

Competing for Scarce Land: Food Security and Farmland Preservation

by

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Executive Summary

Urban areas currently occupy 3 percent of the nation's land. America shifted about 300,000 acres of cropland to urban use annually from 1982 to 1992. If this rate of shift were continued, all cropland would be in urban use in 1,500 years. Statistical analysis indicated that the principal factor explaining the shift of cropland to other uses is lack of farm profitability rather than pressures of urban sprawl. Thus, it is not surprising that most land shifting to other uses from 1982 to 1992 went to recreation, range, wetland, forest, and park use rather than to urban use. These uses are more reversible than is urban use of former cropland.

The world appears to be entering a new era of tighter food supply/demand balance and possibly rising real food prices and land values at the farm level. Nonetheless, the land market alone is unlikely to register the public interest in the option value of land preserved for farming in future years when food supplies may be tighter than anticipated now. This is a national and international food security concern.

Farmland preservation by any one state has no perceptible impact on international food supplies. Hence, the food security dimension of farmland preservation will only be served by combining that dimension with other objectives of farmland preservation.

Although private markets alone will not protect farmland, past public policies often have failed, encouraging urban sprawl into the countryside while creating urban brownfields. The latter are sometimes the unintended consequences of rent controls; the former the product of underpriced or subsidized rural services and infrastructure, motor fuel, and mortgage interest. A useful step to better allocation of land, full marginal cost pricing, would slow movement of people into rural areas.

A second priority is purchase of development rights. PDRs augment the market by compensating farmland owners for holding land in agriculture. The cost is rightly borne by the public which benefits from food security and preserving rural landscapes and not by farmland owners who prefer to sell to the highest bidder. PDRs allow public and private groups to correct market failure. If not used properly, however, PDRs, by themselves, may be counter-productive, contributing to urban sprawl by being fragmented.

Collaborative federal, state, and local efforts at effective land use can preserve cropland for global food security. Recognizing that no one policy alone is likely to be adequate for wise land use, many counties and municipal communities have formulated comprehensive indicative land use plans. One option is to use PDRs near urban growth boundaries to avoid "taking" from farmland owners whose land is most inflated by development potential. Counties and townships can exercise zoning and public infrastructure investment authority over utility hookups to complement PDRs and full cost pricing in a comprehensive package for guiding development. The purpose ordinarily is to channel growth away from prime farmland and reduce sprawl rather than to halt development. Severe restraints on development could sharply raise costs of housing for nonfarm people, causing hardships especially for low income people.

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The World Food Summit held in Rome in November 1996 reinvigorated interest in food security and, indirectly, farmland preservation because of its contribution to food security. Food security is only one dimension of farmland protection, however. Farmland also has scenic, wildlife, recreation, and open space benefits sometimes referred to as rural amenities. Urban sprawl compromises these amenity benefits (rural greenfields) while sometimes leaving behind abandoned buildings and empty lots referred to as urban brownfields. Public policies can be improved to protect rural areas while diminishing urban brownfields. Key questions regarding farmland preservation include:

- What is the proper role of the market and public policy in allocation of land to agricultural versus other uses?
- What is the magnitude and sources of agricultural land loss to other uses? Is the loss mainly due to urban encroachment or the lack of demand for land to produce crops and livestock?
- What is likely to be the future demand for farmland based on long-term trends in food demand and supply? How important is maintaining land in agriculture as an option to respond to future world food needs?
- What are appropriate public policies for long-term preservation of land for agriculture?

The objective of this paper is to address each of these issues.

What is the Public Interest in Private Property?

This nation has relied on markets and public policies to allocate land among its many uses. Markets work best to allocate land to its highest and best use when incremental private costs incurred by market participants align with social costs accruing to society. Values of rural landscapes that do not enter the money accounting of land buyers and sellers are referred to as *externalities*. Reliance on private markets alone does not recognize externalities in pricing and hence does not properly protect agricultural land from loss to development.

Society has long recognized that agricultural land has value for numerous environmental uses in addition to crop and livestock production: *ecological services* such as water quality; *habitat services* such as wildlife for species preservation, hunting, or bird watching; and *amenity services* such as a bucolic scene of grazing livestock, quilted crop rotations, or contoured hills (see Bromley, p. 3). The value of environmental benefits is implicit in outlays for restoring of strip-mined land once in crops. Costs of private back-filling and revegetation mandated by government to restore basic topography and productivity for agriculture in the late 1970s averaged over \$18,000 per acre in Appalachia, \$16,000 per acre in the Midwest, and \$17,000 per acre in the West (Committee on Soil as a Resource, p. 200). These costs at over 20 times the value of land for agricultural production imply huge environmental benefits from land. While the magnitude of the ratio of environmental to agricultural value strains credulity and could merely imply political failure, even allowance for considerable error in public choice implies a very high environmental value for cropland. On the other hand, it is well to remind ourselves that crops cause erosion reducing farmland productivity about 0.05 percent per year in the U.S. and 0.1 to 0.3 percent per year globally (see Tweeten and Hopkins). This erosion coupled with chemical contamination of ground and surface waters remind us that environmental “benefits” of cropland are often costs borne mostly by “downstream” persons.

Permanent grazing or forest land would appear to have greater environmental benefits than cropland. Avery and Avery contend that the optimal strategy for global food security is intensive production of crops and livestock on non-fragile lands, thereby safeguarding fragile lands for wildlife, recreation, and beauty.

More recently, interest has revived in the *option value* of cropland—avoiding conversion of cropland to low-value irreversible non-crop uses (e.g. developmental sprawl onto rural lots “too big to mow and too small to sow”) so that it will be available to future generations if needed. Markets best reflect *use value* for market participants. The price system imperfectly accounts for the *option value* or *existence value* of rural amenities and farmland production capacity preserved from irreversible built-up uses for future generations when needs for food and open spaces might be greater.

Those holding cropland for a time when higher food prices will reward them face much risk. Private firms demand a high return to compensate for that risk. Will the private sector alone insure adequately for the rare multiyear cycle of poor crop conditions especially afflicting poor countries? Because government is involved in many risky investments, the law of averages reduces risk and, hence, the cost of capital. This raises the chances that higher food prices eventually will compensate for holding cropland. Although willingness to pay may be a good measure of the public or private commitment to preserve cropland, government failure to make correct decisions on such issues is at least as frequent as private market failure.

Although people will pay for option value because they might use amenities later or will pay for existence value even if they never plan to directly use the amenities, in many instances no market or public program exists at acceptable transaction cost where they can vote with dollars for preservation. “Free rider” problems add to the market failure. Any individual desiring to preserve farmland and rural landscapes will have an imperceptible impact; that individual, however, will benefit if someone else preserves landscape and farmland. Thus, no individual will act alone and will wait for others to act. Whether the desire to preserve rural amenities, option value for food security, and the high private discount rate justify public intervention in markets to preserve farmland is ultimately a political decision. Some might contend that the only public policy needed is to stop subsidies to infrastructure and services currently encouraging urban sprawl into the countryside. At any rate, the purpose of this paper is to provide information that will help the public to make more informed choices regarding the public interest in private property.

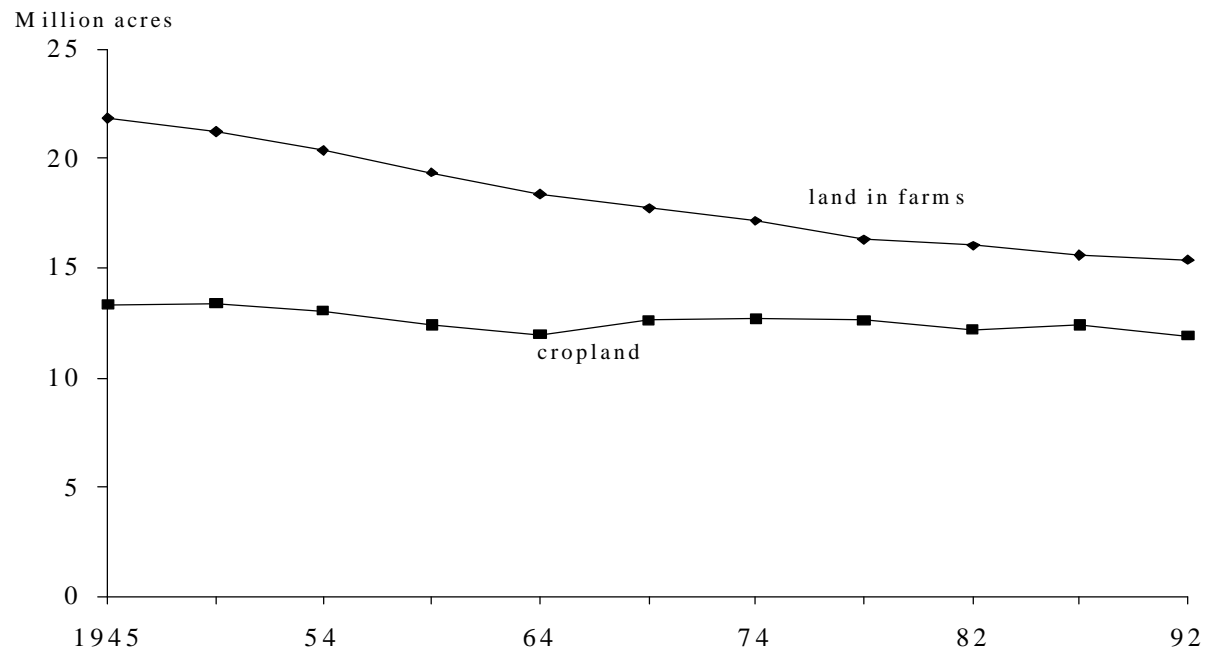
What is the Current Situation?

As a general rule, farmland will be preserved only if society through the market or political choice deems it is worth preserving. At issue is whether the current situation, relying on existing policies and markets, justifies public intervention to preserve farmland.

What Markets Say

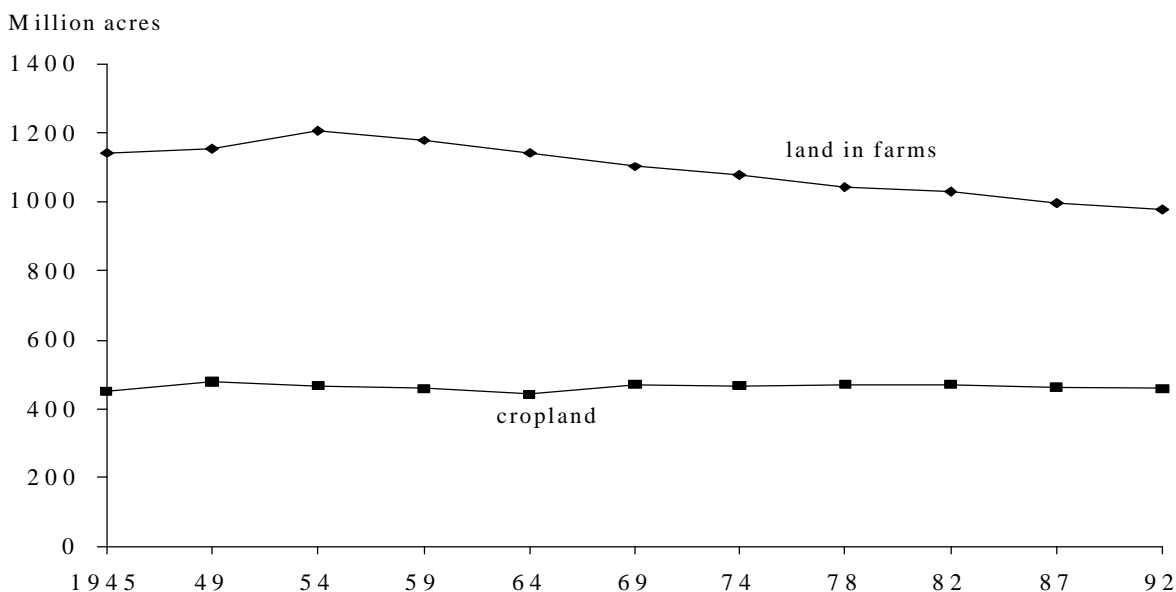
Current forces allocating land, mainly markets supplemented by public policies, are maintaining cropland much better than farmland in Ohio (Figure 1) and the nation (Figure 2). Farmland includes cropland plus grazing land, forest land, and homesteads in farms, defined as operating units normally selling \$1,000 or more of crops and livestock per year. In Ohio, farmland fell from 22 million acres in 1945 to 15 million acres in 1992—an average loss of 138,000 acres or 0.75 percent per year. If that rate continued, all Ohio farmland would be gone in 111 years. The past rate will not continue, however, because urban growth has slowed and because many of the marginal acres least suitable for crops already have been shifted to other uses. More will be said later of land supply and demand.

Figure 1. Land in farms and cropland, Ohio, 1945–1992.



Source: 1992 Census of Agriculture.

Figure 2. Land in farms and cropland, United States, 1945–1992.



Source: 1992 Census of Agriculture.

Cropland, including harvested, idled, and diverted cropland, has remained much more stable than farmland in Ohio, falling from 13 million acres in 1945 to 12 million acres in 1992. That stability in *net* cropland masks the ongoing dynamic process of simultaneous loss of cropland to other uses while cropland elsewhere in the state is created by clearing and drainage.

For the nation, land in farms fell from 1.1 billion acres in 1945 to 1.0 billion acres in 1992 (Figure 2). The loss averaged 3.5 million acres or 0.3 percent per year. If continued, the loss would exhaust all farmland in 349 years.

In contrast, the U.S. had more cropland in 1992 than in 1945 (Table 1). Additional irrigation, drainage, and clearing offset cropland losses to urban development and other uses.

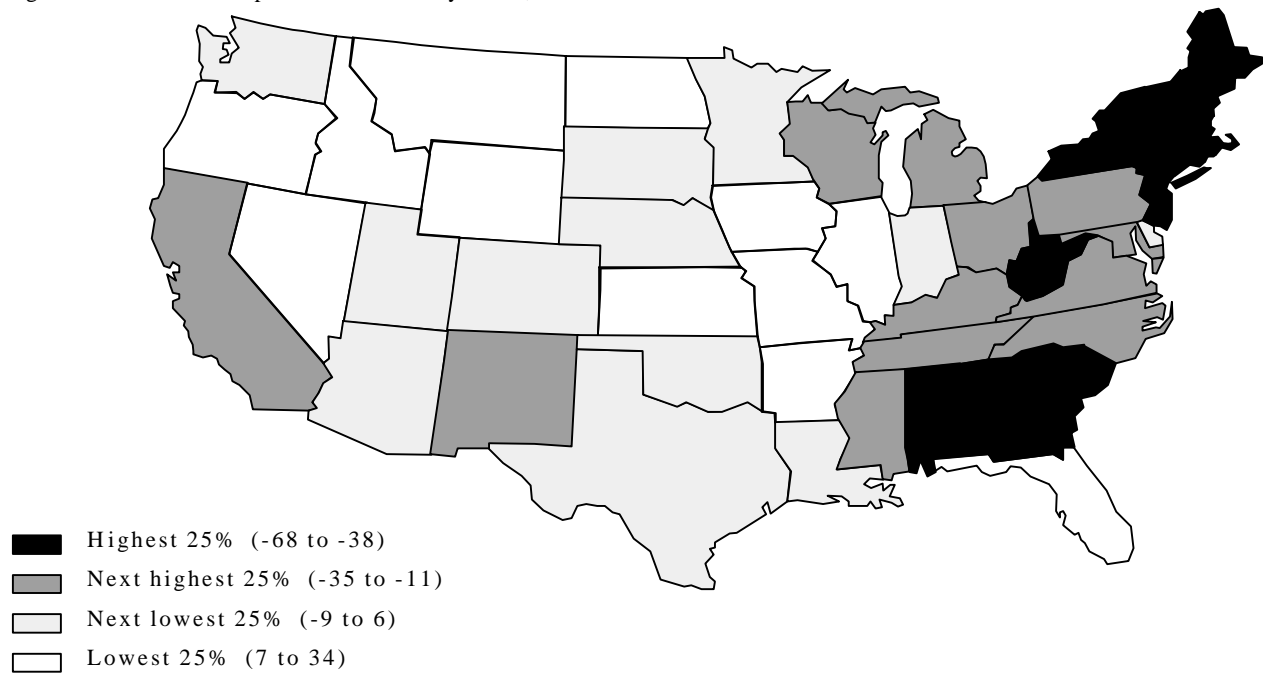
Rather stable national cropland belies uneven rates of cropland change among states. Cropland losses shown by state in Figure 3 are between the year of peak U.S. cropland, 1949, and 1992. Cropland loss rates were highest in the eastern states, especially the extreme northeast with a large urban population and much marginal farmland, and the extreme southeast (except Florida) with a rapidly growing urban population and much marginal farmland better suited for alternatives such as forest land.

Table 1 shows the level of U.S. land cover/use for the selected years from 1945 to 1992. Cropland converted to urban use is of special concern because it is mostly an irreversible shift from agriculture. Of the developed land category in the 48 contiguous states, urban areas (in towns and cities with more than 2,500 people) accounted for only 0.8 percent of all U.S. land area in 1945, 2.6 percent in 1982 and 3.1 percent in 1992. Developed land (urban areas, recreation, transportation, wildlife, and military use) increased from 168.9 million acres in 1982 to 188.3 million acres in 1992, an average of 1.94 million acres or 1.1 percent per year. Urban land increased from 49.6 million acres in 1982 to 58.0 million acres in 1992, an average of 0.84 million acres per year or 1.6 percent per year (Table 1).

Cropland fell by 920,000 acres per year or 0.20 percent per year between 1982 and 1992. Thus, approximately 377,400 acres per year, or 41 percent of this loss, was to urban development in the decade in the 48 contiguous states. If urban use were the only claimant on the 460 million acres of cropland in 1992 such land would last 1200 years.

Highways, parks, wetlands, recreation, wildlife, rangeland, pastureland, forest land, water reservoirs, and military land use account for the bulk of cropland loss. Many of these uses are more reversible than the conversion of cropland to urban use.

Figure 3. Percent cropland decrease by state, 1949–1992.



Source: Basic data from USDA.

TABLE 1. MAJOR USES OF LAND IN THE CONTIGUOUS 48 STATES.

Land use	Land cover/use in 1992							1982 total
	Cropland	Pastureland	Rangeland	Forest land	Other rural land ^b	Developed land	Water areas and federal land	
	(1,000 acres)							
Cropland	361,233.4	14,813.2	2,095.8	3,136.2	34,086.9	4,161.0	1,434.1	420,960.6
Pastureland	11,815.7	104,647.4	1,475.2	8,221.8	2,635.8	2,467.8	622.8	131,886.5
Rangeland	5,685.6	2,416.1	391,653.8	1,523.7	1,852.1	2,119.5	3,649.7	408,900.5
Forest land	1,456.7	2,863.7	1,136.1	379,593.9	1,296.2	5,583.5	2,433.5	394,363.6
Other rural land	1,177.7	808.2	270.9	1,425.5	48,479.6	291.4	371.9	52,825.2
Developed land	251.3	84.7	90.7	216.7	21.9	77,705.3	2.8	78,373.4
Water areas and federal land	696.7	293.4	2,226.1	839.8	251.4	23.9	448,370.3	452,701.6
1992 total	382,317.1	125,926.7	398,948.6	394,957.6	88,623.9	92,352.4	456,885.1	1,940,011.4

Source: U.S. Department of Agriculture, National Resources Inventory.

^aRead this table horizontally to determine how a particular 1982 land use (row heading) was distributed in 1992 (column headings). Read this table vertically to determine where a particular 1992 land use (column heading) came from, in terms of 1982 land uses (row headings).

^bIncludes land under Conservation Reserve Program (CRP) contracts, farmsteads and other farm structures, field windbreaks, barren land such as salt flats or exposed rock, and marshland.

Heimlich and Bills estimate that on average 272,800 acres of cropland were converted to urban and built up uses each year from 1982 to 1992, an annual average of 0.1 percent of the nation's cropland. This estimate is below my estimate shown earlier.

The topography of prime farmland lowers infrastructure costs for development and, hence, makes such land a tempting target for development. Fortunately, much of the nation's urban expansion is not in agricultural regions. According to Heimlich and Bills, on average each year from 1982 to 1992 some 978,000 acres were converted to urban and built up uses. Sources of these acres converted to urban use were as follows:

	(Percent)
Forest land	37
Range and pasture land	29
Cropland	28
Other	6
	<hr/> 100

The 28 percent of urban land from cropland exceeded the 20 percent of all the nation's land in cropland. However, Heimlich and Bills noted that only 39 percent of the converted cropland was classified as prime cropland. The proportion of prime cropland for urban use was lower than the proportion of prime cropland in the nation, hence urban areas made relatively more use of nonprime than of prime cropland. Five additional studies reviewed by Heimlich and Bills showed no consistent relationship between land quality and urbanization. They concluded that

Urban development hinges on location relative to existing population and employment centers and institutional factors and is not significantly affected by soil quality for agricultural production. . . . Thus, developers will not incur significantly higher costs if zoning and other institutional tools are used to direct them toward less productive ag land, as long as it is located in close proximity to the same population and employment centers as more productive land (p. 13).

The numbers for Ohio in Table 2 show that expansion of developed land, 52,000 acres annually from 1982 to 1992, almost exactly equals the loss of cropland. Gains in forest land were offset by losses in pasture land. Adjustment for cropland temporarily idled by the CRP, 377,089 acres, leaves cropland acreage in Table 2 at 12,306,000 acres, nearly equal to cropland acres in Figure 1 which showed little cropland loss in the state.

While the data indicate that cropland losses to pasture, forest, recreation, wildlife areas, roads, reservoirs, and other developed uses are greater than to urban housing, commercial, and industrial uses, the above data do not indicate how important cropland preservation will be for future food security.

Table 2. Nonfederal land cover/use, Ohio.

Type	1982	1992
	— — (1,000 acres)	— —
Developed (%)	3,033 (11.7)	3,558 (13.9)
Cropland (%)	12,447 (48.1)	11,929 (46.5)
Pasture (%)	2,714 (10.5)	2,267 (8.8)
Forest (%)	6,380 (24.6)	6,624 (25.8)
Other rural (%)	1,318 (5.1)	1,275 (5.0)
Total (%)	<hr/> 25,892 (100.0)	<hr/> 25,653 (100.0)

Source: U.S. Department of Commerce. *Statistical Abstract of the U.S. 1996*, p. 229 (1985 ed., p. 194).

Will Cropland Have High Value in the Future?

The future is inscrutable, but we can gain perspective by examining pressures on the land resource from trends in supply and demand for food. Historic global yield and area trends for crops provide the foundation to project future supply of food. Emphasis is on grains because grains directly or indirectly (through livestock) provide over half of all food supplies, because data are more reliable for grains than for other foods, and because grains are pivotal for buffer stocks and for trade. Livestock and livestock products receive less attention in this section because livestock output depends heavily on crop output and because data on livestock productivity trends are meager. Subsequent analysis also examines historic and prospective trends in population and income components of food demand, which are compared with supply projections.

Global oilseed crop area has expanded, but *net* global area in all crops has remained quite stable since 1960 and is not very sensitive to price. The stable net area hides considerable expansion of cropland by drainage, deforestation, and irrigation offset by losses of cropland to desertification, development, and other uses. Although future demand for land is not explicitly measured in subsequent analysis, readers can infer possible needs for additional cropland based on the imbalance between trends in expected demand for food and expected supply of food from yield gains alone.

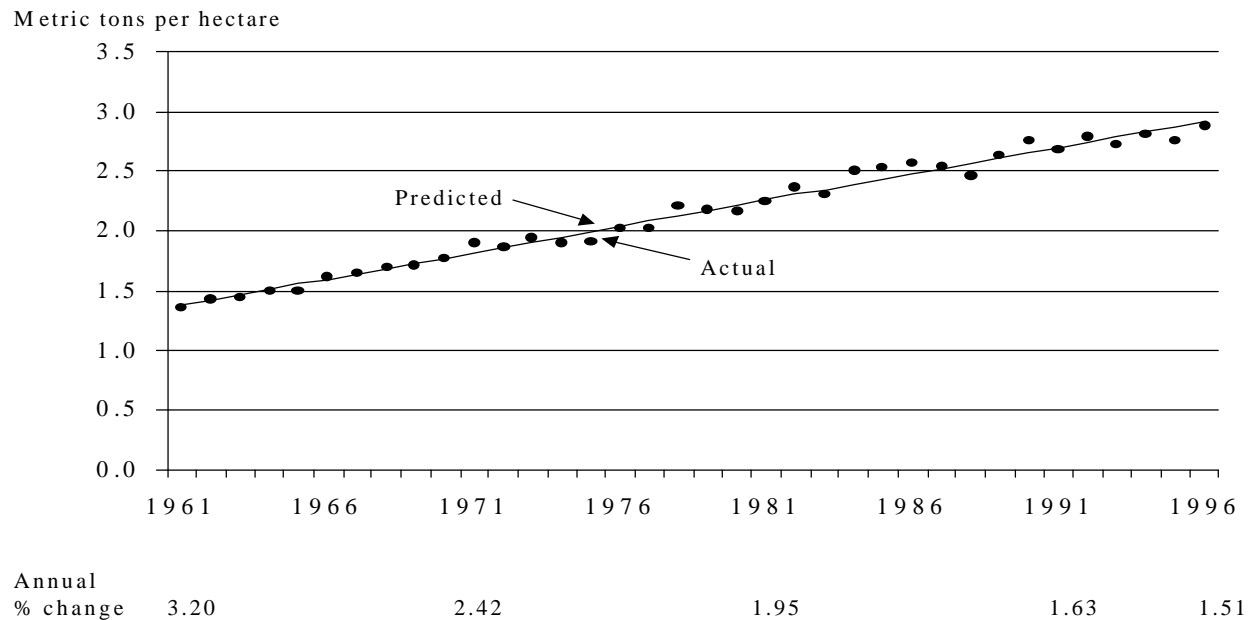
Supply of Food

Only yield data are shown because global harvested area in each of the five major crop categories except oilseeds was almost the same in 1996 as in 1961 and is not expected to change markedly in the future without considerably higher food prices (see Tweeten 1997 for details on this and other analysis in this section).

Cereals. Past cereal supply trends display notable characteristics:

- From 1961 to 1996, global cereal yields expanded around the straight line predicted by Thomas Malthus (Figure 4). The rate of gain averaged 44 kilograms per hectare per year.
- Clusters are apparent of approximately five years of flat yields followed by a sizable yield gain.
- The linear yield line implies declining percentage rates of yield growth. For example, the 3.2 percent trend growth rate for cereal yield in 1961 fell by half to 1.6 percent in 1991. If global population continued to grow at the 1.7 percent annual trend rate of 1990, the portents for world food security would be onerous indeed.

Figure 4. World cereal yields, 1961–1996.



Source: FAO (1997).

Other Crops. Yield graphs (not shown but in Tweeten 1997) for other crops also show linear trends apparent for cereals in Figure 4. In Table 3, projected yields are merely extensions of historic linear yield trends. Yield percentage gains for other crops are lower than for cereals. Like cereals, percentage rates of yield increase were slowing although, unlike cereals, the rates of gain were not halved between 1961 and 1990.

Table 3. World crop yield and demand (population and income per capita) trend growth rates by selected years.

Yield or demand	Historic				Projected					
	1961	1970	1980	1990	2000	2010	2020	2030	2040	2050
	(Percent per year)									
Supply (yield gain)										
Crops ^a										
Cereals	3.20	2.48	1.99	1.66	1.42	1.25	1.11	1.00	0.91	0.83
Vegetables and melons	1.79	1.54	1.34	1.18	1.06	0.95	0.87	0.80	0.74	0.69
Pulses	1.01	0.93	0.85	0.78	0.72	0.68	0.63	0.60	0.56	0.53
Roots and tubers	0.82	0.77	0.71	0.66	0.62	0.59	0.55	0.52	0.50	0.47
Oilseeds	0.49	0.47	0.45	0.43	0.41	0.40	0.38	0.37	0.35	0.34
Total (weighted average) ^a	2.78	2.18	1.77	1.49	1.28	1.14	1.01	0.92	0.84	0.77
Demand										
Population gain										
IIASA (Lutz <i>et al.</i>)	1.83	2.03	1.85	1.74	— ^b	1.47	1.13	0.87	0.67	0.51
UN (medium)	1.83	2.03	1.85	1.74	1.44	1.24	1.08	0.88	0.65	0.48
World Bank (Bos <i>et al.</i>)	1.83	2.03	1.85	1.74	1.47	1.28	1.09	0.91	0.68	0.57
Income effect gain (see Annex Table 1)	0.40	0.38	0.36	0.33	0.31	0.29	0.27	0.24	0.22	0.20
Total demand gain										
UN pop. plus income	2.23	2.41	2.21	2.07	1.75	1.53	1.35	1.12	0.87	0.68
Excess demand										
Demand less yield gain	c	c	c	c	0.47	0.39	0.34	0.20	0.03	-0.09
Price impact										
Price flexibility (3.0) times excess demand	c	c	c	c	1.41	1.17	1.02	0.60	0.09	-0.27

^aExtension of linear trend (see Tweeten 1997). Yields of livestock and other crops are assumed to increase at the weighted (by calories) average for the five crops shown to form the total weighted average yield.

^bNot predicted for year 2000.

^cNot included because depended on stocks, government diverted area, and other considerations not considered in this study.

Livestock. Data comparable to those for crops in Table 3 are not available for livestock and livestock products. However, livestock offer only limited opportunities to expand productivity of agriculture. They require more resources per calorie of food than do crops. Also, they may offer fewer opportunities for productivity advances than do crops. The Office of Technology Assessment (p. 18) projected the following growth rates in American animal production technology from 1982 to year 2000:

<u>Annual growth (%)</u>	<u>Annual growth (%)</u>
Pounds beef per pound feed 0.2	Pounds pigmeat per pound feed 0.6
Pounds milk per pound feed 0.2	Pounds poultry meat per pound feed 2.0

If these rates are representative of world conditions, they provide little optimism that livestock productivity gains will improve food security. Nonetheless, livestock remain an excellent means to utilize land unsuited for crops,

provide a buffer for consumption when crops fail, supply high quality protein and other nutrients, and are a favored food as income rises.

Comment on Yields. In summary, global yield trends for crops and measures of livestock feeding efficiency provide a sobering picture for consumers. The hypothesis cannot be rejected that global yield trends from 1961 to 1996 are linear. If the past yield trends persist, can supply expand enough to meet the growing demand for food without higher real farm and food prices to bring more land into crop production?

Demand Trends

Demand for food is driven by two major components—population and income. Population growth is the more important of these two drivers.

Demographers are projecting a population trend turnaround: the world seems headed for zero population growth (ZPG) in the not too distant future after growing exponentially for at least two centuries. Progress towards ZPG is apparent in all world regions except Africa.

Table 4 shows the year and number of people when zero population growth is achieved as projected by the United Nations (UN medium), World Bank (by Bos et al.), International Institute for Applied Systems Analysis (IIASA by Lutz et al.), and by Steven Mosher (p. A-16) and Dennis Avery (p.7). The five estimates for global ZPG range from year 2030 and 7 billion inhabitants by Mosher to year 2128 and 11 billion inhabitants by the World Bank.

Table 4. Total and annual food demand growth to ZPG from 1995^a

Study	ZPG Population ^b (billion)	Years to ZPG ^b (Year[s])	Per capita food demand increasing: ^c					
			0.2%/year		0.3%/year		0.4%/year	
			Demand growth		Demand growth		Demand growth	
			Total	Annual	Total	Annual	Total	Annual
<hr/>								
<div>(Percent)</div> <hr/>								
Mosher	7.0	35 (year 2030)	34	0.84	39	0.94	44	1.04
Avery	9.0	45 (year 2040)	76	1.26	84	1.36	92	1.46
IIASA (Lutz)	10.5	89 (year 2084)	124	0.91	144	1.01	167	1.11
UN (medium)	10.3	99 (year 2094)	124	0.82	147	0.92	173	1.02
World Bank (Bos et al.)	11.3	133 (year 2128)	163	0.73	201	0.83	243	0.93

Source: see text.

^a1995 world population 5.6 billion.

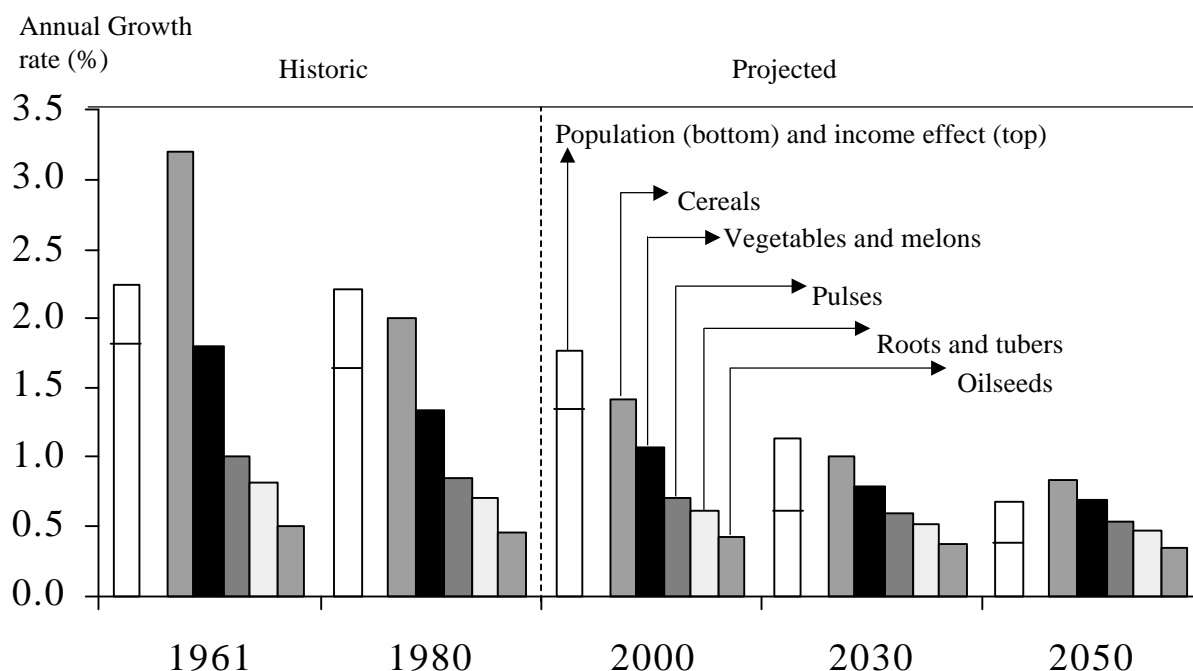
^bWhen data from the source was incomplete, the ZPG population and year was projected using a quadratic equation fitted to available data.

^cSEE TWEETEN 1997, ANNEX TABLE 1, FOR DETAILS.

Overall food demand depends on income as well as population. The most likely scenario is for global aggregate food demand to increase by 0.2 to 0.4 percent per capita annually on average due to rising incomes (Tweeten 1997). At a 0.3 percent rate, *per capita* food consumption gains by ZPG over 1995 range from 10 percent (Mosher, president of the Population Research Institute) to 49 percent (Bos et al. for World Bank). Adding the impact of population growth to income, total demand for food is projected to increase from 39 percent (Mosher) to 201 percent (Bos et al.) from the 1995 level before ZPG is reached. The latter estimate implies that food production will have to triple from 1995 levels before reaching global ZPG.

To address whether expected demand increases will cause real food prices to rise, Table 3 and Figure 5 summarize supply (yield) and food demand trends by decade to year 2050. Projected rates of yield gain are merely extensions of the linear yield trends from 1961 to 1996.¹ Population estimates in Figure 5 are medium UN projections.

Figure 5. Global demand growth rates (from income and population) contrasted with crop yield gains.



Source: Population projections from United Nations (medium).
Yield data from FAO (1997).

Three supply/demand balance periods characterize data in Table 3 and Figure 5: first is prior to 1980, when cereal yield gains on average exceeded demand gains. Real food prices fell sharply and reserve capacity accumulated as diverted acres, storage stocks, and subsidized exports. The trend reversed in the 1980s, but America had enough reserve capacity in commodity stocks and diverted acres to avoid rising real food prices. Real commodity prices at the farm level were not much different in 1996 from a decade earlier, however.

Now that America's reserve capacity of diverted cropland, accumulated stocks, and subsidized exports is spent, a second era, one of potential food insecurity, is apparent to 2040. On average, demand is projected to increase faster than yields. Without yield advances in excess of those anticipated or slower population growth, real prices for farm food ingredients are likely to rise to draw more land and other resources into food production.

A third period emerges after 2040. World demand is expected to increase 0.68 percent per year (medium UN population, 0.20 percent per capita demand growth) in 2050, somewhat less than projected annual crop yield growth of 0.77 percent in 2050 (Table 3).

The prospect of rising real farm and food prices is real, but warrants neither panic nor complacency. In year 2000, demand growth is likely to exceed all crop and livestock yield growth by 0.5 percent per year. A 0.5 percent

¹ Population forecasts by Avery and Mosher are omitted from Table 3 and Figure 5 because they do not provide population estimates prior to ZPG.

global excess food demand growth would raise the price of farm food ingredients 1.5 percent annually. The shortfall of yield growth below demand growth is less and hence price increments are less after year 2000 (Table 3).

Although real farm level food prices may rise in developed and developing countries on average for the next three decades, any increase is likely to be readily absorbed and indeed hardly noticed by consumers in developed countries. Americans, for example, on average spend only 2 percent of this income on farm food ingredients. Even a doubling (absurd) of farm food ingredient prices would reduce consumers' real income only 2 percent. However, rising real food prices are a hardship for low income families at home and abroad because they spend a much higher proportion of their income on food than does the average American family. Farmers benefit from price increases, but are cautioned against excessive bidding for land. Instability will continue to be the major economic problem for commercial farmers, and cyclical downturns in economic conditions could punish land market plungers.

Finally, it is important to note that the data are imperfect and that distant predictions become especially unreliable. Such unreliability could, of course, result in a more or less favorable food supply-demand balance than depicted in this analysis. Realizations of population estimates by Avery and Moser (see Table 4) or major yield-enhancing biotechnology breakthroughs would continue to lower real farm and food prices.

What Explains Conversion of Agricultural Land?

We observed earlier the magnitude of agricultural land converted to development. Two major “generic” forces work to influence this loss of cropland. First, greater profitability of farming and numbers of people on farms create demand for cropland, raise land prices, and retain or expand land in agriculture. The second force is nonfarm development in broad terms, creating demands for cropland to move into urban and other build-up uses. The pressures for development are expressed by per capita income and numbers of nonfarm people.

Thus, level of cropland is the result of the interaction between farm and nonfarm forces. At issue is whether lack of demand for land in farming (low farm profitability and farm population) versus high demand for development (high incomes and nonfarm population) is the major cause of farmland loss.

The contribution of farm and urban influences to cropland was estimated from cross sectional data by state for agricultural census years from 1949 to 1992. Changes in cropland by state were estimated by multivariate statistical analysis as a function of changes in farm population per square mile, urban population per square mile, and the ratio of gross farm income per person on farms to per capita income in the state (see Annex 1). The theory is that a rising ratio of farm income per capita to income of all state residents per capita, or a rising farm population would tend to keep more cropland in farming. Alternatively, a rising ratio of income of all state residents per capita relative to farm income per capita and a rising urban population would convert cropland to other uses.

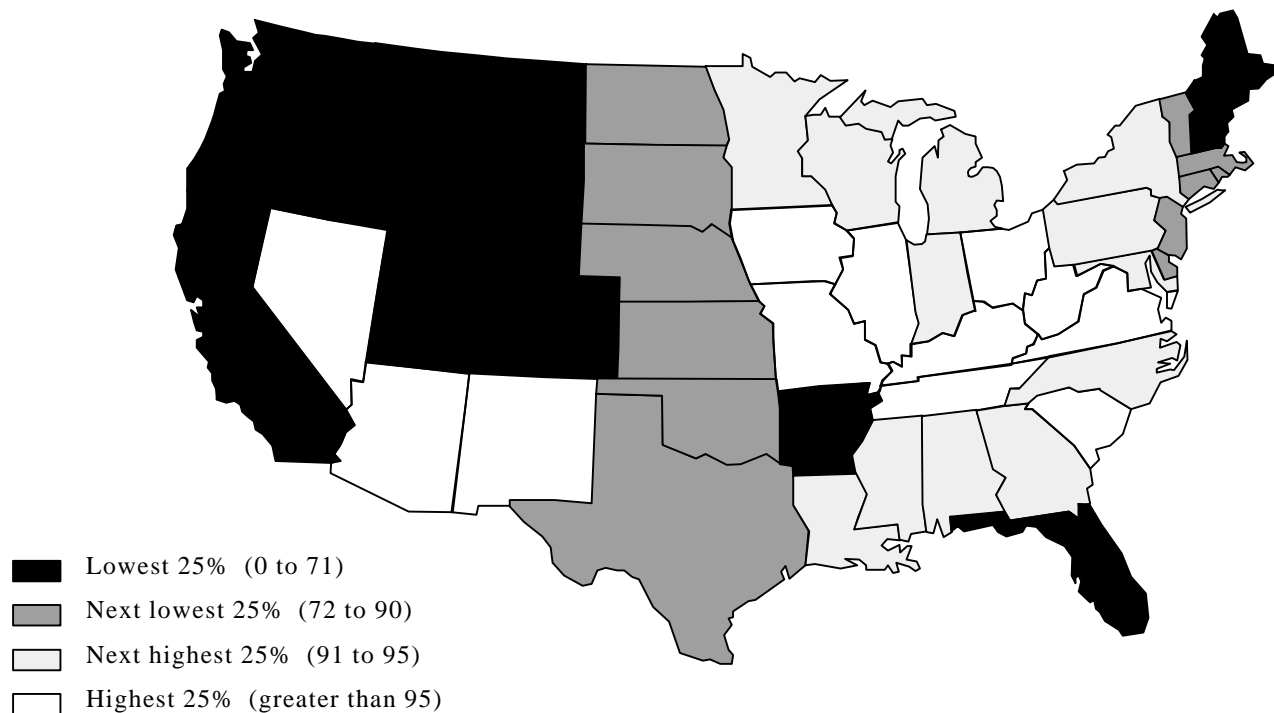
The proportion of cropland loss due to farm sources (lack of farm competitiveness for land) was calculated by multiplying the change in independent variables between 1949 and 1992 times their respective statistical coefficients (Annex 1). This predicted change in cropland due to farm variables (farm population and per capita farm income relative to per capita state income) was then expressed as a percent of the predicted change in total cropland from 1949 to 1992 from the statistical equation shown in the Annex. The farm share for the United States, i.e., the proportion of the cropland change predicted from the change in farm income and population, was 74 percent. The urban share was the proportion of the cropland change predicted from the change in overall state income per capita and urban population and was 26 percent for the United States. In Ohio, the proportion of cropland loss due to urban factors was estimated to be 4 percent and the loss due to farm factors was 96 percent.

State results are shown in Figure 6. Farm influences on cropland loss were least in the Mountain, West Coast, and New England, plus Arkansas and Florida. Farm influence or inability of farming to compete for land to avoid cropland loss was greatest in the Midwest and upper South regions. Alternatively, urban influences were greatest where farm influences were least—the Mountain, West Coast, and New England regions, plus Arkansas and Florida.

The implication of this modest and preliminary statistical analysis is that lack of farm economic viability rather than urban encroachment is the principal reason for cropland loss. This result is consistent with the earlier conclusion from Table 1 that principal cropland losses have been to forest, recreation, wildlife, and other uses rather than to urban development.

It would be tempting to conclude that the best way to hold cropland in farming would be to raise farm commodity prices. Earlier analysis suggests that favorable economic conditions may hold cropland in current use in the next few decades better than did the less favorable economic conditions of recent decades. Government interventions to improve the farm economy's attractiveness through price supports or transfer payments would be a prohibitively costly policy to preserve farmland.

Figure 6. Percentage of loss in cropland due to farm-related sources between 1949 and 1992.



Source: see Annex 1.

What Policy Options are Appropriate to Make Wise Use of the Nation's Land?

Competition for land grows out of its many, valued potential uses: growing crops, grazing, forest, recreation, wildlife, scenery, housing, stores, factories, roads, reservoirs, airports, and the like. For most resources, markets are allowed to allocate land to the highest and best use. In contrast, the public has chosen to intervene in land markets because private costs (benefits) often differ from social costs (benefits). That is, many of the costs and benefits of proper land use accrue not to land market participants, but to others. Markets have shortcomings in such circumstances. Thus, public interest in private property often is expressed through the political system.

The foregoing analysis highlighting that the future global food supply/demand balance is likely to be tighter on average than experienced since World War II in no way implies food shortages and political turmoil in the United States. The prospectively tighter global food demand/supply situation primarily threatens poor nations, especially African nations where food production has fallen per capita and where dependence on food aid imports is substantial.

How much are Americans willing to sacrifice to conserve agricultural land and devote financial resources mostly to help third-world countries? An unanticipated turnaround to very slow technological advancement and more rapid world population growth than expected coupled with a cycle of unfavorable weather could create a world food crisis. Chances that at least one global food crisis will occur before year 2030 are very high. Should individual states such as Ohio take action now to prepare for this contingency?

Ohio accounts for 2.5 percent of the nation's farm production, not far from the 2 percent average per state. And the nation accounts for 10 percent of world food production. Hence, Ohio accounts for only 0.25 percent of global production. The land resource accounts for no more than 20 percent of farm output; other resources account for the rest. Hence, Ohio's farmland accounts for no more than 0.05 percent of world food output. Even doubling Ohio's food output would have little impact on global food security. Such small impact is unlikely to motivate Ohio's citizens to pay the high cost of preserving farmland from development to promote third-world food security. They probably prefer to be "free riders," waiting for other states and nations to make sacrifices to preserve resources for food security.

Every state and nation will want to be a free rider and, hence, no one will take action. Thus, preserving farmland to promote world food security requires a national or, better yet, international effort.

Much food processing would remain and food wholesaling and retailing might expand if productive nonfarm development actually expanded to occupy more agricultural land in a state. Value added in a state might be enhanced if more land-intensive economic activity, such as manufacturing plants or national service firm office buildings, absorbed some additional farmland; especially if availability of such land was decisive in promoting job development.

Policies to preserve farmland ideally recognize the diverse interests in farmland: local areas wish to preserve amenity value, states wish to preserve an economic base, and the national government in cooperation with other countries seeks food security. Often, these interests overlap. Coordination of these interests while allowing markets to work where possible will best serve the public. Two public programs discussed below, full marginal cost pricing in land use decisions, and purchase of development rights augment the market to make it function better.

The following public policies are designed to improve market allocations for land as well as other resources by internalizing of externalities and avoiding the “taking” of property—arbitrary reduction in the value of property and unanticipated by the owner.²

Full Marginal (Incremental) Cost Pricing

The highest priority for proper land use is to correct the currently distorted incentives unduly encouraging farmland to be converted to other uses. Costs per capita of community services and infrastructure are high in open spaces, towns, and small cities due to high costs for hospital, postal, road, communication, electrical, school, and fire protection services (Tweeten and Brinkman, pp. 199-222). Costs per capita of community services and infrastructures are high in large urban centers due to cost of crime and air quality control. Tweeten and Brinkman (p. 199) found costs per capita to be lowest in communities of 20,000 to 1 million residents. Surveys show that many Americans prefer living in smaller cities but within easy trade and commuting distance of metropolitan areas. While the Tweeten-Brinkman study is dated, its findings remain sufficiently valid to predict that *full cost* pricing will discourage nonfarmers from residing in open country or inner cities of metropolitan areas. Many Americans believe that people should be mostly free to live where they choose—subject to paying the full cost especially of living in high cost locations.

Figure 7 shows that per capita local government spending rises sharply as annual population growth accelerates. The figure does not directly indicate rising marginal costs of services but undoubtedly catches some of the costs of providing new schools, access roads, utilities, and other services attending community expansion. Measuring full marginal costs is elusive because expanding communities frequently spread the high cost of adding community services among established and new residents. That is, communities often practice average rather than full marginal cost pricing of services.

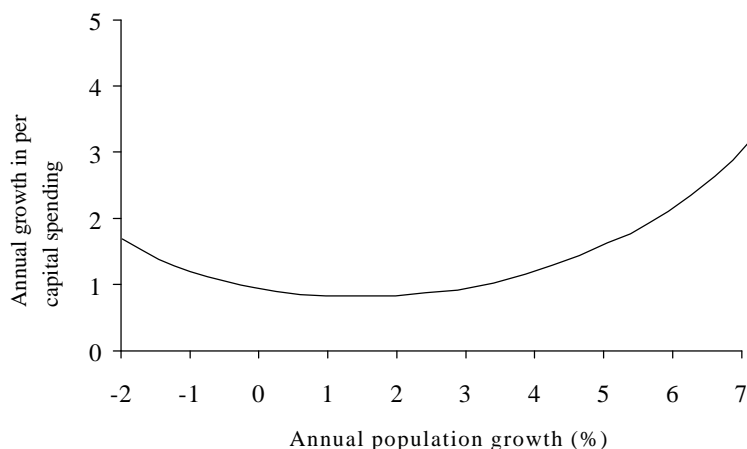
As evidence of unequal taxing among members of the community, Thomas Blaine showed results of studies indicating that *residential* area service demands were \$1.30 to \$1.40 per dollar of taxes paid whereas *agricultural* service demands were only \$0.30 to \$0.40 per dollar of taxes paid. One reason for the disparity between farmers and others is the much greater real estate holdings per capita by farmers than by others. Another reason is because commercial and industrial property pays part of service costs in nonfarm areas. Even with preferential property taxing arrangements, farmers tend to pay higher property taxes per dollar of income because they have substantial investment in real estate per dollar of income. Thus, farmland owners may experience higher taxes as new residents in rural areas are not taxed enough to cover additional costs for new schools and other services. Some communities require developers to pay *impact fees* on new developments to more fully cover marginal service costs for roads, schools, utilities, and other public infrastructure and services.

To be most effective, full marginal cost pricing must be statewide. If impact charges are not statewide, a developer facing fees in one community will shift development to another community practicing average cost pricing. The policy can reduce urban sprawl on farmland, diminish tax burdens on longer-term members of a community imposed by new members, and can slow the abandonment of infrastructure in established areas caused by building

² “Taking” as a legal term usually refers to loss of substantially *all* economic value of a property. Some states recently have decreed that owners can be compensated for “taking” with loss of one quarter of the economic value of the property. In this report, the term “taking” more loosely refers to unanticipated loss of economic value of property.

infrastructure in developing areas. The experience of Florida and other states employing this policy needs to be observed.

Figure 7. The Relationship Between Per Capita Local Government Spending and Population Growth Rate.



Source: Ladd (1992).

Sometimes new residents are charged high costs for services, high impact fees, or sewer hook-up moratoriums as a *de facto* zoning by local NIMBYs (not-in-my-back-yard) advocates to keep out new residents. In other cases, impact fees are legitimate responses to a nuisance LULU (locally undesirable land use). Such efforts may preserve a local landscape but merely send prospective new residents to other rural communities, with no net impact on overall farmland or rural amenity preservation. So while full marginal cost pricing will discourage sprawl, such pricing needs to be used along with other measures to encourage proper land use.

Subsidizing high cost rural services might have made sense in an earlier era when rural areas had a high preponderance of low income farmers who could markedly raise quality of life and reduce isolation with access to services. Such conditions no longer characterize most rural areas. Nonfarmers predominate and poverty rates are only modestly above national averages (Brown and Deavers, Table 5). Ending rural service subsidies would reduce incentives for new residences and cropland loss in rural areas.

Urban sprawl also can be reduced by redevelopment aiming to make cities more livable by recovering and reusing abandoned land and infrastructure sometime called urban brownfields. Redevelopment provides housing choices for those residents who prefer staying in the city and reduces traffic congestion. In many cities, complex administrative procedures, high property taxes, rent controls, zoning, or other measures cause or perpetuate brownfields. Redevelopment costs of \$150,000 or more per acre can result, making farmland development attractive by contrast—especially when cities or other jurisdictions subsidize highways and other services to rural locations.

Some widely used public policies perhaps not intended to influence land use encourage urban sprawl. Some examples of such policies that governments can scrutinize and perhaps adjust are listed below:

Municipal bonds. Tax-exempt municipal bonds often are used to subsidize electrical, mail, school bus, water, solid waste disposal, housing, and other services to rural residents. Most beneficiaries today of these subsidies can afford to pay their own way—whether farmers or nonfarmers. The Farm Service Agency also subsidizes rural utilities and housing with low interest loans. If required to pay their way, some potential open country residents would instead chose to reside in towns and cities where community services cost less and where prime farmland is not sacrificed.

Ending subsidies to rural services and upper middle-class housing mortgages could provide funds to assist the poor, many of whom would choose to locate in low cost areas.

Capital gain tax preferences and mortgage interest tax deductions. The mortgage interest deduction and preferential tax rates on capital gains encourage investment in real estate.³ The result is larger homes on larger acreages, frequently in the country. While home ownership is a social good the public wishes to encourage, the tax advantages could be confined to families with modest real estate holdings—restricting mortgage interest deductions to no more than (say) \$10,000 of mortgage interest per year per family. Indexing capital gains for inflation and taxing real capital gains at the same rate as ordinary income would reduce distortions in taxes currently encouraging overinvestment in residential property. Higher taxes on motor fuels could discourage urban sprawl, reduce traffic congestion, conserve petroleum, reduce pollution, and lessen dependence on foreign oil.

Rural development programs. Governments operate programs specifically to subsidize jobs and place-prosperity in rural areas. Examples are tax abatements, low interest or tax free business loans, technical assistance, and infrastructure and industrial park concessions. New factories, shopping centers, and residences for workers frequently locate on prime farmland—often because such land has topography suited to low cost construction of streets and utilities. Once built up, such land is unlikely ever to return to cropland. Rural development like other programs needs to recognize that people and farms are most likely to make location decision consistent with the public interest if they face incentives that reflect the full costs of their decisions.

Purchase of Development Rights

Efforts to hold land in agriculture that is under threat of development can benefit from a purchase-of-development-rights (PDR) program.⁴ The landowner is paid the capitalized difference between the value of land in development and the value in farming for an easement to development rights for a prescribed period, even perpetuity. The easement is binding if land is sold. Related programs are often carried out by local nonprofit conservation organizations drawing on charitable donations to protect open space and farms at no public cost. A landowner may donate land to the nonprofit organization which in turn preserves the land for conservation or farming through a legally binding conservation easement.

Purchase of development rights (PDR) either by private organizations (e.g. Nature Conservancy, American Farmland Trust) or public agency (e.g. Farmland Protection Program under the 1996 FAIR Federal farm bill) offers special advantages for protection of farmland from development because it operates much like a market with farmland owners compensated for land use restrictions and the public compensated for PDR costs by the food security of land preserved for a time when food has greater urgency.

PDRs avoid coercion, augmenting the market to allow winners to compensate farm landowners for sacrificing rights to higher returns from selling land for development. Preserving farmland for future food security is a public benefit, appropriately paid for by the public with PDRs. It can be argued that farmers cannot be expected to and should not have to pay for protecting farmland through arbitrary restraints dictating to whom and for what the land is sold. However, to avoid possibly huge economic efficiency losses, eminent domain powers allow farmland protected by PDRs to be shifted to other uses serving an overriding public interest.

Although PDRs minimize taking or coercion to save farmland, they have several shortcomings.

- PDRs may never obtain much funding and hence never protect much farmland. According to the American Farmland Trust, less than one-half million acres have been protected through purchase of development rights at a cost of \$800 million or \$1,800 per acre (Williams, p. 4B). According to contingent valuation studies, the public is willing to pay only modest amounts for preserving agricultural amenity

³ Ordinarily taxes need to treat alternative sources of wealth equally to avoid distortions in investment in land and other assets. Current tax laws violate that principle by taxing *nominal* capital gain at rates less than ordinary income. The impact is to favor investment in farmland to realize capital gains. However, land held for long periods with high inflation is likely to face very high real tax rates on real capital gains—most of the tax will be on inflated real estate values which are no real gain in wealth. Many long-term landowners refuse to sell because of the high real tax rate on their capital gain, thereby perhaps keeping land in agriculture. Thus, the *net* effect of capital gains (taxes) on keeping land in agriculture is difficult to judge. While computational burdens would pose problems, much can be said for indexing capital gains for inflation and then taxing real gains as ordinary income to promote tax neutrality.

⁴ A related Transfer of Development Rights (TDR) program transfers development rights from parcels where preservation is desired to parcels where development is targeted. A TDR program typically is operated by a local government because it requires some degree of land use planning.

values—well below the value of land in farming or development (see Poe, pp. 14, 43). If PDRs are never funded well enough to protect a significant amount of farmland, some would agree that is “revealed preference” i.e. the public has gotten what it wants.

- PDRs do not avoid the free rider problem. That is, each individual, firm, or agency will defer to others to pay for preserving farmland, so no one will preserve much farmland. This problem can be reduced by public action, dedicating tax revenues such as from cigarettes to pay for development rights.
- Poorly funded, fragmented PDRs may worsen urban sprawl. That is, PDRs may force new developments to be dispersed, raising service and infrastructure costs. Attempts to contain development by ringing cities with PDRs may merely cause development to leapfrog the ring. Meanwhile, developers can encourage new residents to buy homes near the PDR ring, confident that an undeveloped rural landscape will remain nearby for their enjoyment.

Because a fragmented PDR program encouraging urban sprawl and forcing scattered development of interstices between PDR lands raise costs of infrastructure and services, many believe that rural zoning or a land use plan for utility expansion must attend PDRs. Such zoning can be unrestricted or restrictive. Under very restrictive conditions, only agricultural use is allowed. Under less restrictive arrangements, agricultural processing and input supply firms along with limited housing development are allowed. If one house per 40 acres is allowed, for example, a farmer owning 160 acres could add three houses to his own on his property.

- PDRs may do little to preserve farm production capacity. Preference polls and contingent valuation studies show public interest in protecting farmland and willingness to use taxes to protect farmlands (Bergstrom, Dillman, and Stoll, 1994; Kline and Wichlens, 1994). As reasons for protecting farmland, the public lists environmental objectives as most important, followed by aesthetic objectives, with food security of lesser importance (Kline and Wichlens, 1996). These considerations suggest the PDRs might have higher priority to preserve woods and hills rather than cropland.
- Preserving farmland to provide food security is likely to be the goal only at national and international levels. Without cooperation between local, state, and federal governments to use PDRs to preserve cropland, food security is likely to receive little attention as such. However, the food security option is aided by cropland preserved by states and local governments as an important economic base.

Investment in Science

Science has had mixed influences on preservation of farmland. Crop yields have more than doubled since 1950 due to application of science and technology. In other words, twice as many acres could need to be in crops to produce today's food with the technology of the 1950s. Science and technology have held down land prices, making farmland less able to compete with development (see earlier section). On the other hand, raising output per unit on safe land avoids expansion of crops on fragile land and helps to preserve wildlife, scenic attractions, and recreational areas. Greater investment in gene banks and other measures to conserve biodiversity along with the search for more environmentally benign pesticides and biological controls are helpful adaptations.

Programs that May Supplement the Foregoing Measures to Preserve Cropland

Agricultural interests face intense value conflicts in land use with no easy solutions, only difficult compromises.

Examples include:

1. A commitment to protect farmland from development without compromising farm landowners' cherished rights to sell to the highest bidder.
2. A commitment to protect farmland without compromising rural development programs creating jobs while expanding factories, office buildings, shops, and residences on farmland.
3. A commitment to protect farmland without compromising ability of farmland owners to sell large lots along rural roads to migrants from towns and cities who cherish rural amenities.
4. A commitment to protect rural amenities without compromising farmers' traditional freedom to follow “generally accepted farming practices” even if they emit odors that irritate “rural gentry.”

5. A commitment to full cost pricing of goods and services including energy to discourage urban sprawl without compromising farmers' traditional reliance on low cost diesel fuel, nitrogen fertilizer, and pesticides (all petroleum based).

These are but a few examples of conflicts in land use policy. PDRs, full marginal cost pricing, and investment in science pose some policy conflicts, but are generally consistent with "getting prices right." Despite this advantage, they face political opposition limiting their use. Thus, such programs may need to be supplemented with planning and zoning which, of course, also may be viewed as unwarranted infringements in personal freedom for owners to use land as they please. The following programs may supplement full cost pricing and PDRs to preserve farmland (see Tweeten 1998).

Indicative Comprehensive Planning and Zoning

Planning and zoning have been widely used especially at the local level to encourage desired land use. Planning is called "indicative" because it is intended to be only a guide to sound land use. The objective is for a community or county to decide the direction to take in wise land use before rather than after development pressures arise. Ideally, it is carefully thought out and consistent with the participation and goals of the community rather than a mandate of an elite to be followed at any cost. Such a plan might, for example, call for locating new state facilities away from prime farmland. City and county plans ideally would be consistent with a state land use plan. Ohio recently proposed a comprehensive package of farmland preservation tools that can be a model for other states (Ohio Farmland Preservation Task Force).

Zoning is one of many potential tools for implementing comprehensive land use plans. States ordinarily take no direct zoning action, but empower local governments with planning, fiscal, and regulatory tools for guiding land use. County governments, in most cases, become the principal defender of agricultural land because city governments see farmland as a resource to be converted to build-up uses as the community grows.

Conflicts can be acute. An example is California's Central Valley which has some of the most productive agricultural land in the world coupled with rapid population growth (see Sokolow). Unincorporated portions of counties are targets of intense pressure to approve new residences on large parcels, including ranchettes, rural subdivisions, and farm homesites. Planners and growers typically dislike such patterns because they fragment farm fields, reduce the efficiency of farming, bring new residents opposed to traditional livestock farming practices, place pressures on perhaps already overburdened local services and infrastructure, and make inefficient use of space. States face inefficient use of farmland sold for strip developments of a few acres per lot along county roads. Such inefficient use of farmland is reduced when county zoning boards directs new construction to cities or to land not suited for agriculture. Development in cities also requires land, but is more compact than in rural areas and may be in areas not suited for cropping.

Local government planning and zoning supplement the market. Zoning is designed to avoid incompatible land uses that diminish the value of each use. For example, locating an odiferous food processing plant in the middle of an urban residential area would raise costs to both parties. Residents would experience a lower quality of life and incur expenses to diminish odors in their homes. They might take legal action that would raise the cost of production for the processor. Thus, zoning to separate industrial, residential, and commercial areas can be consistent with sound economics if done properly, but is unlikely alone to save much cropland.

States can encourage comprehensive countywide land use planning to preserve farmland by offering inducements such as current agricultural land use valuation to reduce property tax or exemption of farm property from state estate taxes. Tools for protection include regulation of access to roads and highways; sewer, water, and septic tank restrictions; purchase of development rights; full marginal cost pricing using impact fees; and other measures as discussed in this report.

Urban growth boundaries have been used most notably in Oregon. Communities draw up development plans with provision for roads, sewers, water, and other services that guide development. The state can provide cost-sharing for local governments to formulate such growth-management plans establishing urban growth boundaries beyond which infrastructure will not be extended. While such programs can promote orderly development and conserve farmland, they also can raise real estate prices—as evident by very high housing costs in Portland, Oregon. The result can be severe hardship for low income residents seeking housing.

A number of states provide for *agricultural districts* prohibiting suits against odors or other agricultural "nuisances" within the district. Some states do not allow zoning against such nuisances at least if they are established rather than new nuisances in an area. Producers may be required to follow generally accepted production practices to be exempt from lawsuits. The legal standing of such protections to agriculture increasingly is in doubt, however.

Agricultural zoning entails a public decision to down-zone private land by limiting density of development and restricting nonfarm uses. The economic result is to decrease the development value. It is unacceptable to many agricultural interests who oppose any restrictions on farmland owners to sell to the highest bidder. But, such zoning has been used with success in some areas to preserve agricultural land.

Local zoning options attempt to lower density in agricultural areas or utilize cluster development layouts to protect farmland. One way is through quarter-quarter zoning, which allows one dwelling unit per 40 acres. A 200-acre parcel could accommodate five dwelling units. In contrast, cluster zoning to provide for closer proximity of residences in developments avoids some of the cropland fragmentation that makes farming uneconomic.

Land Use Valuation and Right-to-Farm: Two Popular Options

The extent of intervention in markets to direct land use depends on several factors such as the productivity of local farmland, population growth and economic pressures for development, and the goals and values of residents. *Right-to-farm* legislation protects farmers from lawsuits due to livestock odors or other “nuisances,” often in *agricultural districts* established by law. Such agricultural districts may be favored in other ways as well such as low priority for eminent domain condemnations and subdivision development.

Current Agricultural Use Valuation (CAUV) is widely used to reduce property taxes on farmland whose value is inflated by urban influence. The purpose is to keep land in farming by basing property values and taxes at levels consistent with agricultural rather than urban use. Under most programs, tax concessions at least for the most recent years must be repaid if the farmland is sold for development. The formula for correct use valuation of farm real estate is shown in Annex 2.

Tax deferral or forgiveness reduces the burden on farmers of property taxes inflated by development potential. Such treatment keeps some operators on farms longer by reducing their cash flow problems. Eventually, attractions of selling to the highest bidder are likely to prevail, however. Thus CAUV is unlikely to keep land in farming if owners are allowed to sell to the highest bidder. To keep more land in farms, an alternative is to require repayment of *all* tax reductions (not just three years, as is often the case) plus interest if land is sold for development. A variant of that proposal is repayment of foregone taxes as CAUV land is developed accrues toward purchase of development rights. This latter alternative lacks merit if taxes have higher priority for schools and other uses than for preserving cropland.

Also at issue is an optimal minimum threshold acreage for CAUV eligibility. Having essentially no minimum threshold on eligible acreage unduly encourages urban people to live in “rural” areas to reduce property taxes; a medium threshold such as 5-10 acres may create sprawl and inefficient use of farmland by encouraging urban residents to live on 5-10 acres rather than one-half acre lots, and too high a threshold of (say) 100 acres will not give desired protection for bona fide farms of less than 100 acres. An alternative would be to require crop and livestock sales of at least (say) \$20,000 per year for a farm to be eligible for CAUV.

Similar problems arise if tracts of (say) 5 acres or more are free of community sewer and other subdivision platting restrictions. This policy encourages housing lots of 5 acres or more, converting more farmland than necessary to irreversible residential use.

A *circuit breaker* program used in Wisconsin (the only state without CAUV) limits property taxes after the property tax-income ratio reaches a prescribed threshold. CAUV and circuit breaker beneficiaries are likely to be full time commercial farm operators with considerable wealth. As such, the programs reduce cash flow problems but may transfer income from those with lower to those with higher wealth.

References

Avery, Dennis. “Why the Food Summit Failed.” *Global Food Quarterly* 18:3-7, Fall 1996.

Avery, D. T. and A. A. Avery. *Farming to Sustain the Environment*. Indianapolis: The Hudson Institute, 1996.

Bergstrom, J. C., B. L. Dillman, and J. R. Stoll. “Public Environmental Benefits of Private Land: The Case of Prime Agricultural Land,” *Southern Journal of Agricultural Economics*, 17 (July 1985): 139-149.

Blaine, Thomas. “Does Residential Development in Rural Areas Pay Its Own Way?” Wooster: Ohio State University Extension, 1997.

- Bos, Eduard, My Vu, Ernest Massiah, and Rodolpho Bulatao. *World Population Projections, 1995-95 edition*. Baltimore: Johns Hopkins University Press for the World Bank, 1994.
- Bromley, Daniel. *Agricultural Land as an Environmental Asset*. Madison: Department of Agricultural and Applied Economics, University of Wisconsin, 1997.
- Brown, David and Kenneth Deavers. "Rural Change and the Rural Economic Policy Agenda for the 1980s." Chapter 1 in *Rural Economic Development in the 1980s: Preparing for the Future*. ERS Staff Report No. AGES870724. Washington, DC: Agriculture and Rural Economic Development Division, ERS, USDA, 1987.
- Committee on Soil as a Resource. *Surface Mining: Soil, Coal, and Society*. National Research Council. Washington, DC: National Academy Press, 1981.
- FAO. *Data of Food and Agriculture 1996*. Rome: Food and Agriculture Organization of the United Nations, 1996.
- FAO. FAOSTAT Statistics Database. <http://apps.fao.org>, 1997.
- Heimlich, Ralph and Nelson Bills. "Soils in Urbanized Areas: Changes in Productive Capacity and Limitations for Development." Selected paper presented at the American Agricultural Economics Association annual meeting in Toronto, Canada. Washington, D.C.: Economic Research Service, USDA, 1997.
- Kline, J. and D. Wichelns. "Using Referendum Data to Characterize Public Support For Purchasing Development Rights to Farmland," *Land Economics*, 70 (May 1994): 223-233.
- . "Public Preferences Regarding the Goals of Farmland Preservation Programs, *Land Economics*, 72 (1996): xx.
- Ladd, H. *Effects of Population Growth on Local Spending and Taxes*. Cambridge, MA: Lincoln Institute of Public Policy, 1992.
- Lutz, Wolfgang, Warren Sanderson, Sergei Scherbov, and Anne Goujon. "World Population Scenarios for the Twenty First Century." Chapter 15 in Wolfgang Lutz, ed., *The Future Population of the World*. Laxenburg, Austria: International Institute for Applied Systems Analysis, 1996.
- Mosher, Steven. "Too Many People? Not By a Long Shot." *Wall Street Journal*. February 10, 1997, p. A-18.
- Office of Technology Assessment (OTA). *Technology, Public Policy, and the Changing Structure of American Agriculture: Summary*. Washington, DC: Congress of the United States, 1986.
- Ohio Farmland Preservation Task Force (OFPTF). *Findings and Recommendations*. Report to Governor George Voinovich. Columbus: OFPTF, 1997.
- Poe, Gregory. *Maximizing the Environmental Benefits per Dollar Expended*. EB97-10. Ithaca, NY: Department of Agricultural, Resource, and Managerial Economics, Cornell University, 1997.
- Sokolow, Alvin. "Farmland Policy in California's Central Valley: State, County, and Local Rules." *CPS Brief* 9(4). Berkeley: California Policy Seminar, 1997.
- Tweeten, Luther. "Dodging a Malthusian Bullet in the 21st Century." *Agribusiness: An International Journal*. Vol. 13, 1997.
- Tweeten, Luther. "Food Security and Farmland Preservation." *Drake Law Journal*. 1998 forthcoming.
- Tweeten, Luther and George Brinkman. *Micropolitan Development*. Ames: Iowa State University Press, 1976.

Tweeten, Luther and Jeff Hopkins. "The Economics of Land Restoration and Conservation in an Environmentally Sound Agriculture." Paper presented to Soil and Water Conservation Society meeting in Toronto. Columbus: Department of Agricultural Economics, Ohio State University, 1997.

United Nations. *World Population Prospects: The 1996 Revision*. Annex II and III: Demographic Indicators by Major Area, Region, and Country. New York: UN Department for Economic and Social Information and Policy Analysis, Population Division, 1996.

U.S. Department of Agriculture. *Agricultural Resources and Environmental Indicators, 1996-97*. Agriculture Handbook No. 712. Washington, DC: Economic Research Service, USDA, July 1997.

U.S. Department of Agriculture. Summary Report, *1992 National Resources Inventory*. Washington, DC: Natural Resources Conservation Service, USDA, revised January 1995.

U.S. Department of Commerce. *Statistical Abstract of the United States 1996*. Washington, DC: USDC, 1996.

Williams, Brian. "Must Suburbs Displace Silos?" *Columbus Dispatch*. April 13, 1997, pp. 4B,5B.

World Bank. *From Plan to Market, World Development Report 1996*. New York: Oxford University Press, 1996.

Annex 1

Variables

Cropland: Includes cropland harvested, idle, fallow, failure and in pasture in 1,000 acres per square mile, from ERS-NASS at www.mannlib.cornell.edu/data-set/land/89003

GFII: Ratio of gross farm income, in \$million/farm population from ERS-NASS at www.mannlib.cornell.edu/data-set/farm/93007A divided by dollars of personal income per capita in the state from Regional Economic Information System (REIS). U.S. Table SA2. (Computer printout) U.S. Department of Commerce, Bureau of Economic Analysis, September, 1993 and April 1994. (Statistical results were not improved by replacing gross farm income with net farm income.)

POFA: Farm population of state per square mile from 1990 Census of Population and Housing Summary Tape 3C United States Summary except urbanized areas and their components. U.S. Department of Commerce, Bureau of the Census (CD90-3C-1), reissued May, 1993. [CD-ROM] NOTE: Laami T. Dacquel & Donald C. Dahmann in Residents of Farms and Rural Areas: 1991 [USDA, ERS and U.S. Dept. of Commerce, Bureau of the Census, Current Population Reports, Series P-20 No. 472, August, 1993] estimate U.S. farm population, 1990, at 4,591,000 but do not estimate by States. Source, 1970-1980: *Statistical Abstract of the United States 1985*, Table 1110, p633. U.S. Department of Commerce, Bureau of the Census, December, 1984. Source, 1945-1965: *Farm Population Estimates, 1910-70*. USDA, Rural Development Service (Statistical Bulletin No. 523), July, 1973.

UP: Urban population of state per square mile from U.S. Department of Commerce, Bureau of the Census *State and Metropolitan Area Data Book* (Washington, DC: U.S. Government Printing Office, 1979, 1986, and 1991. Data for 1990 from *1990 Census Lookup*, <http://venus.sensus.gov/cdrom/lookup/848331140>.

Decennial census of population data were adjusted to agricultural census years by linear interpolation except for census year 1992 where decennial census data for 1990 were extrapolated to 1992.

Results

To avoid problems of nonstationary data and multicollinearity, the equation for cropland by state (48 contiguous) was estimated with data in first differences for years 1949, 1954, 1959, 1964, 1969, 1974, 1978, 1982, 1987, and 1992. Results estimated by ordinary least squares are as follows:

Variable	Parameter Estimate	Standard Error	T for H ₀ : Parameter = 0	Prob > T	Mean
Cropland					-0.00205
Intercept	0.00130	0.00069	1.872	0.0619	
GFII	0.00065	0.00074	0.877	0.3812	0.30403
POFA	0.00285	0.00041	6.944	0.0001	-1.00189
UP	-0.00013	0.00005	-2.748	0.0062	5.51363

R² adjusted = 0.1323

Durbin-Watson D = 2.056

(for number of obs.) 432

1st order autocorrelation = -0.03

Annex 2

Appropriate Current Agricultural Use Value Calculations for Farmland

Many misunderstandings arise from failure to properly value farmland (or other durable assets). For example, it is often said incorrectly that farmland is overpriced if it does not cash flow, i.e. if current earnings (rent) does not cover the interest on a fully indebted acre. Yet, it is quite rational to have high land price-earnings ratios if earnings on land are expected to increase in real terms over time. The following analysis demonstrates the correct capitalization formula for land, the cash-flow problems attending land under high inflation rates, and why land properly priced at its current agricultural use value is often incorrectly thought to be inflated (overpriced) by speculation or potential for urban development.

In the following analysis,

R_t= Earnings per acre on land in year t defined as returns to land after subtracting all non-land expenses from gross earnings. R is often measured by cash rent less property taxes.

$P_t =$ Price of land per acre in year t .

i = Annual general inflation rate.

$i' =$ Annual real rate of increase in land earnings R , i.e. the nominal rate of increase in R less the inflation rate i .

$\alpha =$ Market equilibrium (desired) real rate of return on farmland.

It follows that if land returns R_t are expected to increase at rate $i+i'$ (these parameters could be zero), the earnings rate R_t in any year can be expressed as a function of the earnings in the initial year R_0 . R_0 may be known with certainty; most other parameters in this analysis will be expectations. The current rent in year t is

$$(1) \quad R_t = R_0 e^{(i+i')t}$$

where e is the base of natural logarithms. Other functional forms could be used, but the same principles apply that are shown below.

Current land price can be expressed as the discounted value of all future earnings in perpetuity (anyone selling early reaps benefits of all future earnings in the selling price, assuming no transaction cost), so

$$(2) \quad P_0 = \int_{t=0}^{\infty} R_0 \frac{e^{(i+i')t}}{e^{(\alpha+i)t}} dt = \frac{R_0}{\alpha - i'}$$

where the discount rate is $\alpha + i$.

From (2), the current value of farmland per acre is

$$(3) \quad P_t = R_0 \frac{e^{(i+i')t}}{\alpha - i'} = P_0 e^{(i+i')t} = \frac{R_t}{\alpha - i'}.$$

It follows that the current rate of return (R_o/P_o) on farmland is

$$(4) \quad \frac{R_o}{P_o} = \frac{R_t}{P_t} = \alpha - i' \quad (\text{current return rate})$$

The total nominal capital gain rate from (3) is

$$(5) \quad \frac{dP_t}{P_t dt} = i + i' . \quad (\text{total capital gain rate})$$

The total nominal return rate is the current return rate (4) plus the total capital gain rate (5), or

(current return)	(capital gain)	(total nominal return rate from all sources)
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$$(6) \quad (\alpha - i') + (i + i') = (\alpha + i).$$

Note that the current return rate is invariant to inflation. A portion i of this capital gain rate in (6) covers the inflation premium cost, leaving a real return:

(total nominal return) (inflation “cost”) (total real return)

$$(7) \quad (\alpha + i) - i = \alpha.$$

Assume that the interest on a farm mortgage is comprised of a real interest rate α plus an inflation premium i for a total nominal interest rate of $\alpha + i$. The cash-flow shortfall is defined as the shortfall of the current return rate (4) less the mortgage interest on a fully indebted acre, or $\alpha + i$, or

$$(8) \quad (\alpha - i') - (\alpha + i) = -(i + i').$$

Thus, the cash-flow shortfall increases with higher inflation rates and with higher real earning increase i' so that land is a "growth stock."

Land pricing under "normal" conditions

On the average in the 20th century, land earnings have kept pace with inflation although pronounced cycles of deviation from the general pattern are apparent. Thus, taken over the long run, the real earnings rate of gain i' has averaged nearly zero.

If i' is zero and rents are expected to keep pace with inflation, the capitalized value of land from (3) becomes

$$(9) \quad P_o = \frac{R_o}{\alpha}.$$

It is notable that the capitalization rate under these historically "normal" circumstances is the *real* desired (or market equilibrium) return α and *not* the current mortgage interest rate as is commonly, but erroneously, assumed. Historically, α have averaged approximately 0.04 or 4.0 percent, so land price typically is $(1/0.04) = 25$ times net earnings (rent) in a well-functioning market free of urban influence. Thus, if land rent currently is \$120 per acre and is expected to keep up with inflation and property tax is \$20 per acre, then the net rent is \$100 per acre so an investor can pay $25 \times 100 = \$2,500$ and make a 4.0 percent real return on investment.

Land as a growth stock

If land rents are expected to increase (say) 1.0 percent ($i' = 0.01$) in excess of the inflation rate per year, the capitalization rate becomes $\alpha - i' = 0.04 - 0.01 = 0.03$, so current land price is $(1/0.03) = 33$ times rent or \$3,300 per acre if net rent R_o is \$100. If real rent is expected to increase at a rate $i' = 0.02$ or 2.0 percent per year, the capitalization rate is $\alpha - i' = 0.04 - 0.02 = 0.02$. Thus, land price is capitalized at 50 times net rent or \$5,000 per acre given $R_o = \$100$.

Land as a bond

If land is expected to behave like a bond with the same nominal net rent \$100 per year whatever the inflation rate, then $i' = -i$ because *real* rent declines at the inflation rate. Thus, the capitalization formula (3) becomes

$$(10) \quad P_o = \frac{R_o}{\alpha - i'} = \frac{R_o}{\alpha - (-i)} = \frac{R_o}{\alpha + i}.$$

Hence, if $R_o = \$100$, $\alpha = 0.04$, and the inflation rate is expected to be 0.03 or 3.0 percent, then equilibrium land price is $1/(0.04 + 0.03) = 14$ times net rent or \$1,429 per acre.

Concluding comments

It is apparent that, especially with inflation, cash-flow problems differ depending on whether the land asset behaves as it has historically ($i' = 0$), behaves as a growth stock (say $i' = 0.01$), or behaves as a bond ($i' = -i$). If inflation is expected to be 0.04 or 4.0 percent per year, the mortgage interest is $\alpha + i = 0.08$ or 8.0 percent if $\alpha = 0.04$. The current return on farmland R_o/P_o from (9) is 0.04 or 4.0 percent if $i' = 0$. The cash-flow shortfall rate from (8) is $i + i' = 0.04 + 0 = 0.04$ or 4.0 percent. With interest at 8.0 percent and current earnings 4.0 percent,

it follows that current earning from two acres will be required to pay the interest on one acre! Land will seem overpriced and motivate assertions that it is inflated by urban development interests. But, land will not be overpriced because the real rate of return $\alpha = 0.04$ or 4.0 percent will be achieved from farming alone when capital gain of 4.0 percent is added to current return of 4.0 percent.

If land is expected to behave like a bond, the nominal net rent R_o will remain fixed at, say, \$100 per acre through time. This reduces the cash-flow problem. That is because, if $\alpha = 0.04$ and inflation i is expected to be at rate 0.04 or 4.0 percent, the capitalization rate from (10) is 0.08 and the current return on land R_o/P_o is $\alpha + i = 0.08$ or 8.0 percent. With current earnings of 8.0 percent and mortgage interest at 8.0 percent, land “cash-flows.” But as indicated, this is not ordinarily the case in farming. The usual capitalization rate is the real return $\alpha = 0.04$ rather than the “bond” return $\alpha + i$.

The market has conformed to the above formulas, although market participants individually have not necessarily understood this. Consequently, many perceive that the farmland price is unduly influenced (and overpriced for farming) by urban influence. But such land that will not cash flow is often correctly priced for agricultural use alone based on capitalization at the real rate α which may realistically assume that land earnings from farming will keep pace with inflation as it has over the long run.

Land with a high price-earnings ratio and, hence, believed to be “overpriced” because of urban development potential may not be overpriced for agriculture alone when the proper capitalization formula (2) is applied. Nonetheless, many citizens may prefer to provide property tax relief to farmland because farmers tend to pay high property taxes relative to their current income.