CONVERSION OF PRIME AGRICULTURAL LAND TO NONAGRICULTURAL USES IN ONE AREA OF THE SUNBELT

A. Frank Ramsey and Floyd L. Corty

INTRODUCTION

In general, people are aware of the rapid growth of urban areas, the spread of suburban developments, urban sprawl, strip developments, and extensive highway systems, but they are seldom aware of the extent to which prime agricultural land has been, and is being, diverted to these and other nonagricultural uses. By definition, prime agricultural land is land of the highest quality for food and fiber production. In this article, the terms prime land, prime farmland, and prime agricultural land are used interchangeably.

Preservation of prime agricultural land is a controversial subject because, historically, this nation has been concerned with agricultural surpluses more frequently than with scarcities. However, this situation is likely to change as world population increases. Not only will the demand for food and fiber increase, but society will continue to demand more land for urban expansion and related activities such as highways, airports, parks, and industrial sites. These competing demands lead to a diminishing agricultural land base. In this respect, rarely can agriculture compete dollar-wise with nonagricultural land uses.

From 1960 to 1970, about 13.5 million acres of rural land in the United States were urbanized, and on a nationwide average, about 0.139 acre of land was urbanized for each person added to the population (USDA, pp. 7,8).

THE PROBLEM

Conversion of agricultural land to nonagricultural uses is probably more intense in the Sunbelt than in other regions of the United States because of migration of people and industries to the South. This shift in population may be explained by the attraction of warmer climates and employment opportunities associated with the region's complex of petroleum, chemical, and mineral industries. To accommodate the natural population growth of the region and the influx of people and industries from other areas, more and more agricultural land is being converted to nonagricultural uses. In general, the market place allocates land to the highest bidder, and nonagricultural users tend to outbid agriculturists for use of the land. The present research evaluates the relationship of certain economic factors to the loss of prime farmland in order to determine to what extent prime farmland has been lost in the recent past, and to make projections of what might be expected in the near future.

RELATED LITERATURE REVIEW

Muth hypothesized in 1961 that urbanization and agriculture competed for use of land in a von Thunen-like landscape. This theory continues to be the most appropriate for explaining loss of agricultural land to nonagricultural uses. The difficulty in testing this theoretical model rests upon the lack of appropriate data—specifically for non-land costs, changes in technology, and the respective price gradients to reflect the equivalent of commuting and transportation costs.

Numerous articles expressing concern over loss of prime agricultural lands were published in the 1970s. At the end of October, 1977, 40 research projects relating to land use planning, competition for land, and loss of agricultural lands, were reported by the Cooperative Research Information Service (CRIS). Also, in 1980, the *National Agricultural Lands Study Interim Report* presented 1977 estimates of prime land acreages in the various states.

Most researchers recognize that there is no immediate danger that the United States is running out of farmland. The main concern about conversion of farmland to other uses comes not from immediate food shortages, but from the knowledge that prime farmland is in limited supply, contributes to lower costs of production, and is worthy of preservation to meet rising national and worldwide food and fiber needs.

Only a few studies have focused upon the extent of conversion of agricultural lands to nonagricultural uses in specific regions. Dill and Otte reported that about .22 of an acre of land was converted to urban use for each person added to the population in the northeastern part of the

A. Frank Ramsey is a former Graduate Assistant, and Floyd L. Corty is Professor, Department of Agricultural Economics and Agribusiness, Louisiana State University.

United States from 1950 to 1970 (p. 7). Furthermore, they found that 85 percent of the rural land being urbanized went to residential use, and almost 80 percent of that land was of SCS land capability Classes I–III (prime land). They also indicated that in the western part of the United States, more than 74 percent of the land now urbanized was formerly cropland: more than 71 percent of the urbanized land went to residential use (1970, p. 5). Additionally, Otte found that from 1960 to 1970, about one-third of an acre was urbanized per capita increase in population in SMSAs across the United States (p. 8).

In Iowa the average land occupation coefficients for 1960 and 1970 were .25 and .28, respectively (Gibson and Timmons, pp. 32–34). The marginal land occupation coefficient was .40. The study did not specify the quality of lands converted to urban use, but noted that Iowa has a large absolute amount of highly productive soils.

THEORETICAL CONCEPTS AND METHODOLOGY

The demand for prime agricultural land for urban use and an analysis of factors influencing the conversion process were determined through the use of the ordinary least squares regression technique. The regression model used in this study was a modified version of the theoretical model suggested by Muth. The Muth model postulates a market for commodities at some fixed point in space, around which land of homogeneous physical characteristics extends to an infinite distance. Firms of two competitive industries (urbanization and agriculture) vie for the land, and their respective areas of location vary with changes in the conditions of demand and supply for commodities of the two competing industries.

Muth suggested that his theoretical model of changes in urban land area could be tested by use of regression analysis. The regression would be linear, would involve the relative changes in urban land area, in demand for competing products, in non-land costs, in technology, and those relative changes in the two price gradients for transportation costs. However, time-series data for most of these variables were not available; hence, the empirical model tested in this study consisted of the change in urban land area as a function of the changes in aggregate demand for products of the two competing industries—agriculture and urbanization—taking into account: (1) growth in population, (2) family incomes, and (3) price per acre of farmland. To adjust for inflationary price increases, both median family income and average price of farmland were deflated by the consumer price index for all items, 1967 = 100.

Change in urban place population and change in urban place adjusted median family income were used as proxies for the demand for urban services. It was hypothesized that both of these variables would have a positive effect on the demand for prime agricultural land for urban use, with the change in urban population explaining most of the alterations.

Change in adjusted average price per acre of farmland was used as a proxy for the demand for farm products. It was hypothesized that this variable would have an inverse effect on the demand for prime land for urban use.

The criteria used to discriminate in the selection of independent variables were: (1) to retain those variables that resulted in the highest level of significance for the estimated coefficients; (2) if no difference in coefficient significance existed, keep those variables that resulted in the highest R^2 for the model; and (3) observe the signs of the coefficients.

Aggregate census data for Louisiana urban population, urban family income, and prices per acre of farmland were used in the regression analysis. The findings, because of the many agri-industry-based communities in the Mississippi River Delta, are believed to be generally applicable throughout the Delta region of the Sunbelt.

Of the 115 municipalities included in this study area with populations of 2,500 or more, 22 were omitted from the analysis because of specific locations in nonagricultural areas, or because of lack of corresponding data on population growth and urban expansion for the census periods 1960 and 1970 (U.S. Department of Commerce). Accordingly, 93 urban places entered into the analysis of population growth and urban expansion.

MODELS AND RESULTS

Using ordinary least squares regression, the basic statistical models selected were

(1) $Y = a + b_1X_1 + b_2X_2 + b_3X_3 + u$

(2) $Y = a + b_1X_1$

where

Y = change in urban place growth (prime land loss) in acres, 1960–70,

X_1 = change in urban place population, 1960–70,

X_2 = change in urban place adjusted median family income, 1960–70,

X_3 = change in adjusted average price per acre of farmland, 1960–70,

u = random error term, about which the usual assumptions are made (Kelejian and Oates, pp. 27–41).

A correlation matrix was used to determine the direction and degree of correlation among the independent variables (Table 1). The matrix indicated no significant relationship between any of

TABLE 1. Correlation Matrix for Urban Place Regression, Louisiana, 1960–1970

Variable	△ Prime Land (Y)	△ Urban Population (X_1)	△ Family Income (X_2)	△ Farmland Price (X_3)
Y	1.0	.85	.43	-.04
X_1		1.0	.46	.05
X_2			1.0	.13
X_3				1.0
Mean[a]	997.85	1,958.17	2,252.41	121.03
Standard Deviation	1,937.73	4,187.16	1,341.07	119.13
Sum	92,800.00	182,110.00	209,474.00	11,256.30

[a]N = 93

the independent variables. The relationship between the dependent variable (Y) and change in urban place population (X_1) was relatively high, as expected.

The regression of change in urban place area (Y) on change in urban place population (X_1), change in urban place adjusted median family income (X_2), and change in parish (county) adjusted average price per acre of farmland (X_3) is presented in Table 2.

The coefficient for change in urban place population (X_1) was the only significant explanatory variable in the model. The coefficients for change in urban place adjusted median family income (X_2) were of the expected sign, but were not significant at a probability level of 90 percent or more. The lack of significance for X_2 (median family income) was unexpected, but can possibly be attributed to rather routine or traditional demands for living space by most of the urban population. The lack of significance for X_3 (price of farmland) was somewhat unexpected. This may be explained by the fact that the model included the average price of farmland heavily weighted with rural land, and not solely the price of farmland in the immediate metropolitan areas, (which would have been much higher).

Model 1 had a coefficient of multiple determination (R^2) of .74. This indicated that approximately 74 percent of the variation in decennium urban place growth was explained by the three independent variables included in the model.

TABLE 2. Urban Place Overall Regression Coefficients, Louisiana, 1960–1970

Model	Number of Urban Places	Dependent Variable (Primeland)	Intercept	△ Urban Population X_1	△ Family Income X_2	△ Price of Farmland X_3	D.F.	R^2	F
1	93	Y_1	214.10 (.95)[a]	.38 (13.46)**	.10 (1.13)	-1.57 (-1.65)	89	.74	82.77
2	93	Y_2	226.48 (1.93)*	.39 (15.47)**			91	.72	239.38

[a]Numbers in parentheses are t-statistics.

**Represents significance at the 5% level for one-tailed test.

*Represents significance at the 10% level for one-tailed test.

Because population change was believed initially to be the most important factor influencing urban growth, change in urban area was regressed against change in corresponding urban population alone (Model 2). The simple linear model is highly significant, as indicated by the extremely high F-value. There was no problem in this model with nonconstance of the error term, heteroskedasticity, because a plot of the residuals failed to indicate any systematic pattern in the plot.

Autocorrelation, serial correlation in the error term, is usually not considered a problem with cross-sectional data; hence, the Durbin-Watson "D" of 1.70 was regarded as inconclusive. An SAS GPLOT routine, in which all variables were plotted against each other, as well as each one against the combination of the others, failed to indicate any consistent relationship patterns. A model other than the linear relationship was not indicated.

The coefficient of determination (R^2) indicated that more than 72 percent of the variation in growth of urban areas was explained by population growth alone. The coefficient of X_1 was highly significant as indicated by the t-statistic of 15.47 (Table 2).

Additional regression analyses were performed on the theory that family income levels and land prices would play a more dominant role in the rate of conversion of prime land to nonagricultural uses in metropolitan regions than in rural regions. Accordingly, the 93 urban places were sorted, and Model 1 was rerun for Standard Metropolitan Statistical Areas (SMSAs) and non-SMSAs. Correlation matrices indicated no problems with correlation among the independent variables in either group (Table 3). Only the change in urban place population (X_1) was significant in explaining the variation in the change in urban area growth (Y) in both SMSA and non-SMSA groups (Table 4). Regressions were also run for urban places with populations of 2,500 and 15,000, and for urban places of more than 15,000. Because there was no significant difference between the two groups, one "overall" regression equation was considered adequate to explain and project the rate of conversion of prime farmland to nonagricultural uses.

LOSS OF PRIME AGRICULTURAL LAND

In the second phase of this study, emphasis was placed upon determining the extent of loss of prime land to nonagricultural uses. Competition for land use between urbanization and agricultural production is an ongoing process. The effect of this competition was determined by measuring the extent of encroachment or urbanization and associated developments upon prime farmland.

Soil survey maps and soil classifications developed by the Soil Conservation Service were used to determine locations and acreages of prime farmlands. The extent of conversion of prime lands to non-farm uses was measured in terms of land occupied by urban expansion, highway systems, railroads, industrial sites, and publicly owned lands. Moreover, it was noted that practically all urban places in Louisiana with populations of 2,500 or more were located on prime agricultural land.

For purposes of this study, prime farmland included SCS land Classes I, II, and III (including irrigated rice land). These lands are very productive, have a low erodability factor, are effectively served by active markets, and have well-developed farm-to-market road systems.

TABLE 3. Correlation Matrices for Urban Place Regression, by non-SMSA and SMSA Groups, Louisiana, 1960–1970

Variable	Δ Primeland (Y)	Δ Urban Population (X_1)	Δ Family Income (X_2)	Δ Farmland Price (X_3)
		Non-SMSA		
Y	1.0	.63	.16	.01
X_1		1.0	.34	.16
X_2			1.0	.24
X_3				1.0
Mean[a]	524.60	957.95	2,106.74	123.56
Standard Deviation	589.81	1,502.78	1,223.31	132.33
SUM	34,624.00	63,225.00	139,044.79	8,155.08
		SMSA		
Y	1.0	.85	.61	-.11
X_1		1.0	.58	.06
X_2			1.0	-.13
X_3				1.0
Mean[b]	2,154.66	4,403.15	2,608.51	114.86
Standard Deviation	3,233.94	6,092.48	1,561.11	79.89
SUM	58,176.00	118,885.00	70,429.77	3,101.22

[a]N = 66
[b]N = 27

TABLE 4. Urban Place Regression Coefficients, by Non-SMSA and SMSA Groups, Louisiana, 1960–1970

Model	Number of Urban Places	Dependent Variable (Primeland)	Intercept	Δ Urban Population X_1	Δ Family Income X_2	Δ Price of Farmland X_3	D.F.	R^2	F
			Non-SMSA						
1	66	Y_1	372.11 (3.13)[a]	.26 (6.29)**	-.02 (0.45)	-.37 (-0.83)	62	.41	14.10
2	66	Y_2	288.27 (4.26)	.25 (6.47)**			64	.40	41.80
			SMSA						
3	27	Y_3	368.90 (.42)	.36 (6.00)**	.32 (1.20)	-5.44 (-1.28)	23	.76	23.97
4	27	Y_4	407.39 (1.01)	.40 (7.97)**			25	.72	63.45

[a]Numbers in parentheses are t-statistics.
**Represents significance at the 1% level for one-tailed test.

LOSS OF PRIME LAND TO RURAL TRANSPORTATION SYSTEM

There was a rapid increase in highway development in Louisiana from 1930 to 1950, and limited expansion thereafter. Currently, the interstate highway system is almost complete, and losses of prime land to highways are expected to be minimal in the future.

Likewise, conversion of prime lands to railroads has practically ceased. In fact, railroad mileages are being reduced. From 1968 to 1974, about 1,800 miles of railway lines (27,000 acres) were abandoned in Louisiana. However, efforts to cope with the energy problem may well alter this trend. Currently, Missouri-Pacific is attempting to purchase 550 acres in South-central Louisiana for the construction of a switching yard. Additional sites may be needed for coal storage yards, if coal becomes a primary energy source.

LOSS OF PRIME LAND TO URBANIZATION

In the ten-year period 1960–70, population of the 93 urban places in the study area increased by 182,110, and these areas expanded to occupy an additional 92,800 acres. Thus, the marginal urban land occupation coefficient was .51 acre. This means that for each person added to the urban population in the decade of the 60s, an additional half acre of prime land was converted to urban use in this region of the Sunbelt (Table 5).

TABLE 5. Urban Land Occupation Coefficients (Acres Per Capita), Louisiana, 1960–1970

Year	Urban Places	Population	Urban Area (Acres)	Coefficients
1960	93	1,115,394	236,544	0.21
1970	93	1,297,504	329,344	0.25
Change		182,110	92,800	0.51
SMSAs	27	118,885	58,176	0.49
Non-SMSAs	66	63,225	34,624	0.55
Urban <15,000	74	63,635	38,336	0.60
Urban >15,000	19	118,475	54,464	0.46

Source: Calculated from Bureau of Census Data, County and City Data Books, Volumes 1967 and 1977, U.S. Department of Commerce, Washington, D.C.

Moreover, the urban land use coefficient was .21 in 1960 and .25 in 1970, indicating that households in urbanizing areas were more dispersed, or occupied more land per capita in 1970 than in 1960.

A similar analysis was performed with the group divided into 19 large and 74 small urban places, as well as into 27 rapidly growing SMSAs and 66 more rural oriented non-SMSAs. Results indicated that small urban centers and non-SMSA communities tended to have higher urban land occupation coefficients than did the SMSA and larger communities (Table 5); however, the differences were not statistically significant.

PROJECTED URBAN AREA GROWTH AND PRIME LAND LOSS

Because this study determined that increasing urban population is the most siginficant factor in explaining urban area expansion among the variables tested, Model 2 was used to project loss of prime land to urbanization in Louisiana for ten-year periods ending in 1980, 1990, and 2000. Population projections for these time periods were made by the Division of Business and Economic Research of the University of New Orleans. Urban population projections were made using linear-in-logs simple regression estimates based on urban population data from 1900 to 1970.

Projected changes in urban population at ten-year intervals were employed in the "overall" equation ($Y = 226.48 + .39 X_1$) to estimate the corresponding losses of prime agricultural land to urban expansion (Table 6).

The loss of prime agricultural land to urban use was estimated to be 130,424 acres from 1970 to 1980, 147,321 acres from 1980 to 1990, and 122,707 acres from 1990 to 2000. In total, an estimated 400,000 acres or about 4 percent of Louisiana's prime farmland will be converted to urban use during the 30-year period 1970–2000. This translates into an average annual loss of about 13,333 acres. Assuming that 1980 yields and prices for the principal crops produced in this region (soybeans, cotton, rice, and sugar cane), continue over the 30-year period and giving due consideration to the geographic distribution of the population among these respective crop producing regions, a corresponding average annual loss of an additional $5.6 million in farm production is indicated [($168,170,640 ÷ 400,000) x 13,333 = $5,605,548]. Tracking this $5.6 million incremental loss through each of the 30 years, 1970–2000, leads to a compounded loss of about $2.6 billion in farm returns. In the last year alone the agricultural loss from 400,000 acres would be an estimated $168 million (Table 7).

The accuracy of these projections depends on the accuracy of the population projections, urbanization estimates, and assumed price and

TABLE 7. Estimated Annual Value of Agricultural Products Foregone by the Loss of 400,000 Acres of Agricultural Land (1980 Yields and Prices)

Commodity	Absorbed Acres*	Average Yields	Price	Value
			(Dollars)	
Soybeans	160,000	20 bus.	7.90	25,280,000
Cotton	52,000	383 lbs.	0.78	15,534,480
Rice	52,000	35.5 cwt.	12.00	22,152,000
Sugar Cane	136,000	23.3 tons	33.20	105,204,160
Total	400,000			168,170,640

*Proportions based upon population distribution by type of farming area.

Source: Yield and price data from Tables 6, 8, 10, 11, 17, Fielder and Nelson, *Agricultural Statistics and Prices for Louisiana, 1924–1981*, D.A.E. Research Report No. 600, Department of Agricultural Economics and Agribusiness, Center for Agricultural Sciences and Rural Development, Baton Rouge, Louisiana, August, 1982.

TABLE 6. Populations, Projections, and Estimates of Prime Land Loss, Louisiana, 1970–2000

Year	Population Projections[b]	Urban Population Percentage	Estimated Urban Population	Urban Population Change (X_1)-	Estimated Prime Land Loss (Acres)
1970[a/]	3,461,306	66.1	2,406,900		
1980	3,989,432	68.7	2,740,740	330,840	130,424
1990	4,361,426	71.5	3,118,420	337,680	147,321
2000	4,612,220	74.1	3,432,475	314,055	122,707

[a] 1970 data are from Census.

[b] Projections made by the Division of Business and Economics of the University of New Orleans were calculated by the cohort-component method. Three projects for each time period were presented, but only the subjective projection based on trends and expected developments was used in this study.

yield data. Moreover, the estimating equation may change over time, and future institutional constraints may also influence land conversion rates.

SUMMARY

The objectives of this study were: (1) to assess the importance of factors believed to explain the conversion of prime agricultural land to nonagricultural uses; (2) to identify prime agricultural lands, locate them geographically, and determine at what rate they were being converted to nonagricultural uses; and (3) make projections of expected losses of prime lands to the year 2000.

Three factors were hypothesized as being the major determinants of the rate of conversion of prime agricultural land to nonagricultural uses—change in urban population, change in urban median family income, and change in average price per acre of agricultural land. Multiple regression analysis indicated that only the change in urban population was statistically significant, explaining 72 percent of the variation in expansion of urban areas onto prime land. There were no statistically significant differences in the effects of increasing population upon urban expansion by differing community size groups, nor by SMSA and non-SMSA groups.

A pooled 1960–70 cross-sectional analysis of 93 urban places revealed a marginal urban land occupation coefficient of .51 acres per capita, compared to an average urban land occupation coefficient of .21 acres per capita in 1960, and .25 acres in 1970.

In total, Louisiana lost about 92,800 acres of prime agricultural land in the 1960–70 period, an average of 9,280 acres per year. The amount of prime land that may be absorbed by urban expansion during the 30-year period 1970–2000, was estimated at 400,000 acres, or about 4 percent of the prime agricultural land in Louisiana. A loss of 400,000 acres of prime land translates to an annual loss of about $168 million.

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APPENDIX

$Y_2 = a_2 + b_{12} X_{12}$ (equation 2)

$Y_4 = a_4 + b_{14} X_{14}$ (equation 4)

1. H_o: $a_2 = a_4$
   H_A: $a_2 \neq a_4$

The computed F-statistic from the general linear test is 2.91. (1.83)* The critical value for $F_{1,89}$ at the present level is 3.96. Therefore, do not reject the null hypothesis that the two equations have equal intercepts.

2. H_o: $b_{12} = b_{12}$
   H_A: $b_{12} \neq b_{14}$

The computed F-statistic is .9. (.13)* The critical value for $F_{1,89}$ at the 95-percent level is 3.96. Therefore, do not reject the null hypothesis that the two equations have equal slopes.

3. H_o: $a_2 = a_4$
   and
   $b_{12} = b_{14}$
   H_A: $a_2 \neq b_4$
   and
   $b_{12} \neq b_{14}$

The computed F-statistic is 2.27. (1.45)* The critical value for $F_{2.89}$ at the 95-percent level is 3.10. Therefore, do not reject the null hypothesis that both equations have equal intercepts and equal slopes.

*Values computed in comparison of large and small urban places.