	1.8	5.0	1.5	2.0	5.5	2.2	6.2	2.2	6.2	2.4	6.8
wild hay	ton	1.6	1.1	-	1.1	1.2	-	1.4	-	1.2	-	1.3	-
permanent pasture	ton	-	0.30	1.30	-	.33	1.43	.38	1.62	.31	1.43	.36	1.62

Table 5 (cont.)

Crop reporting district and crop		Actual: 1960 yield[a]	"Probable present" yield: Dryland[b]	"Probable present" yield: Irrigated[c]	Linear trend line projection 1975[d]	Calculated 10% increase over "present" yields[e]: Dryland	Calculated 10% increase over "present" yields[e]: Irrigated	Calculated 25% increase over "present" yields[f]: Dryland	Calculated 25% increase over "present" yields[f]: Irrigated	"Probable projected" 1975 yield: Dryland[g]	"Probable projected" 1975 yield: Irrigated[h]	"Optimum projected" 1975 yield: Dryland[i]	"Optimum projected" 1975 yield: Irrigated[j]
Northeast													
wheat	bu.	19.4	29.8	35.0	42.9	32.8	38.5	37.2	43.8	34.3	41.3	40.2	47.2
corn	bu.	47.7	41.5	82.0	40.9	45.6	90.2	51.9	102.5	47.7	96.8	56.0	110.7
grain sorghum	bu.	51.0	39.0	80.0	47.2	42.9	88.0	48.8	100.0	46.0	94.4	52.6	108.0
barley	bu.	21.8	28.7	-	37.3	31.6	-	35.9	-	33.0	-	38.7	-
oats	bu.	37.0	33.0	-	29.2	36.3	-	41.2	-	38.0	-	44.6	-
forage sorghum	ton	2.9	2.4	-	2.5	2.6	-	3.0	-	2.8	-	3.2	-
silage sorghum	ton	11.5	8.9	21.0	14.0	9.8	23.1	11.1	26.0	10.5	24.8	12.0	28.4
alfalfa hay	ton	2.5	2.0	5.2	1.9	2.2	5.7	2.5	6.5	2.4	6.5	2.8	7.0
wild hay	ton	1.3	1.0	-	1.0	1.1	-	-	-	1.0	-	1.2	-
permanent pasture	ton	-	0.33	1.30	-	.36	1.43	.41	1.62	.34	1.43	.39	1.62
East Central													
wheat	bu.	26.5	29.6	35.0	45.7	32.6	38.5	37.0	43.8	34.0	41.3	40.0	47.2
corn	bu.	47.5	41.7	82.0	42.0	45.9	90.2	52.1	102.5	48.0	96.8	56.3	110.7
grain sorghum	bu.	48.9	37.0	80.0	41.5	40.7	88.0	46.2	100.0	43.7	94.4	50.0	108.0
barley	bu.	25.2	28.1	-	42.0	30.9	-	35.1	-	32.3	-	37.9	-
oats	bu.	34.9	38.8	-	38.8	42.7	-	35.0	-	44.6	-	52.4	-
forage sorghum	ton	3.1	2.5	-	2.6	2.8	-	48.5	-	2.9	-	3.4	-
silage sorghum	ton	10.8	8.6	21.0	12.5	9.5	23.1	10.8	26.0	10.1	24.8	11.6	28.4
alfalfa hay	ton	2.7	2.1	5.2	1.8	2.3	5.7	2.6	6.5	2.6	6.5	2.9	7.0
wild hay	ton	1.2	1.2	2.1	1.0	1.3	-	1.5	-	1.3	-	1.4	-
permanent pasture	ton	-	0.33	1.30	-	.36	1.43	.41	1.62	.34	1.43	.39	1.62

Table 5 (concl.)

Crop reporting district and crop		Actual: 1960 yield[a]	"Probable present" yield: Dryland[b]	"Probable present" yield: Irrigated[c]	Linear trend line projection: 1975[d]	Calculated 10% increase over "present" yields[e]: Dryland	Calculated 10% increase over "present" yields[e]: Irrigated	Calculated 25% increase over "present" yields[f]: Dryland	Calculated 25% increase over "present" yields[f]: Irrigated	"Probable projected" 1975 yield: Dryland[g]	"Probable projected" 1975 yield: Irrigated[h]	"Optimum projected" 1975 yield: Dryland[i]	"Optimum projected" 1975 yield: Irrigated[j]
Southeast													
wheat	bu.	28.0	22.6	35.0	38.1	24.7	38.5	28.2	43.8	26.0	41.3	30.5	47.2
corn	bu.	45.0	36.3	82.0	39.2	39.9	90.2	45.4	102.5	41.7	96.8	49.0	110.7
grain sorghum	bu.	46.9	32.0	80.0	34.6	35.2	88.0	40.0	100.0	37.8	94.4	43.2	108.0
barley	bu.	28.1	22.3	-	36.9	35.2	-	27.9	-	25.6	-	30.1	-
oats	bu.	33.0	35.7	-	35.7	39.3	-	44.6	-	41.1	-	48.2	-
forage sorghum	ton	2.8	2.2	-	2.2	2.11	-	2.8	-	2.5	-	3.0	-
silage sorghum	ton	10.0	6.9	21.0	9.2	7.6	23.1	8.6	26.0	8.1	24.8	9.3	28.4
alfalfa hay	ton	2.6	1.8	5.2	1.4	2.0	5.7	2.3	6.5	2.2	6.5	2.5	7.0
wild hay	ton	1.3	1.1	-	1.0	1.2	-	1.4	-	1.2	-	1.3	-
permanent pasture	ton	-	0.33	1.30	-	.36	1.43	.41	1.62	.31	1.43	.39	1.62

a. Actual 1960 yield as reported in Farm Facts, Kansas State Board of Agriculture Report, 1961.

b. "Probable present" dryland yield based on mode of 1955-58 average crop yields as reported by Kansas State Board of Agriculture, for all crops except grain sorghum and pasture. Grain sorghum "present" yields based on average of years 1957-59. See appendix tables 12-20 for average yearly yields for each crop, by crop reporting district, 1941-1959, as reported by Kansas State Board of Agriculture. Pasture yields based on data presented by Jack R. Harlan, "Native Range," Oklahoma State University Bul. B-547, February, 1960. Pasture yields, estimates of forage available for actual consumption, on drymatter basis, tame and prairie grasslands used primarily for pasture purposes.

c. "Probable present" irrigated yields computed on basis of amount by which crop yields under irrigation normally exceed crop yields under dryland conditions, other factors being comparable.

d. Simple regression of yield on time calculated by least squares method, using State Board of Agriculture data, 1941-59, (see appendix tables 12-20) and projected to 1975.

e. Represents a calculated 10 percent increase over probable "present" dryland and irrigated yields.

f. Represents a calculated 25 percent increase over probable "present" dryland and irrigated yields.

g. "Probable projected" 1975 dryland yields were estimated on the basis of the following percentage increases over probable "present" yields: for wheat, corn, barley, oats, and forage sorghum, a 9, 12, and 15 percent increase for the western, central, and eastern thirds of the state respectively; for grain sorghum and silage sorghum, a 12, 15, and 18 percent increase in yields for the western, central, and eastern thirds of the state respectively; for alfalfa hay an 18, 20, and 22 percent increase in the western, central, and eastern thirds of the state respectively; for wild hay a 0 and 5 percent increase for the western third and the eastern two thirds of the state respectively; and for pasture, a 5 percent increase for the whole state.

h. "Probable projected" 1975 irrigated yields were estimated on the basis of the following percentage increases over probable "present" yields: wheat, corn, grain sorghum, and silage sorghum, an 18 percent increase; alfalfa hay, a 25 percent increase; pasture, a 10 percent increase.

i. "Optimum projected" dryland yields were estimated on the basis of the following percentage increases over probable "present" yields: for wheat, corn, grain sorghum, barley, oats, forage sorghums, and silage sorghums, a 25, 30, and 35 percent increase for the western, central, and eastern thirds of the state respectively; for alfalfa hay a 30, 35, and 40 percent increase for the western, central, and eastern thirds of the state respectively; for wild hay, 15 percent; and for pasture, 20 percent.

j. "Optimum projected" irrigated yields were estimated on the basis of the following percentage increases over probable "present" yields: for wheat, corn, grain sorghum, and silage sorghum, a 35 percent increase; for alfalfa hay, a 45 percent increase; and for pasture, a 25 percent increase.

indicate that on the average the yield for a given crop was increasing by three-fourth bushel per year over time. As indicated on Table 6, b values generally increase from west to east across the state. Exceptions to this were evidenced in the case of crops which are widely irrigated in western Kansas. In these cases, the widespread expansion of irrigation in western Kansas in recent years resulted in very high b values for crops such as corn, and alfalfa in the three western crop reporting districts.

The correlation, or r, values measure the amount of association between two variable factors. The r values on Table 6 indicate the degree of association between average crop yields and time. Or in other terms, the r values indicate the amount of change in yield which is related to or explained by a change in time. A high degree of association would suggest that a fairly reliable projection of yield on time might be made. The r values range from +1 to -1 with +1 indicating a perfect positive correlation, -1 indicating a perfect negative correlation, and zero indicating no correlation.

The generally high r values in the eastern part of the state indicate that in this area a fairly substantial amount of yield changes may be explained by passage through time. The generally low r values in the central third of the state indicate the greater variability of yields in this area and suggest that a very small part of yield changes may be explained by movement through time (or the relationship of time and yield may be compounded or covered up by other variables, e.g. variability of rainfall). Again, in the western third of the state, higher r values for some crops reflect the upward influence of irrigation on crop yields in recent years, as was the case for the regression values.

To summarize, the trend line yield projections in Table 5 and the b and r values in Table 6 serve a useful purpose in the determination of probable potential 1975 yields. Very low b and r values for a crop in a certain crop

Table 6. Regression and correlation coefficients for linear regression trend line of yield on time, by crop reporting districts, with level of significance indicated.[a]

Crop	Unit	Regression & correlation coefficients[b]	Northwest	West Central	Southwest	North Central	Central	South Central	Northeast	East Central	Southeast	State of Kansas
Wheat[c]	bu/a	b	0.123	-0.042	-0.024	0.217*	0.173*	0.219*	0.882****	0.999****	0.818****	0.241**
		r	0.141	0.045	0.317	0.280	0.225	0.280	0.963****	0.691****	0.792****	0.335
Corn[c]	bu/a	b	0.335*	1.587****	1.332****	0.122	0.018	0.118	0.394*	0.538**	0.588***	0.491***
		r	0.276	0.798****	0.586***	0.082	0.045	0.098	0.292	0.352	0.402	0.390
Grain sorghum[c]	bu/a	b	0.359**	0.532***	0.498***	0.426**	0.241*	0.345*	0.918****	0.765***	0.629***	0.440
		r	0.295	0.409	0.460***	0.380	0.203	0.280	0.647****	0.590****	0.445	0.385
Barley[c]	bu/a	b	0.252*	0.038	0.005	0.306**	0.215*	0.145	0.621****	0.781****	0.650****	0.334***
		r	0.231	0.036	0.010	0.315	0.225	0.239	0.616****	0.798****	0.647****	0.452
Oats[d]	bu/a	b	-0.306	-0.289	-0.409	-0.133	-0.187	0.231	0.093	0.547***	0.509***	0.199
		r	0.136	0.215	0.247	0.115	0.185	0.264	0.081	0.457***	0.474***	0.242
Forage sorghum[d]	tons/a	b	0.009	0.002	0.001	0.008	-0.004	-0.012	0.011	0.005	0.004	-0.006
		r	0.102	0.022	0.022	0.076	0.033	0.123	0.110	0.048	0.046	0.058
Silage sorghum[c]	tons/a	b	0.147***	0.157***	0.211****	0.122*	0.067	0.065	0.236****	0.184****	0.083*	0.048*
		r	0.463	0.268	0.647****	0.294	0.156	0.187	0.600***	0.607****	0.224	0.147
Alfalfa hay[d]	tons/a	b	0.012	0.041****	0.057	-0.484	-0.016	-0.013	-0.005	-0.012	-0.024	-0.012
		r	0.282	0.677****	0.835****	0.265	0.233	0.210	0.089	0.244	0.190	0.187
Wild hay[d]	tons/a	b	-0.001	-0.007	-0.006	0.007	0.004	0.000	-0.003	-0.004	0.001	-0.004
		r	0.000	0.231	0.209	0.203	0.086	0.000	0.115	.107	0.000	0.088

a. b and r significant at: 20-10% level *; 10-5% level **; 5-1% level ***; 1% level and above ****.

b. Level of r significance of all r values tested by use of two-tailed t-test of null hypothesis Ho: $p = 0$ vs. Ha: $p \neq 0$.

c. Level of significance of b tested by use of one-tailed t-test of null hypothesis Ho: $B = 0$ vs. Ha: $B > 0$.

d. Level of significance of b tested by use of two-tailed t-test of null hypothesis Ho: $B = 0$ vs. Ha: $B \neq 0$.

reporting district would indicate a very high degree of yield variability had occurred in the past for this crop. This would imply that caution should be used in predicting the future attainment of a very great increase in the average yield level for that crop. On the other hand, a high b and r value for a crop in a certain crop reporting district would indicate that the projected linear trend yield might serve as a reliable basis for comparison with the estimated "probable projected" 1975 crop yield.

Ten percent increase. After the "probable present" yields were determined, it was desirable to have available the absolute yield levels which various percentage increases above the "probable present" yields would give, to use as guides in making estimates of the 1975 yield levels. Thus the average crop yields which would be achieved, should be an "across the board" 10 percent increase above the "probable present" yield level occur, are presented in column 5 of Table 5. They are included only to serve as an arbitrary basis of comparison with other figures in the table.

Twenty-five percent increase. The origin and purpose of the figures in column 7 of Table 5 are exactly the same as explained above for column 5. The only difference is in the level of percentage increase, 25 percent as compared to 10 percent.

"Probable projected" yield. As previously defined, the "probable projected" yields presented in column 9 of Table 5 are those yields which might, on the average, reasonably be obtained by farmers in any given crop reporting district in an average year, 1975, assuming a "normal" development of those factors affecting crop yields. The derivation of these yield figures is discussed under Procedure and Methodology, p. 22. As indicated, this was accomplished through a series of interviews with crop scientists at which time consideration was given to actual 1960 crop yields, "probable present" yields, linear trend yield projections, long time average yields, and the amount of impact which various yield influencing factors were likely to exert upon crop yields in the next 15 years. The final figures shown in column 9, Table 5 were established by estimating the percent by which the yield of each crop in each crop reporting district might be expected to increase over its corresponding "probable present" yield by 1975. The percentage increase estimated for each yield figure given in column 9 is indicated in note g at the end of Table 5.

The progressively higher percentages indicated from west to east across the state reflect the limitational influences of moisture upon other yield increasing factors, the impact of which may be more fully realized in the higher rainfall areas to the east. Percentage increases for grain and silage sorghum were set 3 percent higher than for other crops because it was felt "probable present" yields were somewhat conservative in reflecting the very recent influence of sorghum hybrids. Alfalfa yield percentage increases were set at 18, 20, and 22 percent in anticipation of the introduction of alfalfa hybrids within the next 15 years. Very little evidence can be found to justify yield increases in wild hay and native pasture production. However, a somewhat arbitrary 5 percent increase was included for these crops in anticipation of a small yield improvement through better management, over the next 15 years. No dryland yield estimates are given for corn in the WC and SW crop reporting districts as dryland production of this crop in these areas is expected to be virtually non-existent by 1975.

"Optimum projected" yield. As previously defined "optimum projected" yields are those which might, on the average, reasonably be obtained by farmers in any given crop reporting district in an average year, 1975, assuming an "optimum" development of those factors affecting crop yields. The determination of these yield figures, which are presented in column 11, Table 5, was accomplished in the same manner and concurrent with the estimation of "probable projected" yields as discussed in the preceding section. Indeed the only difference between the "probable" and "optimum projected" 1975 yields is in regard to the rate of yield increase which is assumed to occur between the present and 1975. As indicated in the respective definitions, "probable projected" yields were estimated assuming a "normal" rate of development in those factors functionally related to average crop yield increases over time. Conversely, "optimum projected" yields were estimated assuming a higher or "optimum" rate of development (but still well within physical limitations) in these factors functionally related to average crop yield increases over time. This assumed difference in rate of development of yield increases is expressed as a higher percentage increase of 1975 yields over "probable present" levels with "optimum" development than with "normal" development. As a result, the "optimum" 1975 yields are higher than the "probable" 1975 yields.

The "normal" concept implies that yield increases and factors influencing yield increases will be of an "expected," "middle-of-the-road," or "natural" manifestation. The "optimum" concept implies that yield increases and yield increasing factors will have a "better than expected," efflorescence, or more "ideal" quality about them. This is not to imply that the "probable" yields are realistic and the "optimum" yields are unrealistic. Actually, the "optimum" yields are just as realistic as the "probable" yields and the only element needed for their attainment would be for some factor or combination of factors functionally related to crop yield increases to effuse a stronger functional impact upon crop yield increases than is anticipated to occur at the present time. It thus might be said that the two yield levels are separated only by the difference in functional impact upon yield increases which present calculated judgments anticipate actually will occur and what they anticipate actually could occur with reasonable probability.

The actual percentage increases by which the yield figures in column 11, Table 5 were estimated to exceed "probable present" yields are indicated in note i, Table 5. Again a differentiation is indicated from west to east across the state. Percentage increases for all crops are the same with the exception of alfalfa which is again higher in anticipation of hybrid releases. Also, under a more optimum development of influencing factors, yields of wild hay and pasture are anticipated to increase more than under "probable projected" yields.

Irrigated. "Probable present" Yield. This yield estimate was designed to serve the same purpose as explained for the comparable dryland yields. It was actually derived from the dryland "probable present" yields using an empirically deduced conversion factor. The procedure for obtaining this conversion factor and its use in getting the "probable present" irrigated yields is explained in detail under Procedure and Methodology, p. 25.

Examination of the yield figures presented in column 3, Table 5 will reveal a slightly higher level moving from west to east across the state. This reflects the empirical situation and apparently is the result of and explained by a more extensive type of irrigation operation which is prevalent in the western part of the state. Moving east, one finds generally smaller irrigated operational units with a more intensive application of water and other factors.

It will be noted that no irrigated yields are listed for barley, oats, forage sorghum, or wild hay. This is because irrigated acreages of these crops is relatively small in Kansas.

Ten percent increase. The irrigated crop yields appearing in column 5, Table 5 represent a general 10 percent increase over the "probable present" irrigated yield level in column 3. The purpose of the figures in column 5 is for illustration and comparison only.

Twenty-five percent increase. The irrigated crop yields appearing in column 7, Table 5 represent a general 25 percent increase over the "probable present" irrigated yield level in column 3. The purpose of the yield data in column 7 is illustrative and comparative only.

"Probable projected" yield. The definition and concept of "probable projected" yields under irrigation are identical with those under dryland conditions. The determination or estimation of the percent by which the "probable projected" irrigated yields exceed the "probable present" yields was accomplished in a manner identical with that discussed for dryland yields. Note h, Table 5 indicates the estimated percent by which "probable projected" 1975 crop yields are anticipated to exceed "probable present" yields. "Probable projected" irrigated yields are found in column 10, Table 5.

"Optimum projected" yield. "Optimum projected" irrigated yields bear the same conceptual relationship to "probable projected" irrigated yields as existed between the corresponding dryland yield estimates which were previously explained. They have also been established in the same way as were the dryland yield estimates. These yield data are found in column 12, Table 5. The estimated percentages by which they are anticipated to exceed the "probable present" irrigated yields are indicated in note j, Table 5. The percentages are the same for all crops except alfalfa, which is higher to reflect hybrid introduction, and pasture for which a lower increase is foreseen.

Evaluation of Yield Projections

This evaluation is directed toward an assertation of the total effectiveness of the yield estimates derived in this study in terms of their fulfillment of the relevant objectives previously set forth.[1] The establishment of this assertation

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1. See, Objectives, p. 7.

must involve a consideration of the practical and theoretical utility of these yield projections relative to their determined objectives, plus an elucidation of the stronger and weaker characteristics embodied within their supporting framework which, on balance, determine this utility.

It is pertinent to observe that inasmuch as the estimates involved relate to a future time period, it becomes impossible to quantitatively measure their fulfillment of an observable reality within the context of present time. Thus any utility evaluation must be primarily conceived in qualitative terms.

No analytical process can derive a result beyond the limitation of the assumptions bounding it. Thus, contemplation of the usefulness of the yield projections made in this study must be done with constant reference to the limiting assumptions of climatic, political, and general nature previously set forth. At this point, it should be quite obvious that the yield projections derived in this study rest very substantially upon qualitative analysis. To the extent that these qualitative derivations were based upon subjective judgments they are subject to the obvious shortcomings of human error and personal bias. However, in defense of the subjective measures used, it is to be pointed out that these qualitative considerations were based upon and checked against quantitative empirical data. Even more importantly these qualitative derivations were not simply haphazard guesses but rather, were calculated judgments representing a significant cross-section of practical and experienced knowledge. Furthermore, the uncertain and long-range nature of most of the variables functionally related to the yield estimates practically precluded the use of rigid quantitative methods.

In conclusion, it is suggested that the yield projections derived in this study adequately fulfill the purpose for which they are intended, so long as they are retained in a proper perspective regarding the limitational aspects of the assumptions and analysis used in their construction. They are not, and must not be taken, as forecasts of what actually will happen, but rather are informed estimates of what might be expected to occur within the framework of a qualitative yield estimation model.

ESTIMATION OF ACREAGE

Recent Trends

In attempting to anticipate the direction in which harvested acreage of the various livestock feed crops may trend over the next 15 years, it is thought to be helpful to make a brief examination of fluctuations which have occurred over the past. The extent to which this will be beneficial will depend considerably upon how much the factors which have influenced harvested feed crop acres in the past will continue in effect into the future. The period to be considered is 1941-1959. Reference will be made to the harvested acreage of feed grains and forage crops, presented by crop reporting district, in appendix Tables 22 through 38. A brief discussion will be presented in an attempt to informally summarize the significance of the short term fluctuations and the direction of any long term trends which may be readily apparent for the various crops. No attempt has been made in this study to derive a formal mathematical trend line for the various crop acreages.

An examination of crop acreage figures for the northwest crop reporting district reveals the overwhelming prevalence of wheat among the grain crops. Harvested acres of wheat appear to have remained relatively constant within a range of 1 to $1\frac{1}{2}$ million acres over the 18-year period. Major deviations below this level probably are explainable in terms of unfavorable weather conditions and restrictive government programs. Total acreage of the four feed grains in Table 21 appears to have trended downward during the forties, then remained relatively constant until the last half of the fifties when some acreage increase is noted, probably in response to government restrictions of wheat acreage at that time. In terms of individual feed grains it would appear that corn, barley, and oats have experienced some decrease in general level of harvested acreage, whereas this tendency has been in part offset by an increase in harvested acreage of grain sorghum. It is interesting to note that a fairly consistent inverse relation exists between harvested acres of grain sorghum and wheat, thus reflecting the inclination of farmers in this area to plant grain sorghum on abandoned wheat land.

Examination of appendix Table 30 reveals no discernible trend in total harvested acreage of the four forage crops. Individually, harvested acres of forage sorghum appears on the definite decrease whereas sorghum silage and alfalfa hay have increased considerably over the time span. Harvested acres of wild hay and pasture have held relatively constant.

As indicated in appendix Table 22, wheat, with the exception of two years 1951 and 1957, has generally ranged considerably higher in acres harvested than the total for the four feed grains listed, for the WC crop reporting district. Harvested acres of corn and oats range below 100,000 acres as has barley since 1944.

Acreages are generally more variable than for the NW district thus indicating a higher hazard area. This variability from year to year makes it very difficult to anticipate any general trend which may be running through the figures. An exception to this is the case of oats which show a general downward trend over the period. Corn and barley acreages are also lower in the last few than in the first few years of the period but it is impossible to informally determine whether this is evidence of a long-term trend or merely a short-term oscillation. Again as was the case in the NW district, grain sorghums have shown a very sharp upturn in recent years, the result of rather drastic reductions in wheat acreage from adverse weather and government acreage restrictions.

Total harvested acreage of the four forage crops indicated in Table 31 for the WC crop reporting district has moved erratically up and down throughout the period. It ranged from a low of 110,700 acres in 1949 to a high of 401,400 acres in 1955. Relatively constant upward shifts in harvested acres of sorghum silage and alfalfa hay is evidenced, probably a reflection, in part, of expanded irrigation in that district. Harvested acres of sorghum forage are erratic but, with the exception of a sharp upturn during the drought period of the late fifties, appear to have moved generally lower over time. Harvested acres of wild hay have remained quite stable as has been the case of pasture acreage which has remained constant at 1,855,000 acres since 1955.

Harvested acreage of wheat in the southwest crop reporting district (appendix Table 23) has followed a pattern of year to year fluctuation, since 1941, of between one and three million acres. One exception to this was 1957 when a combination of adverse weather and a large soil bank sign up forced a low harvested acreage of only 211,000 acres. Total harvested acreage of the four feed grains has generally tended higher during the fifties than in the forties for the SW district. Prior to 1950, the feed grain harvest exceeded 500,000 acres in only two out of nine years, while in six of the nine subsequent years the same four crops exceeded 1,000,000 harvested acres. Closer observation of Table 23 reveals that to speak of total feed grain acreage in SW Kansas is nearly the same as speaking of grain sorghum acreage since this one crop commands by far the majority of the total harvested acreage. From this it would follow that grain sorghum acres also appear to have tended higher during the latter than during the former part of the period depicted on Table 23. As for the other three feed grains, corn and oats are both insignificant and appear to have become more so during the period although a small increase in corn acreage was apparent during the last three years of the period, possibly the result of irrigation expansion. Barley acreage is also low although it exceeds the total for corn and oats combined. A great deal of short-term unsteadiness characterizes barley acreage but it too appears to have trended somewhat lower.

The main movement in harvested acres of the four forage crops in SW Kansas (appendix Table 32) appears to have been in response to short-term rather than long-term factors. Individually, wild hay appears to have held quite constant at a relatively low level, sorghum silage and alfalfa hay were both moderately higher during the last half of the period than during the first half, while in the case of sorghum forage no general tendency can be detected through informal observation. Pasture acreage shows a modest increase up to the 1955 level where it has since remained constant.

Harvested wheat acreage for the NC crop reporting district (appendix Table 24) ranged generally around 1.5 million acres between 1941 and 1953, fluctuating from a low of 1,183,000 acres in 1943 to a high of 1,749,000 in 1947. Since 1953 the average level has tended lower, the result of government acreage restriction and in some years below normal moisture conditions. Harvested acreage of feed grains in this district ranged from 458,700 in 1956 to 1,309,300 in 1943, for the 19-year period 1941-1959. Although this total acreage appeared to decline amid year to year variation prior to 1956, acreage for the final three years of the period moved back to a point consistent with earlier levels. Individually, corn was the dominant feed grain in this region in terms of harvested acres until 1957 at which time grain sorghum moved into a commanding lead for the remainder of the period. It is noted that barley and oats both exceeded grain sorghum in acres harvested near the start of the period, but each of these crops has shown a general downward trend in acreage to a present level somewhat less than half that during the early forties. It is interesting to point out a tendency toward a shift in composition of the total feed grain acreage in this district relative to the western third of the state, with corn and oats increasing relative to grain sorghum and barley.

Total forage crops harvested in the NC district has generally fallen within the 300 to 400 thousand acre range except during the mid and late fifties when a general increase is observed, probably an attempt by farmers to offset low per acre yields of the drought period plus some shift of diverted wheat acres to forage crop production (see appendix Table 33). By crops, harvested acres of alfalfa hay and sorghum silage have generally increased. Wild hay acreage has remained relatively constant. Acreage of sorghum forage harvested has varied rather widely, decreasing quite rapidly between 1941 and 1952, then increasing to a high point of 271,700 acres in 1955 from which a drop occurred to the low point of the period, 54,000 acres in 1959. Pasture acreage over the period has increased moderately, with the current level of 1,950,000 reached in 1955.

Moving into the central crop reporting district, the mid-section of the state, harvested acreage figures presented in appendix Table 25 indicate the continued predominance of wheat as the most important crop. Acreage levels seem to have fluctuated within a fairly level range until the latter part of the fifties when acreage controls influenced a reduction in this general level. Harvested acres of the four feed grains moved up sharply during the first three years of the period, followed by a four year down trend. The period 1948 through 1956 appears to have been characterized by relatively stable vacillation. The final three years of the period are marked by a sharp upturn in acreage levels culminating in the highest figure, 955,400 acres, for the final year, 1959. Acreage of the four feed grains was divided fairly equally among them during the earlier years of the period. However, a general increase in harvested acreage of grain sorghums resulted in grain sorghum acreage being more than double that of the other three in 1957, 1958, and 1959. Oats generally were second in acreage after being first at the beginning of the period. Corn acreage has exceeded that of barley in all years except 1941, 1942, 1955, and 1959. Fluctuations in acreage of these crops has been so erratic as to make informal observation of any trend impossible.

Total harvested acres of the four forage crops in the central district has ranged generally between 300,000 and 400,000 acres except for an upturn during the 1954-1957 period (appendix Table 34). Individually, wild hay, sorghum silage, and sorghum forage appear to follow fairly closely the trend evidenced by the total acreage figures, that is a fairly level to lower trend up to the mid fifties, then increasing for a few years followed by a decline at the end of the period to near earlier levels. The exception in this case is alfalfa hay which shows a general upward tendency over the period considered. Acreage of pastureland fluctuated considerably prior to 1957. From 1957 to 1959, it remained stable at 1,829,000 acres.

A preponderance of wheat again dominates the acreage of grain crops harvested in the SC crop reporting district. The acreage pattern for wheat over the 19-year period is similar to that encountered for this crop in the rest of central Kansas, namely, a generally level range of oscillation until about 1955, after which acreage restrictions influenced a downward pressure upon this level (appendix Table 26). Total harvested acreage of the four feed grains moved downward toward the middle of the period, with a general upswing in evidence over the last half of the period. A rather sharp upturn in total feed grain acreage during the last three years probably reflects a shift away from wheat to the feed grains. Corn acreage has shown a rather constant downward trend, the result of climatic and disease problems. Conversely grain sorghums have expanded rather dramatically in this area going from a low of 92,000 acres in 1947 to a high of 871,000 acres in 1959. Harvested acreage of both barley and oats slumped downward until 1952 after which an upturn in acreage has been experienced.

Total forage crop acreage for the SC district moved in a series of short-term fluctuations from 1941 to 1959 (appendix Table 35). The high point of these variations was reached in 1955 and 1956. No long-term trend is informally observable. Individually, shifts in sorghum forage acreage also appear to be of a cyclical nature although a slight downturn may have been experienced near the end of the period. Sorghum silage and alfalfa hay seem to have held to a relatively even level over the period, aside from year to year variations. Harvested acres of wild hay appear to have trended modestly downward by some 10 to 12 thousand acres. Pasture acreage in the SC district has experienced a gradual and constant up trend from 1,797,000 acres in 1942 to a present level of 2,199,000, first reached in 1955.

The most striking observance which is made upon turning to harvested acreage of grain crops in the NE crop reporting district (appendix Table 27) is that wheat is no longer the predominate crop. In this district, it moves into second place behind corn. The level of harvested acreage for each of these crops appears more stable than that encountered in more western areas, thus probably reflecting the less hazardous climatic conditions of eastern Kansas. There appears to exist a tendency toward an inverse relationship between corn and wheat in this district, in terms of shifts in acreage. However, a modest slump in harvested acres of both crops is to be observed near the end of the period. At this same time, a sharp upturn took place in harvested acreage of grain sorghum, probably indicating a shift away from both corn and wheat to this latter crop. Oats appear to have slowly, but consistently, been losing ground in number of acres. Although prior to 1957 it ranked third behind wheat, it has since fallen below grain sorghums. Barley acreage has generally been relatively unimportant in this district, reaching a low of only 400 acres in 1951. Since that time, however, it has expanded to the highest level of the period, 24,400 acres in 1959.

Turning to forage crops for this district, total harvested acres, as indicated by appendix Table 36, have been generally stable throughout the period. Individually, wild hay follows the pattern established by total acreage with only small fluctuations evidenced. Alfalfa hay seems to show some inclination to shift upward while a rather steady decline in harvested acreage of sorghum forage has occurred, moving from 49,400 acres in 1941 to only 2,400 acres in 1959. Harvested acreage of sorghum silage moved gradually lower until the early fifties, from where it moved upward to a high of 51,100 acres in 1956. Over the last three years of the period it annually moved lower reaching 29,700 in 1959. Pasture acreage increased to a high of 1,491,000 acres in 1952, then shifted downward to 1,478,000 acres in 1955 at which point it has remained constant.

Leadership in terms of harvested acreage has shifted sporadically back and forth between wheat and corn in the EC crop reporting district over the 1941-1959 period as indicated by appendix Table 28. The low period in terms of wheat acreage was experienced during World War II years. Subsequent to this a somewhat erratic pattern was followed with a depression in the general level resulting from acreage restrictions during the latter fifties. As might be anticipated from the previous indication, the high period in harvested acres of corn for this district corresponds to the low period for wheat, that of World War II. In general, corn acreage for the district has remained fairly stable since that time. Total feed grain acreage reflects the general pattern for corn, ranging mostly above one million acres up to 1947, and stabilizing somewhat below that figure for the remainder of the period. Harvested acreage of grain sorghum declined from relatively high levels in the early forties to a low point of 51,200 acres in 1951. Since then a steady expansion has been accomplished. Barley, the least important of the four major feed grains in this district, has fluctuated widely during the period in terms of harvested acreage. A low of 4,000 acres was reached in 1952, whereas the high point, acreage-wise, was attained in 1955 with 112,300 acres. No general trend can be observed although a considerably higher acreage was harvested during the last five years of the period than previously, possibly indicating some shift of wheat acreage to barley production. Oats, second only to corn in acreage harvested during some of the earlier years has shown a moderate downward inclination over the period indicated by appendix Table 28.

Undulations in harvested acreage of forage crops have shown an almost year by year up and down movement in the EC district (appendix Table 37). However, it would appear they may have tended slightly higher over the latter half of the period. Likewise, movement of harvested acres of wild hay has been erratic in nature with no informally observable evidence to indicate a general trend of significant proportions. Alfalfa hay acreage, also showing considerable variation, appears to have turned some higher toward the end of the period, ranging near or above 200,000 harvested acres from 1954 on, whereas the previous high was 168,000 acres in 1949. Harvested acreage of sorghum silage generally decreased until 1952, moved upward for three years through 1955, and then slumped off for the remainder of the period. The only outstanding trend that can be observed for forage crops in this district is in the case of sorghum forage which slid rather consistently from a high of 101,900 harvested acres in 1941 down to only 10,500 in 1959. Pasture acreage increased erratically until a high of 2,801,000 acres was reached from 1955 on.

The pattern followed by harvested acreage of feed grains and wheat in the SE crop reporting district is very similar to that discussed for the EC district. (appendix Table 29). Wheat has been the leading grain crop in harvested acreage with the exception of 1942-1944 and 1946 when corn acreage predominated. Wheat acreage tended upward following 1946 until a gradual reduction resulting from acreage controls was brought about in the latter fifties. Total feed grain acreage of this district exceeded 1.1 million acres from 1941-1944. Subsequent to this, acreage harvested generally ran well under 1 million reaching a low of 675,000 acres in 1951. Corn and oats acreages have tended somewhat lower over the 19-year period. Acreage of grain sorghum appears to have settled some lower until 1957. A sharp increase occurred in 1958 and 1959. Barley moved erratically lower, reaching 8,800 acres in 1952. The remainder of the fifties is characterized by considerably higher harvested acreages of barley than for the entire previous portion of the period.

Considerable fluctuation characterizes the harvested acreage pattern of forage crops in the SE district although a downward shift is noted over the last five years of the period (appendix Table 38). Little evidence of acreage shifts apart from short term variations is apparent for the four forage crops individually, with the exception of sorghum forage which has tended to decrease. Pasture acreage has moved upward from 2,384,000 acres in 1942 to 3,581,000 acres from 1955 on.

Factors Affecting Acreage

Government Programs. The effect induced upon crop acreages by government programs has become well known in recent years. Programs such as the conservation and acreage reserves, wheat acreage allotments, and more currently the feed grain program, have all been designed to, in one way or another, reduce and/or shift acreage devoted to the production of a certain crop or crops.

The effect of these various programs upon harvested acreages of the various grain and forage livestock feeds considered in this study has perhaps been varied. To the extent that the conservation reserve was successful, it probably shifted some land out of feed grain and forage crop production for a short run period of 3 to 5 years under most contracts. As this land becomes available again, it may either be utilized as hay or pasture acreage or shifted back into crop production, possibly livestock feed. The primary result of the short lived acreage reserve was to drastically curtail wheat seeding in the dry fall of 1956 and consequently cause a shift of this acreage into grain sorghum production the following year.[1] These circumstances, most acute in the western third of the state, resulted in the largest grain sorghum acreage to date for that area of the state.

Traditionally, wheat acreage allotments have precipitated a shift to production of other crops, principally livestock feeds. In western Kansas grain sorghum, increased summer fallow, and possibly some forage crops have been moved onto the idled wheat acres. Farther east, corn and the other small grains have also participated in this shift.

The 1961 feed grain program was designed to voluntarily reduce acreages devoted to corn and grain sorghum. Provision was made to prevent the shifting of idled acres to production of other livestock feed crops. A similar type of provision was included in the 1962 wheat program.

In attempting to predict the effect which government programs may exert upon acreage of livestock feeds in the future, it would seem reasonable to assume that any continuation of current or past programs might be expected to culminate in results similar to those realized in the past under these programs. To

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1. See, Farm Production, Trends, Prospects, and Programs. Agr. Inf. Bul. No. 239, p. 29.

predict what future government programs actually will be is impossible. It would seem probable, however, that so long as agricultural over-production remains with us, some sort of supply control will be attempted. The form and shape these measures may acquire in the future is a matter which must be considered outside the scope of this paper.

Crop Adaptability. This factor certainly plays an important role in the determination of cropping patterns in any given area. Perhaps crop adaptability is most important in Kansas in the western part of the state. Here the semi-arid, high hazard conditions severely restrict the number of crops sufficiently adapted to these circumstances to be profitably produced. The limited acreage of corn and oats found in the WC and SW districts plus the preponderance of wheat grown in these areas as compared to the NE and EC districts are evidence of some of the influence which this factor may exert upon crop acreages. Adaptability plays an important part in selection of crops for irrigation production. In this situation the advantage enjoyed by corn and grain sorghum over the small grains is quite obvious.

The influences which crop adaptability will have upon crop acreage in the future will be related to the development of new varieties and hybrids. Any dynamic developments along this line resulting in major acreage changes seem unlikely. To the extent that present patterns of crop adaptability remain in effect there will be a tendency for present crop trends resulting from this factor to continue.

Relative Profitability. Little need be said here on this topic. Aside from limitations of acreage restrictions and crop adaptability this is probably the most important determinant of allocation of acreage among various crops. The influence of relative profitability upon acreage harvested of various grain and forage livestock feeds in the future will depend upon price relationships, comparative yield potentials, and relative production costs for the various feed crops and possible alternatives.

Farmer Preference. Although perhaps more restricted in effect than the three previous factors, this item can exert an important influence upon acreages of various crops grown. The continuing efforts of some farmers to produce corn under dryland conditions in western and south central Kansas may be in part a reflection of this factor. Also the fact that "in spite of advice to the contrary from many agricultural experts, farmers are raising more oats than ever," may also be related to farmer preference for the production of certain crops apart from and perhaps even counter to economic reasons.[1]

As to future influences which this factor might exert upon crop acreages, it would seem unlikely in the face of increasingly complex and costly farming operations that any significant proportion of farm entrepreneurs would allow preference to overrule economic and adaptation factors in the allocation of crop acreages. However, should a situation arise in which two crops of essentially equal adaptability and profit potential, one a feed, the other a non-feed crop, were available to farmers over a general area of the state, it is possible that farmer preference could play a substantial role in the determination of livestock feed crop acreage.

Acreage Projections

Dryland. Assumed constant. In making estimates or projections of future livestock feed production the allocation of total harvested acres among the various competing crops for purposes of the projection can be accomplished in several ways. The least complex means available is to simply assume that

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1. Patterns and Trends for Crops and Livestock. Marais des Cygnes River Unit, unpublished report, Kansas State University.

harvested acreage of crops will remain fixed at a present level and in present combinations of crops.

An obvious limitation of this method is the fact that it contains a builtin rigidity which arbitrarily detracts from reality. This is to say that any projected shifts in livestock feed production under this assumption will be based only upon changes occurring in crop yield levels with no allowance made for potential shifts which might occur in total production as a result of significant shifts and trends occurring between and among various crops.

Despite its limitations, a certain value may be gained from this type of analysis. By holding acreage constant through time in a set of potential production models, it would be possible to separately analyze and compare changes in livestock feed production over time, which are estimated to occur as a result of potential yield changes.

As previously stated, potential livestock feed production models I and II, developed in this paper, were defined as being based on a "present" acreage level. The determination of this "present" acreage for dryland purposes was based upon the average harvested acreage for each grain and forage crop over the three-year period 1957-1959. The crop acreage figures for the various crops presented in appendix Tables 21 through 38 were used in determining the three-year average. A recent period was selected so as to reflect to the greatest extent possible a truly current acreage pattern. A three-year average was used in an attempt to avoid any extreme variation which might occur in the acreage of a given crop or crops in a particular year due to weather hazards or other variables.

It is to be noted from the discussion of recent trends that the period used includes an inherent bias toward livestock feed production compared to some earlier periods. This is particularly true for the year 1957 in the case of western Kansas grain sorghum acreage. However, since the "present" acreage pattern is used for both present and projected levels of production, this bias will be reflected in terms of the absolute levels of production rather than in the relative positions of present and future production. It is important to point out that the utilization of this particular assumption regarding acreage patterns in the projection of a 1975 feed production model is by no means a prediction that this is the acreage pattern which actually will exist in 1975.

Expected shifts. Although as indicated earlier, limitations of time and information prevented the development of any formal estimations of 1975 acreage patterns, it was thought to be desirable to give a brief, informal look at some of the shifts which may be expected to occur in total harvested acres of various crops by 1975.

Wheat acreage by 1975 will probably be influenced to the greatest extent by the evolution of production controls. This dependence upon government programs makes acreage prediction impossible.[1] To the extent that production controls remain in effect, it would seem reasonable to expect wheat acreage to continue somewhere near its current level. Removal of controls would almost certainly result in an increased acreage of wheat in the state.[2]

Trends in corn acreage to 1975 will depend upon a number of conditions which will vary in different parts of the state. In general, the present relatively low corn acreages may be expected to continue or perhaps decrease slightly under dryland conditions in the western part of the state.[3] Corn will continue to decline in importance as a crop in south central Kansas because of its relatively poor adaptation in this area compared to grain sorghum.[4] A similar situation

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1. Patterns and Trends for Crops and Livestock, Kansas River Units, unpublished report, Kansas State University.
2. Smith, interview, op. cit.
3. Patterns and Trends, loc. cit.
4. Stickler interview, loc. cit.

for corn grown under dryland conditions is to be expected in more northern areas of central Kansas.[1] The future long-term trend in corn acreage in eastern Kansas will likely be affected by a number of factors including potential acreage shifts to soybeans and grain sorghum. Although prediction is difficult, a moderate downward trend leveling off toward 1975 may be probable in the case of corn in much of this area.[2]

Grain sorghum acreage to 1975 in Kansas will depend much upon continued development of improved hybrids, developments in demand as a livestock feed, trends in wheat acreage in western Kansas and relative profitability and adaptability compared to corn and other crops in eastern Kansas.

Although potential influences of government programs make prediction difficult, it would seem likely that grain sorghum acreage may increase somewhat over the state by 1975. In general, it would appear from present indications that this potential increase might be relatively greater in the central and western parts of the state than in the eastern area.[3]

Acreage of barley over the past has been highly erratic in Kansas. It has, with minor exceptions, been the least important of the feed grains in most areas of the state through the years. It would seem that the future does not hold very bright prospects for spring varieties of this crop.[4] However, a continued improvement in winter hardiness and yield potential of winter barley might possibly pave the way for some acreage expansion. This would probably be determined to some extent by acceptance of barley as a livestock feed and any shifts of barley onto diverted acreages of other crops which might take place. Little more can be indicated concerning future trends for barley acreage in Kansas.

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1. Patterns and Trends, loc. cit.
2. Loc. cit.
3. Loc. cit.
4. Walter, loc. cit.

As previously indicated the trend in harvested acreage of oats has been generally lower over the past 20 years for most areas of the state. Little evidence can be found to indicate a reversal in the trend by 1975. As oats cannot compete with wheat and barley as a grain crop, it may be pretty well out of the picture in Kansas by 1975.[1] However, certain factors which favor the production of oats, involving labor requirements, crop rotations, and special feed uses, may hold it on the list of significant crops in some areas of the state.[2]

Future trends in the acreage of forage crops in Kansas will depend much upon developments in livestock production. Acreage has traditionally fluctuated according to weather and relative prices and this situation is not expected to alter by 1975. Further reduction in acreage of grain crops could influence some shift to forage crops. An evolution toward mechanical feeding might influence some shift from forage to silage sorghum production. Programs such as the Great Plains Conservation Program plus a restriction of cultivated crop acreage could stimulate some modest further expansion in grassland acreage in the state.[3] To summarize, little indication is found to suggest any marked increase in acreage of forage crop under dryland conditions. The most likely situation would seem at present, to be one of continued variability about a generally level long-term trend.

Irrigated. Assumed constant. It was previously implied that in developing probable production models I and II of 1975 livestock feed production a constant or present dryland acreage figure was used for each crop, based on an average of the years 1957-1959. This implication bears additional discussion. Total

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1. Heyene, loc. cit.
2. Patterns and Trends, loc. cit.
3. Grassland acreage refers to tame and prairie grasses used primarily for pasture purposes.

average crop acreage was held constant, including both dryland and irrigated acreage for each crop. The reason for emphasizing this particular point at this time will be clarified by an explanation of the approach used in establishing 1975 acreage levels of irrigated crops in this study.

It has been previously indicated that Kansas State Board of Agriculture yield and acreage data makes no distinction between dryland and irrigated production. It has also been pointed out earlier in this discussion the source and procedure whereby present and projected irrigated crop acreage was determined. Present total irrigated acreage, by crops, was taken as reported in Annual County Agents reports.[1] Total 1975 irrigated acreage was based on a projection supplied by the Kansas Water Resources Board which had been developed by Kansas State University personnel, based on recent trends in irrigation expansion, plus an examination and correlation of potential irrigable lands and irrigation water supplies in various areas of the state. For the purpose of this study, average State Board of Agriculture crop acreage for the 1957-1959 period was assumed to represent <u>total</u> crop acres. Furthermore, present dryland acreage was assumed to be the difference between total present acreage estimated from State Board of Agriculture figures and the 1960 acreage of irrigated crops reported by the County Agents Reports. However, for the "present" acreage figure used in potential production models I and II, the total irrigated crop acreage used was the above mentioned 1975 projection. And the allocation of this total 1975 acreage was assumed to retain the same percentage distribution among competing crops as the average percentage allocation over the three-year period, 1958-1960, based again on County Agents Reports. Thus, it is seen that whereas

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1. County Agents Reports, <u>loc</u>. <u>cit</u>.

the total acreage figure used in developing the "present normal" and model I and II levels of expected 1975 livestock feed production was the same, there was integrated into the 1975 acreage estimates a shift, within this total acreage level, from dryland to irrigated crop production based on the above indicated 1975 irrigated acreage projection. And, furthermore, it is seen that whereas total irrigated acreage is assumed or estimated to increase, the relative share of this larger acreage for each crop is assumed to remain at its present or a constant level, based, as stated, on an average of the 1958-1960 period. All this is simply to say that acreage estimations for present and projected levels of livestock feed production are assumed to remain at a constant total, that a shift within this total from dryland to irrigation will occur, but that this shift will be by a constant relative amount for each crop under irrigation

Expected Shifts. Very little information is available upon which to base estimates of future trends in individual irrigated crops. Perhaps the primary influencing factors will be relative profitability and adaptability. At present these two factors seem to favor production of corn, grain and silage sorghum, and alfalfa over the small grains. The extent to which this situation may project itself into the future is largely conjectural at this point. Examination of appendix Tables 39 through 47 will indicate movement in absolute and relative irrigated acreages over the 1954-1960 period. One point of interest is the very consistent decline in the relative position of alfalfa in every crop reporting district. Absolute alfalfa acreage has, however, generally been constant or increasing. However, the time period involved is much too short for basing an estimate of future trends. It might also be pointed out that in most districts grain sorghum and corn together account for nearly half or more of the total irrigated acreage thus giving some indication of the great importance of irrigation in the production of high energy livestock feeds.

Evaluation of Acreage Projections

The discussion of recent trends in feed crop acreages in Kansas was for the purpose of familiarization with past patterns of occurrence. The limitations inherent in the qualitative analysis used should be obvious. Even in the case of relatively obvious trends toward higher or lower harvested acreage levels, the continuation of these trends into the future can be suggested only to the extent that those variable factors influencing acreage levels can be anticipated to extend into the future at rates and in combinations comparable to those existing in the past.

The four areas considered as affecting acreage shifts may be contemplated as general classifications designed to cover the principle variables rather than as all inclusive categories. The fact that they have not been (indeed perhaps cannot be) stated in quantitative terms should not detract from their value as brief qualitative perspectives of the nature of shifts which might potentially occur.

The technique of establishing a 1975 cropping pattern based on an assumption of a static acreage has certain theoretical value, as previously indicated. However, the limitations imposed by this unrealistic assumption markedly decreases the palatability of any production estimates based upon such acreage projections in terms of practical utility. Perhaps the weakest link in this study was the failure to develop quantitative estimates of 1975 feed crop acreages. By thus eliminating two potential production models the versatility of the production estimates was significantly reduced. The qualitative discussions of expected shifts could only partially alleviate this deficiency.

ESTIMATION OF PRODUCTION

The final objective of this study was to develop estimates or projections of potential 1975 livestock feed production in Kansas. These potential production models are presented in this section in tabular form. In addition to the 1975 production estimates will be found two tables containing information relevant to current levels of livestock feed production in the state. Production figures in all cases are listed individually for wheat, corn, grain sorghum, barley, oats, forage sorghum, silage sorghum, alfalfa hay, wild hay, permanent pasture, and all others.[1] Composite production estimates are given for the four feed grains, and the four forage crops. Production figures are presented in tons of total production and also in tons of TDN for all crops considered except wheat for which no TDN conversion was made.[2] Information is presented by crop reporting district with a TDN production sub-total listed for each district and the grand total of TDN production in tons given for the entire state under each separate production estimate made. The following pages contain discussions and explanations of each of the present and 1975 production estimates presented in this section.

"Present Normal" Production

The determination of "present normal" livestock feed production in Kansas was based upon a combination of "probable present" crop yields and "present" harvested acres. Reference to Table 7 indicates yields per harvested acre for dryland and irrigated crops in columns 1 and 2 respectively. As shown in note a, Table 7, these yield figures are taken from the "probable present" yields given in Table 5. The derivation of these yield figures was discussed in the section,

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1. For explanation of all others, see Scope, p. 8; also see note d, Tables 7-10.
2. Thus wheat production was not included in total TDN estimates.

Table 7. "Present normal" livestock feed production in Kansas.

Crop reporting district and crop	Yield per harvested acre[a]		Harvested acres[b]		Total production	TDN[c]	
	Dryland	Irrigated	Dryland	Irrigated	tons	%	tons
Northwest							
wheat	20.5	32.5	918,300	8,000	572,500	-	-
corn	18.0	75.0	86,300	13,600	72,100	80.1	57,750
grain sorghum	24.0	72.0	397,700	11,300	290,000	79.4	217,200
barley	20.0	-	81,700	-	39,200	75.6	29,600
oats	19.6	-	9,400	-	2,900	70.1	2,000
Four feed grains	-	-	575,100	24,900	404,200	-	306,550
forage sorghum	1.5	-	70,700	-	106,000	52.4	55,500
silage sorghum	5.4	18.0	39,500	7,100	341,100	19.0	64,800
alfalfa hay	2.1	4.8	39,200	5,600	109,200	50.7	55,400
wild hay	1.0	-	3,900	-	3,900	44.9	1,750
Four forage crops	-	-	153,300	12,700	560,200	-	177,450
pasture	.27	1.30	1,675,100	900	453,500	50.0	226,750
All others, estimated[d]	-	-	-	-	-	-	225,000
Subtotal, CR District	-	-	-	-	-	-	935,750
West Central							
wheat	16.5	32.5	750,200	52,100	422,100	-	-
corn	15.0	75.0	2,300	24,000	51,400	80.1	41,200
grain sorghum	22.0	72.0	640,600	68,100	555,400	79.4	441,000
barley	15.0	-	57,100	-	20,500	75.6	15,500
oats	15.8	-	5,800	-	1,500	70.1	1,050
Four feed grains	-	-	705,800	92,100	628,800	-	498,750
forage sorghum	1.4	-	104,300	-	146,000	52.4	76,500
silage sorghum	5.4	18.0	19,700	26,000	574,400	19.0	109,100
alfalfa hay	2.0	4.8	2,400	18,000	91,200	50.7	46,200
wild hay	1.1	-	17,100	-	18,800	44.9	8,400
Four forage crops	-	-	143,500	44,000	830,400	-	240,200
pasture	.27	1.30	1,854,000	1,000	602,050	50.0	301,025
All others, estimated[d]	-	-	-	-	-	-	225,000
Subtotal, CR District	-	-	-	-	-	-	1,264,975

Table 7 (cont.)

Crop reporting district and crop	Yield per harvested acre[a] Dryland	Yield per harvested acre[a] Irrigated	Harvested acres[b] Dryland	Harvested acres[b] Irrigated	Total production tons	TDN[c] %	TDN[c] tons
Southwest							
wheat	16.1	32.5	1,254,000	142,000	744,100	-	-
corn	15.0	75.0	17,400	26,300	62,600	80.1	50,100
grain sorghum	22.0	72.0	1,149,700	242,300	1,196,700	79.4	950,200
barley	15.0	-	56,100	-	20,200	75.6	15,300
oats	14.3	-	6,000	-	1,400	70.1	1,000
Four feed grains	-	-	1,229,200	268,600	1,280,900	-	1,016,600
forage sorghum	1.6	-	118,000	-	188,800	52.4	98,900
silage sorghum	5.4	18.0	4,200	47,400	875,900	19.0	16,600
alfalfa hay	2.0	4.8	4,800	42,100	210,500	50.7	106,700
wild hay	1.0	-	4,900	-	4,900	44.9	2,200
Four forage crops	-	-	112,000	89,500	1,280,100	-	224,400
pasture	.27	1.30	2,220,700	5,300	606,500	50.0	303,250
All others, estimated[d]	-	-	-	-	-	-	225,000
Subtotal, CR District	-	-	-	-	-	-	1,769,250
North Central							
wheat	17.8	35.0	1,066,800	3,500	573,400	-	-
corn	22.0	82.0	192,000	48,400	229,400	80.1	183,750
grain sorghum	28.0	80.0	531,000	17,300	455,100	79.4	361,350
barley	17.0	-	52,800	-	21,600	75.6	16,300
oats	22.3	-	88,600	-	31,600	70.1	22,150
Four feed grains	-	-	864,400	65,700	737,700	-	583,550
sorghum forage	2.1	-	73,700	-	154,800	52.4	81,100
sorghum silage	6.1	21.0	69,800	7,800	589,600	19.0	112,000
alfalfa hay	1.6	5.0	266,800	6,900	461,400	50.7	233,900
wild hay	.9	-	45,600	-	41,000	43.9	18,000
Four forage grains	-	-	455,900	14,700	1,246,800	-	445,000
pasture	.30	1.30	1,069,440	860	321,900	52.0	167,400
All others, estimated[d]	-	-	-	-	-	-	225,000
Subtotal, CR District	-	-	-	-	-	-	1,420,950

Table 7 (cont.)

Crop reporting district and crop	Yield per harvested acre[a]		Harvested acres[b]		Total production	TDN[c]	
	Dryland	Irrigated	Dryland	Irrigated	tons	%	tons
Central							
wheat	18.9	35.0	1,423,900	3,100	810,600	-	-
corn	21.5	82.0	94,400	9,400	78,400	80.1	62,800
grain sorghum	28.0	80.0	477,600	13,700	405,100	79.4	321,650
barley	19.5	-	99,870	-	46,800	75.6	35,400
oats	22.0	-	133,170	-	46,900	70.1	32,900
Four feed grains	-	-	805,040	23,100	530,300	-	452,750
sorghum forage	2.0	-	60,700	-	121,400	52.4	63,600
sorghum silage	6.3	21.0	81,600	10,400	732,500	19.0	139,200
alfalfa hay	1.8	5.0	153,200	8,700	319,260	50.7	161,900
wild hay	1.0	-	44,800	-	44,800	43.9	19,700
Four forage crops	-	-	340,300	19,100	1,218,000	-	384,400
pasture	.30	1.30	1,828,500	500	549,200	52.0	285,600
All others, estimated[d]	-	-	-	-	-	-	225,000
Subtotal, CR District	-	-	-	-	-	-	1,347,750
South Central							
Wheat	17.2	35.0	1,912,800	11,800	999,400	-	-
corn	21.0	82.0	52,800	8,100	49,700	80.1	39,800
grain sorghum	23.0	80.0	734,100	19,200	515,800	79.4	409,500
barley	18.0	-	187,700	-	81,100	75.6	61,300
oats	19.8	-	114,400	-	36,300	70.1	25,400
Four feed grains	-	-	1,089,000	27,300	682,900	-	536,000
sorghum forage	1.7	-	107,000	-	181,900	52.4	95,300
sorghum silage	5.7	21.0	98,500	16,200	901,600	19.0	171,300
alfalfa hay	1.8	5.0	146,100	13,300	329,000	50.7	166,800
wild hay	1.1	-	22,400	-	24,600	43.9	10,800
Four forage crops	-	-	374,000	29,500	1,437,100	-	444,200
pasture	.30	1.30	2,197,500	1,500	661,200	52.0	343,800
All others, estimated[d]	-	-	-	-	-	-	225,000
Subtotal, CR District	-	-	-	-	-	-	1,549,000

Table 7 (cont.)

Crop reporting district and crop	Yield per harvested acre[a]		Harvested acres[b]		Total production	TDN[c]	
	Dryland	Irrigated	Dryland	Irrigated	tons	%	tons
Northeast							
wheat	29.8	35.0	351,100	900	314,800	-	-
corn	41.5	82.0	529,000	6,300	629,200	80.1	504,000
grain sorghum	39.0	80.0	255,900	1,900	283,500	79.4	225,100
barley	28.7	-	19,900	-	13,700	75.6	10,350
oats	33.0	-	137,600	-	72,600	70.1	50,900
Four feed grains	-	-	942,400	8,200	999,000	-	790,350
sorghum forage	2.4	-	5,100	-	12,200	52.4	6,400
sorghum silage	8.9	21.0	34,200	3,200	371,600	19.0	70,600
alfalfa hay	2.0	5.2	211,100	1,700	431,000	50.7	218,500
wild hay	1.0	-	74,100	-	74,100	41.4	30,700
Four forage crops	-	-	324,500	4,900	888,900	-	326,200
pasture	.33	1.30	1,477,700	300	478,100	55.0	263,000
All others, estimated[d]	-	-	-	-	-	-	225,000
Subtotal, CR District	-	-	-	-	-	-	1,604,550
East Central							
wheat	29.6	35.0	427,700	300	380,100	-	-
corn	41.7	82.0	380,400	7,800	462,100	80.1	370,100
grain sorghum	37.0	80.0	292,333	1,300	305,800	79.4	242,800
barley	28.1	-	72,600	-	49,000	75.6	37,000
oats	38.8	-	137,200	-	85,200	70.1	59,700
Four feed grains	-	-	882,500	9,100	902,100	-	709,600
sorghum forage	2.5	-	15,400	-	38,500	52.4	20,200
sorghum silage	8.6	21.0	60,300	1,000	539,600	19.0	102,500
alfalfa hay	2.1	5.2	205,800	2,800	446,800	50.7	226,500
wild hay	1.2	-	157,200	-	188,600	41.4	78,100
Four forage crops	-	-	438,700	3,800	1,213,500	-	427,300
pasture	.33	1.30	2,800,700	300	924,600	55.0	508,500
All others, estimated[d]	-	-	-	-	-	-	225,000
Subtotal, CR District	-	-	-	-	-	-	1,870,400

Table 7 (concl.)

Crop reporting district and crop	Yield per harvested acre[a]		Harvested acres[b]		Total production	TDN[c]	
	Dryland	Irrigated	Dryland	Irrigated	tons	%	tons
Southeast							
wheat	22.6	35.0	547,000	300	371,200	-	-
corn	36.3	82.0	299,600	1,500	307,900	80.1	246,600
grain sorghum	32.0	80.0	223,900	1,100	203,100	79.4	161,300
barley	22.3	-	148,200	-	79,300	75.6	59,950
oats	35.7	-	193,700	-	110,700	72.1	77,600
Four feed grains	-	-	865,400	2,600	701,000	-	545,450
sorghum forage	2.2	-	18,900	-	41,600	52.4	21,800
sorghum silage	6.9	21.0	52,400	1,200	386,800	19.0	73,500
alfalfa hay	1.8	5.2	139,800	1,900	261,500	50.7	132,600
wild hay	1.1	-	213,600	-	235,000	41.4	97,300
Four forage crops	-	-	424,700	3,100	924,900	-	325,200
pasture	.33	1.30	3,580,800	200	1,181,950	55.0	650,100
All others, estimated[d]	-	-	-	-	-	-	225,000
Subtotal, CR District	-	-	-	-	-	-	1,745,750
State Total							13,508,375

a. Yields per harvested acre from "probable present" yield, Table 5.

b. Harvested acres, based on average harvested acreage of each crop, 1957-59. See appendix Tables 21-38.

c. TDN estimates based on Morrison, "Feeds and Feeding," 22nd ed., unabridged, 1957, Ithaca, New York, the Morrison Publishing Company.

d. "All other" livestock feeds based upon estimates made by author, considering temporary pasture crops, miscellaneous hays, crop aftermath, etc. Estimates made for state as a whole and one ninth of total assumed to occur within each crop reporting district.

Yield Projections, p. 115. In columns 3 and 4 respectively of Table 7 is given the dryland and irrigated acreage for the various crops listed. As indicated by note b, Table 7 these acreages represent a "present" harvested acreage level for the various crops and are based upon 1957-59 average of the crop acreage figures given in appendix Tables 21-38. A detailed discussion of the determination of this present harvested acreage level is given in the section, Acreage Projections, p. 145.

It will be noted that column 5 in Table 7 is concerned with total production of livestock feed in Kansas under "present normal" conditions. Column 5 contains production estimates in tons for wheat, the feed grains, the forage crops, pasture, and all others.

The derivation of these production estimates was accomplished by multiplying the dryland and irrigated acreage figures times the dryland and irrigated yield figures respectively. Summation of these dryland and irrigated production figures gave the total production estimates presented in column 5.

In the last two columns of Table 7 is given livestock feed production in Kansas under "present normal" conditions in terms of total digestible nutrients (TDN). Column 6 presents the conversion factor or the percent TDN for each of the various feeds as taken from Morrison.[1] Total production in tons from column 5 multiplied times the percent TDN for each crop from column 6 gives the number of tons of TDN of each feed crop estimated under the assumptions and conditions specified for "present normal" livestock feed production in Kansas. These TDN figures are presented in column 7, Table 7.

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1. F. B. Morrison, Feeds and Feeding, 22nd ed., Corn, dent, Grade No. 2, p. 1048; Milo grain, p. 1058; Barley, common, ground, feed grade, p. 1044; Oats, not including Pacific Coast states, p. 1058; Forage Sorghum, sorghum fodder, sweet, dry, p. 1014; Silage Sorghum, Ellis, p. 1042; Wild Hay, TDN estimates based upon average for predominate grasses composing wild hay in western, central, and eastern sections of state respectively; Pasture, TDN estimates based upon average for predominate grasses composing pasture flora in western, central, and eastern sections of state.

In observing Table 7, it will be noted that "present normal" livestock feed production in Kansas has been estimated to total 935,750 tons of TDN for the NW crop reporting district. The comparable figure for the WC district is 1,264,975. Estimates of TDN production for the remaining crop reporting districts totals 1,769,250 for the SW, 1,420,950 for the NC, 1,347,750 for the C, 1,549,000 for the SC, 1,604,550 for the NE, 1,870,400 for the EC, and 1,745,750 for the SE. These crop reporting district subtotals are the summation of the TDN production estimated for feed grains, forage crops, permanent pasture, and all others within each given district. Summation of the nine crop reporting district subtotals gives a state total of 13,508,375 tons of TDN production as estimated within the framework of this "present normal" production model.

Probable Production Model I
("Probable Projected" Yield and "Present" Acreage)

Model I of the 1975 potential livestock feed production estimates developed in this study was derived from the independent variables of dryland and irrigated crop yields per harvested acre ("probable projected" 1975 yields) and dryland and irrigated harvested acres for each crop under consideration ("present" acreage).[1]

The dependent variable, total production, determined within the framework of Model I, is presented in Table 8 along with the independent variables of yield and acreage. Observation of Table 8 will reveal that in Column 5, a 1975 production estimate is given for each of the feed crops considered in the Table. In column 6 is given a TDN percentage figure for each of the four feed grains, the four forage crops, pasture and all others. These TDN percentages taken times

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1. For explanation of "probable projected" yields and "present" acreage, see p. 22.

Table 8. 1975 probable Kansas livestock feed production Model I ("probable projected" yield and "present" acreage).

Crop reporting district and crop	Yield per harvested acre[a]		Harvested acres[b]		Total production	TDN[c]	
	Dryland	Irrigated	Dryland	Irrigated	tons	%	tons
Northwest							
wheat	22.3 bu.	38.4 bu.	946,000	16,300	651,660	-	-
corn	19.6 bu.	88.5 bu.	72,100	27,800	108,500	80.1	86,900
grain sorghum	26.9 bu.	85.0 bu.	386,000	23,000	345,500	79.4	274,300
barley	21.8 bu.	-	81,700	-	42,800	75.1	32,100
oats	21.4 bu.	-	9,400	-	3,200	70.1	2,200
Four feed grains	-	-	549,200	50,800	500,000	-	395,500
forage sorghum	1.6 ton	-	70,700	-	113,100	52.4	59,300
silage sorghum	6.0 ton	21.2 ton	32,200	14,400	498,480	19.0	94,700
alfalfa hay	2.5 ton	6.0 ton	33,300	11,500	152,200	50.7	77,200
wild hay	1.0 ton	-	3,900	-	3,900	44.9	1,750
Four forage crops	-	-	140,100	25,900	767,700	-	232,950
pasture	0.28 ton	1.43 ton	1,674,100	1,900	471,400	50.0	233,700
All others, estimated[d]	-	-	-	-	-	-	247,000
Subtotal, CR District	-	-	-	-	-	-	1,109,150
West Central							
wheat	18.0 bu.	38.4 bu.	743,300	59,000	469,400	-	-
corn	-	88.5 bu.	-	27,300	67,600	80.1	54,100
grain sorghum	24.6 bu.	85.0 bu.	631,600	77,100	618,500	79.4	491,100
barley	16.4 bu.	-	57,100	-	22,500	75.1	16,900
oats	17.2 bu.	-	5,800	-	1,600	70.1	1,100
Four feed grains	-	-	693,500	104,400	710,200	-	563,200
forage sorghum	1.5 ton	-	104,300	-	156,400	52.4	82,000
silage sorghum	6.0 ton	21.2 ton	16,200	29,500	722,600	19.0	137,300
alfalfa hay	-	6.0 ton	-	20,400	122,400	50.7	62,100
wild hay	1.1 ton	-	17,100	-	18,800	44.9	8,400
Four forage crops	-	-	137,600	49,900	1,020,200	-	289,800
pasture	0.28 ton	1.43 ton	1,853,900	1,100	520,700	50.0	260,350
All others, estimated[d]	-	-	-	-	-	-	247,000
Subtotal, CR District	-	-	-	-	-	-	1,360,350

Table 8 (Cont.)

Crop reporting district and crop	Yield per harvested acre[a] Dryland	Yield per harvested acre[a] Irrigated	Harvested acres[b] Dryland	Harvested acres[b] Irrigated	Total production tons	TDN[c] %	TDN[c] tons
Southwest							
wheat	17.5 bu.	38.4 bu.	1,160,000	236,000	880,900	-	-
corn	-	88.5 bu.	-	43,700	108,300	80.1	86,750
grain sorghum	24.6 bu.	85.0 bu.	990,000	402,000	1,638,700	79.4	1,301,100
barley	16.4 bu.	-	56,100	-	22,100	75.1	16,600
oats	15.6 bu.	-	6,000	-	1,500	70.1	1,050
Four feed grains	-	-	1,052,100	445,700	1,770,600	-	1,405,500
forage sorghum	1.7 ton	-	118,000	-	200,600	52.4	105,100
silage sorghum	6.0 ton	21.2 ton	-	78,700	1,668,400	19.0	317,000
alfalfa hay	-	6.0 ton	-	69,900	419,400	50.7	212,600
wild hay	1.0 ton	-	4,900	-	4,900	44.9	2,200
Four forage crops	-	-	122,900	148,600	2,293,300	-	636,900
pasture	0.28 ton	1.43 ton	2,217,300	8,700	633,200	50.0	316,600
All others, estimated[d]	-	-	-	-	-	-	247,000
Subtotal, CR District	-	-	-	-	-	-	2,606,000
North Central							
wheat	19.9 bu.	41.3 bu.	1,064,000	6,300	643,020	-	-
corn	24.9 bu.	96.8 bu.	152,500	87,900	344,600	80.1	207,450
grain sorghum	32.2 bu.	94.4 bu.	516,900	31,400	549,100	79.4	436,000
barley	19.0 bu.	-	52,800	-	24,100	75.6	18,200
oats	25.0 bu.	-	88,600	-	35,400	70.1	24,800
Four feed grains	-	-	810,800	119,300	953,200	-	686,450
forage sorghum	2.4 ton	-	73,700	-	176,900	52.4	92,700
silage sorghum	7.0 ton	24.8 ton	63,500	14,100	794,200	19.0	150,900
alfalfa hay	1.9 ton	6.2 ton	261,100	12,600	574,200	50.7	291,100
wild hay	.9 ton	-	45,600	-	41,000	43.9	18,000
Four forage crops	-	-	443,900	26,700	1,586,300	-	552,700
pasture	0.31 ton	1.43 ton	1,068,700	1,600	333,600	52.0	173,500
All others, estimated[d]	-	-	-	-	-	-	247,000
Subtotal, CR District	-	-	-	-	-	-	1,659,650

Table 8 (Cont.)

Crop reporting district and crop	Yield per harvested acre[a]		Harvested acres[b]		Total production	TDN[c]	
	Dryland	Irrigated	Dryland	Irrigated	tons	%	tons
Central							
wheat	21.2 bu.	41.3 bu.	1,418,300	8,700	912,800	-	-
corn	24.1 bu.	96.8 bu.	76,900	26,900	124,800	80.1	100,000
grain sorghum	32.2 bu.	94.4 bu.	452,300	39,000	510,900	79.4	405,650
barley	21.8 bu.	-	99,870	-	52,200	75.6	39,460
oats	24.6 bu.	-	133,170	-	52,400	70.1	36,700
Four feed grains	-	-	828,140	65,900	740,300	-	581,800
forage sorghum	2.2 ton	-	60,700	-	133,540	52.4	70,000
silage sorghum	7.2 ton	24.8 ton	62,400	29,600	1,183,400	19.0	224,800
alfalfa hay	2.2 ton	6.2 ton	137,000	24,900	455,800	50.7	231,100
wild hay	1.0 ton	-	44,800	-	44,800	43.9	19,700
Four forage crops	-	-	304,900	54,500	1,817,540	-	545,600
pasture	0.31 ton	1.43 ton	1,827,700	1,300	568,500	52.0	295,600
All others, estimated[d]	-	-	-	-	-	-	247,000
Subtotal, CR District	-	-	-	-	-	-	1,670,000
South Central							
wheat	19.3 bu.	41.3 bu.	1,893,900	30,700	1,134,600	-	-
corn	22.9 bu.	96.8 bu.	39,800	21,100	82,700	80.1	66,200
grain sorghum	26.4 bu.	94.4 bu.	703,500	49,800	651,700	79.4	517,450
barley	20.2 bu.	-	187,700	-	91,000	75.6	68,800
oats	22.2 bu.	-	114,400	-	40,600	70.1	28,500
Four feed grains	-	-	1,045,400	70,900	866,000	-	680,950
forage sorghum	1.9 ton	-	107,000	-	203,300	52.4	106,500
silage sorghum	6.5 ton	21.0 ton	72,500	42,200	1,357,450	19.0	257,900
alfalfa hay	2.2 ton	6.2 ton	124,900	34,500	488,700	50.7	247,800
wild hay	1.2 ton	-	22,400	-	26,900	43.9	11,800
Four forage crops	-	-	326,800	76,700	2,076,350	-	624,000
pasture	0.31 ton	1.43 ton	2,195,200	3,800	685,900	52.0	356,700
All others, estimated[d]	-	-	-	-	-	-	247,000
Subtotal, CR District	-	-	-	-	-	-	1,908,650

Table 8 (Cont.)

Crop reporting District and crop	Yield per harvested acre[a] Dryland	Yield per harvested acre[a] Irrigated	Harvested acres[b] Dryland	Harvested acres[b] Irrigated	Total production tons	TDN[c] %	TDN[c] tons
Northeast							
wheat	34.3 bu.	41.3 bu.	347,300	4,700	260,280	-	-
corn	47.7 bu.	96.8 bu.	504,200	31,100	757,700	80.1	606,900
grain sorghum	46.0 bu.	94.4 bu.	248,500	9,300	344,600	79.4	32,400
barley	33.0 bu.	-	19,900	-	15,700	75.6	11,900
oats	38.0 bu.	-	137,600	-	83,600	70.1	58,600
Four feed grains	-	-	910,200	40,400	1,201,600	-	709,800
forage sorghum	2.8 ton	-	5,100	-	14,300	52.4	7,500
silage sorghum	10.5 ton	24.8 ton	21,800	15,600	615,800	19.0	117,000
alfalfa hay	2.4 ton	6.5 ton	204,200	8,600	546,000	50.7	276,800
wild hay	1.0 ton	-	74,400	-	74,400	41.4	30,800
Four forage crops	-	-	305,500	24,200	1,250,500	-	432,100
pasture	0.34 ton	1.43 ton	1,476,400	1,600	504,300	55.0	277,400
All others, estimated[d]	-	-	-	-	-	-	247,000
Subtotal, CR District	-	-	-	-	-	-	1,666,300
East Central							
wheat	34.0 bu.	41.3 bu.	426,900	1,100	455,300	-	-
corn	48.0 bu.	96.8 bu.	358,200	30,000	562,700	80.1	450,700
grain sorghum	43.7 bu.	94.4 bu.	288,600	4,900	366,100	79.4	290,700
barley	32.3 bu.	-	72,600	-	56,300	75.6	42,600
oats	44.6 bu.	-	137,200	-	96,900	70.1	67,900
Four feed grains	-	-	856,600	34,900	1,082,000	-	851,900
forage sorghum	2.9 ton	-	15,400	-	44,700	52.4	23,400
silage sorghum	10.1 ton	24.8 ton	57,500	3,800	694,950	19.0	132,000
alfalfa hay	2.6 ton	6.5 ton	197,700	10,900	584,800	50.7	296,500
wild hay	1.3 ton	-	157,200	-	204,400	41.4	84,600
Four forage crops	-	-	427,800	14,700	1,528,850	-	536,500
pasture	0.34 ton	1.43 ton	2,799,900	1,100	953,600	55.0	524,500
All others, estimated[d]	-	-	-	-	-	-	247,000
Subtotal, CR District	-	-	-	-	-	-	2,159,900

Table 8 (Concl.)

Crop reporting district and crop	Yield per harvested acre[a] Dryland	Yield per harvested acre[a] Irrigated	Harvested acres[b] Dryland	Harvested acres[b] Irrigated	Total production tons	TDN[c] %	TDN[c] tons
Southeast							
wheat	26.0 bu.	41.3 bu.	746,500	800	583,300	-	-
corn	41.7 bu.	96.8 bu.	296,200	4,900	359,100	80.1	287,600
grain sorghum	37.8 bu.	94.4 bu.	221,500	3,500	243,700	79.4	193,500
barley	25.6 bu.	-	148,200	-	91,100	75.6	68,900
oats	41.1 bu.	-	193,700	-	127,400	70.1	89,300
Four feed grains	-	-	859,600	8,400	821,300	-	639,300
forage sorghum	2.5 ton	-	18,900	-	47,200	52.4	24,700
silage sorghum	8.1 ton	24.8 ton	49,900	3,700	495,900	19.0	94,200
alfalfa hay	2.2 ton	6.5 ton	135,800	5,900	337,200	50.7	171,000
wild hay	1.2 ton	-	213,600	-	256,300	41.4	106,100
Four forage crops	-	-	418,200	9,600	1,136,600	-	396,000
pasture	0.34 ton	1.43 ton	3,580,400	600	1,218,200	55.0	670,000
All others, estimated	-	-	-	-	-	-	247,000
Subtotal, CR District	-	-	-	-	-	-	1,952,300
State Total							16,092,300

a. Yields per harvested acre from "probable projected" 1975 yields, Table 5.

b. Harvested acres, taken as average harvested acreage of each crop, 1957-59. See appendix Tables 21-38.

c. TDN estimates based on Morrison, "Feeds and Feeding," 22nd ed., unabridged, 1957, Ithaca, New York, The Morrison Publishing Company.

d. "All other" livestock feeds based upon estimates made by author, considering temporary pasture crops, miscellaneous hays, crop aftermath, etc. Estimates made for state as a whole and one ninth of total assumed to occur within each crop reporting district.

the total production for each respective crop gives an estimate (in column 7) of total feed crop production of TDN in the State under the conditions of this Model.[1]

The first four columns of Table 8 are concerned with the independent variables of yield and acreage. These factors are considered under both dryland and irrigated production conditions. Thus the total production projection of column 5 was determined by estimating dryland and irrigated production (yield times harvested acreage) and summing the two products.

Probable Production Model II
("Optimum Projected Yield" and "Present" Acreage)

Model II of the 1975 potential livestock feed production estimates in this study was derived from the independent variables of dryland and irrigated crop yields per harvested acre ("optimum projected" 1975 yields) and dryland and irrigated harvested acres ("present" acreage) for each crop under consideration.[2]

The dependent variable, total production, determined within the framework of Model II, is presented in Table 9 along with the independent variables of yield and acreage. Observation of Table 9 will reveal that in column 5 is presented a 1975 production estimate for each of the feed crops considered in the Table. In column 6 a TDN percentage figure is given for each of the four feed grains, the four forage crops, pasture, and all others. These TDN percentages, taken times the total production for each crop gives an estimate (in column 7) of total feed crop production of TDN in the state under the conditions of this model.[3]

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1. See footnote, p. 159 for explanation of TDN percentages.
2. For explanation of "optimum projected" yields and "present" acreage, see p. 22.
3. See footnote, p. 159 for explanation of TDN percentages.

Table 9. 1975 probable Kansas livestock feed production Model II ("optimum projected" yield and "present" acreage).

Crop reporting district and crop	Yield per harvested acre[a]		Harvested acres[b]		Total production	TDN[c]	
	Dryland	Irrigated	Dryland	Irrigated	tons	%	tons
Northwest							
wheat	25.6 bu.	43.9 bu.	946,000	16,300	748,200	-	-
corn	22.5 bu.	101.2 bu.	72,100	27,800	124,152	80.1	99,400
grain sorghum	30.0 bu.	97.2 bu.	386,000	23,000	386,848	79.4	307,200
barley	25.0 bu.	-	81,700	-	49,000	75.6	37,000
oats	24.5 bu.	-	9,400	-	3,700	70.1	2,600
Four feed grains	-	-	549,200	50,800	563,700	-	446,200
forage sorghum	1.9 ton	-	70,700	-	134,300	52.4	70,400
silage sorghum	6.8 ton	24.3 ton	32,200	14,400	568,900	19.0	108,100
alfalfa hay	2.7 ton	6.5 ton	33,300	11,500	164,700	50.7	83,500
wild hay	1.2 ton	-	3,900	-	4,700	44.9	2,100
Four forage crops	-	-	140,100	25,900	872,600	-	264,100
pasture	0.32 ton	1.62 ton	1,674,100	1,900	538,800	50.0	269,400
All others, estimated[d]	-	-	-	-	-	-	270,000
Subtotal, CR District	-	-	-	-	-	-	1,249,700
West Central							
wheat	20.6 bu.	43.9 bu.	743,300	59,000	537,060	-	-
corn	-	101.2 bu.	-	27,300	77,300	80.1	61,900
grain sorghum	27.5 bu.	97.2 bu.	631,600	77,100	695,400	79.4	552,150
barley	18.8 bu.	-	57,100	-	25,800	75.6	19,500
oats	19.8 bu.	-	5,800	-	1,800	70.1	1,300
Four feed grains	-	-	693,500	104,400	800,300	-	634,850
forage sorghum	1.8 ton	-	104,300	-	187,700	52.4	98,350
silage sorghum	6.8 ton	24.3 ton	16,200	29,500	827,000	19.0	157,100
alfalfa hay	-	6.5 ton	-	20,400	132,600	50.7	67,200
wild hay	1.3 ton	-	117,100	-	22,200	44.9	10,000
Four forage crops	-	-	137,600	49,900	1,169,500	-	332,650
pasture	0.32 ton	1.62 ton	1,853,900	1,100	595,000	50.0	297,500
All others, estimated[d]	-	-	-	-	-	-	270,000
Subtotal, CR District	-	-	-	-	-	-	1,535,000

Table 9 (Cont.)

Crop reporting district and crop	Yield per harvested acre[a]		Harvested acres[b]		Total production	TDN[c]	
	Dryland	Irrigated	Dryland	Irrigated	tons	%	tons
Southwest							
wheat	20.1 bu.	43.9 bu.	1,160,000	236,000	1,010,280	-	-
corn	-	101.2 bu.	-	43,700	123,800	80.1	99,200
grain sorghum	27.5 bu.	97.2 bu.	990,000	402,000	1,856,400	79.4	1,474,000
barley	18.8 bu.	-	56,100	-	25,300	75.6	19,100
oats	17.9 bu.	-	6,000	-	1,700	70.1	1,200
Four feed grains	-	-	1,052,100	445,700	2,007,200	-	1,593,500
forage sorghum	2.0 ton	-	118,000	-	236,000	52.4	123,700
silage sorghum	-	24.3 ton	-	78,700	1,912,400	19.0	363,400
alfalfa hay	-	6.5 ton	-	69,900	454,400	50.7	230,400
wild hay	1.2 ton	-	4,900	-	5,900	44.9	2,650
Four forage crops	-	-	122,900	148,600	2,608,700	-	720,150
pasture	0.32 ton	1.62 ton	2,217,300	8,700	723,600	50.0	361,800
All others, estimated[d]	-	-	-	-	-	-	270,000
Subtotal, CR District	-	-	-	-	-	-	2,945,450
North Central							
wheat	23.1 bu.	47.2 bu.	1,064,000	6,300	746,280	-	-
corn	28.9 bu.	110.7 bu.	152,500	87,900	395,800	80.1	317,000
grain sorghum	36.4 bu.	108.0 bu.	516,900	31,400	621,900	79.4	493,800
barley	22.1 bu.	-	52,800	-	28,000	75.6	21,200
oats	29.0 bu.	-	88,600	-	41,100	70.1	28,800
Four feed grains	-	-	810,800	119,300	1,086,800	-	860,800
forage sorghum	2.7 ton	-	73,700	-	199,000	52.4	104,300
silage sorghum	7.9 ton	28.4 ton	63,500	14,100	902,100	19.0	171,400
alfalfa hay	2.2 ton	6.8 ton	261,100	12,600	660,100	50.7	334,700
wild hay	1.0 ton	-	45,600	-	45,600	43.9	20,000
Four forage crops	-	-	443,900	26,700	1,806,800	-	630,400
pasture	0.30 ton	1.62 ton	1,068,700	1,600	387,300	52.0	201,400
All others, estimated[d]	-	-	-	-	-	-	270,000
Subtotal, CR District	-	-	-	-	-	-	1,962,600

Table 9 (Cont.)

Crop reporting district and crop	Yield per harvested acre[a] Dryland	Yield per harvested acre[a] Irrigated	Harvested acres[b] Dryland	Harvested acres[b] Irrigated	Total production tons	TDN[c] %	TDN[c] tons
Central							
wheat	24.6 bu.	47.6 bu.	1,418,300	8,700	1,059,100	-	-
corn	46.2 bu.	110.7 bu.	76,900	26,900	182,800	80.1	146,400
grain sorghum	36.4 bu.	108.0 bu.	452,300	39,000	578,900	79.4	459,650
barley	25.4 bu.	-	99,870	-	60,900	75.6	46,000
oats	28.6 bu.	-	133,170	-	60,900	70.1	42,700
Four feed grains	-	-	828,140	65,900	883,500	-	694,750
forage sorghum	2.6 ton	-	60,700	-	157,800	52.4	82,700
silage sorghum	8.2 ton	28.4 ton	62,400	29,600	1,352,300	19.0	256,900
alfalfa hay	2.4 ton	6.8 ton	137,000	24,900	498,100	50.7	252,500
wild hay	1.2 ton	-	44,800	-	53,800	43.9	23,600
Four forage crops	-	-	304,900	54,500	2,062,000	-	615,700
pasture	0.36 ton	1.62 ton	1,827,700	1,300	660,100	52.0	343,250
All others, estimated[d]	-	-	-	-	-	-	270,000
Subtotal, CR District	-	-	-	-	-	-	1,923,700
South Central							
wheat	22.4 bu.	47.2 bu.	1,893,900	30,700	1,316,200	-	-
corn	27.3 bu.	110.7 bu.	39,800	21,100	95,800	80.1	76,700
grain sorghum	29.9 bu.	108.0 bu.	703,500	49,800	739,500	79.4	587,200
barley	23.4 bu.	-	187,700	-	105,400	75.6	79,700
oats	25.7 bu.	-	114,400	-	47,000	70.1	32,900
Four feed grains	-	-	1,045,400	70,900	987,700	-	776,500
forage sorghum	2.2 ton	-	107,000	-	235,400	52.4	123,350
silage sorghum	7.4 ton	28.4 ton	72,500	42,200	1,735,000	19.0	329,650
alfalfa hay	2.4 ton	6.8 ton	124,900	34,500	534,400	50.7	270,900
wild hay	1.3 ton	-	22,400	-	29,100	43.9	12,800
Four forage crops	-	-	326,800	76,700	2,533,900	-	736,700
pasture	0.36 ton	1.62 ton	2,195,200	3,800	796,500	52.0	414,200
All others, estimated[d]	-	-	-	-	-	-	270,000
Subtotal, CR District	-	-	-	-	-	-	2,197,400

Table 9 (Cont.)

Crop reporting district and crop	Yield per harvested acre[a] Dryland	Yield per harvested acre[a] Irrigated	Harvested acres[b] Dryland	Harvested acres[b] Irrigated	Total production tons	TDN[c] %	TDN[c] tons
Northeast							
wheat	40.2 bu.	47.2 bu.	347,300	4,700	425,520	-	-
corn	56.0 bu.	110.7 bu.	504,200	31,100	887,000	80.1	710,500
grain sorghum	52.6 bu.	108.0 bu.	248,500	9,300	394,100	79.4	312,800
barley	38.7 bu.	-	19,900	-	18,500	75.6	14,000
oats	44.6 bu.	-	137,600	-	98,200	70.1	68,800
Four feed grains	-	-	910,200	40,400	1,397,800	-	1,106,100
forage sorghum	3.2 ton	-	5,100	-	16,300	52.4	8,500
silage sorghum	12.0 ton	28.4 ton	21,800	15,600	704,600	19.0	133,900
alfalfa hay	2.8 ton	7.0 ton	204,200	8,600	632,000	50.7	320,400
wild hay	1.2 ton	-	74,400	-	89,300	41.4	37,000
Four forage crops	-	-	305,500	24,200	1,442,200	-	499,800
pasture	0.39 ton	1.62 ton	1,476,400	1,600	578,400	55.0	318,100
All others, estimated[d]	-	-	-	-	-	-	270,000
Subtotal, CR District	-	-	-	-	-	-	2,194,000
East Central							
wheat	40.0 bu.	47.2 bu.	426,900	1,100	513,800	-	-
corn	56.3 bu.	110.7 bu.	358,200	30,000	657,700	80.1	526,800
grain sorghum	50.0 bu.	108.0 bu.	288,600	4,900	418,900	79.4	332,600
barley	37.9 bu.	-	72,600	-	66,000	75.6	49,900
oats	52.4 bu.	-	137,200	-	115,000	70.1	80,600
Four feed grains	-	-	856,600	34,900	1,257,600	-	989,900
forage sorghum	3.4 ton	-	15,400	-	52,400	52.4	27,500
silage sorghum	11.6 ton	28.4 ton	57,500	3,800	774,900	19.0	147,200
alfalfa hay	2.9 ton	7.0 ton	197,700	10,900	649,600	50.7	329,300
wild hay	1.4 ton	-	157,200	-	220,100	41.4	91,100
Four forage crops	-	-	427,800	14,700	1,697,000	-	595,100
pasture	0.39 ton	1.62 ton	2,799,900	1,100	1,093,800	55.0	601,600
All others, estimated[d]	-	-	-	-	-	-	270,000
Subtotal, CR District	-	-	-	-	-	-	2,456,600

Table 9 (Concl.)

Crop reporting district and crop	Yield per harvested acre[a] Dryland	Yield per harvested acre[a] Irrigated	Harvested acres[b] Dryland	Harvested acres[b] Irrigated	Total production tons	TDN[c] %	TDN[c] tons
Southeast							
wheat	30.5 bu.	47.2 bu.	746,500	800	684,200	-	-
corn	49.0 bu.	110.7 bu.	296,200	4,900	421,600	80.1	337,700
grain sorghum	43.2 bu.	108.0 bu.	221,500	3,500	278,500	79.4	221,100
barley	30.1 bu.	-	148,200	-	107,000	75.6	80,900
oats	48.2 bu.	-	193,700	-	149,400	70.1	104,700
Four feed grains	-	-	859,600	8,400	956,500	-	744,400
forage sorghum	3.0 ton	-	18,900	-	56,700	52.4	29,700
silage sorghum	9.3 ton	28.4 ton	49,900	3,700	569,200	19.0	108,100
alfalfa hay	2.5 ton	7.0 ton	135,800	5,900	380,800	50.7	193,100
wild hay	1.3 ton	-	213,600	-	277,700	41.4	115,000
Four forage crops	-	-	418,200	9,600	1,284,400	-	445,900
pasture	0.39 ton	1.62 ton	3,580,400	600	1,397,400	55.0	768,600
All others, estimated[d]	-	-	-	-	-	-	270,000
Subtotal, CR District	-	-	-	-	-	-	2,228,900
State Total							18,693,350

a. Yields per harvested acre from "optimum projected" 1975 yields, Table 5.

b. Harvested acres, taken as average harvested acreage of each crop 1957-59. See appendix Tables 21-38.

c. TDN estimates based on Morrison, "Feeds and Feeding," 22nd ed., unabridged, 1957, Ithaca, New York. The Morrison Publishing Company.

d. "All other" livestock feeds based upon estimates made by author, considering temporary pasture crops, miscellaneous hays, crop aftermaths, etc. Estimates made for state as a whole and one ninth of total assumed to fall within each crop reporting district.

The first four columns of Table 9 are concerned with the independent variables of yield and acreage. These factors are considered under both dryland and irrigated production conditions. Thus the total production estimate of column 5 was determined by estimating dryland and irrigated production (yield times harvested acreage) and summing the two products.

1960 Livestock Feed Production

In order to provide a basis of comparison with the livestock feed production estimates made in this study it was deemed desirable to provide an indication of actual production in some current year. This has been done in Table 10, actual livestock feed production in Kansas, 1960. In this table is given the yield per harvested acre, number of acres harvested and total production in tons for the feed crops considered in this study as these figures were reported by the Kansas State Board of Agriculture in 1960.[1]

In columns 4 and 5 of Table 10 the total actual production figures are converted to TDN. The percent TDN used for the various crops was taken from Morrison.[2]

It will be noted that yield and acreage figures were not separated for dryland and irrigated production as was done in the estimates developed in this study. This change was necessary because State Crop Reporting Board production data is available only as a composite of all production. Thus, although the yield and acreage figures in Table 10 are an average of both dryland and irrigated production and cannot be directly compared with the same figures in the production models, the total production figures are made on the same basis and can be compared. In making comparisons between the 1960 actual production given

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1. Farm Facts, 1961, op. cit.
2. See footnote, p. 159.

Table 10. Actual livestock feed production in Kansas, 1960.[a]

Crop reporting district and crop	Yield per harvested acre		Harvested acres	Total production (tons)	TDN[b] %	TDN[b] tons
Northwest						
wheat	38.1	bu.	1,024,000	1,169,300	-	-
corn	29.9	bu.	77,900	64,600	80.1	51,700
grain sorghum	24.8	bu.	261,000	181,384	79.4	144,000
barley	33.9	bu.	126,100	102,700	75.6	77,600
oats	39.9	bu.	4,210	2,700	70.1	1,900
Four feed grains	-		469,210	351,384	-	275,200
forage sorghum	1.9	ton	83,000	155,950	52.4	81,700
silage sorghum	5.9	ton	51,000	301,150	19.0	57,200
alfalfa hay	2.5	ton	38,600	96,500	50.7	48,900
wild hay	1.3	ton	3,200	4,200	44.9	1,900
Four forage crops	-		175,800	557,800	-	189,700
pasture	0.27	ton	1,718,000	463,900	50.0	231,950
All others, estimated[c]	-		-	-	-	225,000
Subtotal, CR District	-		-	-	-	921,850
West Central						
wheat	36.1	bu.	1,133,000	1,226,000	-	-
corn	58.8	bu.	22,580	37,400	80.1	30,000
grain sorghum	33.5	bu.	423,000	396,800	79.4	307,100
barley	28.8	bu.	54,800	37,900	75.6	28,700
oats	36.6	bu.	2,840	1,700	70.1	1,200
Four feed grains	-		503,220	473,800	-	367,000
forage sorghum	2.0	ton	87,000	175,450	52.4	91,900
silage sorghum	7.3	ton	43,000	313,100	19.0	59,500
alfalfa hay	3.2	ton	15,500	50,400	50.7	25,600
wild hay	1.3	ton	3,600	4,780	44.9	2,150
Four forage crops	-		149,100	543,730	-	179,150
pasture	0.27	ton	1,895,000	511,650	50.0	255,800
All others, estimated[c]	-		-	-	-	225,000
Subtotal, CR District	-		-	-	-	1,026,950
Southwest						
wheat	31.1	bu.	1,958,000	1,829,600	-	-
corn	70.9	bu.	43,630	86,500	80.1	69,300
grain sorghum	36.5	bu.	833,000	852,200	79.4	676,600
barley	25.0	bu.	90,600	54,300	75.1	40,800
oats	32.1	bu.	3,600	1,900	70.1	1,300
Four feed grains	-		970,830	999,900	-	788,000
forage sorghum	2.1	ton	99,000	208,150	52.4	109,100
silage sorghum	7.9	ton	43,000	341,150	19.0	64,800
alfalfa hay	3.2	ton	30,000	96,000	50.7	48,700
wild hay	1.2	ton	6,000	7,460	44.9	3,350
Four forage crops	-		178,000	652,760	-	255,950
pasture	0.27	ton	2,311,000	624,000	50.0	312,000
All others, estimated[c]	-		-	-	-	225,000
Subtotal, CR District	-		-	-	-	1,580,950
North Central						
wheat	22.8	bu.	1,211,000	826,600	-	-
corn	42.2	bu.	268,500	317,400	80.1	254,200
grain sorghum	43.8	bu.	555,000	680,600	79.4	540,400
barley	22.1	bu.	49,400	26,200	75.6	19,800
oats	38.1	bu.	46,780	28,500	70.1	20,000
Four feed grains	-		919,680	1,052,700	-	834,400

Table 10 (Cont.)

Crop reporting district and crop	Yield per harvested acre		Harvested acres	Total production (tons)	TDN[b] %	TDN[b] tons
North Central (cont.)						
forage sorghum	2.6	ton	45,000	115,000	52.4	60,300
silage sorghum	9.5	ton	77,000	731,500	19.0	139,000
alfalfa hay	2.8	ton	202,000	352,800	50.7	178,900
wild hay	1.4	ton	50,500	70,700	43.9	31,000
Four forage crops	-		374,500	1,270,000	-	409,200
pasture	0.30	ton	2,093,000	627,900	52.0	326,500
All others, estimated[c]	-		-	-	-	225,000
Subtotal, CR District	-		-	-	-	1,795,100
Central						
wheat	21.6	bu.	1,638,000	1,063,400	-	-
corn	35.6	bu.	118,890	118,000	80.1	94,500
grain sorghum	39.7	bu.	488,000	542,600	79.4	430,800
barley	21.0	bu.	87,100	44,000	75.6	33,300
oats	31.1	bu.	76,420	38,000	70.1	26,600
Four feed grains	-		770,410	742,600	-	585,200
forage sorghum	3.2	ton	52,000	166,600	52.4	87,300
silage sorghum	9.0	ton	101,000	908,200	19.0	172,600
alfalfa hay	2.5	ton	128,400	318,400	50.7	161,400
wild hay	1.4	ton	60,000	84,000	43.9	36,900
Four forage crops	-		341,400	1,477,200	-	458,200
pasture	0.30	ton	2,058,000	617,400	52.0	321,000
All others, estimated[c]	-		-	-	-	225,000
Subtotal, CR District	-		-	-	-	1,589,400
South Central						
wheat	24.8	bu.	2,144,000	1,595,200	-	-
corn	37.8	bu.	57,950	61,800	80.1	49,500
grain sorghum	38.9	bu.	683,000	744,200	79.4	590,900
barley	23.0	bu.	191,600	105,800	75.6	80,000
oats	27.9	bu.	39,930	17,800	70.1	12,500
Four feed grains	-		972,480	929,600	-	732,900
forage sorghum	2.4	ton	82,000	195,900	52.4	102,650
silage sorghum	8.5	ton	117,000	991,600	19.0	188,400
alfalfa hay	2.5	ton	174,500	436,200	50.7	221,150
wild hay	1.6	ton	25,200	40,300	43.9	17,700
Four forage crops	-		398,700	1,664,000	-	529,900
pasture	0.30	ton	2,349,000	704,700	52.0	366,400
All others, estimated[c]	-		-	-	-	225,000
Subtotal, CR District	-		-	-	-	1,854,200
Northeast						
wheat	19.4	bu.	291,000	169,700	-	-
corn	47.7	bu.	611,900	819,600	80.1	656,500
grain sorghum	51.0	bu.	314,500	449,300	79.4	356,700
barley	21.8	bu.	5,780	3,000	75.6	2,300
oats	37.0	bu.	88,520	52,400	70.1	36,700
Four feed grains	-		1,020,700	1,324,300	-	1,052,200
forage sorghum	2.9	ton	3,200	9,350	52.4	4,900
silage sorghum	11.5	ton	31,200	358,500	19.0	68,100
alfalfa hay	2.5	ton	174,500	436,200	50.7	221,150
wild hay	1.3	ton	86,500	110,700	41.4	45,800

Table 10 (Concl.)

Crop reporting district and crop	Yield per harvested acre		Harvested acres	Total production (tons)	TDN[b] %	TDN[b] tons
Northeast (cont.)						
Four forage crops	-		295,400	914,750	-	339,950
pasture	0.33	ton	1,566,000	516,800	55.0	284,200
All others, estimated[c]	-		-	-	-	225,000
Subtotal, CR District	-		-	-	-	1,901,350
East Central						
wheat	26.5	bu.	415,000	329,400	-	-
corn	47.5	bu.	433,200	575,100	80.1	460,700
grain sorghum	48.9	bu.	318,700	436,500	79.4	346,600
barley	25.2	bu.	34,820	21,100	75.6	15,950
oats	34.9	bu.	74,000	41,300	70.1	28,950
Four feed grains	-		860,720	1,074,000	-	852,200
forage sorghum	3.1	ton	7,200	22,600	52.4	11,800
silage sorghum	10.8	ton	65,200	705,400	19.0	134,000
alfalfa hay	2.7	ton	179,000	483,300	50.7	245,000
wild hay	1.2	ton	187,000	216,260	41.4	89,550
Four forage crops	-		438,400	1,427,560	-	480,350
pasture	0.33	ton	2,892,000	954,400	55.0	524,900
All others, estimated[c]	-		-	-	-	225,000
Subtotal, CR District	-		-	-	-	2,082,450
Southeast						
wheat	28.0	bu.	566,000	475,400	-	-
corn	45.0	bu.	371,450	468,000	80.1	374,900
grain sorghum	46.9	bu.	297,800	391,200	79.4	310,600
barley	28.1	bu.	89,800	60,500	75.6	45,700
oats	33.0	bu.	85,700	45,300	70.1	31,800
Four feed grains	-		2,479,300	965,000	-	763,000
forage sorghum	2.8	ton	11,600	32,000	52.4	16,800
silage sorghum	10.0	ton	45,600	458,000	19.0	87,000
alfalfa hay	2.6	ton	124,000	328,600	50.7	166,600
wild hay	1.3	ton	668,000	868,000	41.4	359,350
Four forage crops	-		-	1,686,600	-	629,750
pasture	0.33	ton	3,582,000	1,182,100	55.0	650,200
All others, estimated[c]	-		-	-	-	225,000
Subtotal, CR District	-		-	-	-	2,267,950
State Total						15,020,200

a. Yields and total production, all crops except pasture forage from Farm Facts, 1961, Kansas State Board of Agriculture report. Harvested acres all crops and total acres pasture forage, from Farm Facts, 1961, Kansas State Board of Agriculture report. Pasture forage yields from "probable present" yield, Table 5.

b. TDN estimates based on Morrison, "Feeds and Feeding," 22nd ed., unabridged, 1957, Ithaca, New York, The Morrison Publishing Company.

c. "All other" livestock feeds based upon estimates made by the author, considering temporary pasture crops, miscellaneous hays, crop aftermath, etc. Estimates made for state as a whole and one ninth of total assumed to occur within each crop reporting district.

in Table 10 and the "present normal" and 1975 projection estimates it should be kept in mind that 1960 was in general an above average year in terms of acreage yields and total production of most feed crops.

Evaluation of Production Projections

In evaluating the production projections developed in this study, it must be recognized, first of all, that any qualities good or bad, inherent in these production models are directly derived from the yield and acreage estimates upon which the production figures are based. The extent to which the estimates of 1975 production may prove to be valid in terms of future realized production can be determined only with the passage of time. Any deviation of reality away from the static assumptions imposed upon the models will result in corresponding shifts of actual production away from the estimates established in this study. Variability in historical data and uncertainty concerning the future tend to multiply any adverse effects upon the validity of the production projections in terms of realized production, which might grow out of any error of human judgment associated with the qualitative analysis used in the study.

Perhaps the most important factor in contemplating the production estimates of this study is to maintain a clear concept and a precise perspective of the assumptional and methodological limitations inherent in the study. Within this limitational framework, it is felt the derived production estimates are firmly grounded in empirical data and informed qualitative judgments. It is thus suggested, that properly conceived, the potential production models presented in this study offer a highly tenable and empirically usable series of estimates of potential 1975 livestock feed production.

SUMMARY AND CONCLUSIONS

The purpose of this paper was the estimation of probable livestock feed production in the state of Kansas for the year 1975. The significance of this purpose is pointed out by the fact that a five-fold increase in Kansas grain sorghum production occurred between 1955 and 1960. At the same time there existed in the southwest area of the United States a situation involving a rapidly increasing population and a low per capita livestock production. This creates a potentially lucrative livestock market for such parts of the country as can competitively supply livestock products to this area. Other studies have shown that Kansas can produce competitively for this southwest market. The question then arises as to how far Kansas meat producers might be able to go in the future toward supplying this market, utilizing Kansas grown grains and roughages. Or, in other words, what is the 1975 Kansas livestock production potential in terms of feed grain and forage crop production within the state?

The problem involved in answering such a question may be theoretically stated in terms of a functional relationship: $Y = f(X_1, X_2, \ldots X_n)$, in which the dependent variable Y (1975 livestock feed production) is functionally determined by a series of independent X variables (factors which will determine the 1975 output of livestock feed in Kansas). In practical terms the problem involved concerns the determination of a 1975 acreage and yield level for livestock feed produced under dryland and irrigated conditions. From these acreage and yield figures can then be determined estimates of total livestock feed production.

The scope of this study covers the livestock feed sector of agricultural production in the state. Specifically included are the four feed grains: corn, grain sorghum, oats, and barley; the four forage crops: sorghum forage, alfalfa hay, and wild hay; permanent pasture production; and all others, feed crops generally occupying less than 350 thousand acres annually in the state. Consideration was also given to wheat, both because of its potential feed value and because of its importance in terms of total acreage grown. However, no wheat production was included in the actual estimates of 1975 livestock feed production.

Methodology used was of the synthetic type in which quantitative analysis was combined with qualitative evaluations in determining the final conclusions. Four probable production models were set up for determination of 1975 livestock feed production estimates. These involved combinations of two yield projections and two acreage projections. The yield projections were (1) "probable projected" yield, defined as that yield level which might, on the average, reasonably be obtained by farmers in any given crop reporting district in an average year, 1975, assuming a "normal" development of those factors affecting yields; and (2) an "optimum projected" yield, defined as that yield level which might, on the average, reasonably be obtained by farmers in any given crop reporting district in an average year, 1975, assuming an "optimum" development of those factors affecting crop yields. The acreage projections were defined as (1) 1975 harvested crop acreage assumed to remain at its "present" level, and (2) "projected" 1975 harvested crop acreage assumed to reflect those shifts which could be anticipated to occur under the impact of relative cost-price relationships, demand, farmer preference, crop adaptability, government programs and other influencing factors. Using the above projections, the following production estimates of 1975 Kansas livestock feed production were outlined:

Model I - "Probable projected" yield and "present" acreage.

Model II - "Optimum projected" yield and "present" acreage.

Model III - "Probable projected" yield and "projected" acreage.

Model IV - "Optimum projected" yield and "projected" acreage.

Due to limitations of inadequate data and insufficient time, it was impossible to develop the latter two models in this thesis.

The estimation of future crop yields required the consideration of many influencing factors. Some of the more important of these along with their major implications are:

Irrigation development. In 1960 irrigation was practiced on slightly more than one million acres in Kansas. By 1975 this figure is expected to approach two million acres. All but some 100,000 to 200,000 acres of this will be private development, mostly from ground water. The balance will be developed through Bureau of Reclamation projects primarily utilizing surface water. Five major Bureau projects, Almena, Cedar Bluff, Kirwin, Kanopolis, and Bostwick are expected to be in operation by 1975. A doubling of acreage plus a 15 to 20 percent increase in yield on presently irrigated acres points to the major production expansion which can result from this factor, particularly in the western part of the state.

Fertilizer use. Expansion in fertilizer use from its present level of 300 thousand tons annually to a 1975 level of between 500 thousand and one million tons may be responsible for as much as three fourths of the increase in crop yields in eastern Kansas by 1975. Expansion will be greatest for nitrogen with consumption of phosphorous, potash and several trace elements growing considerably as knowledge of their use increases.

Plant breeding. Continued work in this area will provide a consistent upward pressure on yield levels. Corn and sorghum hybrid forages and grains will meet with continued improvement. Small grains will come in new varieties with greater built-in hazard resistance. Hybrids in alfalfa may provide a boost of up to 25 percent in yields of this crop.

Cultural practices. Greater control of plant population and spacing in row crops along with better methods of insect and weed control will lead the way toward higher yields through improved cultural practices. Also minimum tillage methods, better planting techniques and better conservation of soil moisture will contribute to the attainment of higher yields.

Management. There is perhaps as much potential for yield increases through better management as occurs with the development of hybrids in a plant species. Wider acceptance of presently recommended practices and quicker acceptance of new yield increasing developments by farmers could have a very considerable influence on future crop yield trends. Other important factors are more optimum timeliness in performing operations and more adequate weed control.

In the recent past crop acres in Kansas have been much influenced by agricultural programs. This has created a downward trend in wheat acres and an upward trend in grain sorghum. Corn acreage over the past decade dipped quite low during the dry period of the fifties but has since moved back to a point somewhat below its level in the early fifties. There seems to be a general uptrend in sorghum silage with sorghum forage moving in the opposite direction. Wild hay and pasture acreage has remained fairly constant in the past few years, with alfalfa generally showing a modest decline toward the end of the past decade. Chances for significantly expanded production of presently minor field crops appear to be slim. Corn will continue to decline in the south central part of the state. The next 15 years may see expanded production of soybeans in eastern Kansas. Likewise, winter barley with increased winter hardiness will be on the uptrend over the state. Conversely, oats seem about finished as a crop in Kansas except for special feed and rotation uses. Increased use of commercial fertilizers will probably cause alfalfa to be the only important legume forage grown with its production being confined mainly to favorable sites. Trends of the major field crops up to 1975 will be largely governed by government programs, relative profitability, farmer preference, and crop adaptation.

Actual yield projections were based on empirical yield data provided by the Kansas State Board of Agriculture, Kansas Agricultural Experiment Station, Branch Stations, Farm Management data, and Irrigation Development Farm Reports. A "probable present" yield was developed for each crop reporting district based on State Crop Reporting Board data. A yield based on an average of 1955-59 data was used for all crops except grain sorghum and pasture. The period 1957-59 was used for grain sorghum to more accurately reflect use of hybrids. Pasture yields were based on data supplied in "Native Range," Oklahoma State University Bulletin B-547, February, 1960. Linear trend-line projections of crop yields to 1975 based on State Board of Agriculture data for 1941-59 were made. The simple regression trend lines of yield on time were tested for significance of b and r values. Calculations of 10 percent and 25 percent yield increases over hypothetical present levels were made for purposes of comparison and illustration. Finally, the "probable projected" and "optimum projected" 1975 crop yield estimations were made at a series of meetings with crop scientists. A percentage increase in yield by 1975, over "probable present" yields, was determined for each crop in each crop reporting district for both irrigated and dryland conditions.

Probable and optimum dryland yields were combined with "present" dryland crop acres to give dryland production figures. Probable and optimum irrigated yields were combined with estimated 1975 irrigated crop acres to give irrigated production figures. Combination of irrigation and dryland production figures gave 1975 probable livestock feed production models I and II. Converted to TDN the final figures show that under Model I 1975 production would exceed "present normal" production by 20 percent for feed grains, 42 percent for forage crops, 4 percent for pasture, 10 percent for all others, with a total increase in TDN production of 20 percent. Similar figures for production under Model II show that with these conditions "present normal" production of TDN would be exceeded 44 percent in feed grains, 62 percent in forage crops, 21 percent in pasture production, 10 percent for all others, with a total 39 percent increase in production of TDN.

A summary of present and 1975 production of TDN in Kansas along with estimated percentage increases is presented in Table 11. The contents of this table together with the figures presented above provide a basis for tentative conclusions regarding future trends in Kansas livestock feed production. It appears, based upon the conditions and assumptions of this study, that with average weather Kansas farmers may reasonably expect by 1975 to be producing 20 to 40 percent greater output of total digestible nutrients than at present without any increase in the acreage devoted to livestock feeds. Observation of Table 11 will indicate that a relatively higher proportion of this increase will occur in forage crops than the feed grains. This probably is a reflection of the greater predominance of forage crops under irrigation. Related to this is the larger increase in forage crop production in western Kansas than in eastern Kansas where irrigation is a much less prominent factor. The apparent increase of forage crop production relative to feed grain production may hold important implications regarding future ratios of forage to grain consuming animals in Kansas.

The excess of actual 1960 production over "present normal" production in the eastern two thirds of the state reflects the record high crop yields and production that was attained in 1960, a very favorable year. The apparent reversal of this relationship for western Kansas is explained by a reduction in 1960 feed crop acres in this part of the state from the high levels of the 1957-59 period used in the "present normal" production figures.

Although an acceptance of the above suggested trends in feed production would seem to be justifiable on several grounds, it is to be stressed that any departure of reality from the assumed political, economic, and weather conditions of this study will have some effect upon production. Obviously the nature, direction, and extent of any such derivations are beyond the realm of human discernment. Finally, it is to be said that the suggested shifts in TDN production in this study are not an insinuation that livestock production will follow a similar

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Some of the major limitations of this study apart from arbitrarily imposed assumptions relate to lack of physical data of a function nature. Only limited information was available concerning the functional impact of physical inputs of various productive factors such as irrigation, fertilizer, soil conservation, etc. Additional limitations were presented by the uncertainty involved in considering an unknown future and such subjective factors as government programs and managment. Although these limitations most certainly have detracted from a most optimum result, it is felt that much of their potential detriment may be negated by keeping them in constant perspective.

On balance, it is suggested the comprehensive nature of the study based upon a sound synthetic analytical procedure serves to provide a usable and defensible fulfillment of the stated objectives. In view of the nebulous nature of the elements which have been under consideration and with full and humble recognition of this study's many shortcomings, it is felt that if the general consensus of future events might be construed as judging the preceding suggestion to be valid, a commendable achievement will have been wrought.

POSSIBILITIES FOR FURTHER INVESTIGATION

There are three general areas related to this study in which it is felt a significant need for further investigation exists. These three spheres pertain, (1) to basic physical data with a generally functional relation to the objectives of the study, (2) to those specific situations within the study which for one reason or another were not developed to a point sufficient to fulfill the objectives established for them, and (3) to those fields of potential investigation beyond the realm of this study for which it serves as an initial development.

Regarding the first area, it is suggested that additional data relating to the identification and relative productive capacity of various soil groups might be highly beneficial for a study of this type. Information regarding the location and extent of ground water supplies for irrigation is less than optimum although studies presently under way may serve to largely alleviate this situation. Only meager data is available indicating production responses that may be anticipated upon establishment of various soil conservation practices. It would appear that the establishment of joint projects between agronomists and production economists, directed toward the derivation of production surfaces for various crops in various areas of the state under different levels and combinations of input factors, is perhaps overdue.

As to the second category set forth above, the most obvious "situation" in need of further research development relates to the estimation or projection of absolute and relative 1975 crop acreage patterns for the state. Estimates of total grassland, cropland, and forest acreages in the state by 1975 have recently been made by the Soil Conservation Service.[1] These estimates, which make allowance for urban and industrial land use as well as anticipated road and reservoir construction, might well provide a starting point in this endeavor. Once a total 1975 crop acreage had been established, various methods of allocating relative proportions to various crops might be utilized. Some tentative suggestions

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1. See, National Conservation Needs Inventory, Kansas State Total. Soil Conservation Service, December, 1959.

would be (1) linear programming techniques, (2) projection of present trends to 1975, or (3) basing 1975 Kansas acreage for various crops upon anticipated "need," assuming effective machinery for equating agricultural supply and demand would be in effect at that time. This latter method would involve estimating Kansas' proportional share of any 1975 national production allocation for a given crop.[1]

As implied by the statement identifying the third area of potential investigation this study may be considered as the initial increment in a more comprehensive total plan. The concern of this study with livestock feed production should suggest the quite natural sequel of potential livestock production in 1975 as the concern of related investigations beyond this study. Basically, 1975 production estimates for various kinds and classes of livestock would be derived from livestock feed production projections presented in this study or future modifications of these projections. The particular analytical procedure and methodology to be used in estimating proportional shares of total livestock feed production which might be utilized by various livestock classes should be designed to provide optimum results within the specific framework of objectives which might be established for such a study.

The preceding suggestions are not intended as comprehensive indications of projects which should be initiated in the various areas. Rather, they are intended as tentative guideposts pointing toward areas which the experience gained in this study indicates would provide needed and fruitful research results.

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1. See Dean, loc. cit.

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REFERENCES

Books

1. Blaird, Morris M. Elementary Statistics. New York: Henry Holt and Co., 1952.

2. Boswell, George. A Treatise on Watering Meadows. London: n.p., 1790.

3. Heady, Earl O. Economics of Agricultural Production and Resource Use. Englewood Cliffs, N.J.: Prentice-Hall, 1952.

4. Howes, Charles C. This Place Called Kansas. Norman: University Press, 1952.

5. Mead, Elwood. Irrigation Institutions. New York: The Macmillan Co., 1903.

6. Morrison, Frank B. Feeds and Feeding: a Handbook for the Student and Stockman. Ithaca, New York: The Morrison Publishing Company, 1957.

7. Snedecor, George W. Statistical Methods. Ames: Iowa State College Press, 1956.

8. Vogt, William. People, Challenge to Survival. New York: William Sloan Associates, 1960.

9. Webb, Walter Prescott. The Great Plains. New York: Grosset and Dunlap, 1931.

Periodicals

1. "Blue Print for Tomorrow." The Kansas Agr. Situation. October 1960, 37:4-15.

2. "Droughts Don't Last Forever." Scientific American. 156:135-36, Feb. 1937.

3. "Four Years of Drought and More to Come." U.S. News and World Report. 37:68-70, Aug. 1954.

4. Knutson, Herbert. "Insect Control--Blue Print for Tomorrow." Kans. Agr. Situation. October 1960, 37:4-15.

5. Miller, L. F. "The Potential for Grain Sorghums in the Plains." Oklahoma Current Farm Economics. 32:64-68, 1959.

6. Orazem, Frank and Wayne Rohrer. "Farm Management and Sociology--Blue Print for Tomorrow." Kans. Agr. Situation. October 1960, 37:4-15.

7. Smith, F. W. "Soil Management--Blue Print for Tomorrow." Kans. Agr. Situation. October 1960, 37:4-15.

8. Stallings, James L. "Weather Indexes." Jour. Farm Econ. Feb. 1960, 42:180-186.

9. Stickler, Fred C. "Crop Production--Blue Print for Tomorrow." Kans. Agr. Situation. October 1960, 37:4-15.

Proceedings

1. Barton, G. T. and R. F. Daly. "Prospects for Agriculture in a Growing Economy." USDA, Agr. Res. Service and Agr. Marketing Service. Address, Conference on Problems and Policies of American Agriculture. Iowa State College. Oct. 27-31, 1958.

2. Bonnen, James and Lawrence Witt. "What is American Agriculture Geared to Produce?" Proceedings, Sixth National Institute of Animal Agriculture. Purdue University. April 19-20, 1956. pp. 49-63.

3. Calvin, James P. "The Present Livestock-Feed Situation," Proceedings of the Iowa State College Feed-Livestock Workshop. Special Report No. 24. Feb. 16-18, 1959.

4. Dean, Gerald W. and Chester O. McCorkle, Jr. "Limitations of Alternative Approaches to Agricultural Adjustment." Proceedings of the Western Farm Economics Association, 31st Annual Meeting, Aug. 13-15, 1958. pp. 97-101.

5. Heady, Earl O. "Analysis of Alternatives in Control of Land Inputs to Decrease Grain and Livestock Outputs." Proceedings of the Iowa State College Feed-Livestock Workshop. Special Report No. 24. Feb. 16-18, 1959.

6. Kutish, Francis. "Prospects for the Next Three Years." Proceedings of the Iowa State College Feed-Livestock Workshop. Special Report No. 24. Feb. 16-18, 1959.

7. McCoy, John H. "Direct Payments to Farmers as an Alternative Program for Increasing Feed Consumption." Proceedings of the Iowa State College Feed-Livestock Workshop. Special Report No. 24. February 16-18, 1959.

8. Montgomery, George. "Adjustment Problems Faced by Commercial Wheat Farmers in the Great Plains." Policy for Commercial Agriculture, Hearings Before the Sub-Committee on Agricultural Policy, Joint Economic Committee, U.S. Congress. Dec. 16-20, 1957.

9. Stewart, H. L. "Prospects for Adjustments in Production and Resource Use." USDA, Agr. Res. Service. Address, 36th Annual Agricultural Outlook Conference, Washington, D.C. Nov. 18, 1958.

10. Thompson, Louis M. and others. "Some Causes of Recent High Yields of Feed Grains." Proceedings of the Iowa State College Feed-Livestock Workshop. Special Report No. 24. Feb., 16-18, 1959.

State and Federal Publications

1. Agriculture, Arkansas-White-Red River Basins, Part II, Section 11. Arkansas-White-Red Basins Inter-Agency Committee. 1955.

2. Agriculture's Capacity to Produce, Possibilities Under Specified Conditions. USDA, Bureau of Agr. Econ. Agr. Inf. Bul. No. 88. Washington: Government Printing Office.

3. Anderson, Kling L. Winter Wheat Pasture in Kansas. Kansas State University, Agr. Expt. Sta. Bul. 345. Aug., 1956.

4. Annual Irrigation Progress Report, Kansas River Projects. U.S. Dept. of the Interior, Bureau of Reclamation, Region 7. June, 1960.

5. Annual Reports on Irrigation Development Farms, Kansas, 1952-1960. Kansas State University, Extension Service.

6. Bennett, William F. Soil Nutrients Removed by Some Crops. Tex. Agr. Ext. Service, L-165.

7. Bidwell, O. W. Major Soils of Kansas. Kans. Agr. Expt. Sta. Circular 336. July, 1956.

8. Bieberly, Frank G., E. A. Cleavinger, and L. E. Willoughby. Warm Season Grasses in Kansas. Kansas State University, Ext. Service, Circular 258. March, 1958.

9. Bloodgood, Dean W., R. E. Patterson, and R. L. Smith, Jr. Water Evaporation Studies in Texas. Tex. Agr. Expt. Sta. Bul. 787. Nov., 1954.

10. Bonnen, C. A. and others. Use of Irrigation Water on the High Plains. Tex. Agr. Expt. Sta. Bul. 756. Dec., 1952.

11. Bonnen, James T. "American Agriculture in 1965." Policy for Commercial Agriculture. Joint Committee Report, 85th Congress, 1st Session. Washington: Government Printing Office, Nov., 1957.

12. Bray, James O. and John A. Schnittker. Legumes or Commercial Fertilizers? Kansas State University, Agr. Expt. Sta. Bul. 384. Nov., 1956.

13. Brensing, O. H. and H. J. Harper. Nitrogen Fertilization of Corn with Supplemental Irrigation. Oklahoma State University, Expt. Sta. Bul. B-557. June, 1960.

14. Brensing, O. H. and J. Q. Lynd. Soil Fertility Treatments for Improved Corn Production in Eastern Oklahoma. Oklahoma State University, Expt. Sta. Bul. B-549. Feb., 1960.

15. Brough, O. L. and A. L. Walker. Crop and Livestock Production Possibilities, Columbia Basin Project, Washington. Wash. Agr. Expt. Sta. Circular 239, revised. March, 1958.

16. Brough, O. L., Jr. and others. Columbia Basin Project, Relative Land Productivity and Income. Wash. Agr. Expt. Sta. Bul. 570. Oct., 1956.

17. Brown, William G. and others. Production Functions, Isoquants, Isoclines and Economic Optima in Corn Fertilization for Experiments with Two and Three Variable Nutrients. Iowa State College, Agr. Expt. Sta. Res. Bul. Aug., 1956.

18. Bunch, Clarence E. and Edd Roberts. Irrigated Native Grasses. Oklahoma State University, Ext. Service Circular E-700.

19. Burzlaff, Donald F. and others. Irrigated Pastures for Nebraska. University of Nebraska Extension Service, CC-170. 1959.

20. Carpenter, Earl T. Farming Opportunities in Missouri Projected Through 1975. University of Missouri, Agr. Expt. Sta. Res. Bul. 746. July, 1960.

21. Chaffin, Wesley. Higher Corn Yields. Oklahoma A & M College, Ext. Division Circular 591.

22. Christensen, Raymond P., Sherman E. Johnson, and Ross V. Bauman. Production Prospects for Wheat, Feed and Livestock 1960-1965. Agr. Res. Service, 43-115. Dec., 1959.

23. Clapp, A. L. 1959 Experiment Station Results with Fall Seeded Wheat, Barley, Oats, Rye. Kansas State University, Agr. Expt. Sta., Circular 373. Sept., 1959.

24. Clapp, A. L. 1958 Experiment Station Results with Fall Seeded Wheat, Barley, Oats, Rye. Kansas State University, Agr. Expt. Sta., Circular 366. Sept., 1958.

25. Clapp, A. L. 1957 Experiment Station Results with Fall Seeded Wheat, Barley, Oats, Rye. Kansas State University, Agr. Expt. Sta., Circular 354. Aug., 1957.

26. Clapp, A. L. 1956 Experiment Station Results with Fall Seeded Wheat, Barley, Oats. Kansas State University, Agr. Expt. Sta., Circular 343. Aug., 1956.

27. Clapp, A. L. 1955 Experiment Station Results with Fall Seeded Wheat, Barley, Oats. Kansas State University, Agr. Expt. Sta., Circular 329. Aug., 1955.

28. Clapp, A. L. 1954 Experiment Station Results--Fall Seeded Wheat, Barley, Oats. Kansas State University, Agr. Expt. Sta., Circular 314. Aug., 1954.

29. Clapp, A. L. 1959 Experiment Station Results with Sudangrass, Millet, Forage Sorghum, and Soybean Varieties. Kansas State University, Agr. Expt. Sta., Report of Progress 38. March, 1960.

30. Clapp, A. L. 1958 Experiment Station Results with Sorghum Varieties and Hybrids, and Varieties of Sudangrass and Soybeans. Kansas State University, Agr. Expt. Sta., Report of Progress 31. March, 1959.

31. Clapp, A. L. 1957 Experiment Station Results with Sorghum Varieties and Hybrids, and Varieties of Sudangrass and Soybeans. Kansas State University, Agr. Expt. Sta., Report of Progress 23. March, 1958.

32. Clapp, A. L. 1956 Experiment Station Results with Sorghum Varieties and Hybrids and Varieties of Soybeans. Kansas State University, Agr. Expt. Sta., Report of Progress 20. Feb., 1957.

33. Clapp, A. L. 1955 Experiment Station Results with Varieties of Sorghums, Sudangrasses, Soybeans. Kansas State University, Agr. Expt. Sta., Report of Progress 17. March, 1956.

34. Clapp, A. L. 1954 Experiment Station Results with Varieties of Sorghums, Sudangrass, Soybeans, Oats, Spring Barley. Kansas State University, Agr. Expt. Sta., Report of Progress 14. March, 1955.

35. Clapp, A. L. 1959 Experiment Station Results with Varieties of Spring Oats, Spring Barley. Kansas State University, Agr. Expt. Sta., Report of Progress 34. Dec., 1959.

36. Clapp, A. L. 1957 Experiment Station Results with Varieties of Spring Oats, Spring Barley. Kansas State University, Agr. Expt. Sta., Report of Progress 21. December, 1957.

37. Clapp, A. L. 1956 Experiment Station Results with Varieties of Spring Oats, Spring Barley. Kansas State University, Agr. Expt. Sta., Report of Progress 18. December, 1956.

38. Clapp, A. L. and William R. Findley. Kansas Corn Tests, 1959. Kansas State University, Agr. Expt. Sta., Bul. 419. Feb., 1960.

39. Clapp, A. L. and William R. Findley. Kansas Corn Tests, 1958. Kansas State University, Agr. Expt. Sta., Bul. 404. Feb., 1959.

40. Clapp, A. L. and William R. Findley. Kansas Corn Tests, 1957. Kansas State University, Agr. Expt. Sta., Bul. 397. Feb., 1958.

41. Clapp, A. L. and others. 1959 Kansas Grain Sorghum Performance Tests. Kansas State University, Agr. Expt. Sta., Bul. 420. March, 1960.

42. Clapp, A. L. 1958 Kansas Grain Sorghum Performance Tests. Kansas State University, Agr. Expt. Sta., Bul. 403. Jan., 1959.

43. Clapp, A. L. 1957 Kansas Grain Sorghum Performance Tests. Kansas State University, Agr. Expt. Sta., Bul. 398. March, 1958.

44. Collins, Norman R. Use of Linear Programming when Provision is Made for Substitution Among Inputs by Processes. Kansas State University, Agr. Expt. Sta., Tech. Bul. 86. Aug., 1956.

45. Dean, Gerald W. and Chester O. McCorkle, Jr. Projections Relating to California Agriculture in 1975. Calif. Agr. Expt. Sta., Mimeo. Report No. 234. July, 1960.

46. Developing a State Water Plan. Bul. No. 1. Kansas Water Resources Board. Oct., 1956.

63. Fritschen, John F. and Wilfred H. Pine. A Study of the Productivity of Selected Soils in Western Kansas. Kansas State University, Agr. Expt. Sta., Report of Progress 24. June, 1958.

64. Gertel, Karl and others. Adjusting to Irrigation in the Loup River Area in Nebraska. University of Nebraska, Expt. Sta. Bul. 434. Feb., 1956.

65. Greve, Robert W., James S. Plaxico, and William F. Lagrone. Production and Income Variability of Alternative Farm Enterprises in Northwest Oklahoma. Oklahoma State University, Agr. Expt. Sta., Bul. B-563. Aug., 1960.

66. Grimes, Donald W. and Jack T. Musick. How Plant Spacing, Fertility, and Irrigation Affect Grain Sorghum Production in Southwestern Kansas. Garden City Branch, Kans. Agr. Expt. Sta., Bul. 414. Dec., 1959.

67. Hanson, Richard E. and Walter R. Meyer. Irrigation Requirements, Estimates for Kansas. Kansas State University, Engineering Expt. Sta., Bul. 69. June, 1953.

68. Harlan, Jack R. Native Range. Oklahoma State University and USDA, Agr. Res. Service, Bul. B-547. Feb., 1960.

69. Hartman, Monroe A. and others. Determining Rainfall-Runoff-Retention Relationships. Tex. Agr. Expt. Sta., Misc. Pub. 404. Jan., 1960.

70. Heady, Earl O. and Harold R. Jensen. The Economics of Crop Rotations and Land Use. Iowa State College, Agr. Expt. Sta., Res. Bul. 383, Aug. 1951.

71. Heady, Earl O., John T. Pesek, and William G. Brown. Crop Response Surfaces and Economic Optima in Fertilizer Use. Iowa State College, Agr. Expt. Sta., Res. Bul. 424. March, 1955.

72. Heady, Earl O., and others. Milk Production Functions, Hay/Grain Substitution Rates and Economic Optima in Dairy Cow Rations. Iowa State College, Agr. Expt. Sta., Res. Bul. 444. Oct., 1956.

73. Heady, Earl O. and others. New Procedures in Estimating Feed Substitution Rates and in Determining Economic Efficiency in Pork Production. Iowa State College, Agr. Expt. Sta., Res. Bul. 409. May, 1954.

74. Heady, Earl O., Stanley Balloun, and Gerald W. Dean. Least-Cost Rations and Optimum Marketing Weights for Turkeys. Iowa State College, Agr. Expt. Sta., Res. Bul. 443. Oct., 1956.

75. Heady, Earl O., Stanley Balloun, and Robert McAlexander. Least-Cost Rations and Optimum Marketing Weights for Broilers. Iowa State College, Agr. Expt. Sta., Res. Bul. 442. Oct., 1956.

76. Henderson, Philip A. Will It Pay to Irrigate Corn? University of Nebraska Extension Service, E.C. 57-805. Aug., 1957.

47. Development of Water and Land Resources of the Arkansas-White and Red River Basins. 85th Congress, Senate Document No. 13. Jan. 17, 1957.

48. Duffin, Robert B. Development of Surface Irrigation in Oklahoma. Oklahoma A & M College, Ext. Service Circular 571.

49. Duffin, Robert B. Irrigation Water from Wells. Oklahoma A & M College Ext. Service, Circular 645.

50. Duffin, Robert B. Sprinkler Irrigation in Oklahoma. Oklahoma State University, Ext. Service, Circular 632.

51. Erhart, Andrew B., Walter R. Meyer, and Ben L. Grover. Irrigation in Western Kansas. Garden City Branch, Kans. Agr. Expt. Sta., Circular 324. May, 1958.

52. Farm Facts. Annual reports of the Kansas State Board of Agriculture. 1941-1959.

53. Farm Price and Income Projections, 1960-65, Under Conditions Approximately Free Production and Marketing of Agricultural Commodities. Report from the USDA and a statement from the Land Grant Colleges IRM-1 Advisory Committee. Senate Document No. 77. Washington: Government Printing Office. January 20, 1960.

54. Farm Production, Trends, Prospects, and Programs. USDA, Agr. Res. Service, Agr. Inf. Bul. No. 239. Washington: Government Printing Office. May, 1961.

55. Fertilizer Use and Crop Yields in the United States. USDA, Agr. Res. Service. Agr. Handbook No. 68. Washington: Government Printing Office. Dec., 1954.

56. Finnell, H. H. Depletion of High Plains Wheatlands. USDA, Circular No. 871. Washington: Government Printing Office. June, 1951.

57. Finnell, H. H. Soil Moisture and Wheat Yields on the High Plains. USDA Leaflet 247, Washington: Government Printing Office. Dec., 1948.

58. Fischbach, P. E. Annual Report of the Nebraska Irrigation Development Farms. University of Nebraska Ext. Service. 1957.

59. Fischbach, P. E. Annual Report of the Nebraska Irrigation Development Farms. University of Nebraska Ext. Service. 1959.

60. Fischbach, P. E. and N. P. Swanson. Use Your Water Efficiently. Reprinted from the Nebraska Expt. Sta. Quarterly, Spring, 1960.

61. Foreman, W. James and Robert S. Eckley. Agriculture. University of Kansas, School of Business, Economic Development in Southwestern Kansas, Part V. Aug. 1, 1951.

62. Fort Hays Branch Experiment Station Results. Fort Hays Branch, Kans. Agr. Expt. Sta., Circular 345. Dec., 1956.

77. Herpich, Russell and R. D. McKinney. Irrigation Farming for Profit. Kans. Agr. Expt. Sta., Circular 372. July, 1959.

78. Higher Farming Profits. National Plant Food Institute in cooperation with Kansas State University. Midwest Regional Office, 228 N. LaSalle St., Chicago, Illinois.

79. Hoover, Leo M. and John H. McCoy. Economic Factors Affecting Wheat in Kansas. Kansas State University, Agr. Expt. Sta., Bul. 369. Jan., 1955.

80. Hoover, Leo M. Kansas Agriculture After 100 Years. Kansas State University, Agr. Expt. Sta., Bul. 392. Aug., 1957.

81. Hughes, William F. and A. C. Magee. Some Economic Effects of Adjusting to a Changing Water Supply, Texas High Plains. Tex. Agr. Expt. Sta., Bul. 966. Oct., 1960.

82. Hughes, William F. and Joe R. Motheral. Irrigated Agriculture in Texas. Tex. Agr. Expt. Sta., Misc. Pub. 59. Sept., 1959.

83. Irrigation and Reclamation, Arkansas-White-Red Basins. Arkansas-White-Red River Basins Inter-agency Committee Report. Part II--Section 6. 1955.

84. Jaccard, C. R. Evaluation of Great Plains Extension Programs with Suggestions for Adjustments. Kansas State University, Ext. Service.

85. Jones, Robert R. What About Wheat as a Livestock Feed? Kansas State University, Agr. Expt. Sta., Circular 369. Feb., 1959.

86. Kansas Agriculture. Reports of the Kansas State Board of Agriculture to the Legislature of the state. 1941-1959.

87. Kansas Farm Management Summary and Analysis Reports, 1955-1960. Kansas State University, Ext. Service.

88. Kansas River Basin, Colorado-Nebraska-Kansas. U.S. Dept. of the Interior, Bureau of Reclamation, Region 7, Denver. Missouri River Basin Project Report. Sept., 1956.

89. Kelly, Paul, John McCoy and Milton Manuel. The Competitive Position of Kansas in Marketing Hogs. Kansas Agr. Expt. Sta. Tech. Bul. 118, Oct. 1961.

90. Kneese, Allen V. Water Resources, Development and Use. Federal Reserve Bank of Kansas City. December, 1959.

91. Knight, Dale A. Economic Considerations for Selecting the Superior Frequency of Fallow for Wheat in Three Locations in Western Kansas. Kansas State University, Agr. Expt. Sta., Tech. Bul. 85. Sept., 1956.

92. Laude, H. H. and others. Growing Wheat in Kansas. Kansas State University, Agr. Expt. Sta., Bul. 370. Aug., 1955.

93. Livestock and Poultry Inventory, January 1, 1961, Number Value and Classes. USDA, Agr. Res. Service. 1961.

94. Magee, A. C. and others. Production Practices for Irrigated Crops on the High Plains. Tex. Agr. Expt. Sta., Bul. 763. June, 1953.

95. Miller, Glenn H., Jr. Mineral and Water Resources. The University of Kansas, Center for Research in Business. Economic Development in South Central Kansas, Part VI. June, 1959.

96. Muckel, Dean C. Replenishing Underground Water Supplies on the Farm. USDA, Leaflet 452. Washington: Government Printing Office. Sept., 1959.

97. National Conservation Needs Inventory, Kansas State Total. Soil Conservation Service, Dec., 1959.

98. Otto, Merton L. and Wilfred H. Pine. Sprinkler Irrigation Costs and Returns South Central Kansas. Kans. Agr. Expt. Sta., Bul. 381. Aug., 1956.

99. Overley, Carl B. and others. Kansas Forage Sorghum Performance Tests 1960. Kansas State University, Agr. Expt. Sta., Report of Progress 49. April, 1961.

100. Overley, Carl B. and others. Kansas Forage Performance Tests Under Irrigation 1959. Kansas State University, Agr. Expt. Sta., Progress Report 40. May, 1960.

101. Pfister, Richard. Water Resources and Irrigation. University of Kansas, Center for Research in Business. Economic Development in Southwest Kansas, Part IV. March, 1955.

102. Pickett, Robert C. Sudangrass in Kansas. Kansas State University, Agr. Expt. Sta., Circular 311, Aug., 1955.

103. Pine, Wilfred H. and Warren L. Trock. Leasing Irrigated Land. Kans. Agr. Expt. Sta., Circular 370. June, 1959.

104. Pope, Alex. Fertilizer Trials on Irrigated Grain Sorghum at Five Locations, High Plains, 1957. Tex. Agr. Expt. Sta., Progress Report 2033. April, 1958.

105. Pope, Alex. Fertilizer Trials on Irrigated Winter Wheat at Seven Locations, High Plains, 1957. Tex. Agr. Expt. Sta., Progress Report 2034. April, 1958.

106. Production Prospects for Wheat, Feed, and Livestock, 1960-65. USDA, Agr. Res. Service, Dec., 1959.

107. Quann, C. J. and J. B. Wyckoff. Potential Beef Production in the Columbia Basin. Wash. Agr. Expt. Sta., Bul. 622. Nov., 1960.

108. Raney, Robert J. and Harry Manges. Results from the Concordia, Kansas, Irrigation Experiment Field, 1953-57. Kans. Agr. Expt. Sta., Bul. 421. April, 1960.

109. Reducing Adverse Effects of Reservoirs. Great Plains Pub. No. 6. Kans. Agr. Expt. Sta. Circular 293. Oct., 1952.

110. Rhoades, H. F. and others. Fertilization and Irrigation Practices for Corn Production on Newly Irrigated Land in the Republican Valley. University of Nebraska, Expt. Sta., Bul. 424. Feb., 1954.

111. Roberts, Edd and Clarence E. Bunch. Water in Oklahoma. Oklahoma A & M College, Ext. Division, Circular 628.

112. Rogers, Robert O. and Glen T. Barton. Our Farm Production Potential, 1975. Washington: Government Printing Office. Agr. Inf. Bul. No. 233.

113. Ross, W. M. and H. H. Laude. Growing Sorghums in Kansas. Kansas State University, Agr. Expt. Sta., Circular 319. May, 1955.

114. Schmidt, John R. and Rudolph A. Christiansen. Potential Crop and Livestock Production and Net Farm Income on Dominant Soils in Northwest Wisconsin. University of Wisconsin, Agr. Expt. Sta., Res. Bul. 219. May, 1960.

115. Scoville, O. J. and J. A. Hodges. Practices and Costs on Wheat Farms in Western Kansas, 1947. Kansas Agr. Expt. Sta., Circular 268. Dec., 1950.

116. Soil Conservation in Kansas. Report of the State Board of Agriculture, No. 271. Feb., 1946.

117. Sorenson, E. L. and others. Cody Alfalfa. Kansas State University, Agr. Expt. Sta., Circular 381. April, 1961.

118. State Water Plan Studies, Part A: Preliminary Appraisal of Kansas Water Problems. Section 1. Marais des Cygnes Unit. Kansas Water Resources Board, Topeka. June, 1958.

119. State Water Plan Studies, Part A: Preliminary Appraisal of Kansas Water Problems. Section 2. Cimarron Unit. Kansas Water Resources Board, Topeka. September, 1958.

120. State Water Plan Studies, Part A: Preliminary Appraisal of Kansas Water Problems. Section 3. Kansas Unit. Kansas Water Resources Board, Topeka. June, 1959.

121. State Water Plan Studies, Part A: Preliminary Appraisal of Kansas Water Problems. Section 4. Lower Arkansas Unit. Kansas Water Resources Board. Jan., 1960.

122. State Water Plan Studies, Part A: Preliminary Appraisal of Kansas Water Problems. Section 5. Walnut-Verdigris Unit. Kansas Water Resources Board. June, 1960.

123. State Water Plan Studies, Part A: Preliminary Appraisal of Kansas Water Problems. Section 6. Upper Republican Unit. Kansas Water Resources Board. June, 1960.

124. Stinson, T. B. Tribune Branch Experiment Station Report on Corn, Sorghums, Sudangrass, and Safflower. Tribune Branch, Kans. Agr. Expt. Sta., Bul. 425. Sept., 1960.

125. Sullivant, Charles A. The Kansas Watershed District. Governmental Research Center, University of Kansas. Citizen's Pamphlet Series No. 27. June, 1960.

126. Swanson, Norris P. and E. L. Thaxton. Requirements of Grain Sorghum Irrigation on the High Plains. Tex. Agr. Expt. Sta., Bul. 846. Jan., 1957.

127. Thorfinnson, T. S. and A. W. Epp. Effect of Pump Irrigation on Farms in Central Nebraska. University of Nebraska, Expt. Sta. Bul. 421. Oct., 1953.

128. Thorfinnson, T. S., A. W. Epp, and W. H. Pine. Systems of Farming in Irrigation Districts in the Republican River Valley. University of Nebraska, Expt. Sta. Bul. 404. Oct., 1951.

129. Throckmorton, R. I. and H. E. Meyers. Summer Fallow in Kansas. Kansas State University, Agr. Expt. Sta., Bul. 293. March, 1941.

130. Trew, E. M. and Carl S. Hoveland. Irrigated Pastures for South Texas. Tex. Agr. Expt. Sta., B-819.

131. Tweeten, Luther G. and W. B. Back. Costs, Returns, and Efficiency of Sorghum and Alternative Crop Production in Western Oklahoma. Oklahoma State University, Expt. Sta. Bul. B-525. Feb., 1959.

132. Walter, Ted L. 1960 Experiment Station Results with Fall Seeded Wheat, Barley, Oats. Kansas State University, Agr. Expt. Sta., Circular 379. Sept., 1960.

133. Walter, Ted L., Gene E. Scott, and A. L. Clapp. Kansas Corn Tests, 1960. Kansas State University, Agr. Expt. Sta., Bul. 432. March, 1961.

134. Walter, Ted L. 1960 Experiment Station Results with Soybean, Forage Sorghum, Sudangrass, Millet, Popcorn, and Castorbean Varieties. Kansas State University, Agr. Expt. Sta., Report of Progress 48. March, 1961.

135. Walter, Ted L. 1960 Experiment Station Results with Varieties of Spring Oats, Spring Barley. Kansas State University, Agr. Expt. Sta., Report of Progress 45. Dec., 1960.

136. Walter, Ted L. and others. Kansas Grain Sorghum Performance Tests 1960. Kansas State University, Agr. Expt. Sta., Bul. 435. March, 1961.

137. Water in Kansas. Report to the 1955 State Legislature. 1955.

138. Water Rights and Soil and Water Conservation. USDA, Soil Conservation Service PA-306. Washington: Government Printing Office. Jan., 1957.

139. Wittmuss, Howard and Paul Fischbach. A Small Well Can Irrigate Your Farm. Reprinted from the Neb. Expt. Sta. Quarterly, Summer, 1958.

Unpublished Material

1. Boone, Larry. Crop Income in Western Kansas for 1917-57 as Affected by Land Allocation, Prices, and Rainfall. Unpublished Master's Thesis, Kansas State University. 1960.

2. County Agents Annual Reports. Unpublished, Kansas State University, 1954-1960.

3. Goetzinger, James D. The Competitive Position of Kansas in Marketing Beef. Unpublished Master's Thesis, Kansas State University. 1960.

4. Patterns and Trends for Crops and Livestock, Kansas River Units. Unpublished reports, Kansas State University.

5. Stallings, James L. Indexes of the Influence of Weather on Agricultural Output. Michigan State University, Unpublished Ph.D. Thesis. 1958.

APPENDICES

APPENDIX I

Procedure for Revision of Average Yield Data

Each year the Kansas State Board of Agriculture issues a report "Farm Facts and Figures" which contains information regarding total production and acreage for the various crops grown in the state.[1] These figures are given for each county, for each crop reporting district, and for the state as a whole. For each of these divisions and derived from the total production and acreage figures, an average yield figure is given for each crop. The data appearing in these yearly reports is of a preliminary nature.

The State Board of Agriculture also issues a report to the governor and legislature each year (formerly every two years).[2] In these reports data are presented showing the total production, acreage, and average yield for the various crops grown in the state on a state basis for each year that records are available. These data are revised and final, and in some years have been changed from the corresponding information appearing in "Farm Facts." These revised figures are for state totals only and no revision is given for the crop reporting districts or counties. Therefore to obtain revised data for each crop reporting district it was necessary to calculate this revision on the basis of the percentage change in the state revision.

To obtain a revised acreage yield for each crop reporting district, the following steps were followed for each crop. (NOTE: in only part of the years do the revised reports show any change from the preliminary reports.)

1. The original state figures (from yearly Farm Facts Reports) and the revised state figures (from 41st Report of State Board of Agriculture) showing

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1. Farm Facts, loc. cit.
2. Kansas Agriculture. Reports of the Kansas State Board of Agriculture to the Legislature of the State. 1941-1959.

acres harvested and total production were arrayed for each crop considered.

Example:

Year	Total Production			Acres Harvested		
	Original data	Revised data	Correction factor	Original data	Revised data	Correction factor
1941	90	100	1.111	400	400	.000

2. The revised state data was then divided by the original state data to give the percentage change brought about by the revision or a "correction factor."

3. The above correction factor was then multiplied by the total production or total acres harvested in each crop reporting district for the appropriate year and crop. This gave a revised total production figure or a revised acres harvested figure in each crop reporting district for each crop. These revisions were checked by totaling the revised figures for the nine crop reporting districts and checking against the revised state totals.

4. This final step involved dividing the revised total production for each crop reporting district by the revised acres harvested for the same district which gave the revised average per acre yield for the district. This procedure was followed on all crops for which data was obtained.

APPENDIX II

Historical Yield Data, All Crops

Table 12. Wheat average yield per harvested acre, by crop reporting districts, state of Kansas, revised.

Year	Crop Reporting District: North-west	West Central	South-west	North Central	Central	South Central	North-east	East Central	South-east	State
	(bushels)									
1941	15.6	14.8	14.1	14.3	17.4	14.7	11.1	13.2	10.5	14.7
1942	22.8	19.9	20.3	19.7	19.4	17.1	16.0	12.3	12.5	19.3
1943	17.5	14.7	11.5	18.0	15.3	11.9	15.8	12.3	10.2	14.2
1944	15.9	15.3	18.6	13.1	17.0	17.2	15.7	17.3	14.3	16.5
1945[a]	22.3	19.1	17.3	13.3	11.3	14.1	14.7	13.3	13.4	15.5
1946	21.3	15.3	13.1	15.0	16.4	17.1	19.3	16.1	14.8	16.2
1947	22.6	23.9	21.3	16.5	17.9	16.0	19.9	18.7	18.7	19.3
1948	19.2	16.4	17.5	17.2	17.5	15.5	22.6	23.1	17.5	17.5
1949	10.3	9.9	11.7	8.6	9.7	10.5	16.4	17.3	14.0	11.0
1950	19.3	12.3	8.4	13.7	13.9	15.1	19.3	22.0	20.6	14.5
1951	14.2	8.5	11.5	12.7	14.4	13.4	12.9	12.4	13.0	13.0
1952	22.2	22.5	21.1	17.2	20.0	22.2	18.3	21.1	23.1	21.0
1953	16.0	8.9	6.5	12.4	10.4	11.0	23.2	22.0	22.6	12.5
1954	14.6	11.2	8.5	21.0	19.0	17.6	24.9	29.1	28.1	17.5
1955	19.7	14.6	10.3	14.3	13.6	8.1	32.8	30.5	21.1	15.0
1956	10.2	10.2	10.6	13.0	15.6	16.2	25.5	32.5	25.6	15.5
1957	23.2	13.9	18.9	16.0	18.0	16.6	29.1	26.1	15.3	19.0
1958	30.2	27.7	25.0	28.1	28.6	28.1	31.9	29.5	28.6	28.0
1959	21.7	21.8	18.1	19.9	18.0	18.8	24.0	24.9	23.9	20.0

a. Beginning in 1945 both spring and winter wheat yields are included in data. Prior to 1945 only winter wheat is included.

Table 13. Corn average yield per harvested acre, by crop reporting districts, state of Kansas, revised.

Year	Crop Reporting District: North-west	West Central	South-west	North Central	Central	South Central	North-east	East Central	South-east	State
	(bushels)									
1941	18.3	15.7	14.5	16.8	16.6	19.4	28.2	27.9	19.0	22.5
1942	18.5	16.1	16.0	25.6	22.0	21.4	33.2	30.5	25.6	26.5
1943	11.5	11.1	11.7	19.2	20.5	17.4	28.6	27.5	19.4	22.0
1944	26.3	23.0	22.9	28.2	24.6	22.2	31.1	28.8	23.3	27.5
1945	18.5	13.8	12.8	21.6	23.7	22.9	25.9	22.5	23.4	23.0
1946	10.6	9.5	9.9	18.4	13.9	10.9	33.1	20.9	13.2	21.0
1947	14.2	12.2	12.4	10.4	15.2	18.9	18.0	18.4	23.4	17.0
1948	15.6	20.5	21.2	26.7	32.1	24.0	40.1	35.4	28.6	32.5
1949	24.3	20.6	19.6	23.2	23.4	25.5	29.1	31.3	28.3	27.7
1950	24.6	23.9	26.7	32.9	34.9	32.3	39.1	36.3	33.1	35.0
1951	25.2	21.4	20.0	25.0	25.8	26.5	22.8	22.6	24.2	24.0
1952	18.0	18.2	11.4	19.0	13.2	13.8	29.5	23.7	17.7	22.0
1953	15.2	14.2	9.7	16.5	18.5	14.0	29.3	20.8	18.7	21.5
1954[a]	15.2	23.4	17.9	18.1	9.0	7.0	33.3	12.7	8.3	20.0
1955[a]	7.4	18.2	13.9	8.3	8.8	9.5	23.5	26.0	27.2	21.0
1956	15.0	32.7	14.8	9.3	6.6	8.8	21.1	31.8	22.4	21.0
1957	21.4	36.0	33.6	22.2	21.5	22.7	33.5	34.1	22.8	29.0
1958	34.7	50.4	49.4	42.4	33.9	33.4	46.2	43.0	40.9	42.0
1959	28.0	51.0	57.1	28.9	31.7	34.0	45.0	48.2	45.1	41.5

a. The figures for 1954 and 1955 were taken from the State Board Agriculture revised figures for counties and are not the same as authors revision.

Table 14. Grain sorghum average yield per harvested acre, by crop reporting districts, state of Kansas, revised.

Year	Crop Reporting District									
	North-west	West Central	South-west	North Central	Central	South Central	North-east	East Central	South-east	State
	(bushels)									
1941	15.1	14.7	16.3	16.0	19.6	16.9	21.0	21.4	16.9	17.2
1942	10.2	10.1	14.5	16.3	18.1	17.0	20.8	21.7	18.0	16.7
1943	10.4	12.3	13.6	14.1	16.2	13.2	19.9	18.8	14.8	14.5
1944	21.9	27.2	23.9	20.4	22.4	19.3	20.8	20.9	18.1	22.1
1945	12.5	12.6	14.3	14.1	18.2	16.3	15.7	17.0	16.9	15.4
1946	12.1	11.6	13.4	14.6	12.4	12.5	24.0	16.7	11.8	13.5
1947	12.8	15.5	15.9	10.8	12.9	14.0	14.7	13.3	14.3	14.5
1948	15.0	20.1	21.7	21.0	25.1	20.7	25.9	23.6	20.6	21.5
1959	23.0	24.9	22.8	18.1	19.9	18.8	21.7	21.3	18.3	21.5
1950	21.5	22.7	18.6	25.5	29.2	25.9	25.2	23.6	23.1	23.0
1951	17.8	23.8	21.9	18.4	24.6	24.1	16.3	16.1	19.0	22.0
1952	16.3	13.7	10.0	17.6	15.0	13.9	21.4	20.1	15.3	14.0
1953	15.0	13.8	11.4	16.4	20.7	18.5	25.4	19.3	17.6	16.0
1954	15.9	13.0	14.1	20.6	10.1	10.2	29.1	18.4	7.7	14.5
1955	6.8	7.1	12.3	6.5	8.1	9.2	20.7	17.9	12.2	11.5
1956	7.5	24.5	21.4	5.9	8.1	6.9	18.9	23.9	13.0	15.0
1957	18.3	19.3	19.6	21.4	23.2	20.4	34.0	31.2	24.6	21.0
1958	30.8	33.3	29.3	35.6	33.6	30.3	42.8	37.8	34.7	33.0
1959	24.0	28.1	32.7	28.7	30.9	34.0	42.9	42.0	42.1	33.0

Table 15. Barley average yield per harvested acre, by crop reporting districts, state of Kansas, revised.

Year	North-west	West Central	South-west	North Central	Central	South Central	North-east	East Central	South-east	State
	Crop Reporting District (bushels)									
1941	21.4	21.1	24.1	19.9	22.4	19.7	19.8	17.3	14.7	21.0
1942	12.3	10.2	10.1	12.4	15.3	15.6	17.5	18.5	15.6	13.5
1943	15.8	12.1	11.6	14.2	14.7	13.2	19.2	16.4	12.4	14.0
1944	14.4	16.1	23.7	11.6	16.0	20.1	15.9	13.2	14.4	17.8
1945	22.8	16.9	19.1	13.2	15.4	18.9	15.4	15.2	14.3	18.5
1946	17.9	13.9	12.8	16.8	20.8	21.5	22.7	20.5	22.9	17.5
1947	20.7	24.6	22.9	19.4	24.0	20.5	20.0	22.1	20.8	22.0
1948	19.5	17.4	17.9	19.0	20.9	18.3	23.7	24.1	21.9	19.0
1949	16.8	19.8	18.7	14.6	14.9	16.1	18.8	20.7	20.5	17.5
1950	8.3	7.5	8.2	8.9	13.8	14.0	19.3	23.5	22.6	14.5
1951	16.1	11.3	14.1	11.3	12.2	12.9	10.8	13.7	11.4	13.0
1952	14.0	11.5	11.3	13.9	14.8	20.6	19.2	26.6	27.4	15.5
1953	13.4	10.3	8.9	10.0	9.8	10.0	22.2	25.2	27.8	14.0
1954	14.9	12.6	10.2	24.2	25.1	22.2	31.8	29.9	30.0	22.5
1955	17.9	12.2	15.1	10.4	12.9	9.9	30.0	30.2	21.7	18.5
1956	7.4	6.4	14.5	10.2	13.3	13.9	24.0	26.3	20.3	18.0
1957	24.1	18.5	19.1	24.0	24.0	20.0	30.9	28.7	19.0	22.0
1958	29.5	22.6	23.8	23.9	27.6	27.8	30.0	27.1	28.1	27.0
1959[a]	28.1	24.2	21.9	25.3	25.5	24.9	22.5	27.5	25.9	25.5

a. Preliminary data.

Table 16. Oats average yield per harvested acre, by crop reporting districts, state of Kansas, revised.

Year	Crop Reporting District									
	North-west	West Central	South-west	North Central	Central	South Central	North-east	East Central	South-east	State
	(bushels)									
1941	26.8	27.0	27.2	26.8	27.7	23.9	27.5	24.5	18.6	24.0
1942	19.5	17.0	16.3	25.9	27.5	23.9	29.4	27.2	22.4	25.5
1943	22.1	12.3	9.7	28.9	27.4	26.8	27.4	21.1	18.4	24.0
1944	19.7	23.5	27.5	15.8	16.9	20.3	16.7	12.5	13.8	16.2
1945	23.4	17.3	17.1	16.1	14.1	18.8	23.0	15.6	15.5	17.5
1946	24.0	17.5	10.6	23.5	25.9	29.0	32.6	30.4	28.0	28.5
1947	28.9	27.3	28.5	26.5	32.4	31.6	23.9	24.5	32.3	29.0
1948	20.2	19.5	20.0	25.7	24.1	16.5	25.4	22.5	17.2	22.0
1949	24.8	23.8	21.6	18.6	19.6	19.7	20.3	20.0	17.8	19.4
1950	9.4	7.7	7.6	14.6	13.9	13.0	25.0	26.3	23.7	21.0
1951	26.2	18.4	19.9	19.6	17.1	17.7	20.8	18.1	14.5	18.0
1952	11.5	10.4	8.4	16.2	18.8	21.7	22.3	22.0	22.7	20.5
1953	12.2	9.3	7.0	14.6	18.1	15.4	23.5	24.4	26.8	21.5
1954	15.6	17.9	11.3	30.2	28.5	25.4	37.9	37.8	35.2	33.0
1955	14.1	11.8	11.5	15.0	19.7	17.2	37.5	37.4	28.5	27.5
1956	8.8	7.0	10.8	13.5	16.8	15.7	22.5	29.2	22.9	21.5
1957	33.8	27.2	21.8	36.5	30.8	23.9	39.0	34.7	24.3	30.5
1958	21.8	17.4	13.2	24.4	20.9	22.3	33.0	25.6	28.3	26.0
1959[a]	19.8	19.2	18.5	20.6	21.1	23.0	22.3	23.8	25.5	23.0

a. Preliminary data.

Table 17. Sorghum for forage average yield per harvested acre, by crop reporting districts, state of Kansas, revised.

Year	Crop Reporting District: North-west	West Central	South-west	North Central	Central	South Central	North-east	East Central	South-east	State
	(tons)									
1941	2.0	1.8	1.9	2.2	2.3	2.2	2.5	2.6	2.4	2.14
1942	1.7	1.6	1.9	2.0	2.7	2.5	2.8	3.8	2.8	2.26
1943	1.2	1.1	1.1	1.8	1.9	1.8	2.4	2.5	2.1	1.61
1944	1.9	2.0	1.8	2.4	2.6	2.1	2.3	2.4	2.4	2.13
1945	1.4	1.3	1.4	1.6	1.9	1.8	1.8	2.0	2.0	1.64
1946	1.3	1.2	1.3	1.8	1.8	1.5	2.3	2.5	2.0	1.60
1947	1.4	1.3	1.4	1.1	1.4	1.6	1.5	1.7	1.6	1.40
1948	1.4	1.7	1.8	1.9	2.2	2.1	2.3	2.6	2.2	1.90
1949	1.9	1.9	1.6	1.7	1.6	2.2	2.0	2.4	2.1	1.85
1950	1.8	1.8	1.7	2.1	2.3	2.4	2.3	2.3	2.0	2.00
1951	1.9	2.0	2.1	2.0	2.4	2.3	1.8	2.0	2.3	2.10
1952	1.5	1.1	1.0	2.1	1.8	1.5	2.1	2.3	1.9	1.50
1953	1.6	1.2	1.2	1.5	1.9	1.6	2.2	1.9	1.8	1.50
1954	1.4	1.3	1.2	1.6	1.2	1.1	2.5	1.7	1.2	1.30
1955	.6	.8	1.1	.8	.9	1.1	1.2	1.2	1.5	.90
1956	.7	.6	.5	.7	.7	.6	1.8	2.0	1.2	.70
1957	1.9	1.7	1.9	2.6	2.8	2.6	2.9	3.1	2.6	2.20
1958	3.0	2.6	2.8	3.4	3.6	2.7	3.7	4.0	3.6	3.00
1959[a]	2.0	1.9	1.8	2.3	2.5	2.3	2.4	3.4	3.0	2.20

a. Preliminary data.

Table 18. Sorghum for silage average yield per harvested acre, by crop reporting districts, state of Kansas, revised.

Year	North-west	West Central	South-west	North Central	Central	South Central	North-east	East Central	South-east	State
	Crop Reporting District (tons)									
1941[a]	-	-	-	-	-	-	-	-	-	6.9
1942	-	-	-	-	-	-	-	-	-	7.0
1943	3.1	3.2	3.4	4.5	5.5	4.5	6.8	6.7	6.6	5.6
1944	4.5	5.8	5.4	6.5	7.2	6.9	7.9	7.8	7.4	7.0
1945	4.1	4.1	4.1	4.5	5.9	5.0	6.0	6.2	6.5	5.5
1946	3.8	3.8	4.8	5.8	5.5	4.8	7.5	7.4	6.3	6.0
1947	3.9	4.7	4.9	3.8	4.4	5.0	4.8	6.0	6.4	5.3
1948	5.2	7.3	6.2	7.4	8.2	7.1	7.6	8.7	7.8	7.6
1949	6.8	7.4	6.6	6.3	6.7	7.1	7.2	8.8	7.8	7.3
1950	6.8	7.8	6.4	9.4	9.5	8.4	9.5	8.6	8.7	8.5
1951	6.7	8.3	7.0	7.1	7.8	7.4	7.8	7.0	8.4	7.5
1952	4.5	4.0	3.5	5.8	5.4	4.6	7.3	7.2	6.1	5.3
1953	4.8	4.6	4.6	6.1	6.9	5.5	8.7	6.4	6.7	6.0
1954	5.2	4.6	4.8	6.6	3.9	3.7	10.7	6.5	4.1	5.0
1955	2.7	3.0	4.8	2.8	3.2	4.0	6.8	6.3	4.9	4.2
1956	3.6	6.3	7.3	3.0	2.9	3.1	7.2	7.8	4.7	4.5
1957	6.9	7.1	7.4	8.1	8.9	7.8	9.9	9.5	7.4	8.1
1958	8.3	8.9	8.8	10.5	10.0	8.1	11.8	10.9	10.7	9.7
1959[b]	6.7	7.7	8.6	7.6	8.5	8.4	10.4	12.1	11.0	8.9

a. Did not report separately until in 1943.
b. Preliminary data.

Table 19. Alfalfa hay average yield per harvested acre, by crop reporting districts, state of Kansas, revised.

Year	Crop Reporting District: North-west	West Central	South-west	North Central	Central	South Central	North-east	East Central	South-east	State
	(tons)									
1941	1.9	2.1	1.9	1.8	2.0	2.0	2.2	2.4	2.4	2.15
1942	1.8	1.9	1.8	2.2	2.4	2.0	2.3	2.5	2.5	2.30
1943	1.9	1.9	1.8	1.8	1.9	1.8	2.0	2.1	2.1	1.95
1944	2.4	2.3	2.2	2.3	2.3	2.1	2.3	2.3	2.3	2.26
1945	1.9	2.3	2.1	2.0	2.2	2.0	2.1	2.1	2.2	2.10
1946	2.1	2.2	2.3	1.7	1.8	1.8	2.0	2.1	1.7	1.90
1947	2.1	2.2	2.3	1.8	1.9	2.0	1.9	2.0	2.1	1.95
1948	2.2	2.6	2.7	2.0	2.3	2.3	2.2	2.3	2.3	2.25
1949	2.2	2.3	2.3	1.7	1.9	1.8	2.1	2.2	2.3	2.00
1950	2.2	2.2	2.2	2.1	2.1	1.8	2.2	2.2	2.2	2.10
1951	2.5	2.5	2.3	2.2	2.3	2.2	2.0	2.0	2.1	2.15
1952	2.1	2.0	2.0	1.5	1.6	1.6	1.6	1.6	1.5	1.60
1953	2.2	2.3	2.5	1.4	1.7	1.5	1.6	1.3	1.4	1.55
1954	2.1	2.3	2.6	1.8	1.6	1.3	2.0	1.5	1.2	1.65
1955	1.6	2.4	2.5	1.2	1.5	1.4	1.7	2.0	1.7	1.60
1956	1.8	2.1	2.5	1.1	1.0	1.1	1.3	1.5	.9	1.25
1957	2.4	2.7	2.9	1.9	2.2	2.1	2.2	2.3	1.9	2.15
1958	2.5	3.1	2.9	2.3	2.5	2.3	2.7	2.8	2.7	2.55
1959[a]	2.2	3.1	3.2	2.0	2.2	2.2	2.5	2.5	2.7	2.40

a. Preliminary data.

Table 20. Wild hay average yield per harvested acre, by crop reporting districts, state of Kansas, revised.

Year	Northwest	West Central	Southwest	North Central	Central	South Central	Northeast	East Central	Southeast	State
	Crop Reporting District (tons)									
1941	1.0	1.0	1.0	1.0	1.1	1.1	1.1	1.2	1.0	1.10
1942	1.1	1.1	1.0	1.2	1.3	1.1	1.2	1.3	1.2	1.25
1943	1.0	1.0	.9	1.0	1.2	1.2	1.1	1.2	1.2	1.15
1944	1.1	1.1	1.1	1.2	1.2	1.1	1.1	1.1	1.1	1.11
1945	1.0	1.0	1.1	1.2	1.2	1.2	1.1	1.2	1.1	1.15
1946	.8	.9	.7	.8	.8	.9	.8	.8	.7	.75
1947	1.0	1.0	1.1	1.0	1.1	1.2	1.0	1.1	1.1	1.10
1948	1.2	1.2	1.1	1.2	1.3	1.3	1.2	1.2	1.3	1.25
1949	1.2	1.3	1.1	1.1	1.2	1.3	1.1	1.1	1.2	1.15
1950	1.2	1.3	1.2	1.1	1.2	1.2	1.1	1.1	1.2	1.15
1951	1.1	1.1	1.2	1.2	1.2	1.3	1.1	1.1	1.2	1.15
1952	.8	.7	.6	.8	.8	.8	.9	.7	.6	.70
1953	.8	.8	.7	.8	.8	.8	.8	.6	.8	.75
1954	1.0	1.0	.8	1.0	.9	.7	1.1	.9	.7	.85
1955	.7	.9	.8	.6	.6	.8	.8	1.0	1.0	.90
1956	.7	.8	.6	.6	.6	.7	.8	1.0	.8	.80
1957	1.4	1.5	1.3	1.1	1.3	1.4	1.1	1.3	1.3	1.25
1958	1.4	1.4	1.2	1.4	1.6	1.5	1.3	1.4	1.4	1.40
1959[a]	.9	1.2	.8	1.1	1.4	1.4	1.2	1.2	1.3	1.20

a. Preliminary data.

APPENDIX III

Historical Acreage Data, Feed Grain and Wheat

Table 21. Feed grain and wheat harvested acreage, Northwest Kansas Crop Reporting District, 1941-1959.[a]

Year	Corn	Grain sorghum	Barley	Oats	Total four feed grains	Wheat
			(acres)			
1941	265,000	113,300	269,600	25,100	673,000	1,033,000
1942	308,900	61,200	173,600	22,100	565,800	1,300,000
1943	296,200	51,300	190,100	25,000	562,600	1,295,000
1944	269,200	108,100	123,200	25,300	525,800	926,000
1945	198,900	74,600	86,300	21,800	381,600	1,381,000[b]
1946	145,600	39,600	75,000	20,100	280,300	1,376,000
1947	93,000	30,300	64,900	19,100	207,300	1,567,000
1948	85,900	66,200	79,700	26,200	258,000	1,206,000
1949	83,600	99,300	43,700	17,500	244,100	1,217,000
1950	100,700	101,700	34,600	12,400	249,400	1,303,000
1951	139,700	209,300	13,900	11,800	374,700	817,000
1952	134,200	79,000	12,400	18,400	244,000	1,541,000
1953	125,400	200,600	19,600	18,400	364,000	1,070,000
1954	129,100	353,150	41,800	16,900	540,950	986,000
1955	42,400	95,323	39,400	10,000	187,123	934,000
1956	29,500	98,000	20,900	2,500	150,900	816,000
1957	97,000	610,000	52,300	14,300	773,600	609,000
1958	104,200	236,000	59,000	8,200	407,400	1,185,000
1959	98,500	381,000	133,800	5,700	619,000	1,093,000

a. Calculated from State Board of Agriculture estimates.
b. Spring wheat included, 1945 to 1959.

Table 22. Feed grain and wheat acreage harvested, west central Kansas Crop Reporting District, 1941-1959.[a]

Year	Corn	Grain sorghum	Barley	Oats	Total four feed grains	Wheat
			(acres)			
1941	19,100	127,100	202,800	19,200	368,200	972,000
1942	28,100	70,700	108,400	15,800	223,000	1,117,000
1943	30,000	83,200	101,000	14,400	228,600	1,133,000
1944	32,500	227,800	170,337	24,400	455,037	834,000
1945	13,200	87,500	70,400	12,300	183,400	1,371,000[b]
1946	9,700	45,200	52,500	11,200	118,600	1,320,000
1947	7,000	56,600	49,200	11,400	124,200	1,631,000
1948	6,400	125,400	60,400	16,100	208,300	1,221,000
1949	5,300	221,100	40,800	11,100	278,300	1,391,000
1950	5,200	196,900	13,200	3,300	218,600	1,284,000
1951	23,400	538,600	20,500	8,200	590,700	529,000
1952	12,200	103,200	17,100	8,600	141,100	1,660,000
1953	13,800	328,600	17,400	12,200	372,000	850,000
1954	12,800	633,800	39,200	9,800	695,600	927,000
1955	8,400	216,000	17,700	5,300	247,400	898,000
1956	9,500	87,700	6,300	2,000	105,500	793,000
1957	20,900	1,080,000	31,600	8,700	1,141,200	108,000
1958	16,100	423,000	57,300	5,000	501,400	1,158,000
1959	15,600	623,000	82,500	3,700	724,800	1,141,000

a. Calculated from State Board of Agriculture estimates.
b. Spring wheat included, 1945 on.

Table 23. Feed grain and wheat harvested acreage, Southwest Kansas Crop Reporting District, 1941-1959.[a]

Year	Corn	Grain sorghum	Barley	Oats	Total four feed grains	Wheat
			(acres)			
1941	18,000	347,700	203,300	29,200	598,200	1,830,000
1942	30,200	254,400	148,500	15,200	448,300	2,142,000
1943	29,500	265,500	88,800	9,100	392,900	2,040,000
1944	17,400	713,400	168,500	22,300	921,600	2,083,000
1945	6,500	312,300	79,400	11,100	409,300	2,621,000[b]
1946	3,200	323,200	43,200	7,400	377,000	2,433,000
1947	2,200	290,100	51,200	10,000	353,500	3,051,000
1948	2,000	370,000	58,600	14,800	445,400	2,653,000
1949	1,800	449,500	35,400	8,900	495,600	2,703,000
1950	1,700	623,800	7,500	600	633,600	1,952,000
1951	9,600	1,080,800	29,600	8,000	1,128,000	1,095,000
1952	6,200	405,700	25,300	9,500	446,700	2,541,000
1953	3,600	427,000	16,100	5,900	452,600	1,593,000
1954	2,900	1,073,000	40,100	5,000	1,121,000	1,346,000
1955	2,100	1,305,000	17,800	4,100	1,329,000	1,016,000
1956	3,500	432,900	8,700	1,800	446,900	1,395,000
1957	11,700	2,065,000	52,700	10,300	2,139,700	211,000
1958	12,500	986,000	47,000	3,700	1,049,200	1,973,000
1959	14,500	1,125,000	68,600	4,000	1,212,600	2,004,000

a. Calculated from State Board of Agriculture reports.
b. Spring wheat included, 1945 to 1959.

Table 24. Feed grain and wheat harvested acreage, North Central Kansas Crop Reporting District, 1941-1959.[a]

Year	Corn	Grain sorghum	Barley	Oats	Total four feed grains	Wheat
			(acres)			
1941	391,100	100,600	221,700	170,100	883,600	1,521,000
1942	543,200	96,200	218,100	193,400	1,050,900	1,306,000
1943	732,200	102,000	218,600	256,500	1,309,300	1,183,000
1944	759,300	185,000	53,300	174,200	1,171,800	1,402,000
1945	694,300	90,000	28,500	130,700	943,800	1,601,000[b]
1946	636,400	79,800	20,000	173,400	909,600	1,529,000
1947	503,447	42,000	18,300	139,500	703,247	1,749,000
1948	521,000	132,000	41,000	204,400	898,400	1,552,000
1949	494,200	108,800	25,000	120,700	730,700	1,669,000
1950	498,000	204,600	23,100	122,600	848,300	1,526,000
1951	526,600	120,100	6,800	83,400	736,900	1,487,000
1952	576,100	133,700	2,600	104,300	816,700	1,713,000
1953	451,300	170,500	5,000	88,200	715,000	1,524,000
1954	439,300	373,000	17,700	101,300	931,300	1,303,000
1955	221,400	139,500	31,300	94,400	486,600	1,099,000
1956	190,300	170,200	24,400	73,800	458,700	1,208,000
1957	196,300	568,000	30,900	99,300	894,500	731,000
1958	215,400	451,000	42,900	79,500	788,800	1,210,000
1959	309,500	626,000	84,600	86,900	1,107,000	1,270,000

a. Calculated from State Board of Agriculture reports.
b. Spring wheat included, 1945 on.

Table 25. Feed grain and wheat harvested acreage, Central Kansas Crop Reporting District, 1941-1959.[a]

Year	Corn	Grain sorghum	Barley	Oats	Total four feed grains	Wheat
			(acres)			
1941	104,900	73,600	145,500	156,600	480,600	2,099,000
1942	195,000	116,400	195,900	219,800	727,100	1,663,000
1943	256,200	141,400	194,100	256,900	848,600	1,651,000
1944	207,400	194,700	55,700	198,200	656,000	2,196,000
1945	169,800	124,200	30,500	134,700	459,200	2,170,000[b]
1946	148,200	65,400	29,700	152,200	395,500	2,285,000
1947	97,800	55,800	28,700	164,700	347,000	2,373,000
1948	98,900	141,100	47,700	144,700	432,400	2,102,000
1949	109,600	92,300	21,000	118,600	341,500	2,278,000
1950	168,000	207,300	30,800	93,500	499,600	2,024,000
1951	145,400	176,800	9,800	98,800	430,800	1,959,000
1952	145,500	165,600	5,300	113,500	429,700	2,467,000
1953	117,400	219,400	9,200	123,800	469,800	2,114,000
1954	106,300	289,200	53,900	146,300	595,700	1,740,000
1955	81,400	158,000	99,700	174,400	513,500	1,563,000
1956	81,400	120,100	73,700	162,500	437,700	1,614,000
1957	86,100	502,000	85,900	175,800	849,800	951,000
1958	110,800	401,000	80,800	86,700	679,300	1,632,000
1959	114,500	571,000	132,900	137,000	955,400	1,698,000

a. Calculated from State Board of Agriculture reports.
b. Spring wheat included, 1945 on.

Table 26. Feed grain and wheat harvested acreage, South Central Kansas Crop Reporting District, 1941-1959.[a]

Year	Corn	Grain sorghum	Barley	Oats	Total four feed grains	Wheat
			(acres)			
1941	141,100	131,900	178,700	187,200	638,900	2,708,000
1942	195,200	163,700	267,500	247,500	873,900	2,167,000
1943	229,000	232,000	233,300	303,200	997,500	2,094,000
1944	163,400	305,200	116,700	266,900	852,200	2,847,000
1945	107,000	164,000	66,200	158,800	496,000	3,024,000[b]
1946	100,400	133,200	51,800	193,600	479,000	2,969,000
1947	65,100	92,300	54,800	190,700	402,900	3,055,000
1948	83,000	186,900	54,100	130,300	454,300	2,824,000
1949	83,400	166,200	32,200	80,900	362,700	3,147,000
1950	130,900	338,200	78,700	75,600	623,400	2,693,000
1951	127,640	313,100	18,100	89,700	548,540	2,525,000
1952	101,700	221,300	9,900	90,600	423,500	3,254,000
1953	92,000	329,900	21,000	129,400	572,300	2,690,000
1954	42,700	366,800	122,400	131,600	663,500	2,419,000
1955	31,200	457,100	131,700	149,200	769,200	1,755,000
1956	47,100	308,000	132,400	150,000	637,500	2,052,000
1957	56,800	780,000	169,300	166,600	1,172,700	1,360,000
1958	72,500	609,000	162,700	68,200	912,400	2,170,000
1959	53,400	871,000	231,000	108,300	1,263,700	2,244,000

a. Calculated from State Board of Agriculture reports.
b. Spring wheat included, 1945 on.

Table 27. Feed grain and wheat harvested acreage, Northeast Kansas Crop Reporting District, 1941-1959.[a]

Year	Corn	Grain sorghum	Barley	Oats	Total four feed grains	Wheat
			(acres)			
1941	622,700	42,000	9,300	260,600	934,600	502,000
1942	682,600	37,100	15,600	287,300	1,022,600	337,700
1943	749,800	26,100	9,600	290,500	1,076,000	303,000
1944	801,400	40,300	5,200	215,400	1,062,300	371,200
1945	730,300	22,300	1,900	171,700	926,200	372,800[b]
1946	781,300	22,000	1,100	284,900	1,089,300	374,500
1947	699,900	11,800	1,200	176,400	889,300	413,000
1948	698,200	29,900	1,700	207,400	937,200	479,000
1949	699,300	20,200	900	146,100	866,500	551,400
1950	669,100	37,900	1,900	184,200	893,100	443,300
1951	594,500	11,700	400	144,500	751,100	423,000
1952	733,500	24,000	600	178,300	936,400	401,600
1953	717,900	38,900	900	171,000	928,700	429,500
1954	691,300	85,000	3,700	194,200	974,200	365,800
1955	669,100	92,900	7,700	184,400	954,100	344,500
1956	553,900	121,700	14,800	172,100	862,500	356,700
1957	517,900	241,200	17,800	163,200	939,600	326,000
1958	461,500	143,700	17,400	109,500	832,100	348,000
1959	626,500	288,500	24,400	140,100	1,079,500	382,000

a. Calculated from State Board of Agriculture reports.
b. Spring wheat included, 1945 on.

Table 28. Feed grain and wheat harvested acreage, East Central Kansas Crop Reporting District, 1941-1959.[a]

Year	Corn	Grain sorghum	Barley	Oats	Total four feed grains	Wheat
			(acres)			
1941	493,700	165,100	33,300	336,500	1,028,600	510,000
1942	601,600	167,900	45,200	349,500	1,164,200	195,800
1943	668,600	131,500	33,100	352,500	1,185,700	209,700
1944	749,100	198,700	9,100	229,300	1,186,200	306,400
1945	596,000	105,900	5,600	102,900	810,400	364,900[b]
1946	671,100	92,800	3,600	266,500	1,034,000	357,400
1947	494,100	73,100	5,200	261,200	833,600	413,000
1948	496,900	126,800	5,000	184,000	812,700	536,000
1949	539,200	87,400	5,200	147,600	779,400	607,000
1950	532,700	100,500	13,700	159,100	806,000	455,300
1951	461,700	51,200	14,900	147,200	675,000	338,100
1952	557,700	87,000	4,000	157,800	806,500	440,000
1953	475,300	133,000	7,300	188,200	803,800	527,900
1954	416,100	204,800	42,900	198,200	862,000	410,300
1955	337,700	252,800	112,300	225,500	928,300	407,200
1956	339,200	190,500	104,600	223,900	858,200	433,300
1957	343,200	212,800	86,200	203,000	845,200	435,000
1958	403,900	302,300	60,900	65,000	832,100	407,000
1959	417,500	365,500	70,800	143,500	997,300	442,000

a. Calculated from State Board of Agriculture reports.
b. Spring included, 1945 on.

Table 29. Feed grain and wheat harvested acreage, Southeast Kansas Crop Reporting District, 1941-1959.[a]

Year	Corn	Grain sorghum	Barley	Oats	Total four feed grains	Wheat
			(acres)			
1941	432,400	175,700	61,800	434,500	1,104,400	552,100
1942	525,200	205,500	59,800	462,400	1,252,900	146,800
1943	522,500	123,800	41,400	468,000	1,155,700	250,600
1944	449,300	255,700	19,800	405,100	1,129,900	411,400
1945	465,000	168,200	14,200	224,000	871,400	510,300[b]
1946	515,100	140,800	10,100	313,700	979,700	503,100
1947	355,300	102,000	16,500	422,000	895,800	603,000
1948	371,700	160,700	13,800	216,100	762,300	648,000
1949	442,500	147,100	16,800	206,500	812,900	715,600
1950	450,600	132,000	50,500	249,800	882,900	599,400
1951	400,500	103,300	15,000	156,400	675,200	527,900
1952	452,800	104,500	8,800	157,000	723,100	631,400
1953	369,300	143,200	15,500	251,900	779,900	744,600
1954	238,500	71,500	97,300	276,700	684,000	571,900
1955	230,300	118,300	230,400	275,600	854,600	542,300
1956	272,500	96,900	192,100	289,400	850,900	576,000
1957	197,100	90,000	161,300	279,900	728,300	538,000
1958	344,100	256,000	139,000	90,200	829,300	508,000
1959	362,000	329,000	144,400	211,100	1,046,500	596,000

a. Calculated from State Board of Agriculture reports.
b. Spring wheat included, 1945 on.

APPENDIX IV

Historical Acreage Data, Forage Crops and Pasture

Table 30. Forage crop and pasture harvested acreage, Northwest Kansas Crop Reporting District, 1941-1959.[a]

Year	Crop: Sorghum forage	Crop: Sorghum silage	Crop: Alfalfa hay	Crop: Wild hay	Crop: Total four forage crops	Pasture[b]
	(acres)					
1941	225,200	-[c]	9,100	4,800	239,100	-[d]
1942	142,200	-[c]	10,900	4,600	157,700	1,627,000
1943	158,200	8,900	12,600	6,900	186,600	-[d]
1944	161,200	13,700	15,900	6,800	197,600	1,577,000
1945	155,500	10,300	16,800	6,100	188,700	-[d]
1946	162,100	4,800	17,800	5,100	189,800	1,587,000
1947	125,100	8,100	23,500	3,200	159,900	-[d]
1948	100,400	8,500	24,700	3,800	137,400	1,726,000
1949	88,400	12,100	28,100	3,900	132,500	1,710,000
1950	101,000	13,300	30,900	4,000	149,200	-[d]
1951	130,800	39,100	34,100	5,600	209,600	1,677,000
1952	107,600	29,200	37,400	6,200	180,400	1,677,000
1953	141,000	53,300	42,700	5,300	242,300	1,693,000
1954	112,200	54,300	49,900	5,900	222,300	1,693,000
1955	260,800	49,100	48,000	3,900	361,800	1,676,000
1956	224,500	38,800	42,400	3,000	308,700	1,676,000
1957	97,000	78,000	47,600	3,600	226,200	1,676,000
1958	53,000	27,000	44,800	4,100	128,900	1,676,000
1959	62,000	35,000	42,000	4,000	143,000	1,676,000

a. Calculated from State Board of Agriculture reports.
b. Tame and prairie used primarily for pasture purposes.
c. Sorghum silage not reported separately until 1943.
d. No pasture acreage report issued.

Table 31. Forage crop and pasture harvested acreage, West Central Kansas Crop Reporting District, 1941-1959.[a]

Year	Crop: Sorghum forage	Sorghum silage	Alfalfa Hay	Wild hay	Total four forage crops	Pasture[b]
	(acres)					
1941	191,500	-[c]	2,700	2,100	196,300	-[d]
1942	151,900	-[c]	2,600	3,500	158,000	1,821,000
1943	171,500	7,000	2,900	3,900	185,300	-[d]
1944	136,300	16,400	4,100	3,900	160,700	1,863,000
1945	170,800	11,000	4,600	4,200	190,600	-[d]
1946	152,000	2,700	4,700	3,500	162,900	1,662,000
1947	123,000	7,600	5,400	2,900	138,900	-[d]
1948	95,700	10,800	8,500	2,800	117,800	1,928,000
1949	85,300	11,700	10,200	3,500	110,700	1,902,000
1950	111,400	26,500	12,300	3,800	154,000	--[d]
1951	125,100	61,200	15,400	4,600	206,300	1,794,000
1952	98,600	24,200	19,300	4,400	146,500	1,794,000
1953	153,200	36,100	20,400	5,300	215,000	1,819,000
1954	125,900	40,200	21,800	5,100	193,000	1,819,000
1955	339,500	37,900	20,900	3,100	401,400	1,855,000
1956	243,400	21,000	16,400	3,200	284,000	1,855,000
1957	169,000	60,000	18,900	3,600	251,500	1,855,000
1958	81,000	40,000	16,800	3,400	141,200	1,855,000
1959	63,000	37,000	15,500	4,400	119,900	1,855,000

a. Calculated from State Board of Agriculture reports.
b. Tame and prairie used primarily for pasture purposes.
c. Sorghum silage not reported separately until 1943.
d. No pasture acreage report issued.

Table 32. Forage crop and pasture harvested acreage, Southwest Kansas Crop Reporting District, 1941-1959.[a]

Year	Crop					
	Sorghum forage	Sorghum silage	Alfalfa hay	Wild hay	Total four forage crops	Pasture[b]
			(acres)			
1941	238,900	–[c]	18,500	5,700	263,100	–[d]
1942	280,300	–[c]	19,800	5,600	305,700	1,855,000
1943	298,800	24,100	17,100	5,900	345,900	–[d]
1944	208,300	26,200	20,600	8,100	263,200	1,882,000
1945	283,000	10,700	19,600	6,300	319,600	–[d]
1946	220,600	11,600	17,900	3,600	253,700	1,801,000
1947	148,900	12,300	21,600	2,800	185,600	–[d]
1948	142,600	16,700	22,700	4,200	186,200	2,105,000
1949	126,400	17,000	23,200	5,600	172,300	2,167,000
1950	163,000	27,600	25,300	5,700	221,600	–[d]
1951	194,600	95,500	30,800	6,100	327,000	2,149,000
1952	142,100	29,100	38,000	6,700	215,900	2,149,000
1953	198,900	45,900	48,000	7,200	300,000	2,172,000
1954	290,300	52,500	50,900	7,700	401,400	2,172,000
1955	318,800	74,100	48,900	6,300	448,100	2,226,000
1956	331,000	33,900	18,900	5,100	388,900	2,226,000
1957	214,000	88,000	38,400	5,400	345,800	2,226,000
1958	72,000	36,000	35,000	4,600	147,600	2,226,000
1959	68,000	31,000	29,600	4,800	133,400	2,226,000

a. Calculated from State Board of Agriculture reports.
b. Tame and prairie used primarily for pasture purposes.
c. Sorghum silage not reported separately until 1943.
d. No pasture acreage report issued.

Table 33. Forage crop and pasture harvested acreage, North Central Kansas Crop Reporting District, 1941-1959.[a]

Year	Crop: Sorghum forage	Sorghum silage	Alfalfa hay	Wild hay	Total four forage crops	Pasture[b]
	(acres)					
1941	245,400	-[c]	65,400	44,700	355,500	-[d]
1942	183,300	-[c]	104,500	44,400	332,200	1,606,000
1943	201,000	42,000	118,500	52,000	413,500	-[d]
1944	143,500	41,000	117,900	50,900	353,300	1,655,000
1945	153,500	35,900	129,700	44,500	363,600	-[d]
1946	155,500	35,200	135,000	45,500	371,200	1,634,000
1947	140,600	27,500	168,100	43,300	379,500	-[d]
1948	82,200	35,600	182,900	42,900	343,600	1,863,000
1949	79,800	25,700	187,500	47,100	340,100	1,883,000
1950	87,700	38,000	195,500	50,400	371,600	-[d]
1951	93,700	45,500	203,200	51,400	393,800	1,896,000
1952	81,300	41,100	202,600	53,100	378,100	1,896,000
1953	90,600	64,900	265,600	51,500	472,600	1,896,000
1954	115,000	69,900	326,400	59,100	570,400	1,896,000
1955	271,700	103,600	313,700	52,300	741,300	1,950,000
1956	222,400	96,100	274,200	41,500	634,200	1,950,000
1957	108,000	108,000	313,100	47,700	576,800	1,950,000
1958	59,000	60,000	289,500	44,200	452,700	1,950,000
1959	54,000	65,000	218,500	45,000	382,500	1,950,000

a. Calculated from State Board of Agriculture reports.
b. Tame and prairie used primarily for pasture purposes.
c. Sorghum silage not reported separately until 1953.
d. No pasture acreage report issued.

Table 34. Forage crop and pasture harvested acreage, Central Kansas Crop Reporting district, 1941-1959.[a]

Year	Sorghum forage	Sorghum silage	Alfalfa hay	Wild hay	Total four forage crops	Pasture[b]
			(acres)			
1941	211,400	–[c]	58,900	44,100	314,400	–[d]
1942	169,000	–[c]	81,000	43,900	293,900	1,584,000
1943	194,700	80,000	87,400	48,900	411,000	–[d]
1944	129,900	67,600	95,400	46,900	339,800	1,633,000
1945	157,300	61,600	100,400	45,000	364,300	–[d]
1946	189,300	64,500	99,800	43,400	397,000	1,604,000
1947	145,800	63,200	123,800	44,000	376,800	–[d]
1948	87,200	69,700	127,300	41,700	325,900	1,820,000
1949	93,700	39,500	125,300	48,400	306,900	1,840,000
1950	94,000	58,900	114,600	51,600	319,100	–[d]
1951	76,500	68,100	113,600	58,700	316,900	1,842,000
1952	76,800	70,100	105,600	56,400	308,900	1,842,000
1953	107,000	103,800	131,100	56,100	398,000	1,842,000
1954	190,900	105,600	179,600	57,800	533,900	1,842,000
1955	217,800	127,400	172,600	52,700	570,500	1,829,000
1956	188,000	116,100	177,900	37,200	519,200	1,826,000
1957	81,000	120,000	188,300	47,300	436,600	1,829,000
1958	45,000	75,000	164,900	42,100	327,000	1,829,000
1959	56,000	81,000	132,400	45,000	314,400	1,829,000

a. Calculated from State Board of Agriculture reports.
b. Tame and prairie used primarily for pasture purposes.
c. Sorghum silage not reported separately until 1953.
d. No pasture acreage report issued.

Table 35. Forage crop and pasture harvested acreage, South Central Kansas Crop Reporting District, 1941-1959.[a]

Year	Crop					
	Sorghum forage	Sorghum silage	Alfalfa hay	Wild hay	Total four forage crops	Pasture[b]
	(acres)					
1941	213,100	-[c]	101,200	33,600	347,900	-[d]
1942	225,500	-[c]	133,500	29,800	388,800	1,797,000
1943	256,900	113,500	143,200	34,000	547,600	-[d]
1944	173,000	96,700	154,400	32,000	456,100	1,849,000
1945	231,100	187,200	155,200	29,500	503,000	-[d]
1946	208,900	69,100	152,800	27,400	458,200	1,876,000
1947	150,500	101,700	184,800	26,500	463,500	-[d]
1948	111,100	101,900	180,900	26,600	420,500	2,050,000
1949	110,000	75,800	168,100	24,500	378,400	2,064,000
1950	136,600	93,600	145,500	26,500	402,200	-[d]
1951	115,500	127,600	142,300	28,600	414,000	2,128,000
1952	104,400	105,600	133,800	27,900	371,700	2,128,000
1953	167,300	140,300	150,100	28,500	486,200	2,124,000
1954	244,200	141,500	228,900	28,800	543,400	2,124,000
1955	211,200	192,200	220,000	26,000	649,400	2,199,000
1956	264,900	133,500	192,500	21,800	612,700	2,199,000
1957	126,000	136,000	186,300	25,000	473,300	2,199,000
1958	95,000	101,000	162,900	20,800	379,700	2,199,000
1959	100,000	107,000	129,000	21,500	357,500	2,199,000

a. Calculated from State Board of Agriculture reports.
b. Tame and prairie used primarily for pasture purposes.
c. Sorghum silage not reported separately until 1943.
d. No pasture acreage report issued.

Table 36. Forage crop and pasture harvested acreage, Northeast Kansas Crop Reporting District, 1941-1959.[a]

Year	Crop					
	Sorghum forage	Sorghum silage	Alfalfa hay	Wild hay	Total four forage crops	Pasture[b]
	(acres)					
1941	49,400	-[c]	163,600	73,600	286,600	-[d]
1942	40,600	-[c]	187,600	73,800	302,000	1,035,000
1943	39,900	23,300	185,600	83,900	332,700	-[d]
1944	23,000	21,100	186,000	84,200	314,300	1,080,000
1945	26,300	15,800	185,100	82,500	309,700	-[d]
1946	19,400	16,500	167,000	79,900	282,800	1,115,000
1947	20,800	20,000	197,100	92,200	330,100	-[d]
1948	10,900	16,400	192,900	75,800	296,000	1,398,000
1949	13,400	12,700	182,300	78,200	286,600	1,425,000
1950	13,800	17,300	165,400	80,400	276,900	-[d]
1951	12,000	17,000	161,800	85,700	276,500	1,491,000
1952	8,000	15,100	126,700	87,300	237,100	1,491,000
1953	13,000	25,300	164,600	79,700	282,600	1,483,000
1954	18,400	28,400	201,600	89,500	337,900	1,483,000
1955	24,600	46,300	193,800	78,500	343,200	1,478,000
1956	18,600	51,100	223,800	79,000	372,500	1,478,000
1957	9,100	49,700	233,700	77,300	369,800	1,478,000
1958	3,700	32,900	223,700	70,900	331,200	1,478,000
1959	2,400	29,700	181,200	74,000	287,300	1,478,000

a. Calculated from State Board of Agriculture reports.
b. Tame and prairie used primarily for pasture purposes.
c. Sorghum silage not reported separately until 1943.
d. No pasture acreage report issued.

Table 37. Forage crop and pasture harvested acreage, East Central Kansas Crop Reporting District, 1941-1959.[a]

Year	Sorghum forage	Sorghum silage	Alfalfa hay	Wild hay	Total four forage crops	Pasture[b]
			(acres)			
1941	101,900	-[c]	133,000	137,600	372,500	-[d]
1942	71,300	-[c]	155,500	146,500	373,300	2,126,000
1943	81,400	82,600	140,000	164,900	468,900	-[d]
1944	61,100	61,100	133,500	172,100	427,800	2,283,000
1945	95,600	51,200	140,300	169,600	456,700	-[d]
1946	72,500	76,400	128,400	169,500	446,800	2,237,100
1947	52,600	65,100	163,000	198,700	479,400	-[d]
1948	25,000	51,400	163,800	167,600	407,800	2,633,000
1949	18,000	39,700	168,300	172,400	398,400	2,708,000
1950	23,700	42,600	167,600	167,100	401,000	-[d]
1951	17,000	45,300	153,600	179,200	395,100	2,696,000
1952	24,300	43,100	121,400	178,200	367,000	2,696,000
1953	39,700	66,600	156,000	164,800	427,100	2,669,000
1954	47,700	67,200	200,500	181,100	496,500	2,669,000
1955	37,600	87,700	192,700	163,200	481,200	2,801,000
1956	34,000	82,600	219,000	166,300	501,900	2,801,000
1957	24,700	76,800	236,000	168,200	505,700	2,801,000
1958	10,900	55,500	216,200	152,400	435,000	2,801,000
1959	10,500	51,500	173,500	151,000	386,500	2,801,000

a. Calculated from State Board of Agriculture reports.
b. Tame and prairie used primarily for pasture purposes.
c. Sorghum silage not reported separately until 1943.
d. No pasture acreage report issued.

Table 38. Forage crop and pasture harvested acreage, Southeast Kansas Crop Reporting District, 1941-1959.[a]

Year	Crop: Sorghum forage	Crop: Sorghum silage	Crop: Alfalfa hay	Crop: Wild hay	Crop: Total four forage crops	Pasture[b]
	(acres)					
1941	108,200	-[c]	89,500	226,800	424,500	-[d]
1942	94,900	-[c]	106,600	238,000	439,500	2,384,000
1943	136,700	77,000	102,800	272,700	589,200	-[d]
1944	88,800	68,200	99,100	288,100	544,200	2,651,000
1945	112,900	52,200	100,300	250,300	515,700	-[d]
1946	121,700	69,200	102,600	260,100	553,600	2,636,000
1947	81,700	103,500	128,700	288,400	602,300	-[d]
1948	37,000	48,000	132,300	245,700	463,000	3,262,000
1949	33,900	49,700	133,000	258,500	475,100	3,305,000
1950	39,800	52,100	137,900	252,300	482,100	-[d]
1951	24,600	53,700	130,400	273,100	481,800	3,361,000
1952	31,900	51,500	121,300	265,700	470,400	3,361,000
1953	52,300	73,900	135,500	254,000	515,700	3,355,000
1954	109,400	73,300	177,300	268,900	628,900	3,355,000
1955	63,000	100,000	170,400	234,000	567,400	3,581,000
1956	61,200	84,900	153,400	212,900	512,400	3,581,000
1957	27,200	61,500	169,700	225,900	484,300	3,581,000
1958	14,400	55,600	141,200	209,500	420,700	3,581,000
1959	15,100	43,800	114,300	205,300	378,500	3,581,000

a. Calculated from State Board of Agriculture reports.
b. Tame and prairie used primarily for pasture purposes.
c. Sorghum silage not reported separately until 1943.
d. No pasture acreage report issued.

APPENDIX V

Historical Acreage Data, All Irrigated Crops

Table 39. Irrigated crops, acres and percent, northwest Kansas crop reporting district, 1954-1960.[a]

Year	Wheat		Corn		Grain sorghum		Forage sorghum		Alfalfa hay		Pasture		Miscellaneous[c]		Total acres
	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%	
1954	880	10.7	2,290	27.9	1,090	13.3	140	1.7	3,150	38.4	550	6.7	100	1.2	8,200
1955	1,880	11.2	4,720	28.1	3,820	22.7	-	-	4,960	29.5	-	-	1,430	8.5	16,810
1956	5,090	17.9	6,400	22.5	5,340	18.8	5,800	20.4	4,960	17.5	560	2.0	250	0.9	28,400
1957	6,340	16.5	8,530	22.2	8,640	22.5	-[b]	-	6,300	16.4	-[b]	-	8,640	22.5	38,450
1958	8,220	19.3	11,250	26.4	10,390	24.3	6,390	15.0	5,420	12.7	560	1.3	440	1.0	42,670
1959	8,270	17.6	13,490	28.7	11,690	24.9	6,600	14.0	5,750	12.2	730	1.6	450	1.0	46,980
1960	8,010	15.8	15,890	31.4	11,710	23.1	7,730	15.3	5,660	11.2	820	1.6	780	1.5	50,600

a. Calculated from county agents annual reports.
b. Forage sorghum and pasture included with miscellaneous.
c. Includes sugar beets, grass seed, fruit, vegetables, potatoes, and others

Table 40. Irrigated crops, acres and percent, west central Kansas crop reporting district, 1954-1960.[a]

Year	Wheat		Corn		Grain sorghum		Forage sorghum		Alfalfa hay		Pasture		Miscellaneous[c]		Total acres
	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%	
1954	19,500	30.2	4,630	7.2	28,720	44.5	610	0.9	9,130	14.1	-	-	2,010	3.1	64,600
1955	13,210	11.4	9,260	8.0	64,260	55.4	7,560	6.5	19,740	17.0	-	-	1,860	1.6	115,890
1956	22,060	15.7	7,970	5.7	55,900	39.8	32,650	23.3	17,540	12.5	1,240	0.9	2,930	2.1	140,290
1957	32,190	20.5	11,300	7.2	59,080	37.6	-[b]	-	10,980	7.0	-[b]	-	43,560	27.7	157,110
1958	39,590	24.5	11,260	7.0	58,610	36.2	24,280	15.0	17,880	11.1	310	0.2	9,760	6.0	161,690
1959	53,190	26.6	23,880	11.9	68,380	34.2	25,500	12.7	17,470	8.7	1,150	0.6	10,590	5.3	200,160
1960	58,430	27.5	28,900	13.6	70,890	33.4	26,090	12.3	16,120	7.6	640	0.3	11,030	5.2	212,100

a. Calculated from county agents annual reports.
b. Forage sorghum and pasture included with miscellaneous.
c. Includes sugar beets, grass seed, fruit, vegetables, potatoes, and others.

Table 41. Irrigated crops, acres and percent, southwest Kansas crop reporting district, 1954-1960.[a]

Year	Crop														Total acres
	Wheat		Corn		Grain sorghum		Forage sorghum		Alfalfa hay		Pasture		Miscel-laneous[c]		
	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%	
1954	56,260	20.6	270	0.1	134,250	49.2	18,820	6.9	53,050	19.5	4,160	1.5	5,770	2.1	272,580
1955	56,680	18.2	5,740	1.8	172,090	55.2	17,240	5.5	50,090	16.1	-	-	9,660	3.1	311,500
1956	94,410	23.2	2,280	0.6	209,660	51.6	29,360	7.2	52,130	12.8	3,200	0.8	15,660	3.8	406,700
1957	104,220	22.2	4,480	1.0	245,440	52.3	-[b]	-	64,270	13.7	-[b]	-	50,780	10.8	469,190
1958	129,490	26.9	8,640	1.8	233,760	48.5	48,070	10.0	47,540	9.9	3,250	0.7	11,030	2.3	481,780
1959	144,510	27.4	25,770	4.9	256,030	48.6	39,940	7.6	39,690	7.5	3,080	0.5	17,660	3.4	526,680
1960	144,150	27.6	44,430	8.5	220,530	42.3	48,200	9.3	25,700	4.9	2,600	0.5	35,220	6.8	520,830

a. Calculated from county agents annual reports.
b. Forage sorghum and pasture included with miscellaneous.
c. Includes sugar beets, grass seed, fruit, vegetables, potatoes and others.

Table 42. Irrigated crops, acres and percent, north central Kansas crop reporting district, 1954-1960.[a]

Year	Wheat		Corn		Grain sorghum		Forage sorghum		Alfalfa hay		Pasture		Miscellaneous[c]		Total acres
	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%	
1954	390	2.6	5,240	34.7	2,700	17.9	1,600	10.6	3,980	26.3	130	0.9	1,080	7.1	15,120
1955	660	2.9	8,030	35.5	4,740	21.0	2,330	10.3	6,440	28.5	-	-	400	1.8	22,600
1956	1,570	5.0	11,090	35.6	7,210	23.1	3,900	12.5	6,700	21.5	440	1.4	280	0.9	31,190
1957	1,380	3.4	15,510	37.7	10,330	25.1	-[b]	-	7,750	18.8	-[b]	-	6,150	15.0	41,120
1958	3,620	5.5	29,590	45.3	18,220	27.9	7,130	10.9	5,720	8.8	300	0.5	740	1.1	65,320
1959	2,930	3.3	48,110	54.4	16,060	18.2	10,090	11.4	8,500	9.6	1,130	1.3	1,660	1.9	88,480
1960	2,450	3.1	52,530	66.7	12,000	15.2	4,600	5.8	3,660	4.6	270	0.3	3,270	4.2	78,780

a. Calculated from county agents annual reports.
b. Forage sorghum and pasture included with miscellaneous.
c. Includes sugar beets, grass seed, fruit, vegetables, potatoes and others.

Table 43. Irrigated crops, acres and percent, central Kansas crop reporting district, 1954-1960.[a]

Year	Crop: Wheat		Corn		Grain sorghum		Forage sorghum		Alfalfa hay		Pasture		Miscellaneous[c]		Total acres
	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%	
1954	1,350	8.5	1,840	11.5	4,750	29.7	3,200	20.0	4,770	29.9	60	0.4	-	-	15,970
1955	1,050	5.3	5,680	28.4	4,940	24.7	2,080	10.4	5,820	29.1	-	-	430	2.2	20,000
1956	2,840	9.3	4,640	15.2	6,190	20.2	7,290	23.8	8,370	27.4	740	2.4	530	1.7	30,600
1957	3,820	9.3	6,320	15.3	11,580	28.1	-[b]	-	9,030	21.9	-[b]	-	10,440	25.4	41,190
1958	4,110	8.6	8,530	17.8	14,030	29.3	8,450	17.6	10,520	22.0	310	0.6	1,940	4.1	47,890
1959	2,290	4.9	10,100	21.4	15,000	31.9	10,620	22.6	7,310	15.5	830	1.8	940	2.0	47,090
1960	2,030	5.7	7,660	21.5	8,910	25.0	9,010	25.3	6,390	17.9	710	2.0	890	2.5	35,600

a. Calculated from county agents annual reports.
b. Forage sorghum and pasture included with miscellaneous.
c. Includes sugar beets, grass seed, fruit, vegetables, potatoes, and others.

Table 44. Irrigated crops, acres and percent, south central Kansas crop reporting district, 1954-1960.[a]

Year	Crop														Total acres
	Corn		Corn		Grain sorghum		Forage sorghum		Alfalfa hay		Pasture		Miscellaneous[c]		
	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%	
1954	2,830	12.1	-	-	5,430	23.2	880	3.8	12,680	54.2	1,680	2.9	900	3.8	23,400
1955	4,820	14.1	2,520	7.3	12,090	35.2	4,960	14.5	7,860	22.9	660	1.9	1,390	4.1	34,300
1956	8,830	15.6	2,550	4.5	10,720	19.0	15,210	26.9	15,540	27.5	1,930	3.4	1,660	2.9	56,440
1957	13,260	19.8	3,350	5.0	20,180	30.1	-[b]	-	13,690	20.4	-[b]	-	16,520	24.7	67,000
1958	9,900	14.3	5,320	7.7	21,300	30.7	14,790	21.3	13,190	19.0	1,800	2.6	2,990	4.3	69,290
1959	11,400	15.5	9,720	13.2	18,660	25.3	17,610	23.9	10,430	14.1	700	0.9	5,260	7.1	73,780
1960	13,910	17.6	9,050	11.5	18,270	23.1	16,430	20.8	16,680	21.1	950	1.2	3,710	4.7	79,000

a. Calculated from county agents annual reports.
b. Forage sorghum and pasture included with miscellaneous.
c. Includes sugar beets, grass seed, fruit, vegetables, potatoes, and others.

Table 45. Irrigated crops, acres and percent, northeast Kansas crop reporting district, 1954-1960.[a]

Year	Wheat		Corn		Grain sorghum		Forage sorghum		Alfalfa hay		Pasture		Miscellaneous[c]		Total acres
	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%	
1954	-	-	3,890	42.7	1,180	13.0	-	-	2,810	30.9	490	5.4	730	8.0	9,100
1955	2,160	12.8	5,490	32.5	2,880	17.0	-	-	4,700	27.8	530	3.1	1,140	6.7	16,900
1956	1,260	10.0	5,250	41.8	1,220	9.7	790	6.3	2,580	20.6	190	1.5	1,260	10.0	12,550
1957	240	4.1	1,700	29.1	1,100	18.8	-[b]	-	450	7.7	-[b]	-	2,360	40.3	5,850
1958	660	4.4	4,130	27.4	3,000	19.9	4,400	29.2	960	6.4	600	4.0	1,310	8.7	15,060
1959	1,220	7.7	5,410	34.3	3,340	21.2	2,320	14.7	2,320	14.7	100	0.6	1,060	6.7	15,770
1960	670	6.1	5,270	48.0	560	5.1	1,600	14.6	1,380	12.6	50	0.5	1,440	13.1	10,970

a. Calculated from county agents annual reports.
b. Forage sorghum and pasture included with miscellaneous.
c. Includes sugar beets, grass seed, fruit, vegetables, potatoes, and others.

Table 46. Irrigated crops, acres and percent, east central Kansas crop reporting district, 1954-1960.[a]

Year	Wheat		Corn		Grain sorghum		Forage sorghum		Alfalfa hay		Pasture		Miscel-laneous[c]		Total acres
	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%	
1954	-	-	1,560	25.6	1,720	28.2	150	2.5	2,150	35.2	210	3.4	310	5.1	6,100
1955	170	1.9	3,570	40.6	1,480	16.8	770	8.8	2,180	24.8	40	0.5	590	6.7	8,800
1956	530	4.5	4,650	39.6	1,210	10.3	1,160	9.9	3,420	29.1	140	1.2	640	5.4	11,750
1957	540	3.9	5,640	40.8	1,730	12.5	-[b]	-	3,720	26.9	-[b]	-	2,200	15.9	13,800
1958	430	3.0	6,300	44.7	1,820	12.9	1,110	7.9	3,450	24.5	240	1.7	750	5.3	14,100
1959	150	1.1	7,810	55.2	1,050	7.4	1,080	7.6	3,060	21.6	300	2.1	710	5.0	14,160
1960	140	1.0	9,450	65.7	920	6.4	940	6.5	1,840	12.8	320	2.2	780	5.4	14,390

a. Calculated from county agents annual reports.
b. Forage sorghum and pasture included with miscellaneous.
c. Includes sugar beets, grass seed, fruit, vegetables, potatoes, and others.

Table 47. Irrigated crops, acres and percent, southeast Kansas crop reporting district, 1954-1960.[a]

Year	Crop														Total acres
	Wheat		Corn		Grain sorghum		Forage sorghum		Alfalfa hay		Pasture		Miscel-laneous[c]		
	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%	
1954	100	3.4	420	14.5	90	3.1	60	2.1	1,420	49.0	100	3.4	710	24.5	2,900
1955	140	3.9	460	12.8	630	17.5	260	7.2	1,430	39.8	-	-	670	18.7	3,590
1956	340	5.2	1,320	20.0	970	14.7	350	5.3	3,120	47.3	210	3.2	280	4.2	6,590
1957	490	7.7	1,380	26.6	580	9.1	-[b]	-	2,230	34.8	-[b]	-	1,720	26.9	6,400
1958	290	5.1	1,510	26.4	700	12.2	1,120	19.5	1,790	31.2	220	3.8	100	1.7	5,730
1959	170	2.7	1,680	26.4	950	14.9	1,040	16.4	2,040	32.1	220	3.5	260	4.1	6,360
1960	280	4.2	1,330	19.9	1,570	23.5	1,210	18.1	1,530	22.9	160	2.4	610	9.1	6,690

a. Calculated from county agents annual reports.
b. Forage sorghum and pasture included with miscellaneous.
c. Includes sugar beets, grass seed, fruit, vegetables, potatoes, and others.

PROJECTIONS RELATING TO KANSAS LIVESTOCK FEED PRODUCTION, 1975

by

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AN ABSTRACT OF A THESIS

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A combination of increasing livestock feed production (particularly grain sorghums) in Kansas together with a rapidly increasing population and low per capita livestock production (especially swine) in the southwest area of the United States has recently created substantial interest within the Kansas livestock industry as to the capacity of Kansas agriculture to produce for and supply this southwest market, utilizing Kansas grown roughages and energy concentrates. Recent studies have indicated that Kansas farmers are in a favorable competitive position to supply beef and pork to this southwest area over the next fifteen years. Assuming these indications to be accurate, it then becomes relevant to consider the actual production potential of the Kansas livestock industry, utilizing feedstuffs produced within the state. Or, in other words, what is the 1975 Kansas livestock production potential in terms of feed grain and forage crop production within the state?

The problem involved in deriving an answer to the above stated question was conceived to be one of determining the independent X variables of a functional relationship: $Y = f(X_1, X_2, \ldots X_n)$ in which Y was defined as 1975 Kansas livestock feed production. Practically speaking, the X variables were defined as estimates of individual 1975 feed crop acreages and yields under both irrigated and dryland conditions. A synthetic type methodology was utilized involving the supplementation of quantitative data with qualitative evaluations in determination of final estimates. The 1975 production estimates were derived through the establishment of probable production models. Two projected crop yield levels were incorporated into these models. These yield projections were (1) "probable projected" yield, defined as that yield level which might, on the average, reasonably be obtained by farmers in any given crop reporting district in an average year, 1975, assuming a "normal" development of those factors affecting yields; and (2) an "optimum projected" yield, defined as that yield level which might, on the average, reasonably be obtained by farmers in any given crop reporting district in an average year, 1975, assuming an "optimum" development of those factors affecting crop yields. Acreage estimates utilized in deriving probable production models were based upon an assumption that crop acreage would remain at a defined "present" average level. Using these estimates of 1975 crop yield and acreage levels, the following production estimates of 1975 livestock feed production were established:

Model I - "Probable projected" yield and "present" acreage.

Model II - "Optimum projected" yield and "present" acreage.

In addition, a "present normal" level of production was established based upon conditions and assumptions comparable to those imposed upon the 1975 production models.

Empirically derived data was utilized as the basis upon which actual yield projections were established. A "probable present" yield was developed for each of the nine crop reporting districts based on Kansas State Board of Agriculture data. Linear trend-line projections of crop yields to 1975 based on State Board of Agriculture data for 1941-1959 were made. "Probable projected" and "optimum projected" 1975 crop yields were estimated at a series of meetings with crop scientists. These estimates were established as percentage increases over "probable present" yields for both dryland and irrigated production. In making the estimates consideration was given to past and current yield levels, apparent trends, previous projections, and the potential impact of those factors which were considered to be functionally related to potential increases in yields by 1975.

Factors affecting increases in crop yields by 1975 fall mainly into five categories. These are expansion in irrigation, wider and more intensive use of fertilizers, development of better varieties and hybrids through plant breeding, improvement in cultural practices, and more optimum management. It was tentatively suggested that acreage trends of the major field crops in Kansas up to 1975 will be largely governed by government programs, relative profitability, farmer preference, and crop adaptation.

Probable and optimum projected dryland yields were combined with "present" dryland crop acres (adjusted for irrigation expansion) to give dryland production figures. Probable and optimum projected irrigated yields were combined with estimated 1975 irrigated crop acres to give irrigated production figures. Combination of irrigation and dryland production gave probable livestock feed production models I and II. Converted to TDN the final estimates indicated that under Model I, 1975 production would exceed "present normal" production by 20 percent for feed grains, 42 percent for forage crops, 4 percent for pasture, and 10 percent for all others, with a total increase in TDN production of 20 percent. Similar figures for production under Model II show that with these conditions "present normal" production of TDN would be exceeded 44 percent in feed grains, 62 percent in forage crops, 21 percent in pasture production, and 10 percent for all others, with a 39 percent increase in total production of TDN.