1982

Projected impacts of cropland conversion on corn and soybean production in Iowa

Florence Lawson
Iowa State University

Recommended Citation

Lawson, Florence, "Projected impacts of cropland conversion on corn and soybean production in Iowa" (1982). *Retrospective Theses and Dissertations*. 16434.
https://lib.dr.iastate.edu/rtd/16434

Projected impacts of cropland conversion on corn and soybean production in Iowa

by

Florence Lawson

A Thesis Submitted to the
Graduate Faculty in Partial Fulfillment of the
Requirements for the Degree of
MASTER OF SCIENCE
Department: Economics
Major: Agricultural Economics

Iowa State University
Ames, Iowa
1982

TABLE OF CONTENTS

LIST OF TABLES

CHAPTER I. INTRODUCTION

This study is concerned with the long term consequences of converting agricultural land to other uses within the state of Iowa. The large role played by this state in national production of corn and soybeans makes it, therefore, an ideal area of study for this research effort.[1]

The Problem of Farmland Conversion

Recent developments both internationally and in the U.S. have emphasized the scarcity of land and, hence, the necessity of considering its allocation [24]. Within the land use allocation issue is the matter of whether urban expansion should be controlled or redirected in the interest of meeting future demand for agricultural products. Unfortunately, due to the uncertainties involved in predicting future needs for agricultural land, it has been difficult for policy makers to arrive at policies and means for dealing with this allocation problem.

Basic economic theory would suggest that the land should be allocated to uses that would yield the highest possible net return. If, however, current land market prices are an indication of this criterion, in most areas where land use conflicts exist, the land

---

[1] In 1980, Iowa produced 22 percent of total U.S. corn production for grain and 18 percent of total soybean production, ranking first in the nation in both categories [11].

should be converted to urban uses. However, these prices may not adequately reflect future values associated with the land when used for agricultural purposes. The value of farmland in the future is a function of future supply and demand. Estimating what either of these factors might be involves extrapolation based on current trends and assumptions for the future. Hence, there is no widely agreed upon estimate of what the market for agricultural land will be in ten or twenty years. Nevertheless, many studies indicate that the present high level of demand for U.S. agricultural products will continue or may even increase [24].

Many factors contribute to the increase in product demand. Some of the primary factors are listed below.

1. Per capita income has been rising in general throughout the world. This increases the effective demand for consumer goods and especially for food and fiber in developing nations [24].
2. Communist countries are also demanding more agricultural commodities. As they establish programs and goals for domestic production, they require additional inputs that they are unable to produce themselves [24].
3. Crop failures due to adverse weather conditions throughout the world have also been a contributing factor to the relative increase in demand [24].
4. Demand for food and fiber is expected to increase as the world's population increases [24].

In conjunction with high foreign demand is the current policy of the U.S. Government to balance the escalating costs of many of its imports by exploiting its comparative advantage in the production of food and fiber [24]. As a consequence, previous policies designed to prevent a glut on the market for agricultural products had been gradually eliminated in the 1970s and increasing amounts of land were brought into production.

Therefore, as demand for agricultural commodities increases, there is a growing concern that the current supply of agricultural land may not be adequate [4]. The underlying reasons for this concern are as follows.

First, the large advances made in agricultural productivity may be coming to an end. This statement is supported by several studies on the subject. For example, it was observed that agricultural productivity growth curves have begun to flatten out in recent years [22]. One explanation for this decline in productivity is that the majority of simpler methods for boosting productivity (such as hybrid seeds and fertilizers) have already been implemented. Although the possibility for additional technological breakthroughs still exists, the cost of development will be much higher. Hence, the rate of productivity growth due to technological change rests in part with future government policy toward allocating funds to research and development [9].

Second, escalating energy costs are likely to have a dampening effect on agricultural production since many of today's agricultural practices were developed during a period of readily available, low-cost energy sources. For example, increasing energy costs could mean that a great deal of potential cropland in the west will remain idle since irrigation will no longer be economically feasible. Indeed, it may even be necessary to cut back on the number of irrigated acres under cultivation [5].

Third, water supply is another major factor affecting the supply of productive agricultural land. Recent increases in irrigated land in the western states has compensated for conversion of land from agricultural uses. However, this irrigation activity has placed greater stress on groundwater aquifers. An additional consideration is the detrimental long term effect of increased salinity in the soil caused by the deposition of salts carried in the irrigation water [4].

Weather is an additional factor affecting productivity. From 1956 to 1973, there were very favorable weather conditions with little variability from the norm. However, in the future, the likelihood of climate variability similar to the span of time from 1890 to 1950 will increase. A study by Thompson predicted that as the deviations from normal weather patterns become more drastic, the yields on both corn and soybeans could drop by as much as three percent due to this variation alone by the year 2000 [23].

In addition, it has been found that pollution is having an impact on crop yields in certain areas of the country. In parts of California, for example, citrus and grape yields have decreased by as much as 75 percent [16]. Meanwhile, in the northeastern states, increases in sulfur dioxide and nitrogen oxide concentrates in the atmosphere have led to acid rain. The acidity level found in precipitation is likely to increase for this region since more electrical generating facilities are being converted from oil to coal [4].

Environmental regulations pose still another impediment to maintaining our present productivity level. Legislators have been receiving pressure from environmental groups to reduce or prohibit the use of various chemicals on crops. This creates the potential for reduced yields at least until suitable substitutes are found. Also, there has been much discussion as to whether farmers should be limited in what they can plant on erosion-prone land [4].

These factors which influence the productivity of agricultural land indicate a need for broadening our agricultural land base. Unfortunately, expanding production on the extensive margins involves costs as well. Much of the land which could be brought into production is less than ideal for agricultural purposes. The amount of the vast reserves of land in capability classes I and II[1] has been largely reduced as agricultural production was encouraged in response to a food shortage world-wide in the early 1970s. Costs of using potential cropland involve not only clearing and preparing

---

[1] See the Appendix for an explanation of the Soil Conservation Service's land classification system.

the land for use as cropland but also the loss incurred by soil erosion. The incidence of soil erosion is likely to continue in an upward trend since the lands being converted to cropland are increasingly fragile.

Coupled with the possibility that expansion of agricultural production on the extensive margins will be associated with increasingly higher costs is the estimate that every year approximately three million acres of agricultural land in the U.S. are being converted to urban and other uses [26]. Approximately, one-third of this converted land is cropland. Many factors play a role in causing this drain of agricultural land. In general, however, the conversion of farmland is induced by the economic laws of supply and demand. Demand for land to be used for housing, transportation, industry, and shopping centers has been increasing for a variety of social and economic reasons while, at the same time, farmers have been induced to offer their land for sale for equally compelling reasons.

One of the chief factors leading to the increased demand for land has been a strong preference for single family housing that has been growing for years [3]. This is due, in part, to rising per capita income. In addition, suburban and rural living have become more attractive. Rising crime rates and pollution levels within large metropolitan areas have driven many people to the suburbs and beyond in an attempt to improve the quality of their lives.

Another factor contributing to the demand for land is the greatly improved U.S. highway system which allows the rural populus easy access to nearby metropolitan areas. In addition, rural living no longer carries with it the necessity of foregoing the modern conveniences available in more densely populated areas [3]. Electricity, water, and sewage systems are available in the country at small increases in costs.

Federal housing policies have also encouraged urban expansion by providing low interest loans [14]. Also, federal tax policies allow interest payments and losses on a home to be treated as deductible expenses.

Finally, with more people removing themselves from the urban environment, it is inevitable that the retail and service industries have followed in order to cater to their demands [3]. These industries themselves create employment which provides incentive for additional families to move to a rural setting.

These factors prompting the increased demand for land tend to interact with each other to create an even greater impact than the sum of all factors when each is considered as acting alone in isolation. The total demand for rural land spirals upward as better highways and the availability of services attract people who in turn attract industry. New industry in the area creates new employment which lures still more people away from the city, thus absorbing more land.

In conjunction with this demand for land has been the availability of land for development. Many farmers have succombed to a variety of personal and economic pressures causing them to offer their land for sale.

One such factor contributing to this occurrence is the rising taxes farmers must pay. As the demand for their land to be converted to other uses increases, its value increases and hence, the owners' taxes rise as well. Taxes are also increased to pay for the expansion in services which takes place once an area begins to undergo development. Since the property tax is the primary source for these funds, the farmers frequently bear a large share of the burden due to their substantial investments in land [3].

A second cause to be considered is the general increase in farming costs. Not only have the prices for supplies such as fuel, fertilizers, and farm equipment increased but the cost of financing these purchases has increased as well. In view of the fact that many farmers finance these inputs through credit, the high interest rates contribute to the forces inducing the land owners to give up their properties [3].

Some additional costs are (1) a decrease in the availability of farm supply centers; (2) the friction between ex-urbanites and farm operators; and (3) a decline in the farmers' influence in local politics. These last two factors frequently result in legislation which regulates against farming activities [3]. Migrants to the rural areas find the farmers' normal farming procedures a nuisance and frequently bring about zoning ordinances which restrict the farmers.

Along with rising taxes and costs, some farmers are losing their desire to continue farming for personal reasons. As they approach retirement age, farmers may sell their farms to speculators (particularly when their offspring are uninterested in carrying on their parents' occupation) [3].

The final contributing factor inducing landowners to relinquish their holdings is the high price they can receive for their land created by the competing uses. This entire process tends to reinforce itself as observed by R. Neil Sampson,

> "Farmland conversion, likewise, feeds on itself. Each plot of farmland lost not only breeds new houses that consume rural resources and services, it also creates another group of farmer speculators who decide that the time is coming soon when the land will make more money by being sold than by being maintained as a producing farm" [19, p. 15].

Hence, the combined effect of these factors is to make available to developers the land they are seeking for the construction of housing, shopping centers, and service related industries. The obvious results are urban expansion and the relocation of farming operations on land further removed from urban areas and generally less suitable for intensive agricultural use.

The foregoing analysis of the farmland conversion process is a common scenario throughout most of the U.S. Until recently, it has received the most attention in the northeastern and Sun Belt states such as Florida [6]. In the case of the former, urban expansion has been the natural result of population shifts out of the densely populated urban areas. In Florida, additional pressure to convert highly productive agricultural land has arisen from a mass immigration of predominantly retired individuals.

However, other areas of the country have not been immune to this process. In Iowa, with its reputation as a large producer of feed grains, the presence of farmland conversion takes on added significance. It is far more likely that land converted to urban uses will be reasonably productive cropland [26].

Although the pressure to convert land from agricultural uses may not be as great in Iowa as elsewhere, evidence of this process is easy to find and indicates that farmland conversion has been taking place for some time now. According to the "Iowa 2000 Study," approximately 3.8 percent of Iowa's total cropland was converted between 1945 and 1978 and it is projected that an additional 600,000 acres will be converted by the year 2000 [13]. Due to the irreversible nature of these land use changes and the fact that there is a limit to the amount of additional agricultural land available, careful analysis of the problem is vital in order to understand the future consequences of decisions made today.

Objectives of Study

The first objective of this study is to inquire into whether Iowa's ability to contribute to feeding much of the world is being jeopardized by the continuous process of converting agricultural land. To accomplish this objective, the current situation will be examined in terms of what the potential is for expansion on the extensive margins as well as in terms of productivity and the rate of conversion both into and out of agricultural uses. Data on both state and national levels will be presented in order to place Iowa within the proper context.

The second objective is to develop and present a procedure which can be used to project the long term implications for agricultural production in Iowa under a series of different assumptions relating to trends in conversion of land into or out of agricultural uses. In addition, the trends will be selected in order to examine the effects of both the overall quality of the land base and the rate of technological change on reducing the negative impact of cropland conversion.

The third and final objective is to analyze the results obtained from the model and examine the policy implications. In addition, the limitations of this study will be discussed as well as further research needs.

Procedures Used to Achieve Objectives

In attaining the objectives outlined above, the area of study will be limited to the state of Iowa and its role in national agricultural production. Secondary data sources will provide the necessary information for estimating present and future trends in productivity and land use shifts on both the national and state levels.

The procedure used to fulfill the second objective will require:

1. Establishing Iowa's share of national corn and soybean production in 1980.
2. Projecting Iowa's output for years 2000 and 2020 based on Iowa's projected share of natural production for those years.
3. Determining what the total Iowa production will be for corn and soybeans under six scenarios.

Organization of Report

This introduction is followed by a discussion of the national and state considerations in farmland conversion in Chapter II. Previous studies will be examined to assess the current situation in land use and to provide evidence of a problem in land use allocation. Chapter III will present the modeling procedure used to make the necessary projections. Chapter IV contains the application of the model to Iowa using six alternative scenarios. The results are summarized in Chapter V which also contains a discussion of policy implications and the limitations of this study.

CHAPTER II. NATIONAL AND STATE CONSIDERATIONS IN FARMLAND CONVERSION

This chapter defines more clearly the problem of farmland conversion and suggests possible consequences of this process. First, definitions of farmland and cropland are provided to clarify the discussion which follows. Then, national and state estimates of both farmland and cropland conversion rates are reviewed. Subsequently, national and state trends in the amount of agricultural land actually under cultivation are presented in terms of the rate of replacement of converted agricultural land and the estimated potential for converting land into agricultural uses. Next, recent trends in productivity per acre are examined for corn and soybeans (the selected crops in this study). The next section deals in a more general sense with the role of technological change in agriculture in the past and present as well as its projected impact in the future. Finally, the possible consequences of the farmland conversion process are discussed in terms of the environmental impact of expanding agricultural production on the extensive margins and in terms of the irreversible nature of the process itself.

Definitions

In order to have a more precise understanding of what is being discussed in the sections which follow, it becomes necessary to define certain terms. Specifically, it is vital to make the distinction between farmland and cropland. In this study, "farmland"

and "agricultural land" are used interchangeably and include any land used for agricultural purposes such as cropland, pastureland, range, and forestland. Cropland is a sub-category of farmland and includes land used for row and field crops, orchards, rotation hay and pasture, and summer fallow [4]. Since this study focuses on the production of corn and soybeans, estimated trends in cropland acreage are included as well as trends for farmland in general in order to indicate the relative impact of farmland conversion on the sub-category, cropland, and hence, on the ability of Iowa and the U.S. to meet their projected production levels for corn and soybeans.

National and State Trends in Farmland Conversion

National trends

Although recent data on the rate of farmland conversion at the national level are unavailable, there were several studies completed in the late 1970s which provide estimates for the trend in farmland conversion up to that point in time. It should be noted that the figures to be presented represent changes in land use from agriculture to other uses only. They do not account for shifts in land use into the agricultural sector. Net changes in farmland acreage will be examined later. It is hoped that by separating the components of the land use process, a better understanding of exactly what is occurring can be obtained.

One such study was undertaken by Dideriksen, Hildebaugh and Schmude in 1977 through the U.S. Department of Agriculture Soil

Conservation Service (SCS) [6]. They calculated the annual agricultural conversion rate in the U.S. for two time periods (1958-1967 and 1967-1975). Their estimates for the two time periods were 1.14 million acres per year and 2.08 million acres per year, respectively. They further estimated that for years 1967-1975, 606,000 acres of cropland were converted each year.

Two additional sets of figures for the farmland conversion rate were estimated in the National Agricultural Lands Study (NALS) which was undertaken chiefly by the USDA and the Council on Environmental Quality [26]. In this instance, one source of data was the National Resource Inventory Series (NRI) which is comprised of the 1975 Potential Cropland Study and the 1967 and 1958 Conservation Needs Inventories (CNI) [27, 30]. Results from this series of studies indicate that between the years 1967 and 1975 the U.S. lost 23 million acres of agricultural land to other uses [27]. A total of 5.4 million acres of cropland were converted during this time period. Urban build-up, and transportation uses accounted for about 70 percent of the converted farmland. Hence, the annual conversion rate for the U.S. as a whole was calculated to be nearly 2.9 million acres per year of agricultural land and 675,000 acres per year of cropland.

The other data source consulted by the NALS was the Census of Agriculture for years 1969, 1974, and 1978 [29]. These data indicate an even greater shift of farmland into other uses. In this case, data on "land in farms" were consulted to obtain estimations of the annual conversion rates. From 1969 to 1974, land in farms decreased by 53.5 million acres and from 1974 to 1978 the data indicated a decline of 34.6 million acres. These figures translate into annual conversion rates of 10.7 and 8.7 million acres for each of the time periods, respectively.

Based on these data, for the ten year period 1969-1979, the conversion rate becomes close to 10 million acres per year which is more than three times the annual rate obtained from the NRI series. The NALS accounts for this difference in terms of "the alternative definitions and land use categories used in the Census and the NRI series" [26, p. 36].

> "The Census's 'Land in Farms' includes not only land actually converted to nonagricultural uses but also some land that moved from farm or ranch ownership through purchase by a speculator, developer, or timber company. Land sold to a developer or speculator is often rented out and kept in agricultural uses for a period of time" [26, p. 36].

In the NRI series, on the other hand, this change in land ownership is included in the categories of "Other Nonfarm" and "Other Land in Farms" and is therefore excluded from the estimate of land actually converted from agricultural uses. This explanation can also be applied to the Dideriksen, et al. study mentioned earlier in which a conversion rate of 2.08 million acres per year was estimated.

Part of the discrepancy between the figures can also be explained by the differences in the time periods involved. The NRI series used data for 1975, 1967, and 1958 while the Census data came from years 1969, 1974, and 1978.

Assuming that data obtained from the NRI study portray a more accurate picture of the actual situation,[1] the rate of farmland conversion has been increasing. The CNI surveys for 1958-1967 indicate an annual conversion rate of 1.14 million acres of agricultural land. If the 1967 CNI and 1975 NRI are compared, an annual conversion rate of 2.9 million acres is indicated. If this trend continues, the Council for Agricultural Science and Technology estimates that by the year 2030, 48 million acres of cropland may have been converted [4].

State trends

On the state level, studies estimating the rate of farmland conversion are more scarce than at the national level. One such study was made for the "Iowa 2000 Study" held at Iowa State University in 1978 [13]. Although an actual conversion rate for agricultural land to other uses was not calculated, the study did indicate that starting in 1948 to the time of the conference, Iowa had converted 3.8 percent of its cropland base. The study also indicated that 1.3 million acres of farmland were converted between 1945 and 1978. This translates into a conversion rate of nearly 40,000 acres per year. The study projected that an additional 600,000 acres would be converted by the year 2000 which implies a substantial increase in the conversion rate.

---

[1] This is a rational assumption since the NRI series takes into consideration land that is still used for agriculture after being sold to developers.

In a detailed study on the topic of farmland conversion, Gibson also produced estimates for annual conversion rates in Iowa [8]. He based his estimates on the 1967 Iowa Conservation Needs Inventory. The data from the 1958 inventory could not be used to make the necessary estimations and projections because the sampling techniques and land capability class definitions used differed from those for the 1967 inventory. Consequently, rather than estimate a conversion rate through comparison of two data sets, Gibson employed nonagricultural land use change estimates for 1960-1970. Since his data set for agricultural land was for 1967, he subtracted three-tenths of the nonagricultural land use estimates from the 1967 cropland base. In this manner, he established agricultural land use acreage bases for years 1970, 1980, 1990, 2000, 2010, and 2020. Based on these estimates, an annual conversion rate for cropland in the state of Iowa can be calculated at approximately 17,894[1] [8, pp. 302-303]. Gibson projected a 3 percent loss of land capability classes I, II, and III cropland between the year 1970 and 2020 or approximately 790,420 acres.

Corresponding to this loss of agricultural land is the estimate that Iowa experienced a 19.7 percent increase in its nonagricultural land use acreage during the period 1960-1970. Of the 371,649 additional acres in this category of land use, over 80 percent of the

---

[1] According to Gibson's estimates, cropland in 1970 was 26,347,326 acres and projected acreage for cropland in 1980 was 26,168,391. The change in acreage estimates is divided by ten to obtain an annual conversion rate.

increase was in the areas of urban and associated land uses [8, p. 202]. Gibson projected that in the future, nonagricultural land uses may consume an additional 1,084,310 acres between 1970 and 2020 [8, p. 245].

Another study concerned with farmland conversion in Iowa was undertaken by the State of Iowa Office for Planning and Programming [21]. In this instance, a conversion rate of 46,300 acres annually was estimated for the years 1967-1977. Of this land use shift into urban uses, slightly less than 30,000 acres was agricultural land.

National and State Trends in Quantity of Agricultural Land Under Cultivation

When viewed alone, these statistics portray a rather alarming prognosis of vanishing farmland and increasing urban sprawl. However, in order to place the problem in its proper perspective, additional information is required on the extent to which this land is being replaced by either converting land from range, pasture, or forest into cropland or by farming more intensively on the remaining acres. Therefore, this section will provide information on the rate of replacement of agricultural land at both national and state levels. The question of farming existing cropland more intensively will be investigated in a subsequent section of this chapter.

Rate of replacement of lost agricultural land and estimates of potential agricultural land nationally

According to the study previously cited by Dideriksen, et al., a comparison of the 1977 NRI with the 1967 CNI indicated a decline in cropland of 18 million acres [6]. However, during this same period of time, irrigated acreage increased by 14 million acres. For the period 1958-1967 a loss of 17 million acres of cropland was compensated for by an increase of 7 million acres of irrigated land. In addition, some of the loss in cropland acreage was compensated for by bringing into production some rangeland, forest land, pastureland, and land set aside in previous years under federal programs designed to restrict agricultural production [6].

The NALS presents a more accurate estimate of the amount of land shifted into agricultural uses. The report cites the 1977 Potential Cropland Study by the USDA/SCS which indicates that a total of 48.7 million acres of land shifted into use as cropland over the period 1967-1975. This shift partially compensated for a loss of 74.2 million acres from cropland use, making a net loss of 25.5 million acres of cropland [26].

As before, the NALS also presented data from the Census of Agriculture adjusted in order to be comparable to the estimates made by the Potential Cropland Study.[1] It was found that during the period 1969-1978, over 35 million acres of land shifted into or out of use as cropland but there was only a one million acre net gain in the quantity of cropland.

In terms of the potential for new cropland, Dideriksen, et al. estimate that in 1977 approximately 14 percent of the nation's rural

---

[1] Inconsistencies in the definition of a farm and changes in statistical procedures among the census years themselves made this adjustment necessary [25, p. 34].

land could be converted to use as cropland. This represents a total of 135 million acres considered to have high or medium potential as cropland. Land classified as having high or medium potential as cropland is not subject to severe soil limitations or committed to relatively irreversible uses. In addition, it must be relatively free of social, economic or resource-related problems [6].

The NALS estimates that in 1977 there were 115 million acres of land in land capability classes I and II that could be converted to cropland. However, only 50 million acres of this land was considered to have high or medium potential for use as cropland. The remaining 65 million acres had a low potential for conversion due to small field size, inaccessibility, or commitment to other uses.

In still another study concerned with estimating potential cropland nationally, it was estimated that 78 million acres of land had a high potential for conversion and that 23 million acres had a medium potential for use as cropland [20].

Rate of replacement of lost agricultural land and estimates of potential agricultural land in Iowa

Two sources of potential cropland estimates were investigated to obtain estimates of the current rate for converting land into agricultural use. The first source is the USDA which provides yearly estimates of land in farms for every state [25]. If these data are used in conjunction with the estimated conversion rate in Iowa for land out of agricultural uses, an approximate replacement rate for farmland can be obtained.

If the State of Iowa Office of Planning and Programming's estimate of a 30,000 acre per year conversion rate is used, then the net loss of 200,000 acres of agricultural land in Iowa that occurred between 1975 and 1980 implies that no new land has been brought into production. In fact, a conversion rate of 30,000 acres per year is a bit too low to explain the 200,000 acre loss in farmland. The estimate of 40,000 acres per year made by the "Iowa 2000 Study" is more likely since it implies that total cropland in Iowa has remained constant over the five year span of time. It can, therefore, be concluded that as of 1975, Iowa was already using its agricultural land resources to their fullest extent. This observation is supported by a CARD publication in which it was estimated that for the years 1972-1974 Iowa was using approximately 93 percent of its available cropland [10, p. 104]. It should be noted that additional quantities of land could become classified as having potential for use as cropland if there were a significant change in economic conditions making it profitable to prepare some areas for crop use.

Another source of an estimate for the replacement rate of agricultural land is Amos [1]. He presented data obtained from the USDA Statistical Reporting Service which showed total acreage harvested in Iowa for years 1964-1977 and estimated acres set aside for the same years. By summing the two data sets for each year an estimate of total cropland is obtained which increased by only .4 million acres from 1964-1977 while cropland harvested increased by 4 million. Consequently, nearly all of the increase in harvested acreage came from set aside land. Given the 30,000 acre per year conversion estimate cited earlier, an average of 60,700 acres of land would have to be converted to agricultural uses each year in order for total cropland to increase by 400,000 from 1964 to 1977.[1]

If the annual conversion rate derived in Gibson's study is used, a more moderate estimate of land shifting into agricultural uses is derived. In this instance, approximately 48,700 acres per year were shifted into use as cropland [8].

In terms of potential cropland within the state of Iowa, Amos presented a series of estimates in his thesis based on 1967 CNI data [1, p. 28]. The potential supply is broken into land capability classes. If only land capability class I is considered, there are only .4 million additional acres that could be converted to use as cropland. If land capability classes one through four are considered feasible, Iowa would have a potential for expanding its cropland base by 5.2 million acres. However, Amos did not indicate in his study how much of this land has a high potential for conversion. Some of it may be inaccessible or in parcels too small to be economically feasible cropland.

National and State Trends in Productivity Per Acre

Obviously, the net loss of agricultural land nationwide cannot be translated directly into declining production of agricultural

---

[1] This approximation is calculated as follows: $\frac{400{,}000}{13 \text{ yrs.}} = 30{,}769$ acres per year. To compensate for land converted from farmland, the annual conversion rate of 30,000 is added to this figure.

commodities because the actual production figures indicate otherwise. Yield per acre has been increasing fairly consistently for most agricultural products. For example, corn yields in the U.S. increased from 32.7 bushels per acre in 1945 to 101 bushels per acre in 1978. Soybeans showed an increase from 18 bushels per acre in 1945 to 29.4 bushels per acre in 1978. This means that corn yields have tripled in the U.S. while soybean yields have increased by more than half [25].

Within Iowa, corn yields went from 44.5 bushels per acre in 1945 to 115 bushels per acre in 1978 and soybean yields increased from 18.5 bushels per acre to 37.5 bushels per acre during the same span of time [25].

The Role of Technological Change

The primary factors responsible for these yield increases are weather, technology, and the education received by farm operators on the implementation of new technologies. As noted earlier, during the last two decades, the Midwest received the benefits of nearly ideal growing conditions. This weather pattern is unlikely to continue as observed by Thompson [23] and, indeed, the Midwest and the U.S. as a whole have been witness to rather severe and unusual weather conditions in the recent past such as the drought of 1980.

However, the major contributing factor to increasing yields is technology. The advances made in agricultural technology provide an excellent example of how a man-made resource, technology, has substituted for a natural resource, land. In this way, the U.S. has been able to conserve its farmland and push back the limits to its productivity. Unfortunately, recent trends seem to indicate that the period of rapid productivity growth may be drawing to a close. Many argue that in terms of a production function for technology, agriculture has reached the third stage of diminishing returns with existing technology.

Lee, et al. present a productivity growth curve for agriculture which depicts, essentially, four phases for change in productivity due to a new technology [15]. The first phase is that time which elapses between the time when the new technology is ready for use until the impacts from its use can be detected. In the second phase, a small number of farmers adopt the new technology and evaluate it. It is during phase three that the bulk of productivity increases are realized as more farmers are attracted to the technology. By the time phase four is reached, most farmers have adopted the new technology and its potential use is exhausted. Lee, et al. hypothesized that the slowed productivity growth in phase three provides the impetus to develop new technologies which serve to shift the S-shaped productivity growth curve outward. They conclude that: "The probability of a limit to growth in agricultural productivity is thereby further reduced" [15, p. 10].

However, Lee, et al. failed to recognize that research and development have become much more expensive relative to the resulting increases in productivity. It is argued that the simpler technologies such as hybrid corn and improved fertilizers have already been developed and the remaining options will require much more time and money to develop before they will be marketable [22].

In addition, the lead time mentioned earlier, is a factor deserving further consideration. The chief determinants of this phase of productivity growth are the cost to the farmers of implementation and how informed they are about the new technology. Generally, the smaller farmers are the last to adopt a new farming technique simply because the size of their operation is too small to warrant investing the time to even educate themselves about the new technique. This lag accounts for the fact that the U.S. continues to experience increases in productivity in spite of the fact that no significant new developments have taken place since the early 1960s.

Of course, there is still room for substantial increases in productivity if new technologies (such as plant varieties with greater leaf area and twinning in beef cattle) are developed to the point of being marketable [9]. However, much additional research will be necessary before these technologies can be profitable and a substantial investment will be required especially if the U.S. is indeed encountering diminishing returns to agricultural research.

Hence, although technological change played a major role in boosting U.S. agricultural production during the last several decades, it seems unlikely that farmers would be able to depend on it continuing to do so in the future. The role of technology as a substitute resource for land hinges on how strong our commitment is to research and the dissemination of information about new technologies. Given the present policy of the U.S. government, prospects for further increases in productivity, at least in the near future, appear to be rather dim.

Consequences of Farmland Conversion

Environmental considerations

Since a continuation of increases in yields is uncertain, the U.S. and Iowa may be forced to depend more heavily on land classified as potential cropland to replace the crop production forfeited when agricultural land is shifted to some other use. However, much of this potential cropland is more susceptible to erosion than an average acre of land already in agricultural use because, as in their 1975 study, Frey and Otte estimated that 155 of the 265 million acres of potential cropland in the U.S. is in land capability class III. This land has "moderately steep slopes, and high susceptibility to water or wind erosion..." [7].

The impact of this erosion is felt in two ways. First, the land is gradually stripped of its productivity as the fertile topsoil is transferred elsewhere. Second, this displaced soil causes environmental damage to streams and rivers. The amount of suspended silt increases and often carries with it the chemicals that were applied to the land in the process of producing fertile soils [1, p. 38].

A quantitative estimate of the extent to which soil erosion increases with expansion of agricultural production on the extensive margins was obtained by Cory and Timmons [2]. In their study, they used projections to 1985 under two scenarios: (1) historical trends continue for crop yield increases, farm size, and export demand; (2) the high level of exports for the period 1973-1975 continues accompanied by increased farm efficiency and favorable agricultural policy. The results obtained showed that land used for crops would increase 18.6 percent under the first scenario and 30.7 percent under the second scenario for the Corn Belt region between the 1967-1972 base period and 1985.[1] The associated soil erosion increases were estimated to be 44.2 and 75.4 percent for the two scenarios. Hence, a one percent increase in cropland used would create a 2 1/2 percent increase in soil erosion.

The situation is even more bleak within the state of Iowa. In this case, Cory and Timmons estimated cropland increases of 20.4 and 28.4 percent under scenarios I and II, respectively, accompanied by soil loss increases of 67.6 and 106.1 percent. This translates into a 3 3/4 percent increase in soil loss for each percent increase in cropland used under the second scenario of high export demand. The environmental consequences of increases in soil erosion of this magnitude would be substantial. Therefore, the implications for soil loss must be considered before implementing any land use policy.

---

[1] Cory and Timmons included Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin in the Corn Belt region.

Implication for future availability of cropland

There is one additional consequence of farmland conversion that is often overlooked. Once agricultural land is developed for housing, transportation, or any other urban use, it is no longer available for farming. Conversion of this nature is irreversible. Failure to take this fact into consideration when allocating land can have serious consequences. Because of uncertainties about the future in terms of population demand for agricultural products, the rate of technological change in agriculture and trends in weather conditions, prudence dictates that a margin of error should be allowed for when forecasting future agricultural land requirements. Consideration for future developments should therefore be included in the land allocation process since many of the decisions made today are permanent.

Summary

This chapter has provided an introduction to the farmland conversion process at both the state and national levels in order to gain some understanding of what is actually occurring.

Recent trends in both national and state conversion rates for land out of agricultural uses indicate shifts in land use of large proportions. The most modest estimate for the U.S. shows a loss of 606,000 acres of cropland annually between 1967 and 1975. At the other extreme is a study which estimates that 1.8 million acres of cropland were converted per year between 1967 and 1977 [6]. Meanwhile, in Iowa, estimates of cropland converted range from 17,894 acres per year to 30,000 acres per year.

This land, which is being shifted to other uses, has been partially replaced by converting other land into farmland. The most accurate estimate indicates a shift in land to cropland of 48.7 million acres between 1967 and 1975 or 6 million acres annually in the U.S. as a whole [26]. For the state of Iowa, it is estimated that approximately 60,700 acres of land were converted to agricultural uses annually for the period 1964 through 1977 [1].

The remainder of the foregone crop production on land converted to other uses has been more than compensated for by increases in yields per acre. According to data published in "Agricultural Statistics," yields for corn have tripled while per acre soybean production has increased by half in the U.S. between 1945 and 1978 [25]. In Iowa, yield increases were just as impressive with corn yields increasing by 60 percent and soybean yields doubling from their 1945 yields.

The driving force behind these productivity increases is technogical change. Through more innovative and efficient farming techniques and through improved seed varieties and fertilizers, the U.S. has managed to boost its production of food and fiber in spite of net losses in the quantity of agricultural land. However, the magnitude of future productivity increases is uncertain, particularly in view of the recent government policy which has reduced the flow of funds into research.

The final section of this chapter suggests some probable consequences of farmland conversion which are (1) increased environmental degradation caused by higher incidence of soil erosion as more fragile lands are brought into production and (2) the fact that many of the land use shifts which occur are irreversible and, hence, foreclose the possibility of land removed from agricultural use ever being returned to its original condition.

CHAPTER III. DEVELOPMENT OF METHODOLOGY

This chapter contains a presentation of the methodology used in estimating the impact of various farmland conversion rates on Iowa's ability to meet future demand for food and fiber. The first section describes the area of study and the selection criteria. Section two presents a description of the shift-share modeling technique which is the analytical method chosen for this study. In section three, the time horizons and the base year are presented as well as the criteria used in selecting them. The next section outlines some of the considerations to be made in projecting Iowa's output for corn and soybeans. The last section gives a description of the scenarios to be simulated in this study.

Area of Study

There are several options available in selecting an area of study. The optimal choice is chiefly a function of the nature of the problem under investigation and the geographic limitations of the data available. In the case of natural resources, the most relevant boundaries are those which encompass the resource itself. For many resources such as water and land, boundaries are easily obtainable.[1] However, a vast number of resources do not occur within definable boundaries. Air, for example, seldom remains stationary and its

---

[1] In the case of water, the recognized method for determining an area of study is to use the boundary of the watershed itself.

movement is difficult to monitor.

When it is no longer practical to use boundaries delimited by the resource itself or when the necessary data are not available, it becomes necessary to rely on an alternative method. In general, political boundaries are used in lieu of resource boundaries. The major disadvantage of using political boundaries is that they seldom encompass the entire resource area or, if they do, a great deal of the area under study may be superfluous, thereby reducing the accuracy of the data used.

However, the use of political boundaries is advantageous in certain respects. First, they may be the only available alternative in determining the area of study. In addition, data are generally collected on the basis of political boundaries. The analytical process is therefore much simpler since secondary data sources frequently provide all the necessary information thereby making the generation of primary data unnecessary. One final consideration which tends to favor the use of political boundaries is that when the results of the study are used to derive new policies, these policies will follow political rather than natural boundaries. Hence, legislatures are most interested in studies which use geographic boundaries coinciding with their jurisdictions. The implementation of a new policy becomes much more complicated when the area of interest is split between two or more political jurisdictions. With the above considerations in mind, the state of Iowa was selected as the area of study.

Shift-Share Modeling

In general terms, the shift-share modeling technique involves estimating the future production emanating from a region based on the trend for its share of national production in previous years and the projected level of national production for some year in the future.

This method for making projections was used by Gibson [8]. However, it has also been used quite extensively by the U.S. Water Resources Council in its "OBERS Projections of Economic Activity" [28]. As stated in the publication, "...the shift-share technique distinguishes a proportional growth element and a differential growth element between a region and the nation in each industry or income component" [28, p. 24]. The corresponding mathematical equation used for their projections is:

$$E_{ij}^{t} = (E_{io}^{t}/E_{io}^{x})\ E_{ij}^{x} + C_{ij}^{x-t}$$

where: $i = 1, \ldots, n$ industries,

$j = 1, \ldots, m$ regions,

o = a summation term,

t = the year to which the projection is made,

x = the base year [28, p. 24].

The first element on the right-hand side is "the proportional growth element." It assigns to an industry at the regional level a rate of change equivalent to one for the same industry at the national level. The other element, C_{ij}^{x-t}, is the "regional share effect" and accounts for the difference between the proportional growth projected by the first term and the actual growth, E_{ij}^{t}.

The shift-share procedure can be used to estimate future values for variables such as production, employment, or resource use in a particular region based on the present or past values of these variables and their share of national production, employment, or resource use. However, making projections is not the sole function of this particular technique. By changing the underlying assumptions, the impacts of various legislative policies can be simulated. Although the accuracy of the projections may be questionable due to lack of data, the general direction of trends is not indeterminate and hence a model of this nature provides a useful tool for policy makers faced with making a decision regarding land use [8].

Time Horizons and Base Year

Selecting the appropriate time horizons involves a trade-off between the accuracy of the projections made and the usefulness of the study as a policy tool. Obviously, as the year to which projections are being made becomes closer to the present, the accuracy of these projections increases. However, the usefulness of the study in formulating policies with long term consequences becomes much more limited. Hence, it is necessary to determine what the relevant time horizon is for the available policy alternatives.

One consideration, for example, is the fact that the legislative process is long and involved. Consequently, a period of several years could elapse between the date a bill is introduced and the date it eventually goes into effect. Projections made for five to ten years into the future have very little value in this case.

The time horizon should also reflect the nature of the problem under investigation. In the case of land use, relatively longer time horizons are called for since the process itself is a phenomenon occurring over a span of many years. The land use changes taking place in a particular area in the course of a year may appear inconsequential but when these shifts in land use accumulate over the span of a decade, the total change could have quite a substantial impact on the local community, both economically and sociologically.

Finally, it is helpful if the time horizons selected for a study coincide with those used elsewhere. In the OBERS report, the years 1980, 1990, 2000, 2010, and 2020 were selected as projection dates. In view of this information and the other considerations listed above, this study selected the years 2000 and 2020 for its projection dates.

The base year used in this study was selected according to the year in which the most recent data are available which is 1977. That was the last year for which the National Resources Inventory published data on land in the various capability classes and subclasses [30]. In 1983, they will make a more recent data set available which will significantly upgrade the accuracy of projections made in the general area of land use.

Iowa's Projected Share of National Production

The model applied to Iowa is relatively simple. First, Iowa's projected share of the national production of corn and soybeans is obtained from the 1974 OBERS study. The next step is to estimate how much corn and soybean will be expected from Iowa in the years 2000 and 2020. Given the national projected output, Iowa's output is determined by multiplying the OBERS projection for U.S. production by Iowa's projected share of that output.

This procedure operates under the assumption that Iowa will continue to supply the same share of national output as indicated by historical data. Whether or not this will be factual is difficult to determine since a host of exogenous factors play key roles in determining Iowa's share of agricultural output.

Technological change and future yield projections

Before the implications of some possible scenarios can be investigated, the impact of technological change must be incorporated into the model. As stated earlier, new technologies in the agricultural sector have led to vast improvements in productivity. In order to account for these productivity changes, projections of future yields are obtained from Pope's study which is concerned with deriving a function for estimating crop yields [18]. The model he developed estimates yields for various crops as functions of technological change, weather, and nitrogen use. Nitrogen use is, in turn, a function of technological progress, corn and nitrogen prices, and weather. In his study, Pope chose to use time as a proxy variable for technological change. The rationale behind this decision was that so many factors interact to bring about technological progress that any attempt to isolate these factors and to identify their relative impacts would, at best, be prone to error and, at worst, misleading. In addition, the use of time as an estimator variable for technological change produces as good a fit as when other variables such as lagged expenditures on research and development are used.

The chief shortcoming of using time to estimate technological progress arises when the results of the regression are used to project future yields. There is no reason to believe that past trends in technology will continue into the future. At present, there are conflicting views on exactly what the trend is in crop yield increases. While Heady remains optimistic about the potential for technological change to maintain a steady growth rate in yields, others are less confident that this will be true [5,9].

Consequently, two trends in yield increases are used for projecting the production of corn and soybeans in 2000 and 2020. The first assumes a future trend in yield increases at half their historical rate. The second trend simply assumes a continuation of the past rate of increases in yields due to technological change. In both cases, average weather conditions are assumed in 2000 and 2020.

Land quality

It would be unrealistic to assume that technological change is the only factor causing a change in yields. If, for example, a greater proportion of the land in capability class one is converted to nonagricultural uses, the average yield per acre is likely to fall since the remaining cropland will be composed of proportions of less productive land. Hence, it is necessary to incorporate the presence of a heterogeneous resource into the analysis.

To estimate this change in average yield per acre and, therefore, total production, the projections for future state average yields obtained from Pope's study are disaggregated into the land capability subclass categories. The method for designating yields by capability subclass is adopted from Gibson's study. Data on maximum relative yield potential relationships for each of the major crops in Iowa are used to obtain the yield estimates according to the following formula:

$$\hat{\bar{Y}}_i = \sum_{k=1}^{n} [\frac{a_k}{C} \hat{\bar{Y}}_{ik}]$$

where $\hat{\bar{Y}}_i$ = state average yield of crop i,

a_k = the number of acres of land in capability subclass k in Iowa,

C = total cropland in Iowa,

$\hat{\bar{Y}}_{ik}$ = yield of crop i on land capability subclass k.

The $\frac{a_k}{C}$ term assigns a weight to each capability subclass to determine that subclass's importance in producing the state average yield. To solve for the $\hat{\bar{Y}}_{ik}$ terms, the estimates of maximum relative yield potential relationships (which appear in Table 3.1) are used to put the right-hand side of the equation in terms of Y_{i1} which is the yield of crop i on land capability class one. The yields for the remainder of the land capability subclasses are then obtained, based on their yield potential relative to that of capability class one. These yield estimates are based upon the expected average yield estimates obtained from Pope's study for 1980 and are then increased on a percentage basis to correspond with the projected state average yields for 2000 and 2020.

It should be noted that by using this technique, the proportional differences in productivity among land capability classes are assumed to remain constant through time. This implies that the responsiveness of any land capability subclass to improved technology is unchanged. This assumption leads to a widening of the gap, in absolute terms, between productivity levels on the various subclasses of land and precludes the possibility of developing technology designed to narrow this gap.

Scenarios

Since this study is limited to the impacts of cropland conversion on corn and soybean production, the conversion rates applied to each land capability subclass are the key factor in determining the outcome of the model. The following scenarios are derived according to the assumptions made about these conversion rates.

Table 3.1. Maximum relative yield potential relationships by land capability subclasses in Iowa[a]

Land capability subclass	Corn	Soybeans
I	1.00	1.00
IIE	.90	.95
IIW	.90	.95
IIS	.60	.95
IIIE	.90	.87
IIIW	.70	.80
IIIS	.50	.80
IVE	.60	.75
IVW	.60	.62
IVS	.40	.62
V	.50	.40
VIE	.60	.40
VIW	.60	.40
VIS	.60	.40
VII (all)	.50	.40

[a] Source: [8, p. 296].

There are six scenarios being investigated in this study. The first of these assumes that there are no net changes in cropland acres in any of the capability subclasses. Any land converted from use as cropland is replaced by an equal amount of land from the same capability class. This scenario provides a baseline estimate of the hypothesized gap between Iowa's projected share of national production in 2000 and 2020 and its present ability to meet that projection.

The second scenario assumes that current trends in land use will not change and current trends in cropland conversion will continue. Specifically, estimates of current trends in conversion rates for each land capability subclass will be used to project cropland availability in 2000 and 2020.

Under this scenario, it is hypothesized that the overall quality of the land base should decrease since it is believed that at the national level land from the first three capability classes is being converted at a faster rate than land in the other capability classes [17, p. 37]. The primary reason behind this is that land well-suited for agriculture is also well-suited for most other uses such as urban development.

However, this theory is not supported by the data obtained for this study. A comparison of the 1977 NRI and the 1967 CNI reveals that the overall quality of the cropland base in Iowa has actually been increasing. In fact, acreage estimates for land capability class two shows a net gain over the ten year period (see

Table 4.3). An explanation for this occurrence is that Iowa has had in the past a fairly large quantity of productive cropland held in reserve which has been gradually brought into production to replace the land converted to other uses [1].

The third scenario assumes that the present overall cropland conversion rate remains unchanged, and the overall quality of the land base also remains constant. In this case, the quality of land converted from any capability subclass is proportional to that subclass' share of total agricultural land.

The fourth scenario is similar to the third in that cropland quality is held constant. However, this scenario also takes into consideration the fact that Iowa has been steadily depleting its supply of potential cropland which has served, in the past, to dampen the effects of the total conversion rate. Hence, for scenario S-4, two conversion rates are necessary. The trend net conversion rate is used until that point in time when it is calculated that Iowa's store of potential cropland will be depleted. After this point, the total conversion rate as estimated by the "Iowa 2000 Study" is used [13].

The fifth scenario simulates the impact of government policy to restrict the conversion of land from agricultural uses to tracts that are less suitable for use as cropland. Specifically, land in capability classes one and two is held constant and any land converted must come from the remaining capability classes in proportion to their share of total cropland. Once again, the same annual conversion rate established by the data in the 1967 CNI and 1977 NRI is used.

The sixth and final scenario simulates the same government policy as in S-5 and only land from capability classes three through seven is allowed to be converted to other uses. However, in addition, it assumes a higher conversion rate to occur once Iowa's estimated potential cropland is depleted. Hence, the same conversion rates used in scenario S-4 are applied here as well.

The basic technique used to estimate the impact of each scenario is as follows. First, the relative quantities of land remaining in the various land subclasses in 2000 and 2020 must be estimated. This is accomplished by multiplying the amounts of land in these subclasses used for cropland in 1977 by the appropriate annual conversion rate for the scenario under investigation. (Each subclass will have its own conversion rate.) This set of figures is then multiplied by the number of years from the base year to the projection date.

It is also necessary to determine how much land in each capability subclass will be used in the production of each of the crops being considered in 2000 and 2020. If trends in the recent past are assumed to continue, then data on the proportions of land in each capability subclass used in production of each of the crops during the base period can be applied to the projected remaining acreages for these land classes in 2000 and 2020.

Given the projected yields per acre obtained earlier on each of the land capability subclasses for both corn and soybeans, it is possible to obtain an estimate of total production of these crops in

2000 and 2020. The estimated acreage remaining in each capability subclass used to produce either crop is multiplied by the appropriate yield estimation. The mathematical interpretation is as follows:

$$P_i^t = \sum_{k=1}^{n} (Y_{ik}^t A_{ik}^t)$$

where P_i^t = total production of crop i in year t,

Y_{ik}^t = yield per acre for crop i on land capability class k in year t,

A_{ik}^t = acres planted in crop i on land capability class k in year t.

To obtain the total production of corn in 2000, for example, the projected yield of corn on land capability class I in 2000 is multiplied by the amount of land in that capability class projected for use in the production of corn in 2000. The same procedure is applied to each of the remaining land classes and the resulting figures are then summed.

The results of the projections made under each scenario are then compared with Iowa's projected share of national production as estimated by OBERS. Consequently, various estimations of the impact of cropland conversion in Iowa's ability to meet future demand can be obtained.

CHAPTER IV. APPLICATION OF MODEL TO IOWA AND RESULTS

This chapter contains a presentation of the analytical technique outlined in Chapter III as it is applied to Iowa. In the first section, the data needs and sources will be presented. Also, the computational procedures used to transform the data into a useable form will be discussed. The second section presents the six scenarios indicating how the data are applied in each instance. The last section contains the actual results obtained from the model as well as the implications for Iowa in terms of meeting its projected share of the national output.

Data Needs and Sources

In order to make the projections as accurate as possible, the land is divided into capability subclasses as defined by the USDA Soil Conservation Service (Appendix). Data on acreage, yield, and conversion rates are obtained following this subdivision. This delineation also permits the model to quantify the impacts of changing the overall quality of the cropland base.

Acreage estimates

Two types of acreage estimates are needed in this study. The first of these is an estimation of total cropland in Iowa. For the purpose of this study, cropland is defined as land actually used in the production of crops and hence, does not include land currently idle. The source for this information is the 1977 Natural Resources

Inventory (NRI) compiled by the USDA Soil Conservation Service [30]. Although other sources such as the Iowa Crop and Livestock Reporting Service have published more recent data on cropland acreages, the 1977 NRI is the only source which provides this information broken down according to the land capability classes and subclasses.

The NRI also presents data on land used strictly for row crops by land capability class and subclass. This information can then be used to estimate the quantity of land in each subclass planted in corn and soybeans in 1977. The procedure used is to multiply the proportion of land planted in each crop during that year by total row crop acres in each land capability subclass. The source for data on acreages planted in corn and soybeans is the Iowa Crop and Livestock Reporting Service [12].

Results of the above estimation procedure indicate that corn comprised approximately 66 percent of the row crop acreage in 1977 and soybeans accounted for most of the remaining share.[1] Hence, when these proportions are multiplied by the data on row crop acres, the ensuing products establish a data base from which to make projections. It should be noted that in order to use this procedure, it is necessary to assume that the proportions of row cropland used for each crop remains constant across all land capability classes.

A summary of the data compiled on cropland acreages is presented

---

[1] Popcorn and white corn account for a small percentage of land in row crops [12].

in *Table 4.1*. Data in the first and second columns on acres of land used for crops and row crops were obtained directly from the 1977 NRI. The third and fourth columns contain the estimates of land planted in corn and soybeans, respectively.

Conversion rates

The conversion rates are considered to be one of the independent variables in this study. Due to inadequate time series data, the conversion rates are used to designate the various scenarios by hypothesizing various trends for these rates. A separate vector of conversion rates is necessary to accompany each of the proposed scenarios. (Table 4.2 contains a summary of the scenarios.)

Scenario S-1 does not require a set of conversion rates since the quantity of land in each capability class and subclass is held constant at the 1977 level.

For scenario S-2, the actual rate of conversion is estimated based on data obtained from the 1967 CNI and the 1977 NRI [27,30]. The change in total cropland over the ten year period in each land capability class and subclass is annualized to obtain the necessary estimates. Table 4.3 contains the data used and the actual vector of estimated conversion rates.

The third set of conversion rates is designed to hold the quality of the cropland base constant while maintaining the same net rate of conversion as in scenario S-2. These rates are based upon the proportion of land in each capability subclass relative to the total land base.

Table 4.1. Total cropland and row crop acreages by land capability class and estimated acreages planted in corn and soybeans in 1977

Land capability subclass	Cropland[a]	Row cropland[a]	Corn[b,c]	Soybeans[b,c]
		(in 1000s of acres)		
I	3,128	2,883	1,900	978
IIE	6,371	5,430	3,759	1,842
IIW	6,721	6,106	4,025	2,071
IIS	539	458	302	155
IIIE	6,438	4,941	3,257	1,676
IIIW	817	787	519	267
IIIS	110	88	58	30
IVE	1,121	728	480	247
IVW	173	98	65	33
IVS	235	148	98	50
V	110	96	63	33
VIE	438	253	167	86
VIW				
VIS	22	7	5	24
VII (all)	163	51	34	17
Total	26,431	22,074	14,732	7,509

[a] Source: [30].

[b] Source: [11].

[c] The formula used to obtain these estimates is: $\frac{a_{ik}}{R_k}$

where: a_{ik} = acres planted of crop i on capability subclass k,

R_k = acres planted in row crops on capability subclass k.

The column of acreage estimates for row cropland is then multiplied by these proportions.

Table 4.2. Scenarios and assumptions

Scenario	Conversion rate 1977-1995	Conversion rate 1995-2000,2020	Land quality
	(in acres/year)		
S-1	0	0	Constant
S-2	2,631	2,631	Continuation of trend
S-3	2,631	2,631	Constant
S-4	2,631	40,000	Constant
S-5	2,631	2,631	Increasing
S-6	2,631	40,000	Increasing

In this study, the total land base includes forest rangeland and pastureland as well as cropland. The total land base rather than the cropland base is used to estimate these proportions since the conversion rates should be based on the total amount of land in each capability subclass available for conversion. In this way, the possibility of replacing some of the cropland converted to other uses can be incorporated into the model since the conversion rates are in net rather than gross terms.

The annual conversion rates are estimated by multiplying the proportions obtained above by the overall net conversion rate of 2,631 acres per year derived from the data in Table 4.3.

Scenario S-4 requires two sets of conversion rates. The first of these is for the first period of time during which part of the cropland converted to other uses is replaced from Iowa's supply of potential cropland. Since scenario S-4 assumes a proportional shift of land from each capability subclass to noncropland uses, the same set of rates calculated for F-3 can be applied here.

The second vector of conversion rates is derived from the median estimated rate of conversion cited from the "Iowa 2000 Study" in Chapter II of this report [13]. Their estimate of 40,000 acres per year is broken down on a proportional basis among the capability subclasses as in scenario S-3.

In scenario S-5, all of the land converted from use as cropland comes from land capability classes three through seven. The acreage estimates obtained from the 1977 NRI are held constant for the first two land capability classes. Conversion rates for the remainder are based once again on their proportional representation of the total land base. However, since land capability classes one and two have zero entries in the conversion rate vector, the proportions derived to estimate the remaining conversion rates must be based on the total land base excluding land in the first two capability classes. The total land base available for conversion is, therefore, reduced from 32,448,000 to 14,118,000 acres. Once again, these proportions are multiplied by the overall net conversion rate of 2,631 to obtain the vector of conversion rates for S-5.

Scenario S-6 is similar to S-5 in that it simulates a government policy limiting conversion to land in capability classes three through seven. However, the supply of potential cropland is assumed to become depleted eventually and a higher conversion rate is assumed to take effect. The conversion rate vector in the first period is identical to that of scenario S-5. The second conversion rate vector is determined by disaggregating the "Iowa 2000 Study" estimated conversion rate of 40,000 acres per year among land capability subclasses three through seven on a proportional basis.

The data used to obtain each of the conversion vectors and the estimated conversion rates are presented in Tables 4.3 through 4.7.

Potential cropland supply and eventual depletion data

Under both scenarios S-4 and S-6, a key factor in estimating the yields in 2000 and 2020 is the point in time when Iowa's supply of potential cropland will be depleted and a second, higher vector of conversion rates will come into effect.

To determine the amount of land in each capability subclass with potential for use as cropland, the technique used by Frey and Otte is applied to data in the 1977 NRI [7]. However, these acreage estimates are merely raw data and give no indication of the feasibility of converting this land into cropland use. There are numerous factors involved in determining how much of this land is actually potential cropland. Amos enumerated these factors in his study which involved the development of a potential cropland supply model [1]. He incorporated into his model considerations for crop prices, the discount rate, investment costs, production costs and crop yields. Any of these economic factors can have an impact on the estimated supply of potential cropland. Crop prices and yields tend to have a positive effect on the supply of potential cropland.

Table 4.3. Estimation of S-2 conversion rate vector

Land capability subclass	Cropland 1967[a]	1977[b]	Change per year
		(in 1,000s of acres)	
I	3,634	3,128	506
IIE	6,065	6,371	-306
IIW	6,085	6,721	-636
IIS	273	539	-265
IIIE	6,914	6,483	431
IIIW	895	817	77
IIIS	93	110	-17
IVE	1,300	1,121	179
IVW	78	173	-95
IVS	195	235	-40
V	139	110	29
VIE	536	438	98
VIW			
VIS	32	22	10
VII (all)	213	163	54
Total	26,452	26,431	25

[a] Source: [27].

[b] Source: [30].

Table 4.4. Estimation of S-3 conversion rate vector

Land capability subclass	Total land base[a]	Proportions of land base	Annual conversion rate[b]
	(in 1,000s of acres)		(in acres)
I	3,216	.099112	261
IIE	6,860	.211415	556
IIW	7,656	.236947	623
IIS	598	.019430	51
IIIE	7,955	.246162	648
IIIW	861	.027535	72
IIIS	117	.004606	12
IVE	1,997	.060595	159
IVW	196	.005040	13
IVS	302	.008307	22
V	376	.010588	28
VIE	1,249	.037492	99
VIW			
VIS	36	.000110	0
VII (all)	1,029	.030712	81
Total	32,448	1.000000	2625[c]

[a] Source: [30].

[b] Obtained by multiplying proportions by 2631 which is the trend conversion rate.

[c] The difference between this term and 2631 is due to rounding error.

Table 4.5. Estimation of second period conversion vector for S-4

Land capability subclass	Total land base[a] (in 1,000s of acres)	Proportion of land base	Annual conversion rate[b] (in acres)
I	3,216	.099112	3,960
IIE	6,860	.211415	8,450
IIW	7,656	.236947	9,479
IIS	598	.019430	777
IIIE	7,955	.246162	9,847
IIIW	861	.027535	1,101
IIIS	117	.004606	184
IVE	1,997	.060595	2,424
IVW	196	.005040	202
IVS	302	.008307	332
V	376	.010588	424
VIE	1,249	.037492	1,500
VIW			
VIS	36	.000110	4
VII (all)	1,029	.030712	1,229
Total	32,448	1.000000	39,920[c]

[a] Source: [30].

[b] Obtained by multiplying proportions by 40,000 which is the assumed conversion rate after 1995.

[c] The difference between this number and 40,000 is due to rounding error.

Table 4.6. Estimation of S-5 conversion rate

Land capability subclass	Total land base[a]	Proportion of land base	Annual conversion rate[b]
	(in 1,000s of acres)		(in acres)
I	0		
IIE	0		
IIW	0		
IIS	0		
IIIE	7,955	.563465	1,483
IIIW	861	.060986	161
IIIS	117	.008287	22
IVE	1,997	.141451	372
IVW	196	.013883	37
IVS	302	.021391	56
V	376	.026633	70
VIE	1,249	.088469	233
VIW			
VIS	36	.002550	7
VII (all)	1,029	.072886	192
Total	14,118	1.000000	2,633[c]

[a] Source: [30].

[b] Obtained by multiplying proportions by 2,631 which is the trend conversion rate.

[c] The difference between this number and 2,631 is due to rounding error.

Table 4.7. Estimation of second period conversion vector for S-6

Land capability subclass	Total land base[a] (in 1,000s of acres)	Proportion of land base	Annual conversion rate[b] (in acres)
I	0		
IIE	0		
IIW	0		
IIS	0		
IIIE	7,955	.563465	22,540
IIIW	861	.060986	2,439
IIIS	117	.008287	332
IVE	1,997	.141451	5,658
IVW	196	.013883	555
IVS	302	.021391	856
V	376	.026633	1,065
VIE	1,249	.088469	3,539
VIW			
VIS	36	.002550	102
VII (all)	1,029	.072886	2,915
Total	14,118	1.000000	40,000

[a] Source: [30].

[b] Obtained by multiplying proportions by 40,000 which is the assumed conversion rate after 1995.

Conversely, if investment or production costs rise, the estimated supply of potential cropland decreases. Although the impact of the discount rate is somewhat ambiguous, it, too, is hypothesized to have a dampening effect on the potential cropland supply.

Given these factors, Amos derived a series of eight scenarios for determining Iowa's potential cropland supply. Three discount rates are applied in each case. For the purposes of this study, an estimate of 661,375 acres of potential cropland is used. This figure represents the mean value for potential cropland in Iowa obtained from Amos' study.

Two criteria are used in selecting this estimate. The first of these is the necessity of compensating for the positive relationship that is believed to exist between yield increases due to technological improvements and the supply of potential cropland. If yields are assumed to increase then the potential supply of cropland will be extended. The estimate of 661,375 used in this study is high relative to what Amos estimated the potential cropland supply to be under his baseline scenario which assumed yields at levels existing during the period 1968-1977. Hence, this higher estimate should allow for the effect of technological change on the supply of potential cropland.

The second criterion takes into consideration the fact that the current supply of potential cropland will not necessarily be used exclusively for cropland. The suitability of a tract of land for use as cropland does not imply that it is unsuitable for any other use.

The same uses which deplete the supply of cropland also deplete the supply of potential cropland as well. In this study, the optimistic assumption is made that somehow the estimated supply of potential cropland is eventually used solely for cropland. The figure used in this study is, consequently, somewhat less than the estimate obtained under Amos' most optimistic scenario.

To estimate the year in which the supply of this resource will be depleted, the previously cited gross conversion rate of 40,000 acres per year is used to determine a depletion rate. The difference between Iowa's gross estimated conversion rate and the net conversion rate of 2,631 acres per year serves as an estimate for the conversion rate of land into cropland use. Hence, 37,369 acres per year is assumed to come into use as cropland. Division of the estimated potential cropland supply by this conversion rate determines the number of years from 1977 to the point in time when the supply of potential cropland will be depleted.

Yield projections

In order to establish the quantitative impact of each scenario on total production, estimates of the projected yields for corn and soybeans in 2000 and 2020 for each land capability subclass are necessary.

First, the yields for corn and soybeans on each land capability subclass are determined for 1980 using the expected yields for that year obtained from Pope's study in conjunction with the maximum relative yield potential relationships used by Gibson. Estimates of these relationships appear in Table 3.1 [8, p. 296].

Expected yields, rather than actual yields for corn and soybeans are used because the actual data can deviate a great deal from the estimated yield function. Although actual yields in 1980 were only slightly higher than the expected yields, their use for projecting yields would still introduce an upward bias into these projections. The formula outlined in Chapter III is then applied to these data and results of the calculations are presented in Table 4.8.

The next step is to project these yields to 2000 and 2020. Pope made state average yield projections to 2000 under six scenarios. Two of these are selected to represent the trend and low-trend productivity increases assumed in this study. To obtain yield projections for 2020, it is assumed that the yield functions for both corn and soybeans will take on a linear trend under each of Pope's scenarios. Linear trends are used rather than the trends indicated in the model because the latter show a positive marginal rate of change in yield increases after 2000. At present, there is no indication that this is likely to occur [18]. Yields in 2020 are, therefore, calculated by doubling the change in yields projected to take place between 1980 and 2000 for each crop and each yield trend.

The following formula is used to obtain projected yield estimates.

Table 4.8. Estimated yields for corn and soybeans by capability subclass in 1980

Land capability subclass	Corn (in bushels/acre)	Soybeans (in bushels/acre)
I	127.2	40.98
IIE	114.5	38.93
IIW	114.5	38.93
IIS	89.1	38.93
IIIE	114.5	35.65
IIIW	89.1	32.78
IIIS	63.6	32.78
IVE	89.1	30.74
IVW	89.1	25.41
IVS	50.9	25.41
V	63.6	16.39
VIE	76.3	16.39
VIW		
VIS	76.3	16.39
VII (all)	63.6	16.39
Average expected yield[a]	111.5	37.14

[a] Source: [18].

$$\hat{Y}_{ikt} = \left[\left(\frac{\hat{Y}_{it} - \hat{Y}_{io}}{\hat{Y}_{io}}\right) + \hat{Y}_{io}\right] \hat{Y}_{iko}$$

where $\hat{Y}_{ikt}$ = projected yield of crop i on land capability subclass k in year t,

$\hat{Y}_{it}$ = projected yield of crop i in year t,

$\hat{Y}_{io}$ = expected yield of crop i in 1980,

$\hat{Y}_{iko}$ = expected yield for crop i on land capability subclass k in 1980.

A set of yield projections for crop i in year t is, therefore, determined by first summing the percentage increase in yields above its 1980 level with the expected yield for that crop in 1980. This figure is then multiplied by the expected yields for each land capability class and subclass in 1980. The results of these computations are presented in Table 4.9.

National and state projected output

As stated earlier, the impacts of the various scenarios are measured in terms of whether Iowa will be able to meet its projected share of national crop production in 2000 and 2020. The projections for both national production and Iowa's share of that production are obtainable from the OBERS Projections of Regional Economic Activity in the United States [28].

These projections were one of the primary outputs of a program concerned with economic measurement, analysis, and projection. At

Table 4.9. Yield projections for corn and soybeans in 2000 and 2020

Land capability subclass	Corn				Soybeans			
	Low trend		Trend		Low trend		Trend	
	2000	2020	2000	2020	2000	2020	2000	2020
	(in bushels/acre)				(in bushels/acre)			
I	152.3	177.4	181.6	236.1	46.8	52.6	53.7	66.3
IIE	137.1	159.7	163.5	212.4	44.5	50.0	51.0	63.0
IIW	137.1	159.7	163.5	212.4	44.5	50.0	51.0	63.0
IIS	106.6	124.2	127.1	165.2	44.5	50.0	51.0	63.0
IIIE	137.1	159.7	163.5	212.4	40.7	45.8	46.7	57.7
IIIW	106.6	124.2	127.1	165.2	37.4	42.1	43.0	53.0
IIIS	76.1	88.7	90.8	118.0	37.4	42.1	43.0	53.0
IVE	106.6	124.2	173.8	165.2	35.1	39.5	40.3	50.0
IVW	106.6	124.2	173.8	165.2	29.0	32.6	33.3	41.1
IVS	60.9	71.0	72.7	94.4	29.0	32.6	33.3	41.1
V	76.1	88.7	90.8	118.0	18.7	21.0	21.5	26.5
VIE	91.4	106.4	110.0	141.6	18.7	21.0	21.5	26.5
VIW								
VIS	91.4	106.4	110.0	141.6	18.7	21.0	21.5	26.5
VII (all)	76.1	88.1	90.8	118.0	18.7	21.0	21.5	26.5
Average projected yield	133.5[a]	155.5[b]	159.2[a]	206.9[b]	42.4[a]	47.7[b]	37.1[a]	60.1[b]

[a] Source: [18].

[b] Estimated from 2000 projections according to the following formula:

$$Y_{t2,i} = [(Y_{t1,i} - Y_o)2] + Y_o$$

where: $Y_{t2,i}$ = yield of crop i in 2020; $Y_{t1,i}$ = yield of crop i in 2000; Y_o = expected yield of crop i in 1980.

the time of its initiation in 1964, the program was run jointly by the Office of Business Economics (OBE), U.S. Department of Commerce, and the Economic Research Service (ERS), U.S. Department of Agriculture. The term "OBERS" was derived by combining the initials from these two entities. Several years following the initiation of the program, the Office of Business Economics was renamed and is now called the Bureau of Economic Analysis (BEA). However, the term "OBERS" was retained as the title for the program due to its widespread acceptance.

OBERS national projections were based upon domestic food use, domestic nonfood use, and net foreign market use. Each of these was in turn based on a series of interrelated factors including projected population growth, projected rates of per capita consumption, and livestock production.

In order to project the state share of national food requirements, historical trends established during the period 1947-1970 were used. A curvilinear regression analysis was used which adjusted the rate of change in a state's share of national output downward if that state's share had been increasing or the projected share was adjusted upward in the opposite case. The analysis was carried out in such a manner that the state shares would sum to one. Hence, in order to estimate Iowa's projected production requirements for corn and soybeans, the projected national food requirements for the crops of interest are multiplied by Iowa's projected share of these national requirements. Table 4.10 contains the projections obtained from

OBERS on both the national commodity requirements for corn and soybeans and Iowa's projected share of these crop requirements.

Table 4.10. Projection of national and state crop production requirements for corn and soybeans[a]

Year	Corn		Soybeans	
	U.S.	Iowa	U.S.	Iowa
	(in millions of bushels)		(in millions of bushels)	
2000	6,761.1	1,552.6	1,684.6	292.7
2020	7,294.9	1,678.6	1,811.3	329.7

[a] Source: [27].

Application of Data to Scenarios

In this section, three steps for estimating the impact of cropland conversion on Iowa's future production capacity for corn and soybeans are applied to each of the six scenarios. In brief, these steps are:

1. to estimate the quantity of land remaining in each land capability subclass in 2000 and 2020,
2. to determine the quantities of land used for each of the crops in each capability subclass in 2000 and 2020,
3. to estimate Iowa's actual production capacity for each crop based on yield projections in 2000 and 2020.

Under scenario S-1, land used as cropland must remain in that use. Alternatively, this scenario implies that although conversion of cropland to other uses may be taking place, any land removed from cropland use is being replaced by an equal amount of land from the same capability subclass. Hence, the only change occurring is in the yields within each capability subclass which are allowed to increase to their projected levels.

Since the conversion rate is assumed to be zero for this scenario, the first step which involves determining the quantity of land remaining for use as cropland is omitted. Instead, the acreage data presented in Table 4.1 for row cropland are used to make the projections.

The second step in the procedure involves multiplying the vector of data on acres used for row crops by the proportion of total land in row crops used for corn and by the proportion used for soybeans.

The final step is to estimate total production in 2000 and 2020. However, in order to do this, the acreage estimates for land planted in corn must be adjusted to reflect the quantity of land to be harvested for grain. Once again, the procedure used is to calculate the proportion of land planted in corn that is harvested for grain to total land harvested for both corn and silage. For the base year, 1977, this proportion is .933. The column of estimates of land planted in corn is multiplied by this proportion. The resulting vector contains estimates of the quantity of land from which corn for grain is harvested by land capability subclass. To estimate the levels of production in 2000 and 2020, this vector is multiplied by the vectors of projected yields.

Scenario S-2 assumes that the conversion rate for Iowa over the past decade will continue through both projection dates. The amount of land remaining for use in row crops in 2000 and 2020 is calculated using the method outlined in the third chapter using the conversion rate vector derived for this scenario. The results of these calculations are then subdivided into land planted in soybeans and land planted in corn using the proportions obtained earlier in this chapter (see page 46). The final step of the procedure is identical to that of scenario S-1. First, the amount of land actually harvested for corn grain in each projection year is determined. Then the acreage projections for both crops are multiplied by the corresponding yield projections.

Calculations for the remainder of the scenarios are carried out in a similar fashion using the appropriate conversion rate in each instance. Scenarios S-4 and S-6 differ slightly in the technique followed since it is necessary to use two sets of conversion rates in each case. The initial vector of conversion rates is multiplied by 18 (1995-1977) and the second vector is multiplied by either 5 or 25 depending on the year to which the projection is being made.

Results and Implications

Table 4.11 contains the results of each scenario for each of the crops being considered. Two separate yield trends are assumed and the projections are made for the years 2000 and 2020 in each case.

Relative impacts of the scenarios

The relative impact that each set of assumptions has on future production of corn and soybeans in Iowa is for the most part what one would expect. The scenario which reduces production by the greatest amount is S-4. In this scenario, a higher conversion rate vector is assumed from 1995 onward and land is converted from each subclass on a proportional basis. As indicated in Table 4.12, the production of corn is below the baseline projection by about 24.3 million bushels in 2000 and 895.0 million bushels in 2020 (assuming trend yield increases). In percentage terms, production is 1.1 percent below the baseline projection in 2000 and nearly 32 percent below this projection in 2020. Furthermore, this is the only scenario in which corn production falls in 2020 from its level attained in 2000. Similarly, the production of soybeans is 3.9 and 20.4 million bushels short of the baseline projections for 2000 and 2020, respectively, (or 1.07 percent below the baseline projection in 2000 and 9.55 percent below the same projection in 2020).

Projected production under scenario S-6 is somewhat higher than scenario S-4 due to the fact that only land in capability classes

Table 4.11. Production projections for scenarios S-1 through S-6

		Corn		Soybeans	
Scenario	Year	Low trend yields	Trend yields	Low trend yields	Trend yields
		(in bushels)		(in bushels)	
S-1	2000	1,825,733	2,200,800	319,608	366,910
	2020	2,126,604	2,829,463	359,353	452,543
S-2	2000	1,831,293	2,201,324	323,466	371,359
	2020	2,128,588	2,832,094	364,411	465,717
S-3	2000	1,820,967	2,194,906	318,758	364,436
	2020	2,113,096	2,813,614	357,647	450,290
S-4	2000	1,754,797	2,176,484	316,201	362,998
	2020	1,454,244	1,934,818	343,121	432,101
S-5	2000	1,821,357	2,195,289	318,888	366,083
	2020	2,117,032	2,816,726	357,839	451,014
S-6	2000	1,807,939	2,178,486	316,665	363,531
	2020	1,987,457	2,517,998	345,552	435,122

Table 4.12. Scenario S-1 compared with scenarios S-2 through S-6

Comparison	Year	Corn		Soybeans	
		Low trend yields	Trend yields	Low trend yields	Trend yields
		(in 1000s of bushels)		(in 1000s of bushels)	
S-1 vs S-2	2000	-5,559	-524	-3,857	-4,449
	2020	-1,984	-2,630	-5,058	-13,174
S-1 vs S-3	2000	4,766	5,893	849	2,474
	2020	13,507	15,849	1,706	2,252
S-1 vs S-4	2000	70,935	24,316	3,407	3,911
	2020	672,360	894,981	16,231	20,441
S-1 vs S-5	2000	4,376	5,511	720	826
	2020	9,571	12,736	1,513	1,528
S-1 vs S-6	2000	17,794	22,314	2,943	3,379
	2020	139,147	311,404	13,831	17,420

three through seven is permitted to be converted from cropland use. Hence, the overall quality of the land base increases under this scenario and the impact of the higher conversion rate on total production of both crops is dampened somewhat as a consequence. The estimated production of corn in 2000 and 2020, assuming trend yield increases, is below the baseline projections by 1.01 percent and 11.01 percent, respectively, and soybean production projections fall short of the baseline projections in 2000 and 2020 by .92 percent and 3.85, respectively.

The scenario ranked third in terms of projected impact on corn and soybean production is S-3. This scenario has a lower overall conversion rate than the previous two which accounts for its relatively higher production figures. The gap in productivity levels between scenarios S-3 and S-1 is, therefore, smaller. In 2000, corn production is .27 percent below the baseline projection and soybean production is projected to fall short by .67 percent. In 2020, these percentages are .56 percent for corn and .49 percent for soybeans.

Scenario S-5 has a smaller impact on projected production levels than S-3 because the overall quality of the land base is increasing through time whereas under S-3 this factor is held constant. Consequently, although the same overall conversion rate is assumed in both cases, the changing quality of the land base under scenario S-5 leads to higher production levels.

The last scenario, S-2, actually leads to production levels in excess of those projected under the baseline scenario. Once again, the explanation lies with the overall quality of the land base. In spite of an overall conversion rate equivalent to that used in scenarios S-3 and S-5, the improved quality of the land base is sufficient to outweigh the negative impact on total projected production due to a decrease in the size of the land base.

From 1967 to 1977, the number of acres in all subclasses of land capability class two increased. Under scenario S-2, this trend is assumed to continue. Obviously, such an assumption is highly implausible in view of the fact that land in any single capability class is finite in quantity and will eventually be depleted. Scenario S-2 is, therefore, included among the scenarios to illustrate the importance of including land quality considerations in the analysis.

Impacts of trend and low trend yield increases

Technological change is another factor which can dampen the impact of cropland conversion on future crop production. Obviously, the yield trend assumption leads to higher projected state production figures. In addition, the dispersion in total production figures among scenarios is generally greater under the assumption of trend yield increases. This is due to the fact that yield increases within any land capability subclass are assumed to increase on a percentage basis rather than in absolute terms. Hence, while the proportional relationships in yields among land capability subclasses are preserved, the absolute differences increase between the low trend and trend yield assumptions as well as the differences created by time. Consequently, any difference in land quality between the scenarios becomes magnified in the projections. For example, a comparison of scenarios S-4 and S-6 for corn production in 2020 reveals that under the low trend yield assumption, production of corn in S-6 exceeds that of S-4 by 533 million. This disparity increases to 583 million under the assumption of trend yield increases. Therefore, the future rate of technological change is likely to play a key role in determining Iowa's ability to maintain or increase crop production on a shrinking cropland base.

Implications concerning Iowa's ability to meet future production requirements

The results of scenarios S-1 through S-6 can have little meaning without criteria to measure them by. Therefore, the projected crop requirements obtained from OBERS are used for this purpose.

Table 4.10 contains projections of U.S. crop production requirements in 2000 and 2020 for corn and soybeans as well as Iowa's share of these requirements in absolute terms. Comparing these data with the data in Table 4.11 shows that in most cases, Iowa will be capable of meeting its projected crop production requirements for corn in both 2000 and 2020. The only exception is under scenario S-4 where estimated production of corn in 2020, under the low trend yields assumption, falls below the required production level by approximately 224 million bushels or 13.36 percent of the projected production requirement.

In the case of soybeans, results indicate that Iowa will be able to fulfill its share of the projected U.S. crop requirements under all scenarios in both 2000 and 2020 regardless of the yield trend assumed. In fact, even under the most pessimistic scenario, S-4, with low trend yields, Iowa would be able to produce an additional 24 million bushels of soybeans above its projected production requirement.

CHAPTER V. SUMMARY, POLICY IMPLICATIONS, AND LIMITATIONS OF STUDY

This chapter is divided into three sections. The first section summarizes the study in terms of the objectives, the procedures used, and the results. The second section discusses the policy implications indicated by the results. In the last section, the limitations of the study are outlined.

Summary

The first objective of this study is to examine current trends in agricultural and cropland conversion rates and trends in crop productivity in order to establish a basis for the research. Although the primary focus of this study is Iowa, both state and national trends are reviewed to place Iowa within the proper context.

The second objective is to develop and present a means for projecting the long term impacts of cropland conversion on total state production of corn and soybeans. In addition, the study examines the effects of changes in both the overall quality of the land base and the rate of technological change on reducing the impact of cropland conversion.

Due to a lack of adequate time series data, the shift-share modeling technique is used to project state production in 2000 and 2020. In general, relationships that existed in the base year are assumed to hold through both projection dates. Data on cropland acreages are collected according to land capability subclass delineations and yield estimates in 1980 are disaggregated according to the same land classification system. This disaggregation is necessary in order to measure the impact of changing the overall quality of the land base. To study the effect of the rate of yield increases, two trends are assumed. The trend yield assumption uses the trend established by historical data and weather data. The low trend yield assumption uses a trend which is half that of the historical trend.

Six scenarios are simulated under two yield assumptions to obtain twelve projections for state production of each crop in each projection year. Two factors are allowed to change among the six scenarios. These are the net conversion rate and the overall quality of the cropland base.

Scenario S-1 is the baseline scenario under which the conversion rate is constrained to zero and the quality of the cropland base is held constant. Hence, this scenario measures Iowa's present ability to meet future production requirements as estimated by OBERS. Scenario S-2 assumes that the actual net conversion rate for the period 1967-1977 will continue and that trends in the quantity of land in any capability subclass will also continue. Scenario S-3 has the same overall conversion rate but the quality of the land base is held constant. Under scenario S-4 the conversion rate increases after 1995 to reflect the impact of depleting Iowa's store of potential cropland and the quality of the land base is held constant.

Scenario S-5 assumes the same conversion rate as S-2 and S-3 but the quality of the cropland base increases due to the assumption that all land converted to other uses must come from land capability classes three through seven. Finally, scenario S-6 combines the conversion rates used in S-4 with the trend in land quality in S-5.

Results of the study indicate that, in general, Iowa should have no problem meeting its share of the projected U.S. crop requirements. The one exception is under scenario S-4 for the year 2000 in which there is a deficit amounting to 13 percent of the projected crop requirement if the low yield trend is assumed.

This outcome points out the important role played by trends in yield increases. Obviously, the task of forecasting future yields without error is impossible. The best alternative is to base future expectations on what has occurred in the past. Unfortunately, there is no reason to believe that past trends will hold in the future. If recent cuts in spending on research and development are an indication, a slow down in yield increases may be approaching. If the slow down is large enough, Iowa could encounter difficulty in meeting its projected production requirements.

The only unexpected result of this study is that under scenario S-2 in which conversion is taking place, the projected production levels are in excess of those obtained under the baseline scenario. This outcome emphasizes the importance of the role played by land quality in determining future crop production.

Policy Implications

It is obvious from the results discussed above that at least for the time being, a legislative policy curbing cropland conversion would be premature. The problems experienced by regions of the Northeast and Southeast [6] do not seem to be of sufficient magnitude in Iowa to warrant action on the part of the state government.

However, this conclusion does not mean that trends in cropland conversion should not be monitored. Perhaps the best policy for the state government is to enact legislation that requires the compilation of a land use inventory on a regular basis. In this way, time series data would become available which would improve the accuracy of projections and hence, the appropriations of policy initiatives.

In addition, some restrictions on cropland conversion may be necessary if the potential for reducing soil erosion losses is a consideration. Currently, cropland is being converted at various rates from all seven land capability classes in Iowa. Eventually, the supply of highly productive potential cropland may become exhausted and land used to replace the converted cropland will be of inferior quality. This land frequently has serious erosion problems and a substantial investment would be required to effectively deal with the problem of soil loss. Consequently, a policy similar to the one simulated by scenarios S-5 and S-6 may be called for.

The response within Iowa to the perceived need for land use legislation has led to the recent passage of a land use bill (Senate File 2218) [12]. The bill requires the establishment of county level land preservation and use commissions. Each of these commissions will have two objectives. The first is the compilation of county land use inventories to be completed by January 1984. In addition to current land use data, the inventories must contain estimates of the quantity of agricultural land converted to residential, commercial, or industrial use since 1960. The second objective required of the county commissions is to develop and submit to the county boards of supervisors land preservation and land use plans by September 1, 1984. Each county board then has the option of rejecting or accepting the plan.

An additional provision of the bill allows farmers to place their property into agricultural districts designed to protect the land from development pressures. The incentives for farmers to follow this course of action include protection from nuisance suits and high priority for water use.

Iowa's land use bill seems to concur with the policy implications of this study by requiring the assessment of current needs (in the form of a land use inventory) before any action is taken. In its present form, however, the bill makes no provision for conducting land use inventories on a regular basis. Such time series data would be much more useful since it would allow for the estimation of changes in trends in cropland conversion.

Limitations of Study

The primary disadvantage of undertaking a study dealing with the area of land use is the lack of adequate time series data. This particular study was faced with choosing between using highly aggregated cropland data collected on a yearly basis or cropland data classified by capability subclasses collected on a limited basis. In the interest of measuring the impact of land quality on Iowa's production potential, the second of these data sets was selected.

Another limitation of this study is that it ignores the impact of economic variables. One such variable is commodity prices. If the price of corn relative to soybeans changes, then one crop will become more profitable to produce. As a consequence, the proportion of cropland planted in each crop is likely to change and the assumption that the initial projections of land planted in each crop will hold through 2020 is invalidated.

A change in commodity prices may also induce the farmer to plant the more profitable crop in more productive land and plant the other crop on land in the lower capability classes. Action of this nature would invalidate the assumption that the same relative proportion of each crop is planted in each of the capability classes.

Finally, if either or both of the commodity prices rise, the supply of potential cropland is also likely to increase since it would become profitable to convert some land to cropland that may have been marginally profitable before. However, it should be noted that this is likely to be a short run phenomenon since the key factor is relative prices and all prices generally exhibit an upward trend. Hence, the change in relative profitability either between crops or between land uses may quickly reverse itself or return to the original state of economy.

Another economic variable omitted from this study is the opportunity cost of withholding cropland from other uses as under scenarios S-5 and S-6. The foregone opportunity of developing land for urban uses could be quite substantial relative to the benefits gained from maintaining Iowa's present crop production capacity. This disparity would be likely to increase through time if the demand for cropland by other uses increases.

The possible benefits of a reduction in soil erosion losses are also omitted from the analysis. Under scenarios S-5 and S-6 part of the opportunity cost may be offset by these benefits. Since all land being converted comes from the lower capability classes, the overall quality of the cropland base will increase and the average annual rate of soil loss will fall.

In addition, this study ignores the impact of possible yield increases on the supply of potential cropland. As in the case of price increases, a greater profit may be derived from each acre. Hence, land with potential for use as cropland is likely to become more valuable and additional land will be included in this category once the potential profits outweigh the costs of converting the land to cropland. To the extent that yield increases continue through time, it can be hypothesized that the supply of potential cropland will continue to expand. Therefore, the accuracy of the projections made by this study would be increased if the impact of yield increases could be incorporated into the procedure used to estimate the supply of potential cropland.

One final limitation to be considered is that the shift-share modeling technique does not allow for the impact of shocks to the system. Projections made using this technique are based on historical trends which establish the rate and direction of change of one variable relative to any other. As a consequence, any unprecedented occurrence (such as the depletion of the water supply for irrigated land in the west) could have a substantial effect on the actual crop production requirements for Iowa.

In spite of these limitations, this study does provide useful insights into the perceived problem of cropland conversion in terms of potential impacts of changes in technology and land quality. In addition, it suggests the regular compilation of land use data as an avenue of legislative policy for which there is a definite need. It is hoped that the land use bill recently passed by Iowa's legislature will eventually be enhanced by requiring the compilation of land use data on a regular basis.

REFERENCES

1. Amos, Orley M. "Supply of Potential Cropland in Iowa." Unpublished Ph.D. dissertation. Iowa State University, Ames, Iowa, 1979.

2. Cory, Dennis C. and Timmons, John F. "Responsiveness of Soil Erosion Losses in the Corn Belt to Increased Demands for Agricultural Products." Journal of Soil and Water Conservation 33 (September-October, 1978):221-226.

3. Coughlin, Robert E. "Agricultural Land Conversion in the Urban Fringe." In Farmland, Food and the Future. Edited by Max Schnepf. Ankeny, Iowa: Soil Conservation Society of America, 1979.

4. Council for Agricultural Science and Technology. "Preserving Agricultural Land: Issues and Policy Alternatives." CAST Report No. 90, April 1981.

5. Crosson, Pierre. "Agriculture as Land Use: A Technological and Energy Perspective." In Farmland, Food and the Future. Edited by Max Schnepf. Ankeny, Iowa: Soil Conservation Society of America, 1979.

6. Dideriksen, R.I.; Hildebaugh, A.R.; and Schmude, K.O. "1977 Potential Cropland Study." U.S. Department of Agriculture, Soil Conservation Service of America, Washington, D.C., 1979.

7. Frey, H. Thomas and Otte, Robert C. "Cropland for Today and Tomorrow." U.S. Department of Agriculture, Washington, D.C., July, 1975.

8. Gibson, James A. "Land Use Processes and Projections: Interrelationships of Iowa Nonagricultural and Agricultural Land Uses." Unpublished Ph.D. dissertation. Iowa State University, Ames, Iowa, 1976.

9. Heady, Earl O. "Technical Change and the Demand for Land." Unpublished paper prepared for "A Conference on the Adequacy of Agricultural Land: Future Problems and Policy Alternatives." Under the sponsorship of Resources for the Future, Washington, D.C., June 1980.

10. Huemoeller, William A.; Nicol, Kenneth J.; Heady, Earl O.; Spaulding, Brent W. Land Use. Ongoing Developments in the North Central Region. Center for Agricultural and Rural Development, Iowa State University, Ames, Iowa, September 1976.

11. Iowa Department of Agriculture, Iowa Crop and Livestock Reporting Service. "Iowa Agricultural Statistics 1981." State Capital, Des Moines, Iowa, 1981.

12. Iowa Senate. A Bill for an Act relating to the uses of land in this state by requiring inventories by county organizations, authorizing agricultural use ordinances and agricultural areas, and providing for the restriction of certain proceedings and assessments. Senate File 2218, Committee on Natural Resources, April 24, 1982.

13. "Iowa 2000 Study, Land, Water, and Energy - An Examination of Policies and Issues." A report of a conference held at Iowa State University. Under sponsorship of the Cooperative Extension Service, Iowa State University, Ames, Iowa, May 24, 1978.

14. Lee, Linda K. "The Conversion of Agricultural Land to Urban Use: An Examination of the Land Use Processes in Urbandale, Iowa 1950-1974." Unpublished Ph.D. dissertation. Iowa State University, Ames, Iowa, 1977.

15. Lee, Yao-Chi; Cline, Philip; and Quance, Leroy. "Prospects for Productivity Growth in U.S. Agriculture." U.S. Department of Agriculture, Economics, Statistics and Cooperative Service, Agricultural Economics Report No. 435, September, 1979.

16. National Academy of Sciences. Agricultural Production Efficiency. Washington, D.C.: NAS, 1975.

17. Plaut, Thomas R. "Urban Expansion and the Loss of Farmland in the United States: Implications for the Future." American Journal of Agricultural Economics 62 (August, 1980):537-42.

18. Pope, Arden C. "The Dynamics of Crop Yields in the U.S. Corn Belt as Effected by Weather and Technological Progress." Unpublished Ph.D. dissertation. Iowa State University, Ames, Iowa, 1981.

19. Sampson, R. Neil. "The Ethical Dimension of Farmland Protection." In Farmland, Food and the Future. Edited by Max Schnepf. Ankeny, Iowa: Soil Conservation Society of America, 1979.

20. Shulstad, Robert N. and May, Ralph D. "Conversion of Non-cropland to Cropland: The Prospects, Alternatives and Implications." American Journal of Agricultural Economics 62 (December, 1980):1091-92.

21. State of Iowa Office of Planning and Programming. "Quality of Life in Iowa: An Economic and Social Report to the Governor." State of Iowa, Des Moines, 1977.

22. Tammeus, William D. "Evidence of Growth Limits in Agriculture Seen." The Kansas City Star, November 2, 1975.

23. Thompson, Louis M. "Climate Change and World Grain Production." Prepared for the Chicago Council on Foreign Relations. College of Agriculture, Iowa State University, Ames, Iowa, January 22, 1979.

24. Timmons, John F. "Agricultural Land Retention and Conversion Issues: An Introduction." In Farmland, Food and the Future. Edited by Max Schnepf. Ankeny, Iowa: Soil Conservation Society of America, 1979.

25. U.S. Department of Agriculture. Agricultural Statistics. Washington, D.C.: U.S. Government Printing Office, 1976, 1978, 1980.

26. U.S. Department of Agriculture. "National Agricultural Lands Study: Final Report 1981." Washington, D.C.: U.S. Government Printing Office, 1981.

27. U.S. Department of Agriculture, U.S. Conservation Needs Inventory Committee. National Inventory of Soil and Water Conservation Needs, 1967. Washington, D.C.: U.S. Government Printing Office, 1967.

28. U.S. Department of Agriculture and U.S. Department of Commerce. OBERS Projections of Economic Activity in the U.S. Vol. 1-7. Washington, D.C.: U.S. Government Printing Office, 1974.

29. U.S. Department of Agriculture and U.S. Department of Commerce. U.S. Census of Agriculture, 1969, 1974, 1978. Washington, D.C.: U.S. Government Printing Office, 1969, 1974, 1978.

30. U.S. Department of Agriculture, Soil Conservation Service. National Resource Inventories, 1977, Final Estimates. Magnetic tape, Statistical Laboratory, Iowa State University, Ames, Iowa, 1979.

ACKNOWLEDGMENTS

First, I would like to thank my major professor, Dr. John F. Timmons, who provided guidance and support not only for work on my thesis but throughout my graduate career. In addition, I would like to extend my appreciation to Shirley Baum for typing the final draft of my thesis. Special thanks are also extended to Ruth Bender, Terry Dinan, and Wipada Soonthornsima for their support and encouragement.

Finally, I would like to express my gratitude to my parents, Frances and William Lawson, for their continuing support in my endeavors.

APPENDIX: DEFINITIONS OF LAND CAPABILITY CLASSES AND SUBCLASSES [27]

I. Land capability classes

Class I: Soils in this class have few limitations restricting their use and, hence, may be used for a wide variety of plants. These soils are nearly level, deep, well drained and easily worked. In addition, they respond well to fertilizer imputs if they are not already well supplied with plant nutrients.

Class II: Class II soils have some limitations. However, with proper soil management, these soils may be suitable for use as cropland. Some of the limitations are the effects of gentle slopes, moderate erosion, soil depth somewhat less than optimal, and poor drainage.

Class III: The limitations for class III soils are severe and, hence, reduce the latitude in choice of plants and management practices. Conservation practices are usually more difficult to apply and maintain than in class II. Land in this class is considered suitable for cultivated crops. The limitations associated with class III soil are moderately steep slopes, greater incidence of erosion problems, shallow soil depth, and poor drainage and fertility.

Class IV. Class IV soils have severe limitations in terms of plant choice and management practices. Careful management is essential when using these soils for cultivation. Permanent characteristics which restrict the use of these soils include steep slopes, severe erosion problems, shallow soil depth, and excessive wetness.

Class V. Although soils in this class have no erosion hazard, other problems associated with these soils restrict their use to primarily pasture, range, or forestland. The chief characteristics limiting their use are wetness, frequent overflow by streams, or stoniness.

Class VI. Soils in this class are considered unsuited for cultivation in most instances. Permanent limitations associated with these soils are steep slopes, high erosion hazard, stoniness, shallow soil depth, and wetness.

Class VII. Due to very severe limitations, soils in this class are unsuited for cultivation of any kind. The permanent limitations restricting use of these soils are very steep slopes, erosion, shallow soil depth, stones and wetness.

II. Capability subclasses

Subclasses are delineations within classes that possess the same dominant limitation for agricultural use due to soil and weather conditions.

Subclass (E): Erosion is the dominant hazard associated with use of soils in this subclass.

Subclass (W): Excess water is the dominant limitation in this instance due to poor soil drainage, wetness, or high water table.

Subclass (S): Root-zone limitations are the dominant characteristics restricting the use of these soils.