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Is There a Critical Mass of Agricultural Land Needed to Sustain an Agricultural Economy? Evidence from Six Mid-Atlantic States[1]:

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EXECUTIVE SUMMARY

The critical mass concept is based on the idea that a certain amount of agricultural activity must be sustained in order for the agricultural economy in an area to remain viable. As production levels decline below a given threshold, costs will rise, and support businesses will close or relocate. If the input and output firms exit the region, the closest input supplier may not only be farther away for a farmer but may also charge higher prices for inputs, veterinarian services, and equipment repairs. Similarly, if the nearest processor goes out of business because it cannot cover its fixed costs due to an insufficient supply of a commodity to process as acreage decreases, the nearest outlet for the product could involve additional transportation costs and/or a lower purchase price, either raising farmers' production costs or decreasing their revenue. A decline in agriculture profits and thus a higher relative return for conversion to other uses such as residential housing or forestry may increase the rate of loss of farms and farmland in the area. Particular agricultural sectors may need a certain number of acres, production or sales to remain viable. Thus at the very least, if the area lost this needed size, farmers would be forced to shift to other commodities or livestock options to remain profitable.

We examine the rate of farmland and farm loss for six Mid-Atlantic states, Delaware, Maryland, New Jersey, New York, Pennsylvania, Virginia, over the last 50 years to determine if once they have lost a certain number of farmland acres or dollars of sales, the rate of farmland and farm loss accelerates. Our results indicate that for the 50-year period, there was a critical mass threshold in terms of harvested cropland acres per county; this threshold was 189,240 harvested cropland acres per county. Once a county fell below that number of acres, the rate of farmland loss was higher. Counties with less than 150,000 farmland acres had a higher rate of farmland loss than counties with more than 250,000 acres. To determine if total sales for the county were an important indicator, we also examine the relationship between the level of sales and the farmland loss. In terms of sales, we find that if counties fell below $438 million in sales (the mean sales for the entire sample is $488.1 million) they experienced an increased rate of farmland loss. In addition, the health of the local economy as measured by the rate of unemployment and median income impacts the rate of farmland loss.

However, these threshold results were not constant over time. Because agricultural technology, agricultural policies, and trade patterns have been changing over this almost 50-year period (1949-1997), we also analyze the most recent time period from 1978 to 1997 to determine if the critical mass threshold had altered. In addition, by the early 1980s, all counties had instituted preferential taxation programs for agriculture and some had begun farmland preservation programs. These programs were expected to slow the rate of farmland loss. For the later time period of 1978 to 1997, we do not find that the level of harvested cropland acres had an impact on the rate of farmland loss. The rate of farmland loss has actually decreased since the early 1970s. For example, between 1949 and 1974, an average of 56,000 farmland acres was lost each year in Maryland, since 1974 the rate of loss has been 21,000 acres per year. Similarly, the 5-year rate of farmland loss for the six states between 1949 and 1978 was 9.19%, and between 1978 and 1997 it was 5.13%.

Changes in the last 25 years have apparently altered the impact of this critical mass variable. Thus while the initial results indicated that once a county dropped below the critical mass threshold that agriculture was doomed, we find that the rate of farmland loss has actually slowed. We hypothesize that farmers have shifted to alternative crops, have found alternative marketing mechanisms (such as direct marketing rather than depending on processing plants), or have begun using alternative purchasing channels such as the Internet or using delivery services to obtain their input needs. As an example of changes in agriculture patterns, by 1997, 110 counties (42%) in these six states had changed the commodity or animal source from which they had received the majority of their income in 1949. The loss of support sectors may have stimulated a shift to commodities that rely less on local processors and suppliers. Thus farmland and farms have been able to survive in areas that are not dominated by agriculture.

Many factors explain the rate of farmland loss including sales per acre, expenses per acre, population per acre, percent of unemployment, percent change in median family income and percent change in housing units. As the number of harvested acres increases by 10% for example, the rate of farmland loss decreases from the predicted 5-year rate of 7.9% to 7.67%. As harvested cropland acres, sales, and income increase, the rate of farmland loss falls. Similarly, as expenses, population density, housing units, and percent unemployment increase, the rate of farmland loss accelerates. A county with a preferential taxation program lost farmland at a much slower rate (a 5-year rate of 4% compared to 7.9%) than a county without one. A county in a metropolitan area has a higher rate of loss than a non-metropolitan county.

Similar factors explain the rate at which farms are lost including the number of harvested cropland acres, sales per acre, expenses per acre, population per acre, percent of unemployment, percent change in median family income, and percent change in housing units. As harvested cropland acres, sales, median income, and educational level increase, the rate of farm loss falls. As expenses, population density, total housing units, and percent unemployment increase, the rate of farm loss accelerates. In addition, if resource-based employment decreases, more farms exit the county. The 5-year rate of farm loss in counties with a preferential taxation program was 9.08% compared to the predicted rate of 12.07%, while counties with an agricultural preservation program had loss rate of 9.76%. Being in a metropolitan area, however, increases a county's rate of farm loss to 12.76%. Counties with less than 200,000 acres had a 2-3% higher rate of losing their farms than counties with more than 250,000 acres. Compared to the predicted 5-year rate of loss of 12.07% per county, counties with fewer farmland acres had a farm loss rate of 13.67-14.7%.

The Maryland Office of Planning predicts that if current trends continue, 500,000 more acres of farms, forests, and other open spaces will be converted to development over the next 25 years. In the Washington, D.C., metropolitan area, the rate at which land is being consumed exceeds the population growth rate by almost 2.5 times. According to the Chesapeake Bay Foundation, this rate of growth is expected to consume more land over the next 20 years than all the land developed in the Chesapeake watershed over the last 200 years. Therefore, concerns about the conversion of agricultural land to housing development are well founded especially if the development patterns are consuming more land than previously. However, we found that not all farmland loss is being caused by development pressure. Farmland is lost in counties where the population is decreasing. One thought is this farmland is being converted to a forest or recreational use. Thus while programs to ensure less conversion to housing are important, policy makers also need to consider why farmland is lost in de-populating areas. In addition, some farms in metropolitan counties have been and continue to be profitable and successful.

Our results do suggest that there has been a relationship between the level of productive agricultural land and the rate of farmland and farm loss. Given this relationship, programs to preserve or support agriculture may accomplish more if targeted toward counties and regions where high levels of farmland remain. However, even for those counties that have lost farmland, these results can be seen as hopeful. The critical mass may vary with changes in technology and with the type of farming. Thus, farmers who adjust to changing circumstances and take advantage of new situations may be able to survive and flourish. Preferential taxation programs in particular appear to slow the rate of farmland loss, and both taxation and preservation programs slow the rate of farm loss. Over the past 25 years, the rate of farmland loss has decreased in the counties studied, suggesting that farmers are adopting new technologies and more profitable crops, as well as finding alternative coping mechanisms for their changing landscape and industry.

Specific Findings for the State of Maryland

We examined whether Maryland counties had particular factors that would explain farmland and farm loss. In the Maryland-only model, we found that a county with fewer harvested cropland acres was likely to lose farmland at a faster rate, all else the same. However, we did not find that there was a particular number of acres (a critical mass threshold) above which the farmland loss rate increased. As the number of harvested cropland acres increased 10%, the 5-year rate of farmland loss decreased from the predicted rate of 6.61% to 6.26%. At 6.57%, Maryland on average had a lower 5-year rate of farmland loss than the 7.58% average for the 6 states in the region studied. Still, Maryland lost 1.9 million acres, or 47% of its farmland, between 1949 and 1997. Interestingly, 75% of this farmland was lost before 1974. Between 1949 and 1997, Central Maryland lost 765,000 acres, more acres than any other Maryland region . However, Southern Maryland lost the highest percentage of its 1949 farmland (67%), while the Lower and Upper Shore lost the least (37% and 29% respectively).

We hypothesize that the first land to leave agriculture was the most marginal land, as the total cropland decreased by only 29%, compared to farmland at 47%. The proportion of farmland that is used as harvested cropland has increased since 1949, from 67% to 86%. The Upper and Lower Shore have the highest proportion of cropland harvested, at 95% and 93% respectively. Maryland also has more harvested cropland per county than do the other six states, averaging 63,000 acres per county compared to the 6 states' average of 54,000 acres per county

The 5-year rate of farmland loss was lower in counties with a higher percentage of people employed in resource industries. As this variable increased by 10%, the rate of farmland loss decreased from 6.61% to 5.21%. The proportion of employed persons working in agriculture, forestry, fisheries and mining declined statewide, from a high of

7% in 1950 to 2% by 1990. The Upper Shore and Lower Shore had the highest proportion of people employed in these sectors.

Population density and the rate at which houses were being built increased the rate of farmland loss significantly. As the population per acre increased by 10%, the rate of loss increased from 6.61% to 7.22%. The population of Maryland has more than doubled since 1949, from 2.3 million to 4.8 million inhabitants. Over half the state's population lives in Central Maryland (60%). In some regions, high population growth rates occurred, for example 268% in Southern Maryland. In addition, the housing stock grew 175%, a rate considerably greater than the rate of population growth of 109%. As the percent change in housing stock increased by 10%, the rate of farmland loss increased from 6.61% to 8.75%, all else the same. Unlike in the more general model, though, we found being in a metropolitan area did not affect a county's rate of farmland loss.

While median family incomes have risen 170% since 1949, to $54,437 in 1990, the change in median family income did not impact the rate of farmland loss. The Upper Shore had a 236% growth in incomes, followed by the Lower Shore (201%), Southern Maryland (163%), Central Maryland (161%), and Western Maryland (116%). In 1990, Southern Maryland had the highest median family income, at $57,941, followed by Central Maryland ($54,985), Upper Shore ($46,331), Lower Shore ($37,926), and Western Maryland ($32,034). Similarly, although median housing values have increased 185%, the percent change in median housing value in a county did not affect the rate of farmland loss. The Upper Shore and Lower Shore saw median housing values increase by 303% and 251% respectively. Southern Maryland and Central Maryland had the highest median housing values in 1990, at $146,628 and $144,428, respectively.

Maryland has had a preferential taxation program since 1956. Therefore, while the preferential taxation program could be one explanation for why Maryland's average rate of farmland loss was lower than that for the six states, it would not have affected the loss rate between counties within the state.

While Maryland's farmland decreased by 47%, total agricultural sales grew 23% in real terms from 1949 to 1997, to $1.3 billion. The Lower and Upper Shore experienced considerable growth of 114% and 59%, while the rest of the state experienced declines. The Lower Shore, Central Maryland, and Upper Shore accounted for the majority of the state's total sales.

The average per acre sales had increased 132%, from $262 to $609. The highest was the Lower Shore's average of $1349 per acre (total sales in the county which includes crops, livestock, poultry, dairy and others divided by farmland acres in the county), which was a 239% increase from 1949. The Upper Shore had the next largest growth in per acre sales (123%). Western Maryland's sales grew 96%, Central Maryland's 66%, and Southern Maryland's 46%. Per acre production expenses rose 118%, from $169 in 1949 to $369 in 1997. Per acre production expenses in the county are computed by dividing total production expenses, which includes cost of crops, livestock, poultry, dairy and others divided by farmland acres in the county. However, changes in expenses varied across the state's different regions. The Lower Shore had the highest expenses at $981/acre, followed by the Upper Shore at $331/acre, Central Maryland at $236/acre, Southern Maryland at $105/acre, and Western Maryland at $88/acre. However, while one would hypothesize that profitability would affect the decision to remain in agriculture, neither sales per acre nor expenses per acre were found to be significant factors in explaining the rate of farmland loss.

The value of land and buildings per acre had more than quadrupled since 1949, from $772 in 1949 to $3176 in 1997. This increase was largely realized before 1978. Value of land and buildings per acre peaked for Maryland in 1978. By 1997, Central Maryland had the highest value at $3887/acre, followed by Southern Maryland ($3601), the Upper Shore ($2962), the Lower Shore ($2262), and Western Maryland ($1591).

Cropping patterns have changed as well. Vegetable acres have decreased 65% since 1949. In no part of the state did vegetable acreage exceed 4% of harvested cropland in 1997. Poultry operations have become increasingly dominant in Maryland's agricultural economy since 1949. In 1949, the dairy and poultry industries were nearly equivalent in terms of total sales, each having 25% of total receipts. Poultry's share had grown to $569 million by 1997. The dairy industry had shrunk to $175 million. Poultry operations are concentrated in the Upper and Lower Shore regions. The Lower Shore poultry industry grew 262% between 1954 and 1997, accounting for 71% of the state's total poultry sales in 1997. Due to a decline in dairy in the Upper Shore, which accounted for only 16% of the state's total dairy receipts in 1997, the industry concentrated in the Central region of the state, where sales account for 77% of the state's total dairy sales.

Does the Rate of Farmland Loss Increase When the Number

Of Acres Falls below a Critical Threshold?

I. Introduction

The Maryland Office of Planning predicts that if current trends continue, 500,000 more acres of farms, forests and other open spaces will be converted to development over the next 25 years (Bay Journal 1997). In the Washington, D.C., metropolitan area, the rate at which land is being consumed exceeds the population growth rate by almost 2.5 times. The average number of people per household has been decreasing as well, fueling this land consumption pattern. Maryland's 2000 population was 5.3 million and is expected to grow to 6.0 million by 2020. This rate of growth is expected to consume more land over the next 20 years than all the land developed in the Chesapeake watershed over the last 200 years (Chesapeake Bay Foundation, 2000). Will this continuing conversion of farmland to other uses result in too few acres or too little farm activity to sustain an agricultural economy in the state?[2] Since in many areas the rural population depends heavily on the farm sector for its economic well being, what will happen to these communities?

Is There a Critical Mass?

The issue of whether there is a critical mass of farmland acres or farming activity necessary to sustain an agricultural economy can be divided into two parts. Farmers and

[2]This is a slightly different question than that posed in the 1970s when citizens advocated farmland preservation for food security reasons. Several research studies in the early 1980s by Fischel, Dunford, and the National Agricultural Land Study analyzed whether the rate of farmland conversion would affect the national agricultural production capacity. They found that while farmland was disappearing from certain regions, there were sufficient national land resources still available to ensure the nation's food security.

thus farm activities are impacted by input and output markets over which they have little or no control, which may be affected by the number of remaining farmland acres. They also make their own investment decisions for their farm which may be affected by the perception of a critical mass in their region. This report examines the first part whether the rate of farmland leaving agriculture increases after acreage in a county drops below a critical level. This report does not distinguish between the land use to which the farmland could be converted. For example, farms can leave agriculture to become houses, businesses, or forests.

Does the Rate of Farm and Farmland Loss Increase When the Number of Acres Falls below a Critical Threshold?

Many people see the logic in the idea that there is a critical mass of agricultural activity that must be sustained in order for an area's agricultural economy to remain viable. The critical mass concept is based on the idea that economies of scale exist in both input and output businesses and services that are essential to agriculture. As production levels decline below a given threshold, costs will rise, and support businesses will close or relocate. If the input and output firms exit the county, the closest input supplier may not only be farther away for a farmer but may also charge higher prices for inputs, veterinarian services, and equipment repairs due to less competition and need to covered fixed costs. Similarly, if the nearest processor goes out of business because it cannot cover its fixed costs due to an insufficient supply of output as acreage decreases, the nearest outlet for the product could involve additional transportation costs and/or a lower purchase price, either raising farmers' production costs or decreasing their revenue.[3] Changes in farmers' comparative advantage and their net revenues alter the relative returns of exiting farming. A decline in agriculture profits and thus a higher relative return for conversion to residential, recreational or forestry uses may increase the rate of loss of farms and farmland in the area.

Researchers and policymakers articulated the concept of critical mass and recognized its complexities as early as the 1970s. Lapping noted that the critical mass level would vary from crop to crop, and that local growing conditions, traditions, and existing infrastructure would affect the profitability and sustainability of agriculture and the level of a critical mass threshold in any particular geographic area. Further, the threshold was believed to change over time due to technological changes. (For example, the transition of suppliers from traditional farm supply stores to internet sales using delivery services could overcome some of the negative consequences of a local input supplier leaving the area.)

Attempts at Defining a Threshold

Proving the existence of and exact level of a threshold remains a challenge. Attempts to do so have varied in their approach and complexity. In 1974, for example, Dhillon and Derr estimated the critical farm size necessary to operate at or close to the minimum per unit production costs level. Focusing on agricultural commodities grown

[3] Alternatively, if smaller locally based input and output firms are consolidated permitting larger more regionally focused businesses, these firms may achieve greater economies of scale. Then the major factor would be the effect of increased transportation costs on farmer's costs.

in the Philadelphia-New York-Boston corridor, they determined critical production levels for various mixes of dairy, poultry and fresh market vegetable production. In 2001, Daniels and Lapping took another approach, capturing some of the complexity of estimating a critical mass threshold while simplifying the concept by using an either/or formulation, using 1) at least 100,000 acres, 2) $50 million in agricultural sales, and/or 3) 20,000 acres of preserved farmland as criteria to identify counties where a critical mass may or may not exist. Farmland preservation programs, which use minimum parcel sizes in an attempt to preserve a critical mass of farmland, have set preserving farmland in blocks of at least 1000 contiguous acres as a goal. This size block is expected to slow the incursion of development (Anon. 2001). Others define critical mass solely in terms of a minimum level of aggregate farmland acres. The American Farmland Trust, for example, suggests that Maryland's critical mass is 2 million acres (AFT 1997), although we were not able to locate someone who knew how this figure was derived. However, given that the agricultural sector depends on non-agricultural sectors for off-farm employment, non-agricultural sectors may need to be considered in computing critical mass definitions.

Recognizing the phenomenon of critical mass provides information for policymakers engaged in activities that impact land-use decisions and the preservation of farms and farmland. To increase efficiency, farmland preservation programs may need to target areas where a critical mass of agricultural activity exists (Daniels and Lapping) rather than spread their resources to those areas where agriculture is less likely to survive because they have already dipped below the critical mass. Given the limited funds available, prioritizing where and how to protect farmland ensures the highest level of open space preservation and agricultural activity. Programs that target contiguous agricultural areas rather than random, non-contiguous farms may also achieve more success. Fragmentation of farming areas results in conflicts between farmers and residential and commercial neighbors – the nuisance complaints that sometimes ensue can make normal farm operations burdensome and cause farmers to incur additional costs in order to reduce the impacts of their activities on neighbors.

Farm and Farmland Loss

The continued health of the agricultural sector is the key issue in discussions of critical mass. The loss of farms and farmland land can signal an industry adjusting to new conditions or can signal individual farmers exiting what they perceived to be a doomed enterprise due to increased non-farm populations or to decreased farm profitability. Both the U.S. and the Mid-Atlantic states have experienced a substantial decline in numbers of farms and farmland over the past 50 years. Low net returns, and development and population pressures explain some of this farmland conversion.

In an assessment of development pressure on farmland across the country, AFT identified the twenty most threatened agricultural regions based on the rankings on each area's market value of agricultural production, development pressure, and land quality correlated with high rates of farmland conversion. The Northern Piedmont region, which encompasses southeastern Pennsylvania, Maryland, and northeastern Virginia, ranked second; the Mid-Atlantic Coastal Plain/Delmarva Peninsula, which encompasses Delaware and Maryland's Eastern Shores, ranked ninth; parts of the Eastern New York

Upland areas ranked tenth; and the Ontario Plains/Finger Lake areas ranked eleventh. Most of the counties in this study are included as part of these top 20 regions identified by AFT as most threatened.

In the Mid-Atlantic States included in the current study, metropolitan, transition, and non-metropolitan counties[4] all account for losses proportional to their share of farms and farmland. But although development pressure and other factors cause farmland declines in urbanizing areas, much of the farmland loss is in more rural areas. In many areas, farmland loss occurs simultaneously with population decreases. There, the losses may relate to the profitability of agriculture and off-farm economic opportunities.

What Is Causing Farmland Conversion?

Muth presented a methodological framework of rural-urban land conversion in the early 1960s. He suggested that land-use patterns developed according to the relative values of land in urban and agricultural uses. In this vein, the changes in profitability of agriculture and changes in the demand for development of land for non-agricultural purposes drive the conversion of land from agricultural uses to development. The framework is extended to consider the abandonment of agricultural purposes to an unspecified use (usually forest), which would depend more heavily on the profitability of agricultural enterprises in a particular location.

[4] The classification of counties as metropolitan, transition or non-metropolitan used in this analysis is based on whether a county was classified as metropolitan throughout the study period, became metropolitan at some point during the study period, or was never considered metropolitan, as defined by the Census.

Demand for Land for Agriculture

The demand for land for agriculture depends on expected net returns of engaging in agricultural production. Agricultural profitability determines whether the owner actively farms the land or idles it while waiting for the optimal development time. Idling could occur if the present value of the land in an agricultural use is less than the present value of the land in a developed use where there is high development pressure but the optimal date to sell or convert the land has not occurred. In areas with low development pressure, change in agricultural profitability drives land-use decisions. In areas near growing population centers, encroaching development may increase the costs of farming and result in alternative land-use decisions such as conversion.

Agricultural production systems have evolved dramatically over the past 50 years. Technological innovations have increased the yield per acre of agricultural land. In the 1940s, as growers became able to cultivate more acreage with less labor, they began increasing their farm size. Most of the growth in farm size this century occurred between 1950 and 1975 (Gardner 2002). Consistent overproduction and the resulting low prices may have driven the demand for land for agricultural purposes to decrease.

Nearby development may affect agricultural profitability. For some growers, the rapid loss of farms and farmland in their region confirms their belief that the viability of the sector is dissipating. Given their bleak assessment, they reduce investments in anticipation of selling their farm, a phenomenon known as the "impermanence syndrome." Other growers however, have adapted to their changing surroundings, diversifying into direct marketing operations, nursery crops, horse boarding or breeding facilities, or other enterprises.

Encroaching development may change a farmer's costs and/or the prices received. As mentioned previously, costs may rise as farmers adopt practices more compatible with residential neighbors or because of the relocation of support businesses. Labor costs may increase as farmers must compete increasingly with off-farm employers. Transportation costs may increase or decrease, as local processors or buyers go out of business or relocate, or as farmers have shorter distances to travel to an expanding customer base nearby. Land rental rates may increase as fewer acres are available for agricultural production or rental rates could decrease as non-farming owners seek people to farm their land. The limited land available may result in diseconomies of scale. On the other hand, prices received may increase as a result of direct marketing opportunities or may decrease if processors exit the area.

Some farmers, as mentioned, have adapted their operations to accommodate their new conditions or sold-out to other farmers who have made these adaptations. In 1989, Lockeretz found smaller farm sizes, a higher proportion of harvested cropland, and more reliance on crops than livestock in counties closer to metropolitan areas. He also found that farmers in metro counties had a noticeably higher standard of living than U.S. farmers as a whole, which he attributes to higher off-farm income. In 1994, Gardner found that higher household income stems the loss of farms (but not farmland), furthering the argument that off-farm opportunities allow farmers to stay in business. Lockeretz also found higher intensity use of farmland in those metropolitan areas that have experienced the greatest decline in number of farms. The proportion of harvested cropland of total farmland in these counties exceeded that of non-metropolitan areas. Larson, Findeis and Smith found that more than half the value of U.S. farm production is derived from urbanizing counties, suggesting agricultural viability may still exist in these metro areas.

Urbanization impacts different *types* of farming in different ways as well. In 1998, Adelaja, Miller and Taslim found that urbanization in New Jersey impacts the dairy industry more than other sectors due to the higher land values and the extensive land use generally involved in dairy operations. In another study in 1988, Lockeretz found that more intensive crop farming occurred in areas with high population density and growth. Lopez, Shah and Altobello found that vegetable producers received higher prices in urbanized areas. In general, urbanization results in more intensive use of land.

Demand for Land for Development

In addition to farm profitability, demand for land for development affects whether farmland is converted to another use. Several studies have been conducted to identify the influence of development pressure on land prices and on the decline of farms and farmland.

One would expect to find a relationship between population growth and the loss of farms and farmland. Surprisingly, evidence on this issue is not as strong as one would anticipate. In a study of metropolitan counties between 1964 and 1987, Gardner found that a 100% increase in population resulted in an 11% decline in farmland. Farm numbers were less strongly related to population growth per se, though they did decline 14.4% more in counties that contain a major city. However, analyzing changes between 1969 and 1982, Lockeretz found only a weak relationship between population growth and changes in the number of farms, farmland, or total agricultural sales in the Northeast. In 1989 he conducted a nationwide study, comparing metro and adjacent non-metro counties from 1949 to 1982, and found that farmland did decline at a faster rate in metro counties.

Farmland prices have become higher than those suggested from the on-going income stream from an agricultural use due to development pressure. Researchers classified 55% of the North-Atlantic Slope (parts of VA, MD, NJ and Southeastern PA) as urban-influenced and attributed 63% of farmland's real estate value to the urbanization effect (Anon. 2000). However, Lockeretz (1986) argues that metro areas have higher farmland values because of higher quality land and intensity of use.

Hardie, Narayan, and Gardner hypothesize that both agricultural value and non-farm factors influence farm values. In their study of agricultural and real estate values in the Mid-Atlantic, they find that the median price of the county's residential houses significantly affects the price of farmland. The authors conclude that programs that help the farmer's profitability will be less effective at preserving farmland than those that affect the housing market.

Farmland Preservation Programs

It is possible that it is in society's best interest to convert farmland for residential and other uses. People obviously are willing to pay higher prices for the land for some non-agricultural uses. However, there is some evidence that markets where land is bought and sold may not operate efficiently, i.e., may not result in the outcomes desired by the general public. Inefficiency can result because both positive and negative externalities (non-market amenities and negative attributes) arise when land is lost to agriculture and converted to a developed use that affect the general public not just the individual making the selling or purchasing decision. Maintaining land in agriculture provides open space, improved quality of rural life, landscape vistas, groundwater recharge areas, and contributes to the local economy; all of which impact society as a whole. On the other hand, agricultural land is also associated with odors from livestock operations, drift from chemical pesticide, water quality concerns from fertilizer use, dust, and noise.

As a response to public concern about the loss of farms and farmland, state and local governments have introduced many different programs to stem this loss: agricultural protection zoning, purchase of development rights/agricultural conservation easements, transfer of development rights, preferential taxation, right-to-farm laws, and agricultural districts. Maryland enacted the first state preferential tax assessment program in 1956. Southampton, New York, created the first local purchase of development rights program in 1972, followed by Suffolk County, New York, in 1974. Maryland and Massachusetts each introduced state Purchase of Agricultural Conservation Easement (purchase of development rights programs (PDR/PACE)) programs in 1977. We examine whether agricultural land preservation programs and preferential taxation have had an impact on the rate of farmland and farm loss.

II. Model and Results

As farmland acreage decreases, there are fewer purchasers of farm inputs and fewer sellers of farm outputs. If economies of scale exist – i.e., costs decrease as volume of sales increases, in both the input and output sectors – then a decrease in the number of farmers who buy inputs and sell outputs would change the cost structure and decrease profits in the agricultural industry's support sector. If the input and output firms exit the county due to these changes, the closest input supplier may not only be farther away for a farmer but may also charge higher prices for inputs, veterinarian services, and equipment repairs. Similarly, if the nearest processor goes out of business because it cannot cover its fixed costs due to an insufficient supply of output to process as acreage decreases, the nearest outlet for the product could involve additional transportation costs and/or a lower purchase price.[5]

[5] Of course, this assumes that all farmers patronize identical input and output firms. Given that dairy farmers may have different needs from apple growers, in the analysis, we group farmers into geographic regions (crop reporting districts) that will have similar cropping or animal production patterns.

We analyze whether once a county has lost sufficient farmland – i.e., goes below a critical mass of farmland – the rate of conversion of farmland and cropland to other uses, which could include housing, businesses, forestry or recreational, accelerates.[6] Figure 1 presents a graph in which the rate of farmland loss is steeper or increasing if a county has less than 165,000 acres. Harvested cropland is used as a proxy for the level of economic activity in the agricultural sector. For example, acreage that is enrolled in the Conservation Reserve Program requires the purchase of few inputs and produces no output and may not contribute in the same manner to maintaining a profitable agricultural support sector. Other idled land would also contribute little to the agricultural sector. This analysis assumes that when the number of farmland acres in a county decreases below a critical level, the input and output industries may leave. The closing of these support industries could cause input and marketing costs to increase. This may result in the remaining farmers being less profitable. As their profitability decreases, they may sell their farmland for another use (residential, forestry, recreational). Thus, the county would experience an increase in the overall rate of conversion to non-agricultural uses. If this increase in conversion rates is not found, it may be an indication that the farmland loss rate is not affected by number of farmland acres or that the remaining farmers have found alternative coping mechanisms such as delivery services, more profitable crops per acre, or direct marketing.

[6] Another possible method to use to study this issue would be to examine input suppliers' and processing firms' cost structure. However, even if businesses would permitt this, many of the relevant businesses that we would most like to examine have already exited the region over the past 50 years.

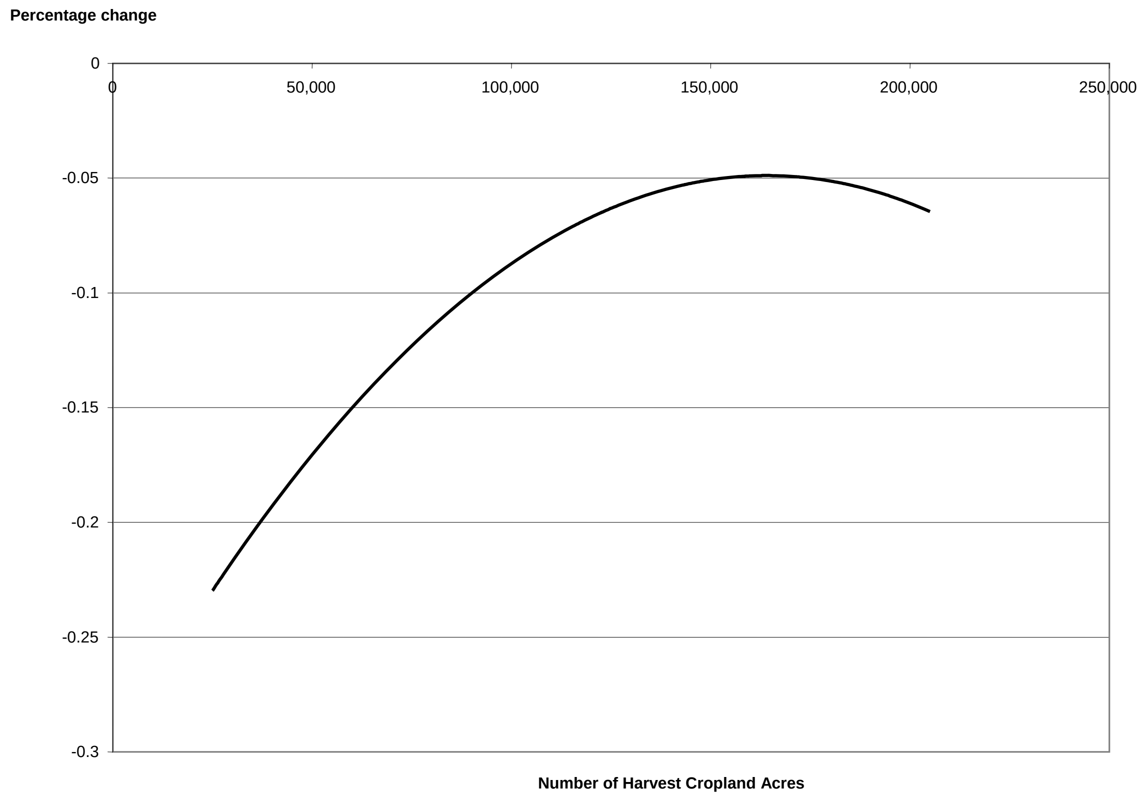

Figure 1. Percentage Loss of Farmland as a Function of the Number of Harvested Cropland Acres

Analyzing the Loss of Farmland

Data from the agricultural census and population census was collected and assembled by county for the last 50 years for six Mid-Atlantic states: Maryland, Delaware, Pennsylvania, New Jersey, New York and Virginia.[7] There were 260 counties and 10 five-year time periods used in the analysis. Several econometric models (see Appendix B) were estimated to determine if a threshold exists below which the rate of farmland and farm loss increases.[8] Both metropolitan and non-metropolitan counties are

[7] The data and data manipulations are described in the Appendix A: Data Description.
[8] Using Lagrange Multiplier and Hausman tests, we find in most of our models that a random effects estimation procedure is more efficient. See Appendix B for more details.

included in the analysis. The dependent variable is the percent loss of farmland[9] from the beginning of a period to the end of a period: thus the percentage change between 1949-1954, 1954-1959, etc., through 1992-1997. Because farmland conversion is affected by changing agricultural conditions, demand for land for non-agricultural purposes, landowners' alternative employment opportunities, and preservation policies, we include variables to control for these factors as well. Table 1 provides the variable names and definitions. Table 2 contains the descriptive statistics for the variables included in the analyses. Table 3 outlines the various models analyzed.

[9] We also estimate this set of econometric models for the percent loss of number of farms.

Table 1. Names and Definitions of Variables Included in the Analysis

Variable name	Variable definition
Dependent variables:	
Pcfland	Percent reduction in farmland
Pcnumf	Percent reduction in number of farms
Independent variables:	
Critical mass variables:	
Flandd	Total farmland (1,000 acres)
Fland2d	Total farmland squared (1,000,000,000)
Hclandd	Harvested cropland (1,000 acres)
Hcland2d	Harvested cropland squared (1,000,000,000)
Sales	Total agricultural sales ($1,000)
Sales2d	Total agricultural sales squared ($1,000,000,000)
Ctylt50a	= 1 if county had less than 50,000 acres farmland
C50100a	= 1 if county had between 50,000 and 100,000 acres farmland
C100150a	= 1 if county had between 100,000 and 150,000 acres farmland
C150200a	= 1 if county had between 150,000 and 200,000 acres farmland
C200250a	= 1 if county had between 200,000 and 250,000 acres farmland
Pagffm	Percent of adults employed in agriculture, forestry, fisheries and mining
Agricultural variables:	
Salesper	Sales per acre ($/acre)
Exppera	Expenses per acre ($/acre)
Development variables:	
Poppera	Population per acre
Madummy	=1 if county in metropolitan area
Pctothu	Percent change in total housing units
Pcmfinc	Percent change in median family income
Pcmhval	Percent change in median housing value
Phighsch	Percent of adults with at least high school education
Punemp	Unemployment rate
Policy variables:	
Stax	= 1 if state has preferential taxation program for agricultural land
Presprog	= 1 if state and/or county has purchase or transfer of agricultural conservation easement program

Table 2. Descriptive Statistics for the Entire Sample and for the Maryland Sample

	Entire Sample (1949-1997)		Maryland (1949-1997)	
	Mean	Std.Dev.	Mean	Std.Dev.
Pcfland	7.58%	0.1256	6.57%	0.0722
Pcnumf	11.76%	0.1376	9.92%	0.1092
Hcland	54.252	47.097	62.915	34.599
Fland	141.688	107.014	129.651	54.774
Sales	$48,808	62,464	$59,141	44,372
Pagffm	9.96%	0.1056	9.87%	0.0912
Ctylt50A	17.59%	0.3808	5.22%	0.2229
C50100A	23.87%	0.4264	25.22%	0.4352
C100150A	22.07%	0.4148	39.57%	0.4901
C150200A	13.72%	0.3441	20.43%	0.4041
C200250A	8.74%	0.2824	6.96%	0.2550
Salesper	$549.07	2394.1100	$482.67	409.6486
Exppera	$331.51	2227.9300	$290.55	306.4540
Poppera	0.5773	1.8430	0.5045	0.7709
Madummy	33.72%	0.4728	37.39%	0.4849
Pctothu	8.09%	0.0689	13.04%	0.0872
Pcmfinc	11.92%	0.0838	13.92%	0.0709
Pcmhval	11.66%	0.1017	15.28%	0.0760
Phighsch	48.41%	0.1847	49.83%	0.1985
Punemp	5.49%	0.0223	5.04%	0.0232
Stax	56.63%	0.4957	80.00%	0.4009
Presprog	8.47%	0.2785	40.00%	0.4910

Table 3. Models of Farm and Farmland Loss in the Mid-Atlantic

1a.	All counties and time periods with harvested farmland (2604 observations)
1b.	All counties and time periods with total farmland (2604 observations)
1c.	All counties and time periods with total agricultural sales (2604 observations)
2.	All counties and time periods with binary variables (2604 observations)
3a.	All counties for time periods: 1949 to 1978 (1574 observations)
3b.	All counties for time periods: 1978 to 1997 (1030 observations)
4a.	Counties classified as metropolitan in 1950 in all time periods (578 observations)
4b.	Counties not classified as metropolitan in 1950, but classified as metropolitan by 1990, in all time periods (689 observations)
4c.	Counties not classified as metropolitan at any point during study period, in all time periods (1337 observations)
5.	All Maryland counties in all time periods (230 observations)

The variables we use to proxy for the critical mass threshold include number of harvested cropland acres and percent of the county population in agricultural, forestry, fishing or mining activities (Model 1a). In two additional separate regressions, we also use the actual number of farmland acres (Model 1b) and the total sales per county (Model 1c) to compare the relative values of the threshold for each of these three indicators. Areas with a large number of harvested acres should have a more active agricultural sector. Similarly if the agricultural crops are high value per acre, sales may be a better indicator of the strength of the agricultural economy. However, farmland acres can be put back into agricultural production more readily than forested or developed acres if conditions are right, so we test to determine if the absolute number of acres behaves similarly. To further investigate the importance of the farmland level, we create measures for each county for each time period to indicate if it has less than 50,000 acres during that time period, between 50-100,000 acres, between 100-150,000 acres, between 150-200,000 acres, between 200-250,000 acres or more than 250,000 acres. We use these measures in

Model 2. The first set of estimations (Models 1a-c, 2) use all 260 counties and all 10-time period combinations.

The relative return of agriculture is proxied by agricultural sales per acre and expenses per acre. If sales increase more than expenses, a farmer's earnings increase and thus he or she may stay in agriculture. Price and technology changes are incorporated into these expenses and sales numbers. In addition, these numbers should reflect shifts to alternative crops. For example, in the last 50 years, the Delmarva Peninsula has become more prominent in poultry, with higher per acre sales, and New Jersey has shifted from animal agriculture to horticultural crops. By 1997, 110 of the counties (42%) in these six states had changed the commodity or animal source from which they had received the majority of their income in 1949 (Figure 2).

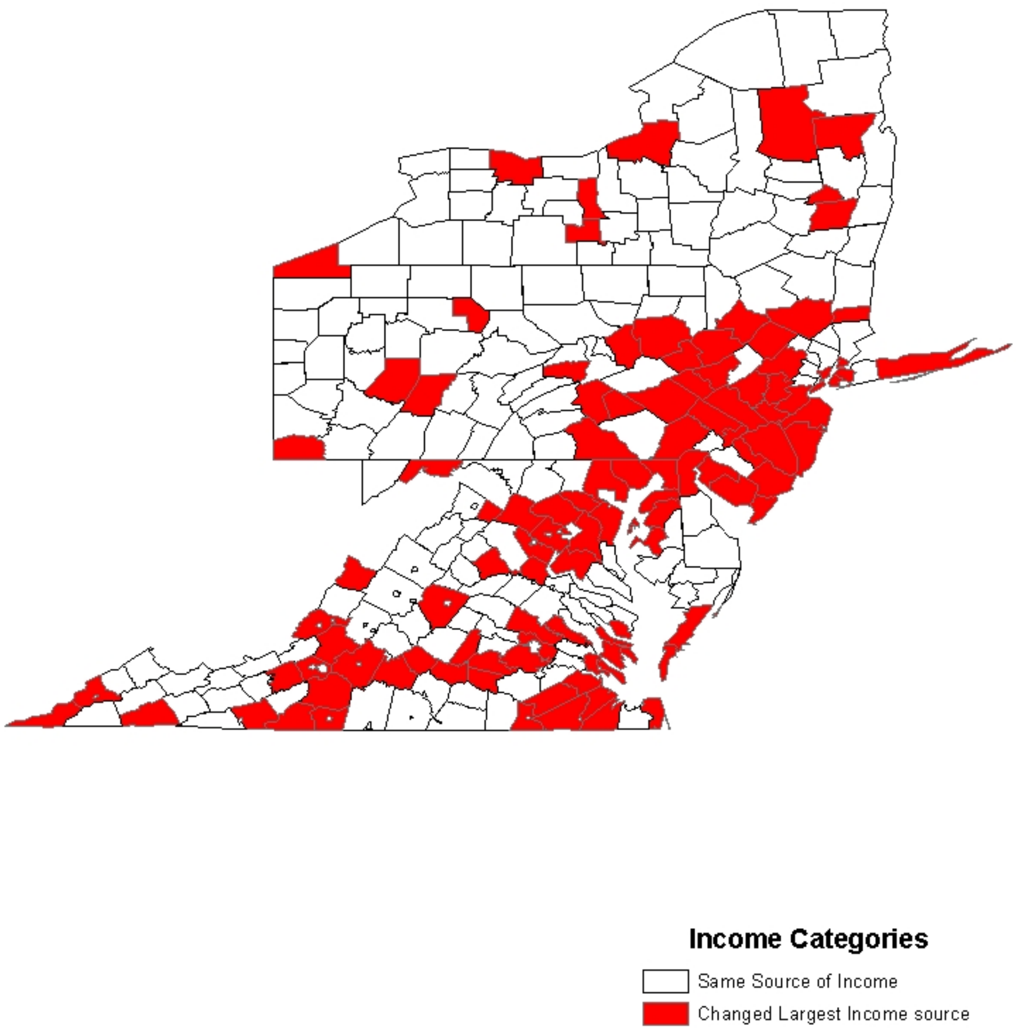

Figure2. Counties that Changed Largest Income Category Between 1949 and 1997

Several variables are included to represent demand for land for non-farm uses[10]: the population per acre (population density) in the beginning year of each five-year period, whether the county is in a metropolitan area at the beginning of the period, the percent change in total housing units during the period, percent change in median family income, and percent change in the median housing value. As population increases, demand for land for houses and commercial structures will also increase. Over this 50-year period, the number of individual per housing units has changed, thus we include another variable that indicates actual growth in the housing stock. As mentioned above, the rate of land consumption in the Washington, D.C., metropolitan area has exceeded the population growth rate by almost 2.5 times. People have also chosen to move farther from the city, extending the metropolitan area's reach into more counties as the population increases. As family incomes increase, we have also seen a desire for larger homes on larger parcels. Therefore, we would expect increases in income to increase demand for rural lands. Similarly, an increase in the median housing value may indicate an increase in the demand for land in a county. Conversely, it may indicate a limited supply of housing relative to a constant demand. In either case, one may expect that in areas with increasing housing values there is an increased demand for farmland conversion.

Many farmers have supplemented their on-farm income with off-farm employment. Their off-farm income opportunities will be higher if they are better educated and the unemployment rate in the county is low. However, as off-farm

[10] If agricultural land is being converted to housing because returns for agricultural use are lower than in a residential use, this is not evidence of critical mass. However, if a county's farmland decreases below a certain level after which returns in agriculture decrease to this point, this would provide some evidence of a critical mass. We are trying to isolate the effect of a critical mass from other reasons that farmland might be lost.

opportunities increase, the relative benefit of selling the land and shifting full-time to alternative employment may be greater. Both the percent of the county population that has a high school education and the percent of unemployment are included as proxies for off-farm employment opportunities, which could have a negative or positive effect on farmland conversion.

In addition, policy variables are included to determine if having a preferential taxation program for agricultural land during the time period and/or some type of farmland preservation program impacted the rate of farmland loss. These policies are expected to slow the rate of farmland loss.

Because over the 50-year time-span there have been many changes in both agriculture and the pattern of city and housing development, Models 3a-b are estimated to determine if the critical mass threshold level and the importance of the other factors varied by time period. Gardner found that the U.S. lost almost half its farms in the two decades between 1950 and 1970, for example. The rate of decline moderated after 1970, but farm numbers continued to fall until the 1990s. He also found that after 1940, output per U.S. farm grew for 40 years at a high rate. After 1980, output per farm started to grow more slowly. Labor became a smaller percent of input costs through the 1980s. U.S. farm size was also growing rapidly between 1950 and 1975. Gardner finds that U.S. farm size has grown less rapidly since 1980. Given these findings and the census years, we divide the 50 years into 2 periods: 1949-1978 and 1978-1997.

Previous research has suggested that different factors affect farmland loss in metropolitan areas than in rural areas. Therefore, three additional models (Models 4a-c) were estimated, divided by metropolitan status as defined by the Census Bureau. The three status variables were as follows: “metropolitan,” for counties classified as metropolitan during the entire study period; “transitional,” meaning the county was not metropolitan in 1950 but became metropolitan by 1990; and “rural,” meaning rural (non-metro) during the entire study period.

We also examine whether Maryland counties had particular factors that would explain farmland and farm loss. Therefore, the last regression was estimated for Maryland counties alone (Model 5).

Results

All else the same, we find from the estimation of the first model (Model 1a) that there is a critical mass of harvested cropland acres of 189,240 acres per county (Table 4). (Tables containing estimated regression coefficients are reported in Appendix B.) If a county has less than 189,240 harvested cropland acres, its rate of farmland loss is higher.[11] The threshold number for total farmland acres is higher, at 440,908 acres, as indicated from Model 1b (Table 4). Thus counties with fewer than 441,000 acres have a higher percent loss of farmland than counties with more than this number of acres. We

[11] To determine the critical mass or threshold level, we compute at what level or number of acres the estimated regression coefficients have a slope of zero. Thus using the estimated coefficients on number of harvested cropland acres and harvested cropland acres squared from the regression equation, we found that the rate of farmland loss was zero when the number of acres equaled 189,240 acres and increased as the number of acres decreased below 189,240.

also found a threshold level of sales at $438.08 million from Model 1c (Table 4). If a county earns less than this level of sales, it loses farmland at a higher rate. The intensity of land use has a large impact on the rate of loss, as the harvested acres threshold is 251,668 acres less than the total farm acres threshold.

To further study these numbers, we create variables that indicate a county's level of farmland, such as 50,000 acres or less, between 50,001 and 100,000 acres, etc. From this analysis (Model 2), counties with less than 50,000 acres are found to have a higher rate of farmland loss than those with more than 250,000 acres (Table 5). The 5-year predicted rate of loss over the 50 year time period was 7.85%. For a county with less than 50,000 acres, the predicted 5-year rate increased to 11.8%.[12] Similarly, counties with between 50,000 and 150,000 acres are found to have a higher rate of farmland loss (9.4-9.9%) than those having more than 250,000 acres. While the differences between the rates of farmland loss may not seem very large, consider that if in 1949 a county had 500,000 acres, by 1997, 300,000 acres would remain if the rate of loss were 5%, and 174,000 acres would remain if the rate of loss were 10%. This is a difference of 126,000 acres.

Many factors explain the rate of farmland loss including: sales per acre, expenses per acre, population per acre, percent of unemployment, percent change in median family housing, and percent change in housing units. Figure 3 shows the relative change in the rate of farmland loss for a 10 percent increase in these variables. For example, Model

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[12] The average rate for counties with less than 50,000 acres is actually 10.95%. The calculated rate of change indicates what it would be if all other variables are held constant.

la's results indicate that as the number of harvested cropland acres increases by 10% (5,400 acres), the percentage loss decreases from the predicted 5-year rate of 7.9% to 7.67%. As harvested cropland, sales, and income increase, the rate of farmland loss falls. Similarly, as expenses, population density, total housing, and percent unemployment increase, the rate of farmland loss accelerates. As can be seen in Figure 4, a county with a preferential taxation program has a rate of farmland loss almost 4% lower than one without a program. A metropolitan county has a rate of farmland loss that is 1% greater than a rural county.

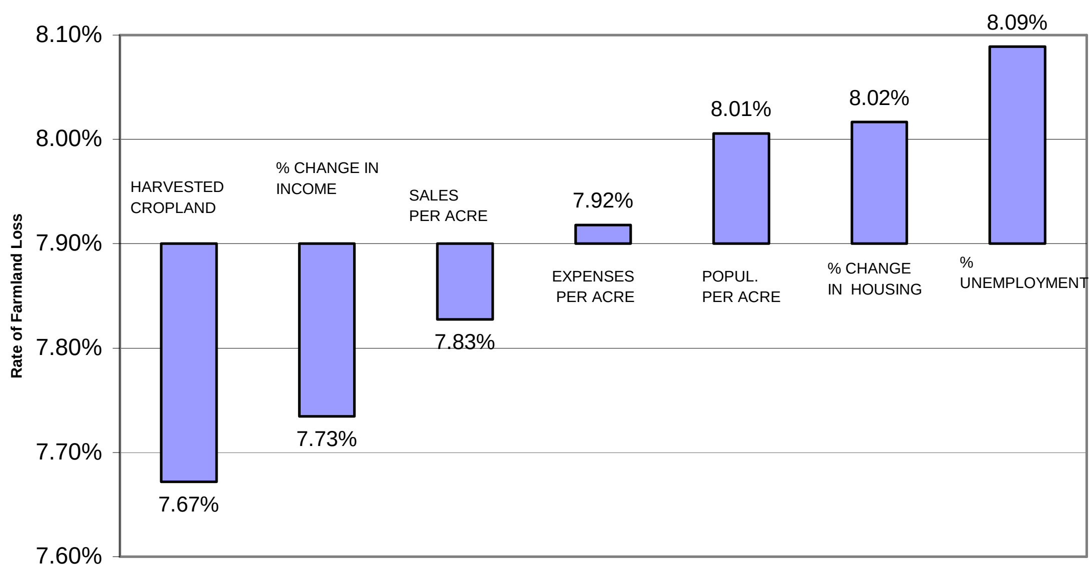


Figure 3. Change in the 5-year Rate of Farmland Loss for a 10% Increase in Variable

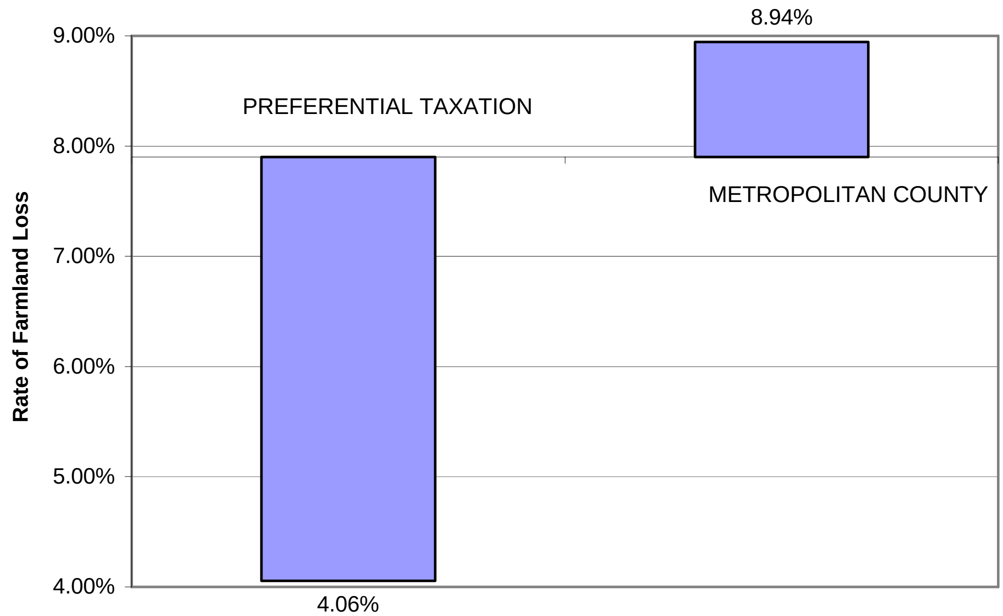


Figure 4. Change in the 5-year Rate of Farmland Loss due to Preferential Taxation Programs and Being a Metro County

Because development pressure often results in farmland loss, we took this element into account. An agricultural landowner may decide to sell his land because a developer offers a price greater than the discounted value of the net agricultural returns, i.e. the value of what the farmer expects to earn over the lifetime of the farm. If conversion for development is the explanation, the rate of farmland loss may have less to do with a critical mass of farmland acres and more to do with the disparity in value between land in a developed use and in an agricultural use.[13] Landowners will consider the relative difference between the agricultural value and the possible development value when making land-use decisions. Landowners may also find relatively higher returns from

[13] Development pressure and the resulting land conversions may result in a county dropping below a critical mass of acres. The question though is whether there is a threshold level below which the rate of loss increases, assuming that the development pressure is constant.

converting the land to a forest use and will exit agriculture for this reason. Thus we include information on the agricultural value over time (per acre sales and per acre expenses) and information on elements that would affect the value of the land for alternative uses.

Results indicate that as sales per acre decrease and expenses per acre increase, the rate of farmland loss will increase. We find this result in all Model 1s (1a-c). Thus one can say that as the net returns to agriculture decrease in a county, the county will lose farmland at a quicker rate. The average sales per acre were $549 and the average expenses were $332. For Model 1a, if sales increased by 10% ($55 per acre), the rate of farmland loss decreased from the predicted 7.9% to 7.83%. If expenses increased by 10% ($33 per acre), the rate of farmland loss increased from 7.9% to 7.92%. Thus the same percentage change in sales per acre appears to have a bigger impact on farmland loss compared to expenses per acre. The results of Model 1b indicate a slightly greater effect of an increase in sales, and of Model 1c a slightly lower effect.

The variables included to represent development pressure also explained some of the farmland loss. If population per acre increases by 10% (the average population per acre was 0.56), the rate of farmland loss increased from 7.9% to 8.0%. Similarly, the percent change in housing units in the county impacted the farmland loss rate. As housing units grew by 10%, the farmland loss increased from 7.9% to 8.02%. We found that being in a metropolitan area also increased the rate of change. The rate of farmland loss was higher in metropolitan areas increasing from 7.9% to 8.9%, assuming all else remains equal.

Interestingly, we find that an increase in the median family income decreased farmland loss. As incomes grew 10%, the rate of farmland loss decreased from 7.9% to 7.73%. This could be a function of better off-farm employment opportunities or people with higher incomes choosing to purchase a farm and keep farming the land. If the unemployment rate in the county was high, farmland loss rate increased. For example, if the percent of unemployment increased by 10%, the rate of farmland loss increased from 7.9% to 8.09%. Farmers in counties with high unemployment may have had fewer off-farm opportunities for themselves or family members and sold the farm. Another explanation is that in counties with depressed economies and high unemployment, the support industries exited the area, raising costs for agricultural production.

We also found that states and counties with a preferential property tax assessment for agricultural landowners experienced slower farmland loss. Counties where preferential taxation existed had a farmland loss rate almost 4% lower than counties without it – 4.01% compared to 7.9%. All of these preferential taxation programs were enacted between 1956 and 1978. However, having a preservation program (purchase of development rights, transfer of development rights, or purchase of agricultural conservation easements) did not impact the rate of farmland loss. Few of these programs existed before the 1980s, and some of them have not had the resources to preserve many acres. It is possible that farmland preservation programs will have more of an impact in the future.

As mentioned above, over this 50-year time-span many changes in both agriculture and the pattern of city and housing development have occurred. Therefore, we examine whether these variables' impacts were consistent over two time periods: 1949-1978 (Model 3a) and 1978-1997 (Model 3b). We found that while the results were remarkably similar to those reported above for Model 1 for the earlier time period, they diverged in the later time period (Table 6). Surprisingly and contrary to public perception, the rate of farmland loss has decreased since the early 1970s. For example, between 1949 and 1974, over 56,000 farmland acres were lost each year in Maryland, while the acreage lost since 1974 has averaged only 21,000 acres per year. The 5-year rate of farmland loss for the six states between 1949 and 1979 was 9.19%, and between 1979 and 1997 was 5.13%.

The critical mass threshold in the early period (Model 3a) was estimated to be 180,795 harvested cropland acres similar to the threshold of 189,240 harvested acres in Model 1a. If harvested cropland acres increased by 10%, the 5-year percentage loss decreased from the Model 3a predicted 10.2% to 9.82%. If sales increased by 10%, ($55 per acre), the rate of farmland loss decreased from 10.2% to 9.99%, compared to a slightly smaller impact in Model 1a. If expenses increased by 10%, the rate of farmland loss increased from 10.2% to 10.25%. A change in sales and expenses had a larger impact on farmland conversion in this earlier period than in the later period. Many of the other variables estimated in this earlier period had the same impact as reported above for Model 1a.

We do not find a critical mass threshold in the later years (1978-1997). The level of harvested cropland acres has no effect on the rate of farmland loss. One hypothesis for this is that the changes in agriculture and development patterns have altered the impact of this critical mass variable. This model does not include any direct measures of changes in these patterns therefore we cannot directly test this hypothesis. It could be that farmers have shifted to alternative crops, have found alternative marketing mechanisms (such as direct marketing rather than depending on processing plants), or have begun using alternative distribution channels such as making purchases on the Internet or using delivery services to obtain their input needs. Additional investigation of what exactly are the strategies that have allowed counties to lower their rate of farmland loss is warranted.

Model 3b again indicates that an increase in population density per acre increases the rate of farmland loss. The surprising result in Model 3b is that an increase in the dollar value of sales per acre actually increases farmland loss and that an increase in expenses per acre decreases the loss rate. A 10% increase in the dollar value of sales per acre increases the farmland loss rate from Model 3b's 5-year predicted value of 5.01% to 5.10%, and a 10% increase in expenses per acre decreases the rate of loss from 5.01% to 4.91%. We hypothesize that those farmers who respond to changing signals and adopt new technology and purchase more high-value inputs (higher costs) in order to increase yields are those most likely to stay on the land. One would also expect these farmers to have higher sales value. If one assumes that only the most marginal land is going out of production and only the most productive and adaptive farmers remain in production, the average sales per acre for the county would increase. Thus our result on the sales per acre suggests that where all the marginal land goes out of production and sales per acre increase, one could see an increase in sales per acre accompanied by an increased rate of farmland loss.

We also examined whether a significant difference between rural and metropolitan counties exists in the critical mass threshold. Models 4a-c were estimated (Table 7). In both metropolitan and rural counties, we find that having fewer harvested cropland acres increases the rate of farmland loss. The threshold or critical mass needed in the rural counties is 147,600 acres of harvested cropland. No "threshold" exists in the metro counties, but an increase in harvested cropland acres of 10% acres decreased farmland loss from the 5-year predicted value in Model 4a of 10.23% to 9.98%. In the transition counties, which moved from a rural designation in 1950 to become part of a metropolitan area by 1990, the number of harvested acres had no effect on the rate of farmland loss. The variables that impacted farmland loss in these transition counties were the percent change in number of houses built and the presence of a farmland preservation program. Having a preservation program in these transition counties decreased farmland loss from the 5-year predicted value of 7.43% to 4.48%. In both metro and rural counties, development pressure (population per acre) and agricultural variables (sales per acre) affected the rate of farmland loss. We also find that having a preferential property tax program slowed the 5-year rate of loss in metro counties from 10.23% to 0.4%, and in rural counties from an average of 7.59% to 3.64%. Preferential property tax programs have the biggest impact in metro counties where the difference between highest and best use value for property tax purposes and agricultural value is the largest.

In the Maryland-only model (5), we find that a county with fewer harvested cropland acres was likely to lose farmland at a faster rate but that no threshold level existed (Table 8).[14] As the harvested cropland acres increase 10%, the 5-year rate of farmland loss decreased from the Model 5 predicted rate of 6.61% to 6.26%. The lower the percentage of people in the county employed in resource industries, the higher the rate of farmland loss. As this variable increased by 10%, the rate of farmland loss decreased from 6.61% to 5.21%. As the population per acre increased by 10%, the rate of loss increased to 7.22%; as the rate of house building increased by 10%, the rate of farmland loss increased to 8.75%.

Loss of Farms

We find many of the same results for the rate of farm loss as for farmland loss, but differences in the effects of certain variables do exist. Looking at the rate of decrease in the number of farms, we find no critical mass of harvested cropland acres, farmland acres, or sales (Table 9). While no "threshold" exists, the higher the number of farmland acres, the lower the loss of farm numbers will be. If a county has 10% more harvested cropland acres, the 5-year rate of farm loss decreases from a predicted rate of 12.07% to 11.89%. Model 2 with the level of farmland acres represented by categorical variables

[14] We also estimated a model using the binary variables of levels of acres in each Maryland county as described above. This analysis also found no threshold level. The estimated coefficients for this model are not reported here.

was also estimated. The results for rate of farm loss are similar to Model 2 for rate of farmland loss (Table 10). Counties with less than 200,000 acres had a 2-3% higher rate of losing their farms than counties with more than 250,000 acres. Compared to the 5-year predicted rate of loss of 12.07% per county, the counties with fewer farmland acres lost farms at a rate of 13.67% to 14.7%.

Many of the same factors explain the rate of farm loss that explained the rate of farmland loss including: harvested cropland, resource based employment, sales per acre, expenses per acre, population per acre, percent of unemployment, percent of the county population with a high school education, percent change in median family income, and percent change in housing units. Figure 5 shows the relative change in the 5-year rate of farm loss estimated for a 10% change computed at the mean of these variables. As harvested cropland, sales, resource based employment, education, and income increase, the rate of farm loss falls. Similarly, as expenses, population density, total housing, and percent unemployment increase, the rate of farmland loss accelerates. As can be seen in Figure 6, a county with a preferential taxation program has a 5-year rate of farm loss of 9.08% compared to the predicted 12.07% and a county with a preservation program has a rate of 9.76%. A metropolitan county has a rate of loss of 12.76% compared to the predicted farm loss rate of 12.07%.

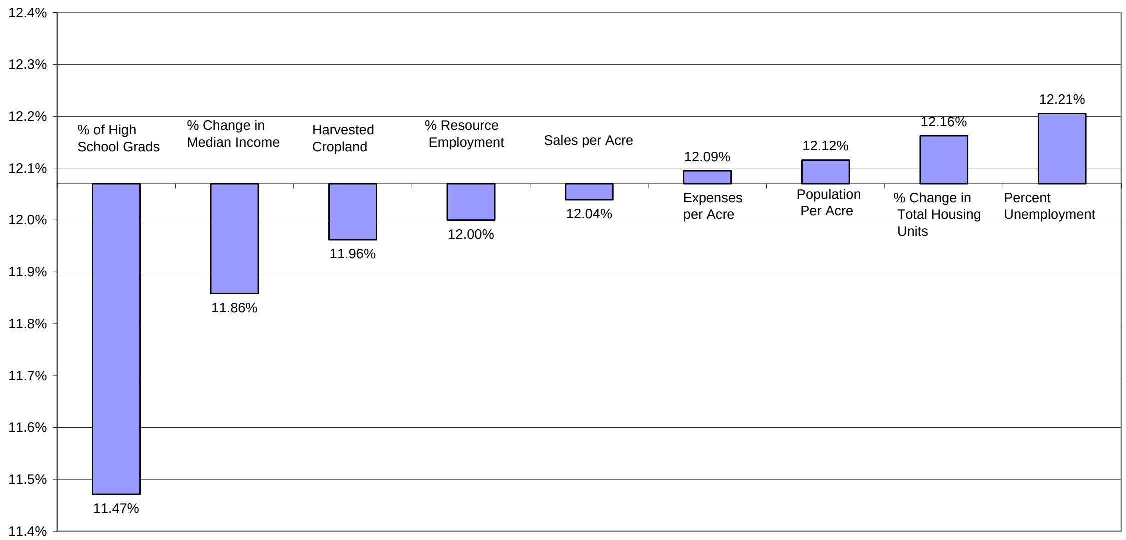


Figure 5. Change in the Rate of Farm Loss for a 10% Increase in Variable

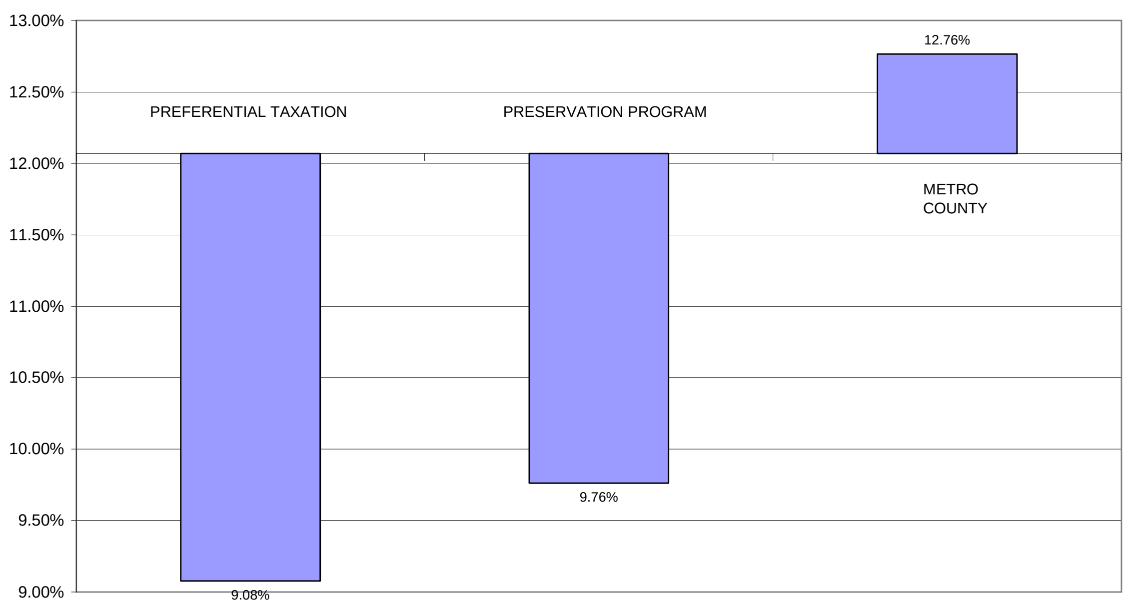


Figure 6. Change in the Rate of Farm Loss due to Having a Preferential Taxation Programs, Preservation Programs and Being a Metro County

The percent of employment in resource-based sectors was also included as a critical mass variable. A high rate of such employment was expected to decrease the rate of farmland and farm loss. With regard to the farmland loss rate, we found that a decrease in the percent of employment in these sectors increased farmland loss only in the rural counties and in Maryland. However, this variable appeared to affect the rate of farm loss more frequently. A decrease in resource-based employment increased the loss of farms in Models 1a-c. If the average percent of resource-based employment increased by 10%, the 5-year rate of farm loss decreased from the predicted 12.07% to 12.00%.

As with farmland, we found that as sales per acre increase, the rate of farm loss will decrease, and as the expenses per acre increase, the rate of farm loss will increase. This is true for all Models 1s (1a, 1b, 1c). Thus, one can say as the net returns to agriculture decrease in a county, the county will lose farms at a quicker rate. The average sales per acre were $549 and the average expenses were $332. If sales increased by 10%, the 5 year rate of farm loss decreased from Model 1a predicted rate of 12.07% to 12.04%. If expenses increased by 10%, the rate of farm loss increased from 12.07% to 12.09%. The effect of sales and expenses on farm numbers is smaller than on farmland loss. And unlike with farmland loss, a change in sales per acre appears to have the same impact on farm numbers compared to expenses per acre. One could see this as a positive result: lower net returns will not accelerate farm loss dramatically; or as a negative result: even if net returns increase; the impact on the rate of farm loss will be small.

An increase in population per acre also increases the rate of farm loss, just as it increases farmland loss. If population per acre increased by 10%, the rate of farm loss increased from 12.07% to 12.12%. Similarly, the percent change in housing units in the county impacted the farm loss rate. As the percent of housing units increased by 10 percent, the 5-year rate of farm loss increased from 12.07% to 12.16%. We found that being in a metropolitan area also increased the rate of change, but with a slightly lower impact than on farmland loss. The rate of farm loss was 12.76% in metropolitan areas compared to the predicted rate of 12.07% for all counties.

Similar to farmland loss, we find that an increase in median family income decreased the rate of farm loss. The effect of income is even larger on the rate of farm loss than on farmland loss. This could be a function of better off-farm employment opportunities or people with higher incomes choosing to purchase farms and keep them in production. A 10 percent increase in the median family income decreases the 5-year rate of farm loss from 12.07% to 11.86%. Farms were lost at a higher rate if the unemployment rate in the county was high. If unemployment rate increased by 10%, the rate of farm loss increased from 12.07% to 12.21%. In such cases, farmers may have had fewer off-farm opportunities and sold the farm. Unlike in the farmland loss models, education affected the rate of farm loss. If the percent of the county's population had a high school education increased by 10%, the rate of farm loss decreased from 12.07% to 11.47%.

We found that having a preferential property tax assessment for agricultural landowners also resulted in lower rate of farm loss. Counties where preferential taxation existed had a 5 year farm loss rate of 9.08% compared to the predicted rate of 12.07%. Similarly, having a preservation program (purchase of development rights, transfer of development rights, or purchase of agricultural conservation easements) resulted in a lower percent of farms lost. Counties with these programs had a rate of farm loss of 9.76%. Thus, we find that preservation programs are saving farms, although the results on saving farmland are mixed. We found that preservation programs have an impact on rate of loss of farmland acres only in the transition counties Model 4b.

The models for the two time periods were also estimated to determine if these variables' impacts were consistent over time: 1949-1978 (Model 3a) and 1978-1997 (Model 3b). We found that while the results were remarkably similar to those reported above for Model 1 for the earlier time period, they diverged in the later years (Table 11). In the earlier period, no critical mass threshold for farm numbers was found, although a decrease in the number of harvested crop acres did increase the rate of farm loss. A decrease in the percent of the county population that worked in resource-based sectors also increased farm loss. Sales and expenses per acre had slightly larger impacts in the early period. If sales increased by 10%, the 5-year rate of farm loss decreased from the predicted rate in Model 3a of 16.23% to 16.27%. If expenses increased by 10%, the rate of farm loss increased from 16.23% to 16.27%. In Model 3a, being in a metropolitan area had a bigger impact in the earlier period than in Model 1a, increasing the rate of farm loss from 16.23% to 18.30%. Similarly, as the percent of unemployment increased by 10%, the percentage of farms lost increased to 16.47%, a higher loss rate than in the more general Model 1a. Interestingly, the existence of a preferential tax program had no effect on the farm loss rate in this early period. Many of the other variables estimated in this early period had the same magnitude of impact as they did in Model 1a.

We do not find a critical mass threshold in the later years. In fact, as harvested cropland decreases, the rate of farm loss decreases as well. Changes in agriculture and development patterns have altered the impact of many variables on the number of farms lost. As a whole, Model 3b did not explain well what is impacting the loss of farms. We do find that in this later period increases in population density per acre continued to increase the rate of farm loss. We also find that counties with agricultural preservation programs lose a smaller percentage of farms. The predicted 5-year farm loss rate during this later period was 6.13%. Counties with preservation programs lost farms at a rate of 2.32%. Given that all counties had a preferential taxation program by this time, we could not assess the existence of a differential rate for this type of program in the later years.

We also examined whether there is a significant difference between rural and metropolitan counties in terms of farm loss. Estimating Models 4a-c, we find that having fewer harvested cropland acres increases the rate of farm loss only in rural counties (Table 12). There is no “threshold” in these rural counties, but a 10% increase in harvested acres decreased the 5-year rate of farm loss from 12.17% to 12.08%. In both the metro and transitional counties, the number of harvested acres had no effect on the rate of farm loss. However, in both metro and transitional counties the percentage of county population employed in resource-based industries did impact the rate at which farms were lost – as resource-based employment decreased, the rate of farm loss increased. Sales and expenses per acre were also important determinants. As sales per acre increased, fewer farms were lost. As expenses per acre increased, more farms were lost. (Sales and expenses in metro counties averaged $1,386 and $893 per acre, respectively.) Sales and expenses were not significant in the rural counties in determining farm numbers (average sales per acre were $290 and average expenses $161). In the metro counties, increases in population per acre resulted in a higher rate of farm loss. We find that as transitional counties became metropolitan, their rate of farm loss increased. In the metro counties, having a farmland preservation program decreased the 5-year farm loss rate from 13.00% to 8.28%; the existence of a preferential taxation program in metro and transitional counties, however, had no influence on farm loss rate. Too few preservation programs existed in rural areas to determine whether they had an impact. We do find that reduced property tax programs decrease the loss of farms in rural counties from 12.17% to 8.10%. Development pressure (population per acre, metro status) and agricultural variables (sales per acre) affected the rate of farm loss in metro and transitional counties. While in rural counties, it was the level of harvested cropland and demographics such as income, housing value, and employment level that affected farm loss.

In the Maryland-only model (5), we did not find that counties with fewer harvested cropland acres were more likely to lose farms at a faster rate (Table 13). However, the lower the percentage of people employed in resource industries, the higher the rate of farm loss. As more people enter the county and take non-resource-based jobs, the percent of people in agriculture decreases and the number of farms drops quickly. Thus while the results do not indicate that number of harvested acres explains farm loss, the predominance of resource-based employment for a county's population certainly seems to be important in preserving farms in an area. Farmers could be finding off-farm jobs to replace their occupation as farmers rather than just as supplementary income. Surprisingly, being in a metropolitan county slowed the rate of farm loss. This would imply either that farmers are able to supplement their farm income and thus stay on the farm or that people buying farms for housing purposes continue to farm the land as well. As the rate of house building increased, the rate of farm loss also increased.

III Conclusion from Critical Mass Analysis

We collected agricultural and population census information on 269 counties in 6 Mid-Atlantic states - Delaware, Maryland, New York, New Jersey, Pennsylvania, and Virginia - for the period of 1949 to 1997. The rate of farmland and farm conversion was computed for 5-year periods. The average 5-year rate of farmland conversion was 7.6%; Maryland had an average rate of farmland loss of 6.57%. However, the biggest 5-year rates of farmland loss for the six states occurred between 1949 and 1974, the period for which farmland acres were actually at their highest. Eighty percent of the farmland that was removed from farming between 1949 and 1997 was lost before 1974. In addition, we find that the rate of farmland loss is greater than the rate of harvested cropland loss. Thus, it is likely that the most marginal land in a county is being converted to housing or forest or idled first.

Land is converted if the relative profitability of the farm sector decreases relative to other farm regions or to forestry, if farmers and farm families can earn more off the farm than on, and/or if the demand and thus price for land for residential or commercial uses increases. Therefore, we include a range of variables to account for the trends in these levels. For example, to examine the profitability of the agricultural sectors, we include the average sales and expenses per acre on the farms. The number of harvested cropland acres acts as our critical mass variables to test whether the existence and viability of the agricultural support sector is affected by the agricultural activity. Because not all farms use the same set of input and output firms, we group them by crop reporting districts, which share similar cropping patterns.

Alternative income opportunities are included using the percent of unemployment in the county, the median family income, and the percent of the population that has finished high school as an indicator of educational attainment. Given that the question we are posing was whether there is a critical mass of land necessary to keep agricultural viable, we wanted to isolate the effects of an increase in demand for land for housing from the impact of the level of farm acreage on agricultural viability. Therefore, we included the percent change in population density, the percent change in the number of housing units, and the percent change in median housing values as development pressure indicators.

We find that in the general model for all counties in all time periods there is a critical mass of harvested cropland acres of 189,240 acres per county. Once a county falls below that number, the rate of farmland loss is higher. We also find that if counties fall below $438 million in sales they experience an increased rate of farmland loss. To further investigate farmland effects on farmland conversion, we create discrete measures of number of farmland acres for each county. We find that if a county has less than 50,000 acres of farmland, it will have a rate of farmland loss greater than those with more than 250,000 acre. Counties with less than 50,000 acres had a 5-year rate of farmland loss of 11.8% as compared to the average rate of loss of 7.85%. Counties having between 50,000 and 150,000 acres had a rate of farmland loss of 9.4% to 9.9%. Counties with between 150,000 and 250,000 acres had a rate of farmland loss that was not statistically different from counties with more than 250,000 acres. In addition to acreage, the health of the local economy as measured by the rate of unemployment and median income impacts the rate of farmland loss.

However, these results must be viewed with caution. Given the changes in agricultural technology and trade patterns during this 50-year period, we also estimate a model (3b) for the later period -- 1978 to 1997. By the early 1980s, all counties had instituted preferential taxation programs for agriculture and some were implementing farmland preservation programs. For this later time period, we do not find that the level of harvested cropland acres had a statistically significant impact on the rate of farmland loss. The data also indicate that the rate of farmland loss has decreased since the early 1970s. For example, between 1949 and 1974, 56,000 farmland acres were lost each year in Maryland, while since 1974 the rate of loss has been only 21,000 acres per year. The 5-year rate of farmland loss for the six states between 1949 and 1979 was 9.19%, and between 1979 and 1997 it was 5.13%.

Changes in agriculture and development patterns have apparently altered the impact of this critical mass variable. It could be that farmers have shifted to alternative crops, have found alternative marketing mechanisms (such as direct marketing rather than depending on processing plants), or have begun using alternative distribution channels such as making purchases on the Internet or using delivery services to obtain their input needs. Efforts to support and encourage these adjustments may facilitate farmers' transition and success.

We found that many factors explain the rate of farmland loss including sales per acre, expenses per acre, population per acre, percent of unemployment, percent change in median family housing and percent change in housing units. As harvested cropland, sales, and income increase, the rate of farmland loss falls. Similarly, as expenses, population density, total housing units, and percent unemployment increase, the rate of farmland loss accelerates. A county with a preferential taxation program has a rate of farmland loss almost 4% lower than a county without one. A county in a metropolitan area has a rate of farmland loss one percent higher than a non-metropolitan county.

Similar factors explain the rate at which farms are lost including number of harvested cropland acres, sales per acre, expenses per acre, population per acre, percent of unemployment, percent change in median family income and percent change in housing units. As harvested cropland, sales, median income and educational level increase, the rate of farm loss falls. Similarly, as expenses, population density, total housing units, and percent unemployment increase, the rate of farm loss accelerates. In addition, if resource-based employment decreases, more farms exit the county. The 5-year rate at which farms leave a county which has a preferential taxation program is almost 2.6% lower than in counties without one, and if the county has an agricultural preservation program, 1.7% lower. Being in a metropolitan area, however increases a county's 5-year rate of farm loss by almost 1%. Counties with less than 200,000 acres had a 2-3% higher rate of losing their farms than counties with more than 250,000 acres. Compared to the predicted 5-year rate of farm loss of 12.07% per county, counties with fewer farmland acres lost farms at a rate of 13.67% to 14.7%.

We conclude that the relative profitability of the agricultural enterprise affected how quickly farmland and farms converted in the county. Therefore, as would seem obvious, programs that increase farm profitability would be one mechanism to stem farmland loss. The health of the local economy also played a role in both farmland and farm conversion. Many farm families use off-farm employment to supplement farm income, so employment opportunities must be available in the surrounding region. As the percent of the county population unemployed increased, more farmland was shifted out of agriculture. Similarly, local economic conditions such as a decrease in family median income increased farmland loss. Thus, policies that focus attention on the entire region's economic performance would promote farmland retention.

Higher levels of demand for land for housing and commercial purposes resulted in higher rates of farmland loss. Both the increases in the number of people per acre and the number of housing units increased farmland loss. Local communities can affect both the number of houses built and the pattern of the construction. Given the Chesapeake Bay Foundation's finding that the rate at which land is being consumed exceeds the population growth rate by almost 2.5 times, designing polices that focus on reducing land consumption may be the optimal strategy to limiting the impacts of both population growth and housing development. Being in a metropolitan area did increase the rate of growth; thus these counties may need to be even more active in implementing policies and programs to encourage farmland retention and to strengthen the agricultural economy in the area. We also found that the introduction of a preferential taxation program slowed the loss of farmland. While all the farms in this study area now have or had the ability to join a preferential taxation program, a re-evaluation of these programs may be warranted as well as an examination of who participates (if participation is voluntary) and who does not. Perhaps an enhancement of these programs would be a worthwhile endeavor. Enhancement could potentially be financed through a higher tax rate to recapture some of the benefits farmers accrued from the preferential tax program when landowners choose to convert the land from agriculture to a non-farm use.

We also examined the impact of the county having an agricultural land preservation program. We found that these programs did not impact the rate of farmland conversion although they slowed the rate at which farms were lost. Most of these programs were introduced after the late 1970s and some face financial constraints and thus haven't been able to preserve many acres. Therefore, it is possible the impact of these programs could be greater as more time elapses.

The concept of a critical mass is intuitively appealing. Economically, it is plausible that a region would need a foundation or a sufficient activity in a sector to achieve relative profitability. We see this is the agglomeration of firms in the computer industry in Silicon Valley as well as elsewhere. Thus one could hypothesize that the agricultural sector in a region would become relatively less profitable as its base diminishes. Our findings suggest that while the number of farmland and harvested cropland acres affects the rate of farmland loss, there is not a statistically determinable "threshold" that has maintained over the last 50 years. Nor does all farmland that has been converted shifting into housing or commercial use. We hypothesize that some of the earlier loss of farmland (1949-1978) resulted from a shift to forest or recreational use.

Because our results suggest that the higher the number of harvested cropland acres the lower the rate of farmland loss, programs to preserve or support agriculture may accomplish the most by targeting at regions where high levels of farmland still exist. These programs may consider that why agricultural profitability is important; improvements in the economy of the whole region may help strengthen the farm sector. On the other hand, many metropolitan counties farmers who have adjusted to the changing agricultural sector in their region and taken advantage of new situations appear to be surviving and flourishing.

Background Information on Agricultural and Urban Trends in the Last 50 years

IV. Agricultural Trends in the Mid-Atlantic

The Mid-Atlantic States of Delaware, Maryland, New Jersey, New York, Pennsylvania and Virginia together accounted for over 26 million acres of farmland in 1997, or 3% of the U.S. total. Higher than average sales per acre mean that the region accounts for a larger portion of total agricultural sales, with nearly $12 billion total sales, or 6% of the U.S. total. The average farm size for the region was less than half the size of the national average, 185 acres compared to 487 acres. The region is more reliant on livestock, deriving nearly two-thirds of total sales from livestock, compared to about half of the U.S. total sales. Dairy is the predominant type of agriculture in much of New York and Pennsylvania and portions of Maryland, while poultry is dominant in areas of Delaware, Maryland, Virginia and Pennsylvania. However, other types of agriculture dominate in some smaller regions, such as hogs in some parts of Pennsylvania, fruits and vegetables in southern New Jersey, tobacco in southern Virginia or nursery crops in the areas of New Jersey and New York State closest to New York City. The six states comprise 269 counties[15]. USDA defines crop-reporting districts, which are similar in geography and soil type. Appendix A contains a map with the six-state study area divided into crop production regions.

[15] The number of "counties" as calculated for this study is 269, however, this includes some independent cities. Also, in several cases, due to either aggregation in data, or actual boundary changes during the study period, counties and/or independent cities have been combined for this analysis. Further explanation of these aggregations is given in Appendix A.

Number of Farms, Land in Farms and Average Farm Size

In the past one hundred years, the U.S. has experienced divergent trends in the number of farms and farmland, as the number of farms has generally been in decline since 1920, but total farmland continued to increase until 1950, after which time it began to decline. The total number of farms in the U.S. was 5.7 million at the turn of the century, rising to 6.5 million by 1920. Farm numbers continued to increase gradually until the mid-1930's, after which time the number of farms began to decline. Between 1950 and 1970, the total number of farms in the U.S. declined by nearly half. Between 1970 and 1990, the rate of decline slowed. Since 1990, USDA estimates a slight increase in the number of farms (Gardner 2002). There were 2.2 million farms in the U.S. in 2000 (USDA NASS 2001)

In contrast to the general decline in farm numbers over the past century due in part to the consolidation and larger acreages per farm, total farmland in the U.S. has increased over the same time period. Total farmland in the U.S. increased by nearly 100 million acres between 1900 and 2000, to end at 943 million acres in 2000 (Gardner 2002; USDA NASS 2001). Total farmland increased until it reached its peak in 1950, at over 1.2 billion acres. Since then, the total has declined by almost 25% (Gardner 2002).

The Mid-Atlantic States have experienced different trends in farms and farmland over the past century, with dramatic declines in both. Since 1910, the number of farms in the Mid-Atlantic States has declined by 80%, while total farmland declined at a somewhat slower but still large rate of 62%. Average farm size in the Mid-Atlantic increased from 97 acres in 1910 to 185 in 1997.

The Mid-Atlantic has lost farms and farmland at a faster rate than the U.S. in general. Between 1949 and 1997, the U.S. lost 65% of its farms, while the Mid-Atlantic lost 71% (Figure 1). The difference is more pronounced in terms of acreage. While the U.S. experienced a 20% decrease in the amount of land in farms from 1949 to 1997, the Mid-Atlantic region experienced a 50% decrease (Figure 2). Cropland has also decreased more rapidly in the Mid-Atlantic, 36% compared to 10% for the U.S. (Figure 3). Mid-Atlantic farms are smaller compared to the U.S. average. The U.S. average farm size was 487 acres in 1997. In the Mid-Atlantic, farms are less than half the size at 185 acres on average (Figure 4). Farm size has increased more slowly in the Mid-Atlantic than in the U.S. as a whole. Figure 5 demonstrates the changes in farmland acres and number of farms for the six Mid-Atlantic states.

The total number of farms in the six state study area decreased from nearly 500,000 in 1949 to 142,000 in 1997. In 1997, Pennsylvania had the most farms (45,457), followed by Virginia (41,095), New York (31,757), Maryland (12,054), New Jersey (9,101) and Delaware (2,460). Ninety percent of this decline occurred between 1949 and 1974. The decline between 1969 and 1974 is at least partially due to the change in farm definition between those census years, increasing the minimum sales requirement to qualify as a farm for census purposes. The total number of farms in the six states declined by over 33,000, or 16%, between 1969 and 1974. Across the six-states, the rate of loss of farms was relatively uniform, ranging from a 63% decrease in New York to a 73% decrease in Virginia. Between 1974 and 1978, the number of farms increased in all six states, after which time, the decreasing trend continued. Notable is the gain in the number of farms in New Jersey from 1982 to 1997, while all other states saw continual declines in farm numbers.

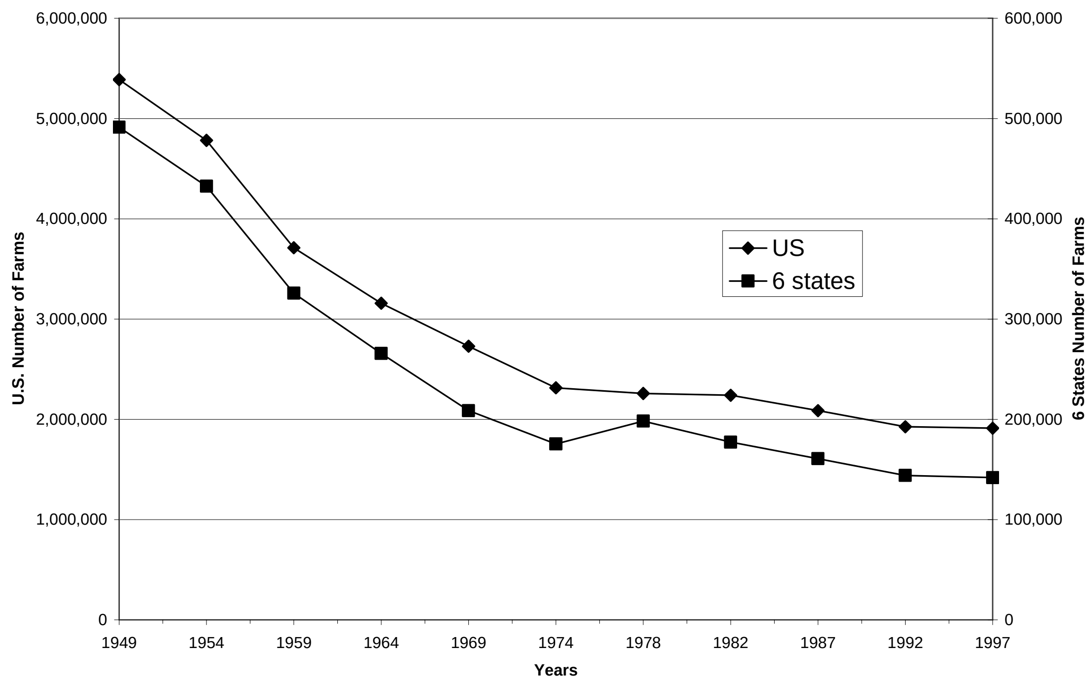


Figure 1. Number of Farms in the U.S. and in 6 Mid-Atlantic States from 1949 to 1997

Total farmland in the six states declined by 50% from 1949 to 1997, from 52 million acres to 26 million acres. By 1997, Virginia had the greatest area in farmland (8.2 million acres), followed by New York (7.3 million acres), Pennsylvania (7.2 million acres), Maryland (2.2 million acres), New Jersey (0.8 million acres) and Delaware (0.6 million acres). Similar to the decline in the number of farms, 80% of the decline in farmland occurred before 1974. The decrease in the amount of land in farms is less uniform across the six states. Delaware farmland decreased by only 32%, while New York farmland decreased by 55% from 1949 to 1997. Decreases were recorded for all states in all time periods, except from 1974 to 1978, when all states had increases.

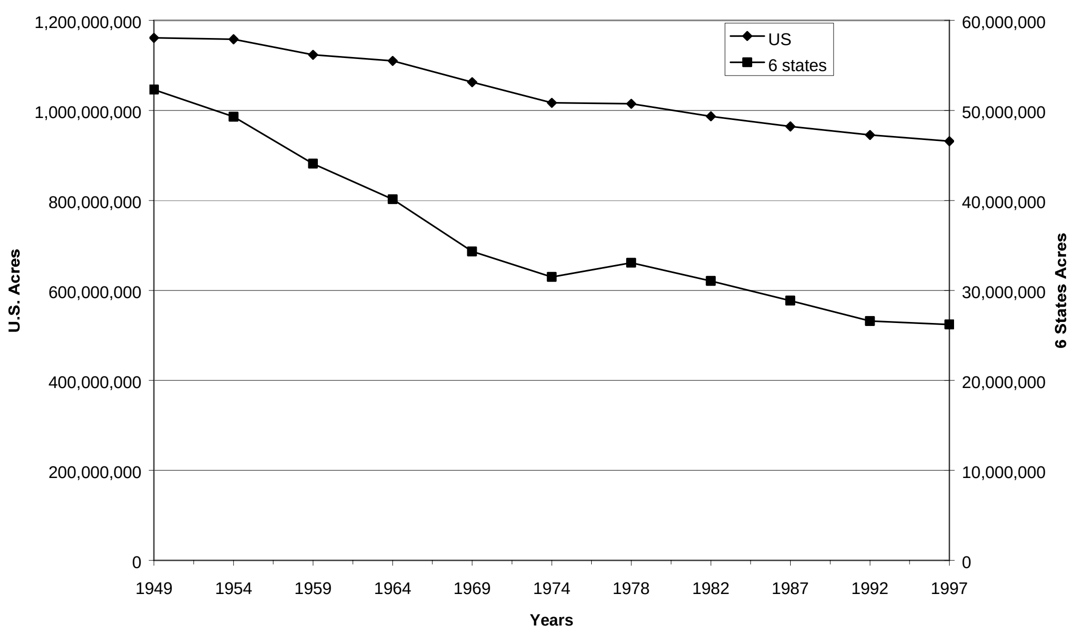


Figure 2. Number of Farmland Acres in the U.S. and in 6 Mid-Atlantic States from 1949 to 1997

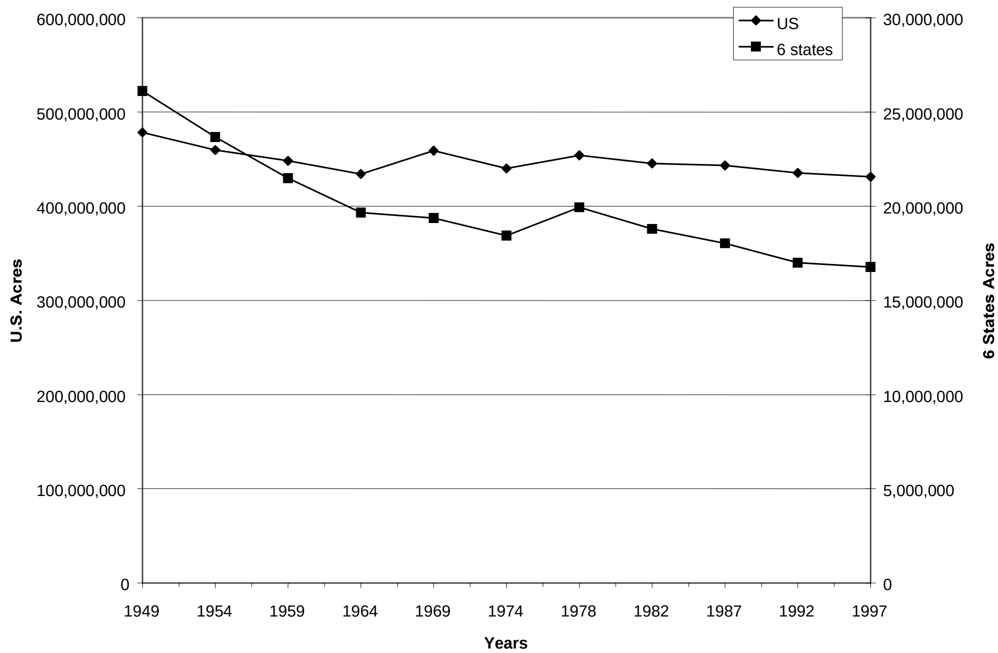


Figure 3. Number of Cropland Acres in the U.S. and in 6 Mid-Atlantic States from 1949 to 1997

Figure 4. Average Farm Size in the U.S. and in 6 Mid-Atlantic States from 1949 to 1997

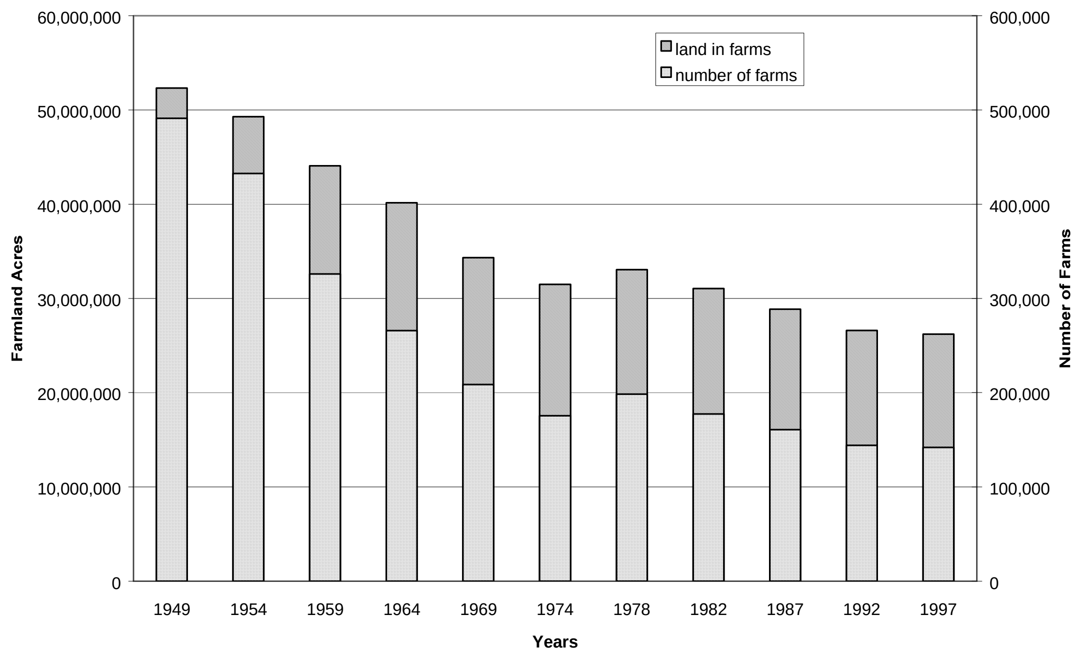


Figure 5. Farmland Acres and Number of Farms in 6 Mid-Atlantic States from 1949 to 1997

Average farm size has steadily increased, as the greater decline in number of farms than farmland would suggest. On average across the six states, average farm size increased from 106 acres to 185 acres. New Jersey has consistently had the smallest farms, averaging 70 acres in 1949 and 91 acres by 1997. Average farm size was greatest in New York, until 1997, when Delaware surpassed it. In 1949 the two states had average farm sizes of 114 acres and 128 acres for Delaware and New York, respectively. By 1997, New York had an average of 228 acres, and Delaware had an average farm size of 236 acres. Farm size decreased in all states but Delaware between 1974 and 1978. New Jersey also experienced declines in average farm size from 1982 to 1997.

The portion of farmland devoted to crops[16] has decreased less than the total land in farms. Overall, cropland decreased by 36% between 1949 and 1997. Delaware had the smallest decrease in cropland, of only 9%. The other states had decreases in total cropland between 25% and 45%. The proportion of cropland that was harvested has increased overall between 1949 and 1997, from 67% to 75%. The trend in proportion of cropland harvested was flat or increasing in all years in all states, apart from declines between 1964 and 1969, and again between 1982 and 1987. Delaware has the highest proportion of cropland harvested, 96% by 1997, and Virginia has the lowest portion of cropland harvested, 58% in 1997, only slightly higher than in 1949 when 57% of the total cropland area was harvested.

While still a small portion of total farmland, the amount of farmland under irrigation increased dramatically during the study period, by over six-fold. New Jersey has the most irrigated acreage, over 90,000 acres in 1997, accounting for 11% of total farmland acreage. Delaware has increased irrigated acreage by the highest proportion, from only 404 acres in 1949 to over 72,000 in 1997, and accounting for 13% of total farmland acreage. All other states had 3% or less of total farmland irrigated.

Vegetable acreage has declined by 43% through the study period across all six states. New York and New Jersey have the largest acreage devoted to vegetable production, though New Jersey and Delaware have the largest percentage of total

[16] Cropland includes land from which crops were harvested or hay was cut; land in orchards, citrus groves, vineyards, nurseries, and greenhouses; cropland used only for pasture or grazing; land in cover crops, legumes, and soil-improvement grasses; land on which all crops failed; land in cultivated summer fallow; and idle cropland.

farmland in vegetable production, at 12% and 10%, respectively. The other states have 4% or less of total farmland in vegetables.

Sales

Pennsylvania has highest total sales of agricultural products, followed by New York, Virginia, Maryland, New Jersey and Delaware. Gross sales of all agricultural products for the six state study area totaled $1.9 billion in 1949 and $11.9 billion in 1997. In real terms, this is only a slight change, accounting for a decrease of only 1%. Although this is a small change overall, individual states experienced much larger changes. New Jersey and New York each experienced substantial declines in total sales, of 27% and 47%, respectively. Total sales growth in the other four states ranged from 19% in Pennsylvania to 47% in Delaware. All states except New Jersey saw heightened total sales in 1974 and 1978, and generally higher sales through the period from 1974 to 1987.

With the large losses in farmland, these trends in sales indicate an overall increase in per acre sales (Figure 6). Indeed, by 1997, per acre sales were $453 on average across the six states, almost twice as large as in 1949. Most of this gain was realized by 1974, a year in which per acre sales were at peak levels for the study period, for Maryland, New Jersey, New York and Virginia and near peak levels for Delaware and Pennsylvania. Delaware has had the highest per acre sales since 1974, and in 1997, averaged over twice the overall average of the study area with farmers earning $1192/acre. New Jersey had the second highest per acre sales in 1997, at $838/acre. Per acre sales were somewhat varied across the other four states in 1997, Maryland had average sales of $609/acre, Pennsylvania had $558/acre, New York had $391 and Virginia had the lowest sales at $285/acre. Per acre sales growth between 1949 and 1997 was generally high across the region, between 116% and 134% for Delaware, Maryland, Pennsylvania and Virginia. New York's per acre sales growth was lower than the regional average at 61%, while New Jersey had by far the slowest growth, at only 9% from 1949 to 1997.

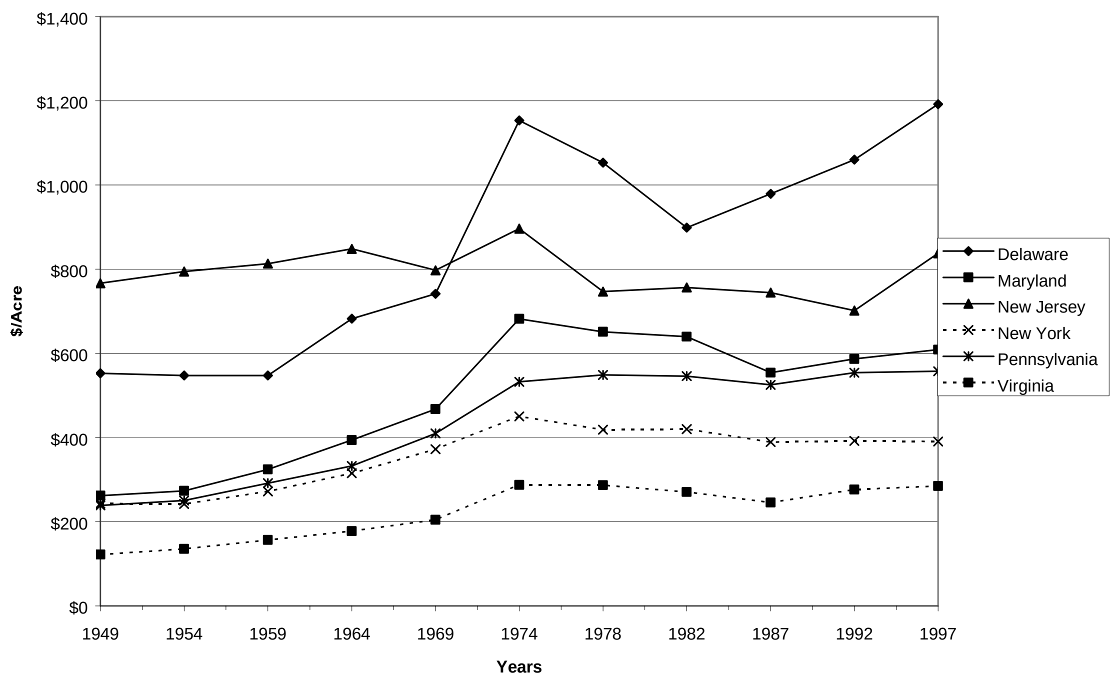


Figure 6. Sales Per Acre by State from 1949 to 1997

Type of Farming Operations

Apart from New Jersey, farming activities have been more or less uniformly divided between crops and livestock across the study area over the study period. The majority of sales are derived from livestock and livestock products (Figures 7, 8 and 9). At the state level, between 51% and 84% of sales have been derived from livestock and livestock products for all states besides New Jersey. This range narrowed to between 65% and 75% in 1997. New Jersey, however, has largely replaced its livestock operations with crop production, shifting from 35% of total sales from crops and nursery products in 1949 to 85% in 1997 (Figure 10). This is believed to be due to encroaching residential development in proximity to farms, and the resulting conflict over odors associated with livestock operations (Adelaja). New Jersey has consistently had the highest per acre value of sales from crops, excluding livestock sales, at nearly $1000/cropland acre in 1997. Delaware has the next highest per acre crop value at $359/acre, followed by Maryland, Pennsylvania, New York and Virginia. Per acre crop values peaked in 1974, at levels between 30% and 96% higher than 1969.

Dairy has traditionally been the dominant type of livestock operation in the region, accounting for roughly one third of total agricultural sales, primarily due to the large industries in New York and Pennsylvania. However, this dominance seems to be slipping slightly since 1982. New York has consistently derived over 50% its total agricultural sales from dairy products. Between one-third and 42% of Pennsylvania sales are from dairy. Maryland and New Jersey have experienced substantial declines in the dairy industries, from deriving around a quarter of total sales from dairy, to just 13% and 5% respectively. Delaware's dairy industry accounted for about 10% of total sales through the 1950's, declining to 3% in the 1990's. Virginia's industry has remained relatively stable between 12% and 17% of total sales, though a decline is apparent since 1987.

Poultry is the next largest livestock category for the region, with large industries in all states except New York and New Jersey, where the poultry industries have experienced major declines throughout the study period. The poultry industry in Virginia and Maryland, has grown remarkably over the past 50 years, by 174% in Virginia and 102% in Maryland, with most growth in Maryland occurring prior to 1978 and the majority of growth in Virginia occurring since 1969. Delaware agriculture is dominated by the poultry industry, which has accounted for 54% to 71% of the state's total agricultural sales since 1949. Delaware's industry has experienced a more modest level of growth, of 43%, between 1949 and 1997.

Cattle and calves are another major livestock category in the region, accounting for between 9% and 12% of total sales from 1949 to 1997. While the share of total sales comprised by cattle/calf operations exhibits no apparent trends, total sales peaked in 1978 for Pennsylvania, Virginia and New York, which have the largest industries.

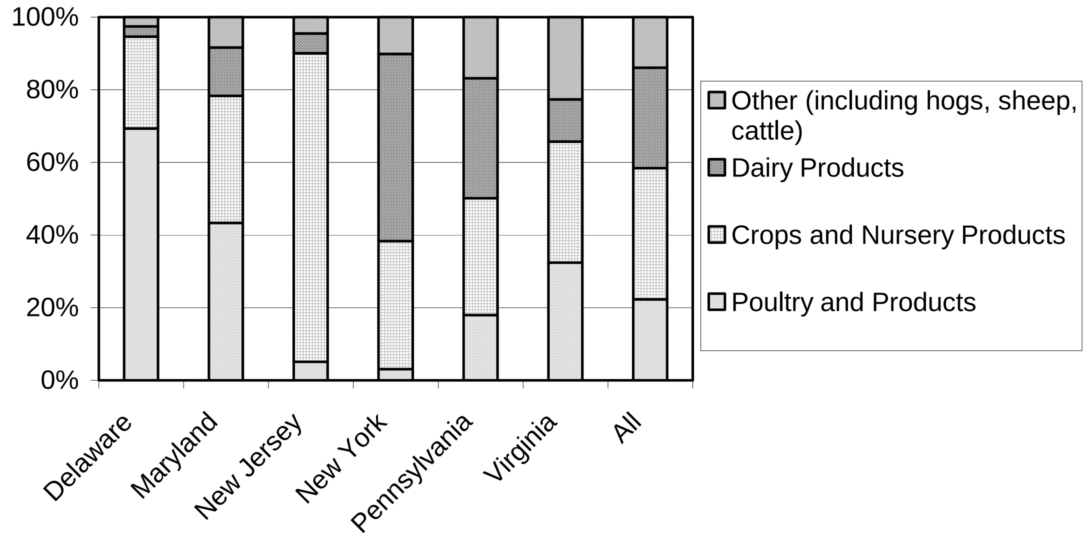


Figure 7. Distribution of Sales Sources by Crop Type by State in 1997

Figure 8. Largest Income Category in 1949

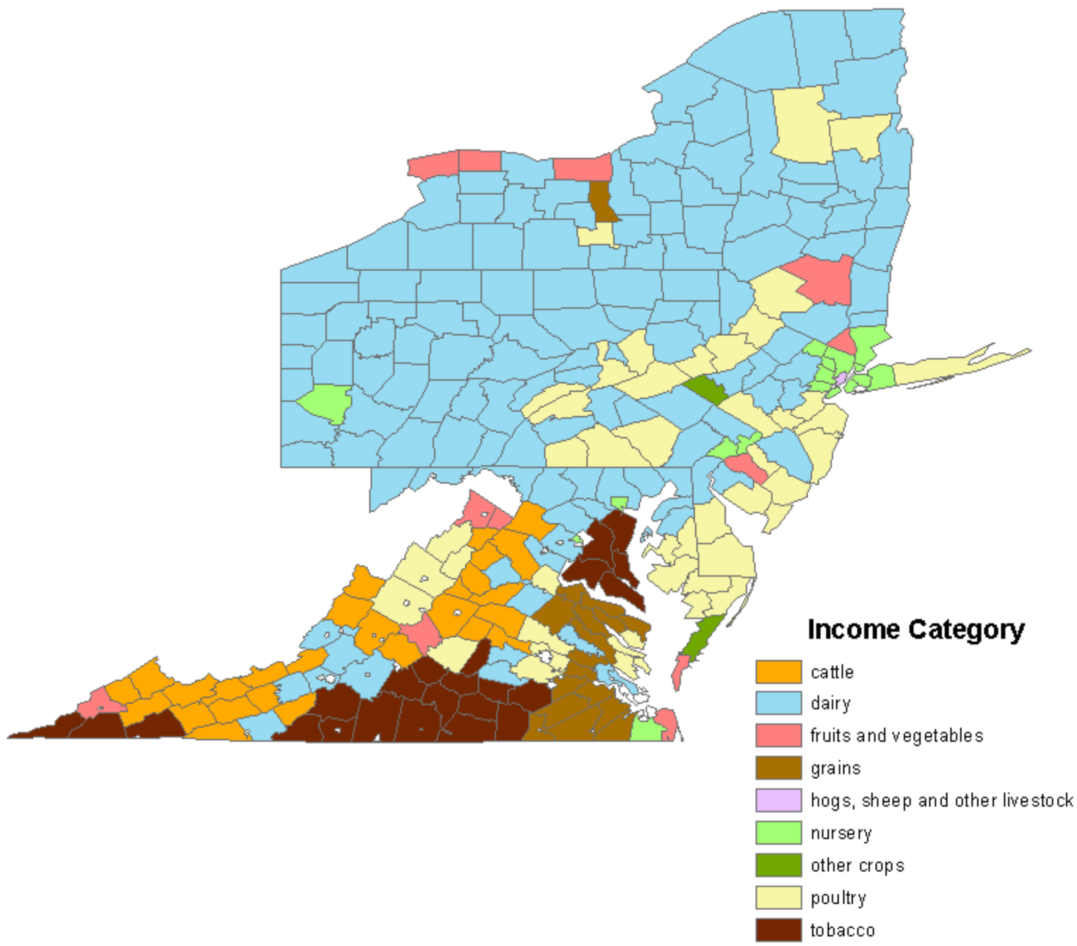
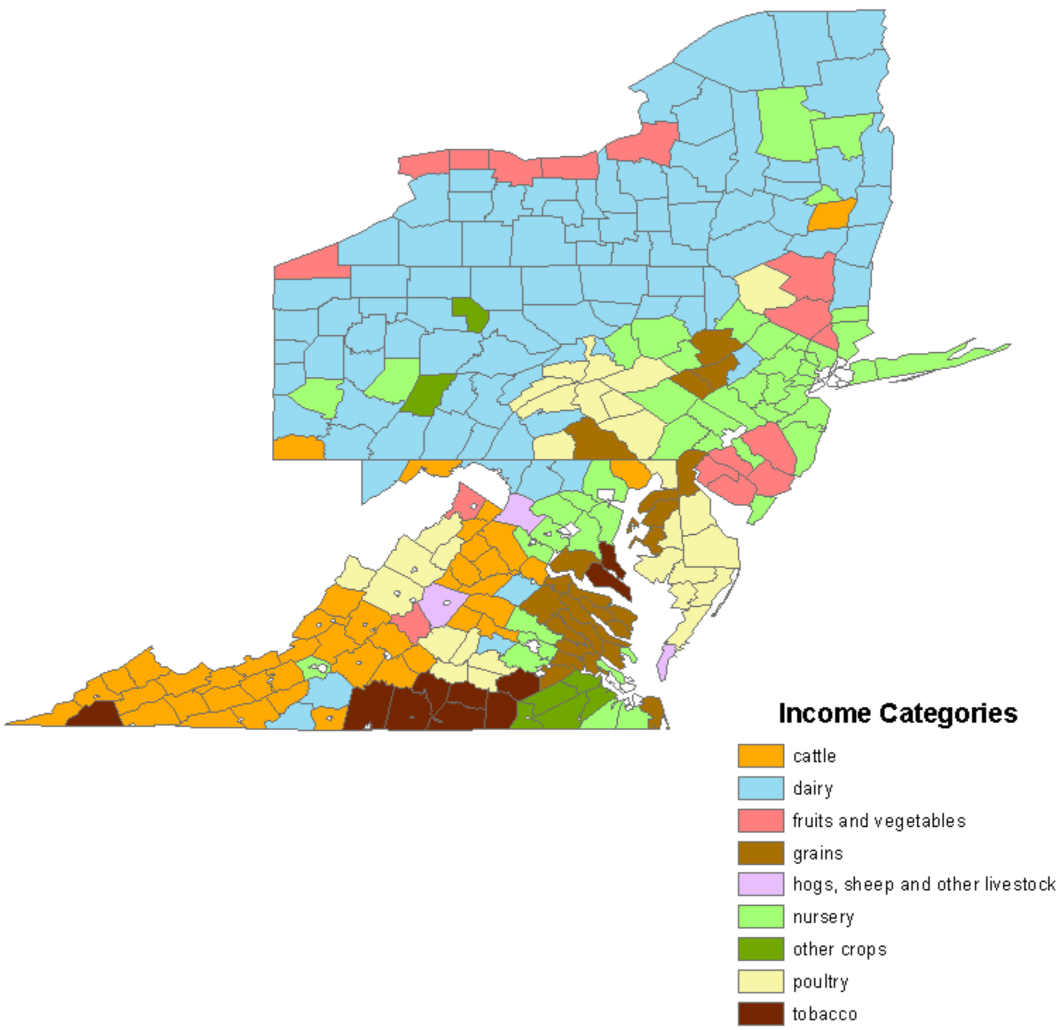


Figure 9. Largest Income Category 1997



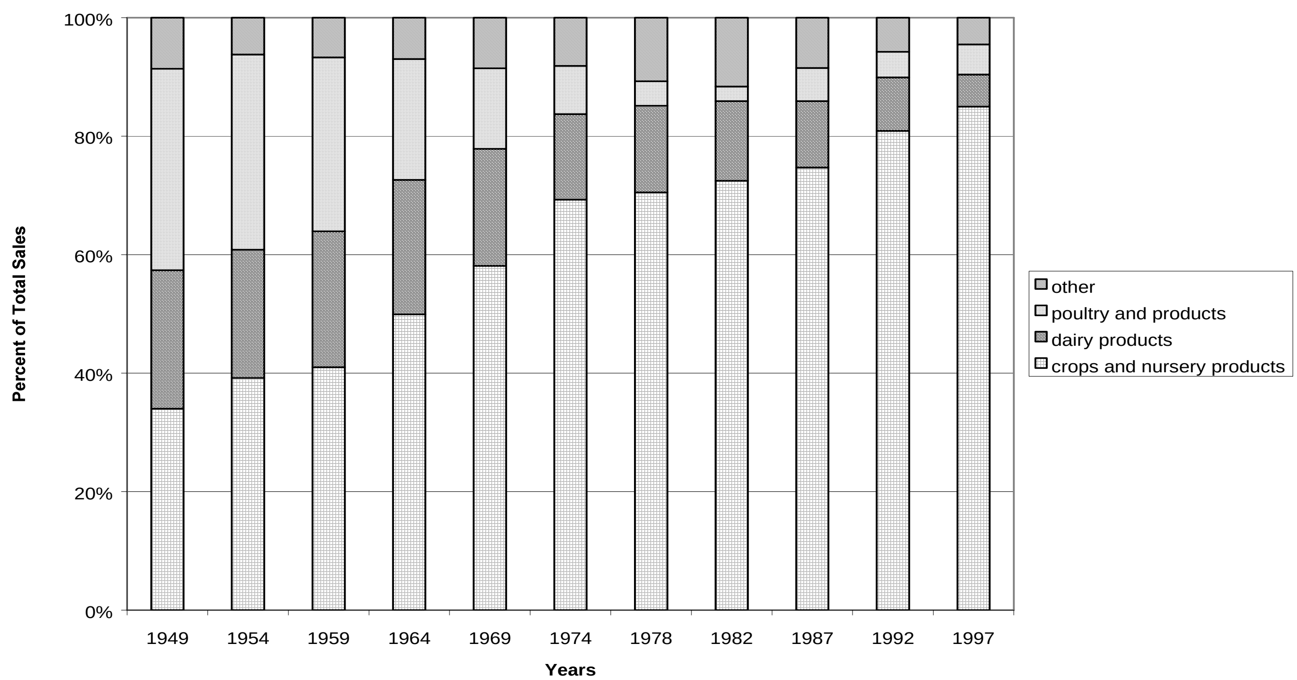


Figure 10. New Jersey Distribution of Sales by Crop Type from 1949 to 1997

Hog and pig operations, while comprising a relatively small proportion of total regional sales, between 2% and 4%, has undergone major shifts. The two states that have had the largest industries are Virginia and Pennsylvania, whose industries were of very comparable magnitude until 1978, when Pennsylvania's industry continued to grow, and Virginia's industry began to decline. Pennsylvania's hog and pig sales peaked in 1982 at over $260 million. Hog and pig operations accounted for 6% of Pennsylvania's total agricultural sales in 1997 and 3% of Virginia's total sales.

A small livestock sector, sheep, lamb and wool sales have declined, especially in Virginia, where the industry was worth over $25 million in 1949, declining to just under $5 million by 1997.

Expenses and Value of Land and Buildings

Per acre production expenses rose sharply between 1959 and 1974, after which time, levels have remained somewhat constant, closely mirroring the trend in per acre sales (Figure 11). Farm production expenses have risen throughout the study period in all states except New Jersey. On average, expenses rose 68%, from $139/acre to $233/acre, with the greatest increases in Virginia (147%), followed by Delaware (122%), Maryland (118%), Pennsylvania (80%), and New York (20%). New Jersey had the highest per acre expenses from 1949 to 1964, but statewide average expenses steadily declined until 1987, with a slight rise from 1992 to 1997. Since 1969, Delaware has had by far the greatest per acre expenses, reaching nearly $900/acre in 1997.

The per acre value of land and buildings has also risen since 1949, tripling on average, from $633/acre in 1949 to $2142/acre in 1997, with a peak in 1978 (Figure 12). Values are highest in New Jersey, which had an average value of land and buildings of $6642/acre in 1997. Maryland has the next highest value at $3176/acre. New York has the lowest value at $1284/acre.

Principal Occupation and Off-farm Work

The proportion of operators stating that farming was their principal occupation, reported since 1974, exhibits little change besides an initial dip between 1974 and 1978. In 1997, Delaware had the highest proportion of farmers with farming as their principal occupation, with 61%, and New Jersey the lowest, with 43%.

Farmers have become more reliant on off-farm work to supplement their income (Figure 13). Forty-five percent of farmers reported working off the farm in 1949, increasing to 52% by 1997. A large proportion of these farmers spend a substantial amount of time working off the farm. Thirty-three percent of farmers reported working over 100 days off the farm in 1949, rising to 44% in 1997. New Jersey has the greatest percentage of farmers reporting off-farm work, with 57% reporting any and 50% reporting more than 100 days. Delaware has the smallest proportion of farmers reporting off-farm work, only 45% reporting any days off farm work and 38% reporting more than 100 days.

Tenure

Ownership of the ground one farms has shifted dramatically in the region since 1949, away from owning all the acres that one farms (full-ownership), largely, and from owning none of the acres that one farms (full-tenancy) to a lesser extent, and towards owning part of the acres one farms (part-ownership). The trends are more dramatic in acreage terms than in terms of farm numbers, indicating a large number of small farms remaining in full-ownership (Figures 14 and 15). Full owners accounted for 69% of the acreage and 77% of farms in 1949, decreasing to 38% of acreage and 62% of farms by 1997. Part ownership increased from 19% of the acreage and 12% of farms in 1949 to 54% of acreage and 30% of farms in 1997. Trends in tenancy are less clear, though on average, tenancy has decreased, from 12% to 8% for both acreage and number of farms. Delaware has the greatest proportion of acreage farmed by part-owners, at 68% in 1997. New York has consistently had relatively low tenancy rates, between 4% and 7% of both acreage and number of farms. New Jersey's declining trend in full-ownership slowed since 1978, at the same time that an increasing trend in tenancy reversed. Acreage under part-ownership in the state increased or remained flat in all periods, except between 1982 and 1987. The number of farms in New Jersey under part-ownership increased through 1964, and has decreased since 1982.

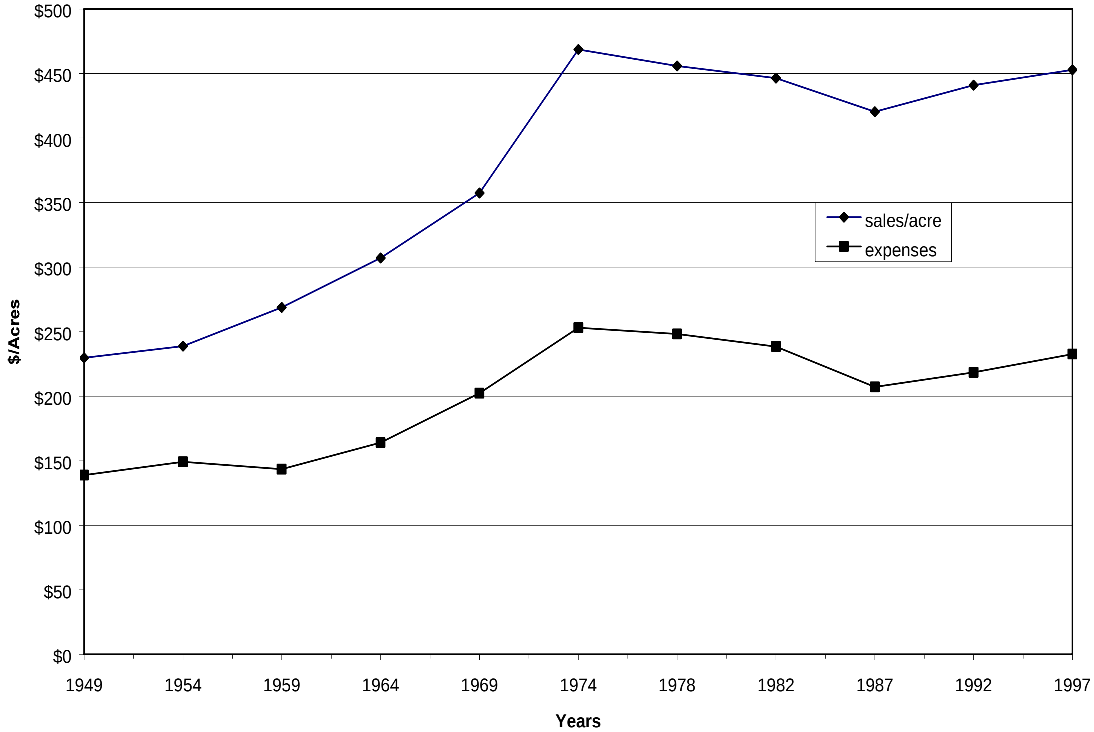


Figure 11. Per Acre Sales and Expenditures for 6 Mid-Atlantic States from 1949 to 1997

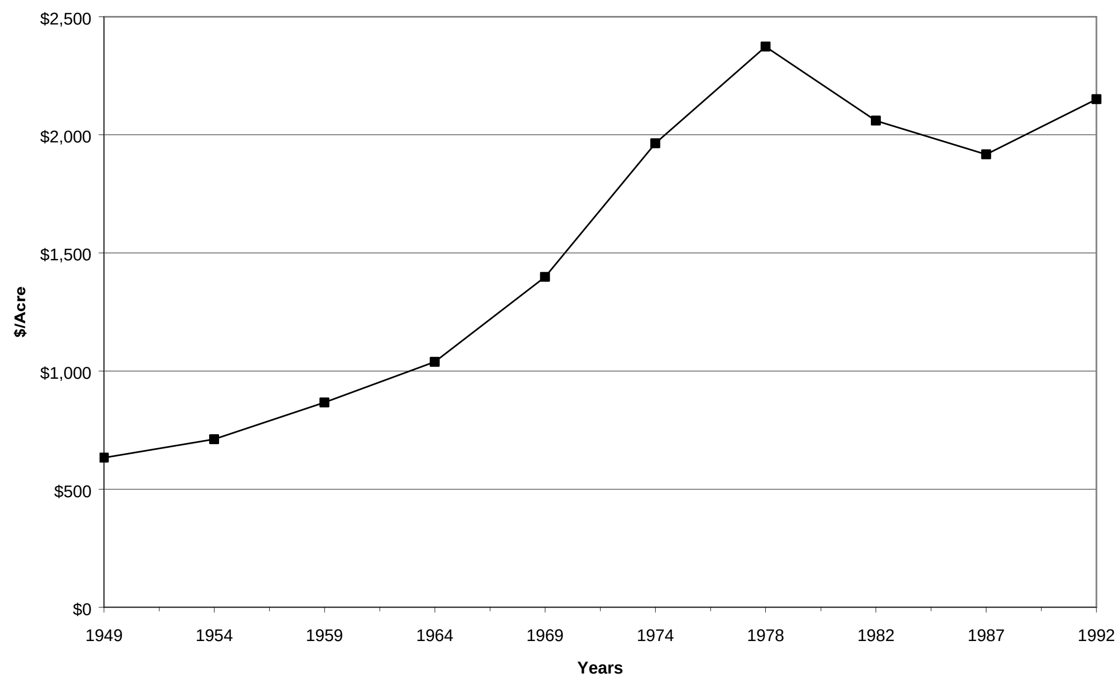


Figure 12. Value of Land and Buildings for 6 Mid-Atlantic States from 1949 to 1997

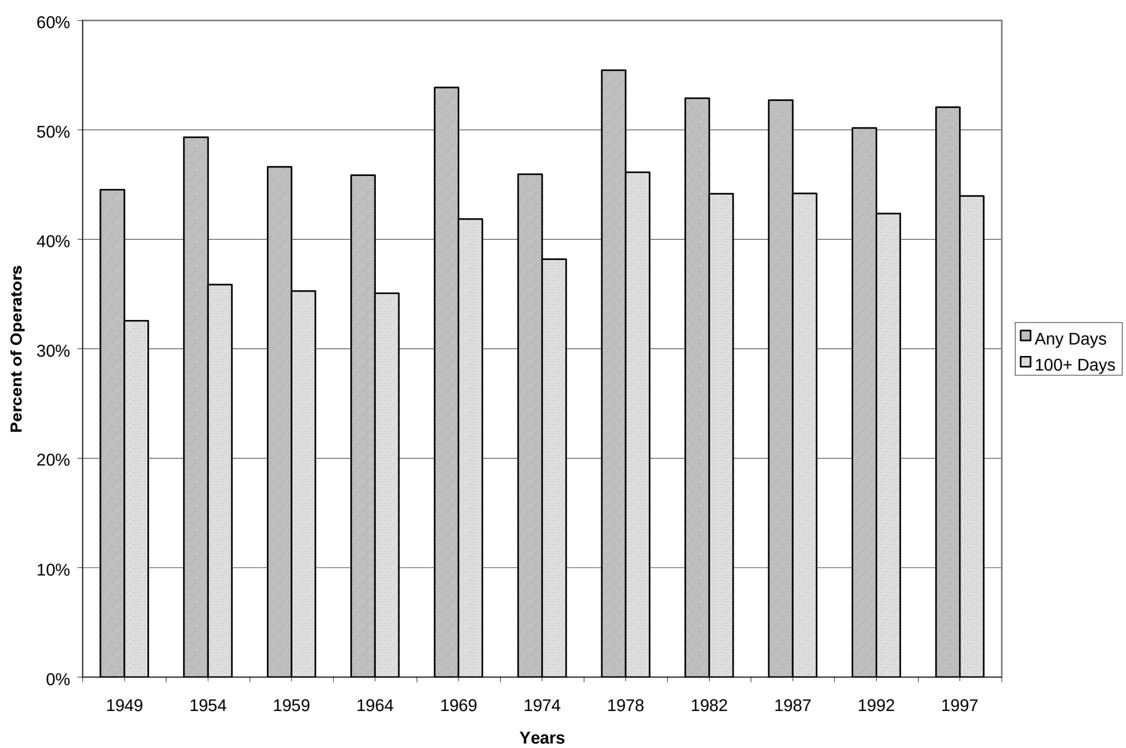


Figure 13. Percent of Operators Who Work Off the Farm At All or for More than 100 Days Annually for 6 Mid-Atlantic States from 1949 to 1997

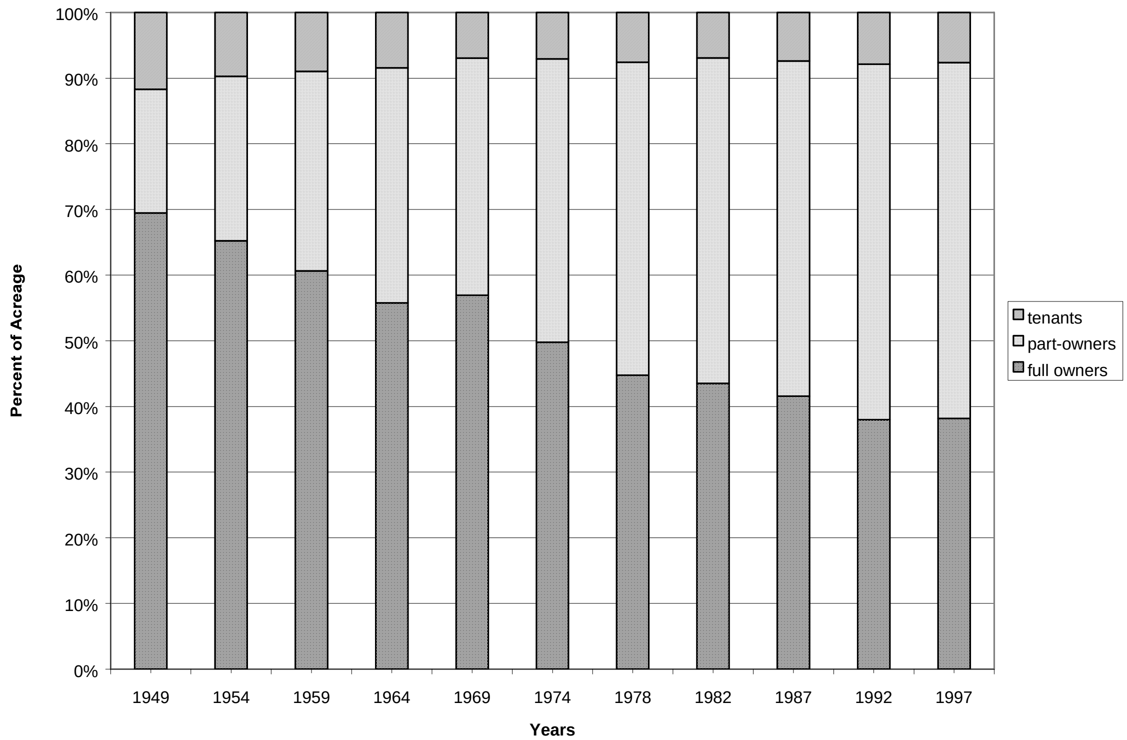


Figure 14. Percent of Acreage Farmed by Different Ownership Structure for 6 Mid-Atlantic States from 1949 to 1997

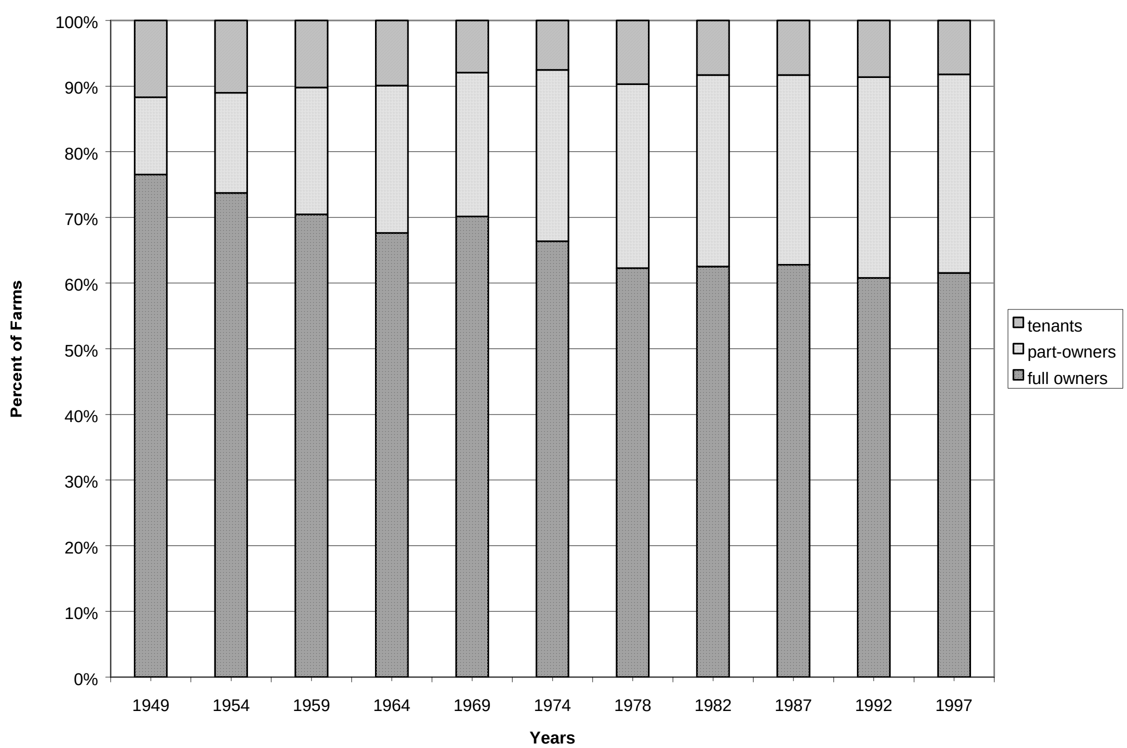


Figure 15. Percent of Farms Under Different Ownership Structure for 6 Mid-Atlantic States from 1949 to 1997

V. Urbanization Pressure in the Mid-Atlantic

Population

Total population in the six states has increased by 43% since 1950, climbing from 35 million to 50.1 million people (Figure 1). Although the number of people who moved into Delaware during this period was the smallest (430,000), it saw the largest percentage increase, at 135%, with Virginia right behind at 134%. Virginia's population increased by almost 3 million people. Maryland's population increased by 119%, or 2.8 million. New Jersey increased by 70%, or 3.4 million people. New York and Pennsylvania had smaller increases, at 26% (3.9 million people) and 16% (1.7 million) respectively. All the states also experienced increased population density. While the number of people per acre increased an average of 43% across all states, we find a large range across individual areas, from a 9 percent decrease in the population density in Southwestern Pennsylvania to a 327% increase in density in Northern Virginia (Figure 2).

As the population grew, in four of the six states the percent of total residents in rural areas decreased (Figure 3). In Virginia it decreased from more than 50% in 1950 to 32% in 1990, in Maryland from over 30% to 18%, and in Delaware from 37% to 27%. In New Jersey, already an urban state, the percent of population in rural areas decreased from 13% to 11%. In New York and Pennsylvania, on the other hand, people moved out of the cities into rural areas, increasing the percent of rural population slightly, by 1% and 2% respectively. Certain areas within each state show a more noticeable shift. For example, Kent County in Delaware saw a large increase in percent of urban population, from 22% to 53%. The percent of urban population in the Southern region of Maryland increased from less than half the region's population in 1949 to over 85%. Southeastern and Northern Virginia also saw their urban populations increase significantly. .

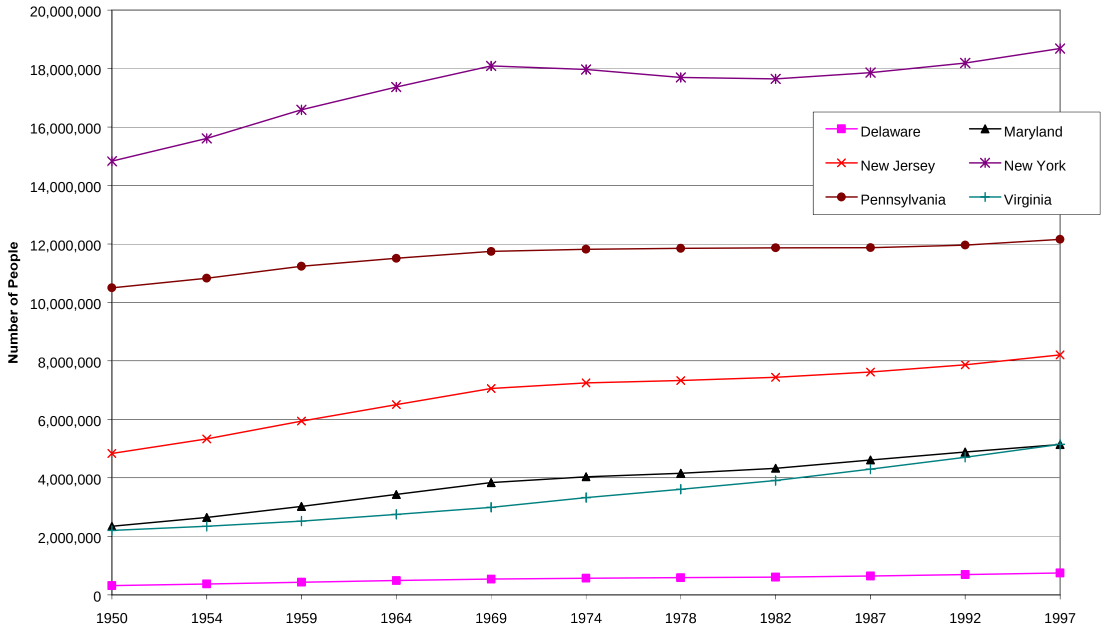


Figure 1. State Population between 1950 and 1997

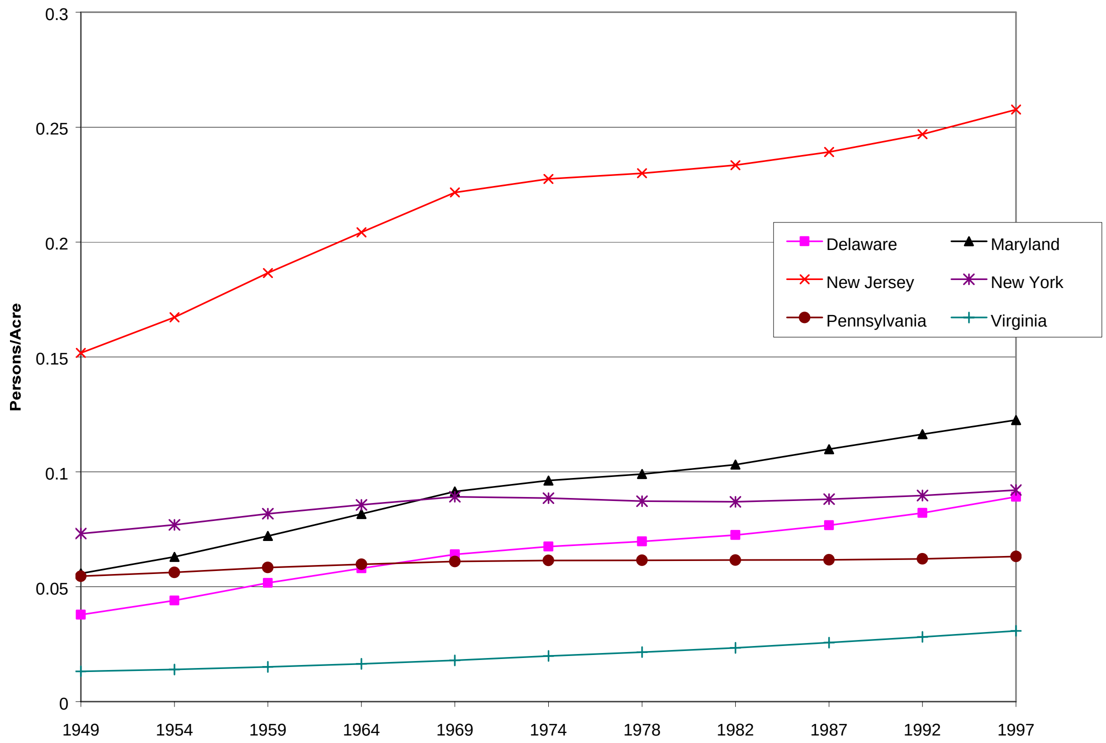


Figure 2. Population Density between 1949 and 1997

Education and Median Family Income

All six states saw an increase in the percent of people with a high school education. In 1950, the percent of people who had completed high school hovered around 30-35%. By 1990, over three-quarters of the six states' population over 25 years old had finished high school (Figure 4). People also were continuing on to college. In 1950, 6-8% of the states' residents had completed college. By 1990, this had grown to 18-26%. Eighteen percent of Virginia's residents have completed college and 26% of Maryland's. These trends in education were seen in all regions of these states, both rural and urban.

This increase in education can be seen alongside the growing median family income in these states (Figure 5). Family incomes also grew as more households had dual wage earners. Delaware's median family income grew from $16,400 in 1950 to $44,000 in 1990, a 166% increase. Maryland's grew from $16,000 to $49,000, a 205% increase. Virginia had the largest percentage increase, at 216%, with a median family income of $10,500 in 1950 and $33,200 in 1990. Similar results can be seen in the other three states. Income growth ranged from 118% in Pennsylvania to 216% in Virginia Median family income growth was consistent across all regions of the states, except for a decrease in Western Pennsylvania between 1980 and 1990.

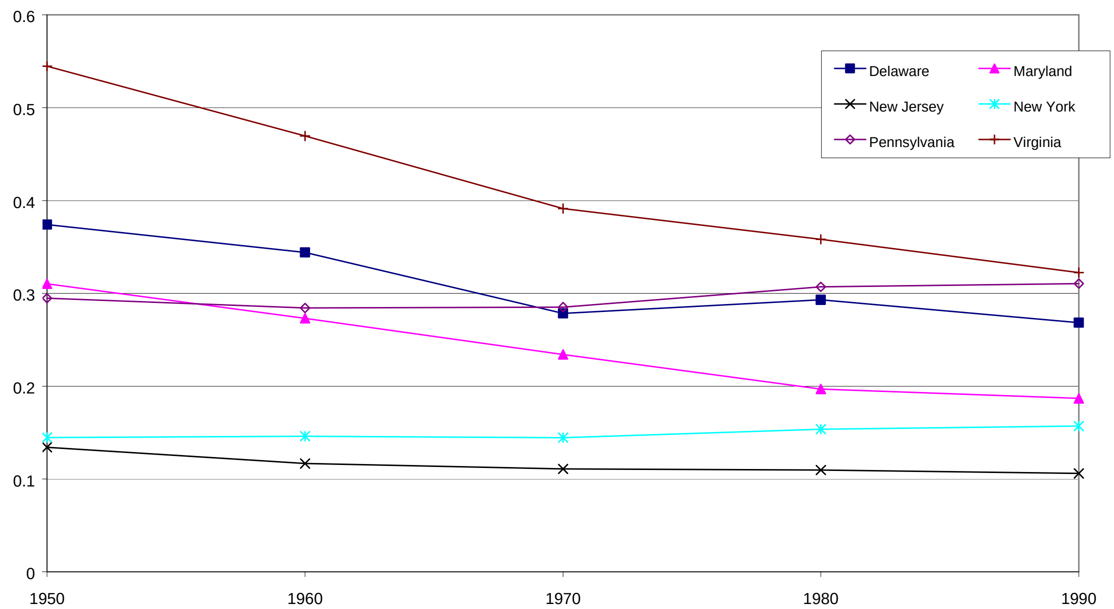


Figure 3. Percent of Rural Population between 1950 and 1990

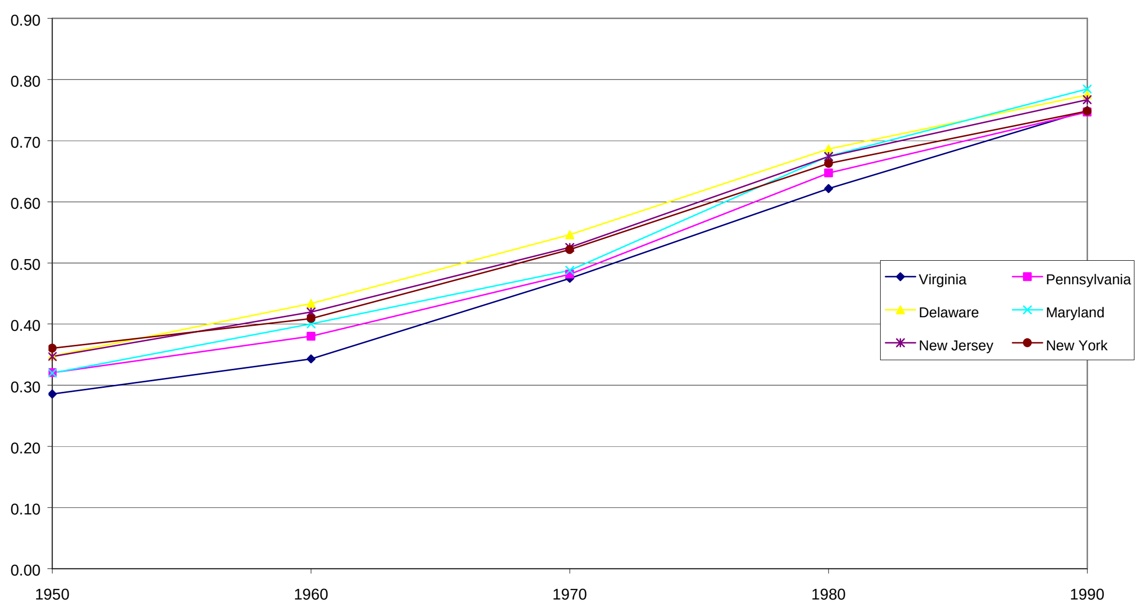


Figure 4. Percent of Adults over 25 who have received a High School Education between 1950 and 1990

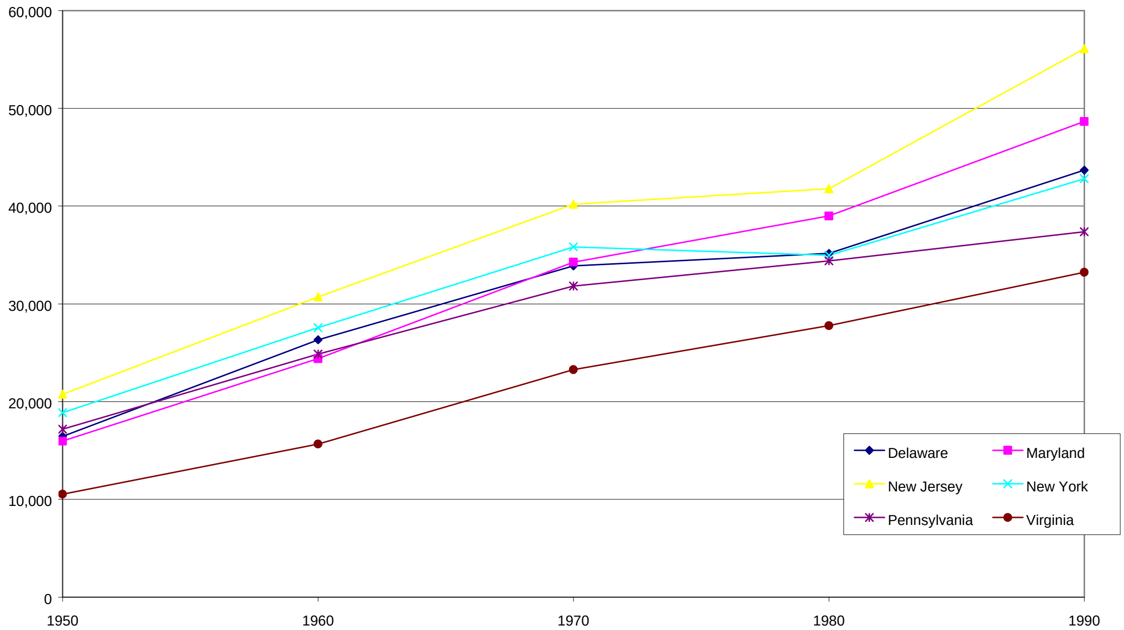


Figure 5. Median Family Income Between 1950 and 1990

The median value of housing has also increased steadily, with increases ranging from 110% in Pennsylvania to 231% in New Jersey during this period (Figure 6). Much of this increase in value occurred between 1970 and 1990. Delaware's median housing value grew from $44,000 to $108,000 (146%). Maryland saw housing values increase from an average of $37,000 in 1950 to $124,000 in 1990; New Jersey's increased from $54,000 to $180,000; and New York's climbed from $48,000 to $116,000. In New York, the boroughs of New York City, Long Island, and the Southeastern region drove the results. From 1980 to 1990, the boroughs and Long Island saw median housing value climb to $182,000. The Southeastern region of New York State saw values increase to $121,000. While an increase in housing value occurred consistently in most regions of these six states, some regions saw median housing value remain steady or drop.

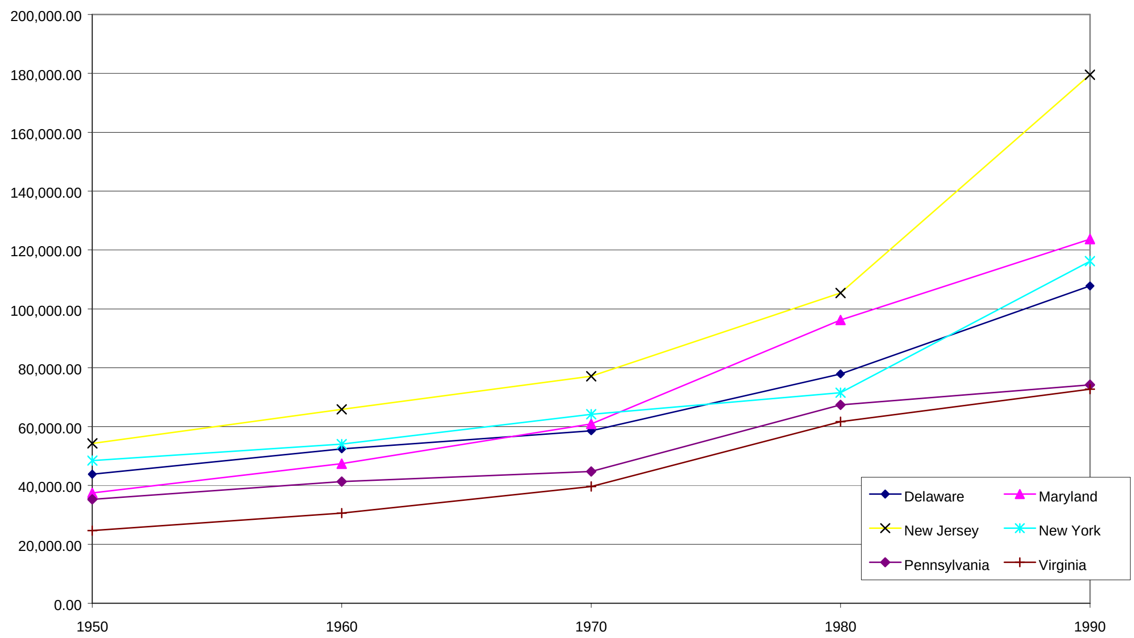


Figure 6. Median Housing Value Between 1950 and 1990

Housing

For example, Maryland's Western region saw no increase from 1980 to 1990. Pennsylvania's Southwestern, Western, Northwestern, and North-Central regions experienced a decrease in housing values (the Eastern section of the state saw increases in housing values). Median gross rents have followed similar trends.

As housing values were growing, the number of housing units was increasing as well (Figure 7). The growth rate between 1950 and 1990 ranged from 56% to 199% among the six states. Delaware increased its number of housing units from 97,000 to 290,000 (199%). Maryland's housing stock grew from 689,000 to 1.9 million (175%). The number of housing units in New Jersey more than doubled, from 1.5 to 3.1 million.

Virginia also saw a large jump, from 859,000 to 2.4 million units (176%). New York added 2.6 million more housing units between 1950 and 1990, increasing its previous number by 56%. Pennsylvania added 1.9 million, increasing its number by 63%.

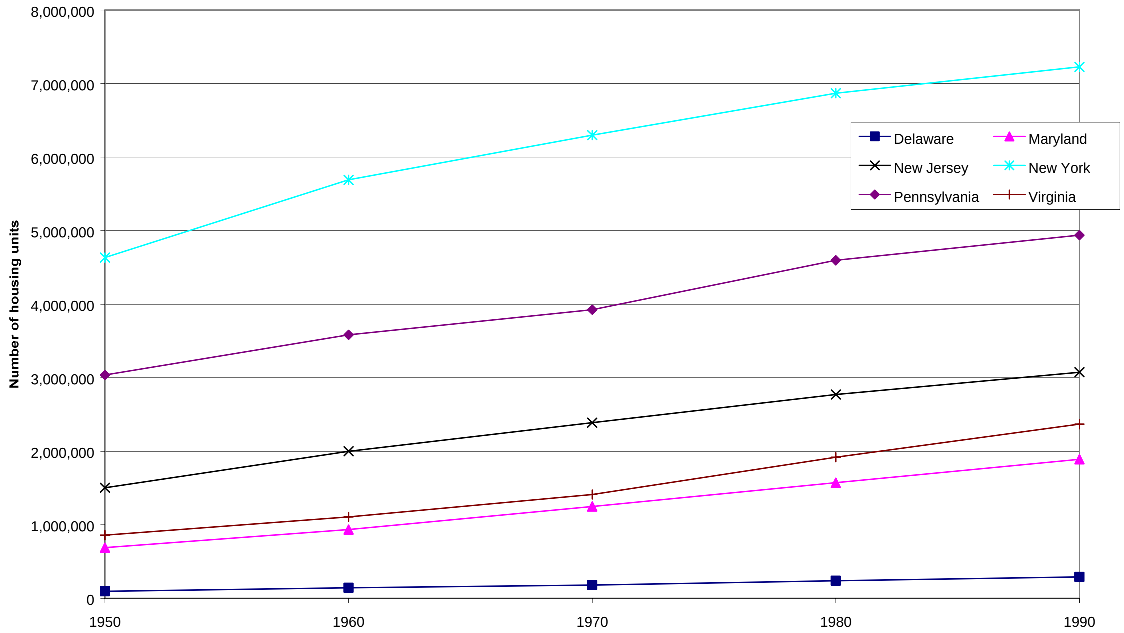


Figure 7. Housing Units between 1950 and 1990

Housing density has also increased, but percentages vary by region of the state. Virginia's Northern region has seen housing density increase from below 0.05 units an acre in 1950 to over 0.2 in 1990. Similarly, the Southeastern region of Virginia has seen an increase in density. Most areas of Pennsylvania had a housing density of about 0.1 house per acre in 1990. Southeastern Pennsylvania is the exception, with density climbing from 0.38 in 1950 to 0.66 in 1990. Housing density in the Central and Southern regions of Pennsylvania has also increased, from 0.22 in 1950 to 0.53 in 1990 in the Central area, and from 0.09 to 0.41 in the Southern counties.

Labor

Unemployment in the six states has ranged from 4.7-5.2% in 1950 to 4-6.9% in 1990. Delaware had the lowest unemployment rate at 3.1% in 1990, compared to New York with the highest at 6%. No consistent regional patterns were discovered. Unemployment rates did fluctuate throughout these years, reaching highs in 1980 before decreasing in 1990.

The percent of the labor force employed in agriculture, forestry, fisheries and mining (resource-oriented) sectors ranged from 2.7-17.7% in 1950. By 1990, this range had decreased to 1.1-2.6% (Figure 8). In Virginia, 123,883 workers left resource-oriented employment during this period, decreasing the percent of employment by 15.2 percentage points. New Jersey and New York decreased less (by 10,614 and 80,053 people, respectively) but also started with a smaller percent of the labor force in this type of employment in 1950. Delaware saw almost 4,000 people leave the sector. Maryland lost 20,900 workers. Pennsylvania lost the largest number at 227,850. The agricultural sector had become smaller during this period but it also had become more capital intensive, resulting in fewer workers needed per acre. We find the largest decreases between 1950 and 1970, which coincides with the majority of farmland loss during the 1950 to 1997 period. Populations increased in these states, but most of the new residents were not hired into agricultural employment, which also decreased the percentage of workers in resource-oriented sectors.

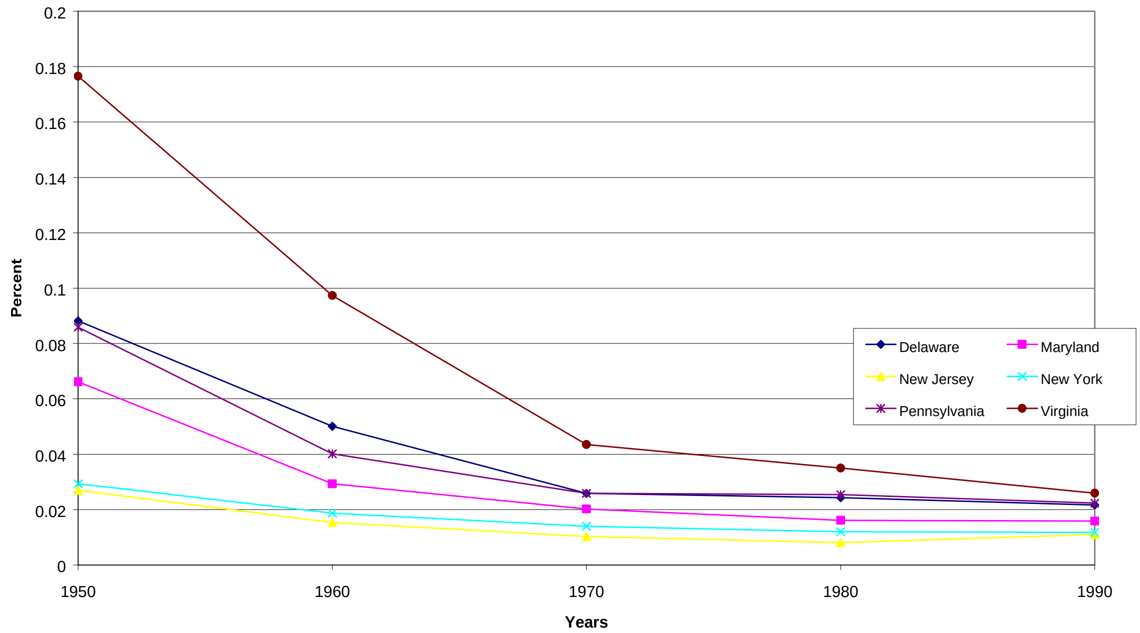


Figure 8. Percent of the Labor Force in Resource Oriented Employment between 1950 and 1990

VI. Maryland Agriculture and Urbanization

Number of Farms, Land in Farms and Average Farm Size

As in the rest of the six-state study region, Maryland has lost a majority of its farms since 1949 (Figure 1). In 1949, Maryland had 36,107 farms, and in 1997, only 12,084, a reduction of 67%. This reduction was generally uniform across the different regions of the state, varying from 63% in the Upper Shore to 71% in Southern Maryland. As in the rest of the region, the vast majority of these losses occurred prior to 1974, accounting for 87% of the decline. The total number of farms increased between 1974 and 1982, after which time the decline resumed. Central Maryland has always been the largest region in terms of number of farms, accounting for between 39% and 45% of the state's total.

In 1949, Maryland had just over 4 million acres in farms, and by 1997, only 2.2 million acres, a reduction of 47%, or 1.9 million acres (Figure 1). Three-quarters of the loss of Maryland farmland was realized prior to 1974. Total farmland decreased in every period except between 1974 and 1978, when there was a slight gain. This change was more variable from one region to the next, with Southern Maryland experiencing the greatest loss, of 67%, followed by the West (56%), Central Maryland (49%), Lower Shore (37%), and Upper Shore (29%). Central Maryland has the greatest amount of land in farms, 789,000 acres in 1997, but has also lost the most acres of farmland since 1949 at 765,000 acres.

As this would suggest, areas that lost the least amount of farmland had the greatest increases in average farm size. Average farm size grew the most on the Lower Shore (111%) and Upper Shore (91%), followed by Central Maryland (42%), West (37%) and Southern Maryland (14%). The Upper Shore had the largest farms in 1997, averaging 302 acres/farm, compared to 178 acres for the state average.

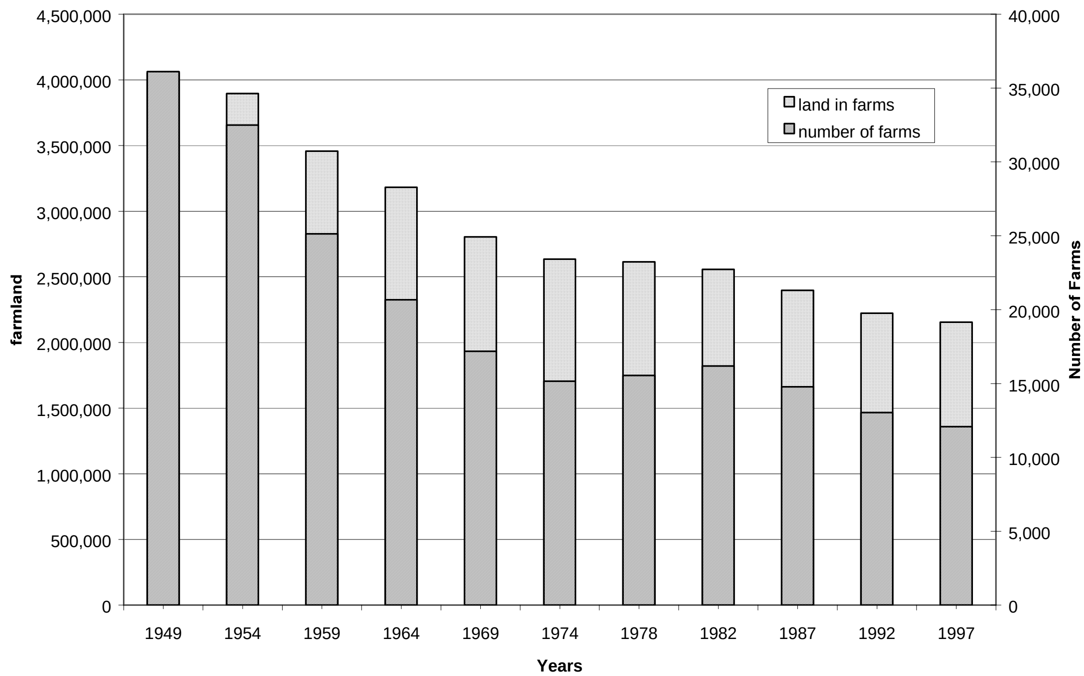


Figure 1. Farmland Acres and Number of Farms in Maryland from 1949 to 1997

Cropland losses were smaller than farmland losses. Total cropland decreased by 29% in the state, mostly in Southern Maryland (59%), much less in the Upper Shore (10%) and Lower Shore (4%). The proportion of cropland harvested has increased from 67% to 86% since 1949. The Upper and Lower Shore have the highest proportion of cropland harvested, at 95% and 93% respectively. The West harvests the lowest percentage of cropland, at 67%.

Vegetable acreage has decreased by 65% in the state since 1949, with the highest losses in Central Maryland (73%) and lowest losses in Southern Maryland (8%). Vegetable acreage is concentrated in Central Maryland, the Upper Shore and Lower Shore, but in no part of the state does vegetable acreage exceed 4% of harvested cropland in 1997.

Irrigated land increased dramatically in the state, from 697 acres in 1949 to nearly 70,000 acres in 1997. The Upper and Lower Shores account for nearly all of this increase. However, even in these two regions, the proportion of total farmland acreage that is irrigated did not exceed 7% in 1997

Woodland has declined substantially on Maryland farms over the past 50 years, from 1.2 million acres to 335,000 acres in 1997, a decrease of 71%, a much higher rate of loss than for farmland in general. All regions of the state saw nearly equal percentage declines in woodland acreage.

Sales

Maryland's total agricultural sales were $1.06 billion in 1949 compared to $1.3 billion in 1997. In real terms, this is an increase of 23%. However, there are substantial differences in sales trends for different areas of the state. While the Lower and Upper Shores experienced considerable growth, of 114% and 59% respectively, the rest of the state experienced declines, the greatest in Southern Maryland, which had a 51% decline, all in real terms. As would be expected based on the breakdown of acreage by region within the state, the Lower Shore, Central Maryland and the Upper Shore account for the majority of the state's total sales. The Lower Shore, due to the growth of the poultry industry there, has accounted for an increasing share of the state's total sales, from 20% in 1949 to 39% in 1997 (Figure 2).

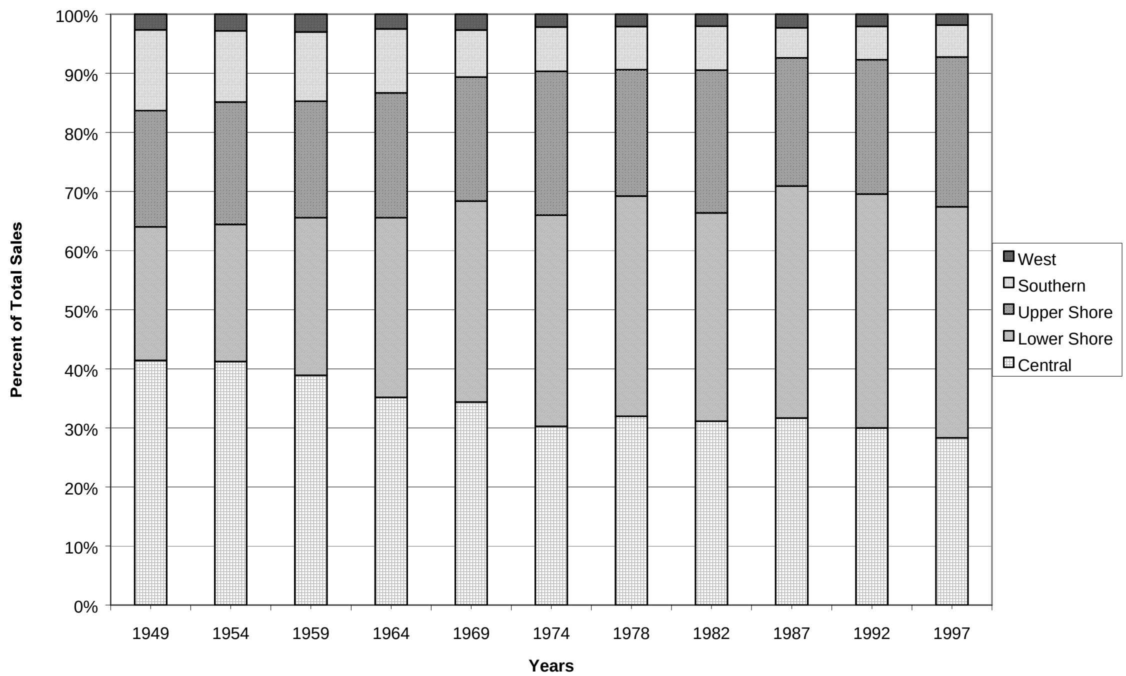


Figure 2. Distribution of Maryland Sales by Region from 1949 to 1997

The state's average per acre sales has increased from $262/acre to $609/acre, a 132% increase. The Lower Shore had the highest per acre sales in the state in 1997, at $1349/acre, and had the greatest increase in per acre sales, of 239% (Figure 3). The Upper Shore had the next largest growth in per acre sales (123%), followed by the West (96%), Central Maryland (66%) and Southern Maryland (46%). Per acre sales were generally increasing throughout the state through 1974, and have declined slightly since then.

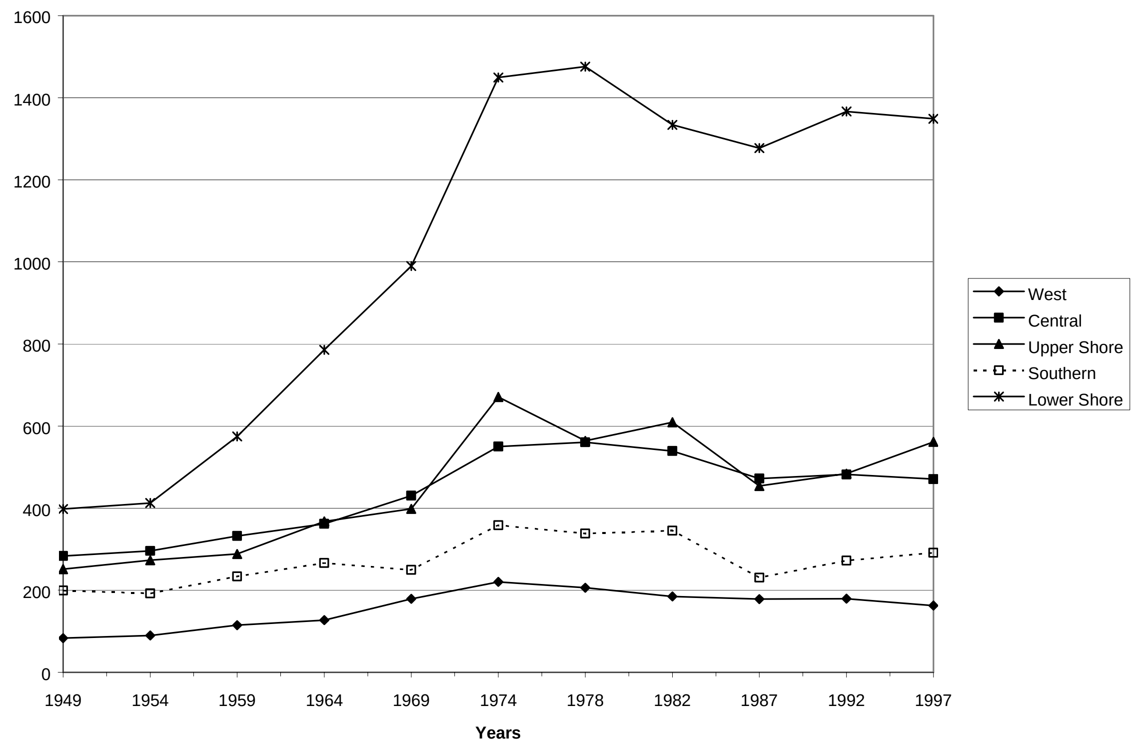


Figure 3. Sales Per Acre in Maryland By Region from 1949 to 1997

Type of Farming Operations

Throughout the study period, the proportion of Maryland's total agricultural sales derived from livestock operations has varied between 59% and 74%, with no apparent trend at the state level. Southern Maryland has traditionally been more reliant on crops and nursery products, which routinely account for between 76% and 85% of total sales (Figure 4). The Upper Shore also relies on crops and nursery products for a substantial portion of total sales, 46% in 1997. Central Maryland's share of sales from crops and nursery products has increased from 26% in 1949 to 46% by 1997.

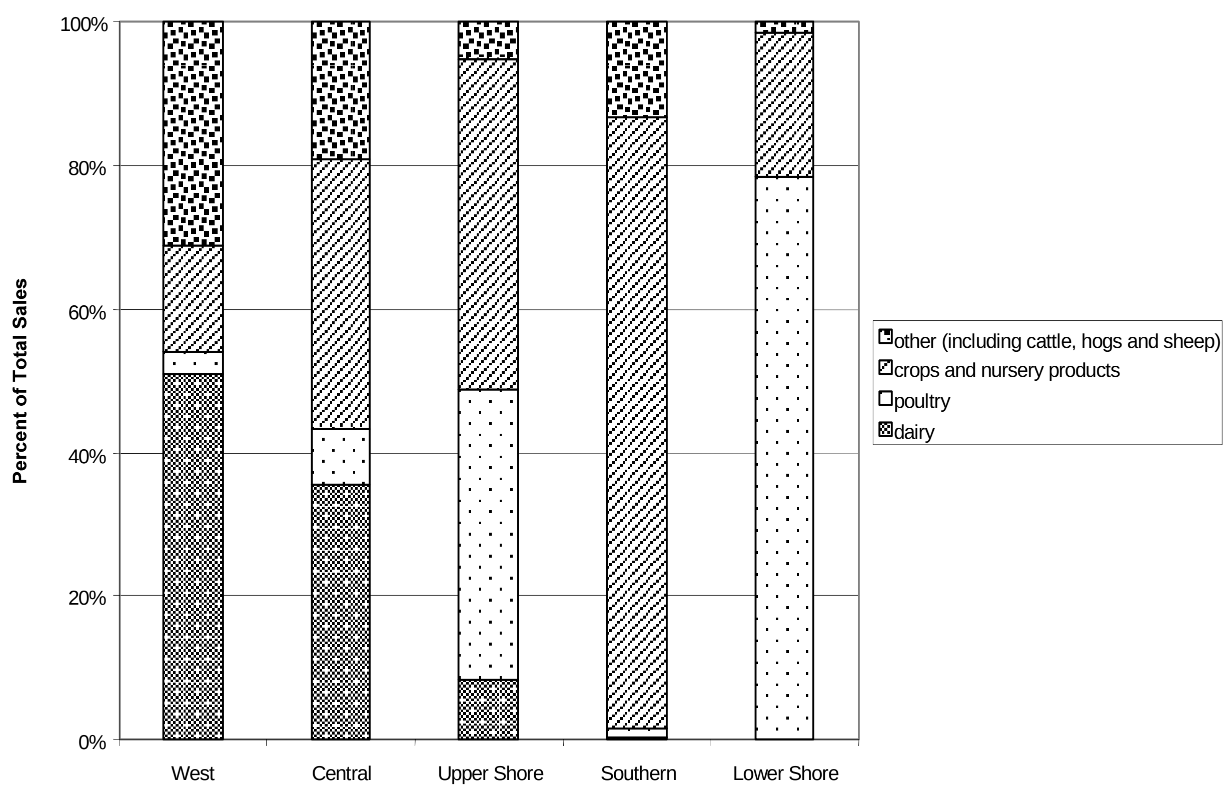


Figure 4. Distribution of Income Sources in Maryland by Region

Poultry operations have become increasingly dominant in Maryland's agricultural economy since 1949 (Figure 5). While in 1949, the dairy and poultry industries were nearly equivalent in terms of total sales, each accounting for about one-quarter of the state's total receipts, poultry's share has increased to 43%, to become a $569 million industry by 1997, compared to the dairy industry which had shrunk to $175 million. Poultry operations are concentrated on the Eastern Shore, in the Upper and Lower Shore regions. The Lower Shore poultry industry underwent tremendous growth, of 262%, between 1954 and 1978, since which time sales have declined slightly. The Lower Shore accounts for the greatest proportion of poultry sales in 1997, 71%, the Upper Shore accounted for 24%, and Central Maryland accounted for 5%.

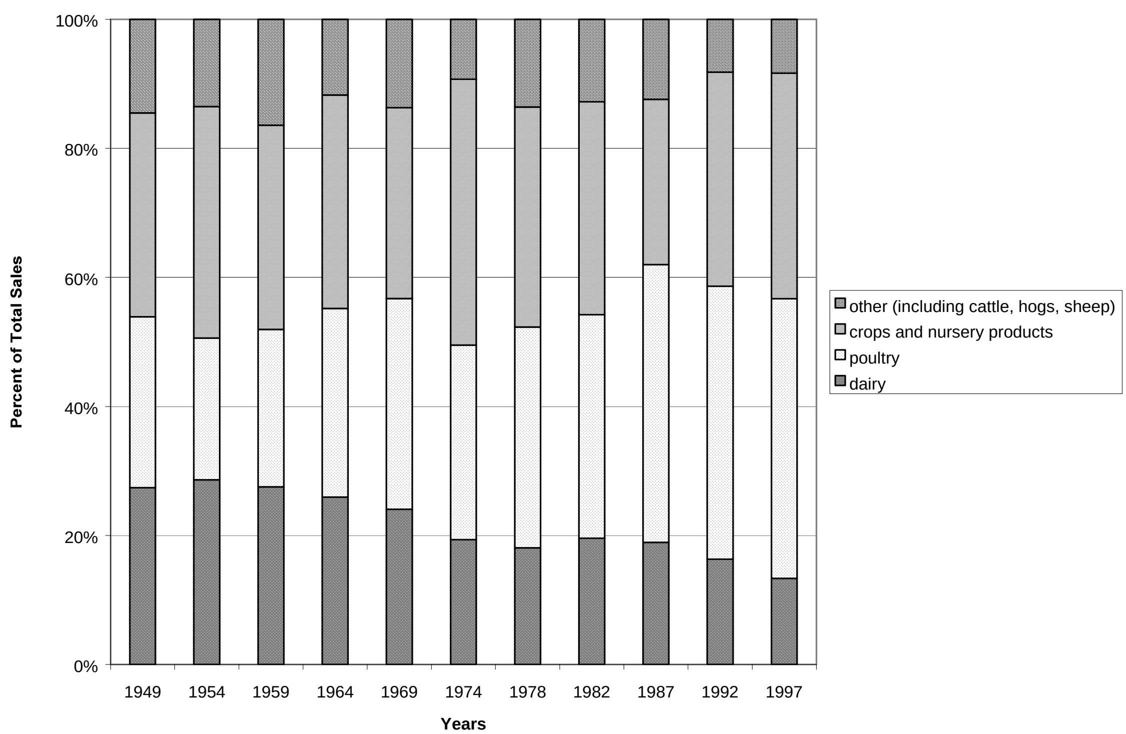


Figure 5. Distribution of Sales Sources in Maryland from 1949 to 1997

The dairy industry is concentrated in Central region of the state, with 77% of total dairy sales in 1997. The primary dairy counties in that region are Frederick, Washington and Carroll. The Upper Shore dairy industry has declined precipitously since 1949. Dairy accounted for 33% of this area's total agricultural sales in 1949, and only 8% of its total agricultural sales by 1997. If one looks at total dairy sales revenue, the Upper Shore still accounted for 16% of Maryland's dairy revenue; the West accounted for the remaining 7% of dairy sales.

Cattle operations account for a substantial portion of income in some parts of the state, while overall they represented only 4% of total sales in 1997. In the Western part of the state in particular, cattle sales have risen in importance, accounting for 18% of total regional sales in 1949, and increasing to 29% by 1997. Central Maryland also has a significant cattle industry, which accounted for 11% of total sales in 1997.

Hog and pig, and sheep, lamb and wool sales are a small part of total sales in the state. Hogs have accounted for between 1% and 4% of total sales since 1949. The Lower Shore experienced rapid growth in hog and pig sales between 1964 and 1982, of nearly 479%, to a value of $26 million in 1982, but by 1997 the industry had declined to less than $2 million. Central Maryland, which had the largest hog and pig sales in 1949, has seen a decline in the industry of 76% since 1949. The hog and pig industry in Southern Maryland accounted for 11% of the region's total sales in 1987, but had declined to just 2% by 1997. Sheep, lambs and wool have never accounted for more than 0.25% of the state's total sales. However, in the Western region, the share of total sales derived from sheep, lambs and wool has declined steadily, from 1.3% of total sales in 1949 to 0.3% by 1997.

Expenses and Value of Land and Buildings

Per acre production expenses have risen by 118% for the state as a whole, from $169/acre in 1949 to $369/acre in 1997. However, there is a wide variability in expenses between regions (Figure 6). The Lower Shore has the highest expenses in the state, at $981/acre, followed by the Upper Shore at $331/acre, Central Maryland at $236/acre, Southern Maryland at $105/acre, and the West at $88/acre. Expenses in the Lower Shore rose dramatically between 1949 and 1974, from $325 to $1034, and have declined slightly since then. For the state in general, expenses peaked in the 1970s and have declined in real terms since that time.

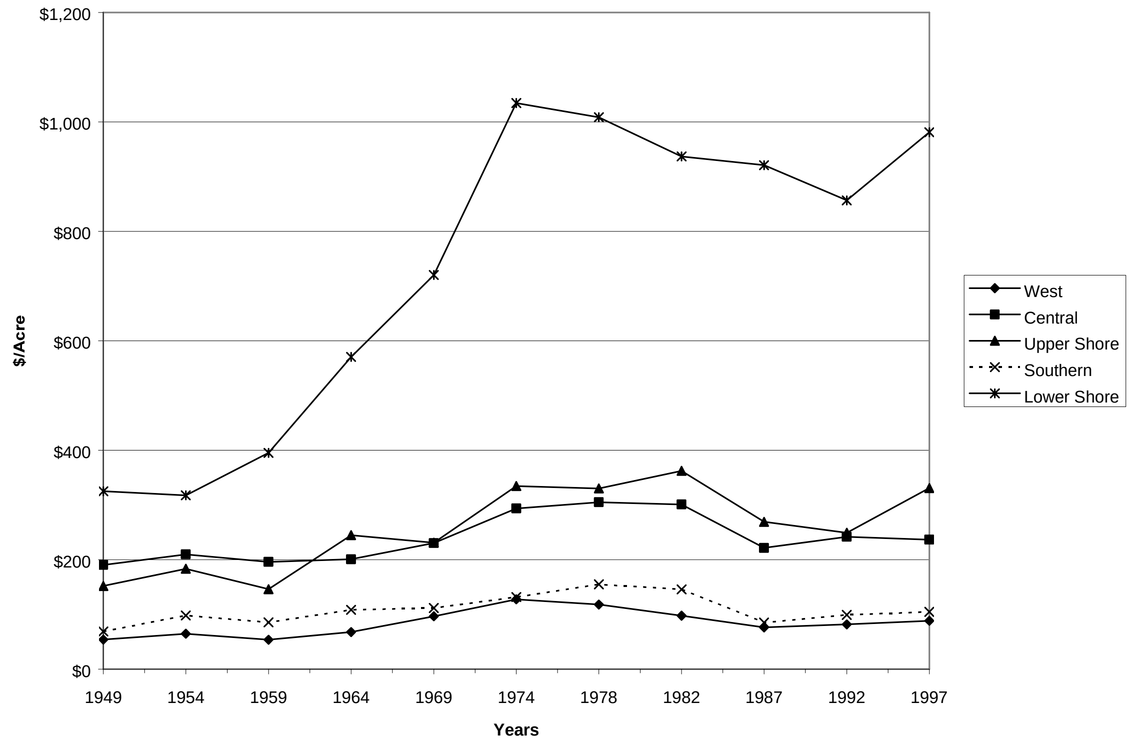


Figure 6. Maryland Farm Production Expenses Per Acre by Region from 1949-1997

The value of land and buildings per acre has more than quadrupled since 1949, from $772/acre in 1949 to $3176/acre in 1997. Again, this increase was largely realized in the first half of the study period. Value of land and buildings per acre peaked for Maryland in 1978. By 1997, Central Maryland had the highest value at $3887/acre, followed by Southern Maryland ($3601), Upper Shore ($2962), Lower Shore ($2262) and West ($1591).

Principal Occupation and Off-farm Work

The proportion of operators stating that farming was their principal occupation has declined for the state as a whole, from 62% in 1974 to 52% in 1997. The Lower Shore has the largest percentage of operators reporting farming as their principal occupation (62%), followed closely by the Upper Shore (59%). The other regions have between 46% and 48% of operators reporting farming as their principal occupation.

Maryland farmers are spending more time working off the farm. In 1949, 43% of the state's farmers reported working any days off the farm. By 1997, this figure had increased to 53%. Thirty percent of farmers worked over 100 days a year off the farm in 1949, increasing to 45% by 1997.

Tenure

Trends in ownership of the land that is farmed within the state are similar to those at the larger regional level, away from full-ownership (owning all the land one farms) and full-tenancy (owning none of the land one farms), and towards part-ownership (owning some of the land one farms). Full ownership has decreased more rapidly in terms of acreage than number of farms. Full owners farmed 62% of the acreage in 1949, decreasing to 34% in 1997. Tenancy also declined, from 23% of total acreage in 1949 to 14% in 1997, while part ownership increased from 14% to 53%. In terms of the number of farms, full ownership declined from 72% of farms in 1949 to 63% in 1997, tenancy decreased from 19% in 1949 to 11% in 1997, and part ownership increased from 9% to 26%. The West and Southern Maryland have the greatest percentage of acreage under full-ownership, at 53% and 52% in 1997. The Lower Shore has the greatest proportion of acreage in part ownership, at 68%.

Population

The total population of Maryland has more than doubled since 1949, from 2.3 million to 4.8 million inhabitants. Central Maryland region, which includes Baltimore City, accounts for more than 60% of the state total, followed by Southern Maryland region, which grew by 268% between 1949 and 1990, and accounted for 29% of the state total in 1990. All other regions experienced population growth between 1950 and 1990. Figure 7 illustrates the change in population density per acre resulting from the increased number of people.

The proportion of population that is classified as rural has decreased across the state, as would be expected with the increases in population and as more areas become classified as urban. In 1949, 31% of the state population was classified as rural, decreasing to 19% by 1990. The Upper Shore has the greatest proportion of rural population, at 83%, followed by 67% in the Lower Shore, 50% in the West, and 13% and 15% in Central Maryland and Southern Maryland, respectively. Southern Maryland has experienced the greatest decline in rural population, from 53% in 1950 to 15% in 1990.

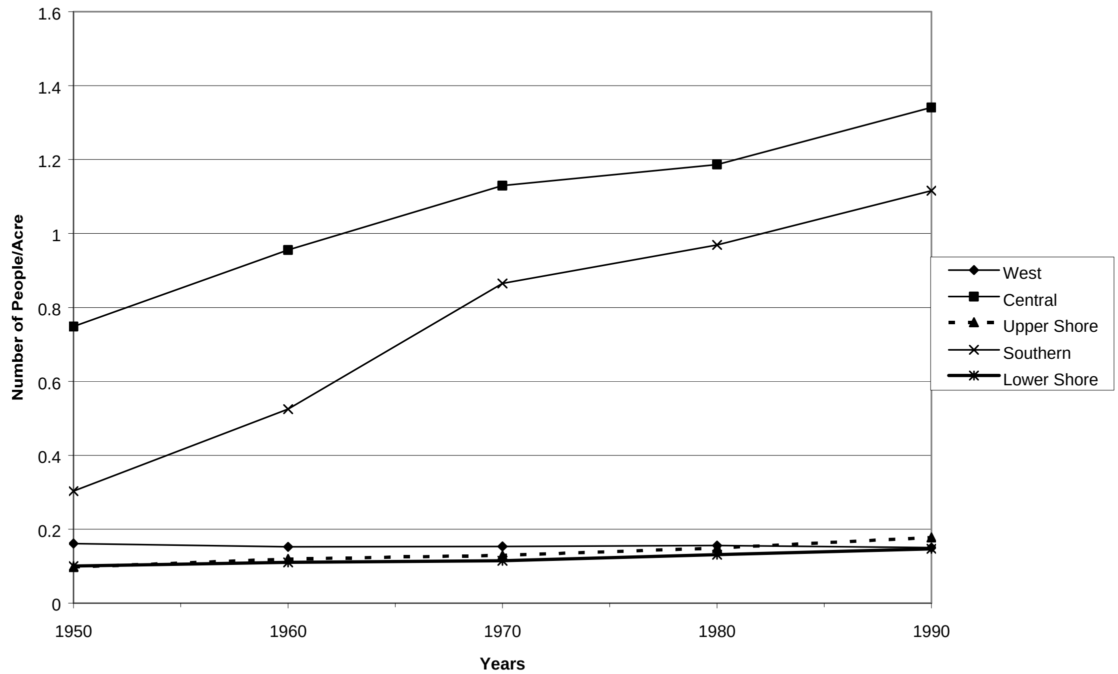


Figure 7. Population Density Per Acre in Maryland By Region from 1950 to 1990

Education

Educational achievement has increased dramatically and uniformly across the state. In 1950, 32% of adults over 25 had a high school education, and 7% had a college education. By 1990, those figures had increased to 78% and 26%, respectively. Southern Maryland had the highest proportion of adults with a high school education by 1990 (82%), followed by Central Maryland (78%), Upper Shore (73%), West (70%) and Lower Shore (69%). Central Maryland had the highest proportion of adults with a college education (29%), followed by Southern Maryland (24%), Upper Shore (16%), Lower Shore (15%) and West (11%).

Employment

Statewide unemployment rates fluctuated between 5% and 9% between 1950 and 1990. The West and Lower Shore have consistently had the highest unemployment rates, while Southern Maryland has had the lowest.

The proportion of employed persons working in agriculture, forestry, fisheries and mining has declined, from a high of 7% for the state in 1950 to 2% by 1990. The Upper Shore and Lower Shore have the highest proportion of people employed in these sectors. In 1950, 27% and 25% of employed persons worked in these sectors in the Upper and Lower Shores, respectively. By 1990, these figures had declined to 6% in both regions.

The state average median family income was $54,437 in 1990. Median family incomes have risen steadily across the state, 170% from 1950 to 1990. The Upper Shore had the largest growth in incomes, with an increase of 236%, followed by the Lower Shore (201%), Southern Maryland (163%), Central Maryland (161%) and West (116%). In 1990, Southern Maryland had the highest median family income, of $57,941, followed by Central Maryland ($54,985), Upper Shore ($46,331), Lower Shore ($37,926) and West ($32,034).

Housing

The housing stock also grew considerably between 1950 and 1990, recording an increase of 175%, which is considerably greater than the rate of population growth. With the highest population growth (268%), Southern Maryland region also had the highest growth rate in the housing stock, of 363%. The West had the slowest growth in the housing stock, but even with the decreasing population in that region it grew 43%.

Average housing density for the state increased from 0.11 units/acre in 1950 to 0.30 units/acre in 1990. Central Maryland had the highest housing density in 1990, of 0.53 units/acre, followed closely by Southern Maryland, with 0.41 units/acre (Figure 8). The other regions all had much lower housing densities, of between 0.07 and 0.09 units/acre.

Median housing values and median gross rents have also increased substantially, by 185% and 126%, respectively. The greatest increases occurred in the Upper Shore, where median housing values increased by 303% and median gross rent by 142%. The Lower Shore also had a large increase in median housing values of 251%, though the increase in median gross rent was only 86%, well below the state average. Southern Maryland and Central Maryland had the highest median housing values in 1990, of $146,628 and $144,428, respectively. The lowest housing values were recorded in the West, of $59,969. A similar pattern exists for median gross rent.

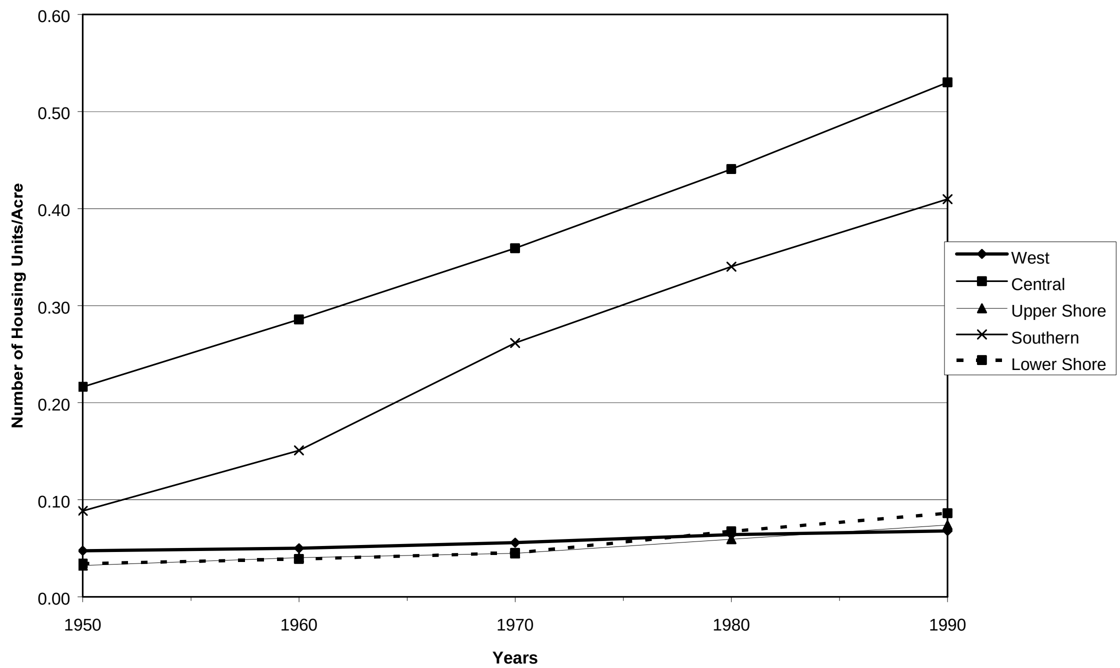


Figure 8. Housing Units Per Acre in Maryland by Region from 1950 to 1990

Appendix A. Data Description

The dataset includes county-level agricultural and demographic statistics for 1949 to 1997 for six Mid-Atlantic States: Delaware, Maryland, New Jersey, New York, Pennsylvania and Virginia. Data were derived from two primary sources: the Census of Agriculture and the Census of Population and Housing. All dollar figures are reported in 1997 dollars unless otherwise indicated. Numbers were deflated using the Gross Domestic Price Index as reported in Table No. 1435 of the Statistical Abstract of the United States (1999). The classification of counties into crop reporting districts (CRDs) is from the USDA National Agricultural Statistics Service (Figure 1, Table 1). Information on state and local farmland preservation programs is based on summaries compiled by the American Farmland Trust.

Census of Agriculture

The Census of Agriculture was conducted by the Department of Commerce's Bureau of the Census until 1997, at which time the responsibility was transferred to the U.S. Department of Agriculture's National Agricultural Statistics Service. Since 1949, the Census of Agriculture has normally been conducted once every five years, though the interval was shortened to four years between 1974 and 1982 in order to synchronize the survey with other economic censuses. The 1949 census includes estimates of sales for 1949 and acreage and inventories for 1950. The Census of Agriculture provides county-level statistics on agricultural activity throughout the U.S.

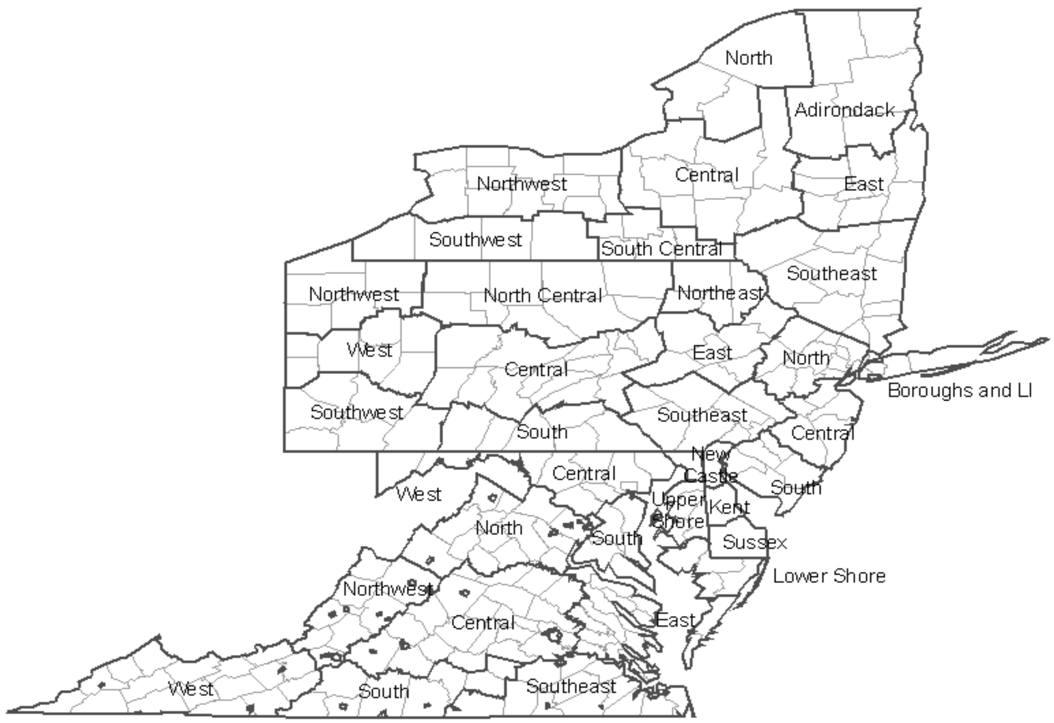


Figure 1. Distribution of Counties among Crop Reporting District.

The definition of a farm for census purposes was changed substantially twice during the period of time considered in this study. In 1959, the definition was changed from a place of 3 or more acres if the value of agricultural products (sales and production consumed by the farm household) was $150 or more, and places of any size if the value of sales (excluding production consumed by the farm household) was $150 or more, to places of any size if estimated sales were at least $250 and places of 10 or more acres if estimated sales were at least $50. The second major change was made for the 1974 census, when the minimum sales criterion was increased from $250 to $1000 per farm and the minimum size was dropped. This remains the definition used by the census. This change in definition had the greatest impact on the number of farms, but also impacted the acreage estimates. The impact on U.S. sales is considered minimal, as 152,000 farms had sales of less than $1000, using the 1959 definition, which accounted for less than .06% of total sales.

Several adjustments were made to the raw Census of Agriculture data to create consistent variables over data derived from eleven separate censuses. First, changes in actual jurisdiction boundaries, or in level of reporting, were addressed. For Maryland, estimates for Baltimore City and County were reported separately in the 1949 census, together in 1954, 1959 and 1964, and only for Baltimore County in 1969 and after. Therefore, Baltimore City and County estimates were added for 1949. Virginia has independent cities that are separate jurisdictions from counties. Between 1950 and 1997, these independent cities changed their boundaries by annexing land or consolidating with other independent cities or counties. The following description explains how these cities were incorporated into counties to conduct the analysis. Nansemond County, which was consolidated with Suffolk City in 1973, is reported in all periods as Suffolk City.

Chesapeake City, Norfolk County, South Norfolk City, Princess Anne County and Virginia Beach City are aggregated in order to address consolidations and annexations in those jurisdictions, and are reported under "Chesapeake City and Virginia Beach." In addition, in order to create consistent jurisdictions accounting for numerous annexations between cities and counties, data for several counties were aggregated: Bedford and Campbell, Carroll and Grayson, Dinwiddie and Prince George, and James City and York. Finally, Elizabeth City, Warwick and "Other Independent Cities" reported in 1949 and 1954 were dropped from the dataset.

Second, a change in the number of tenure categories after 1964 was addressed. In the earlier census years, four categories were reported: full owner, part owner, manager and tenant. From 1969 on, the manager category was dropped. For those censuses from 1949 to 1964, the percentages of acreage and farms operated by full owners, part owners and tenants are calculated over the sums of only these three categories.

Third, expenditure items reported also vary between census years. Items included in the calculation of per acre production expenses include: machine hire; hired labor; contract labor; feed for livestock and poultry; livestock and poultry purchased; seeds, bulbs, plants, and trees purchased; gasoline and other petroleum fuel and oil; commercial fertilizer; lime and liming materials; and other agricultural chemicals. In addition, "livestock and poultry purchased" and "seeds, bulbs, plants and trees purchased," which were reported in 1949 and 1959 but not in 1954, were interpolated for 1954 and included.

Fourth, livestock sales categories varied slightly between census years. In 1969, cattle and calves sales were calculated as the sum of "dairy cattle and calves" sales and "other cattle and calves" sales. Also, in 1969, sales of hogs, sheep and goats were reported together. In order to create sales figures for hogs and pigs separate from sheep, lambs and wool, these were interpolated from 1964 and 1974 levels.[17] It should be noted that in 1969 and 1974, sales of cattle and calves sold and dairy products sold are reported only for farms with over $2500 sales, as opposed to all farms in all other years. Similarly, the value of hogs and pigs sold, and sheep, lambs and wood sold, is reported only for farms with over $2500 sales in 1974, as opposed to all farms in all other years. Also, in 1969 the value of poultry and products sold is reported for farms with over $2500 in sales, as opposed to all farms in all other years.

The acreages reported as operated by full owners in Northumberland and Nottoway counties of Virginia in 1950 were apparently transposed in the reports and were corrected.

In counties where publication of an estimate would allow the identification of an individual enterprise, estimates are not reported to retain the confidentiality of all respondents. In instances where data on number of farms or farmland were not reported in a particular year for confidentiality reasons, those values were interpolated based on reported values for prior and later years.

[17] The value of sales of hogs and pigs in 1969 was calculated by taking the average of sales in 1964 and 1974.

Census of Population and Housing

The Census of Population and Housing is conducted once every ten years and provides estimates of the numbers and characteristics of total population and housing units. Estimates are available at geographic levels smaller than the county, though county-level estimates are used here. The Censuses of 1950 through 1990 are used in this study, as the 2000 census figures are not yet available for most variables included in the analysis. In order to create a dataset combining the data from the Censuses of Agriculture and the Censuses of Population and Housing, the population and housing estimates were interpolated and extrapolated to the Census of Agriculture years. Extrapolations were made assuming a constant percentage change.[18]

Two classifications used in the Census of Population and Housing need explanation. First, a metropolitan area (MA) is one of a large population nucleus, together with adjacent communities that have a high degree of economic and social integration with that nucleus. Some MAs are defined around two or more nuclei, such as the Baltimore-Washington area. Metropolitan areas are designated and defined by the Federal Office of Management and Budget and are used by many different Federal agencies in order to consistently present a wide variety of statistical information. Each MA must contain either a place with a minimum population of 50,000 or a Census-defined urbanized area and a total MA population of at least 100,000 persons (75,000 in

[18] Interpolated estimates were calculated by dividing the change in values between census years by ten, multiplying that annual change by the appropriate number of years, and adding that change to the earlier year. Extrapolations were calculated for years 1992 and 1997, based on estimated values from the 1980 and 1990 censuses. The annual percent change in the estimated value from 1980 to 1990 was calculated, then applied to 1990 data.

New England). An MA also may include one or more outlying counties that have close economic and social relationships with the central county. Metropolitan area classifications were interpolated by taking the classification from the closest census year (e.g. 1950 metropolitan area classification is used for 1954, 1960 metropolitan area classification is used for 1959, etc.).

The Census also classifies areas as urban or rural. This distinction has changed only slightly over the past 50 years. The Census defines urban as comprising places of 2500 inhabitants or more incorporated as cities, boroughs, and villages; incorporated towns of 2500 inhabitants or more[19]; the densely settled urban fringe, including both incorporated and unincorporated areas, around cities of 50,000 or more; and unincorporated places of 2500 inhabitants or more outside any urban fringe.

Changes in jurisdictions were also addressed in the population and housing data. In order to create population and housing statistics for Baltimore City and County that are consistent with the agriculture data, data for Baltimore City and County were aggregated for all census years. Addressing the jurisdictional changes in Virginia between 1950 and 1997 was more involved for the population and housing data, as many independent cities not included in the agricultural data, grew by annexing portions of neighboring or surrounding counties. In some cases, the aggregation is in all periods, as the jurisdictions existed in all periods, but annexations were made at some point between 1950 and 1990. Those jurisdictions that were added only up to or after a certain year either were

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[19] Except in New England, New York, and Wisconsin, where "towns" are simply minor civil divisions of counties.

incorporated or consolidated during the study period, and so did not exist during some portion of the study period. The following aggregations were made in order to create consistent jurisdictions across the time period of the study:

Albemarle includes Albemarle County and Charlottesville City in all periods.

Alleghany includes Alleghany County and Clifton Forge City. Covington City is added in 1960 and after.

Augusta includes Augusta County, Staunton City and Waynesboro City in all periods.

Bedford and Campbell includes Bedford County, Campbell County and Lynchburg City and adds Bedford City in 1970 and after.

Carroll and Grayson includes Carroll County and Grayson County and adds Galax City in 1960 and after.

Chesterfield includes Chesterfield County, Colonial Heights City and Richmond City in all periods.

Dinwiddie and Prince George includes Dinwiddie County, Prince George County, Hopewell City and Petersburg City in all periods.

Fairfax includes Fairfax County and Alexandria City, and adds Fairfax City in 1970 and after.

Frederick includes Frederick County and Winchester City in all periods.

Greensville includes Greensville County and adds Emporia City in 1970 and after.

Halifax includes Halifax County and adds South Boston City in 1960 and after.

Henry includes Henry County and Martinsville City in all periods.

James City and York includes James City County, York County and Williamsburg City and adds Poquoson in 1980 and after.

Montgomery includes Montgomery County and Radford City in all periods.

Suffolk City includes Nansemond County and Suffolk City until 1980 when Nansemond County is dropped.

Chesapeake City and Virginia Beach includes Norfolk County, Princess Anne County, Norfolk City, Portsmouth City and South Norfolk City, adds Virginia Beach City in 1960 and after, adds Chesapeake City and drops Norfolk County and Princess Anne County in 1970 and after.

Pittsylvania includes Pittsylvania County and Danville City in all periods.

Prince William includes Prince William County and adds Manassas and Manassas Park in 1980 and after.

Roanoke includes Roanoke County and Roanoke City and adds Salem City in 1970 and after.

Rockbridge includes Rockbridge County and Buena Vista City and adds Lexington City in 1970 and after.

Rockingham includes Rockingham County and Harrisonburg City in all periods.

Southampton includes Southampton County and adds Franklin City in 1970 and after.

Spotsylvania includes Spotsylvania County and Fredericksburg in all periods.

Washington includes Washington County and Bristol City in all periods.

Wise includes Wise County and adds Norton City in 1960 and after.

Independent cities where there was no agricultural activity and that did not merge with or annex an area with agricultural activity are excluded. For aggregated jurisdictions, variables representing medians were calculated by taking the weighted average of the medians of the jurisdictions, e.g. the median housing value for Baltimore City and County was calculated by taking the average of the median housing values for the city and county, weighted by the total number of housing units in the city and county.

In cases where a value was expressed as out of the response ranges provided–e.g. a median housing value of “less than $5,000” or “over $20,000” – the value was taken to be the upper or lower bound.

For Giles and Buchanan counties in Virginia – both of which lost population between 1980 and 1990 and consequently lost their distinction as urban areas, causing extrapolated values of rural population to be over 100% – percent rural housing and population were set equal to 100, and percent urban population and housing were set to zero.

Farmland Preservation Programs

Four different types of preservation programs are considered in the study: state preferential taxation programs, state purchase of agricultural conservation easement programs, local purchase of agricultural conservation easement programs and local transfer of development rights programs. Information on the date of establishment of all programs was gathered from publications by the American Farmland Trust (AFT 1997, 2001a, 2001b). Counties are considered as having a transfer of development rights program if any township within the county has such a program. Programs where no acreage was enrolled, or information on enrolled acreage was not available, are not considered.

Appendix B. Econometric Model and Tables with Regression Results

Many datasets have observations for individuals or individual units, which are named cross-sectional data sets. Others have observations over time periods, which are named time-series data. Some data sets however combine the cross sectional and time series data together into a "panel." This type of dataset can have variations across individuals or groups (the cross-section) and variation across time periods. For example, trade policies, interest rates or tax rates could change from one time period to another but treat each individual or group the same in a given time period. Similarly, a crop-reporting district could have a different climate or soil type than another district, which affects its possible crops/profitability, but these do not vary across the time periods. The census is an example of a data set that contains observations about individual counties over many time periods.

These group and time variations are expected to stay constant for a given crop reporting district over time, i.e. the soil type does not change over time, and for a given time period over all crop reporting districts, i.e. U.S. trade policy is the same for all crop reporting districts in any one time period. These group and time period effects can be fixed or random. If the effect is fixed, the variation is incorporated through simple shifts or constants (binary variables) for each group and for each time period. This is called fixed effects of each group's characteristics or each time period variations. The model is:

$$y_{it} = \alpha_i + \gamma_t + \beta' x_{it} + \varepsilon_{it} ,$$

where y_{it} is the vector of the county level percent loss of farmland for counties in crop reporting district *i* in time period *t*, α_i is the vector of (unobserved) group effect of being in crop reporting district *i*, γ_t is the vector of (unobserved) effect of being in time period *t*, β is the vector of estimated coefficients, x_{it} is the matrix of county level characteristics that explain farmland loss for crop reporting district *i* in time period *t* such as sales per acre, percent change in housing units, and preservation programs, and ε_{it} is the error term which is the effect of unobserved variables that vary over both crop reporting district and over time. The error is assumed to be independently identically distributed with mean zero and variance σ^2.

The other alternative is a random effect. For example, some of the unobserved variables that constitute the random error inherent in estimating an econometric model will be factors related specifically to a crop-reporting district or to a particular time period. Others may represent differences that affect a individual crop reporting in the same way through time; for example if a state highway or bridge was in place throughout the entire time period affecting commute times and transportation costs there but not in another region where the state highway does not exist. Using Lagrange Multiplier and a Hausman tests, we find in most of our models a random effects estimation procedure is more efficient.

Thus the unexplained variation in farmland loss or the residual is comprised of three parts, ε_{it}, μ_i and w_t. The mean of the three disturbances are assumed to be zero and each has a variance equal to σ_ε^2, σ_μ^2, and σ_w^2. The covariances between the error terms are also assumed to be 0. The model incorporates both the within and the between random components.

The random effects model is (Greene, 1995):

$$y_{it} = \alpha + \beta' x_{it} + \varepsilon_{it} + \mu_i + w_t$$

where y_{it} is the vector of the county level percent loss of farmland for counties in crop reporting district *i* in time period *t*, α is the vector of constant effects, β is the vector of estimated coefficients, x_{it} is the matrix of county level characteristics that explain farmland loss for crop reporting district *i* in time period *t* such as sales per acre, percent change in housing units, and preservation programs, and ε_{it},, μ_i and w_t are the error terms which are the effects of unobserved variables that vary over both crop reporting district *i* and over time *t* and within each crop reporting district and within each time period.

In addition to the data adjustments outlined in Appendix A, certain counties were deleted from the analysis. If the sales per acre in the county were missing (usually due to confidentiality problems), the county was deleted for that period. In addition, counties with less than 5 farms were excluded. Six other counties were excluded from the entire analysis due to limited agricultural activity in 1949: Bronx, Queens, Richmond, Kings, and New York, New York as well as Arlington, Virginia. Table 1-3 are reported in Section II. Model and Results.

Regression Results

Table 4. Results of Model 1a-c for Farmland Loss, Including All Observations in All Time Periods, Using Different Measures of Critical Mass

	Model 1a		Model 1b		Model 1c	
	Coeff. (Std. Err.)		Coeff. (Std. Err.)		Coeff. (Std. Err.)	
HCLANDD	-0.0006	***				
	(0.0001)					
HCLAND2D	0.0016	***				
	(0.0006)					
FLANDD			-0.0002	***		
			(0.0001)			
FLAND2D			0.0002	*		
			(0.0001)			
SALESD					-0.0002	***
					(0.00007)	
SALES2D					0.0003	**
					(0.0001)	
PAGFFM	0.0285		0.0415		0.0267	
	(0.0329)		(0.0334)		(0.0333)	
SALESPER	-0.00001	***	-0.00001	***	-0.00001	***
	(0.000002)		(0.0000)		(0.000002)	
EXPPERA	0.000005	***	0.000005	***	0.000005	**
	(0.000002)		(0.0000)		(0.000002)	
POPPERA	0.0183	***	0.0187	***	0.0196	***
	(0.0017)		(0.0017)		(0.0017)	
MADUMMY	0.0104	*	0.0103	*	0.0114	*
	(0.0058)		(0.0059)		(0.0059)	
PCTOTHU	0.1443	***	0.1587	***	0.1728	***
	(0.0394)		(0.0401)		(0.0402)	
PCMFINC	-0.1388	***	-0.1321	**	-0.1395	***
	(0.0537)		(0.0540)		(0.0542)	
PCMHVAL	0.0306		0.0236		0.0336	
	(0.0304)		(0.0307)		(0.0306)	
PHIGHSCH	0.0445		0.0141		0.0125	
	(0.0306)		(0.0318)		(0.0320)	
PUNEMP	0.3445	***	0.3207	*	0.3114	**
	(0.1220)		(0.1255)		(0.1263)	
STAX	-0.0384	***	-0.0404	***	-0.0380	***
	(0.0102)		(0.0105)		(0.0105)	
PRESPROG	-0.0023		-0.0047		-0.0016	
	(0.0093)		(0.0095)		(0.0096)	
CONSTANT	0.0746	**	0.0875	**	0.0743	*
	(0.0373)		(0.0387)		(0.0386)	
R2	.1691		.1647		.1615	

Note: Three asterisks (***) indicates that based on an asymptotic t-test, the H_0: B=0 is rejected using a 0.001 criterion. We can be 99.9% confident that there is a significant relationship between farmland loss and the variable. Two asterisks (**) and one asterisk (*) reject using a 0.05 criterion and 0.10 criterion respectively.

Table 5. Results for Model 2 of Farmland Loss Using Incremental Binary Variables for Critical Mass of Farmland

	Coefficient (Std. Err.)
CTYLT50A	0.0397***
	(0.0093)
C50100A	0.0201**
	(0.0082)
C100150A	0.0155*
	(0.0080)
C150200A	0.0101
	(0.0085)
C200250A	0.0123
	(0.0095)
PAGFFM	0.0388
	(0.0339)
SALESPER	-0.000013***
	(0.000002)
EXPPERA	0.000005**
	(0.000002)
POPPERA	0.0187***
	(0.0017)
MADUMMY	0.0106*
	(0.0059)
PCTOTHU	0.1596***
	(0.0408)
PCMFINC	-0.1293*
	(0.0542)
PCMHVAL	0.0218
	(0.0309)
PHIGHSCH	0.0009
	(0.0332)
PUNEMP	0.3091*
	(0.1284)
STAX	-0.0382***
	(0.0106)
PRESPROG	-0.0033
	(0.0097)
CONSTANT	0.0530
	(0.0392)
R2	16.45
N	2604

Note: Three asterisks (***) indicates that based on an asymptotic t-test, the H_0: B=0 is rejected using a 0.001 criterion. We can be 99.9% confident that there is a significant relationship between farmland loss and the variable. Two asterisks (**) and one asterisk (*) reject using a 0.05 criterion and 0.10 criterion respectively.

Table 6. Results of Models 3a-b of Farmland Loss, 1949 to 1978 and 1978 to 1997

	1949 to 1978 (3a)		1978 to 1997 (3b)	
	Coeff. (Std. Err.)		Coeff. (Std. Err.)	
HCLANDD	-0.0010	***	-0.00004	
	(0.0002)		(0.0002)	
HCLAND2D	0.0027	***	-0.0002	
	(0.0007)		(0.0010)	
PAGFFM	0.0477		0.0500	
	(0.0381)		(0.0972)	
SALESPER	-0.00002	***	0.00002	***
	(0.000002)		(0.000005)	
EXPPERA	0.00001	***	-0.00003	***
	(0.000002)		(0.00001)	
POPPERA	0.0175	***	0.0148	***
	(0.0019)		(0.0053)	
MADUMMY	0.0193	**	0.0078	
	(0.0082)		(0.0088)	
PCTOTHU	0.1780	***	0.0823	
	(0.0498)		(0.0861)	
PCMFINC	-0.1416	**	-0.0588	
	(0.0608)		(0.1311)	
PCMHVAL	-0.0025		0.0462	
	(0.0448)		(0.0651)	
PHIGHSCH	0.0251		-0.0032	
	(0.0462)		(0.0584)	
PUNEMP	0.3313	**	0.2931	
	(0.1643)		(0.2201)	
PRESPROG			-0.0082	
			(0.0111)	
STAX	-0.0358	***		
	(0.0112)			
CONSTANT	0.1162	***	0.0172	
	(0.0415)		(0.0514)	
R2	.2344		.0623	
N	1574		1030	

Note: Three asterisks (***) indicates that based on an asymptotic t-test, the H_0: B=0 is rejected using a 0.001 criterion. We can be 99.9% confident that there is a significant relationship between farmland loss and the variable. Two asterisks (**) and one asterisk (*) reject using a 0.05 criterion and 0.10 criterion respectively.

Table 7. Results of Models 4a-c of Farmland Loss for Metropolitan, Transition and Non-Metropolitan Counties

	Metropolitan (4a)	Transition (4b)	Non-Metropolitan (4c)
	Coeff. (Std. Error)	Coeff. (Std. Error)	Coeff. (Std. Error)
HCLANDD	-0.0006 **	-0.0007 *	-0.0006 ***
	(0.0003)	(0.0004)	(0.0002)
HCLAND2D	0.001	0.0025	0.0019 **
	(0.001)	(0.0029)	(0.0009)
PAGFFM	-0.2978	-0.1427	0.0769 **
	(0.1974)	(0.1011)	(0.0345)
SALESPER	-0.00001 ***	-0.00006	-0.00008 *
	(0.000003)	(0.00007)	(0.00005)
EXPPERA	0.000006 **	0.0001	0.00008
	(0.000003)	(0.0001)	(0.00007)
POPPERA	0.0283 ***	-0.0093	-0.0101
	(0.0025)	(0.0184)	(0.0417)
MADUMMY		0.0168	
		(0.0138)	
PCTOTHU	0.1173	-0.0083	0.0984
	(0.0903)	(0.0854)	(0.0617)
PCMFINC	0.1533	-0.0857	-0.1495 ***
	(0.1460)	(0.1293)	(0.0522)
PCMHVAL	0.0311	-0.0071	0.0843 **
	(0.0767)	(0.0636)	(0.0385)
PHIGHSCH	0.0473	0.0664	0.0414
	(0.0639)	(0.0634)	(0.0431)
PUNEMP	0.4189	-0.1613	0.3488 ***
	(0.4107)	(0.2908)	(0.1330)
STAX	0.0986 ***	-0.0173	-0.0395 ***
	(0.0244)	(0.0190)	(0.0135)
PRESPROG	0.0051	-0.0294 *	
	(0.0212)	(0.0177)	
SPACE			0.0132
			(0.0133)
CONSTANT	0.0942 **	0.1134 **	0.0823 **
	(0.0476)	(0.0575)	(0.0397)
R2	.2384	.1073	.1523
N	578	689	1337

Note: Three asterisks (***) indicates that based on an asymptotic t-test, the H_0: B=0 is rejected using a 0.001 criterion. We can be 99.9% confident that there is a significant relationship between farmland loss and the variable. Two asterisks (**) and one asterisk (*) reject using a 0.05 criterion and 0.10 criterion respectively.

Table 8. Results of Model 5 of Farmland Loss for Maryland Counties

	Maryland (1949-1997)
	Coeff. (Std. Err.)
HCLANDD	-0.0009 **
	(0.0005)
HCLAND2D	0.0031
	(0.0031)
PAGFFM	-0.1406 *
	(0.0860)
SALESPER	0.00006
	(0.00007)
EXPPERA	-0.00009
	(0.0001)
POPPERA	0.0122 *
	(0.0073)
MADUMMY	-0.0089
	(0.0128)
PCTOTHU	0.1647 **
	(0.0690)
PCMFINC	0.0017
	(0.1265)
PCMHVAL	-0.0915
	(0.0792)
PHIGHSCH	-0.0957
	(0.0593)
PUNEMP	-0.1240
	(0.2680)
LPRESPRG	0.0144
	(0.0177)
CONSTANT	0.1650 ***
	(0.0528)
R2	.2739
N	230

Note: Three asterisks (***) indicates that based on an asymptotic t-test, the H_0: B=0 is rejected using a 0.001 criterion. We can be 99.9% confident that there is a significant relationship between farmland loss and the variable. Two asterisks (**) and one asterisk (*) reject using a 0.05 criterion and 0.10 criterion respectively.

Table 9. Results of Models 1a-c for Loss of Farms, Using Different Critical Mass Measures

	Model 1a	Model 1b	Model 1c
	Coeff. (Std. Err.)	Coeff. (Std. Err.)	Coeff. (Std. Err.)
HCLANDD	-0.0002 *		
	(0.0001)		
HCLAND2D	0.0001		
	(0.0005)		
FLANDD		-0.00009 *	
		(0.00005)	
FLAND2D		0.00002	
		(0.0001)	
SALESD			-0.00005
			(0.00007)
SALES2D			0.00002
			(0.0001)
PAGFFM	-0.0660 **	-0.0588 **	-0.0655
	(0.0294)	(0.0294)	(0.0294) **
SALESPER	-0.000007 ***	-0.000007 ***	-0.000007
	(0.000002)	(0.000002)	(0.000002) ***
EXPPERA	0.000007 ***	0.000007 ***	0.000007
	(0.000002)	(0.000002)	(0.000002) ***
POPPERA	0.0108 ***	0.0108 ***	0.0116
	(0.0015)	(0.0015)	(0.0015) ***
MADUMMY	0.0089 *	0.0079	0.0085
	(0.0052)	(0.0052)	(0.0052) *
PCTOTHU	0.1229 ***	0.1200 ***	0.1295
	(0.0361)	(0.0361)	(0.0361) ***
PCMFINC	-0.1740 ***	-0.1696 ***	-0.1725
	(0.0474)	(0.0474)	(0.0475) ***
PCMHVAL	0.0432	0.0398	0.0456
	(0.0269)	(0.0269)	(0.0269) *
PHIGHSCH	-0.1328 ***	-0.1320 ***	-0.1377
	(0.0307)	(0.0305)	(0.0305) ***
PUNEMP	0.3000 ***	0.3085 ***	0.3046
	(0.1151)	(0.1150)	(0.1153) ***
STAX	-0.0265 ***	-0.0275 ***	-0.0265
	(0.0095)	(0.0094)	(0.0095) ***
PRESPROG	-0.0173 **	-0.0182 **	-0.0176
	(0.0086)	(0.0086)	(0.0087) **
CONSTANT	0.1990 ***	0.2001 ***	0.1886
	(0.0533)	(0.0533)	(0.0534) ***
R2	.3458	.3476	.3448
N	2604	2604	2604

Note: Three asterisks (***) indicates that based on an asymptotic t-test, the H_0: B=0 is rejected using a 0.001 criterion. Two asterisks (**) and one asterisk (*) reject using a 0.05 criterion and 0.10 criterion respectively.

Table 10. Results for Model 2 for Number of Farms Lost Using Incremental Binary Variables for Critical Mass of Farmland

	Coeff. (Std. Err.)
CTYLT50A	0.0286 ***
	(0.0084)
C50100A	0.0178 **
	(0.0074)
C100150A	0.0191 **
	(0.0071)
C150200A	0.0183 **
	(0.0075)
C200250A	0.0075
	(0.0083)
PAGFFM	-0.0621 **
	(0.0297)
SALESPER	-0.00001 ***
	(0.000002)
EXPPERA	0.00001 ***
	(0.000002)
POPPERA	0.0108 ***
	(0.0015)
MADUMMY	0.0080
	(0.0052)
PCTOTHU	0.1232 ***
	(0.0364)
PCMFINC	-0.1675 ***
	(0.0475)
PCMHVAL	0.0397
	(0.0271)
PHIGHSCH	-0.1369 ***
	(0.0313)
PUNEMP	0.3005 **
	(0.1165)
STAX	-0.0264 **
	(0.0095)
PRESPROG	-0.0174 **
	(0.0087)
CONSTANT	0.1720 **
	(0.0534)
R2	34.8
N	2604

Note: Three asterisks (***) indicates that based on an asymptotic t-test, the H_0: B=0 is rejected using a 0.001 criterion. We can be 99.9% confident that there is a significant relationship between farmland loss and the variable. Two asterisks (**) and one asterisk (*) reject using a 0.05 criterion and 0.10 criterion respectively.

Table 11. Results of Models 3a-b for Number of Farms Lost: 1949 to 1978 and 1978-1997

	1949 to 1978		1978 to 1997	
	Coeff. (Std. Err.)		Coeff. (Std. Err.)	
HCLANDD	-0.0006	***	0.0004	***
	(0.0002)		(0.0002)	
HCLAND2D	0.0011		-0.0014	**
	(0.0007)		(0.0007)	
PAGFFM	-0.0797	**	0.0826	
	(0.0375)		(0.0673)	
SALESPER	-0.00001	***	0.000004	
	(0.000002)		(0.000004)	
EXPPERA	0.00001	***	-0.000004	
	(0.000002)		(0.000007)	
POPPERA	0.0090	***	0.0204	***
	(0.0019)		(0.0037)	
MADUMMY	0.0207	***	0.0058	
	(0.0083)		(0.0061)	
PCTOTHU	0.1387	***	0.0668	
	(0.0506)		(0.0643)	
PCMFINC	-0.1538	***	-0.0484	
	(0.0593)		(0.0929)	
PCMHVAL	0.0692		-0.0258	
	(0.0440)		(0.0516)	
PHIGHSCH	-0.1388	***	-0.1105	**
	(0.0499)		(0.0479)	
PUNEMP	0.4618	***	0.0349	
	(0.1717)		(0.1620)	
PRESPROG			-0.0380	***
			(0.0089)	
STAX	-0.0086			
	(0.0116)			
CONSTANT	0.2241	***	0.1079	*
	(0.0276)		(0.0585)	
R2	.4772		.0841	
N	1574		1030	

Note: Three asterisks (***) indicates that based on an asymptotic t-test, the H_0: B=0 is rejected using a 0.001 criterion. We can be 99.9% confident that there is a significant relationship between farmland loss and the variable. Two asterisks (**) and one asterisk (*) reject using a 0.05 criterion and 0.10 criterion respectively.

Table 12. Results of Models 4a-c for Number of Farms Lost, Metropolitan, Transition, and Non-Metropolitan Counties

	Metropolitan (4a)		Transition (4b)		Non-metropolitan (4c)	
	Coeff. (Std. Err.)		Coeff. (Std. Err.)		Coeff. (Std. Err.)	
HCLANDD	-0.00009		0.00007		-0.0003	*
	(0.0002)		(0.0004)		(0.0002)	
HCLAND2D	-0.0005		-0.0013		0.0014	
	(0.0009)		(0.0026)		(0.0009)	
PAGFFM	-0.4259	***	-0.2028	**	-0.0175	
	(0.1593)		(0.0873)		(0.0357)	
SALESPER	-0.000007	***	-0.0002	***	0.000007	
	(0.000002)		(0.00006)		(0.00005)	
EXPPERA	0.000008	***	0.0003	***	-0.00002	
	(0.000002)		(0.00008)		(0.00007)	
POPPERA	0.0090	***	0.0132		0.0223	
	(0.0020)		(0.0170)		(0.0441)	
MADUMMY			0.0193	*		
			(0.0114)			
PCTOTHU	0.0669		-0.0088		0.0634	
	(0.0762)		(0.0767)		(0.0640)	
PCMFINC	-0.1267		-0.1721		-0.1205	**
	(0.1902)		(0.1076)		(0.0535)	
PCMHVAL	0.0531		0.0127		0.0818	**
	(0.0750)		(0.0523)		(0.0396)	
PHIGHSCH	-0.0897		-0.1538	***	-0.1615	***
	(0.0859)		(0.0604)		(0.0485)	
PUNEMP	0.1009		-0.0827		0.4905	***
	(0.3860)		(0.2664)		(0.1412)	
STAX	-0.0233		-0.0191		-0.0407	***
	(0.0213)		(0.0164)		(0.0142)	
PRESPROG	-0.0472	***	-0.0233			
	(0.0178)		(0.0154)			
SPACE					0.0148	
					(0.0139)	
CONSTANT	0.2036	***	0.2303	***	0.1979	***
	(0.0767)		(0.0670)		(0.0558)	
R2	.4246		.3679		.3330	
N	578		689		1337	

Note: Three asterisks (***) indicates that based on an asymptotic t-test, the H_0: B=0 is rejected using a 0.001 criterion. We can be 99.9% confident that there is a significant relationship between farmland loss and the variable. Two asterisks (**) and one asterisk (*) reject using a 0.05 criterion and 0.10 criterion respectively.

Table 13. Results of Model 5 for Number of Farms Lost for Maryland Counties

	Coeff. (Std. Err.)
HCLANDD	0.0002
	(0.0006)
HCLAND2D	-0.0021
	(0.0041)
PAGFFM	-0.3954 ***
	(0.1107)
SALESPER	0.00008
	(0.0001)
EXPPERA	-0.0001
	(0.0001)
POPPERA	0.0068
	(0.0095)
MADUMMY	-0.0331 **
	(0.0164)
PCTOTHU	0.1685 *
	(0.0911)
PCMFINC	-0.0229
	(0.1784)
PCMHVAL	0.0248
	(0.1104)
PHIGHSCH	-0.1183
	(0.0885)
PUNEMP	0.3171
	(0.3592)
LPRESPRG	0.0168
	(0.0226)
CONSTANT	0.1568 *
	(0.0853)
R2	.3321
N	230

Note: Three asterisks (***) indicates that based on an asymptotic t-test, the H_0: B=0 is rejected using a 0.001 criterion. We can be 99.9% confident that there is a significant relationship between farmland loss and the variable. Two asterisks (**) and one asterisk (*) reject using a 0.05 criterion and 0.10 criterion respectively.

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