Measurement of the Effectiveness of Use-Value Taxation

by Jerry T. Ferguson

This article has two objectives: to establish a methodology to gauge the effectiveness of use-value taxation as a way of preserving farmland and other low density uses, and to apply the methodology to a study area as an illustration.

The study of the four Virginia localities that implemented the program in 1972 (Fauquier, Loudoun, Prince William, and Virginia Beach), and thus have had time to show some results, examines the relationship of preferential assessment and farm conversion. Using land-use statistics from the last agricultural census completed in 1976, the research utilizes time series analysis to show that *no significant departure* from the past trend has occurred in any of the four localities under study. This statement is based on significance levels of 0.05 and smaller. These results occur despite the fact that economic conditions were generally more favorable for farmers than in the 1950s and 1960s. The paper establishes some of these conditions.

A second type of statistical analysis, a paired-difference test, *does* show that the conversion rate over the last agricultural census period for the four study localities is significantly smaller than for their immediate neighbors without use-value taxation. This test result is valid for a level of significance of 0.01 (99% confidence). Although this test is weaker because it does not establish the relationship of preferential assessment to a conversion rate in the individual counties, it does provide an indication that the four counties have fared

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better as a group since instituting the program than have their neighboring local governments.

The research concludes that additional measures, such as the transfer or lease of development rights, are needed to reach the stated goals of the General Assembly of Virginia of preserving prime farmland and promoting a more orderly development.

By the end of 1978, over four-fifths of the states in the U.S. and several provinces of Canada had some form of preferential property tax treatment of farmland. Many also accord similar treatment to commercial forests and certain other uses of land, such as golf courses and parcels with scenic public easements. The preferential approach takes varied forms, such as using a lower fraction of market value (Tennessee) or allowing a credit against state income taxes if the amount of the property tax exceeds a certain percentage of farm income (Michigan). The most common technique, however, is the use of a different evaluation method for farmland than for other properties; this method is called land-use or use-value taxation.

The justification for preferential assessment is that the influence of developmental potential drives up value of the land and the property tax on it. Eventually, the tax increase becomes so great that farm income is reduced to the point that the land will be sold. The use-value approach ignores the developmental potential by capitalizing the actual farm income (or some average income for acreage in the county or state) into an assesed value for tax purposes.

To be given such special treatment, the owner must usually register with local tax officials and agree to have the land remain as a farm for a specified period. Most often, he must pay back some or all of the tax savings with interest when the land is converted to other uses.

The program supposedly benefits all citizens of the state in several ways: with a *retained* "green space" or breathing room around urban areas; a more orderly or slower developmental rate in the county; and even a cheaper or more plentiful food supply. The last advantage is related to the fact that over 60% of all vegetables in the United States are grown within SMSAs (Standard Metropolitan Statistical Area) on relatively small farms near the urban market.[1]

Therefore, if land-use taxation is to be justified on a basis other than tax relief, it must influence landowner decisions concerning the conversion of farms and forests to housing developments and other urban uses. The problem is finding a method to evaluate the effect of preferential assessment and to show quantitative evidence of its accomplishments. This study establishes the secular trend of farmland conversion in four Virginia counties prior to their adopting use-value assessments. By projecting this trend to a year when the agricultural census is taken, a quantitative comparison is possible between the conversion rate based on past data and the actual rate for the period. Any significant difference between the rates, applicable to the period over which differential assessment has been implemented, is assumed to be evidence of a definite and positive influence of preferential assessment. If the actual rate falls within the confidence limits established for the trend, however, the supposition is that no significant relationship exists between the conversion rate and land-use taxation. In addition, the losses in farmland from the four counties are compared with losses in neighboring counties without programs for any substantial difference. The results of the two tests form the basis of a conclusion about the land-use control capability of use-value taxation.

Prior to this quantitative analysis, consideration is given to the techniques and outcomes of several other studies concerning the effectiveness of use-value taxation and to the computation of descriptive statistics of use transformation in Virginia.

OTHER APPROACHES TO EVALUATION

Two reports have attempted to demonstrate the influence of preferential assessment on land use by the responses of landowners enrolled in the program. Koch, Morrill, and Hausamann interviewed 311 participating New Jersey farm owners and found that 40% felt that the plan has enabled them to continue farming, including 44 farmers who turned down offers of sale despite believing a fair price was offered.[2] The questionnaire approach was employed also by Barron and Thompson in the state of Washington, but with fewer favorable responses—only 19% of over 1,000 believing that the program there has enabled them to maintain agricultural or forestry use or has influenced their decisions to sell land or convert its use.[3]

Sowens and Thirsk established a model to explain the development pattern of land.[4] The independent variables are quantitatively measurable characteristics of land chosen for development. When the property taxation variable is tested for significance greater than zero, it is shown to contribute nothing to the explanation. They conclude that property tax is only a minor consideration in development decisions.

The main problem with the reports based on participant questionnaires is transforming the responses into the effect on low density land use. The 40% of New Jersey landowners that reported they would have sold might have found the market price of another farm or residential home unattractive. Furthermore, they might have sold to other farmers. Yet, it is dangerous to conclude that the only 19% favorable response in Washington means no effect on land-use patterns. The farmland or forestland held by the 190 or so owners that was not sold might have significantly affected the conversion rate in the test areas.

The regression model approaches the problem of evaluation from the viewpoint of the urban developer. While the property tax may be a negligible influence on the decision to buy, it may be an important factor in the decision to sell. Compared to development costs and profit potential, the tax is relatively small; compared to farm income, it is often large—an average of 17.3% of average money income for farmers.[5]

The contention is that the most reliable indication of the land-use influence of differential assessment is the amount of change in farm and forestry acreage converted to other uses, not the opinions of present landowners.

LAND CONVERSION RATES

There are several rates of change that may reflect the extent of land conversion. For example, *Table 1* shows the overall annual percentage change for a 50-year period in the four study areas. The difference in acreage is expressed in terms of 1920 as the base year.

However, the time series data are expressed as percentages of the total acreage of each country. Any change from year to year is relative to this total acreage as reported for 1920 when the Agricultural Census began. The result of this approach is shown in *Table 2.*

Various statistics illustrate that the decrease in farmland has been increasing since the 1950s. This situation is characteristic of much of the United States, the Middle-Atlantic states especially. The time series matched to such data must show a nonlinear trend line, suggestive of a parabolic relationship.

TABLE 1

CHANGES IN FARM ACREAGE FOR
SELECTED VIRGINIA COUNTIES, 1920-1970

County	Farm Acreage 1920	Farm Acreage 1970	Total Percentage Change	Average Annual Percentage Change
Fauquier	379,779	252,086	- 61.42	- 1.23
Loudoun	305,906	216,574	- 29.20	- 0.58
Prince William	162,245	53,594	- 66.97	- 1.34
Virginia Beach	94,544	52,486	- 44.49	- 0.89

Source: Virginia Cooperative Crop Reporting Service, *County Farm Statistics* (Richmond: Statistical Reporting Service, July 1973).

TIME SERIES ANALYSIS

Table 2 shows the farm statistics used for the regression analysis. For a time series, the year is the independent variable; the farm acreage percentage is the dependent variable.

Of the relatively simple equations involving just one independent

TABLE 2

FARM ACREAGE IN SELECTED VIRGINIA COUNTIES EXPRESSED AS PERCENTAGE OF TOTAL ACREAGE FOR THE YEARS 1920-1970

	Fauquier		Loudoun		Prince William		Virginia Beach	
Year	Acreage Thousands	%age[a]	Acreage Thousands	%age[a]	Acreage Thousands	%age[a]	Acreage Thousands	%age[a]
1920	379.8	89.9	305.9	92.5	162.2	73.1	94.5	57.0
1925	333.1	78.9	281.7	85.2	136.9	61.7	104.5	63.0
1930	344.9	81.7	283.5	85.7	125.4	56.5	90.1	54.3
1935	372.6	88.2	297.6	89.9	150.5	67.8	91.6	55.3
1940	358.2	84.8	279.2	84.4	124.3	56.0	87.6	52.9
1945	353.4	83.7	305.1	92.2	130.2	58.6	93.1	56.2
1950	315.6	74.7	290.3	87.7	108.6	55.7	92.4	55.7
1955	309.0	73.2	277.2	83.4	98.2	47.4	78.5	47.4
1960	324.7	76.9	252.7	76.4	89.3	36.4	60.4	36.4
1965	292.8	69.3	234.2	70.8	69.0	38.0	63.0	38.0
1970	252.1	59.7	216.6	65.4	62.6	31.7	52.5	31.2

[a] Percentages are calculated from unrounded figures.

Source: Derived from data of Virginia Cooperative Crop Reporting Service, *County Farm Statistics* (Richmond: Statistical Reporting Service, July 1973).

variable, the parabola provides better fit to the change in the percentages than does the arithmetic straight line or logarithmic straight line. The standard error of estimate is lower; the coefficient of determination, higher. Furthermore, the percentages have no extreme values that can unduly influence the parabola. The second purported disadvantage of this curve—that it can become unreasonably steep if projected far in the future—is not relevant to its use in this analysis because the intended projection is but one future period.[6]

The four equations that result from the regression analysis and other pertinent statistical measures are shown in *Table 3.*

TABLE 3

REGRESSION EQUATIONS AND STATISTICAL MEASURES FOR PERCENTAGE CHANGES OF FARM ACREAGE IN SELECTED VIRGINIA COUNTIES, 1920-1970

County	Regression Equation (Percentages)	Standard Error of the Estimate (Percentage Points)	Coefficient of Determination (Percentage)	Durbin-Watson Statistic
Fauquier	$84.70 + 0.88 (X) - 0.31 (X^2)$	4.84	79.5	2.30
Loudoun	$87.01 + 2.25 (X) - 0.43 (X^2)$	3.89	84.0	2.09
Prince William	$68.00 + 1.48 (X) - 0.26 (X^2)$	4.74	91.3	1.45
Virginia Beach	$57.76 + 0.93 (X) - 0.36 (X^2)$	3.89	88.1	2.09

Source: Regression Analysis of data from Table 2.

The use of the equations can be demonstrated by a projection for Fauquier County. The 1975 census would be the eleventh period in the series; the 1980 census would be the twelfth, and so on. The estimate for 1975 would be found by the following substitutions:

$$84.70 + 0.88\ (11) - 0.31\ (11)^2 = 56.87\%$$

The 95% confidence interval is found by multiplying the forecast error by the appropriate t-score "value for eight degrees of freedom":[7]

$$56.87 + 5.33\ (1.895) = 56.87\% \text{ to } 66.97\% \text{ for Fauquier.}$$

The 66.97 is termed a "critical value" because if the actual census percentage is greater, the difference *cannot* be attributed to chance deviation. In other words, the percentage lies outside the range of the estimated trend and the actual conversion rate is less than expected. The usual procedure calls for establishing a test hypothesis so that there is no significant difference between the estimated and actual rates; this statement can be rejected if the actual rate is outside (higher than) the confidence interval. The alternate hypothesis (that the census rate is higher) is accepted.

Likewise, the predicted values by the regression equations are as follows:

County	Predicted %
Fauquier	56.87
Loudoun	59.73
Prince William	20.26
Virginia Beach	24.43

This compares with the census figures from the Agricultural Reporting Service for 1975 as follows:

County	Acreage	% of Total Acreage
Fauquier	246,596	58.44
Loudoun	214,944	64.96
Prince William	53,594	24.13
Virginia Beach	42,734	25.78

The range for a 95% confidence interval with 11 observations and 8 degrees of freedom are indicated as:

County	Indicated Interval	Critical Values (0.05 significance)
Fauquier	56.87 + (1.895) 5.33	66.97
Loudoun	59.73 + (1.895) 4.63	68.50
Prince William	20.26 + (1.895) 5.64	30.95
Virginia Beach	24.43 + (1.895) 4.63	33.20

In each case, the census acreage is expressed as a percentage of 1920 acreage and does not exceed the critical values associated with the 0.05 level of significance. While the results of these tests are more fully explored in the conclusions of the study, they show that the actual data for 1975 indicate no substantial departure from the past trend. The most apparent exogenous factor related to a difference is use-value taxation, and there is no statistical evidence of a lesser conversion rate than past data indicate.

STANDARD ERROR OF A FORECAST

The inference that there is no significant change of trend in any of the four counties is generally based on the various standard errors. In actuality, the proper concept of probable or expected error involves a slightly different statistical measure, the standard error of forecast—the limits within which a new observation can be expected to lie. "It takes into account the sampling error in the regression line itself and is obtained by combining the standard error and the standard error of the regression life."[8]

For a large sample, this approach does not greatly affect the standard error unless the prediction is being made far into the future. In this instance, the sample size is 11—the number of five-year intervals for which data are available. This relatively small sample causes the forecast error to exceed the standard error by nearly 20%. The resulting increases are as follows:

County	Standard Error	Standard Error of Forecast
Fauquier	4.48	5.33
Loudoun	3.89	4.63
Prince William	4.74	5.64
Virginia Beach	3.89	4.63

Because the new parameter is larger than the standard error, the critical values are increased when the hypothesis of no significant change is tested. However, if the standard error were used to establish the critical values, the result would be the same: the hypothesis cannot be rejected at the 0.05 level of significance.

Figure 1 to Figure 4 illustrate that the actual 1975 census data points (percentage of acreage farmed) shown by the ⊡ lie well within the intervals bounded by the critical values associated with a level of significance of 0.05.

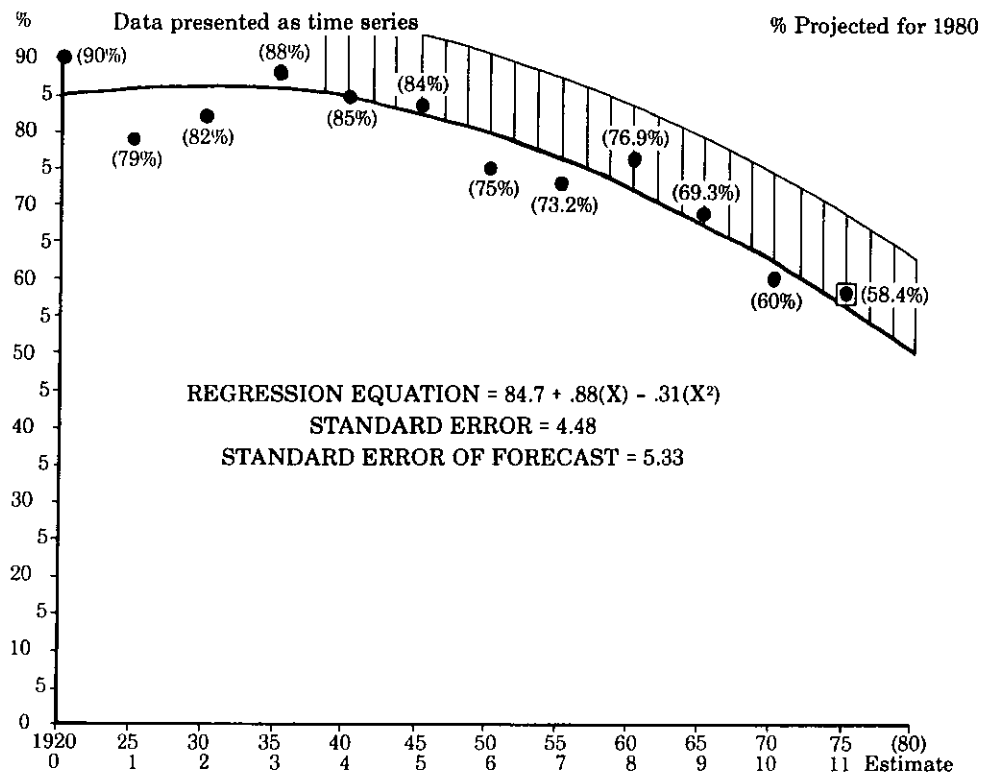
CROSS-SECTIONAL DATA

The chi square test and time series analysis have examined data for significant change within the localities, yet there is further evidence of the differences in the conversion rates associated with implementation of preferential assessment. If rates are computed for all neighboring localities to the four study areas, a "paired-difference" test is possible.[9] This is a simple example of a blocking design in which

FIGURE 1

FAUQUIER

Percentage of county used as farmland using 1920 as base period acreage & showing least-squares trend



Source: Derived from data in USDA census for 1975

pairing is planned, not randomized.[10] The percentages are the decreases in farm acreage from 1969 to 1974, expressed relative to the total acreage in the county. The test matches the percentage from each of the four counties with ones from neighboring counties that have not yet implemented a program. The results are shown in *Table 4.*

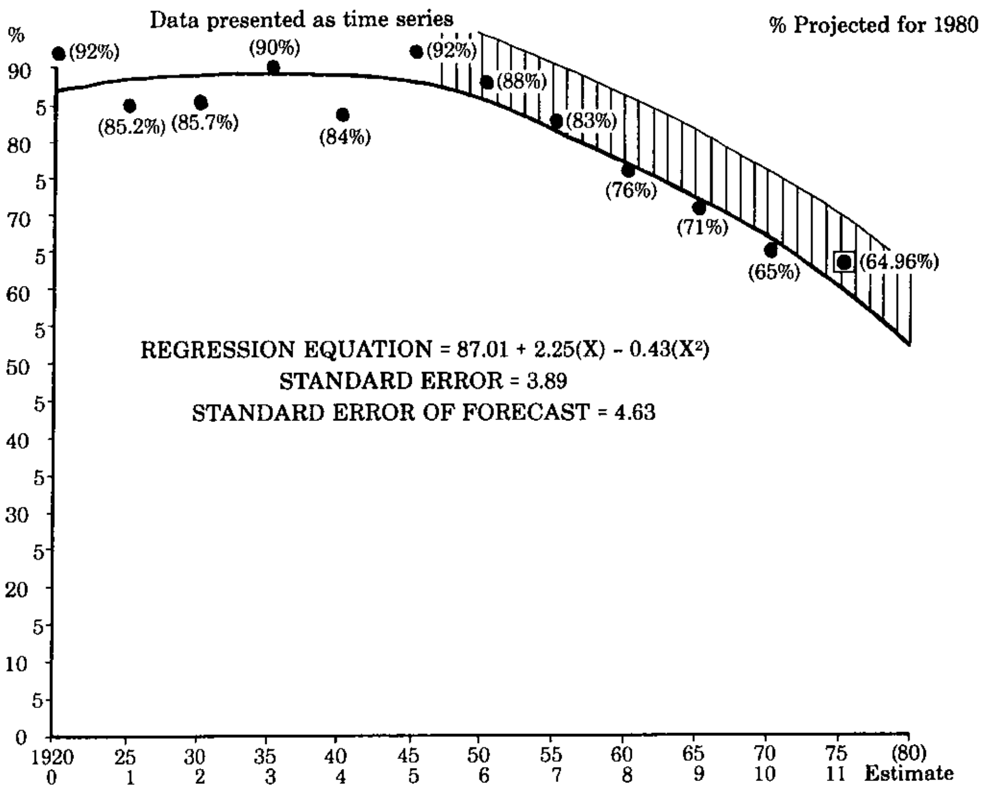
The average of the differences ($\bar{d}$) is 0.0276; and the standard deviation (S_d) is 0.0336, with the standard error found by ($S_d/\sqrt{n}$) dividing this figure by the square root of the number of pairings. This estimate is 0.0106. The hypothesis of no significant difference between the rates in program and nonprogram counties can be tested by the following procedure:[11]

$$\frac{\bar{d} - 0}{\text{Standard error}} = t$$

FIGURE 2

LOUDON

Percentage of county used as farmland using 1920 as base period acreage & showing least-squares trend



Source: Derived from data in USDA census for 1975

TABLE 4

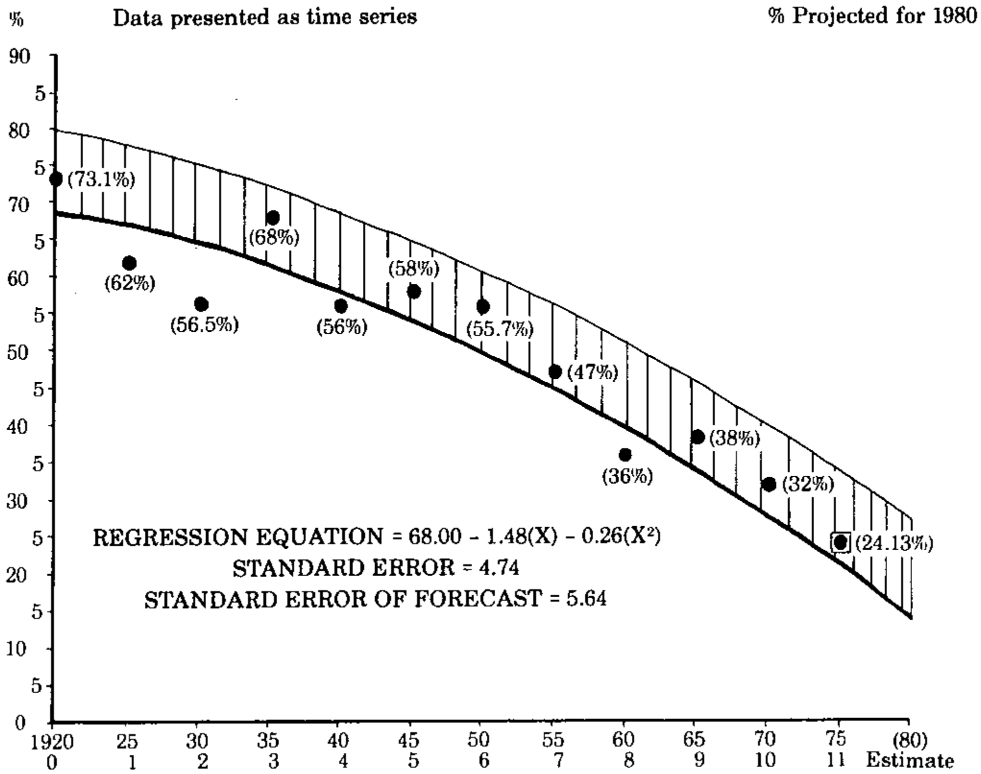
SELECTED PAIRINGS OF FARMLAND CONVERSION RATES IN VIRGINIA COUNTIES, 1974

Neighboring Nonprogram Locality	Conversion Rate 1969-1974 (Percentage)	Program County	Conversion Rate 1969-1974 (Percentage)	Difference in Rates (Percentage)
Stafford	.0448	Fauquier	.0367	.0081
Culpeper	.0623	Fauquier	.0367	.0256
Rappahannock	.0661	Fauquier	.0367	.0294
Fairfax	.0524	Fauquier	.0367	.0157
Warren	.1241	Loudoun	.0049	.1192
Fairfax	.0524	Loudoun	.0049	.0475
Culpeper	.0630	Prince William	.0406	.0224
Stafford	.0448	Prince William	.0406	.0042
Fairfax	.0524	Prince William	.0406	.0118
Chesapeake	.0510	Virginia Beach	.0588	(.0078)

Source: Derived from data contained in *Census of Agriculture, 1974, Virginia,* Vol. 1 (Washington: U.S. Department of Commerce, 1977).

FIGURE 3

PRINCE WILLIAM
Percentage of county used as farmland
using 1920 as base period acreage
& showing least-squares trend



Source: Derived from data in USDA census for 1975

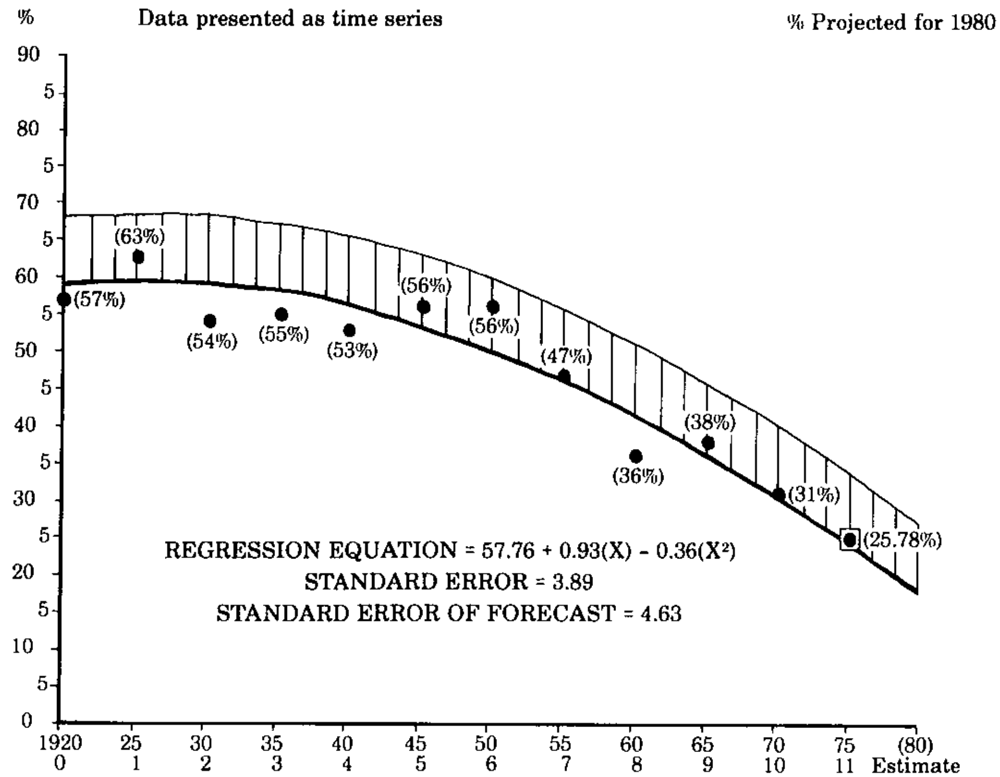
If the calculated "t" value is greater than the critical value of "t" for a two-tailed statistical test, significance level of 0.05 and nine degrees of freedom, the hypothesis is rejected. The calculated value is 2.59; the critical value is 2.306. The inference is that the average conversion rate in program counties is less than that for nonprogram counties.

CONCLUSIONS

Two dissimilar statistical tests have shown apparently conflicting evidence of the relationship of the use-value taxation program to loss of farm acreage, yet the differences are not pronounced when the approaches of the tests are examined. The regression analysis of the time series does not say that no possible benefit exists; it says that the positive difference between the actual farm acreage and that projected

FIGURE 4

VIRGINIA BEACH
Percentage of county used as farmland
using 1920 as base period acreage
& showing least-squares trend



Source: Derived from data in USDA census for 1975

by the 50-year trend is not large enough, in any of the four counties, to be statistically significant. The comparison is between the past (when there was no program) and the relative present (when there is) for each jurisdiction.

The paired-difference test compares only one interval, 1970-1975, for the study areas with that of immediate nonprogram neighbors. The result would indicate that the four use-value taxation counties as a group have lost statistically-significant less acreage. If compared individually, the difference would probably be less pronounced.

The conclusion is that the loss of farmland will continue at an increasing rate for the near future in these four counties, although at a slightly lesser rate than those nearby areas with no program. Because the aim of the Virginia legislature was to preserve prime farmland and forestland, the use-value program cannot be counted successful in the areas studied. Farmland is not being preserved; it is being converted more slowly in these counties. But the good fit provided by the parabola illustrates the loss to be at an increasing rate. While there is a limit to this acceleration of loss as the remaining acreage becomes smaller, the inescapable answer is that other remedies, such as purchasing or renting development rights, are needed to slow these increasing losses.

The value of this study is that it offers some means to assess the potential effect of land-use taxation. The indication is that the Virginia counties are better off with the program than without, yet it is not significantly slowing the conversion rate. The nonfarmers, who must shoulder an additional tax burden, receive few of the advantages that were given for passage of the legislation. For them, the revenue lost would be better spent in the acquisition of land for parks and in the obtainment of public easements.

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5. Fred C. White, Bill R. Miller, and Charles Logan, "Comparisons of Property Tax Circuit Breakers Applied to Farmers," *Land Economics,* Vol. 53 (August 1976), p. 361.
6. For a discussion of this characteristic of polynomial regressions, see John Neter and William Wasserman, *Applied Linear Statistical Models* (Homewood, IL: Richard D. Irwin, Inc., 1974), p. 274-275.
7. William A. Spurr and Charles P. Bonini, *Statistical Analysis for Business Decisions* (Homewood, IL: Richard D. Irwin, Inc. 1973), p. 293-294. The degrees of freedom are based on the possible deviations when the variance is measured. Because three constants are used in the estimation of the curvilinear regression line, three degrees of freedom are lost (n-3, where n is equal to the number of five-year intervals).
8. Mendenhall, *op. cit.,* p. 275. The expected forecast error is found by multiplying the standard error by $\sqrt{1 + \frac{1}{n} + \frac{(Xp - \overline{X})^2}{(X_1 - X)^2}}$ where

   (a) n = sample size, (b) Xp = the number of the forecast intervals (11), (c) $\overline{X}$ = the average of the X values (5), and (d) X_1 = each of the X values (0, 1, 2, 3, ... 10).
9. Mendenhall, *Ibid.,* pp. 237-239.
10. The use of a rate in more than one pairing is acceptable when a different match occurs.
11. Mendenhall, *op. cit.,* p. 238.