Allocation of farm resources for economic production and utilization of pasture in the Bluegrass region of Kentucky

Ernest Joseph Nesius
Iowa State College

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ALLOCATION OF FARM RESOURCES FOR ECONOMIC PRODUCTION AND UTILIZATION OF PASTURE IN THE BLUEGRASS REGION OF KENTUCKY

by

Ernest Joseph Nesius

A Dissertation Submitted to the Graduate Faculty in Partial Fulfillment of The Requirements for the Degree of DOCTOR OF PHILOSOPHY

Major Subject: Agricultural Economics

Approved:

Signature was redacted for privacy.

In Charge of Major Work

Signature was redacted for privacy.

Head of Major Department

Signature was redacted for privacy.

Dean of Graduate College

Iowa State College

1950
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INTRODUCTION

A bibliography of all the information pertaining to the production, to the utilization, and to the place of pasture forage in farming systems would fill many volumes. In spite of the great mass of information there is much confusion and doubt with respect to the true physical and economic relationships of pasture forage to other forms of agricultural production. During recent years the pasture forage problems have been drawn into the limelight in scientific circles. Utilization of pasture, combinations of grasses and legumes to produce maximum output, conservation of soil resources, substitutability of green, fermented, and dried forage for concentrates, and many other important aspects all claim a high priority in the agricultural research programs, in the farm magazines, and the agricultural action programs.

The reasons for such a development are not difficult to understand:

1. The increase in output of food products per unit of farm resources due to technical and technological progress has been greater than the increase in demand. Therefore, the demand for agricultural products can be supplied from relatively fewer resources than was possible several decades ago.

This situation permits resources to be devoted to enterprises
that yield a relatively low energy return. Forage production, consumable only by livestock, is such a product. Consequently, agricultural leaders, conscious of surpluses, have pushed an expansion of grassland farming.

2. Depletion of the soil resources and widespread recognition of the complementary effect of some proportion of grasses and legumes on subsequent crops has focused attention on sod crops.

3. Full employment of the nation's human resources has increased the ability of rank and file consumers to purchase meat and meat products. This has resulted in a clearly marked shift in consumer demand away from the crop staples and toward livestock products. Favorable price ratios for the livestock products have made livestock production, which gets most of its sustenance from forage, profitable.
OBJECTIVES AND METHODOLOGY

With the great quantity of literature available on the subject of pasture forage production and utilization, it should be a relatively simple task to determine the economic aspects. Yet, anyone intimately acquainted with the problems will readily admit that the over-all task of fitting pasture production into the structure of individual farm organization is complicated and somewhat confusing. The objectives of the analysis are: (1) to clarify economic relationships of the production and utilization of pasture forage, especially as they relate to the Kentucky Bluegrass Region; (2) to formulate hypotheses and suggest appropriate tools of economic analysis for solutions to pasture problems; and (3) to test hypotheses whenever primary or secondary data are available.

To carry out the intent of the above objectives a comprehensive statement of the problem is necessary in terms of the magnitude of the gap between the ideal and actual system. The ideal may be apparent from knowledge of similar situations in a different environment, or it may be obvious once the problem has been defined. The latter is the case in this problem. After the problem has been defined and its magnitude explained it is next carefully decentralized into relevant
areas of study. For this study there are four such areas. The areas of study are next subdivided into the important elements and subelements. The elements and subelements may be considered as the causal factors that create the problem. Once the effects of these factors are understood theoretical optimums, models, and hypotheses are likely to be apparent. Models as used in this analysis are presumed to correspond, in a usable sense, to hypotheses. In the formulation of hypotheses and models, the writer will draw heavily upon the basic relationships of economic theory and the tools of analysis that are used to explain the theory.

Because of the absence of data to describe the physical relationships and because of the objective of examining the nature of the problems for each phase the analysis will stop, in most instances, at the hypothesis and model formulation stage. When data can be uncovered and submitted to analysis, more complete solutions will be suggested. The writer is hopeful that the orderly process of exploring the relationships and subrelationships with the presentation of hypotheses will provide adequate foundation for extending the area of pasture forage research in the future.

The approach to the problem is that of the entrepreneur; this contrasts with studying the broader and very important area of place and effect of expansion of pasture production on a nation's economy. The writer realises that pasture
production is only one segment of the farm production process, but the problems peculiar to its production and its relationships with other forms of agricultural production merit segregation for economic study.
THE PROBLEM

Forage may be offered to livestock in several forms. Alteration of the form is done either to preserve the nutrients or to shift the time of consumption to some period other than the actual period of production. While the forms of forage can be complete substitutes for each other they are not perfect substitutes (e.g., corn silage and field-cured hay). Forage, within certain physical limits, is also an imperfect substitute for concentrates in the rations of livestock. Once the physical limits are defined for each class of livestock, the optimum ratio is prescribed by equalizing the ratios of prices and the marginal rates of substitution.

As the entrepreneur views the task of allocating his resources, he is impressed with the complexity of choosing among the many possible resource combinations. He finds that the production and utilization of forage is a consideration in nearly every production process; he is made aware of the many forms in which he can provide forage for the livestock; he realizes that each forage type has its attendant need for production equipment and storage which may or may not be adaptable to other uses; he knows that production functions are neither linear or single valued; and he knows that his expectations have a high probability of error.
because of weather and price uncertainty. If his knowledge pertaining to these conditions were perfect, and product and factor prices were established with certainty at the outset of the production period, then the optimum allocation of resources would be greatly simplified. However, the actual case is a set of conditions contrary to the ideal ones enumerated above.

At this stage the overall problem for study can be stated:

What are the governing principles which the entrepreneur can use in determining the economic "optimum" in allocation of specific resources to the production and utilisation of pasture?

1. To maximise the stream of net revenues to the firm.
2. To stabilise income fluctuations.

From this problem statement one can readily conclude that this problem must be set in a dynamic framework.²

---

¹ The stream of net revenues is used to indicate that the firm desires to maximise the net revenues over time. The future may be thought of as composed of a number of periods of time (days, weeks, years, etc.,) and the firm wants to maximise the stream of surpluses occurring in the time periods.

² Dynamics in economic theory and as used here means that we are concerned with the time relationships of economic variables. In other words, economic quantities (inputs, outputs, outlays or revenues) must be dated. Static economics in contrast to dynamic economics is not concerned with dating the economic quantities. Definitions similar to the above can be found in: Hicks, J. R. Value and capital. 2d. Oxford, Clarendon Press, 1946, p. 115; Dilling, E. R. Economic analysis. New York, Harper & Brothers, 1948, p. 782; Samuelson, F. A. Foundations of economic analysis. Cambridge, Harvard University Press, 1948, p. 284.
However, certain production functions will be examined in static conditions in order to explore the problematic situation and to explain certain relationships. When time is a part of the analysis, economic allowances for maintaining productivity of the resources is automatic as long as maximizing the stream of net revenues is the objective. Stability conditions which involve minimizing annual income fluctuations are important to the entrepreneur because of his relatively fixed demand for income to meet living expenses and the safety measures employed due to fear of owned-borrowed equity relationships.

The Bluegrass Region of Kentucky is chosen as the farm economy in which hypotheses may be tested, either by actual data or by deductive and inductive reasoning. Here is a region where pastures have been the foundation for farming systems for more than 100 years. In later sections, wherein the type of agriculture is described and the historical analysis presented, the reason for choosing this region will be evident.

Division of the problem into four stages of study permits a systematic deduction of facts and the subsequent inductive process for final analysis. These stages are:
1. Historical analysis
2. The production of pasture forage
3. The utilization of pasture forage
4. The over-all production plan

Historical Analysis

Observation of the agriculture of the Bluegrass prompts one to inquire how such a system developed. What were the internal and external forces of the past that helped to shape the system of farming? What are the historical answers to questions relative to productivity maintenance in the long run? What sorts of technological knowledge was available to farmers before federal and state research agencies were established to study their problems? These questions are pertinent to the analysis of grassland systems. The answers provide a background of knowledge which serves to suggest hypotheses and to assist in deductive analysis of problematic situations.

Production of Pasture Forage

Production problems with respect to pasture forage are concerned with variability of yields, economic levels of output, and the relations of pasture forage to other crops. Contrary to the commonly accepted belief, securing high returns from pastures is not always accomplished by obtaining
except for use as pasture.

that certain soils or certain slope have no water runoff use portion of the land in pasture and for growing the deep rooting

sources have been one of the strong arguments for a higher pro-

Moreover, the value of pasture for conserving the soil re-

land area to secure maximum output and maximum net revenue.

to other crops are problems of crop combinations for a given

The competitive and complementarily relations of pasture

nary.

to prevented rotations from good authority will be increased

availability data for each nutrient are limited and the results

fermentative use of the cooperative agencies of production.

rations with the same management practices on different soil and slope classes.

the marginal value productivities must be determined by verifying

To find solutions to the economic levels of output.

require of reducing variability.

reached. The problem is to compare the marginal costs and

obtained. The efficiency of resources use is measured by-

This failure through the whole resource allocation back.

drew up and execute farm plans with a whole system of factors and between periods is important to cause improvements to

matter yield of pastures within pasture production periods

which yields productivity in the nutritive value and dry
Utilization of Pasture Forage

Pasture forage is considered as a product when analyzing production, but with livestock it is a factor. It differs from most of the other livestock feeds in that its only market is through livestock;¹ surpluses and deficits in supply for a constant livestock population cause problems; and, unlike other crops a market price is almost non-existent. These conditions cause difficulty with pasture forage in determining its economic range of substitutability for harvested forages and for grains by classes of livestock, especially when pasture production within years and between years is always changing. Added to this phase is the degree of tolerable short-time² shifts that the entrepreneur can make in the feed rations without materially affecting rate of production. Dairymen, for example, are hesitant to make any shifts that increase the probability that the daily rate of production will fall. They contend that to restore the rate of production after a drop in the daily output may

¹ Silage and in some instances hay, can be marketed only through livestock.

² Short time here is intended to imply shifts within a season or month as might be dictated by changing feed price ratios. (Implied is the assumption that supply and demand for the factors will be reflected in prices for the factors).
require weeks or even months. Producers of meat are also conscious of rate of daily gain, adhering closely to the hypotheses that the most rapid gains are the most profitable. Pasture utilisation problems are also closely related to quality of livestock product and consumer demand.

In the discussion of the problem of pasture forage production, reduction of variability within production periods and between periods was implied as desirable. In general this may be true, but there may be instances when the variation within periods may be more economically met by adjusting livestock numbers or by selection of certain types of livestock whose patterns of consumption are similar to the pasture production pattern. The cost of reducing variability as against the cost of alternative methods with corresponding returns needs to be appraised.

The Production Plan

The outline of the problem up to this point contemplates separation of the task of production of pasture forage from utilization. In this manner attention can be focused on the specific problems with greater clarity and singleness of purpose. To do this, certain assumptions will be necessary, which in the final\(^1\) production plan for the firm

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\(^1\) Final as used here is intended to mean that a decision is made for a line of action. In no sense, is it intended to mean the decision made is the final one for all time.
will be removed to permit each contributing force to have its effect in combination with the other forces in shaping the operative farm pattern. The tasks of the entrepreneur in making the over-all production plan are: (1) to choose the product combinations, (2) to apportion the resources to equalize their marginal productivities in all uses, (3) to select the production processes which result in the lowest and most elastic supply curve, and (4) to determine the optimum scale of production. These tasks are performed with some anticipation of the nature of the demand function for each product.

The variables most likely to be of strategic importance in making the foregoing choices are: (1) degree of uncertainty in expectations, (2) owned equity and willingness to bear risk, (3) opportunity for flexibility or prevalence of rigidities, and (4) time distribution of income. The problem for this analysis then is to determine the importance of these considerations in the formation of the production plan for the firm.
DESCRIPTION OF THE BLUEGRASS REGION

The limestone valleys of Pennsylvania, Virginia, North Carolina and Eastern Tennessee all trend toward the central basin of limestone soils lying between the Ohio and Tennessee Rivers. Geologically the limestone exposed in the Kentucky Bluegrass Region is the oldest.¹

The Bluegrass Region is circular in shape and includes an area of about 8,000 square miles. Figure 1 shows the type-of-farming regions of which the Bluegrass Region is number 3. It is bounded on the north by the Ohio River and on the east, south and west by the Knobs Region. In the center is a subregion of approximately 2,400 square miles, called the Inner Bluegrass (subregion 3c), which has undulating topography and is the most productive of the three subregions. In this subregion most of the race-horse farms are located, yet they occupy only a few of the larger tracts. The land commands high prices and most farms support substantial residences.

The area enclosing the Inner Bluegrass is the Intermediate Bluegrass (subregion 3b), geologically called the Eden Shale Belt. This subregion comprises portions of eighteen counties and includes about 2,500 square miles. It is

Fig. 1. Type-of-Farming Regions in Kentucky.
hilly with long ridges which are fairly narrow across the
top and the valleys are "V" shaped. The slopes are long and
range from twenty to thirty-five percent in steepness. This
area is distinctly inferior relative to the other two areas,
and there is a greater tendency toward farms of a subsis-
tence type.

Encircling the Eden Shale Belt is the Outer Bluegrass
(subregion 3a), or geologically the Maysville-Richmond Lime-
stone Belt, comprising about 3,000 square miles. The topo-
graphy is similar to the Inner Bluegrass, although it is more
rolling and not as productive. Large estates are fewer but
the type of agriculture is similar. The major difference is
a greater emphasis on dairying which is caused by the proxi-
mity to Cincinnati and Louisville markets.

The soils in all subregions are inherently productive.
The limestone-clay soils are naturally high in calcium and
phosphorous. The Haury soil type of the Inner Bluegrass is
so high in phosphorous that, in the words of Professor
George Roberts,¹ "It would make good fertilizer for the soils
low in phosphorous." The feature of high availability of
calcium and phosphorous makes the land a natural grassland
area.

¹ Prior to his retirement, Head of the Department of
Agronomy, University of Kentucky.
Most of the top soil in the Intermediate subregion has been washed away, consequently, much of the acreage has been semi-retired to locust thickets. Even in this area, the high phosphorous content extends to the subsoil and grass soon reclaims the land and, with a little encouragement, will provide excellent pasturage. The only severe erosion has occurred in the Outer and Inner subregions when the sloping land was cultivated and exposed to the annual forty-five inches of rainfall.

Comparison with Other Regions of Kentucky and Northern Boundary States

The feed and livestock position of the Bluegrass, relative to the other regions of Kentucky and to the sister states, Ohio, Indiana and Illinois, is shown by presentation of comparative maps of the livestock population and the livestock-feed production ratios.¹ Livestock population, in terms of tillable acres (land for crops and plowable pasture), is generally lower in Kentucky than the states that join on the north (Figure 2).² One is impressed with the low


² The use of tillable acres as a standard of measurement tends to over-emphasize the importance of livestock in the topographically rough areas. This is especially evident in the southern tier of Kentucky counties.
Fig. 2. Comparison of Animal Units on Farms for Kentucky, Ohio, Indiana, and Illinois.

Fig. 3. Comparison of Feed Units in Hay and Pasture Produced in 1942 per Animal Unit for Kentucky, Ohio, Indiana, and Illinois.
Fig. 4. Comparison of Feed Units in Grain Produced in 1942 per Animal Unit for Kentucky, Ohio, Indiana, and Illinois.

Fig. 5. Comparison of Gross Income from Farm Products Sold in 1944 for Kentucky, Ohio, Indiana, and Illinois.
livestock population of the Bluegrass Region relative to its productivity; this suggests underemployment of the land resources. Grain production was a minor enterprise while roughage production was a major enterprise (Figures 3 and 4). For 1944, cash income to the inner Bluegrass farmers compared favorably with the best areas in the states joined on the north (Figure 5). In fact, only three counties exceeded the four best counties of Kentucky. An excellent crop of tobacco in 1944 and the presence of wartime controls on corn and meat products combined to give the Kentucky counties

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Feed units for all feeds except plowable pasture were obtained from Jennings, R. D. Feed consumption by livestock 1910-1941. U. S. Dept. of Agri. Cir. 670. p. 11. A unit of feed is presumed to equal one pound of corn. Plowable pasture was assigned a constant value per acre for all counties. Such a procedure for pasture evaluation causes distortions, such as exaggerating the productivity of low-grade lands and underestimating the productivity of high-grade lands. Therefore, the true relative value of the Bluegrass Region is understated. The greatest value of these maps is in differentiating broad areas. Feed units used were as follows:

<table>
<thead>
<tr>
<th>Grain items</th>
<th>Relative value per pound</th>
<th>Forage items</th>
<th>Feed units per ton</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn</td>
<td>1.00</td>
<td>Hay, annual</td>
<td>1100</td>
</tr>
<tr>
<td></td>
<td></td>
<td>legumes</td>
<td></td>
</tr>
<tr>
<td>Wheat</td>
<td>1.09</td>
<td>Alfalfa</td>
<td>1200</td>
</tr>
<tr>
<td>Oats</td>
<td>.91</td>
<td>Sweet clover or red clover</td>
<td>1200</td>
</tr>
<tr>
<td>Barley</td>
<td>.97</td>
<td>Lespedeza</td>
<td>1200</td>
</tr>
<tr>
<td>Soybeans</td>
<td>1.64</td>
<td>Clover and timothy, mixed or alone</td>
<td>1020</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Small grain hay</td>
<td>960</td>
</tr>
<tr>
<td></td>
<td></td>
<td>All other tame hay</td>
<td>520</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Plowable pasture</td>
<td>1100</td>
</tr>
</tbody>
</table>

feed units per acre.
an advantage that they probably do not have at the present time.

Comparison within the Bluegrass Region

Farming in the Bluegrass is an example of an intensive-extensive type, with tobacco as the intensive enterprise, and the pasture-livestock combination accounting for the classification of extensive. Such a combination of enterprises has made possible continuance of many large farms since the land was settled and in the past years the pasture-livestock combination has had the effect of stabilizing income fluctuations when tobacco income was erratic.

In 1944 the sale of crops as a percentage of total cash income accounted for 63, 69 and 73 percent, respectively, for the Outer, Intermediate, and Inner subregions; nearly all of the income received from the sale of crops was provided by tobacco (Table 1, Appendix). 1 According to census classification, 80.4 percent of the farms in the Outer subregion were grouped as crop-speciality (Table 2, Appendix). Corresponding percentages for the Intermediate and Inner subregions were 73.3 and 65.9 percent, respectively. Tobacco on 4 percent of the land in the Outer subregion produced two-thirds.

1 During 1944 government price controls were in force and livestock prices were unfavorable relative to tobacco.
of the gross cash income. For the Intermediate and Inner sub-regions the ratios were; three to two-thirds and, six and one-half to three-fourths (Tables 1 and 3, Appendix).

Available data for 1948 on tobacco production revealed the reasons for farmers' allegiance to this farm commodity (Table 1).

Table 1. Yield Per Acre, Price and Farm Value Per Acre of Burley Tobacco for the Outer, Intermediate, and Inner Subregions. 1948.

<table>
<thead>
<tr>
<th>Subregions</th>
<th>Yield per acre</th>
<th>Price per pound</th>
<th>Farm Value per acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outer</td>
<td>1302</td>
<td>44.6</td>
<td>5583.30</td>
</tr>
<tr>
<td>Intermediate</td>
<td>1185</td>
<td>41.9</td>
<td>496.51</td>
</tr>
<tr>
<td>Inner</td>
<td>1593</td>
<td>47.6</td>
<td>758.26</td>
</tr>
</tbody>
</table>


Voluntary reduction of acreage and government price supports have kept tobacco production in a favored competitive position for more than a decade and a half. The writer knows many farmers who through judicious management and fertilization have been able to gross one thousand dollars per acre. Labor was the greatest cost chargeable against tobacco as three hundred to three hundred and fifty hours of man labor were required per acre. Machinery and housing costs were
nominal in comparison to returns. Thus, tobacco has been the
king of farm production and all other enterprises commanded
only secondary consideration.

Pasture in 1944 averaged nearly 62 percent of all farm
land in the Outer subregion; for the Intermediate and Inner
subregions it accounted for 71 and 62 percent, respectively
(Table 3, Appendix). Outer Bluegrass farmers were averse to
plowing the land as only about 12 percent of the farm land
was in corn and tobacco. Corresponding percentages for the
Intermediate and Inner subregions were 9 and 15 percent, re-
spectively. Aversion to plowing the land caused a restriction
on the hay acreage on most farms as it was the third year crop
after plowing. This restriction caused greater dependence on
pastures for roughage, and without adjusting pasture produc-
tion to seasonal needs more land was left to accumulate sur-
plus forage for consumption in off-pasture seasons. Thus,
underemployment of the land resources was a frequent occur-
rence.

The distribution of farms by size according to the 1945
census showed many small farms (Table 4, Appendix); for the
Outer subregion 38.7 percent were under 50 acres, and for the
Intermediate and Inner subregions 37.1 and 35.9 percent, re-
spectively, were as small. While a sizeable number owner-
operated small farms were found in these subregions, espe-

cially in the Inner area, the major cause for the large percentage
was the high proportion of tenancy. Among all farms 49 percent
were operated by tenants in the Outer subregion and 38 and 52 percent in the Intermediate and Inner subregions were tenant operated (Table 7, Appendix). The proportion of tenants operating whole farms (usual definition) was small.

In the Outer subregion two-thirds of all farms were less than 100 acres in size and controlled one-third of the land. On the other hand, in the Inner subregion 72.2 percent of all farms were under 100 acres but controlled only 22 percent of the land. One-fourth of all farms falling in the 100-500 size group controlled 53 percent of the land. Two percent of all farms were over 500 acres but controlled 25 percent of the land. These data depict the picture of large estates and many tenants.

Conversion of 1945 livestock numbers to animal units indicated a livestock population correlated with land productivity. The Intermediate subregion had approximately 9 acres of farm land for one animal unit while the Outer subregion had nearly 7 acres per animal unit and the Inner area had about 6 acres (Table 5, Appendix).1 Grain-consuming animal units accounted for only about one-sixth of the livestock

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1 The weights assigned to livestock numbers to secure animal units were obtained from: Roberts, J. E. Feed for Kentucky livestock. p. 9. They were: milk cows, 1.0; other cattle, .70; hogs, .30; sheep and lambs, .12; horses and mules, .95; and chickens, .019.
population. Milch cows predominated in the Outer subregion and other cattle (beef) in the Inner subregion. The livestock population in the Bluegrass was considerably less than in the northern states because of the absence of grain-consuming livestock.
DEVELOPMENT OF AGRICULTURE AND THE GRAZING SYSTEM IN THE KENTUCKY BLUEGRASS REGION

The Kentucky Bluegrass Region, rightfully earns its reputation for productive lands and for high incomes based on a system of grassland farming. But how did such a system develop? The region is now 175 years old (1950) and the soil is more productive than much of the land settled many years later. Is not such a condition linked with the amount of cultivation and the amount of land in grass? How did the system and method of agricultural production change over many years? What were the main influences which shaped the agricultural economy? How did farmers proceed to improve their methods, crops and livestock breeds despite the absence of experiment stations? To seek the answers to these questions this study of the development of agriculture and the grassland economy in the Bluegrass Region of Kentucky, was undertaken. The period from settlement to 1890 was selected in order to study agricultural development before the influence of experiment stations.¹

Settlement History

James Harrod and some companions attempted settlement in the Bluegrass Region in 1774 at Boiling Springs which is three miles east of the present town of Harrodsburg. However, the Kentucky Agricultural Experiment Station was established in 1885.

¹
the Indians threatened their lives and they returned to Virginia. Several years later Harrod returned to establish Harrodstown. In the meantime, Daniel Boone, as a representative of the Transylvania Company, completed the fort at Boonsborough. Soon other settlements were made at Bryan Station, Lexington, McClellan's Station (now Georgetown), Logan's Fort and McGary's Fort.¹

The Transylvania Company, organized by Judge Richard Henderson in 1775, was the first organization to offer Kentucky lands for sale to settlers. In 1776 Kentucky county, which included all of the present state, was established by the Virginia legislature. Two years later this same legislature legally annulled the title of the Transylvania Company.²

The method of land settlement which was known as the patent system, was governed by the mother state, Virginia. This patent system differed considerably from the federal land policy which began in 1790 after all the Kentucky lands had been appropriated.

All the lands were originally acquired by one of three kinds of rights.

1. Land grants, given as rewards for military services rendered in the Revolution, ranged from 100 to 15000 acres.


² Kinkead, E. S. A history of Kentucky. Cincinnati, American Book Co. 1896.
The size of the grant was determined by the official status of the recipient in military service. ¹

2. Four hundred acres were given to every person or family who had settled in the region before January 1, 1779. ²

3. Persons settling after 1779 acquired their land through treasury warrants which were secured at one of the Virginia land offices for a small fee.

The method of granting lands resulted in relatively few settlers on large tracts of land and the theory of landed aristocracy which Kentucky inherited from the mother state was easily practiced on these large estates. Herein was laid the basis for the institution of slavery. Because of the several methods of apportioning the lands many disputes arose over rightful ownership, resulting in the first land court to settle claims to be opened at Logan's Fort in 1779. By 1780 the land commissioners had passed on claims for a total of 3,500,000 acres. ³

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² Henning, W. C. The statutes at large: being a collection of all the laws of Virginia from the first session of the legislature in the year 1619. Vol. 10. Richmond, Va., George Cochran. 1822. p. 35-45.

The Bluegrass Region for many years had only the Wilderness Trail as its slender line of communication. The Trail tapped the densely populated regions of Virginia and North Carolina, whose emigrants had a major influence on Kentucky's early social and political development. The character of the first settlers, the rich soil, and the segregated position in the west combined to give the Bluegrass economy certain definite characteristics which were expressed in the individuality of the inhabitants.¹

Pioneer Agriculture

To the first settlers, agricultural pursuits of extent greater than necessary for maintaining life were of minor concern because of the depredations of Indians. Not until after the 20th of January, 1783, when hostilities ceased between United States and England, and after the Indians had been demoralized by George Rogers Clark, could the settlers be encouraged to build cabins outside the walls of their protecting forts.²

The types and kinds of vegetation, and trees growing on the land when the settlers constructed their cabins have been described by a number of writers. Describing the


Elkhorn lands in the Inner Bluegrass Region, Filson wrote:

Here is plenty of fine cane, on which the cattle feed and grow fat. This plant, in general, grows from three to twelve feet high, of a hard substance, with joints at eight or ten inches distance along the stalk, from which proceed leaves resembling those of a willow.¹ There are many cane brakes so thick and tall that it is difficult to pass through them, where no cane grows, there is abundance of wild rye, clover, and buffalo grass, covering vast tracts of country, and affording excellent food for cattle. The fields are covered with abundance of wild herbage not common to other countries; the Shawnee sallad, wild lettuce, and pepper grass, and many more, as yet unknown to the inhabitants, but which, no doubt, have excellent virtues.²

William Stickney said that the country surrounding Lexington (Kentucky) was covered with heavy timber under which a thick growth of cane was so intertwined with pea-vine as to be almost unpenetrable to man and beast.³

The soil as described by Samuel Brown was black and friable, but sometimes of a deep vermilion hue or the color of strong ashes.⁴ In the woods the earth was not encumbered

¹ The cane is described as an evergreen by Imlay, Gilbert. Topographical Description of the Western Territory of North America. 2d ed. London, J. Debrett. 1793. p. 45. It is described as having a leaf resembling Indian corn but not as long or as broad, by Stickney, William. An autobiography of Amos Kendall. Boston, Lee and Shepard. 1872. Amos Kendall was a pioneer in Kentucky and father-in-law to William Stickney.


³ Op cit., p. 112.

with the rubbish of fallen timbers or the trunks of partially decayed trees, as in the northern states. The trees did not in many places average more than twenty to an acre.¹ F. A. Michaux described the tree population as that found on the most fertile soils.² This included: the cherry tree, white walnut, buck-eye, white, black or blue ash, hackberry, slippery elm, black-jack oak, coffee tree, honey locust,³ and papaw. The richest land was described by the last three. Along the rivers where the banks were not steep he observed the over-cup white oak, sugar maple, beech, yellow and white poplar, and cucumber tree. All these trees, he observed, were ones which denoted "first rate land."⁴

¹ The observations about the density of the tree population in the original state are contradictory. Probably there were large areas of sparse tree population and others of a dense population.


³ The author must have meant black locust. Honey locust is not considered a good land tree.

⁴ Ibid., p. 230. Second rate land was identified by chestnut trees, red oak, black oak, sassafras, persimmon, sweet gum and gum trees. Third rate lands were commonly dry and mountainous and produced very little except black and red oaks, chestnut oaks, rocky oak pines and Virginia cedars.
Inlay was enthusiastic about the feeding value of the wild cane for livestock.

It is ... perhaps the most nourishing food for cattle upon earth. No other milk or butter has such flavor and richness as that produced from cows which feed upon cane. Horses which feed upon it work nearly as well as if they were fed upon corn....

That bluegrass was not a part of the natural vegetation was apparent from the description of the early travelers. Judge Samuel H. Wilson of Lexington did considerable research in an attempt to prove that Kentucky Bluegrass was indigenous to the region. Judge Wilson based his claim on testimony given in the land court in Lexington in 1806. Bluegrass was a type of vegetation rare enough to command the attention of a number of travelers as early as 1776. The testimony given in the court showed that it was observed on a tract in Montgomery County by Ebenezer Chorn in 1776, by a Mr. Harper in 1781, and a party of six men in 1779. The testimony of Mr. Moses Thomas, a member of the six-man party in 1779, had a significant observation: "We turned out our horses to feed on the bluegrass or English Grass which was the first we had


2 Wilson, Samuel H., Kentucky Bluegrass is native product, Lexington Herald, April 15, 1926. Also by same author, Kentucky Bluegrass - A brief for the State's most famous product (typed manuscript). Wilson Library, University of Kentucky, 1927.
seen in the country....

As settlement progressed domestic cattle were introduced in sufficient numbers to graze the cane so closely as to kill it and the pea-vine, leaving the forest without any undergrowth. The cane and vine were soon replaced by a thick and luxuriant growth of bluegrass. Brown observed in 1617 that the reed cane had almost disappeared; he continued:

But a still more valuable succedaneum has sprung up in its stead, so that the woods and commons in the best counties afford a rich and luxuriant pasture. This is a short, nutritious grass called 'nimble will' which has completely overlapped with astonishing celerity, almost every spot of waste or uncultivated ground. The inhabitants affirm that the range is now better for horses and cattle than it was when the country was in a state of nature.

Now the unbroken 'canebrakes' were prepared for agricultural use is described by James Finley in an autobiography of his father who settled in the spring of 1790 in Bourbon County on what was then called Cane Ridge.

We had to cut out roads before we could haul the logs to build our cabins. The cane was

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1 Higgins Heirs vs. Barnall's Devises. 1806. The original documents of the testimony are in the Wilson Library, University of Kentucky. The land in question is at the mouth of Grassy Nick Creek near Mt. Sterling in Montgomery County.


3 This is assured toseen bluegrass as Stickney, op. cit., p. 112, states that "The cane and vine were soon replaced by a thick and luxuriant growth of bluegrass."

4 Brown, Western gazetteer, p. 109.
so thick and tall that it was almost impossible for a horse or cow to pass through it. We first cut the cane and gathered it in piles to be burned. This was performed by a cane-hoe. The next thing was to plow which was done by first cutting the cane roots with a coulter, fastened to a stock of wood, which was called the blue-boar. This turned no furrow and hence it was necessary to follow it with the bar shear, which turned over the sod.\(^1\)

Wooded areas were cleared for cultivation and even larger areas were prepared for grazing purposes by 'belting' the trees to deaden them and to permit sunlight to reach the ground in order that vegetation could flourish.

Up to 1790 surplus grain and meat were sold to the emigrants.\(^2\) Indian corn, wheat and tobacco were of primary importance and soon the pressure of surpluses produced on the rich lands was cause for concern. Tobacco was the first object of culture for a foreign market. In June 1797 General James Wilkinson sold the first Kentucky 'produced' tobacco in New Orleans.\(^3\) This enterprising gentleman of doubtful character opened a market for this product by securing from

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2 Franklin Farmer. (Frankfort, Kentucky). July 4, 1838.  
the Spanish Governor, Miro, "permission to import on his own account to New Orleans, free of duty, all the productions of Kentucky."\(^1\) Almost immediately warehouses and collection points were located all along the Kentucky River for receiving tobacco and other produce of central Kentucky. Wilkinson sent more than $100,000 worth of Bluegrass produce to New Orleans in his boats during the four-year period, 1797-1791.\(^2\) Following the Pinckney Treaty of 1795, the Bluegrass farmers responded with even greater production.\(^3\) Within several years Wilkinson was shipping to New Orleans 1500 to 2000 hogsheads of tobacco annually.\(^5\) Soon products other than tobacco were floated down the river to market in spite of other but less important outlets; twenty-five pounds transported over the mountains were more costly than 1000 pounds sent down the river.\(^6\)

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\(^1\) Ibid., p. 22.


\(^3\) Staples, C. R. History of pioneer Lexington (Kentucky) 1799-1806. Lexington, Kentucky. Transylvania Press. 1939. p. 57. This author obtained most of his information from Lexington Gazette.

\(^4\) A hogshead contained about 1000 pounds of tobacco.


\(^6\) Kerr, op. cit., p. 500.
The transition from pioneer economy to a settled agriculture was described by Timothy Flint.

...in a few weeks they have reared a comfortable cabin, and other outbuildings. Pass this space in two years and you will see extensive fields of corn and wheat; a young and thrifty orchard,... Pass it in ten years, and the log buildings will have disappeared. The shrubs and forest trees will be gone. The Arcadian aspect of humble and retired abundance and comfort, will have given place to a brick house....

The Critical Period 1800-1830

The real crudeness of the first pioneer days and the depredations of the Indians were over before the end of the eighteenth century. Information about the wonders of the West filtered to the eastern seaboard and to the European continent. Consequently, by the nineteenth century and for two decades afterward, a constant flow of emigrants by way of the Wilderness Road and Limestone (Maysville) came to settle the land and develop enterprises.

The period 1800-1830 is segregated here for study because it was important in establishing the type of agriculture and because the period was one of growing prosperity that reached fantastic heights and then crashed to an unbelievable "low". Recovery was slow, but by 1830 the region resembled a

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Flint, Timothy. Recollections of the last ten years passed in occasional residences and journeys in the valley of the Mississippi (a series of letters to Rev. James Flint of Salem, Mass.). Boston, Cummings, Hilliard and Company. 1826.
strong and stable economy.

To study the region during this period, attention will be focused on: (1) settling the land and establishing farm units, (2) developing adaptable systems of farming, and (3) searching for market outlets.

Settling the land and establishing farm units

In 1802 Michaux observed that the land was well cultivated and the enclosures well constructed on the plantations surrounding Washington, Kentucky. He did not comment on the degree of settlement about Lexington. In 1808 or 1809 Fortescue Cuming noted that the country between Maysville and Washington was wonderfully abundant in grain, chiefly Indian corn. He observed that between Millersburg and Paris the good land showed very little improvement because of the uncertainty of land titles. About 1809 the Lexington Immigration Society made strong efforts to attract "industrious

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1 Michaux, F. A. Travels to the west of the Alleghany Mountains. p. 195. Washington is in the Outer Bluegrass Region, about four miles from Maysville on the old road from Maysville to Lexington.

farmers to locate on the lands in the vicinity of Lexington;  
it prepared and published pamphlets telling of the advantages  
and desirable features of the Bluegrass lands. ¹ Brown, who  
visited central Kentucky in 1797 and again in 1817 noted that  
in 1797 the best farmers were living in log cabins and wore  
hunting shirts and leggings and that a good farm could be  
purchased for five dollars per acre. By 1817 he noted that  
the log cabins were replaced by costly brick mansions, well  
painted and enclosed by fine yards indicating good taste and  
wealth. Whole farms had sold for as high as $100 per acre.²  

In 1818 Faux noted that the land along the road near  
Lexington was rich, cultivated, cleared and well settled.  
With the exception of the wooden worm fences, this country  
reminded him of the best districts in England, although the  
Kentucky soil was better.³ The cane had almost entirely dis-  
appeared but a luxuriant and nutritious grass had taken its  
place.⁴ Faux stated, "...here is the finest arable and

¹ Staples, C. E. History of pioneer Lexington 1799-1806.  
p. 133.

² Brown, Western gazetteer. p. 91

³ Faux, W. Memorable days in America, being journal of  
a tour to the United States. London, 1823. In Thwaites,  

pasture land in the known world, on which grass, the most luxuriant, is seen rotting for want of cattle. ¹ By 1818 many of the large farmers were wealthy and carried out the best traditions of their Virginia heritage. Elias P. Fordham described a wealthy Kentucky farmer as one with twenty or thirty slaves and 2000 or 3000 acres of land of which 500 were cleared and in cultivation.² Apparently settlement in the seven Inner Bluegrass counties³ was complete by 1820 because the population of 100,000 persons remained about the same level for the next thirty years.⁴ After the crash of prices in 1819 and the subsequent panic and until about 1827, improvements and progress were at a standstill. In fact, according to some writers, for a time the region was one of desolation.⁵

¹ Paux, op. cit., p. 190.


³ The seven Inner Bluegrass counties included Bourbon, Clark, Fayette, Jessamine, Harrison, Scott and Woodford counties.

⁴ U. S. Census 1800-1860 (2nd to 8th).

By 1830 the formative stage of society was past. Of the Inner Bluegrass counties, Hall had this to say:

There is something substantial, as well as elegant, in the residence of a farmer of this part of Kentucky;... The fields are extensive and well cultivated. Not a spot remains in its pristine state of wilderness.... Every foot of ground has been adorned or rendered productive. The woodland pastures which are peculiar to this section of the country are remarkably beautiful, giving to its extensive farms an unusual degree of elegance.... The woodlands are all enclosed; the underwood, and the useless trees are removed, while the valuable trees are left, standing sufficiently wide apart to admit the rays of sun, and the free circulation of air, between them. The ground is then sown in grass, ....

Wilson recognized the late thirties and early forties as the time when the agricultural life of the State reached large proportions.  

Developing adaptable systems of farming

During the period from 1830 to 1835 the basic foundation was laid for future farming systems. During this period the land had to be paid for and, in addition, the cost of clearing, the cost of improvements (buildings and fence), and the

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cost of living had to be met despite poor market outlets. The pressure of these requirements and the rich soil caused this region to produce surplus amounts almost from the very beginning. At the turn of the century wheat was the outstanding staple and continued as such until 1803, when low prices at New Orleans and the erratic opening and closing of the port at New Orleans caused the crop to diminish in importance. About this time the development of the "Kitefoot" light leaf tobacco and the clearing of the forests caused tobacco and whiskey to grow in importance.\(^1\) By 1810 hemp was the major staple which was valued at $690,622.\(^2\) Between 1810-1818 the money crops were hemp, wheat and tobacco. The years 1816 to 1819 were bad years for the farmers as they were beset with drought, hot spring weather, insects, and cold summers, which caused poor crops and difficulty in meeting obligations despite the high prices.\(^3\) After the crash of prices in 1819 the three staples diminished in importance.\(^4\)

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2. Hopkins, James F. The hemp industry in Kentucky. (Unpublished Doctorate Thesis) Duke University. 1948. p. 120.


Tobacco disappeared almost completely in all of the Inner Bluegrass counties and was reduced to minor importance in the "hill" counties. Depression prices and competition from the West Indies and several European countries were too discouraging to the Bluegrass farmer who had other opportunities. Wheat farming in the Bluegrass could no longer compete with similar farming along the Ohio River.\(^1\) Hemp was affected least by the panic but the low prices of $40 to $60 per ton in 1825\(^2\) caused it to lose its relative importance until the 1840's.

While hemp, tobacco, and at times wheat were commanding first importance, the way was being prepared for a new type of agriculture to substitute for the hemp-tobacco-wheat economy. Bluegrass, by 1818, covered the land not in cultivation or forest;\(^3\) the Wilderness Road was improved in 1815-16 for better transportation to the Carolinas and the Cotton South;\(^4\) steamboat traffic on the Ohio had attained significant

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proportions before 1820; the overland trade to the South and East had developed rapidly;\(^1\) and the quality of livestock was improved through importation of "blooded stock." Because of these developments, the region was ready, when forced from its staple crops, to change to a livestock economy. That the transition was painful is evident from the accounts of the economic distress and the migration of farmers from the region between 1820 and 1827.\(^2\) By 1825 the income from hogs probably exceeded the aggregate income from all other livestock. The hogs were fattened on corn and clover.\(^3\) Hides and cattle were also major enterprises. By 1831 the exports of the Bluegrass Region were estimated to be worth $2,750,000, of which hemp and hempen goods accounted for $759,000, being second only to livestock.\(^4\) Thus, with the spread of bluegrass over the region and expansion of corn and clover acreage livestock came into prominence.

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\(^3\) Stickles, op. cit., p. 75.

\(^4\) Hopkins, The hemp industry in Kentucky. p. 139
Farmers began soon after settlement to improve their cattle. In 1785, the sons of Matthew Patton, Sr., and a Mr. Gay brought some half-blooded "English" cattle to Jessamine County. 1 Matthew Patton, Sr., followed to Kentucky in 1790, bringing more of the same type cattle. 2 From this stock the famous "Patton stock" originated. 3 Col. Lewis Sanders in 1816 made the first direct importation of cattle into the bluegrass region. From this stock when inter-bred with the "Patton stock" came the famous "Seventeens" and the foundation of the Shorthorn breed in Kentucky. The Shorthorns which were the first important cattle to develop in the Bluegrass made a significant imprint on development of the Shorthorn breed in the United States. Their popularity was assured for most of the nineteenth century. The first importation of Hereford cattle was made by Henry Clay in 1817. Clay did not import any more, probably because of the popularity of the Shorthorns.

Apparently after the "Merino Mania" of 1810-16, sheep did not command any special attention for more than a decade.

1 The cattle were identified as English cattle without any reference to a particular breed. All that is known is that they represented two distinct types; locally, one was known as the milk breed and the other as the beef breed.

2 Franklin Farmer. February 9, 1839.

In 1829 Henry Clay imported fifty "full blooded" Spanish Merinos. Until this time and for several years afterward, farmers were interested mainly in the wool which determined the value of the sheep. About 1830 farmers were awakening to the potential value of bluegrass for producing mutton and the emphasis in sheep production began to shift from fine wool sheep to mutton types.

The American Jack stock had its origin in the importation of George Washington, Henry Clay and Messrs. Young and Everett. The latter and Henry Clay were from the Bluegrass Region. To Henry Clay, however, belongs the honor of having made the first important and valuable importation of Jack stock. In 1827, he imported the Maltese Jennet, Calypso, and in 1829, a Maltese Jack called Achilles. His most significant importation was Warrior, who was considered second to none, except Imp. Mammoth, in fashioning American stock. Mammoth, who was purchased by Messrs. Young and Everett, was imported about 1840 from Castileonia, Spain. When his blood was fused with the offsprings of the Clay stock, the resulting progeny laid the basis for Kentucky's prestige as a center of fine Jack stock.¹

No attempt will be made to explore the breeding and raising of horses for pleasure, except to note that it was an

important enterprises for the wealthier individuals in the region as early as 1787; in this year the first race track was laid out in Lexington. In 1817 Brown observed that the horse was the favorite animal of the Kentuckians and that every person of wealth had from ten to thirty of good size and condition, upon which they lavished their "corn with a wasteful profusion."  

Fitting crops into the farming system was easy because of the high yields obtained from the bluegrass lands. Yields of corn are generally reported to have been from 40 to 60 bushels per acre for the average year and 60 to 75 bushels in good years. Yields of 100 bushels were reported for the second and third years after clearing. Wheat yielded about 25 bushels per acre after corn, and 30 to 40 bushels on fallowed land. Usual yields from an acre for rye were 25 bushels, for barley 40 bushels, for oats 40 bushels, for potatoes 250 bushels, hemp 300 pounds, tobacco 2000 pounds, and for hay three tons.  

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1 Brown, Western gazetteer. p. 109.

2 Fallowing the land meant to plow the land ahead of the wheat which could not be done if the wheat followed corn. To get the higher yield a crop of oats (probably spring sown) was grown between the corn and wheat crop.

3 Yields for the various crops are found in Cuming, Sketches of a tour.... p. 175; Michaux, F. A. Travels. In Thwaites, Early western travels. 3. p. 237; Staples, History of pioneer Lexington. p. 133; Faux, Memorable days in America. In Thwaites, Early western travels. 11. p. 186.
Searching for market outlets

Marketing surplus produce was a real problem to the early settlers. The cost to transport bulky produce overland to the east was prohibitive and to transport by flatboat to New Orleans was not without many discouragements. In order to market the produce at a profit one of two requirements had to be met: (1) it had to be of high value relative to bulk, or (2) it could be driven to market. In the first instance, whiskey and ginseng qualified, and when prices were favorable processed commodities and manufactured articles could meet the high costs. To meet the second requirement, livestock was a "natural" — for in one animal could be marketed the production of three or four acres.

Outlets for livestock were developing by 1800 over the Wilderness Trail.¹ Michaux observed in 1802 that droves of fifteen, twenty, and thirty horses were driven over the Wilderness Trail and sold in South Carolina and other Southern states.² They were driven during the early part of the winter over the distance of 700 miles from Lexington to Charleston, S. C., in eighteen to twenty days. Dealers bought droves

¹ Through Crab Orchard to the Cumberland Gap and thence up the valley of Holston River in Virginia was the route of the Wilderness Trail.

of 200 to 300 lean horned-cattle and drove them along the Potomac River to Virginia, where they were sold to graziers to be fattened for the Baltimore and Philadelphia markets. Apparently at this time (1802) hogs were marketed down the river to New Orleans as Michaux does not mention the overland trade for hogs which developed at a later date.

Two kinds of trade comprised Kentucky's overland traffic — livestock and wagon trade. The livestock trade was the first to begin and the last to cease. In 1805 George Renick of Southern Ohio drove the first cattle from west of the Alleghany Mountains to Baltimore; as a marketing venture the operation was a complete success. In 1808 or 1809 Cuming, travelling in Ohio, chanced across a Mr. Johnston from Lexington, who was driving 130 cows and oxen to Baltimore. McElroy said that by 1812 Kentucky was sending 500,000 hogs annually over the mountains, and that the trade by water was proportionally large. The size of the

1 Farr, Elizabeth. Kentucky's overland trade with the ante-bellum South. Op cit., p. 75.
3 Cuming, Sketches of a tour..... p. 206.
4 McElroy, R. M. Kentucky in the nation's history. p. 379.
hogs shipments was tremendous in terms of the agricultural system of the era. Because of this size and because of the failure of other writers to recognize an enterprise of such scale, it is doubtful that the number was correct.

By 1817 Brown observed that great numbers of cattle were bought to be driven to the Baltimore and Philadelphia markets, and that large droves of cattle were bought annually to supply the new territories.\(^1\) By implication the cattle were at this time fattened in the region as contrasted with Michaux's observation in 1802 that they were bought in Kentucky and fattened in Virginia.

To reach markets in Philadelphia and Baltimore, the drovers followed a road connected with the "Wilderness Road" that went up the Holston River and thence through West Virginia and Maryland to Philadelphia. From the Virginia Road a branch lead to Richmond where Kentucky stock could be marketed. Besides these markets, Kentucky had, by 1814, found demand for her produce in the Carolinas. At a later date her produce was sent to Georgia, Alabama, Mississippi, and Florida. The Natchez Trace was another important overland route to the South. Its northern link extended from Maysville, Kentucky, to Nashville, Tennessee.\(^2\) Over this

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\(^1\) Brown, Western gazetteer, pp. 95, and 109.

\(^2\) Farr, Kentucky overland trade, p. 72.
route the wagon trade reaches its greatest development.

When the Spanish officials closed the port at New Orleans in October 1802, Kentucky producers were ready to resort to war to have it reopened.\(^1\) A. B. Hulbert believed that the pressure of the surplus produce in the Blue-grass Region under the unstable and annoying rule of the Spanish was the most important single reason in compelling the United States to purchase Louisiana.\(^2\)

The first steamboat to travel down the Ohio River to New Orleans was the "New Orleans" in 1811. Apparently the first successful upstream trip was accomplished by the "Washington" in 1817.\(^3\) The effect of the steamboat was tremendous; the cost of transportation on the river was reduced two-thirds and the trip down the river reduced to six or seven days.\(^4\) When the market prices began to decline

\(^1\) The port was reopened in May of 1803.


\(^3\) Merrick, C. B., and Tibbals, W. R. Genesis of steamboating on western rivers, Proceedings State Historical Society of Wisconsin, 1911. p. 97-151. Kerr, History of Kentucky, 2. p. 721, says that the "Enterprise" was the first steamboat up the river to Louisville.

after the prosperous period which followed the War of 1812, the Kentuckians became enthusiastic over the possibilities of extending commerce on the river to bolster their economic structure. Governor Slaughter in 1812 believed that the steamboats would give a "new spring to the agriculture and commerce of the western country."\(^1\) By 1819 more than 40 steamboats were plying between Louisville and New Orleans.\(^2\)

As we survey the events of the thirty-year period (1800-1830), two developments, outside the control of the farmers in the region, were of greatest importance in shaping the farming patterns for that time. They were: the War of 1812 with its disastrous after-effects; and, the development of the Cotton South as a market for flour, pork, mules, hemp, and other products of lesser importance. These two developments acted together to make some farmers quite wealthy and to ruin others and to change the system of farming from an economy based on hemp, tobacco, and wheat to one dependent on livestock and hemp. Hogs, which were replaced by cattle in a later period, provided most of the livestock income before 1830.

The Grazing System 1830-1890

The Bluegrass Region recovered rapidly, in the period

\(^1\) Kerr, History of Kentucky. p. 722.

\(^2\) Stickles, op. cit., p. 6.
1827-1830, from the paralyzing panic of 1819, and by 1830 it had the semblance of a settled state. The system of farming changed, during the decade prior to 1830, from reliance chiefly on cash crops to major dependence on livestock. For the next sixty years the emphasis was on the "grazing system" and the related enterprises.

Overall view of the Bluegrass economy

Income data of varied degree of completeness are available to indicate the main income sources to the Bluegrass in the thirties. Reports for the number of livestock passing over Cumberland Ford and through the Cumberland Gap are available for most of the years from 1825 to 1842¹ (Appendix Table 6).

Mr. Fred Becton of Wilkinson's Cross Roads, Tennessee, reported that Mr. S. O. Martin of Clarke County told him: "In ten miles square of that county in the year 1834, the cattle exported and sold returned to the raisers $165,300 besides $68,000 more for hogs, and the hemp, mule and horse sales too."² Some notion of the farming system and its profit in 1835 and 1836 was indicated in a letter from a

¹ Reports from both locations are comparable as nearly all the stock passing over the Cumberland Ford also went through the Cumberland Gap.

² Franklin Farmer. December 2, 1837.
Mr. Jacob Hughes of Fayette County. He reported that on his farm of 1800-1900 acres he cultivated 200 acres of corn, harvested 100 acres of wheat and rye, had 20 acres in meadow, and kept the rest in pasture. He grazed and fed 300 head of purchased cattle and raised and sold 200 hogs. These farm operations required ten laborers. His profit in 1835 was $9,945 and in 1836, $10,475. Another source stated that exports from Bourbon County for 1835 were 10,000 head of fat cattle, 40,000 fat hogs, 3,000 horses and mules, whiskey worth $70,000, bacon and lard worth $50,000, and various hemp products. General James Garrard made a personal inquiry concerning 84 farms in Bourbon County for the period September 1, 1837, to June 1, 1838, and found that cattle accounted for $76,000, hogs for $65,000, horses and mules for $23,000, and hemp and livestock of various kinds for $136,000.

For the year 1838 General R. B. Mcafee in a letter to the president of the State Agricultural Society reported that the estimated total exports for Anderson, Mercer, Jessamine and Garrard Counties amounted to $215,100 for horses and mules, $236,000 for hogs, $182,500 for beef and $102,500 for hemp. No doubt wheat and tobacco were grown but were not important

1 Franklin Farmer. September 23, 1837.

2 Gray, History of southern agriculture. 2. p. 877.

3 Franklin Farmer. January 5, 1839.
enough to mention in the reports.

It is difficult to draw any conclusion from the above reports as to the single predominant source of income in the 1830's. Probably cattle were first on a regional basis with horses, mules, and hogs almost as important. The rapid expansion of the heavy cattle enterprise in the thirties probably resulted from a growing demand for beef and the spreading of bluegrass over the region. Income from horses and mules, one of the foremost sources up to the Civil War, probably exceeded hogs and cattle in some years between 1830 and 1840. Hemp, a staple grown in the Bluegrass Region from the time the first settlers turned the soil, was grown in earnest in the late thirties. When the prices for hemp held up longer than livestock and other crops, following the panic of 1837, interest in hemp replaced much of the "Short-Horn fever". The peak of hemp production in the nineteenth century was reached about 1850. Although hemp was the main source of income on many Bluegrass farms, it never became the major source for the entire Bluegrass Region because of the

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2 Hopkins, The hemp industry in Kentucky. p. 95a.
restricted area in which it could be grown. Hogs, however, were a major source of income in the twenties and continued as such up to the Civil War in all of the Bluegrass counties. Kentucky ranked second in the nation in hog production in 1840 and 1850.

The Cotton South was a ready market for necessities to supply her plantations. The mule was associated with the slave and was as necessary as the slave; the hog was indispensable for feeding the slaves and the plantation owner's family; the horse provided enjoyment and a means of transportation to the plantation owner and his family and hemp was necessary for bagging and cordage to enclose the bales of cotton. All these commodities were available from the farmers of the Bluegrass Region and they directed their efforts to supply the demand. The wealth brought to the region from the sale of the Bluegrass production is probably the principal reason for the widespread interest during the thirty years prior to the Civil War in improvement of the livestock breeds, primarily Shorthorn cattle. Coinciding with the interest in Shorthorns was an intense desire to employ so-called "scientific methods" in all forms of agricultural production. The wealth of the farmers was indicated by the prices that farmers paid for "blooded stock." As indicated by the statistics of the census and other sources, the late thirties probably were the most prosperous years of the entire nineteenth century.
In the ten-year period following the Civil War, production of all the main agricultural commodities, except hemp, in the seven Inner Bluegrass counties dropped tremendously (Appendix Tables 9 and 10). Numbers of horses and mules dropped 39 percent from 1860 to 1870; all cattle declined 12 percent, sheep 45 percent, and swine 45 percent. Wheat production dropped 64 percent, and corn production decreased 30 percent. Hemp production increased 5 percent. No doubt, the freedom for the negro worker, the confusion of a divided populace, the reduction in the Southern trade, and the decline of prices combined to cause the greatest set-back the agriculture of the region had received since settlement.1

From 1864 to 1876 the trend in general prices was downward, excepting a four-year period of good prices from 1860 to 1863. Consequently, Bluegrass farmers experienced many difficulties in attempting to re-establish their livestock interests and to recover from the effects of the Civil War.

A singular event, the discovery of White Burley tobacco, which occurred in 1868 was destined to completely change the type of agriculture in the Bluegrass. In 1872 Spaulding and

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1 Slaves, according to the Census of 1860 accounted for slightly more than 40 percent of the total population in the seven Inner Bluegrass counties.
Merrick of Chicago successfully established a brand of cut tobacco from this new type that had been rejected earlier by manufacturers. This caused White Burley leaf to bring double and sometimes quadruple the prices paid for leaf produced in other regions. The lower costs to produce this higher priced product resulted in an income that was two to three times as great as from any other type of tobacco. By 1880 the White Burley variety had replaced every other variety in the Bluegrass.\(^1\) The importance of this tobacco on the Bluegrass economy is shown by the census data for the years prior to and after 1870 (Appendix Tables 9 and 10). From 1840 through 1870 tobacco production for the seven Inner Bluegrass counties ranged from 167,862 pounds in 1850 to 325,824 pounds in 1870. By 1880 production had increased to 1,399,882 pounds. Proportionally this was still a minor enterprise. By 1890, production was increased to 23,756,139 pounds. Again the Kentuckians of the Bluegrass had a main cash crop, which they have always wanted in preference to greater diversification.

**Early agricultural improvement**

Writers from other states recognized the superior type of livestock raised in Kentucky in the 1850's. The editor of

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the "Ohio Farmer" wrote in reference to the State Fair, 1957:
"...for Durham Cattle, we will risk Kentucky against all the
world. ...we have no doubt the show surpassed the recent
Royal Show at Chelmsford or any that England can make. In
short, Kentucky beats England in Shorthorn Cattle." Mr.
S. P. Chapmam writing in the "Rural New Yorker" said: "The
show of Shorthorns was probably the best exhibition ever
made in the world. I never saw anything like its equal, and
several persons who have attended the English shows assure
me that they never saw it equalled in that country."¹

These accounts express quite clearly the deep feeling
held by the Bluegrass farmers for improvement of the farm
production which gave pride and dignity to the agricultural
profession. One writer in 1843 said that men should no
longer be "educated for amusement or mere intellectual im-
provement."² Another said, "Science is what is wanted first
and then art and taste will come as handmaids."³ Another
writer summarized the seven great improvements for which
farmers were indebted to modern science.

¹ State Agricultural Society. Report to the Legislature
² Diller Farmer, Louisville, Kentucky. February, 1843.
³ Franklin Farmer, August 12, 1837.
1. "A correct knowledge of the nature and properties of manures, mineral, animal and vegetable; the best modes of applying them and the particular crops for which particular manures are best suited."

2. "The method of using all manures of animal or vegetable origin while fresh...."

3. "The knowledge and means of chemically analyzing soils, by which we can ascertain their constituent parts...."

4. "The introduction of the root husbandry...." (a source of feed for livestock whereby a given acre will produce the most "nutritive matter.""

5. "Laying down lands to grass, either for pasture or mowing, with a greater variety of grasses, and with kinds adapted to a greater variety of soils...."

6. "Substitution of fallow crops (fall seeded small grain) for naked fallow."

7. "The art of breeding the best animals and best vegetables,..."

In 1878, one enthusiastic person wrote, "Pedigrees are the textbook of the stock man and 'horse talk', 'cattle talk', and 'hog and sheep talk', are accomplishments that are so universal that no man can be considered well posted or finely educated who is deficient in this great and elegant attainment." 

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1 Franklin Farmer, October 7, 1877.

Development of the grazing system

As has been previously pointed out, the Bluegrass Region was well settled and prosperous in the thirties. Bluegrass was established on the cleared but non-cultivated land; and a ready market existed for livestock and livestock products in the South and East, but a market for corn had not been developed except for making whiskey and for feeding livestock. The cultivation of corn and following the land for wheat, rye, and oats, resulted in the loss of the virgin fertility, leaving an exhausted and often eroded soil. Because of these conditions and the adaptability of the land to bluegrass, the grazing system was developed; it was a system which called for full use of the available land for productive purposes by emphasizing the "setting" of woodlands in bluegrass for pasture and the rotation of crops on the open land. The systematic crop rotation which came into prominence about this time contributed to the conservation of soil fertility and restoration of the productivity of the exhausted or worn out lands. Such a system that involved grasses and legumes naturally brought livestock production to the forefront. The grazing system was characterized as: establishing and using a systematic rotation of crops; and, adapting the livestock systems to the feed-crop production. The sentiment of the time, expressed by a central Kentuckian in 1838, has been re-echoed by many current writers. "...the
time will come when two blades of grass will be made to grow where only one is now found.\textsuperscript{1} The grazing system and its connection with livestock in 1837 was appraised by one writer in the following manner:

But our grazing system, is in fact, the very best of all systems of manuring; and the means by which we have effected and sustained such wonderful improvement in the breed of our livestock, have contributed more than any other, to the preservation and improvement of our soil. ...it is not surprising that grazing lands, maintain such enormous prices; for their intrinsic value is appreciable by a two fold ratio.\textsuperscript{2}

The writer was emphasizing the idea that grass fattens livestock and livestock improve the soil. A gentleman who farmed in the Green River section expressed his view to the editor of the "Franklin Farmer" by saying, "...that he scarcely ever read a number of the paper, without throwing it down in a rage at his own folly in cultivating tobacco instead of grass and corn."\textsuperscript{3} The editor observed that where tobacco was grown, land became poorer and poorer. To the tobacco farmers he gave the following advice: "Every farmer who adopts the grazing system...doubles his income...." This

\begin{itemize}
  \item \textsuperscript{1} Franklin Farmer. April 28, 1836.
  \item \textsuperscript{2} Franklin Farmer. December 2, 1837.
  \item \textsuperscript{3} Franklin Farmer. May 19, 1838.
\end{itemize}
editor attempted to discourage the farmers who distilled
t heir rye and corn into whiskey. In communities where farmers
followed this practice, corn was grown continuously on the
same land; woodland enclosures, grass, cattle, sheep and
mules were absent and the ultimate consequence was impover-
ished soil. Bourbon County was cited as an example, where
the farmers had discontinued the distillation of grain, and
changed to the grazing system with the result that land had
tripled in price and the worth of an hour's labor doubled
what it had been under the corn system.

Enthusiasm for the grazing system was still dominant
in the minds of the Bluegrass farmers in the late fifties.
Grass was recognized as the "proper basis of agriculture" in
all of the highly developed and prosperous regions of the
middle latitudes. Moreover, where grass was the basis of
the farming systems, less labor was necessary; livestock pro-
duction of every description was possible; and, soil improve-
ment was the usual case because grass was the only crop that
improved the soil and at the same time produced abundant
value. If land, too steep to be cultivated, was "well set"
in grass it would be nearly as profitable as that which was

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1 Breckinridge, R. J. On crops or staples of any kind. In. Kentucky State Agricultural Society. Report to the
well cultivated by manual labor. Colonel Scott in a letter to the editor was particularly strong in his remarks.

There is no good farming without an abundance of grass, as it is at once the manure of his soil and the subsistence of his stock. Old fields, which are exhausted by a long continued and murderous cultivation, should be sowed with grass seed, instead of merely thrown out, and naked to be scorched by the suns of summer, and washed away by the rains of winter. The man who pursues such a ruinous agriculture is but little better than he who murders his own mother in the flesh, and leaves her dead body exposed to the wrath of the elements and the beasts and birds of the fields. One kills the mother who bore him, and the other the mother who fed and clothed him.

According to Colonel Todd, the method of converting woodlands into productive pastures was brought to the region about 1800 by emigrants from the south branch of the Potomac who settled between Paris and Winchester. Two methods were recommended by Colonel Todd for establishing woodland pasture: (1) cut out the firewood and undergrowth and sow the grass seed in the early winter and trample the land with livestock until the middle of February; (2) belt the trees

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2 Kentucky Farmer. Frankfort, Ky. March 1859. Col. W. S. Scott was a prominent farmer in Franklin County.

3 Franklin Farmer. May 12, 1838. Col. Todd was a prominent farmer in Fayette County.
sometime in the summer preceding the seeding of grasses. The latter method permitted plenty of sunlight which was one of the first requirements of a good woodland pasture and as the deadened trees rotted and fell to the ground they could be used for firewood. Burning of the leaves was discouraged. Otherwise the second method was like the first. The preferred grasses were bluegrass and orchard grass. Woodland pastures were expected to yield an annual profit of about three dollars per acre, which was about half as much as expected from open pasture.

Apparentely cleared land was not seeded to remain in pasture for more than five years unless it was newly cleared or worn out land. In that case, the process was to seed small grain (wheat, barley, or rye) in the fall, and to scatter the timothy, orchard grass, clover, and bluegrass seed on the frozen land, and to trample it with livestock until February 15 to get the seed in the soil.

To have pasture forage available for winter, summer,

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1 Beltling was a method of deadening the trees by cutting the cambium layer.


3 One reason that farmers hesitated to belt their trees was the fear of running out of firewood.
and fall, after the bluegrass growth had stopped was accomplished by refraining from pasturing one or more of the fields from June to November, thus, a surplus of pasture forage was left to accumulate on the land. Justification for this method is provided by Breckinridge:

Bluegrass not grazed after June, will support nearly as much stock the following winter, as it would have done if grazed on till winter feeding commenced. 1

Isaac Cunningham, "The patriarch of graziers," wintered 700 cattle on bluegrass alone until March when they were fed some fodder. 2 A grazing system to include a long pasture season was logical because before 1890 the farmers of the seven Inner Bluegrass counties did not harvest much hay. The idea of periodic grazing which gained prominence in the Hohenheim system as developed in Germany during World War I was expressed at a much earlier date in a letter to the Franklin Farmer:

It is the practice, we believe, of most graziers, to put upon a given pasture, as much stock as it will maintain, without shifting them during the season, as, besides saving labor it renders the cattle more quiet and contented. Other, however, fence off their pastures into separate divisions, to undergo a regular succession of periodical grazings. This plan secures a constant

1 Breckinridge, On crops or staples of any kind. p. 98.

2 Franklin Farmer. May 26, 1838.
supply of fresh grass, very tasteful to the animals and it is believed to be more economical, as much less is trampled and rejected by the cattle. 1

Farmers were conscious of their lands "wearing out"; this is evidenced by the writings of leading farmers in the early issues of the "Franklin Farmer". 2 No doubt this problem had been obvious many years before. Writers chided the farmers for cultivating too much corn and for general mistreatment of their land which caused it to wear out. One writer called it "murderous cultivation"; another called it "...a sin against ourselves, our neighbors, our posterity and especially against our mother earth...." 3 Various methods of restoring soil productivity were suggested for the Bluegrass Region. Seeding red clover, rotating crops, and leaving the land in grass for several years were the most popular devices. 4 Others suggested broadcasting two bushels

1 Franklin Farmer. April 7, 1835.
3 Franklin Farmer. October 21, 1837.
4 Franklin Farmer. July 7, 1838, September 9, 1837, Beatty, Southern agriculture. p. 82.
of corn per acre in the spring and plowing it under as green forage in August. ¹ Another plan was to sow the land in buckwheat and to plow it under, adding manure, lime and ashes.² The use of stable manure was barely mentioned before 1860; it was not considered necessary, because clover in four or five years would restore the virgin fertility.³

The writers who referred to the evils of corn culture did not believe that the total quantity of corn (bushels) harvested should be reduced. They insisted that the same quantity could be produced on half as many acres by a "merciful rotation of crops and grasses", deeper ploughing, and wider use of barnyard manure.⁴

The corn-grass economy, called the grazing system, is explained in a letter to the editor of the "Franklin Farmer" in defense of corn in a controversy between having root crops or corn in the rotation. The writer argued that six to eight

¹ Dollar Farmer. October 1843.
² Franklin Farmer. June 12, 1839.
⁴ Franklin Farmer. March 24, 1838, May 12, 1838.
laborers could produce enough corn in the summer, while the livestock were on grass, to fatten 100 beef cattle during the winter; the same laborers could attend to all the farm operations in the winter. He climaxd his argument for corn with this statement:

Away then with the Ruta Saga, Mangel Wurtzel, etc., it will do for countries where corn cannot be raised and labor is cheap; corn and grass for us; not only for cattle, but for horses, mules and hogs. 1

The logic of the leading agriculturists can be summarized in reviewing the suggested cropping systems of two able writers, Publius Agricola 2 and Adam Beatty. Publius Agricola assumed a 100 acre farm on which he suggested a rotation for improving crop yields. His plan proposed one field of 20 acres in woodland pasture, and four open fields of 20 acres each to be used in the following way. In one field he suggested corn, plus root crops to the extent that labor was available and in another 20 acres he would sow winter small grain (sown in the fall on the land after cultivated crops were harvested). The third field of 20 acres was to be sown in grass for the scythe, sowing and grazing, in a proportion that kept the most livestock for the number

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1 Franklin Farmer. December 16, 1837.

2 A pseudonymous writer, who contributed many worthwhile articles to the leading farm papers.
For the three rotations we fixed to grow the following crops in corn, the approved method
paring the soil for planting in corn, the heavy plowage, and the
and the problem of planting the heavy plowage and the

Before farming too late were sufficiently developed.Temperature

devoted to hay

as the crop to maintain fertility, and (2) the soil nutritious
population of these two winter crops.Five winters standing out in the
harvesting of the soil then corn, two winters standing out in the

observed to wheaten corn, over the land it was more or

were to become a part of the three-year rotation. If the legume
were to be used as the deep tillage and the deep tillage then
rotation on the three ridges (six years) the best yield of
year rotation of corn, field and clover. After two rounds of

years? the other three ridges were to be used in a three
one third was to be planted to keep for the consecutive

seed and corn seed. In the second season 5 acres for seed, garden vegetables, keep
for woodshed, 25 acres corn, 15 acres for corn. The remaining 15 acres

was needed a 300 acre farm and supplied 75 acres

of wheat or rye and 1/4 tone of hay.

of wheat or rye and 1/4 tone of hay.
1

of wheat or rye and 1/4 tone of hay.

of wheat or rye and 1/4 tone of hay.

of wheat or rye and 1/4 tone of hay.
deep to turn over the sod; second, to follow with the second
plow in the same furrow throwing the "mould" on top of the
sod and thus burying the sod below the working depth. In
some cases the third plow followed and turned a couple of
inches of the clay which was supposed to contain some
fertilizing qualities.\(^1\) One way to avoid the extra labor of
breaking the heavy sod was to lengthen the rotation by having
a succession of corn, corn, small grain, and then grass for
five years.

Livestock and the grazing system

The system of grazing and fattening cattle was well de-

\(^1\) Franklin Farmer, April 21, 1838.

\(^2\) The methods of handling cattle were taken from two ex-

The methods of handling cattle were taken from two ex-
cellent sources: Beatty, Southern agriculture, pp. 264-272
and Eighth U. S. census of agriculture, Vol. 2. pp. cxxix-
cxxxii, 1860.
prize animal, (six-years old) weighed 3506 pounds. After the first railroads were established in the late fifties and more predominantly after the Civil War, the cattle were fattened to lighter weights with greater dependence upon grass as their feed and sold when three to four and one-half years of age. One writer in contrasting the two methods of feeding said: "Of course, the quality of the beef of cattle so young, and handled after this fashion, can bear no comparison with that as made by the former method."  

The process of preparing cattle for market can be divided into two stages: the growing stage and the fattening stage. The growing stage took three or four years. If the beef animals were fed as much as half of a full-feed of corn when not on pasture, then the growing stage took three years and produced an animal ready to be fattened that weighed about 1250 pounds. If the cattle received only corn stover and very little corn when not on grass, an extra year or two were necessary to bring the animals to the fattening stage. After the railroads were available, the growing period was shortened about one year and the cattle were sent to the feed lots when they weighed about 900 pounds. When three or four

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2 It was not the practice under any conditions to feed cattle corn while on pasture.
years old the cattle were prepared for the fattening stage by
keeping them on the best pasture throughout the grazing sea-
son. The following January, or February they were brought
to a full feed of one-half bushel of corn per day. They were
fed on corn fodder (ears not removed) for a period of four to
five months and then sold between June and October. Two acres
of pasture and one acre of corn (40 bushels) were considered
normal requirements to fatten a bullock or spayed heifer.1

The cattle were fat and ready for market when they weighed
1500 to 1800 pounds. It seems reasonable to estimate that
many cattle at this weight had consumed 100 bushels of corn.

The large operators who called themselves graziers
purchased nine-tenths of their cattle from other farmers in
the region and preferred cattle of least one-half Durham.
They fattened from 100 to 700 four-year old cattle. Ap-
parently the profits in some years were large as many large
estates were paid for with cattle. The high regard for
cattle was expressed by one writer:

In the calcareous (limestone) lands of Kentucky,
it is not likely that the business of rearing
cattle will ever be superseded by more profitable
pursuits.2

Cattle fitted into the grazing system because they

1 The heifers were spayed before six weeks old.

2 Franklin Farmer. November 4, 1837.
obtained most of their feed from bluegrass and their droppings were left to enrich the soil. Corn fitted in the cattle-system because the corn fodder (ears attached to the stalk) was fed to the cattle in the pasture fields, preferably on the areas where the soil was run down, thus, all was returned to the land.

Hogs were fitted into the grazing system in a remarkably unique way, especially on farms that fattened cattle. Pigs farrowed in March or April were kept in a growing condition on good pasture and a small amount of grain until the following January or February when they were put in the feed lots with the fattening cattle. The ratio of hogs to fattening cattle was about two to one when the cattle were on full feed and one to one when the cattle were on half feed. After the cattle were sold, (in the late spring) the hogs were put on good clover pasture and from there they were moved to the grain fields to pick up the gleanings after harvest. After the gleanings were exhausted, they were fed night and morning on pumpkins and green stalk corn with the ears intact. After the corn husks turned brown, the hogs were turned into a corn field which was fenced with split rails into lots of ten acres for each one hundred hogs. Hogging down the corn was considered especially good for improving the land. The hogs were ready for market when they were eighteen or nineteen months old and weighed between
September 10, 1939

Kentucky Farmer

by

[Text continues]
of sheep for the mountainous areas but without saying a good word for them on Bluegrass farms. ¹ He asked for farmer opinion and in subsequent issues several farmers concurred with his view.

Horses and mules fitted perfectly into the grazing system as their subsistence came entirely from the products of the system. Young mules and horses, fed on grass and a small quantity of corn, were kept until two years old and then driven to the Southern states. A common practice among Bluegrass farmers was to buy good jacks and place them on farms in Indiana. The young mules sired by the jacks were then purchased by Kentucky farmers as yearlings, kept another year, and then driven to southern markets. The mule from a dam with some race horse blood was quite popular because they produced a mule that held its head high and displayed snap and alertness. To call a mule a 'Kentucky mule' was to add several dollars to its value.

¹ Dollar Farmer. November 1943.
THE ANALYTICAL FRAMEWORK FOR ECONOMIC ANALYSIS

The analyst is fortunate when as he pursues a problem of applied economics to have at his disposal a well developed body of economic theory on which he can rely for testing the functional relationships made apparent by delineation of a problem. As stated earlier, the task is one of allocation of the firm's resources in the production and utilization of pasture forage to maximize the stream of net revenues and minimize income fluctuations. Thus, the problem will be approached from the viewpoint of the entrepreneur.

The resource allocation task brings into focus consideration of the prices paid for the factors of production, the prices received for the products, and the physical input-output relations between factor and product. Prices are given by the market and the input-out relations are provided by the technical and technological conditions. Given the above conditions the firm acquires factors and sells products with the goal of maximizing the difference between their values within limits imposed by: (1) forces beyond control of the firm; (2) entrepreneurial preferences; and (3) management capacity vested in the entrepreneur. These conditions are constantly changing. The proportionate relationship between them also changes from one point in time to the next. Therefore, in the most accurate sense, there is a
different solution to the problem for each successive moment of time. In the discussion that follows we will assume that we are dealing with conditions at some specific time, i.e., static theory. We will consider later the conditions of equilibrium when the economic quantities are dated, i.e., dynamic theory.

Perfect competition will be assumed throughout the analysis in the sense that the firm does not exert any noticeable influence on the prices of the things it buys or sells. Institutional restraints, immobility of resources and lack of perfect knowledge are restrictions on complete acceptance of the concept of perfect competition. For this section, they are recognized but not considered as a barrier to the equilibrium conditions.

Basic Concepts

To the student of production economics the general framework of relevant economic theory is readily apparent from the foregoing discussion. Extreme simplicity in production is represented when a single factor $K$ is used to produce a single product $A$. Assume that prices of $K$ and $A$ are given by the market and that the input-output relations are given by the production curve (technical conditions). From these data the schedule of marginal costs for each increment of input can be calculated and the equilibrium
conditions determined. The equilibrium conditions for the case of single factor into single product are: (1) units of the factor X are added to produce an added output until the marginal cost equals the price of the product; (2) the marginal cost must be increasing; and (3) average cost must be increasing. For this case a drop in the price of the factor or an increase in the price of the product results in an expansion of output. The reverse is true for output change when the price of the factor increases or the price of the product drops. If the changes are general throughout the economy, supply and demand conditions will cause a tendency for return to the former output.

This method of analysis may be made more powerful if inputs can be lumped together in one commodity such as money, and the outputs similarly. This is possible when the relative prices of inputs and outputs can be assumed to remain consistent.1

Equilibrium conditions for a variation of the one-factor and one-product case are appropriate at this point. If the firm is employing more than one factor, each producing a separate product, then the marginal physical products (MPP_A, MPP_B, MPP_C) of all the factors must be proportional to their

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1. Hicks, op. cit., p. 33.
prices \((p_a, p_b, p_c)\), or stated another way:

\[
\frac{MPP_a}{p_a} = \frac{MPP_b}{p_b} = \frac{MPP_c}{p_c}
\]

When a factor \((x)\) is used to produce two products, A and B (joint products), then the sum of the marginal value products must equal the price of the service, or stated another way:

\[
MPP_a \times p_a + MPP_b \times p_b = p_x
\]

A more realistic production situation is represented when two factors \((x_1, x_2)\) can be employed to produce a single product \((A)\). Given by technical conditions the quantity of A that will be produced with any combination of \(x_1\) and \(x_2\) provides a complete schedule of outputs to represent a physical production surface. On a three-dimensional diagram the factors \((x_1, x_2)\) are measured on the two horizontal axes and the product \((A)\) is measured on the vertical axis. A line, parallel to the base plane and on the production surface connections all the points of equal output. The line is an iso-product contour and any point on it represents a combination of input quantities which will produce the same output. Any number of iso-product contours may be drawn on the production surface. When the output interval between contours is constant the nature of the returns to scale is immediately apparent. If the intercepts on a diagonal drawn
from the origin become larger and larger then equal proportionate inputs produce decreasing returns to scale. If the intercepts become smaller and smaller the inputs produce increasing returns to scale. If the intercepts do not change, the inputs produce constant returns to scale.

The total value of the factors, \( X_1 \) and \( X_2 \) used in the production of \( A \) is to be minimized. This can be accomplished with a map of iso-cost contours (straight lines because this is for a competitive firm) which represent constant costs for different combination of \( X_1 \) and \( X_2 \). When the product contour map is superimposed on the iso-cost map, the points of tangency between an iso-product contour and an iso-cost contour represent the lowest cost combination of \( X_1 \) and \( X_2 \) for the corresponding output level. At the point where each product contour is tangent to some iso-cost contour, the marginal rates of substitutes of the two inputs are equal to the ratio of their prices. A line connecting these optimum points is the scale line. Knowing the value of the product and the cost we can determine from the scale line the optimum scale of operations and the optimum proportions of input quantities. This case is illustrated in Figure 6.

The iso-product contours are represented by the curves that are convex to the origin. The iso-cost contours (price ratios of \( X_1 \) in terms of \( X_2 \)) are the straight lines.
Arbitrary values have been assigned indicating that the optimum level of output for maximum profit will result from input combination \( a \) of \( x_1 \) and \( b \) of \( x_2 \).

Fig. 6. Iso-product and Iso-cost Contours and Scale Line for Variable Inputs \( x_1 \) and \( x_2 \).

What happens when the price of \( x_2 \) drops and \( x_1 \) remains constant? According to Hicks the typical result is an increase in the supplies of the product and an expansion in the demand for other factors.\(^1\) He points out that an increase in the output of one product will induce an increased supply of other products and an increased demand for the factors. However, when the fixed resources are important substitution among the factors will occur rather than expansion

\(^1\) Hicks, op. cit., p. 97.
of outputs and inputs.

In the previous discussion the iso-cost contours (constant cost) were shown as straight lines expressing the ratio of prices between two variable inputs \( X_1 \) and \( X_2 \). Suppose the firm wants to employ its resources in the production of more than one product, e.g., A and B. It finds that the resources can be combined in a varying manner to yield a varying quantity of products A and B. The quantities of the products possible from the resources are shown by a transformation curve (iso-cost) Figure 7. The line \( dd \) represents the ratio of prices between A and B. At the point of tangency \( P \), output of combination \( a \) and \( b \) is maximum for the price relations, and the marginal rate of substitution in the production of the products (A and B) equals the ratio of prices. Another necessary condition is true: the marginal rate of substitution will increase for an incremental change in A (or B) or stated alternatively, for each incremental change in A, more B is required to substitute for it.

![Figure 7. Transformation Curve for Use of a Set of Resources to Produce Two products.](image-url)
The entrepreneur will want to combine his resources as shown by the scale line to produce each product (A and B) so that it is being produced in an optimal manner. Conceive a product contour diagram for each product (A and B) with the same inputs on the horizontal axis of both diagrams (Figure 6). On the first (A) the scale line may favor the $X_1$ axis and on the second scale line may favor the $X_2$ axis. From these scale lines the iso-cost curve (transformation curve) may be derived. The curvature of the iso-cost curve will depend upon the rise in the slope along the respective scale lines. As described, the firm will buy and sell inputs ($X_1$ and $X_2$) to maintain optimum combinations. In the real world the firm arrives at the resources it will employ by such a method. For the farm firm this is made more realistic by assuming the land area fixed and labor and capital as the inputs $X_1$ and $X_2$.

A dominant characteristic of the farm firm is to produce primary outputs (feed crops) which later are used in the production process as factors to yield a secondary output (milk). The firm with its resources ($X_1, X_2, \ldots, X_n$) can produce various combinations of outputs A and B (Figure 7). The products of the resources as factors are used to

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1 A primary output may be described as that which originates from the land, e.g., corn and forage. A secondary output is produced by use of the primary outputs, e.g., livestock.
produce C (Figure 8). Equilibrium in the use of the resources is attained when the marginal rates of substitution of factors and products are equal.

![Diagram](image)

**Fig. 8. Transformation Curve for the Use of the Firm's Resources in Production of a Product to be Used in Production of a Secondary Product.**

If the firm has a number of factors \((X_1, X_2, X_3)\) that can be used in the production of products \((A, B, C)\) it will desire to minimize the use of \(X_1, X_2, X_3\), and maximize the outputs, \(A, B, C\). These conditions will be met when it is not possible for the entrepreneur to combine the factors in different uses to increase the output (income) of the firm. If the entrepreneur finds that he can shift factors to different uses and increase the output of one product without a decrease in another product, or if the output of the product affected by the removal of a decrement of factor is
reduced proportionally less than the increase in output from substitute employment, the entrepreneur will benefit by making the change. Thus, optimum allocation of the factors \( x_1, x_2, x_3 \) among the products \( A, B, C \) is accomplished when the marginal productivities (marginal value productivities) are proportional in all uses.

Now the three conditions for equilibrium of the firm corresponding to the three conditions enumerated in the one factor into one-product case can be collected and presented.\(^1\)

1. Corresponding to the condition that price of the product should equal marginal cost are three sorts of conditions.

   a. The ratio of prices between any two products should equal the marginal rate of substitution between the two products.

   b. The ratio of prices between any two factors should equal their marginal rate of substitution.

   c. The ratio of price between any factor and any product should equal the marginal rate of transformation between the factor and the product.

2. When one product can be substituted for another the marginal rate of substitution should be increasing; and when one factor can be substituted for another, the marginal

\[^1\] Hicks, op. cit., p. 86.
rate of substitution should be diminishing; and when one factor is transformed into any product the marginal rate of transformation must be diminishing.

3. The average cost of producing each product and each group of products must be rising and the net output positive.

The discussion to this point has been concerned with the conditions of static economics. The conditions are more realistic when the economics is evaluated in a dynamic framework. The discussion that follows assumes dynamic conditions and a competitive firm that cannot influence prices with the things it buys or sells.

The planning of production by the firm is a necessary prerequisite to the carrying out of production processes. The production plan may be defined as the schedule of dated quantities of outputs (income).\(^1\) Generally, the firm makes its plans for some period of time in which the production processes, once initiated, are completed. Logically, the period of time may be called the production period. The farm firm is likely to have a separate production period for each enterprise. Thus, the planning period which occurs in advance of execution of the plan is critical. The entrepreneur presumably chooses the plan whose present capitalized value

\(^1\) Frequently these quantities are called "streams" of inputs and "streams" of outputs.
is the greatest.

The use of dynamic economics is, for the most part, an extension of static economics; outputs of different dates are regarded as different outputs, and inputs of different dates as different inputs. The same conditions of equilibrium hold as in static economics; the variation is due to consideration of time periods. Corresponding to the condition that price of product must equal marginal cost are three variations: (1) the marginal rate of substitution between outputs of any two dates must equal the ratio of their discounted prices; (2) the marginal rate of substitution between inputs of any two dates must equal the ratio of their discounted prices; (3) the marginal rate of transformation of any input into any output must equal the ratio of their discounted prices.¹

Risk, Uncertainty, and Expectations²

An important part of dynamic theory is concerned with risk, uncertainty, and expectation. Risk may be defined as

¹ Hicks, op. cit., p. 197.

the holding of anticipations which are not "single valued" but constitute a probability distribution having known parameters. Uncertainty is defined as the holding of anticipations under which the parameters of the probability distribution are themselves not single valued.\(^1\) Knowing the parameters of probability distribution the firm can set up its schedule of production with full knowledge of the risk cost assignable to each alternative plan. However, under conditions of uncertainty the firm is forced to make decisions based upon a subjective evaluation of the probability distribution parameters. The types of uncertainty confronting the firm may be classed as: (1) price uncertainty for products, factors and production services; (2) technical uncertainty, caused by lack of knowledge with respect to production functions and the effect of weather; (3) technological uncertainty caused by new developments, innovations, inventions, etc. As the entrepreneur views the prospects of the future he is forced to formulate expectations about the occurrence of certain events. An uncertain future influences the process of decision-making, and the attitude of the entrepreneur toward his goals, and the capital structure of

the firm. One of the major influences, in this connection, is the tendency toward employment of measures and methods which inject safety into the production plan. These effects will be discussed in some detail in the subsequent discussion of the decision to act and the means chosen for ameliorating uncertainty.

The decision-making process

Faced with the necessity of making a decision in the world of uncertainty, the entrepreneur attempts to formulate expectations based upon his interpretation of the forces impinging on the situation. After the expectations are formed he chooses some production plan that can be employed in accordance with the expectations. The choice between plans and the choice between products may be influenced by the expected range and the expected skewness of the variance of the probability distribution about the probable mean or mode. With other things equal the entrepreneur will probably choose the product or plan with the lowest variance about the probable mode and/or he will prefer one for which the probability distribution is skewed in such a manner as to minimize losses in case his expectations are wrong.

In developing the production plan for a single enterprise or for a combination of enterprises, the entrepreneur

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1 From a single enterprise several products may be produced, single or in combination.
must make four important choices: (1) choice of products, (2) choice of factors, (3) choice of production processes, and (4) choice of scale of operations. The "timeless" theory of classical economics assumes that firm's attempt to maximize net revenue. However, when time and uncertainty are added considerations, the firm is likely to maximize the stream of net revenue with "safety" in the relevant planning period or economic horizon. The relevant planning period may differ from the economic horizon in that for the latter the firm may hope to maximize returns over fifteen years, but the first five years may be the crucial ones to survival of the firm for the longer period. In this instance, the first five years are the relevant planning period; for this period the firm may adopt the plan with the lowest modal or mean income expectation provided the variance is low. Thus, the firm may be willing to forgo some possible gain if the chance for losses are minimized.

Safety measures employed by the firm for pasture production fall into two classes: (1) those which reduce the dispersion or range of possible results, and (2) those which improve the prospects of the firm to withstand unusual losses.

With uncertain expectations, two types of inefficient resource allocation will probably occur in the short run. (1) If the expectations turn out to be correct, misallocation of resources is likely to occur because, instead of equating
marginal costs and marginal revenue the entrepreneur will plan with safety. The usual result in this instance is that marginal revenue exceeds marginal costs. Other things being equal, the greater the confidence of the entrepreneur in his estimate, the more nearly will he allocate the resources of the firm in an optimal manner. (2) If the expectations turn out to be incorrect, severe misallocations are in prospect. These will, of course, depend on the extent of the error. If the entrepreneur anticipates that he will have sufficient pasture forage for fifty head of steers and, due to unfavorable weather conditions he has sufficient pasturage for thirty, a radical adjustment is necessary. He is faced with the necessity of either liquidating two-fifths of his herd or substituting hay, reserved for winter, for summer pasture. If prices happen to be unfavorable at the time, significant losses may be incurred regardless of his choice.

Reducing Uncertainty

In the uncertain world the entrepreneur has several alternative methods which he may employ to reduce uncertainty. The first method is flexibility. Flexibility may be defined as the organization of production to permit changing

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1 It is recognized that certain types of flexibility could be included in his scheme of production to minimize losses. However, flexibility is an added cost, direct or indirect, as will be brought out later.
plans during the production process to take advantage of improvement in expectations or knowledge. It involves adopting production functions which permit relatively wide fluctuations in output with only small changes in marginal cost; and it also involves the utilization of capital, equipment, and other factors to make possible a shift from one product without incurring heavy costs in the process. The choice between two processes to produce a given product is illustrated in Figure 9.

Fig. 9. Average Cost Curves For Two Production Processes.

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1 Johnson, Forward prices, p. 41.
The curve AA represents the average cost over the possible output range OX. Because of refinements in the process and certain rigidities or inflexibilities, the cost curve declines rapidly with further increases in output. On the other hand, cost curve BB is for an alternative process in which relatively small changes in cost occur for each change in output; however, the low point is higher even though it occurs at the same output as AA. If the firm were going to produce OP in every period, or if it will average OP but produce more than O6 or less than O8, then it should use the process shown by AA. On the other hand, if output varies outside the ranges of O6 and O8 the firm will choose the process shown by BB. When the firm is faced with technical uncertainty wide variation in output is likely to be great. This is especially true for the farm firm.

A second method of reducing uncertainty is by diversification of product. Diversification, by a farm firm, is the production of several different commodities which do not necessarily complement each other but increase the probability of having a product that makes a crop or catches a favorable market. Diversification of product may be introduced into the farm system to distribute income or production

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Diversification for the purpose of increasing the income because of price variation has been shown by Johnson, Forward prices for agriculture, p. 52, to be a weak argument because of the high correlation between price movements of all farm commodities.
more uniformly over time.

A third method is through safety measures in choosing the productive services, such as planting two or more varieties of grass with the expectation that one of them will catch and make pasture. A fourth method is to keep an excess quantity of resources on hand to meet unusual conditions. For example, the firm may have surplus labor, surplus machinery or surplus pasture forage. A fifth method is to provide storage whereby surpluses of one period can be stored for use during a period when the occurrence of an unexpected event causes a shortage. A sixth method is to maintain a liquid position by keeping ready cash on hand to meet exigencies and to take advantage of opportunity.
THE PRODUCTION OF PASTURE FORAGE

The ideal pasture program for any farm can be described only in its relation to the over-all forage production plan. The ideal for any given farm unit is to have forage available for consumption at any time, of constant quality that meets the optimum requirements of a livestock program dictated by available land, labor and capital resources, and market outlets. Pasture production should be used to provide the forage requirements up to the point at which the cost of an increment of pasture forage is equal to the cost of a corresponding unit of harvested forage, accounting for any price differentials (for products) that may occur as a consequence of the change.1 Within this framework the ideal pasture program for a given farm firm can be described.

1. Maximum stream of pasture forage with minimum variation in supply and nutritive value for the period of pasture production.
   a. Within pasture production periods.
   b. Between pasture production periods.

2. An acreage in pasture in proportion to other crops

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1 To make this statement valid, the writer assumed that the cost calculations will account for alternative use of the pasture land because actual cash outlay against the pasture crop would, in most instances, result in extension of pasture forage consumption beyond the point dictated by the rule. Furthermore, there are some conditions of uncertainty that would cause a firm to utilize pasture forage differently than as suggested by the rule.
such that the stream of net revenues from the farm is maximized.

In the discussion that follows, only the problems relevant to production of forage (mostly pasture) will be considered. No consideration will be given to the manner in which the forage is utilized.

Variation in Supply of Pasture Forage;
Within Production Periods and Between Production Periods

Variation in the yield of pasture forage differs from variation in the yields from other crops because the harvesting of pasture forage is a continual process throughout the period of sufficiently warm weather. On the other hand, most other crops are harvested at a specified period. Variation in the production of pasture forage is of importance to the livestock producer because, in a sense, the production of today’s livestock product is dependent upon the pasture forage produced in the past week. The total output for the season may be large but if the variation in weekly (daily) production is also large the value of pasture as a livestock feed will not be as great as it would be if the variation in production were small. Let us turn our attention to the variation problem.
Extent of yield variation

A pasture project in Kentucky, begun in 1936 (completed in 1948), was set up to measure the effect of rotational grazing and the value of bluegrass for grazing purposes. The pastures received no soil treatment during the period of the experiment except the droppings of the dairy heifers grazing the herbage, but volunteer white clover was allowed to grow. Differences in yield due to rotational grazing were not significant. However, the data provide some worthwhile information on variation in yields within pasture production periods and between periods.

Highest variation between periods (years) occurred in the months of April and October (Table 2). This was due to the variation in starting and ending dates. May had high yields and low variation; June had favorable yields and relatively low variation; July had low yield and fairly high variability; August had low yield and low variability; and September had low yield and high variability.

Yield variation for bluegrass pastures within production periods was greater than between years (Table 3). An example of the within-year variation can be seen for the successive years 1937, 1938, and 1939. Over all the years the

Morrison, S. B. and Ely, Fordyce. Clipping vs grazing by dairy heifers as means of estimating yield of bluegrass pastures. Jour. of Dairy Sci. 29:393-405. 1946. Details of the experiment can be found in this article.
Table 2. Variation in Bluegrass Pasture Yields between Years for the Pasture Months 1937 through 1949. Lexington Experiment Field, Kentucky

<table>
<thead>
<tr>
<th>Month</th>
<th>Mean yield</th>
<th>Standard deviation</th>
<th>Coefficient of variation</th>
<th>&quot;t&quot; values</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TMD per acrea</td>
<td>TMD per acre</td>
<td>Percent</td>
<td></td>
</tr>
<tr>
<td>April</td>
<td>228</td>
<td>174.2</td>
<td>76.4</td>
<td>4.53</td>
</tr>
<tr>
<td>May</td>
<td>583</td>
<td>122.2</td>
<td>21.9</td>
<td>16.51</td>
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<td>June</td>
<td>168</td>
<td>118.4</td>
<td>25.3</td>
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<td>July</td>
<td>319</td>
<td>115.0</td>
<td>36.0</td>
<td>9.61</td>
</tr>
<tr>
<td>August</td>
<td>231</td>
<td>91.4</td>
<td>27.6</td>
<td>12.56</td>
</tr>
<tr>
<td>September</td>
<td>237</td>
<td>166.7</td>
<td>59.1</td>
<td>5.96</td>
</tr>
<tr>
<td>October</td>
<td>169</td>
<td>141.8</td>
<td>86.6</td>
<td>3.91</td>
</tr>
</tbody>
</table>


aTotal digestive nutrients were computed from the beef gains by the method of allowing 3.53 TMD's per day for each pound of gain and 2.73 TMD's subtracted for each pound lost plus a maintenance allowance of 8 TMD's per day for each 1,000 pounds live weight.

the range in the coefficient of variation was from 19.7 percent in 1938 to 85.6 percent in 1948. Reduction of the variation within years was substantial when the months of April and October were omitted because production in these two months varied more than the other pasture months (Table 3). Low variation occurred in years when monthly rainfall was evenly distributed and conversely. Since the difference between years was not significant at the .05 level (t test) and the within-year variation (months) was highly significant at the .01 level, the within-period variation is the greatest problem
Table 3. Yield Variation within Years for the Months April through October and for the Months May through September 1937-1948 Inclusive. Lexington Experiment Field, Kentucky.

<table>
<thead>
<tr>
<th>Years</th>
<th>April-October inclusive</th>
<th>May-September inclusive</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Year mean</td>
<td>Coefficient of variation</td>
</tr>
<tr>
<td>acre</td>
<td>percent</td>
<td>acre</td>
</tr>
<tr>
<td>1937</td>
<td>2143</td>
<td>77.0</td>
</tr>
<tr>
<td>1938</td>
<td>3946</td>
<td>19.7</td>
</tr>
<tr>
<td>1939</td>
<td>3493</td>
<td>73.3</td>
</tr>
<tr>
<td>1940</td>
<td>2967</td>
<td>55.1</td>
</tr>
<tr>
<td>1941</td>
<td>2641</td>
<td>60.7</td>
</tr>
<tr>
<td>1942</td>
<td>3736</td>
<td>39.4</td>
</tr>
<tr>
<td>1943</td>
<td>3257</td>
<td>64.0</td>
</tr>
<tr>
<td>1944</td>
<td>3759</td>
<td>60.1</td>
</tr>
<tr>
<td>1945</td>
<td>3411</td>
<td>50.2</td>
</tr>
<tr>
<td>1946</td>
<td>3737</td>
<td>25.5</td>
</tr>
<tr>
<td>1947</td>
<td>4357</td>
<td>46.6</td>
</tr>
<tr>
<td>1948</td>
<td>2944</td>
<td>85.6</td>
</tr>
</tbody>
</table>

*See Table 2 for source of data and method of computing total digestive nutrients.*

for the Bluegrass farmer (Table 4).

This experiment was for a single grass with whatever volunteer white clover occurred during the pasture production period. It is a system which is typical on many bluegrass farms. An alternative system might be to select pasture mixtures that produce during the months when bluegrass population is low but this system also failed to cause significant reduction in variation (Table 5).
Table 4. Analysis of Variance of Bluegrass Pasture Yields for April through October 1937-1946 Inclusive, Lexington Experiment Field, Kentucky

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Degrees of freedom</th>
<th>Mean square</th>
<th>( F )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Months</td>
<td>6</td>
<td>247,065</td>
<td>15.6**</td>
</tr>
<tr>
<td>Years</td>
<td>11</td>
<td>22,393</td>
<td>1.41</td>
</tr>
<tr>
<td>Error</td>
<td>66</td>
<td>15,838</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>83</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Significant at .01 level of probability.

Table 5. Analysis of Variance of Bluegrass Pasture Yields for May through September 1937-1946 Inclusive, Lexington Experiment Field, Kentucky

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Degrees of freedom</th>
<th>Mean square</th>
<th>( F )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Months</td>
<td>4</td>
<td>166,060</td>
<td>14.40**</td>
</tr>
<tr>
<td>Years</td>
<td>11</td>
<td>19,594</td>
<td>1.52</td>
</tr>
<tr>
<td>Error</td>
<td>54</td>
<td>12,911</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>59</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Significant at .01 level of probability.

How does the variability of total pasture yields compare with other crops? An attempt to answer this question was made by comparing acre yields of a three-year rotation of corn, wheat, followed by mixed hay (called the Manure Experiments), with the acre yields of the pasture experiment, 1

1 Four tons of stable manure were applied each round of the rotation; the pastures did not receive treatment. The manure applied was assumed to equal the droppings of animals on pasture.
previously explained.

Table 6. Yield Variation between Years for Corn, Wheat, and Hay in Three Year Rotation and Continuous Bluegrass Pasture 1936-1948 Inclusive. Lexington Experiment Field. Kentucky

<table>
<thead>
<tr>
<th>Crop</th>
<th>Yield per acre</th>
<th>Coefficient of variation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean yield</td>
<td></td>
</tr>
<tr>
<td>Corn</td>
<td>62.5 bu.</td>
<td>28.7 percent</td>
</tr>
<tr>
<td>Wheat</td>
<td>24.9 bu.</td>
<td>33.2 percent</td>
</tr>
<tr>
<td>Haya</td>
<td>2340 lbs.</td>
<td>52.5 percent</td>
</tr>
<tr>
<td>Hayb</td>
<td>3379 lbs.</td>
<td>37.9 percent</td>
</tr>
<tr>
<td>Bluegrass pasture</td>
<td>2310 TDN's</td>
<td>20.7 percent</td>
</tr>
</tbody>
</table>

Source: Freeman, J. F. Corn, wheat, and hay yields on the manure plots. Unpublished data. Agronomy Department, Kentucky Agricultural Experiment Station. For pasture yields op. cit.

aHay was not available for harvest, four of the thirteen years due to failure to obtain a stand.

bThese data were for the nine years that hay was available.

The variability between years for bluegrass pasture was obviously much lower than for harvested crops. This surprising fact is logical because pasture production is spread over more months and owing to the nature of the product it can, within a short period, recover from the depressing effects of poor weather conditions. For most of the other farm crops this condition cannot occur. However, measuring acre yields between years obscures the fact that the variation within periods for bluegrass pastures was greater than between
production periods. Knowledge of this fact reduces the significance of the low variation in pasture yields as shown above. However, if other plant mixtures or variable inputs of productive services reduce within-season variation to insignificance, then the low variation between years would be significant.

When the entrepreneur seeds his grasses and legumes he is aware that they may fail to produce a stand. The cost of failure and the concern of what to do with the land after failure may cause him to: (1) sow more seed than is ordinarily necessary, (2) sow more kinds of grasses and legumes than are necessary, in the hope that several will "catch"; frequently, mixtures contain six or more grasses and legumes. In addition to the possibility of failure to secure a stand is the uncertainty of obtaining a stand with the same proportion of grasses and legumes as was scattered on the land. Therefore, the costs of securing the desired stand, obviously, are greater than many admit. In numerous instances, known by the writer, the possible gains of the good pasture are not considered worth the cost, however, such a decision is frequently made by the entrepreneur who is influenced by capital rationing or aversion to taking chances.

Evidence of variability reduction

Data from several experiments indicated that as output per acre was increased the variability decreased. An increase
in mineral fertilizers, or adding legumes to a pure grass
seeding (Table 7), or adding stable manure, or partial to
complete control over the water supply in the soil, and other
practices of lesser importance acted to increase output and
lower variability.¹ Moreover, transferring forage from one
period to another by storage reduced variation in supply and
also had the effect of increasing output.²

Analysis of weather data

An analysis of the amount and distribution of rainfall
in the summer and early fall months showed clearly the im-
portance of weather conditions on forage production. 3-hirty
years of data provided some important information. Slightly
more than one-third of the annual precipitation occurred in
the five months of June through October (Table 9). The

¹ Robinson, R. P. and Sprague, V. G. The clover popu-
lation and yields of a Kentucky bluegrass sod as affected by
nitrogen fertilization, clipping treatments and irrigation.
Freeman, J. P. Interpretation of yield data from longtime
soil fertility experiment. Am. Soc. Agron. Jour. 40:874-
1945.

² For the years 1932-35 (four years) hay yields were
determined on the pasture plots reported in Table 8. Be-
cause of the short time-span the evidence was not conclu-
sive. However, for the years compared, hay yields were 20
to 40 percent greater than yields from clippings. The
variability between years for hay was greater than for
clippings.
Table 7. Dry Matter Yields and Coefficient of Variation from Pasture Clippings for Different Plant Combinations and Treatment with Nitrogen 1932-1942 Inclusive. Lexington Experiment Field, Kentucky

<table>
<thead>
<tr>
<th>Plant mixture</th>
<th>Mean yield</th>
<th>Coefficient of variation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bluegrass alone</td>
<td>737</td>
<td>50</td>
</tr>
<tr>
<td>Bluegrass and pasture - type legume</td>
<td>1168</td>
<td>36.8</td>
</tr>
<tr>
<td>Bluegrass and hay - type legume</td>
<td>1727</td>
<td>40.9</td>
</tr>
<tr>
<td>Bluegrass and nitrogen</td>
<td>1485</td>
<td>33.9</td>
</tr>
</tbody>
</table>

Source: Fergus, E. N. Dry matter yields from pasture lots. Agronomy Department. Unpublished data. Kentucky Agricultural Experiment Station.

- **a**Oven dry.
- **b**White clover plants removed.
- **c**Average of three bluegrass plots seeded to hop clover, white clover, and yellow trefoil, respectively - no other treatment.
- **d**Average of three bluegrass plots seeded to alfalfa, sweet clover, and korean lespedeza, respectively - no other treatment.
- **e**Average of five bluegrass plots with different methods of applying nitrogen. Input of nitrogen varied from 16 to 32 pounds per year. Differences in yield due to added nitrogen were not significant.

Variation in monthly rainfall between years was as large as the standard deviation; in every month it was greater than 50 percent of the mean quantity. Therefore, mean rainfall for any of the pasture months is of very little assistance to the entrepreneur in making his plans for pasture forage.

<table>
<thead>
<tr>
<th>Month</th>
<th>Mean</th>
<th>Coefficient of variation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>inches</td>
<td>percent</td>
</tr>
<tr>
<td>June</td>
<td>4.01</td>
<td>53.4</td>
</tr>
<tr>
<td>July</td>
<td>4.36</td>
<td>54.4</td>
</tr>
<tr>
<td>August</td>
<td>3.36</td>
<td>60.5</td>
</tr>
<tr>
<td>September</td>
<td>2.73</td>
<td>53.6</td>
</tr>
<tr>
<td>October</td>
<td>2.33</td>
<td>66.8</td>
</tr>
</tbody>
</table>


To know the frequency and the magnitude of rainfall is of greater value in making pasture production plans than the knowledge about the mean. Rains occurred on 26 percent of the days in June of which about 90 percent were less than 1 inch (Table 9). Precipitations in July, although they occurred on almost as many days as in June, tended to be heavier with about 10 percent of the rains greater than \( \frac{1}{2} \) inches (Table 9).

The interval between rains indicates the nature of drought conditions. In June the interval between rains was usually short and the rains were light. On the other hand, in September the intervals between rains were much longer and the rains heavier (Table 11, Appendix). An interval of eleven to fifteen days without rain occurred on an average of every other year in the months of June, July, and August (Table 10). The most serious droughts occurred in September and October as the
Table 9. Percentage of Days within Each Month that Precipitation of Specified Amounts Occurred 1920-1949. Lexington Weather Station, Lexington, Kentucky.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0.10-.50 inches</td>
<td>16.2</td>
<td>12.1</td>
<td>11.9</td>
<td>9.9</td>
<td>10.7</td>
</tr>
<tr>
<td>0.51-1.00 &quot;</td>
<td>7.1</td>
<td>5.7</td>
<td>4.5</td>
<td>4.6</td>
<td>3.1</td>
</tr>
<tr>
<td>1.01-1.50 &quot;</td>
<td>1.9</td>
<td>2.6</td>
<td>1.7</td>
<td>1.6</td>
<td>1.6</td>
</tr>
<tr>
<td>1.51-2.00 &quot;</td>
<td>.3</td>
<td>1.0</td>
<td>.4</td>
<td>.1</td>
<td>.3</td>
</tr>
<tr>
<td>2.01 and over</td>
<td>.6</td>
<td>.9</td>
<td>.4</td>
<td>.1</td>
<td>.1</td>
</tr>
<tr>
<td>All rains</td>
<td>26.1</td>
<td>22.3</td>
<td>18.9</td>
<td>16.6</td>
<td>15.3</td>
</tr>
<tr>
<td>No rains</td>
<td>73.9</td>
<td>77.7</td>
<td>81.1</td>
<td>83.4</td>
<td>84.7</td>
</tr>
</tbody>
</table>

Source: U. S. Weather Bureau, op. cit.

*Precipitations less than .10 inch were omitted.

The interval between rains was significantly greater, and in two years out of the thirty a drought of thirty-six to forty-one days occurred. On the other hand, no droughts longer than twenty-five days were recorded for July and August in the thirty years.

From the knowledge provided by the foregoing data it can be concluded that safeguards against droughts for September and October are of greater importance in the planning process than for the other summer months. The data also suggested the hypothesis that for July and August, selection of plant mixtures for seasonal production may be more important than the safeguards against drought.
Table 10. Percentage of Years in which Droughts of Specified Intervals Occurred 1920-1949. Lexington Weather Station, Lexington, Kentucky.

<table>
<thead>
<tr>
<th>Class interval</th>
<th>June</th>
<th>July</th>
<th>Aug.</th>
<th>Sept.</th>
<th>Oct</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>percent</td>
<td>percent</td>
<td>percent</td>
<td>percent</td>
<td>percent</td>
</tr>
<tr>
<td>11-15 days¹</td>
<td>50.0</td>
<td>56.7</td>
<td>56.7</td>
<td>15.0</td>
<td>26.7</td>
</tr>
<tr>
<td>16-25 &quot;</td>
<td>3.3</td>
<td>20.0</td>
<td>20.0</td>
<td>36.7</td>
<td>30.0</td>
</tr>
<tr>
<td>26-35 &quot;</td>
<td>3.3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>10.0</td>
</tr>
<tr>
<td>36-50 &quot;</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>6.7</td>
<td>0</td>
</tr>
</tbody>
</table>


¹Precipitations less than .10 inch were omitted.

Analysis of methods for reducing yield variation

The ideal pasture program as described earlier emphasized constancy, within and between periods, in quantity and quality of pasture forage in direct proportion to the needs of the livestock. For the discussion that follows it will be necessary to modify the ideal by assuming that the desired condition is a supply constant in quantity and quality for every month.¹

In order to facilitate the analysis forage has been considered apart from that for summer consumption. Thus,

¹Such a simplifying assumption clarifies the problem and makes the analysis easier. The method is still valid when the supply requirements are presumed to vary within the year.
the period of production is purely for pasture production.\(^1\)

Given the fertility and productivity level, then the pasture forage production for any week is dependent upon:

1) the temperature; (2) the amount of soil water; (3) the stage in the life cycle of the pasture plants; and (4) the nature and density of the plant population. Quality of the pasture forage under the given assumptions is a function of the same variables. Therefore, for this analysis, reduction in variation will be assumed to cause an increase in quality. The weather effects, (1) and (2), are independent of the latter two, (3) and (4), but (3) and (4) are in varying degree dependent upon the first two. Therefore, it appears that weather effects are most important in affecting variation within any one short time period.

The solution for controlling the variation in supply of forage for consumption during the pasture production period may be found in some combination of the following methods:

1) choice of plant mixtures, (2) management practices which reduce variation, (3) storage of surplus production from one period for use in another, and (4) control of soil water supply.

**Choice of plant mixtures**

The choice of plant mixtures seeded for reducing

\(^1\) Certain crops harvested for forage provide pasturage after removal of the crop for storage. This does not hurt our analysis as the use of the crop aftermath of hay crops is one of the methods employed to counteract seasonal variation.
variation will be influenced by: (1) the probable distribution of production over the pasture production period, and (2) the expected probability of securing the desired stand. Significant results can be attained in equalizing the time distribution of production by choosing grasses and clovers by their seasonal habits of production. However, to have three or four mixture combinations, each chosen to produce at a certain time period, results in more fields, more fence, more complicated arrangements, and greater cost.

If the entrepreneur found from experience or other sources that the ratio of output from a unit of land for three successive time periods was 5:4:3 he could equalize production by adjusting acreage for each time period to an inverse proportion to production. Final decision on the proportion of acreage in each combination will be made only after consideration has been given to the cost of alternative methods of adjusting production, e.g., storage. If the entrepreneur entertain a high probability of failure in securing a stand, his actions may be governed by the importance of capital rationing and his aversion to risk. If he entertains a low probability of failure his actions may indicate an active desire to control variability. In either case the entrepreneur can attempt reduction in variability to the extent that the value of one percent predicted reduction in variability is equalized with the marginal cost of securing the same.
By interaction and perception control is possible to observe man's behavior and if associated with some of operation such precautionary measures can be taken to reduce his part in the operation, however, if the entrepreneur has a full complement of personnel and sufficient number of custom made suitable for production or units of production of equipment, the need for cooperation with the respective methods may no longer be necessary, costs of source, any or others, are not likely to be reason.

Another advantage of cooperative control is that it is based upon a cooperative method. If the trend forecast is correct, cost of surplus or deficiency, capital additional expenditure for the entrepreneur in a definite period of surplus production from a surplus portion is the result of deliberate production from one period for use in a period of surplus production from that period and potential changes in weather or any other factors that may affect the operation. The trend forecast is based on the trend for comparison in another period to the current period and potential production, which must be considered to the entrepreneur for reducing variation in a great variety of management practices are available.
and other water conserving measures. The cost for either method of control will usually be lower when joint products result from the method. Irrigation and livestock water supply can be joint products in the first instance and erosion control and soil water control by the latter method. In these cases control can be extended until the sum of the marginal products of the productive service, each multiplied by the value of the product equals the price of the service.

Synthesis of the methods

As the entrepreneur appraises all the methods at his disposal for reducing variation within the pasture production period and between production periods he may be impressed with the additional cost attached to securing constant supply. The costs are of two types: (1) sacrificing probable production of one period for probable gain in another; and (2) additional cash outlay. These are depicted in two models (Figures 10 and 11).

The transformation curves A4, B5 and C6 (Figure 10) each represent the expected quantities of spring and summer forage from three different plant mixtures. Mixture AA obviously is one with high spring and low summer production — e.g., red clover and timothy. Such a mixture falls far short
of providing a constant supply. In order to secure a constant supply (based on expectation of average production) the firm must either harvest the surplus and store it for consumption in the summer months or seed another mixture which has inherent tendencies to produce in the summer months as a supplement to AA. Curve CC represents such a mixture - e.g., lespedezas as the major plant. The total production of mixture CC is less than AA. Therefore, to substitute some acreage of mixture CC for mixture AA results in sacrificing some total production as the cost for getting a constant supply of pasturage. The alternative of harvesting and storing surplus from mixture AA in most cases is more costly, so the entrepreneur will prefer to sacrifice considerable spring production to obtain summer production.¹ The economic test is the total value of production sacrificed compared to the total cost of harvesting, storing and feeding.

Because of the uncertainty of pasture production "hitting" these expected ratios the entrepreneur is likely to add a third mixture for safety. He will prefer one that provides some insurance against unfavorable events occurring either in the spring or in the summer. Thus, he will choose one with an expected probability of providing equal amounts of spring and summer production and will prefer a mixture for

¹ In regions where summer pasture production can only be secured at high total cost, harvesting and storing the spring surplus may be more economical.
for which the elasticity of the transformation curve favors the summer production because of the higher probability of an unfavorable event in the summer months. Such a condition is represented by curve BB. The total production resulting from this mixture is less than either of the other mixtures. Therefore safety has meant a sacrifice of production from AA and CC.

As indicated by the transformation curves (Figure 10) the cost per unit of output is higher for summer production than for spring production. We now inquire whether the entrepreneur can profitably transfer the production from one period to another for consumption, and how can be determine the constancy level for the season. We may have a set of cost curves similar to those in Figure 11.

BB represents the marginal cost for spring production and HH for summer production. If SF is the average of a unit of output, then constancy in output is obtained at SA by storing the output MN for consumption during the summer period. The question is can the entrepreneur profitably transfer the surplus quantity MN from one period for

1 If we adopt an arbitrary scale on these hypothetical cases, we find that one unit of land in mixture AA produces 1700 pasture forage units, one unit of land for mixture CC produces 1300 units, and one unit of land in mixture BB produces 1200 units. The total production of all three units of land is 4200 units of pasture forage. If all three units of land had been in mixture AA the total production would have been 5200 units of pasture. Therefore, in this hypothetical case, distribution of production and guarding against uncertainty meant the sacrifice of 1000 units of pasture forage.
Fig. 10. Transformation Curves for Obtaining Spring and Summer Pasture Production.

consumption in another period? Summer forage has a higher scarcity value than spring forage, and the total nutrients obtained when harvested is greater than when pastured. The variable cost of storing a unit of forage must not exceed the sum obtained by multiplying the difference between the scarce price and CP by the quantity mm plus the value of the additional output due to harvesting. Whether the additional cost is low enough to meet these requirements will depend largely on the volume of production. In the case of the small firm where costs of storage are likely to be high,
production in the summer months may be pushed to $k$ on the HI curve and production stopped at $d$ on the GG curve. Thus, average marginal costs will equal $GP$. The surplus forage $AB$ may be left on the land as a residual to consume during the summer. This will result in lower quality product but the quality sacrifice will not be as great as the cost of storage.
The latter case is more feasible for the beef producer than for the dairy producer. This analysis assumes some normalised expectations in the planning period for the season production. It is the sort of analysis the entrepreneur must use in determining the level of livestock production.

This model may be used to explain the position of a practice which changes the elasticity of the supply curve for summer production, e.g., irrigation (Figure 11). Suppose the supply curve for summer production to be HH when irrigation is added and all variables on the SS curve are the same at each level of output. It is impossible at the present to predict the nature of this curve, therefore, the HH curve is purely imaginary for purposes of explaining the possible relationship. If HH is the cost curve without irrigation and curve H'H' is irrigation, then, the entrepreneur would plan to use irrigation to extend summer output from OA to OB. He would be attaining constancy of output at OB, whereas, by harvesting and storing the surplus at output OA, constancy was obtained at output OA. Therefore, the irrigation may permit the firm to carry more livestock. In addition to providing greater output irrigation stabilizes the variability of output.

After an irrigation system is installed the effect of a small change in the value of the forage has a significant effect on the output because of the elasticity of the
irrigation supply curve. Knowledge of this fact can be a
deterrent influence on investing large capital sums to in-
stall an irrigation system.

Pasture Output and Nutritive Value

The foregoing discussion was pointed to emphasize the
importance of reducing the variability in the production of
pasture forage. It was evident in the discussion that vari-
bility is closely associated with rate of output. The pres-
ent discussion will emphasize maximization of the stream of
outputs within an economic framework.

The second condition for the ideal pasture production
program was that the pasture acreage should be in proportion
to the acreages of the other crops in accordance with the
objective of maximizing the stream of net revenues. Ob-
viously, all the conditions for the "ideal" are related.
Yet, the net revenue stream cannot be given full considera-
tion until the over-all production plan is evaluated. There-
fore, only the appropriate aspects of the second condition
will be considered in this section, reserving final discussion
for the over-all production plan.

In the discussion on variation within and between pas-
ture production periods, fertility and productivity were as-
sumed as given. Now they can be removed, but we shall as-
sume that the patterns of production with respect to varia-
tion originating with weather can be normalized, thus giving
a set of expectations which correspond, in a sense, to the
expectations of the entrepreneur at the beginning of the
planning period.

Pasture Accounting

Fixed cost for using the land by any crop in the usual
accounting procedure is assumed to be the present rent value.
When once determined on the market or by calculations, the
usual practice is to extend that price into the future at a
constant value as long as prices of farm products remain
constant. Such a procedure leads to exploitation of the land
resources because the value, based on the usual patterns of
production, encourage the tenant of the land to extend the
pattern of production on the exploitative side. Thus, if
the land charge is based on the common practice of a four-
year rotation, the tenant is tempted to use a three-year
rotation.

Such an accounting procedure will discourage pasture
production because of its failure to account for productivity
and natural fertility changes which are closely associated
with land use. For level land the significance of a variable
land charge according to use may be insignificant. However,
for land of greater slope, the significance of the difference
in actual land cost increases in proportion greater than the
proportionate increase in slope. Therefore, an accounting
system which entered on the cost side that amount assignable
to soil loss would more accurately portray the true condition.\(^1\) The idea here corresponds to Keynes' "User Cost" concept. User cost as defined by Keynes is, "simply the equivalent of the current disinvestment involved in using the equipment"\(^2\) or, "the reduction in the value of the equipment due to using it as compared with not using it."\(^3\)

If the effect of different cropping systems on the productivity and natural fertility can be determined correctly, and translated into cost, the costs for certain crops on land subject to erosion will be greater than the usual balance sheets show. Such a "land cost" will not change the slope of the supply curve but will change its relation to the total revenue curve.\(^4\) Figure 12 illustrates the differences.

\(^1\) Such a system is fraught with difficulties. Assigning values for varying slopes, of varying length, of varying soil types, and of varying depths of top-soil in a world of varying notions of interest rates and the multitude of ways for reducing soil loss, confronts the researcher with an almost impossible task. This does not mean that the researcher should "do nothing about everything." An intelligent approximation is better than closing one's eyes to an obvious truth.


\(^3\) Ibid., p. 70.

\(^4\) Some depletion of the soil fertility could occur in addition to erosion effects because of crop removal and other physical relations but the effect would not cause any significant change in the slope of the total cost curve.
Fig. 12. Total Cost and Total Revenue Curves for Two-Year Rotation on Two Grades of Land.

If two homogeneous soils are chosen, but of different slopes (3 and 12 percent are suggested in Figure 12), and applied the same input cost to both, for a two-year rotation of corn followed by small grain, the total cost curve (TC) might be as TC₁ and TC₂. If "land user cost" are added, the total cost curve might appear as TC₂ and TC₄, indicating what is profitable (difference between total cost and total revenue, TR) by one accounting system is not profitable by the other.
Entrepreneurs in making their production plans naturally consider such a system. The extent to which they abide by it is largely dependent on their present value of future earnings. The analysis of output problems in this paper will use in principle the "land-user cost" concept.

Output of Pasture

Concern with optimum output levels for pasture production immediately raises the question of the elasticity of the production curve and how it compares with other crop production. Comparison of the production response of additional inputs to pasture and to other crops cannot be made because of the lack of data. In the absence of such information the most logical hypothesis is that the production response is similar to related crops.

All studies observed, for specific inputs, on the comparative yields of forage for pasture and for hay indicated higher dry-matter yields when the forage was harvested as hay. 1 The yields from the pasture experiments at Kentucky 2 indicated favorable comparison with the three-year rotation of


2 Explained in connection with Table 2.
corn-wheat-mixed hay;\textsuperscript{1} grain and hay yields for the thirteen year period, 1936-1948 inclusive, averaged 1925 total digestive nutrients per acre while the bluegrass pasture for the same period averaged 2310 FCE's. Logically, the pasture yields in the Bluegrass Region can be greater than the average of the three-year rotation when inputs and plant mixtures are optimum because the growing season for pasture is longer and pasture can recover within the same season from unfavorable weather conditions.\textsuperscript{2} If this is true, and the entrepreneur is able to secure approximate constancy in available forage within production periods, then the competitive position of grain crops is at a disadvantage. It is also possible that the elasticity of the pasture production curve may be less at the lower input levels and greater at the higher input levels than for other feed crops. The effect of such a relationship would discourage pasture when the ratio of input-output prices is small and encourage it when the ratio is large.

The output of pasture forage from a given acreage may be considered as a function of: (1) weather conditions, 

\textsuperscript{1} See Table 6 for yields. This experiment received four tons of stable manure once in the rotation. The pasture experiments received no treatment.

\textsuperscript{2} While this may be true, farmers may not be able to utilize the forage effectively because of inability to secure constancy in pasture output.
(2) topography, (3) soil type, (4) inputs of soil nutrients, (5) the plant population, and (6) grazing management. There are numerous other variables, which under particular conditions would be of major importance in determination of the economic level of output. However, on the whole the above are the most important in the cost structure of producing pasture forage.

At the outset of each planning period the entrepreneur is faced with the task of combining the above variables into a system which maximizes the stream of outputs for the pasture production period. He must assume some sort of a normalized weather pattern for the forthcoming period. Topography and soil type are given to him by nature and, except for employment of certain engineering practices, they are not subject to human manipulation. When the entrepreneur knows the production response from the variables (4), (5), and (6) for each defined soil type, topographic class, and weather condition, he can begin to make specific plans. Diagrammatically, the probable relations can be shown if all

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1 Plant population as used here has two dimensions; the number of pasture plants per given area, e.g., per square foot, and the proportion of the plant population composed of legumes. Legumes serve to favorably affect the yield and quality of the vegetation. Using the term "plant population" in this capacity assumes that an index of the two dimensions can be developed by production technicians.
variables are fixed except nutrient inputs and plant population.\(^1\) The entrepreneur at the beginning of the planning period may visualize a set of production relations for each slope class similar to those shown in Figure 13.\(^2\) The \(x_1\) axis measures the plant population input and the \(x_2\) axis, the nutrient inputs. For poor weather conditions he might expect a set of product contours resembling the MM contour and for good weather conditions he might expect a set corresponding to QQ. The contours QQ and MM explain the nature of the production surface in the good and poor years; in the good years the marginal productivity of additional inputs of soil nutrients is greater than in the poor years, indicating that soil nutrients are relatively more important in good years and relatively unimportant in poor years.\(^3\) Another condition

\(^1\) To simplify the analysis, soil type could be expanded to soil series within a region; topography could be handled as slope of classes, e.g., 0-3 percent, 4-6 percent, etc., weather conditions could be classed as gradients in a range from poor to excellent.

\(^2\) Soil type is omitted here because on most farms the slope class will in most cases also define the soil type. When this is not true an additional set of production relations can be analyzed for each slope class within each soil type.

\(^3\) This relation is borne out in actual conditions; during drought conditions addition of fertilizer has very little effect; more important is the choice of pasture plants to cope with a scarce supply of soil water. (e.g., deep-rooted plants).
Fig. 13. Iso-product Contours for Good and Poor Weather Conditions.

Apparent from the production contour is the higher marginal rates of substitution of $X_2$ for $X_1$ in the good years. This is shown by the greater convexity of the product contours.

If the objective of the entrepreneur is to maximize output and to minimize variation, he may choose the combination of inputs where the highest product contours from the poor-year surface (QQ) intersected (within the competitive range of QQ) the contours of the good-year production surface.
If the weather conditions were opposite from the expected, the tree would be on a lower product contour. In the weather conditions were opposite from the expected, the contour of the tree would be as indicated by $F$. In other case, the ratio of products were the same as $F$, then the contour on the other hand, if we knew that $F$ were the blue contour, we could be optimum. Then the input computation shown by $F$ would be optimum. The year and if represented the ratio of products for $F$ and were constant that $F$ were the line contour for the contour...
certainty on the scale lines of either QQ or MM. 

The reason for water control is to get a production response from $X_1$ and $X_2$ as suggested by the QQ contour, where the scale line on the production surface rises rapidly (Figure 13). We can demonstrate the effect of water control on the production surface, and the method of determining its profitability in the short run, if we begin with the contour MM and by various methods add increments of water control; the resulting pattern will be a higher contour at each combination of $X_1$ and $X_2$ rotated clockwise in the direction of QQ. If each contour line represents the value of the product less the cost of water control, then an iso-cost line (for $X_2$ in terms of $X_1$) and the scale line will tell the extent that water control is profitable when weather conditions produce the curve MM.

Measures to control the supply of soil water, for the most part, are associated with long-time investments. Complete control is costly, in fact, very few farms in the humid

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1 The variation as indicated is still great with an output range of 1000 to 4000 but any other combination would make it greater or put the firm on a lower product contour if weather conditions were opposite to the planned input combination. Any point to the left of $\bar{c}$ (toward the $X_1$ axis) on the MM contour would put the firm on a lower contour for a good year; any point to the right of $\bar{c}$ on the QQ contour would result in lower contour for a poor year; and, any point to the right of $\bar{c}$ on the MM contour would result in a higher contour for a good year, thus, increasing the variation. (A tangency point on the MM contour to the right of $\bar{c}$ is not likely to occur because of the slope).
provide a substantial price to producers by creating a market for wheat that is not used for feed needs. This reduces the value of wheat in the market, leading to a glut of wheat and storage problems.

Another problem is the inelastic demand for wheat, which leads to price fluctuations. The demand for wheat is very sensitive to changes in supply, and small changes in supply can lead to large changes in price.

To illustrate the difference between the probable differences in value of wheat over time by comparing assertions, knowing the information about the firm, and assessing the data, we can determine

the extent that market control by producers (e.g., Figure 2) can be used to determine the regions that practiced general farming have experienced it.
efficient utilization of harvested feeds. Winter pastures, according to the logic of this writer, are economically sound when they occur as a joint product. As a single product the cost relative to output is too high to compete with harvested feeds.
The value productivity of a unit of pasture forage for any day, as a substitute in the feed rations for livestock, depends upon four classes of variables: (1) the types of livestock and their products, (2) level of feeding and proportion of total feed supplied by pasture forage, (3) the quality of the pasture forage, and (4) the prices for factors and products. While these variables account for the value productivity of a single day, the entrepreneur is interested in maximizing the value productivity, not only for one day, but for all the days during the pasture production period; therefore, equalizing the value productivity of pasture forage for one day with the subsequent days is an important part of maximizing returns.

The marginal rates of substitution of pasture forage for concentrates and harvested forage, as affected by the type of livestock, differ first, between grain-consuming and roughage-consuming livestock, and second, within the roughage-consuming group depending on whether the product is meat or milk. Moreover, the rates of substitution are affected by the level of feeding and the proportion of the total feed supplied by pasture forage, in that for a higher level of feeding the proportion of total feed supplied by concentrates is greater, resulting in a decrease in the marginal
rates of substitution of pasture forage for concentrates. Also, when the level of feeding is low a higher proportion of the total feed is utilized for body maintenance than when the level of feeding is high. Quality influences the value productivity of pasture forage in that an increase in the index of quality increases the efficiency of feed utilization. The proportion of total feed supplied by pasture forage is considered in the discussion that follows.

Pasture Forage as a Substitution in the Feed Rations of Livestock

Pasture forage, in the previous sections has been considered as a product, however, in the present analysis it will be regarded as a factor which produces livestock meat or livestock products. Livestock output as a product is shown by the production function:

\[ Y = f (X_1, X_2, X_3, X_4, X_5) \]

where \( Y \) is the livestock output; \( X_1 \) is grain; \( X_2 \) is protein feed; \( X_3 \) is harvested forage; \( X_4 \) is pasture forage; and \( X_5 \) is equal to all other production factors (labor, capital, etc.). Pasture forage, \( X_4 \), is a technical substitute for any one or all of \( X_1, X_2, \) and \( X_3 \). The degree that \( X_4 \) is an imperfect substitute for \( X_3 \) cannot be determined (by this writer) when all other factors are held constant, however, a likely hypothesis is that they are almost perfect substitutes. One of
the greatest difficulties, in determining their substitut-
ability for each other is in making certain that the feeding
qualities of the respective forages are identical. For this
analysis we will assume that the product contour resulting
from these two variables are straight lines. As perfect
substitutes the entrepreneur ascertains the cost of each one
and chooses the cheapest. When they are fed in combination,
under these conditions, it is because one supplements the
other.

On the other hand, when pasture forage is substituted
for harvested forage less concentrates are needed to produce
the same output. The supposed effect is shown in Figure 14
when a constant quantity of forage for forage-consuming live-
stock is assumed. The hypothesis suggested by the model
are: first, that pasture forage substitutes for both grain
and protein supplement but proportionally more for protein
than for grain, thus, the marginal rates of substitution of
grain for protein supplement are greater when pasture forage
is fed than when harvested forage is fed; second, that the
effect on the curvature of the substitution curves is to
cause a tendency toward flatness, indicating that the com-
plementary effect of protein is less when pasture forage is
fed.

Suppose the product contour MM represented the substi-
tution curve for protein supplements and grain in the
Fig. 14. Iso-product Contours to Explain Protein-Grain Substitution When Harvested Forage and Pasture Forage are Fed.

Livestock ration when harvested forage is fed: NH may represent the substitution curve to produce the same output when pasture forage is fed. When the cost ratios for protein and grain are \( a_1 \) and \( a_2 \) (same ratio), \( CF \) of protein and \( FC \) of grain would be fed for the harvested forage case, and \( CD \) of protein and \( DJ \) of grain would be fed for the pasture case. Therefore, changing from harvested forage to pasture forage reduced the protein requirements proportionally.
more than the grain requirements.

If the cost of grain declined relative to protein supplements (due to a drop in the price of grain or a raise in the price of protein, while the other remained constant) as indicated by the price ratios \( \frac{pp}{pp'} \) and \( \frac{pp''}{pp'} \) (same ratio), the optimum proportions of concentrates, when harvested forage is fed, would be 05 of protein and 35 of grain. On the other hand, the optimum proportion when pasture forage is fed would be 90 of protein supplement and 65 of grain. The indicated sensitivity caused by a change in relative prices when pasture forage is fed is borne out in the real world by farmers' reactions similar to those described above.

After an evaluation of the separate effects of pasture forage on the utilization harvested forage, grain, and protein supplements, we can generalize the broad relationships and indicate the effects of pasture forage on scale of enterprise (Figure 15). The iso-product contour, \( NN \), describes the substitution curve for harvested forage and concentrates; \( NN' \) shows the substitution curve of pasture forage and concentrates. (Pasture forage supposes measurement on an air-dry basis, and both curves are for the same livestock output level). A comparison of the contours (\( NN' \) and \( NN \)) indicates that the marginal productivity of concentrates is less when pasture forage is fed than when harvested forage is fed or, stated alternately, the marginal rates of
Concentrates $X_1 + X_2$

Forage input $X_3$ or $X_4$

Fig. 15. Comparison of Iso-product Contours for the Same Level of Livestock Output When Pasture Forage is Fed (NN), and When Harvested Forage is Fed (MM).

substitution of pasture forage for concentrates are greater than the marginal rates of substitution of harvested forage for concentrates.

Given the technical rates of substitution and the ratio of prices for the input variables (concentrates and pasture forage, or concentrates and harvested forage) the most profitable combination can be determined by equalizing the rates
of substitution and the ratio of prices for pasture forage and concentrates or harvested forage and concentrates. In addition to the most profitable combination of forage and concentrates the firm will want to determine the optimum scale. The optimum combination and the optimum scale are determined from the scale line which intersects each product contour where the marginal rates of substitution are equated with the ratio of factor prices.\footnote{The method is described in detail in connection with Figure 6.} If a pound of air-dry pasture forage costs the same as a pound of air-dry harvested forage the scale line on NN will lie to the right of the scale line on MM and the optimum contour, indicating scale of enterprise, will be higher.\footnote{The relationships are generalized in Figure 15. They are explained in greater detail when the particular classes of livestock are discussed.} Thus, the ratio of concentrates to pasture forage will be less than the ratio of concentrates to harvested forage. These generalizations are evident when we consider $ss$ and $st$ as representing the ratio of prices when a pound of air-dry pasture forage costs the same as a pound of harvested forage. The tangency point on NN is $H$ and the tangency point on MM is $J$ where the marginal rates of substitution and the ratio of prices are equal; therefore, the scale line for pasture forage will lie to the right of the scale line for harvested forage, indicating that the proportion of concentrates to forage would be less when
pasture forage is fed than when harvested forage is fed.

A more realistic situation is where a unit of pasture forage is less costly than a unit of harvested forage; then the scale line will lie farther to the right and the optimum scale will be on a higher contour. The optimum combination of pasture forage and concentrates because of lower cost for pasture forage, relative to harvested forage, will cause the firm to rely more heavily on pasture forage than it would if harvested forage were fed. When \( \frac{PP}{FM} \) represents the ratio of concentrate costs to pasture forage costs, the optimum combination of pasture forage and concentrates is at point \( K \); for the output \( XM \) the firm will feed \( 0X \) of concentrates and \( XM \) of pasture forage. If \( J \) on the \( XM \) substitution curve represents the optimum combination of harvested forages and concentrates and the optimum scale for the existing product prices, then the optimum scale for pasture forage utilization will be shown on the scale line, \( TT \), on a higher contour where the total cost of concentrates and pasture forage is equal to the sum of the costs of \( CC \) concentrates and \( CJ \) of harvested forage.

Supply Effect on Pasture Utilization

The discussion of pasture forage production was, for the most part, based upon the postulate that a large output of forage, constant in supply and nutritive value established
the ideal for livestock utilization. Although the physical "ideal" may be a maximum pasture output distributed evenly throughout the season, it may not be economic. Therefore, the problem of utilization during the pasture production period should be examined for the conditions of constant supply and variable supply. Unless indicated otherwise, the discussion in the subsequent sections will be concerned with the actions of the firm at the beginning or during the pasture production period.

Constant supply and constant nutritive value

Were the firm able to anticipate pasture yield and nutritive value with certainty (near), the task of allocating factors and choosing livestock products would be simplified. Resources would be allocated more efficiently since investment in flexibility would be unnecessary. Too, farm firms could more nearly attain the optimum scale of output (because of a more efficient employment of given resources and a willingness to employ greater quantities of resources). However, because expectations are uncertain, flexibility arrangements in the structure of the firm can be used to diminish the

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1 Constancy in supply and nutritive value is assumed to be possible by altering the time of production by certain practices (choice of plant mixtures, soil water control, fertilization, etc.) and by harvesting and storing the surplus of one period for use in a deficit period. Nutritive value would have to be balanced by varying the composition and quantity of concentrates.
output or product results in lower profits, the firm may be less willing to produce at a higher output level and to employ the re-

producers, as a result of increased investment, may cause the firm to produce at a higher output level. The firm will proba-

ble supply the market with a greater quantity of the product when there is a larger demand for the product. In gen-

eral, a larger demand for the product will lead to a greater quantity supplied.
the net income to the firm would be governed by the elasticity
of the demand curve and the number of firms stabilizing the
forage supply. Independent of the price and income effects,
social benefits will probably accrue when firms act ration-
ally to stabilize the supply of forage during the pasture
production period because of more optimal allocation of re-
sources.

Variable supply and variable nutritive value

In this section the relationships of livestock to pas-
ture production will be examined when the latter varies
throughout the production period. Decisions of two kinds
face the firm at the start of the pasture production period:
(1) long-run adjustments, and (2) short-run adjustments.¹

Before considering the short-run decisions the entrepreneur
usually determines whether any long-run changes are economic.
From previous transactions and production processes, the firm
possesses a collection of machinery and equipment, storage
facilities, and certain products in process of production.

¹ The short-run as used here refers to the period within
which the physical plant is fixed, i.e., the overhead costs
are fixed. On the other hand, in the long-run all costs are
variable. It should be recognized that many long-run deci-
sions are made because of occurrence of a major unexpected
event. The economics for the short-run in this instance cor-
responds to the condition of minimizing losses whereby the
entrepreneur avoids complete failure by a long-run investment
(or disinvestment).
If the entrepreneur acted rationally in buying the above resources he would have equalized the marginal present value of future gains with the present marginal value of future costs so as to maximize the income stream.

The production decisions for the short-run involve two activities by the entrepreneur at the beginning of the pasture season: (1) the formulation of price and yield expectations in the year ahead, and (2) the formulation of plans consistent with his expectations, capital position, ability to undertake risks, etc. In formulating the production plans, the entrepreneur must decide whether to emphasize reduction of variability, or to adjust livestock output to fit the pasture production pattern, or to do both.

In undertaking the task of reducing seasonal variability, the firm must employ the least-cost methods first if it is to maximize profit; and add more costly methods until the marginal cost is equal to value of a corresponding reduction in variability. The costs may be of two kinds: alternative costs and cash costs.

The cash costs are items such as seed mixtures, fertilizer inputs, labor inputs, etc. These are relatively unimportant when compared to the long-run costs (harvesting equipment and storage facilities) and to the alternative costs. The alternative costs are the marginal value productivities of the competing resources in alternative employment. If
the marginal value productivity of the same resources in another use is considerably greater than for pasture and if the other 'use' can be employed without limit the value of a unit reduction in variability will be small. If restrictions are imposed on the quantity of resources (due to external forces or internal rigidity) that can be employed on a produced yielding higher marginal returns, then the value of a unit reduction in variability will depend on the proportion of available resources that are free for other employment.

Tobacco, in the Bluegrass, is a crop with high marginal value productivity for the resources employed but certain restrictions are imposed (government control) upon the quantity of resources (land) that can be devoted to it. When the marginal value productivity of resources employed in tobacco is large relative to alternative uses and the degree of employment is large the value of a unit reduction in variability of pasture production is small. After several decades of relatively good prices for tobacco, farmers tend to be interested in fitting a livestock program to tobacco and the natural production habits of bluegrass. The reason is that restrictions are imposed on the acreage to be used for tobacco but not on the quantity of resources that can be used on the allotted acreage. Consequently, farmers have increased greatly the resources devoted to each acre of
tobacco compared to precontrol days. The fitting of the livestock program to the production habits of bluegrass is generally considered as a low-cost method that requires a minimum of the resources that compete with tobacco.

There are a number of schemes for adjusting the livestock program to fit the normal production pattern of pasture forage. One method is to utilize the pasture as it is produced and then sell the livestock or move them to drylot feeding when pasturage is insufficient; another method is to choose the types of livestock whose demands for pasturage are similar to the average pasture production pattern. The major advantage of these methods is the low-cost of pasture forage production. The major disadvantage is that demand and supply conditions, because of the wide acceptance of the methods, may reduce the price margins so that in most years, the entrepreneur can expect only normal profits.

Decisions made necessary by the occurrence of a drought may be critical to the firms that have chosen to adapt the livestock program to the average pasture production pattern, because of the probable absence of flexibility arrangements in the pasture production program; instead, the livestock program is the flexibility arrangement. On the other hand, the firms that have made arrangements for a constant supply of forage (through selection of plant mixtures, fertilization, storing surplus forage of one period for use in a deficit
period, and perhaps control of soil water supply) can easily meet most drought by replacing the deficit pasture forage with harvested forage.

In the Bluegrass Region, generally speaking, the farmers have done very little toward providing a constant supply of forage for the pasture production period. Earlier analysis of the variability of bluegrass pasture yields showed that variation of yields from bluegrass pasture was large and that the variation within years was greater than between years. What actions can a Bluegrass firm take in event a drought occurs? If the firm has livestock for which only maintenance rations are needed, the problem is not as severe. Sheep fit the latter case, and to a certain extent beef cows producing calves are in the same category. Beef cows can draw on their body resources and produce milk for the suckling calf. In the case of dairy cows and fattening cattle, a drop in the feed supply to maintenance conditions results in a direct financial loss for every day of the feed deficit.

If the firm had perfect knowledge and knew the exact number of days a drought would prevail, it could sell the livestock at the beginning of the drought and repurchase them when it was over. 1 Without perfect knowledge as to the duration of daily loss in production, the firm would not sell its

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1 The writer recognizes that this would be an impossible solution if the drought is general because everyone would do the same thing.
In body wheat will keep the amount in production condition.

ditions or if the livestock area breeding stock, the reserve can be put in a drylot to be fattened sufficiently for market con-
time. In these instances, if they are fattened livestock they

get so that the livestock are carrying surplus grain at all

between would have lost. If we can plan the phase of daily

and paid for a certain phase of preparation with the money

passed satisfaction with such a deduction – stating that they

routines. The writer knows several farmers who have ex-

a fair chance in the production equipment or storage.

(2) Why we can sell the livestock. (3) He can decide to

can see the winter supply and replace it with purchased

February will not be too high in price, the entrepreneur

produce forecasts for winter, or (5) if the drought is local and

(continued)

At present, under this condition, the crop arrangement

The reversible possibility may exist here: (4) If the

reserves mentioned for winter for the current season. The

(1) he can use up the

and corn, and soybeans and feed soybeans he can choose one or more of the following:

feed with a drought and having no appreciable

615
In both instances resources would be misallocated and must be considered as the cost of safety.

Dairy Cattle and Pasture Utilization

Pasture utilization for dairy cows because of the reliance on forage holds an important place in the feeding program during the pasture production period. Moreover, dairy production differs from meat production in that the production of each day is measured or weighed, causing the entrepreneur to be more acutely aware of deviations from some expected normal than he would be if the production was recorded less frequently. Therefore, deciding the economical rate of daily output for any class of livestock with a continuous flow of product is fundamental.

Forage utilization as related to other factors

A host of influential factors can cause variation in daily milk yield. The most important appear to be: (1) level of feed intake, (2) size of the cows, (3) stage in lactation, and (4) inherent production. Each of these will be discussed in relation to forage utilization on the following pages. For analytical purposes these variables, if appropriately stratified can be handled as though they were independent of each other. Significant work showing the effect of all four variables on milk production has been published
by Jensen and others. However, data showing the relationship of pasture forage in the ration is insufficient for complete analysis.

**Level of feed intake**

Some agricultural workers adhere to the principle that the only economic rate of daily output is the maximum output. Animal nutritionists who are proponents of this principle assume a straight line relationship between the input of feed for any day and the output for that or a later day to the point where the animal has no further capacity for consuming feed. The findings of Jensen and others proved diminishing returns to hold even when substitutions were made between feeds as the level of feed input was increases, e.g., the ratio of concentrates to forage changed with each increased feed input. This study was based upon a yearly output, but the same relationship should hold for a shorter period.

If it is assumed that all the feed consumed in one day is on the same or the next day converted to milk, the optimum ration for greatest daily profit can be determined. By using a period as short as one day, nearly all costs except

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2. Ibid., p. 19.
feed and slight variation in labor and marketing costs due
to differences in outputs are, in a sense, fixed. Also by
using milk as the product, the going price for the day can
be used as the value of the product. By simplifying the
case in this manner the optimum ration for any output can
be determined when the entrepreneur knows the technical
rates of substitution of the feed inputs, the outputs that
result from each input combination, and the prices for the
product and factors. To illustrate, assume a production
surface with concentrates as a factor on the Y axis and
forage on the X axis. The iso-product contours will re-
present the different levels of attainable output for that
day with the corresponding inputs. Each contour of an iso-
cost map (straight lines and on the same diagram) represent-
ing the ratio of factor prices will be tangent at some point
on a product contour. From the resulting scale line, the
optimum output and optimum combination of concentrates and
forage will be determined and equilibrium conditions will be
met (Figure 6). The scale line will be near the X axis be-
cause of the physical necessity for proportionally less bulk
in the ration as daily output is increased. In other words,
the marginal rates of substitution of forage for concentrates
diminish, proportionally, as larger daily outputs are real-
ized. As the daily rate of output is increased, the total
cost of the ration will increase faster than total feed in-
puts because of the changing proportion of concentrates to
forage; concentrates, the more expensive, increase faster than forage. Consequently, the increasing cost feature alone may be sufficient to prove that the optimum ration is not the one that produced the maximum daily output — even though the physical input-output relationships are thought to be a straight line.

Changes in milk or feed prices react on production in the customary manner. An increase in the price of milk without a change in the price of feed, or a drop in the prices of feed without a corresponding drop in the price of milk, will cause a higher daily output to be more profitable. A drop in the price of one factor will cause more of that factor to be used and an increase in rate of daily output. An interesting possibility develops if economical rate of feeding is near the maximum physical intake and the price of forage drops. Physical limitation may forbid greater consumption of forage without a drop in rate of daily output. In this instance the entrepreneur may take advantage of the drop in forage price by increasing the concentrate portion of the ration and produce on a slightly higher contour.

Size of cows

From published research on feeding dairy cows, the effect of size can be generalized; the larger the dairy cow within reasonable limits, the greater is her capacity for a large daily output disregarding differences due to stage in
lactation, inherent production, etc.\(^1\) Exception is noted by Autrey and others in case the cow obtains all her sustenance from harvested forage.\(^2\) Statistical analysis indicated that unexplained differences in output were greater than differences due to size of cow or quantity of feed intake. The same analysis, however, showed that when concentrates were fed a positive relationship existed between cow size and milk production. The comparative size of cows does not raise any particular problems with respect to pasture forage utilization if appropriate stratification methods are used to account for the differential due to size.

**Stage of lactation**

Daily production of milk is closely related to the stage of lactation. The peak in daily production for one lactation is usually reached in the second month. After that time, rate of daily output declines constantly.\(^3\) (Table 12, Appendix). With the decrease in daily production the

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1. Largeness in dairy cows refers primarily to size, and capacity in the sense of ability to consume large quantities of feed. It is associated with weight but not with surplus flesh.


efficiency of feed utilization also declines. The concentrate portion of the ration is apparently more effective for increasing milk flow in the early period of the lactation.

One method suggested by research to lessen the decline is to feed larger quantities throughout the lactation period than is suggested by the Standard.¹

The foregoing discussion suggests that a production surface with concentrates on the Y axis and forage on the X axis will change with each change in the lactation period. If we visualize a production surface on the first day of lactation and note the change on each successive day with all other factors constant (including the ratio of factor prices), a likely hypothesis is that the scale line on each successive day will shift a little to the left (toward the Y axis) for the first two months and then reverse the direction and shift to the right (toward the X axis) and in the latter stages of the lactation period the scale line may lie to the right of its original position. Of greater importance than the shift of the scale line is the tendency toward less steepness of the production surface as daily milk production declines because this means an increase in feed relative to output. The probable effect of lactation on the production surface is shown in Figure 16. At the time of

¹ The Standard refers to the rules developed from research studies as to the requirements for maintenance and daily output. Writers refer to the Morrison standard and Keeney standard.
freshening the supposed daily output is 50 pounds ($\text{HH}$); at the end of two months the daily output might be 60 pounds ($\text{GG}$); and at the end of seven months the output might be 30 pounds daily ($\text{KK}$). If the price ratio of concentrates and forage were constant throughout the period the optimum daily ration for $\text{HH}$ is 03 of concentrates and 58 of forage; for $\text{GG}$ it is 0.5 of concentrates and 0.8 of forage; and for $\text{KK}$ it is 0.1 of concentrates and 0.4 of forage. The marginal rates of substitution of forage for concentrates decrease.
for the first two months and then increase throughout the remainder of the lactation indicating that proportionally more concentrates would be fed for the first two months and afterwards proportionally more forage would be fed. The relationships brought out above pose some important questions relating the time of freshening to pasture production. If the supply and nutritive value of forage are constant throughout the pasture production period, the best time of freshening (economically speaking) is governed by price relations between the factors and the product. An entrepreneur, acting independently of other entrepreneurs, would plan his breeding program so that the lactation period begins when the difference between product prices and factor prices was expected to be the greatest.

If the entrepreneur expects: (1) the peak output of pasture to occur in the spring and a deficit supply to exist in the summer, and (2) lowest factor costs and product price in the spring and higher prices in the summer, the sum of the daily net revenues will be maximised if the lactation period is timed to correspond with variations in forage production. This arrangement has the effect of combining grass effect (stimulant) and the lactation effect. However, it should be

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This analysis assumes that body weight does not change during the lactation. Apparently, many dairymen permit body weight to decline in the early months of the lactation and then feed to increase it in the latter months. If this is the best way, then the variation in the daily ration would not be as great as indicated in Figure 16.
pointed out that the alternative methods of utilizing or storing the surplus forage may give greater returns from alternative systems.

**Inherent productivity**

Cows with greater inherent productivity are more efficient in converting feed into milk than cows of lower ability. This fact is evident from research studies. With concentrates and forage on the axes of the conventional three-dimensional diagram as previously described, the product contour for the daily output of cow producing 5,000 pounds of milk annually may be similar to KK in Figure 16. On the other hand, the contour of the daily output of a cow producing 10,000 pounds annually may appear as OO. This leads to the conclusion that for any ratio of factor prices the optimum daily ration for a 10,000-pound cow will include a higher proportion of concentrates to roughage than the optimum ration for a 5,000-pound cow.

The writer has been unable to find research studies in which all causal factors previously mentioned were evaluated in order that a pure concentrate-forage production surface could be shown. This may be due to failure in finding the right experiment.
Beef Cattle and Pasture Utilization

Pasture forage, in the Bluegrass Region, is made available for off-pasture-season months by under-utilization during the pasture production months, leaving a residue on the land for consumption after forage growth has stopped.\(^1\) Farmers in the region justify the practice of under-utilization because: (1) the sacrifice in output is less than the cost of producing, harvesting and feeding a hay-type forage; bluegrass is not a hay-type grass, but grows naturally without treatment, (2) to minimize the labor input for forage production and utilization, eliminates competition with tobacco for the resources, and (3) to under-utilize the pastures is a form of insurance against drought conditions. As long as these arguments prevail, beef cattle are naturally adapted to the Bluegrass Region.

Beef cow herds

Pasture forage to the beef cow herd is a complete substitute for all feeds during the pasture production period. To feed harvested forages is not considered during the pasture

\(^1\) Actually some growth takes place during the winter months. Research studies show that growth occurs whenever the temperature is as high as 42° F., for a few days. Based on the maximum temperature for the 30-year period 1920 through 1949, a mean temperature of 42° F., or above was estimated to occur for about 25 percent of the days between November 1 and March 31.
period except in the case of an extended drought to avoid starvation conditions. Therefore, pasture utilization problems for the beef cow herd bear a closer relationship to over-all farm organization than to concentrate-forage substitution. Consequently, discussion will be reserved for the section on the over-all farm production plan.

Based upon expected nutrient requirements for maintaining a beef cow for one year and for raising a calf to weaning time, Bluegrass farmers depend upon pasture forage to provide approximately 78 percent of the total digestive nutrients consumed.\(^1\) The pasture forage requirements are greatest for June through September (Table 13, Appendix).

**Feeder cattle**

A distinction between types of forage (pasture or harvested) are not made in the subsequent diagrams because the broad relationships are assumed to be similar to those described in connection with Figure 14, and the analysis would proceed as described there. By following this procedure refinements can be made in the forage-concentrate relations.

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\(^1\) Cost studies indicated that about 3000 pounds of roughage, 100 pounds of concentrates and 311 days of pasture per cow represented the usual case in the Bluegrass Region. The product of this feed was 450 pounds of beef per cow per year. (.9 calf). Dept. of Farm Economics. Unpublished data. Ky. Agri. Exp. Sta.
performance have shown that the above determination is correct.

Taller scenes to the E. rain - on - scene or dry - up period, and the
intermediate scene to the all purpose period, and the
first period corresponds to the E. rain - on - scene, and let curves (Fig. 7)
during period projects transformation functions that con-
the first, second, and third scenes of the reader capture pro-
from a given input of feed the enterprise, during

be illustrated as in Figure 7.

period, and retardation period. The e. rain - on - scene and retardation
a rain - on - scene on intermediate growing and retardation
as the enterprise enters the second of one year the situation.
100 pounds to be harvested for market the following fall.
and of purchase in the fall, reader cattle marketed between 500 and
The plan most commonly found in the Okanagan region is to
there are many plans to grow end faction reader cattle.

Leaves
- problems, although basically similar, must be handled dif-
not be marketed for many months. The pasture utilization
is the ratio of market to dry - up output of not recorded and may
marketed cattle not revenue. On the other hand, when better
put when empirically the rank of determining the ration that
adaption. The determination makes and sells the dairy cattle.
dairy output to meet market conditions is an important con-
Determine the optimal dairy ration for a certain

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and economical, as long periods in the fattening stage are generally unprofitable. The main distinction between the first and second stage is in the source of feed and the corresponding cost of production. A small winter gain in weight is followed by a large pasture gain, but a large winter gain is followed by a small pasture gain.\(^1\) Pasture gains are less expensive; therefore the distinction is logical.\(^2\)

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2. The writer recognizes that under certain resource productivity conditions, pasture forage may not be less expensive.
The entrepreneur may choose the proportions of growth to fat as, RG to GR for the first stage. Such a decision will depend on his available feed supply, the size of the cattle, and the economic rate of daily output. For the intermediate stage he may choose, GL of growth and GS of fat and for the latter stage, TG of growth and FT of fat. On many farms the entrepreneur follows the practice of feeding to keep the daily output of growth and fat about constant for each stage. Thus, the changes in rations during any one stage are in quantity of feed rather than the proportions of the various feeds. Under these conditions the transition from one stage to another is made by changing the proportions during a short period of perhaps one week; thus, the break is fairly sharp. It appears logical to continually change the ration in very small amounts so that the transition from point A to point F is a continual process following the path A → B → C → D → E → F. Thus, the growth-fat relationship would be nearly optimum for any day.

The utilization of pasture forage for feeder cattle, in this analysis, will be discussed in relation to the intermediate and fat stages. At the beginning of the pasture production period, the entrepreneur formulates expectations with

1 Economic rate of daily output will be discussed later.
respect to the product price, five or six months in the future. The expectations will be for different attainable market grades at various selling dates. He knows from past experience that he may be able to raise the present market grade of his cattle one or two grades, e.g., from commercial to good or to choice. Each grade increase results in a higher price. The grade increase is associated with the final weight, which is influenced by the rate of daily gain between the present and the future selling date. As the entrepreneur deliberates about the future, he is conscious that interest on the investment and risks will be additional costs. Taking all these matters into consideration along with the availability of feed supply, the entrepreneur determines a present price for which he will sell rather than feed to a market date in the fall. This value, for our analysis, becomes the present value of today's output at the beginning of the pasture production period. However, final decision about the value of today's output is not made until the entrepreneur has considered the effect of different rates of daily gain. He may reason that an average of one pound and one-half daily gain will result in the grade "good", and an average daily gain of two pounds per day will result in the grade "choice". Therefore, the present value of each different rate of daily gain will have a different price.
Choice of the optimum average rate of daily gain for the future period may be determined when the prices of the factors, the technical rates of substitution of forage and concentrates, and the value of the product are known (Figure 13). The product contours for three rates of daily gain from a supposed production surface indicate: (1) that larger daily gains are obtainable only at a greater feed cost (diminishing returns), (2) that the larger daily output requires a higher proportion of concentrates to forage than does the lower daily output, and (3) that the range of substitutability of forage for concentrates at the higher daily outputs is less than at the lower rates of daily output. To maximize the daily net revenue assume that each contour has a different price per pound of gain as described above, then maximum net revenue is determined from the scale line (88). Finding the rate of daily gain for maximum net revenue also specifies the optimum proportions of concentrates and roughage to feed.

The analysis to this point assumed that the ratio of prices for the factors and factors to product was constant throughout the pasture production period. If the price relationship of concentrates to forage is expected to change, but only to the extent that it results in a different combination of inputs without affecting total cost, then the entrepreneur will plan to stay on the same product contour.
Fig. 18. Iso-product Contours to Explain the Effect of
Different Rates of Daily Gain on Substitution
Forage for Concentrates.

throughout the period. However, if the total cost is ex-
pected to change relative to value of product, the plan may
call for different rates of daily gain, depending on the re-
lative change. He may plan to equalize the marginal value
productivities of the factors over time. By holding the
value of product constant (arrived at by the method pre-
viously described) and given the production surface for rate
of daily gain, the changes in factor prices relative to pro-
duct prices may make an expected one pound per day most pro-
fitable for one period while an expected two and one-half
pounds per day will be most profitable for another period.

Experiments were conducted at Illinois to determine
the inputs of feed to raise the market grade of cattle when
fed in the drylot and when fed concentrates on pasture. ¹ The
data provided by this experiment were used to compare the
additional feed requirements for cattle of different weights,
on pasture and in the drylot (Table II). As might be ex-
pected, the gains at higher weights to secure a higher mar-
ket grade required more feed, thus the marginal productivity
of feed in terms of additional beef decreases as cattle be-
comes heavier. However, the marginal value productivity de-
creases less rapidly because of the increase in the product
value at a higher grade.

The validity of comparison in this study lies in the
similarity of rate of daily output. Many of the experiments
compared grain-on-grass with drylot conditions when the
cattle on pasture gained about one-half as much as those in
the drylot. When this situation exists the proportion of
the total feed used for maintenance was greater for the pas-
ture-fed cattle; thus, comparisons were difficult to make.

Ordinarily, the extent that entrepreneurs utilize pas-
ture forage for feeder cattle will depend upon: (1) the price
expectations held by the entrepreneur for each attainable

¹Animal Husbandry Department. Eighteenth cattle feeders
Table 11. Comparison of Feed Requirements for Drylot and Grain-on-pasture to Raise Fattening Steers to a Higher Market Grade. Illinois, 1946a

<table>
<thead>
<tr>
<th>Weight interval (lbs.)</th>
<th>Market grade at end of period</th>
<th>Feed fed per hundred-weight gained</th>
<th>Average daily gain</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Concentrates (lbs.)</td>
<td>Hay (lbs.)</td>
</tr>
<tr>
<td>Drylot</td>
<td></td>
<td>401</td>
<td>173</td>
</tr>
<tr>
<td>742-823 good</td>
<td></td>
<td>691</td>
<td>269</td>
</tr>
<tr>
<td>824-979 choice</td>
<td></td>
<td>954</td>
<td>306</td>
</tr>
<tr>
<td>980-1188 prime</td>
<td></td>
<td>1017-1202 choice</td>
<td>740</td>
</tr>
</tbody>
</table>

Grain-on-pasture

| 740-834 commercial     |                                | 304 | - | 2.95 |
| 835-1016 good          |                                | 454 | - | 2.93 |
| 1017-1202 choice       |                                | 740 | - | 2.09 |

Reduction of harvested feed by pasture

| First                   |                                | 97 | 173 |
| Second                  |                                | 237 | 269 |
| Third                   |                                | 214 | 306 |


aThe difference in market grade is attributable to the difference at the start of the experiment. The drylot group graded 'choice' at the beginning while the pasture group graded 'good'.

market grade at selling time; (2) the amount of available pasture forage; (3) the technical rates of substitution of pasture forage in the rations, and (4) the relative costs of feeds. Given the data suggested by the above, the entrepreneur
may determine the economical rate of daily output that maximizes returns to the resources.

Other Livestock and Pasture Utilization

Sheep in the Bluegrass Region obtain approximately 38 percent of their total feed requirements from pasture forage (Table 14, Appendix). They consume approximately one-third of their pasture forage between the first of November and the first of April. Most of the pasturage in this season is the surplus from the growing season, though part of it is obtained from fall-seeded small grain. Sheep are the ideal livestock for the Bluegrass Region because: (1) their requirements for feed correspond closely to the usual pasture production pattern; (2) their demands for attention do not compete with tobacco production; (3) they are housed in tobacco barns when the latter are not employed.

Pasture utilization problems in sheep production are related more closely to alternative resource employments. Therefore, they can be more appropriately discussed with the over-all production plan.

Although pasture utilization problems for hogs and poultry are of minor importance to Bluegrass farmers, some mention is made of them. The effect of pasture forage for both types of livestock is to change the marginal rate of substitution of protein supplements for grain. For the usual
production surface with protein supplements on the Y axis and grain on the X axis, the addition of pasture forage will cause the scale line to rise faster and to incline toward the grain axis indicating that when pigs are on pasture the marginal rates of substitution of grain for protein supplements are greater than when the pigs are fed in the drylot. Research done by Keith and others provided the data for the iso-product contours shown in the accompanying diagram¹ (Figure 19). The iso-product contours are for a 100-pounds gain for the weight interval of 75-130 pounds.

Pasture forage in this instance is a fixed cost against the ration of protein supplements and corn. The entrepreneur will view it as such at the beginning of the pasture production period where he is trying to decide whether or not to plan pasture forage for the hogs. Consideration of distance from water and feed may overshadow the value of pasture. If corn is two cents per pound and protein supplement five cents per pound, the optimum economic ration would be 16 pounds of protein supplement to 230 pounds of corn on rape pasture to produce 100 pounds of pork (Figure 19). In drylot the proportions would be 44 pounds of protein supplement and 212 pounds of corn; at the above prices the value

Fig. 19. Effect of Alfalfa and Rape Pasture on the Rates of Substitution of Protein Supplement for Corn in the Rotations of Hogs between 75-130 Pounds. Pennsylvania. 1940 and 1941.

Productivity of rape pasture is 88 cents per hundred weight of pork produced. If 20 hogs are fattened per acre with a total gain of 3500 pounds of pork the value productivity of an acre employed as hog pasture would be about $31.00. Such a figure ($31.00) is meaningful when the value productivity in alternative employment is computed.

\(^1\) Value productivity determined by amount of feed saved. Production specialists say that there will be fewer runts in a lot fattened on pasture and that the cost of sanitation will be less. These are added values (or reductions in cost) to be credited to the value productivity of pasture for hogs.
THE OVER-ALL PRODUCTION PLAN

In the preceding sections, the variation of pasture forage production within and between pasture production periods was suggested as the core of the economic problem in production and utilization of pasture forage. The variation within periods proved to be greater than between periods. The ideal pasture was described as the condition when the supply of pasture forage was maximum and, unless the livestock program demanded otherwise, was without seasonal variation. The ideal was not considered economically feasible in some cases and alternative measures were suggested. Output per acre was analyzed as a function of soil type, topography, weather, management, plant population, and yield increasing inputs.

Pasture forage was shown to be utilized as technical substitute for part or all of the concentrates and harvested forage. Substitution of pasture forage for harvested forage in the livestock ration was shown to be complementary to concentrates indicating that pasture forage has a higher marginal rate of substitution for concentrates than does hay. The conclusion was reached that when the firm has a supply of forage, constant in quantity and quality, it will have types of livestock that are continually producing a product.
The Character of the Production Plan for the Farm Firm

The production plan, as previously defined, is a schedule of inputs and outputs expected at some specific time in the future. Thus, each item (or entry) has three magnitudes — date, quantity, and value.\(^1\) Every firm has some kind of a production plan (or plans). The plan (plans) may vary from a sketchy mental outline to an elaborate recorded form.

If the future events of importance to the plan are fairly certain, the production plan will approach the elaborate case. If the future events are highly uncertain or if knowledge is expected to improve in a very short time, the production plan is likely to be simple and sketchy.

To analyze the farm firm from an economic viewpoint, it must be thought of as having at least two primary production plans, a long-run plan and a short-run plan.\(^2\)

The production plan is interpreted here in broader terms than by many writers. It is conceived as the operative plan to be followed in the future by the entrepreneur in the conduct of the firm's business. Presumably, the above definition does not provide for a method of financing the actions of the firm. However, farm firms attempt to adjust selling and buying dates so that they coincide. When this is not possible or is not economical, the firm may have a separate schedule for borrowing and repaying funds.

Long run is defined here to mean that all the factors are variable except entrepreneurship. Long-run plans, for most farm firms, consider land as a fixed factor. However, the exceptions are frequent enough to consider land as a variable. Short run is defined to mean that all factors in the major investment class are fixed. Thus, land, buildings, major machines, land improvements, and even family labor may be considered fixed to the firm.
long-run plan features the major changes that should occur in the structure of the firm at future dates. Items on the firm's business account classed as fixed costs must be justified in making the long-run plan. Certain events, which in the long run can be predicted from the frequency of occurrence in the past, e.g., droughts, are carefully studied to determine whether an investment is justifiable. A silo, a forage harvester, or an irrigation system are examples of investments which might be determined in such a manner.

Cyclical occurrences (such as livestock price cycles), family growth and needs, rates of progress, trends in technological development, individual preferences, and a multitude of minor, but sometimes important considerations enter into the scheme in formulating the long-run plan.

On the other hand, the short-run plan features the methods for attaining the projected changes as stipulated in the long-run plan. It is the operative plan in which the entrepreneur specifies the extent of employment of variable resources and the manner in which he intends to employ his fixed resources. While the long-run plan is important to the firm's organization, the short-run plan is of greater current interest.

When the individual farm firm makes the short-run production plan, it is aware that the physical output, as affected by weather conditions, appear more uncertain than
prices for products or factors. This is because prices are determined by industry action and the price level. A great staff of agricultural workers are constantly trying to evaluate the trend of events as they might affect price, and governmental programs are designed to reduce the dispersion of prices about some anticipated mean. When this information is available to the entrepreneur he has a fair knowledge of the possible range of prices and the likely skewness of their distribution. On the other hand, physical output may be affected by local weather conditions which probably have no visible effect on the overall supply conditions. In addition, the distribution of output about some expected mean appears as a normal distribution which eliminates the possibility of taking advantage of any anticipated skewness.\(^1\)

This analysis leads to the conclusion that flexibility arrangements for meeting uncertainties of physical output in the short run are of greater importance than those for meeting uncertainties of price.

On the other hand, in making the long-run plan the future prices for factors and for products appear more uncertain than output. The fluctuations in output from given resources over a number of years tend to be counterbalanced.

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\(^1\) The firm can inject certain features in the short-run plan which will result in a skewness of the probability distribution of output. For example, heavy fertilization will have some beneficial effect in case of a drought, but in good years it will have a greater beneficial effect.
causing normative expectations to be formed. The entrepreneur knows from past experience that the good and poor years due to weather will be randomly distributed about some mean. The future of prices, however, cannot be predicted from the past; the variables which determine the price cannot be predicted. Consequently, the firm is faced with a probability distribution of a probability distribution. To meet this situation the firm can, under normal competitive conditions, make more accurate forecasts of the future by considering the price ratios between products and between factors and products. The tendency towards consistency in cyclical movements provides some basis for anticipating price relationships. Another element in the uncertainty of future prices is the action of the government, since no assurance is given in the long run that its policy will be consistent.

The wide range of possible errors of expectation, inherent in the production plan, leads some entrepreneurs and agricultural workers to conclude that a plan for the farm firm is a useless expenditure of effort. Yet, if the farm firm anticipates only one change it must have some sort of a plan; the realistic case is that the firm anticipates many changes. Flexibility arrangements must be planned as a part of the production plan as they are difficult to add after the production process has been started. Therefore, the short-run production plan must be considered as a necessary
instrument of management, and it must be conceived as being subject to change at any time.

Factors that Cause the Firm to Plan to Operate at Some Level Other than Optimum

Of the many influences which cause the firm to plan to operate at some level other than optimum, in a historic sense, five are important enough to segregate for discussion: uncertainty of future events, indivisible resources, time, distribution of income, proportion of owned to borrowed equity, and preference for leisure.¹

Uncertainty of future events

When uncertainty is a feature of importance in the production plan (short or long run), how does it influence the decisions of the firm? First, areas, farm firms, products, and product combinations must be classified according to their position with respect to magnitude of returns relative to other areas, products, etc., and variability of the returns. Four classes are apparent: (1) high returns over time and high variability; (2) high returns and low variability; (3) low returns and high variability; (4) low returns

¹ The optimum plan, in the ex ante sense, is the one that provides adjustments to cope with the above influences. Thus, it may call for certain restrictions on the firm's actions which by traditional analysis were indicated to be uneconomic.
and low variability.\textsuperscript{1} The ideal combination from the viewpoint of the individual firm is high return and low variability; the untenable combination is low return and high variability.

Tobacco, before governmental control, was an example of high returns and high variability. Since the introduction of governmental controls it has shifted to the class of high returns and relatively low variability. The consequence of such a shift has been to capitalize the security of returns into the right to grow to tobacco, i.e., tobacco base allotment. Dairy production, in areas surrounding metropolitan centers, is an example of high returns and low variability. Here the security of high returns is capitalized into location, i.e., the land. Fruit growing in areas of low adaptability to fruit is an example of low returns and high variability. Sheep production, in most areas, is an example of relatively low returns and low variability. The existence of low returns and low variability is justifiable: (1) when the enterprise complements an enterprise of high returns and high variability, or (2) when a firm changes from the condition of low returns and high variability to low returns and low variability, and a higher alternative is not possible.

\textsuperscript{1} High and low returns are used here to correspond in a general sense to intensity in the use of capital and, more generally, in the use of labor.
Poultry in the mountainous areas exemplifies this latter condition.  

Typically, the actions and plans of the individual firm indicate a desire for high returns and low variability. What are the consequences? Economic logic indicates that the condition of high returns and low variability will tend toward moderate returns and low variability, because of the tendency, after some time, to capitalize the gains into the investment structure, or for prices to tend to decline relatively. Thus, other things being equal, profits will tend to diminish over time. When average returns are maintained at a high level for many years the firms probably have a location or monopolistic advantage which makes it possible for the firms, through collective effort, to affect some control over price and the variation in price. Irrespective of location, methods are available to the individual for controlling variability of output. This he accomplishes by flexibility arrangements or by sacrificing gains for a lower but more probable output.  

Thus, it is apparent that low variability in returns is attainable at a cost to someone (investment cost, cash cost or sacrifice cost). The final test for the individual or society is whether the gain from more optimal allocation of resources resulting from lowering the variability is greater than the

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Poultry is a low return enterprise in the mountainous area because production and selling costs are relatively high.
cost.

Relative returns and variability, and their relation to the overall production plan, can be shown diagrammatically (Figure 20). The case is for the entrepreneur at the beginning of the production period when he is making the short-run plan, or it might be the case in long-run planning when the entrepreneur is anticipating particular years. For the case of high returns and high variability for a particular product, prices may be expected to range from $P_2$ to $P_3$ about a modal price of $P_1$. Expected variability of the marginal costs may vary about the modal cost curve $C_1$, from $C_3$ to $C_2$. Variation of net returns for any output, therefore, are indicated by the variability of product price and of marginal cost. For the case of high returns and low variability, price may be expected to vary from $P_4$ to $P_5$ about the modal price, $P_1$. Marginal costs for the same conditions may be expected to vary from $C_5$ to $C_4$ about the modal cost, $C_1$. Models

1 In making the long-run plan the entrepreneur must evaluate the future in terms of particular periods (years). In discounting future incomes and costs to a present value he will make some estimate of the individual years.

2 Price variability may be conceived as a function of the general supply and the general price level. To the firm it is a horizontal line. The probable price estimated by the entrepreneur will be influenced by his interpretation of the forces governing price.

3 Variability about an expected modal marginal cost curve is a function of uncertainty of weather conditions and uncertainty of factor prices.
Fig. 20. Expectations of Variation in Prices of Product and Marginal Costs at the Beginning of a Production Period.

for the cases of low returns and low variability and for low returns and high variability may be thought of as the same general pattern, but the elasticity of the cost curves will probably tend toward greater steepness.
The ideal condition is expressed by the marginal cost curves, $C_2$ and $C_6$, and the price curves, $P_4$ and $P_3$. This is the ideal condition because product prices would not fall below $P_4$ from the modal price $P_1$, while they could rise from $P_4$ to $P_3$; the firm could realize large windfall gains without suffering great windfall losses. Moreover, the narrow range in possible marginal costs ($C_6$ to $C_2$) at a high output would keep the firm in a favorable position to realize the windfall gains. The ideal with respect to the cost curves could be improved even more if the probability distribution of occurrence were skewed to the right so that nearly all deviations from the most probable cost curve would put the firm on a lower cost curve (move to the right). In the same manner, the price conditions could be improved if the firm could expect a probability distribution of possible prices with the minimum at $P_4$, the modal price at $P_1$, and the maximum at $P_3$, or higher. As in the case of marginal costs, nearly all deviation from the expected modal price would give the firm a higher price. Of course, the ideal as described, if assured to the firm, would, unless monopolistic conditions existed, raise the industry supply and lower the price. The attempt by the government to restrict supply of tobacco by acreage reduction with a minimum floor price is a fair example of satisfying this ideal condition. Expanding demand and reduction in acreage have caused prices to remain at a
high level.

In absence of the ideal conditions, the willingness or ability of the entrepreneur to take chances will influence greatly his preference for high returns and high variability versus high returns and low variability. The entrepreneur who has confidence in his ability to outguess his fellow producers, and/or in his ability to influence the skewness of the price and cost distributions may prefer the condition of high returns and high variability. In other words, he probably believes he can realize the rewards of windfall profits more often than the pitfalls of windfall losses.

He is likely to prefer to specialize in two products of the high returns and high variability class. As evidence, before governmental controls were put on farm products many entrepreneurs specialized in tobacco and heavy feeder cattle. For both enterprises, windfall profits when they occurred, were large. With such a combination, the entrepreneur was betting that the probability of a simultaneous occurrence of windfall losses for both products would not occur before he had secured a firm control of his resources. For the above enterprises the proportion of variable to fixed costs for both products was large, which made it possible for the firm to adjust quickly to minimize losses.

The entrepreneur who has confidence in his ability but tends to act with caution may prefer a product with high
returns and high variability, but he may also prefer a second product with high fixed costs relative to variable cost. In this manner if a loss occurs, the income from the product of high fixed costs may be sufficient for providing family needs and avoiding the loss of control over his resources. Sheep flocks and beef cow herds are examples of enterprises with high fixed costs relative to variable costs. They also provide relatively low returns with relatively low variability. Tobacco and sheep, or tobacco and beef cow herds, or tobacco, sheep and beef cow herds predominate among the combinations found in the Bluegrass.

The entrepreneur who has only little confidence in his ability will probably prefer the "more sure" conditions and forego the likelihood of large windfall profits. Therefore, he may choose to specialize in a single product of high returns and low variability because of the security and safety associated with it. Also, he will be more willing to increase his fixed cost structure relative to variable costs; he will tend toward housing structures and types of equipment with less and less flexibility. As this occurs the firm becomes more and more committed to a specialized type of production, such as dairy cattle.

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1 The writer has heard many farmers say, "Few people get rich with sheep but rarely do they go broke."
The entrepreneur whose alternatives are limited to low returns and low variability can only secure large total returns if he can obtain at low cost large quantities of either labor or land resources. Government owned range lands for sheep production are an example of surplus land resources. Areas of surplus population which tends to be immobile, such as is found in the mountainous areas, are examples of surplus labor resources. In either of the above examples high total returns are secured by employing the surplus resources which do not have alternative employment.

Indivisibility of resources

Indivisibility of resources oftentimes causes the firm to operate below or above the point where over-all marginal costs and marginal revenue are equalized. Hiring of productive services and cooperative ownership, as a solution to indivisibility, increases the probability of strain on human relations. This causes the entrepreneur to sacrifice gains for sociological reasons. Indivisibility is an important problem to firms in pasture producing areas because stabilizing supply and nutritive value of the pasture usually requires investment in harvesting equipment, storage structures, and possibly irrigation. Low average costs are possible on these items when the firm has sufficient employment to justify the larger units. Small firms, or firms not requiring
power equipment for other types of crop production experience difficulty to provide sufficient machine employment to include the more efficient types in their long-run plan. Consequently, they are forced to resort to the use of smaller machines and more costly means of handling the forage, or they may under-utilize the pasture surplus, leaving it for consumption in a later period. When the surplus forage of one period is not utilized or when the firm's resources are under-employed (low livestock population relative to acreage), the firm may feel that additional inputs to increase the productivity of pastures are uneconomical. The surplus resources would be further unemployed if purchased feed were substituted for a surplus product that otherwise has no value. Consequently, the problem of indivisibility is frequently acute in the above described firms.

Time distribution of income and leisure preferences

Needs for a monthly income or for a growing family may cause the firm to have preferences for income distribution within years and between years which do not correspond to optimum resource allocation. Leisure preferences frequently play a part in the production plan. Proportion of owned to borrowed equity affects the actions of farm firms in many ways, causing it to adopt a policy which it believes is best for keeping control of the resources. All of these causal
factors and probably others are important to some degree in the production plan of any individual firm.

The Ideal Pasture Program and the Production Plan

The ideal pasture production program was described as minimizing the variation in supply and nutritive value of the forage within and between pasture production periods, having a high output level consistent with cost price relationship, and having an acreage devoted to pasture so that the income stream was maximized. The second of the above ideal conditions, viz., level of output, is of importance but has been sufficiently discussed in previous sections.

Without control over variability in supply and nutritive value of summer forage the firm may find that it will be forced to select types of livestock and plan their production patterns in agreement with the pasture production pattern.¹

¹ Control over the variability as previously described influences the production and distribution of pasture forage within the pasture production period. No control in the Bluegrass Region may be interpreted to mean that the entrepreneur follows the path of least resistance by permitting bluegrass to occupy all his land for pasture. The entrepreneur does not attempt to influence the plant population, nor does he make any attempt to store the surplus of one period for use in another, except for winter use. Such an entrepreneur may be producing at the optimum output level for his pasture. The control case is where the entrepreneur carefully selects the pasture mixtures and allots the correct acreage of the correct mixture for each season. He will also carry out management practices, such as timing the application of fertilizer, mowing, and other practices to influence seasonal production. Finally, he will carry out a program of storing surpluses of one period for use in another.
When the supply and nutritive value of pasture forage is left to fluctuate without control, the ratio of fixed costs relative to variable costs will be high for the segment of the farm business associated with pasture. This is true because most of the costs of pasture forage production and the costs for the types of livestock adaptable to pasture production without control originate from the investment rather than items such as seeds, feeds, or labor. Types of livestock will be chosen that can subsist for considerable periods of time on maintenance rations. Also the segment of the farm business associated with pasture production will probably have a low elasticity of production because of the tendency toward inflexibility in the ratio of fixed to variable costs. In consequence of the foregoing reasons, a firm wholly dependent upon pasture for its sources of income, without control, will tend toward the type of a business with low relative returns of low variability.\(^1\)

Investment in stabilizing yield and nutritive value of pasture will be profitable if the pasture-produced secondary product results in a greater value productivity for labor and capital than a competing primary crop. The control firm will have more flexible arrangements for meeting unfavorable events

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\(^1\)While the choice to operate without control over variability may be justifiable from the entrepreneur's viewpoint, it results in unemployment or under-employment of large areas of pasture land. Under-employment exists when the capacity of the land to produce is barely realized.
than the noncontrol firm and it will probably have types of livestock which are at all times producing a product (dairy or feeder cattle). Under these conditions more labor, feed, etc. will be spent on the secondary product. Therefore, the proportion of fixed to variable costs will tend to be less under control as compared to lack of control over within-season variability. With a higher proportion of variable to fixed costs the elasticity of production will probably be greater.

A primary reason for controlling distribution of the summer forage supply is to narrow the range of possible marginal cost curves. If the method of control increases output the cost curve may be lowered. If the method (or methods) does (do) not affect output, or only affects output slightly, the cost curves will be raised or remain at the same level but have less variability. Ordinarily, the cost curves will be raised because the firm will employ a number of methods, many of which will be cost increasing rather than output increasing. Costs associated with control of supply are not without compensation; they may cause skewness of the probability distribution of marginal costs and price to the right. Skewness to the right is possible because of the greater proportion of variable to fixed costs, permitting adjustments to be made quickly. With respect to the probability distribution of prices, the firm is in a better position to choose a time to market its products thus causing a
of the resources of the firm to

See these

The even of attracting the resources of the resources
called by making an assumption up or down the expenses
whether to employ the same resource, proportionately to
when the scale of scale of the production remains for proceeds
the resources proportionately to proceeds, the marginal productivity
when two or more factors can be added in the production of
factors will be combined in such a manner that
chooses which maximizes the present value of returns to the
the firm. In order that, product combination will be
scale in a manner which maximizes the net revenue stream to
is combined to combine proceeds, factors, production processes, and
in conventional conditions, the entrepreneur is assumed

enlightenment

proceedure determined for the general conditions for economic
sources. However, consideration of arithmetical does not
a central part of the firm's success in allocating the re-
resulting deeper and meaningful of factors operations to

enlightenment for the business plan

have to plan to sell when prices are unpredictable.

awareness to the right while without control the firm may
as fixed in supply but have certain limits; if less than the lower limits are used under-employment or unemployment will exist.¹ Since the firm is not likely to employ all its labor and capital in the production of a single product, it will want to know the amount of output from several enterprises it can produce at different levels of labor and capital employment. When the firm knows the returns to its resources at different levels of employment for the competitive products, then the entrepreneur can determine the output level for each product that proportionally maximizes the net marginal returns for a unit of the resources.

If the present value of future net marginal returns of three products appears as A, B, and C (Figure 21), and the firm has limited quantities of labor and capital, proportionality will be achieved in the planning process by giving first consideration to the input Gw' in A. The next input of labor and capital would be Ox in B; and the next X'w'' in A and XX' in B. The allocation process would follow this procedure until all the allocatable resources are

¹ The attempt here is to depict a farm, fixed in acreage, with a certain quantity of investment in buildings, fence and equipment to which capital (livestock, fertilizer, feed, etc.) can be added. Also the farm has a supply of family labor (1, 1.5, or 2 men) which may have alternative employment if not fully employed on the farm; however, in the usual case the family labor does not accept alternative employment unless the unemployment is considerable.
distributed. If the firm has unlimited supply of labor and capital it will immediately plan inputs $Ov, St$, and $Os$. In the cases of complementarity between products or joint products, the firm will give first consideration to the product combination rather than to separate products.

Fig. 21. Net Marginal Returns from Three Products.

There are a number of exceptions to this allocation process. These have been previously discussed, i.e., indivisibilities, leisure preferences, time distribution of income, etc. However, the process is valid to describe the general rule for allocating limited resources. The process of planning for long-run and short-run would be practically the same. The difference would be in the types of costs considered.
Research on such procedures to adjust apparent because the
any venture, on would be the limit for pressure output. The
of "other crops" and "other pressure to not be expanded to have
Another (2) any further innovation in a reduce the output
in output of pressure, maximum output of 0k to the apparent
and pressure force will increase the output of "other crops" in pressure.
for any given acreage of land when pressure is produced in
when with other crops (Figure 2). The pressure response that
same may be expressed when pressure is considered to combine-
feasibility of the complementarity range. The feasibility of
(further force) because the venture is no longer than the
in this case, the limit cannot put a value on the product
not a complementor with other products for use of the land
alternative area of expected "other pressure"
pressure product is always above expected in the lowest
use expected pressure. Such a value assures that hand devoted to
natural products plus the pressure match has an allowance
necessary to secure maximum complementarity effect on the other-
for any intentional term, should be equal to the average
further = the limit to the production of land in pressure.
seemed below because of their general appearance and important
the two future are the
terming the quantity of resources that should be allocated
allocations, which are frequently occupied as the guide for de-
There are two rules, commonly used in agricultural.
product, (pasture forage), does have some value, which will make it a competitive crop over part of the combination range. It is possible that the relative production of pasture

![Graph](image)

**Fig. 22.** Possible Iso-resource Curves for Production of Pasture and "Other Crops!"

is low and the rest of the transformation curve is of the nature indicated by EB. Thus, the range of competitiveness is small, leaving the impression that the competitive range does not exist. For the Bluegrass Region, curves EBC or EAD, which indicate a wide competitive range, are more probable because of the seasonal advantages of pasture versus grain production.¹

¹ Tobacco benefits from pasture as do other crops, but the proportion of the land employed by tobacco is so small that from the standpoint of land use it can be omitted.
The second rule as frequently asserted by agricultural leaders is: since pasture utilization is the lowest-cost-method known for livestock production, the more pasture forage consumed by an animal, the lower the cost and the greater the net return. Such a statement assumes the accounting system of the rule that pasture has no alternative value and assumes that pasture forage is a perfect substitute for other feeds. The entrepreneur must be cautious about accepting rules based upon faulty economic logic. Simple rules to govern the conduct of the farm firm are prevalent in agricultural circles. Perhaps the major cause is the uncertainty of future events which causes the entrepreneur to fix on something more concrete than an unpredictable future.
SUMMARY AND CONCLUSIONS

The production and utilization of pasture forage is a consideration in nearly every major production process on the farm firm in the Bluegrass Region of Kentucky on account of its close relationship to production of other crops and the livestock program. The core of the economic problem of pasture forage output is uncertainty of supply during the pasture production period; however, the economic level of output, and allocation of resources to pasture production and utilization are also important aspects. Much research has been done in these fields, but the task of fitting pasture production into the organizational structure of the individual farm is difficult, resulting in conflicting hypotheses and conclusions.

The objectives of this study were: 1) to clarify the economic relationships of production and utilization of pasture forage, especially as they relate to the Bluegrass Region; 2) to formulate hypotheses and to suggest appropriate tools of economic analysis for solutions to pasture problems; 3) to test hypotheses whenever primary or secondary data were available.

The method of study was to assume the role of an entrepreneur and to seek facts by deductive analysis of the problematic situations. The construction of economic models and
formulation of hypotheses were attained by: 1) evaluating the historical development of the grazing system; the manner in which farmers met critical situations (panics, wars, droughts, inflation, etc.); and the ways that farmers improved their knowledge and farming methods; 2) appraising the economic limits of control over variability in supply of summer forage; 3) comparing the effects of substituting pasture forage for harvested forage on input combinations, economic returns, and scale of enterprises; and 4) integrating pasture in the farm plan to maximize the stream of net revenues to the firm.

To facilitate the analysis, the problem was delineated into four major areas of study: 1) the development of agriculture and the grazing system in the Bluegrass Region, 2) the production of pasture forage, 3) the utilization of pasture forage, and 4) the over-all production plan.

The Bluegrass Region is circular in shape and includes an area of about 6000 square miles. It is composed of three distinct subregions: the Inner-Bluegrass, the Intermediate-Bluegrass, and the Outer-Bluegrass. Each of the subregions is productive but the Inner-Bluegrass is most superior in all respects. In 1944, the gross cash income per acre in the Inner-Bluegrass was exceeded by only two counties in Illinois and one in Ohio among all of the counties in Ohio, Indiana, Illinois and Kentucky. In that same year tobacco, which was
helped and renewed growth. Tobacco, beef, horses, and cotton
In the south created a great demand for farm and food products,
development of cotton farming. Steady and large plantations
of unsecured for surplus farm commodities, the subsequent
increase in produce (mainly tobacco) meant the opening
the Kentucky, Ohio, and western areas in 1879 to food

A crop by demand stimulated so new cotton by way of
deeply conditioned for the development of cotton by the
quick cotton produce by the cotton and the land
Virgil's method of the southern, the then cotton's, and the dete-

ary way and by boosting the demand of the cotton
for the northern land. Cotton by the recession

section by section of your hundred acres to ready

Vision's method of the appointment of the land to the army

and the training of the army

By 1870, various were reported in another place of production.
It was reported to cover the uncollected open land by 1870.

rapidly after the introduction (apparently prior to 1875), it is
grasses and cabbages were the predominant crop. It spread
part of the natural vegetation that covered the land, as

thus began, at the time of settlement (1875), was not a

produced property was undetermined.

put to pasture with the cotton to other areas or
the beef became. Fifty-two percent of the land was devoted
grown on 6 percent of the frame land, provided 73 percent of
The peak of production during the nineteenth century was

Korea

portion of the hope were diversion to southern and eastern met-

pounds, most of the cattle, horses, and a large pro-

to weights of 1,500 to 2,000 pounds and hope to 400 or 500

butting down corn from the steading snatch, gette very red

from generating the small grain from their stock, and from

from roasting the corn after cattle, from red to orange, purple,

into the grain system by leftening much of their sustenance

to the livestock during the warm winter months. Hope finished

montane) and 2 (the feeding of corn rodder (ears eaten)

companied or underfed, pass into the system

to increase on pastureess pasture for ten months of grazing (co-

were 1 (the feeding of the rodders in grasses, 2) the re-

practiced grazing system. The practice of the grazing system

cattle (from corn and pastureess was the basis of the inlent

livestock production (horse, cattle, hogs, and beef

same, afterward to 1890.

to 1890, presented up in the cattle men, and on a smaller

stock production. This system excludes for several years prior

changed to one or more dependence on livestock and live-

iscope but after the peak of 1890 the system of farming

were. However, before 1890 the main objective was on game

the most important sources of income from 1890 to the start

production of these products to varying degrees provided
The important study emphasized several pertinent

outlining the pretensions to greater efficiency in farm crops

and the price of grains in the economy. By marking possible use

The growth of tobacco as a major source of income stimulation

been of farmers, and by 1700 tobacco was a major product.

To assess the luciferous careers to galvanize change, the

of white sugar in the 1700s and the high prices paid for

agricultural productivity took place. However, the depression

importance of useful energy in the early 1800s. Moreover, the

performed in luciferous careers occurred in the decade.

...several criticisms in the vitreous state that cannot be discouraged by the most

forces made an impact on the responsible types of livestock

bread and the American bread, hogs, and the short

stock such as the Shorthorn breed of cattle, the Thoroughbred

farms came to interest in breeding of "brooded" live.

present date. Comparison with the development of the Heref

the numbers of livestock were greater than they are at the
carefully exceeded any other period of the century. In fact,

farmers exceeded the export ratio to a much greater extent than in the

probably reached in the 1830s. During this period farming

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rising prices and prosperity of 1812-1816, 1825-1837, and 1850-1860. In contrast, hemp production increased in relative importance following the severe price declines of 1819, 1837, and 1860. 3) Many of the ideas and concepts that are considered a part of modern science were expressed with much thoroughness a century ago.

The emphasis changes now to analysis of the current problems of pasture production. However, we should note that the historical analysis of the problem provided significant information to explain the functioning of the Bluegrass economy under different environments.

The ideal pasture production program for a given farm firm was described as one that: 1) provided a maximum stream of pasture forage output with a minimum variation in supply and nutritive value within and between pasture production periods, and 2) had an acreage in pasture in proportion to other crops such that the stream of net revenues to the firm was maximized.

Data from a thirteen year project on utilization of bluegrass pastures at Kentucky showed that the variation in output of pasturage forage was greater within periods than between periods. Analysis of variance of pasture yields indicated that the difference between monthly outputs were highly significant at the .01 level ("t test), while the difference between the periods was not significant at the .05 level. Because of the marked variation within periods, and
the needs of a livestock program for a stable supply, mea-
sures for reducing within-period variation and their costs
are of prime importance to farming systems based on pasture.

Rains over a thirty year period at Lexington, Kentucky
occurred on 26 percent of the days in June with 90 percent
of them less than one inch. As the season progressed the
rains fell on a smaller percentage of the days, but tended
to be larger. Droughts longer than sixteen days occurred four
out of ten years in September and October and two out of ten
in July and August. A drought between twenty-six and thirty-
five days occurred once in ten years in October, and one
longer than thirty-six days occurred once in sixteen years
in September and part of October.

Experiments showed that output increasing practices
affected the dispersion of probable yield of pasture forage
in a varying manner. In general, except for the addition of
legumes in the plant mixture and irrigation, they reduce
variation in good years, but tend to increase variation be-
tween good and poor years because of the impetus given to
production in good years. Control of variation in supply of
summer forage is most likely to result from a combination of
the following methods: 1) choice of plant mixtures, 2) manage-
ment practices, 3) storage of surplus production from one
period for use in another, and 4) control of soil water supply.

The costs of reducing variation in supply of summer
the output of pasture forage from 7 even crops may

places of the firm

importance of pasture to the meat income-pasture system

a unit reduction in very slightly depends upon the pasture
degression in very slightly to equal to the value. The value of

vegetation can be added until the marginal cost of a unit of

of the ecosystem in output. Each costs for reducing

surplus will be proportional to the cost is less than the value

showing the surplus of the sale of pasture production for animal con-

with respect to the levels, the above to the herd and

erformance for reducing the depression of pasture.

If stock force were optimal and (2) each output for certain

surplus force when the production per acre would be greater

force are of two types: (1) sacrifice of output of

99
probably show greater complementarity between $X_1$ and $X_2$. Output in the poor years will be maximized and variation between good and poor years minimized when the input combinations are chosen from the product contours of the good-year surface that produces the greatest output in the poor years.

Pasture forage in the previous discussion was considered as a product, now it is to be considered a factor in the production of livestock. Its value productivity, for any day, as a substitute in the feed rations of livestock, depends upon four classes of variables: 1) the types of livestock and their products, 2) the level of feeding and proportion of total feed supplied by pasture forage, 3) the quality of pasture forage, and 4) the prices for the factors and products. Because the entrepreneur wants to maximize the value productivity throughout the pasture production period he will equalize the value productivity of one day with subsequent days.

Livestock output as a product is shown by the production function:

$$Y = f(X_1, X_2, X_3, X_4, X_5)$$

where $Y$ is the livestock product; $X_1$ is grain; $X_2$ is protein feed; $X_3$ is harvested forage; $X_4$ is pasture forage; and $X_5$ is equal to all other production factors (labor, capital, etc.). Pasture forage, $X_4$, is a technical substitute for any one or all of $X_1$, $X_2$, and $X_3$. It is considered as a perfect substitute
(near) for harvested forage but complementary to concentrates. When pasture forage is fed, the marginal rates of substitution of grain for protein are likely to be greater than when harvested forage is fed. At the same price ratios for grain and protein feeds the entrepreneur would feed proportionally less protein feeds to livestock on pasture than when on harvested forage. When protein feeds and grains were considered together as concentrates, the marginal rates of substitution of pasture forage for concentrates are probably greater than the rates of substitution of harvested forage for concentrates. If true, the optimum scale of the livestock enterprise will be greater when pasture forage is fed even though the prices of the factors are the same.

If the marginal value productivity of the same resources employed in another use is considerably greater than for pasture and if the "other use" can be employed without limit, the value of a unit reduction in variability of summer forage supply will be small. In this case, the entrepreneur may choose types of livestock that have demands for pasturage similar to the average pasture production pattern. Faced with a drought and without appreciable flexibility arrangements, such an entrepreneur would probably resort to one or more of the following methods to minimize losses: 1) feed the reserve harvested forages intended for winter consumption, 2) sell the livestock, 3) effect a major change in the
production equipment or storage facilities, 4) permit the livestock to use their reserve of body weight.

Pasture utilization for dairy cows differs from meat-producing livestock in that the production of each day is measured and weighed. Deciding the economical rate of daily output over the production period for a class of livestock producing a continuous flow of product is fundamental. The most important factors that cause variation in daily output are: 1) level of feed intake, 2) size of cows, 3) stage in lactation, and 4) inherent production. Research studies indicated the principle of diminishing returns to hold as the level of daily feed intake is increased, making possible the determination of optimum daily output from the scale line once the technical rates of substitution (forage and concentrates) for successive outputs and the prices of factors and the product are known. The model used to describe the relationship showed that the ratio of concentrates to forage increased with larger daily outputs, and as larger daily outputs are realized the marginal rates of substitution of forage for concentrates diminish.

The problems of utilization of pasture forage by feeder cattle are similar to dairy production in that the cattle are at all times producing a daily output, and the entrepreneur desires to maximize the sum of the daily net revenues. They differ from dairy cattle in that the daily output is not
measured or sold until some future date. Also the rate of
daily output has considerable influence on the market grade
at selling time. The value of a day's output at the begin-
ning of the pasture production period is the price the en-
trepreneur will sell the cattle rather than feed them to a
later market date. To him, each rate of daily gain will have
a different value. The optimum daily output and the propor-
tions to feed can be determined from the scale line as de-
scribed for dairy cattle. If the cost of the factors were
expected to change relative to the value of the product the
optimum daily rate of gain may be expected to vary over the
period. Experiments conducted at Illinois to determine feed
requirements to raise feeder cattle to higher market grades
showed that daily gains from feeding grain-on-grass were as
good as feeding in the drylot and pasture, in addition to
substituting for all the hay, replaced 22 to 33 percent of
concentrates.

To analyze the organization of the farm firm when un-
certainty is a feature of importance to the over-all pro-
duction plan, classification of products or product combina-
tions according to relative returns and expected variability
of returns is necessary to understand the actions of entre-
preneurs in choosing their enterprises. Four classes are
apparent: 1) high returns over time and high variability of
returns, 2) high returns and low variability, 3) low returns
and high variability, and 4) low returns and low variability. The ideal combination for most entrepreneurs is high returns and low variability, and the untenable combination is low returns and high variability. Logically, the condition of high returns and low variability cannot persist over time unless monopolistic elements are present. In this case, the relative returns may diminish because of the tendency to capitalize the security of returns into the structure of the firm, or as in the case of tobacco, the base allotment.

In general, a high proportion of variable costs relative to fixed is associated with high returns and high variability, and low variable costs relative to fixed are associated with low relative returns and low variability. Bluegrass pastures, without control over the variability of summer forage supply, are typical of the case of low variable costs relative to fixed. Consequently, the selection of livestock that have production patterns corresponding to bluegrass production pattern, and have costs which are largely fixed (sheep and beef cow herds), makes a natural combination with tobacco. Before governmental control of acreage, tobacco was in the class of high returns and high variability. A loss in tobacco production was offset, in part, by income from an enterprise or enterprises of low variable costs. On the other hand, entrepreneurs with confidence in their ability to outguess their fellow producers and influence the skewness
of the distribution of costs and product prices chose a combination of two enterprises of high returns and high variability. Tobacco and heavy feeder cattle were an example of this condition. Windfall profits when they occurred, were large.

Indivisibility of resources is a significant obstacle to firms in pasture-producing areas because stabilizing the supply of summer forage usually means investment in forage harvesting equipment, storage structures and possibly irrigation. Small firms or firms not requiring power equipment for other types of crop production experience difficulty to provide sufficient employment to include such investment in the long-run plan. The frequent result is underutilization of the pasture forage, or higher costs.

Without control over variability of the supply of summer forage the firm may be forced to select types of livestock that can subsist for considerable periods of time on maintenance rations, or it may underutilize the pasture forage during the growing period to leave a residue on the land for consumption in a deficit period, or it may do both. Also, the segment of the farm business associated with pasture production will probably have a low elasticity of production because of the tendency toward inflexibility in the ratio of fixed to variable costs. If such a firm is wholly dependent upon pasture for its sources of income it will tend
to be a type of business in the class of low returns and low variability.

The ideal pasture forage program is not beyond realization by many farms. Investment in stabilizing the summer supply of forage will be profitable if the pasture-produced secondary product results in a greater value productivity for labor and capital than a competing enterprise. On the other hand, when the marginal value productivity of competitive resources are higher for primary production, and can be employed without limit, stabilizing the supply of summer forage may not be economic. The firm exercising the control will have more flexible arrangements for meeting unfavorable events than the noncontrol firm and it will probably have types of livestock which are at all times producing a product.
APPENDIX
### Table 1. Sources of Income for the Bluegrass Region, Kentucky, 1944

<table>
<thead>
<tr>
<th>Source</th>
<th>Outer Bluegrass</th>
<th>Intermediate Bluegrass</th>
<th>Inner Bluegrass</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Per Farm Acres</td>
<td>Per Farm Acres</td>
<td>Per Farm Acres</td>
</tr>
<tr>
<td>Crops sold</td>
<td>$2138 2130</td>
<td>$1442 1460</td>
<td>$3724 3502</td>
</tr>
<tr>
<td>Value tobacco</td>
<td>$2399 2390</td>
<td>$1630 1650</td>
<td>$4054 3812</td>
</tr>
<tr>
<td>Total livestock sold</td>
<td>1011 1134</td>
<td>658 745</td>
<td>1358 1478</td>
</tr>
<tr>
<td>Dairy products</td>
<td>451 596</td>
<td>256 290</td>
<td>163 177</td>
</tr>
<tr>
<td>Poultry products</td>
<td>82 93</td>
<td>83 94</td>
<td>72 78</td>
</tr>
<tr>
<td>Other livestock and products</td>
<td>473 536</td>
<td>319 361</td>
<td>1123 1223</td>
</tr>
<tr>
<td>Forest products</td>
<td>2 2</td>
<td>1 1</td>
<td>- -</td>
</tr>
<tr>
<td>All farm products sold</td>
<td>3151 3535</td>
<td>2101 2376</td>
<td>5082 5532</td>
</tr>
<tr>
<td>All farm products in households</td>
<td>303 340</td>
<td>282 319</td>
<td>335 365</td>
</tr>
</tbody>
</table>


*Value of tobacco and crops sold are not precisely comparable because "crops sold" includes total product sold during 1944. Since the tobacco sale season extends over the latter part of one year and into the first part of the next the product of two years will be sold in each year. "Value of tobacco" is for 1944 only.*
Appendix

Table 2. Degree of Specialization in the Bluegrass Region. Kentucky, 1944

<table>
<thead>
<tr>
<th>Item</th>
<th>Outer Bluegrass</th>
<th>Intermediate Bluegrass</th>
<th>Inner Bluegrass</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crop specialty</td>
<td>30.4</td>
<td>73.3</td>
<td>85.9</td>
</tr>
<tr>
<td>Dairy specialty</td>
<td>5.6</td>
<td>6.6</td>
<td>1.2</td>
</tr>
<tr>
<td>Livestock specialty</td>
<td>5.6</td>
<td>10.5</td>
<td>10.2</td>
</tr>
<tr>
<td>General and other specialties</td>
<td>8.2</td>
<td>9.6</td>
<td>2.7</td>
</tr>
</tbody>
</table>

### Appendix

Table 3. Pastureage of Farm Land in Specific Uses in the Bluegrass Region. Kentucky. 1944

<table>
<thead>
<tr>
<th>Item</th>
<th>Outer Bluegrass (Area 3a)</th>
<th>Intermediate Bluegrass (Area 3b)</th>
<th>Inner Bluegrass (Area 3c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow crops</td>
<td>12.8</td>
<td>8.8</td>
<td>15.0</td>
</tr>
<tr>
<td>Corn</td>
<td>(8.2)</td>
<td>(5.4)</td>
<td>(8.0)</td>
</tr>
<tr>
<td>Tobacco</td>
<td>(4.2)</td>
<td>(3.1)</td>
<td>(6.5)</td>
</tr>
<tr>
<td>Other</td>
<td>(.4)</td>
<td>(.3)</td>
<td>(.5)</td>
</tr>
<tr>
<td>Crop failure, cropland idle or fallow</td>
<td>2.3</td>
<td>1.6</td>
<td>2.2</td>
</tr>
<tr>
<td>Small grain</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(for grain)</td>
<td>4.4</td>
<td>1.2</td>
<td>6.2</td>
</tr>
<tr>
<td>Hay</td>
<td>19.1</td>
<td>9.8</td>
<td>9.3</td>
</tr>
<tr>
<td>Land used for pasture(^a)</td>
<td>61.8</td>
<td>71.0</td>
<td>61.7</td>
</tr>
<tr>
<td>Woodland not pastured</td>
<td>1.9</td>
<td>1.5</td>
<td>1.0</td>
</tr>
<tr>
<td>All other land(^b)</td>
<td>6.7</td>
<td>6.1</td>
<td>4.6</td>
</tr>
<tr>
<td></td>
<td><strong>100.0</strong></td>
<td><strong>100.0</strong></td>
<td><strong>100.0</strong></td>
</tr>
</tbody>
</table>

Average size farm: 89.1 acres 74.1 acres 83.5 acres


\(^{a}\) Included cropland used for pasture, woodland pasture and other land pastured.

\(^{b}\) Mostly waste land, land in roads, farmstead, etc.
Appendix

Table 4. Percentage Distribution of Farms by Size Intervals in the Bluegrass Region, Kentucky, January 1, 1945

<table>
<thead>
<tr>
<th>Acreage</th>
<th>Outer Bluegrass</th>
<th>Intermediate Bluegrass</th>
<th>Inner Bluegrass</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under 10</td>
<td>17.8</td>
<td>12.9</td>
<td>22.0</td>
</tr>
<tr>
<td>10 and under 50</td>
<td>20.9</td>
<td>24.2</td>
<td>33.1</td>
</tr>
<tr>
<td>50 and under 100</td>
<td>27.7</td>
<td>27.4</td>
<td>16.3</td>
</tr>
<tr>
<td>100 and under 180</td>
<td>23.7</td>
<td>24.3</td>
<td>14.5</td>
</tr>
<tr>
<td>180 and under 260</td>
<td>6.6</td>
<td>7.2</td>
<td>6.1</td>
</tr>
<tr>
<td>260 and under 500</td>
<td>2.9</td>
<td>3.2</td>
<td>4.7</td>
</tr>
<tr>
<td>500 and over</td>
<td>.4</td>
<td>.5</td>
<td>2.2</td>
</tr>
</tbody>
</table>


Table 5. Animal Units of Specific Types of Livestock in the Bluegrass Region, Kentucky, January 1, 1945a

<table>
<thead>
<tr>
<th>Type</th>
<th>Outer Bluegrass</th>
<th>Intermediate Bluegrass</th>
<th>Inner Bluegrass</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horses, mules and colts</td>
<td>23.8</td>
<td>21.7</td>
<td>28.0</td>
</tr>
<tr>
<td>Milk cows</td>
<td>51.6</td>
<td>36.0</td>
<td>25.0</td>
</tr>
<tr>
<td>Other cattle</td>
<td>33.1</td>
<td>25.9</td>
<td>60.1</td>
</tr>
<tr>
<td>All hogs and pigs</td>
<td>16.9</td>
<td>6.5</td>
<td>18.4</td>
</tr>
<tr>
<td>Sheep and lambs</td>
<td>8.2</td>
<td>13.5</td>
<td>27.4</td>
</tr>
<tr>
<td>Chickens</td>
<td>10.2</td>
<td>9.2</td>
<td>9.5</td>
</tr>
<tr>
<td>Total</td>
<td>143.0</td>
<td>112.8</td>
<td>165.4</td>
</tr>
</tbody>
</table>

Acres per animal unit | 6.95 | 8.36 | 5.94 |


aTo convert livestock numbers to animal units the following factors were used: milk cows, 1.00; other cattle, .70; hogs, .30; sheep and lambs, 12; horses and mules, .95; and chickens, .019.
### Table 6. Capitalized Value of Resources in the Bluegrass Region. Kentucky. January 1, 1945

<table>
<thead>
<tr>
<th>Item</th>
<th>Outer Bluegrass</th>
<th>Intermediate Bluegrass</th>
<th>Inner Bluegrass</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value of land and buildings</td>
<td>$7869</td>
<td>$88.41</td>
<td>$5112</td>
</tr>
<tr>
<td>Value of implements</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Value of machinery</td>
<td>542</td>
<td>6.08</td>
<td>271</td>
</tr>
<tr>
<td>Value of livestock</td>
<td>1053</td>
<td>11.83</td>
<td>822</td>
</tr>
<tr>
<td>Average size of farms</td>
<td>89 acres</td>
<td></td>
<td>74 acres</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>64 acres</td>
</tr>
</tbody>
</table>


### Table 7. Tenure in the Bluegrass Region. Kentucky. 1945

<table>
<thead>
<tr>
<th>Item</th>
<th>Outer Bluegrass</th>
<th>Intermediate Bluegrass</th>
<th>Inner Bluegrass</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full owners</td>
<td>48.0</td>
<td>57.1</td>
<td>42.4</td>
</tr>
<tr>
<td>Part owners</td>
<td>2.6</td>
<td>5.1</td>
<td>4.6</td>
</tr>
<tr>
<td>Managers</td>
<td>0.2</td>
<td>0.1</td>
<td>1.2</td>
</tr>
<tr>
<td>All tenants</td>
<td>49.0</td>
<td>37.7</td>
<td>51.0</td>
</tr>
</tbody>
</table>

Table 3. Numbers and Value of Livestock Passing Through Cumberland Gap or Cumberland Ford 1825, 1828-1839, 1841-1842

<table>
<thead>
<tr>
<th>Year</th>
<th>Location</th>
<th>Item</th>
<th>Number</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1825</td>
<td>Cumberland Gap</td>
<td>Horses</td>
<td>4019</td>
<td>$361,710</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mules</td>
<td>1019</td>
<td>61,140</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hogs</td>
<td>63036</td>
<td>441,252</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cattle</td>
<td>1393</td>
<td>41,790</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$905,892</td>
</tr>
<tr>
<td>1828</td>
<td>Cumberland Gap</td>
<td>Horses</td>
<td>3112</td>
<td>307,030</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mules</td>
<td>5226</td>
<td>225,970</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hogs</td>
<td>97455</td>
<td>584,750</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sheep</td>
<td>2141</td>
<td>4,282</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Beef cattle (stall fed)</td>
<td>1525</td>
<td>45,740</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$1,167,862</td>
</tr>
<tr>
<td>1832</td>
<td>Cumberland Ford</td>
<td>Horses</td>
<td>3363</td>
<td>$431,320</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mules</td>
<td>1518</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hogs</td>
<td>50572</td>
<td>354,004</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sheep</td>
<td>674</td>
<td>26,960</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$612,304</td>
</tr>
<tr>
<td>1833</td>
<td>Cumberland Ford</td>
<td>Horses</td>
<td>5337</td>
<td>$601,560</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mules</td>
<td>1247</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hogs</td>
<td>64077</td>
<td>512,568</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sheep</td>
<td>977</td>
<td>36,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$1,150,128</td>
</tr>
<tr>
<td>1834</td>
<td>Cumberland Ford</td>
<td>Horses</td>
<td>4632</td>
<td>$839,560</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mules</td>
<td>2061</td>
<td>164,880</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hogs</td>
<td>83583</td>
<td>752,217</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sheep</td>
<td>1051</td>
<td>40,040</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>648</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$1,329,375</td>
</tr>
<tr>
<td>1835</td>
<td>Cumberland Ford</td>
<td>Horses</td>
<td>4716</td>
<td>$533,360</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mules</td>
<td>1951</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sheep</td>
<td>2435</td>
<td>104,370</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hogs (sows)</td>
<td>2867</td>
<td>18,300</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sheep</td>
<td>1320</td>
<td>5,260</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hogs (fat)</td>
<td>69107</td>
<td>1,031,802</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$1,890,012</td>
</tr>
</tbody>
</table>
Table 9. (Continued)

<table>
<thead>
<tr>
<th>Year</th>
<th>Location</th>
<th>Item</th>
<th>Number</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cumberland</td>
<td>Horses</td>
<td>5891</td>
<td>$740,610</td>
</tr>
<tr>
<td>Ford</td>
<td></td>
<td>Mules</td>
<td>2338</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hogs</td>
<td>68285</td>
<td>1,151,296</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Beeves</td>
<td>2689</td>
<td>121,005</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sheep</td>
<td>1500</td>
<td>6,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>$2,015,911</strong></td>
</tr>
<tr>
<td></td>
<td>Cumberland</td>
<td>Horses</td>
<td>5185</td>
<td><strong>$744,990</strong></td>
</tr>
<tr>
<td>Ford</td>
<td></td>
<td>Mules</td>
<td>3426</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hogs</td>
<td>80464</td>
<td>397,070</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Beeves</td>
<td>3673</td>
<td>126,555</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sheep</td>
<td>2294</td>
<td>9,172</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>$1,309,791</strong></td>
</tr>
<tr>
<td></td>
<td>Cumberland</td>
<td>Horses</td>
<td>4039</td>
<td><strong>$577,280</strong></td>
</tr>
<tr>
<td>Ford</td>
<td></td>
<td>Mules</td>
<td>3177</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Beef cattle</td>
<td>4549</td>
<td>227,459</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hogs</td>
<td>68764</td>
<td>962,696</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sheep</td>
<td>3250</td>
<td>13,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>$1,790,426</strong></td>
</tr>
<tr>
<td></td>
<td>Cumberland</td>
<td>Horses</td>
<td>2765</td>
<td>not given</td>
</tr>
<tr>
<td>Gap</td>
<td></td>
<td>Mules</td>
<td>2247</td>
<td>not given</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Beef cattle</td>
<td>2406</td>
<td>not given</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hogs</td>
<td>54813</td>
<td>not given</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sheep</td>
<td>718</td>
<td>not given</td>
</tr>
</tbody>
</table>

aMiles Weekly Register. March 4, 1826.
bThe farmer's guide and western agriculturist. Published under the patronage of the Hamilton County (Ohio) Agricultural Society, Cincinnati, Buckley, DeForest and Company, 1832. p. 354. This book was originally published as the "Western agriculturist and practical farmers guide" in 1832.
cFranklin Farmer. January 13, 1833.
dCollins, 6. op. cit., p. 43.
eKerr, 7. op. cit., p. 742.
Appendix

Table 9. Production of Crops for Seven Inner-Bluegrass Counties 1840-1890 Inclusive, Kentucky

<table>
<thead>
<tr>
<th>Year</th>
<th>Wheat</th>
<th>Oats</th>
<th>Rye</th>
<th>Corn</th>
<th>Hay</th>
<th>Tobacco</th>
<th>Sheep</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(000)</td>
<td>(000)</td>
<td>(000)</td>
<td>(000)</td>
<td>(000)</td>
<td>(000)</td>
<td>(tons)</td>
</tr>
<tr>
<td>1840</td>
<td>830</td>
<td>902</td>
<td>641</td>
<td>7105</td>
<td>21</td>
<td>259</td>
<td>5484</td>
</tr>
<tr>
<td>1850</td>
<td>1357</td>
<td>965</td>
<td>70</td>
<td>8526</td>
<td>11</td>
<td>168</td>
<td>10953</td>
</tr>
<tr>
<td>1860</td>
<td>1333</td>
<td>1066</td>
<td>133</td>
<td>7711</td>
<td>13</td>
<td>261</td>
<td>4944</td>
</tr>
<tr>
<td>1870</td>
<td>475</td>
<td>631</td>
<td>272</td>
<td>5400</td>
<td>20</td>
<td>326</td>
<td>5180</td>
</tr>
<tr>
<td>1880</td>
<td>1926</td>
<td>296</td>
<td>61</td>
<td>6036</td>
<td>18</td>
<td>1490</td>
<td>3927</td>
</tr>
<tr>
<td>1890</td>
<td>1779</td>
<td>557</td>
<td>63</td>
<td>3310</td>
<td>67</td>
<td>23756</td>
<td>5002</td>
</tr>
</tbody>
</table>

Source: U. S. Census 1840-1890.

Table 10. Numbers of Livestock and Estimated Animal Units for Inner-Bluegrass Counties 1840-1890 Inclusive, Kentucky

<table>
<thead>
<tr>
<th>Year</th>
<th>Horses and Mules</th>
<th>Cattle</th>
<th>Sheep</th>
<th>Swine</th>
<th>Total Animal Units$^a$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(000)</td>
<td>(000)</td>
<td>(000)</td>
<td>(000)</td>
<td>(000)</td>
</tr>
<tr>
<td>1840</td>
<td>71</td>
<td>111</td>
<td>179</td>
<td>290</td>
<td>211</td>
</tr>
<tr>
<td>1850</td>
<td>61</td>
<td>91</td>
<td>132</td>
<td>234</td>
<td>176</td>
</tr>
<tr>
<td>1860</td>
<td>74</td>
<td>91</td>
<td>94</td>
<td>161</td>
<td>175</td>
</tr>
<tr>
<td>1870</td>
<td>45</td>
<td>80</td>
<td>51</td>
<td>110</td>
<td>125</td>
</tr>
<tr>
<td>1880</td>
<td>43</td>
<td>84</td>
<td>177</td>
<td>132</td>
<td>150</td>
</tr>
<tr>
<td>1890</td>
<td>53</td>
<td>87</td>
<td>123</td>
<td>124</td>
<td>151</td>
</tr>
</tbody>
</table>

Source: U. S. Census 1840-1890.

$^a$An animal unit is the equivalent of one cow in feed consumed. Without body weights or the proportion of the total represented by young stock these figures can only be considered as the best estimate possible. The following factors were used to convert to animal units: Horses and mules, .9; cattle, .8; sheep, .166; and hogs, .111.
Appendix

Table 11. Frequency of Intervals Without Rain in Summer and Early Fall Months 1920-1949, Lexington Weather Station, Lexington, Kentucky

<table>
<thead>
<tr>
<th>Class interval</th>
<th>Frequency of Occurrence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-5 days</td>
<td>186</td>
</tr>
<tr>
<td>6-10 &quot;</td>
<td>47</td>
</tr>
<tr>
<td>11-15 &quot;</td>
<td>15</td>
</tr>
<tr>
<td>16-20 &quot;</td>
<td>0</td>
</tr>
<tr>
<td>21-25 &quot;</td>
<td>1</td>
</tr>
<tr>
<td>26-30 &quot;</td>
<td>0</td>
</tr>
<tr>
<td>31-35 &quot;</td>
<td>1</td>
</tr>
<tr>
<td>36-40 &quot;</td>
<td>0</td>
</tr>
<tr>
<td>41-</td>
<td>0</td>
</tr>
<tr>
<td>Totals</td>
<td>250</td>
</tr>
</tbody>
</table>


Table 12. Average Daily Milk Production as Affected by Stage in Lactation

<table>
<thead>
<tr>
<th>Lactation period</th>
<th>Milk Production</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>lb.</td>
</tr>
<tr>
<td>Year, total</td>
<td>6000</td>
</tr>
<tr>
<td>1st month, daily</td>
<td>30</td>
</tr>
<tr>
<td>2nd month, daily</td>
<td>32</td>
</tr>
<tr>
<td>4th month, daily</td>
<td>26</td>
</tr>
<tr>
<td>6th month, daily</td>
<td>18</td>
</tr>
<tr>
<td>8th month, daily</td>
<td>12</td>
</tr>
<tr>
<td>10th month, daily</td>
<td>6</td>
</tr>
</tbody>
</table>

### Table 13. Requirements for Maintenance of One Beef Cow and for Production of Calf to Weaning Time, Kentucky Bluegrass Region

<table>
<thead>
<tr>
<th>Month requirements</th>
<th>Expected TDM's</th>
<th>Concentrate TDM's</th>
<th>Source of Feed harvested TDM's</th>
<th>Pasture forage TDM's</th>
<th>Percent of total pasture</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan.</td>
<td>325</td>
<td>15</td>
<td>310</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Feb.</td>
<td>315</td>
<td>50</td>
<td>265</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Mar.</td>
<td>449</td>
<td>15</td>
<td>290</td>
<td>144</td>
<td>3.6</td>
<td>3.6</td>
</tr>
<tr>
<td>Apr.</td>
<td>435</td>
<td>-</td>
<td>50</td>
<td>345</td>
<td>9.5</td>
<td>9.5</td>
</tr>
<tr>
<td>May</td>
<td>449</td>
<td>-</td>
<td>-</td>
<td>449</td>
<td>11.1</td>
<td>11.1</td>
</tr>
<tr>
<td>June</td>
<td>526</td>
<td>-</td>
<td>-</td>
<td>526</td>
<td>13.0</td>
<td>13.0</td>
</tr>
<tr>
<td>July</td>
<td>526</td>
<td>-</td>
<td>-</td>
<td>526</td>
<td>13.0</td>
<td>13.0</td>
</tr>
<tr>
<td>Aug.</td>
<td>553</td>
<td>-</td>
<td>-</td>
<td>553</td>
<td>13.6</td>
<td>13.6</td>
</tr>
<tr>
<td>Sept.</td>
<td>565</td>
<td>-</td>
<td>-</td>
<td>565</td>
<td>13.9</td>
<td>13.9</td>
</tr>
<tr>
<td>Oct.</td>
<td>415</td>
<td>-</td>
<td>-</td>
<td>415</td>
<td>10.2</td>
<td>10.2</td>
</tr>
<tr>
<td>Nov.</td>
<td>315</td>
<td>-</td>
<td>50</td>
<td>265</td>
<td>6.5</td>
<td>6.5</td>
</tr>
<tr>
<td>Dec.</td>
<td>325</td>
<td>-</td>
<td>100</td>
<td>225</td>
<td>5.6</td>
<td>5.6</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>5200</strong></td>
<td><strong>80</strong></td>
<td><strong>1065</strong></td>
<td><strong>4055</strong></td>
<td><strong>100</strong></td>
<td></td>
</tr>
</tbody>
</table>

**Source:** Expected total digestive nutrient requirements computed from standards in assuming 1000 pound cow producing .9 calf annually (450 pounds of beef per cow). Feeding methods were obtained from (unpublished data) Dept. Farm Econ. Ky. Agri. Exp. Sta.

*aTotal digestive nutrients.*
## Table 14. Requirements for Maintenance of One Ewe and Production of Wool and Lamb, Kentucky Bluegrass Region

<table>
<thead>
<tr>
<th>Month</th>
<th>Expected TDN requirements</th>
<th>Concentrates</th>
<th>Harvested Forage</th>
<th>Pasture Forage</th>
<th>Percent of total pasture forage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TDN's</td>
<td>TDN's</td>
<td>TDN's</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jan.</td>
<td>73</td>
<td>6</td>
<td>25</td>
<td>42</td>
<td>5.6</td>
</tr>
<tr>
<td>Feb.</td>
<td>76</td>
<td>8</td>
<td>35</td>
<td>33</td>
<td>4.4</td>
</tr>
<tr>
<td>Mar.</td>
<td>82</td>
<td>7</td>
<td>10</td>
<td>65</td>
<td>8.6</td>
</tr>
<tr>
<td>Apr.</td>
<td>95</td>
<td>4</td>
<td>-</td>
<td>91</td>
<td>12.1</td>
</tr>
<tr>
<td>May</td>
<td>112</td>
<td>-</td>
<td>-</td>
<td>112</td>
<td>14.9</td>
</tr>
<tr>
<td>June</td>
<td>72</td>
<td>-</td>
<td>-</td>
<td>72</td>
<td>9.5</td>
</tr>
<tr>
<td>July</td>
<td>53</td>
<td>-</td>
<td>-</td>
<td>53</td>
<td>7.0</td>
</tr>
<tr>
<td>Aug.</td>
<td>53</td>
<td>-</td>
<td>-</td>
<td>53</td>
<td>7.0</td>
</tr>
<tr>
<td>Sept.</td>
<td>57</td>
<td>-</td>
<td>-</td>
<td>57</td>
<td>7.6</td>
</tr>
<tr>
<td>Oct.</td>
<td>59</td>
<td>-</td>
<td>-</td>
<td>59</td>
<td>7.0</td>
</tr>
<tr>
<td>Nov.</td>
<td>57</td>
<td>-</td>
<td>-</td>
<td>57</td>
<td>7.6</td>
</tr>
<tr>
<td>Dec.</td>
<td>65</td>
<td>-</td>
<td>-</td>
<td>60</td>
<td>7.6</td>
</tr>
<tr>
<td>Total</td>
<td>854</td>
<td>25</td>
<td>75</td>
<td>754</td>
<td>100</td>
</tr>
</tbody>
</table>

Source: Expected total digestive nutrients requirements computed from standards in assuming one ewe weighing 110 pounds, bred on September 1, producing 1.2 lambs, weighing 80 pounds per lamb by June 15. Requirements for 1/25 of ram were added. Feeding methods were obtained from (unpublished data) Dept. Farm Econ. Ky. Agri. Exp. Sta.
BIBLIOGRAPHY

Anderson, W. S. and Hooper, J. J., American jack stock and

Autrey, E. R., Cannon, C. Y., Espe, D. L. Efficiency of
dairy rations containing various quantities of grain.

Baker, W. L. The use of native grass in producing finished

1943.

Black, J. D. and others. Farm management. New York, The

Boulding, K. E. Economic analysis. New York, Harper and
Brothers. 1948.

Breckinridge, R. J. On crops or staples of any kind. In
Kentucky State Agricultural Society Report to the
Legislature of Kentucky, p. 94-99. Frankfort, Ken-
tucky. A. G. Hodes. 1857.


H. C. Smithwick. 1817.

Bryant, E. F. and others. Kentucky agricultural statistics.
Part 1 - County estimates: crops, livestock, farm value.
Part 2 - Agricultural processing industries by counties.

Carlson, Gene. A study on the pure theory of production.
London, P. S. King and Son, Ltd. 1939.

Cassels, J. M. On the law of variable proportions. In
Explorations in economics, p. 223-236. New York,

of Kentucky, for their patronage and support.

In the meantime, a series of lectures to the public of the country, and a course of instruction to the clergy and ministers of Kentucky, was commenced by the Reverend Mr. Henry J. Mccoy, at the Pennyroyal (Museum of American Science). New York, 1877.

Franklin Farmer. Vols. 1 and 2. Frankfort, Kentucky, 1837 and 1838.


Heady, E. O. The economics of rotations with farm and production policy applications. Jour. of Farm Econ. 30: 645-664. 1948.

Elementary models in farm production economics research. Jour. of Farm Econ. 30:201-225. 1948.
Hennings, W. W. The statues at large; being a collection of all the laws of Virginia from the first session of the legislature in the year 1619. Vol. 10. Richmond, Va., George Cochran. 1822.


Higgins Heirs vs. Darnall's Devices 1806. (Original documents). Wilson Library, University of Kentucky.


Kaldor, N. The equilibrium of the firm. Econ. Jour. 44:60-76. 1934.


Kinkaid, E. S. A history of Kentucky. Cincinnati, American Book Co. 1896.


———. Theory of the firm and farm management research. Jour. of Farm Econ. 21:570-586. 1939.


ACKNOWLEDGMENTS

The writer owes much to his teachers, friends, and colleagues for their encouragement and kindly criticism in the preparation of this dissertation. He is particularly indebted to Professor W. D. Nicholls, Head, Department of Farm Economics, University of Kentucky for unselfish cooperation in making the necessary administrative arrangements to complete this graduate study; to Professor E. O. Heady for inspiration as a teacher, guidance as a friend, and critical comments during the writing process; to Professor J. A. Nordin and E. D. Ross for their stimulus of thought and helpful suggestions on parts of the dissertation; to Margaret Nesius, wife and counselor, for devotion and encouragement throughout this period of intense effort; to Mrs. Sophia Campbell for contributing her versatile abilities in taking care of the many contingent details; to Miss Virginia Martin for her care in the final typing of the dissertation; and to the clerical and secretarial staff of the Department of Farm Economics, University of Kentucky for their willingness to assist with the various phases of this manuscript.