Urban and Built-Up Land Area Changes in the United States: An Empirical Investigation of Determinants

Ralph J. Alig and Robert G. Healy

Conversion of commodity-producing rural lands to urban and other built-up uses received considerable attention in the professional literature and in the popular press in the early 1980's (U.S. Department of Agriculture and U.S. Council on Environmental Quality 1981; Fischel 1982; Raup 1980; Brown, et al. 1982). Although some have concluded that the forces encouraging the conversion of land will remain and become stronger (e.g., Barron and Dickinson 1975), few empirical studies at regional or national levels have examined determinants of area changes for urban and built-up uses or supported long-term area projections of such uses. Possible determinants include the inter-regional distribution of population growth and patterns of land use within regions, particularly patterns of human settlement. Both types of determinants are subject to change in the future and both might reasonably be influenced by public policy. If we understand how built-up area is determined, it may be possible to project and even to deliberately influence the future level of land consumption for built-up uses.

This study critically examines alternative measures of built-up area, including the two major data series currently available for the United States; presents a regression model of changes in built-up area; and makes long-term national projections of built-up area under alternative assumptions. For purposes of this article, the term "urban" will be used only in its more restrictive sense of "census-defined urban territory" and the term "built-up area" will be used to denote population concentration more generally.

Urban land area in the United States as a whole has been steadily increasing over the last two decades. According to Census of Population data,[1] urban area increased by 9 million acres during 1960–1970 and 13 million acres during 1970–1980 (Frey 1984). Mean urban acreage per person has also increased (i.e., decrease in urban population density), rising from 0.20 in 1960 to 0.23 in 1970 and to 0.28 in 1980. In addition, a surge of residential construction in rural areas as well as major growth in rural industry, highways, airports, and power plants would seem to imply significant expansion in the amount of built-up land not classified as urban.

Built-up uses are notable for several characteristics. In market value per acre, built-up uses tend to easily dominate other uses. Prices for built-up land are nearly always considerably higher than the $1,000–$3,000 per acre generally commanded by crop production or the $200–$800 per acre associated with timber production.

The term built-up uses as applied is often a misnomer because residential lands, the largest component of the urban area total, are only partially built-up. Less than half of the typical residential lot is actually covered by a structure. The ratio is far lower in most rural areas. At the extreme, say with rural residential

The authors are, respectively, Project Leader, U.S.D.A. Forest Service, Southeastern Forest Experiment Station, Research Triangle Park, North Carolina; and Senior Associate, The Conservation Foundation, Washington, D.C.

Portions of this research were funded by the U.S.D.A. Forest Service, Resources Program & Assessment, Washington, D.C. Tim Marty provided valuable research assistance. The authors would like to thank Fred C. White, Richard Forstall, James Short, William Fischel, and anonymous reviewers for helpful comments and suggestions.

[1] Frey (1984) suggests that data on urban area reflect an increasing tendency to include vacant land within urban area boundaries; thus, decadal comparisons may tend to overstate the areal extent of urbanization activity.

Land Economics Vol 63. No. 3, August 1987
0023-7639/00/-0001 $1.50/0

tracts in the range of 5–40 acres, considerable opportunities exist for wildlife and watershed use, and perhaps even some limited agricultural, grazing, or forestry activities.

Many nonresidential lands, for which site improvements occupy only a small portion of relatively large tracts, are also classified as built-up. For example, rural industrial plants and associated improvements (e.g., parking lots) often occupy 10 percent or less of their sites, with the remainder in pasture or forest. Airports such as Dulles (Washington, D.C.) and Tallahassee cover large areas, much of which is dense forest. This is equally true for scout camps, schools, and cemeteries. Little of this land is now used for commodity production but may be available for such use should future demand warrant it.

Existing Measures of Built-up Area

Only two measures of built-up area are available on a consistent basis for the nation as a whole.[2] The first is the acreage in "urban" areas published decennially by the U.S. Bureau of the Census as part of the Census of Population. This measure is available for the years 1950, 1960, 1970, and 1980, although there have been some relatively minor definitional changes over time.[3] The second is the built-up area data (subdivided into several categories) collected by the U.S. Department of Agriculture, Soil Conservation Service (SCS) as part of its National Resources Inventory (NRI). Because of definitional changes, most of the data from the most recent survey in 1982 are not comparable to other SCS surveys for prior years.

Census Urban. The "census urban" measure is calculated after each decennial census by the Geography Division of the U.S. Bureau of the Census. Urban areas are defined on the basis of population levels and densities, and then mapped. The census defines two kinds of urban areas: (1) "urbanized areas," defined as an incorporated place and adjacent densely settled surrounding area that together have a minimum population of 50,000. The density cutoff at the urban fringe is, with some exceptions, 1,000 persons per square mile. Urbanized areas are further subdivided into "central city" area and area outside the central city. (2) "Other urban areas," defined as incorporated or unincorporated places with populations of 2,500 or more, located outside of urbanized areas. For an incorporated place, with rare exceptions, the entire area within corporate limits is designated as urban; for an unincorporated place, which in 1980 was termed a "census-designated place" (CDP), the cutoff point is where population density falls below 1,000 persons per square mile. However, according to a Census Bureau analyst, "We use the density criterion (for CDP's) only as a guideline—we try to identify a 'community-like clustering of people.' Also, we have to make our defined urban places end at some physical boundary, such as a road, stream, powerline, or mountain range. Thus some of our places tend to be overbounded."[4]

In 1980, the Census Bureau identified as urban territory a total of 46.9 million acres in the 48 contiguous states,[5] of which 33.1 million were in urbanized areas and 13.8 million were "other urban" land. Urbanized area population density was an average of 2,765 persons per square mile, against 1,286 for other urban areas.

For the purposes of measuring land economically removed by human settlement from the renewable resource base, the Census Bu-

[2] Area data published every 5 years (e.g., Frey and Hexem 1984) by the Economic Research Service of the USDA include rural transportation areas not in the Census urban data, but they perhaps are best viewed as a source of supplementary data rather than as a substitute for census urban data.

[3] For our purposes, the most relevant change is a decision in 1980 (see *Federal Register*, March 25, 1980) to make it easier to designate certain smaller than-average places as urbanized areas (UA). This change added 60 UA's (to bring the total to 366 in 1980) that would otherwise not have qualified. Criteria for designating UA's seem more likely to allow pockets of lightly populated land to be designated as urban than do the criteria for designating urban land outside of UA's. Thus the definitional change may overstate the actual change in urban land between 1970 and 1980. Definitional changes also preclude a time series analysis of urban area data.

[4] Joel Miller, 1984, personal communication. It should be noted that the objective of the Census Bureau is to measure urban population and the urban area measure is collected for that purpose, rather than for land classification purposes.

[5] All subsequent U.S. area or population data in this paper exclude Alaska and Hawaii.

reau's urban land measure has two major limitations, which tend to work in opposite directions. On one hand, defined urban areas undoubtedly include some land that can be (and is being) used for agriculture, for grazing, and probably to a far lesser extent, for wood production. Such land is most likely to be found in the urbanized areas and in incorporated parts of other urban areas because of the Census Bureau's practice of defining nearly all land within incorporated boundaries as urban. This procedure also leads to regional bias. The procedure overstates the amount of urban land in areas of the country where incorporation of new municipalities or annexation of lightly settled urban fringe areas to existing cities is easy and understates the amount of urban land where incorporation or annexation of such areas is relatively difficult.

The tendency of census urban to overstate built-up land is offset, however, because the measure considers only "urban" settlements. It takes no account of the land occupied by the 55.9 million persons living in rural areas. Moreover, although census urban includes such facilities as roads and airports if located within incorporated places or inside urbanized areas, it does not include land devoted to those uses in rural places or on the urban fringe.

Soil Conservation Service NRI. The measure of built-up area developed by the SCS in its NRI is quite different from that of the Census Bureau. SCS has taken several periodic surveys of the nation's land use, beginning in 1958. The latest was taken in 1982, with final figures released in July 1984. Because of definitional changes, built-up area data for 1982 are not comparable to those of prior years (Lee 1985). However, the 1982 survey is believed by SCS to be much more accurate than earlier surveys and special emphasis was given to the measurement of built-up area.

The NRI is based on approximately 900,000 sample points, with data collected on the ground by SCS field personnel. Because data are derived from a sample, NRI built-up land figures are statistically valid only for aggregated areas, including states, and a set of 105 county aggregates called Major Land Resource Areas.

The NRI contains three separate data categories relevant to measuring built-up land (U.S. Department of Agriculture, Soil Conservation Service 1984):

1. Urban and built-up land which includes land in residential, industrial, commercial, and institutional uses and land in rail yards, airports, landfills, spillways, and water control structures, where any of those uses occupy more than 10 acres (46.3 million acres in 1982);
2. farmsteads and ranch headquarters (10.7 million acres in 1982); and
3. small built-up areas which include the uses defined in 1. above, when they occupy fewer than 10 acres but more than 0.25 acres (5.2 million acres in 1982).

One important feature of the NRI data classification, which is markedly different from that of the Census Bureau, is the attempt to exclude areas devoted to crops, forestry, or similar purposes even when they were within a parcel or a contiguous area that was otherwise built-up. For example, the extensive woodland within the boundaries of Washington, D.C.'s Dulles Airport is classified by the NRI as forest. The same was done for forest or cropland surrounding factories. Similarly, an undeveloped area of more than 10 acres within a developed area would be classified according to land cover and not, as is the general practice with the census urban data, as urban.

Overall, the NRI data appear to give a relatively "tight" measure of built-up land, with consistent treatment of land in incorporated and unincorporated areas. This tightness is perhaps best illustrated by the fact that the Census Bureau identifies 46.9 million acres of land as urban, whereas the NRI identifies 46.3 million acres as "urban and built-up land." The NRI measure includes not only all the land occupied by the urban population, but also land occupied by nonfarm rural built-up uses larger than 10 acres.

A comparison of estimates of per capita land consumption further indicates the relative tightness of the NRI measure of built-up area. We computed census urban area per urban resident and NRI total built-up area (sum of the three NRI categories above) per resident

(either urban or rural) for the nine U.S. Bureau of Census regions. Although the NRI measure encompasses built-up areas that would not be classified as urban by the Bureau of Census, the average land consumption per person for the 48 contiguous states is 0.28 acres in both cases. The standard deviations are likewise similar, with the NRI-based statistic (0.25) slightly larger than the census value (0.22). Further, even though the two surveys measure somewhat different categories of built-up land, the correlation coefficient between the census urban and NRI developed area measures across the 48 contiguous states is 0.93.

Census urban estimates of land consumption per capita are larger than the NRI estimate in the three Southern regions, the New England, the Middle Atlantic region, and the Pacific region. The NRI average built-up area per resident (0.48 acres) is notably larger than the census urban figure (0.36 acres) in the predominantly agricultural West North Central region.[6] Conversely, the census land consumption per capita value (0.48 acres) is highest for the East South Central Region, while the corresponding NRI value is 0.32. The lowest per capita land consumption estimates for both surveys are for the Middle Atlantic region, where both are approximately 0.18 acres.

MODELING BUILT-UP AREA

Previous Studies

Few previous studies have attempted to model the relationships between expansion of urban or built-up areas and economic and demographic variables at the regional or national level. Coughlin, et al. (1977) summarized several studies of the amount of land urbanized per new person in various parts of the country. Land consumption per additional person ranged from 0.071 acres (for "48 western counties, 1950–1960") to 0.481 acres (for "3 rapidly growing counties in Florida, 1957–1969"). Then, using 41 counties in the eastern half of the United States as observations, Coughlin, et al. estimated urban area in 1970 as a function of population density and as a function of housing density. In both cases the relationship was quite close but nonlinear (i.e., the proportion of county land area classified as urban increases at a decreasing rate as population density or housing density increases).

Thamodaran et al. (1981) estimated a regression relationship between urban land area (including urban roads, industrial space, and small parks) and explanatory variables such as population and housing density for the years 1960–1970. Units of observation were 105 agricultural production regions. Estimated relationships were linear, with positive and significant coefficients for population and for housing density. Regional dummy variables were significant for groups of states in the Corn Belt and Great Lakes area, Delta States, Mountain States, Southern Pacific States, and Northern States.

Alig (1986) estimated econometric models of six land uses in the United States Southeast by using time series of land use data for the entire land base (available only for that region) collected during 1949–1984 in periodic surveys by the USDA Forest Service. Zero sum restrictions were imposed for explanatory variables across land use equations to satisfy the fixed land base constraint. Urban population and personal income were consistently significant in explaining the share of land devoted to urban and related uses. Logarithmic models outperformed linear models.

Other studies have investigated land use change for selected parts of the country or regions. Zeimetz, et al. (1976) found considerable regional variation in urban and residential densities, with land development at higher densities than previous for fast growth areas. Brueckner and Fansler (1983) examined 40 selected urbanized areas across the country (with 1970 populations ranging from 52,000 to 257,000), concluding that urban spatial area is related to population, income, and agricultural rent. They infer that the land market balances the gains and losses from urban sprawl, restricting spatial growth when the process consumes a valuable resource such as land.

[6] It is noteworthy that farmsteads and ranch headquarters (NRI data category 2.) occupy 45% of the NRI total built-up land in this region, compared to the average of 17%.

Findings of the aforementioned studies suggest several avenues of investigation that might produce further insight into determinants of the expansion of built-up area. First is the opportunity to analyze the newly available built-up area data from the 1982 NRI and to compare the results with analysis of the 1980 census data. Second, there is the opportunity to analyze how various settlement patterns (e.g., central city and suburban, other urban, rural) are related to land occupancy. Third, it is possible to investigate whether significant regional variations exist for land consumption. A final research question to explore is the significance of farmland values in influencing built-up area expansion, using data corresponding to urbanized areas and also state level data.

Model Specification

Six regression equations were specified with dependent variables representing urban and built-up area. Two are based on census data for 363 urbanized areas (in the contiguous 48 states): (1) central city area and (2) urbanized area outside central cities. In addition, state level data were analyzed to develop regression equations for (1) the extent of urban area as defined in the 1980 Census of Population; (2) changes in census urban area between 1970 and 1980; (3) the extent of total built-up area defined by the 1982 NRI, consisting of the sum of area in the three NRI data categories described above; and (4) the extent of small built-up area for NRI data category 3.

Urbanized area is hypothesized to be a function of urban settlement patterns—represented by urban populations of central cities and urbanized areas outside central cities—and per capita income and farmland price per acre. Investigation of how settlement patterns influence land occupancy is conditioned by the delineation of central cities and surrounding closely settled territory for urbanized areas by the Bureau of the Census. Although central cities and suburbs are integrated economically, an urban density gradient exists as suggested by location theory (Alonso 1964). Based on the 1980 census, central cities have a population density of approximately 5.6 persons per acre, compared to 3.4 persons per acre for urbanized area outside central cities.[7] Estimating separate urbanized area equations for central cities and other urbanized area is useful in attempting to isolate differences in development density related to population, income, and farmland values.

Squared population terms are included to represent the nonlinear expansion of an urbanized area as the urbanized area population increases. Coefficients for the squared population variables are hypothesized to be negative to reflect that larger urban areas have larger densities. This occurs because of the desire to take advantage of agglomeration economies (e.g., employment, shopping, other services) that make it worthwhile to substitute capital for land.

Per capita income is included because of the hypothesis that urban land is a superior good, so that per capita land consumption rises with real income (Alonso 1964). Farmland price is included to test the hypothesis that urban land consumption is inversely related to farmland values, with urban fringe residents in areas of high agricultural land prices economizing on land by adopting more compact settlement patterns or smaller lots. Ideally, this variable should represent raw farmland values, which do not include the value of buildings and other improvements. However, a consistent set of raw farmland value data was not available, and Census of Agriculture farmland values (land plus improvements) were used as a reasonable proxy to reflect regional variations in farmland values.[8]

---

[7]The central city population density is higher in 332 of the 363 urbanized areas. There also appears to be no regional patterns for those 31 cases where the central city density is lower: Northeast—4, North Central—6, South—13, and West—8.

[8]County farmland values are from the U.S. Bureau of the Census, *Census of Agriculture, 1982*. Farmland values corresponding to urbanized areas were derived by selecting the county or counties containing an urbanized area. If multiple counties were involved, the arithmetic mean of farmland values across those counties was computed. Candidate counties with less than 30 farms were excluded (e.g., Queens county in the New York-NE New Jersey UA).

Independent variables in the census urban area equation are similar, except for the aggregation of population by urbanized areas and outside urbanized areas.[9] Changes in census-defined urban area between 1970 and 1980 are hypothesized to depend on changes in total urban population, levels of per capita income, and levels of farmland values.[10]

Change in NRI-defined total built-up area are hypothesized to depend on the same variables as census-urban land, with the exception that the level of rural population is added as an independent variable. This reflects the fact that the NRI measure includes rural built-up areas that would not be classified as urban by the Bureau of the Census. In order to look more closely at the determination of these smaller built-up places, we estimated a sixth regression, relating NRI-defined "small built-up areas" to rural population and to the average price of farmland.

The hypothesized equations are of the following form:

$$\begin{aligned}
\text{CC} &= a_1\,\text{CCPOP} + a_2\,\text{CCPOP}^2 + a_3\,Y \\
\text{UAOCC} &= b_1\,\text{OUAPOP} + b_2\,\text{OUAPOP}^2 + b_3\,Y + b_4\,\text{FARMVAL} \\
\text{URBNAREA} &= c_1\,\text{UPOP} + c_2\,Y + c_3\,\text{FARMVAL} \\
\text{UA7080} &= d_1\,\text{UPOP7080} + d_2\,\text{Y} + d_3\,\text{FARMVAL} \\
\text{NRIDEV} &= e_1\,\text{UPOP} + e_2\,Y + e_3\,\text{FARMVAL} + e_4\,\text{RURPOP} \\
\text{NRISBU} &= f_1\,\text{FARMVAL} + f_2\,\text{RURPOP}
\end{aligned}$$

where:

a_i, b_i, c_i, d_i, e_i, f_i = regression coefficients;
CCPOP = central city population;
OUAPOP = population in urbanized areas outside central cities;
UPOP = total urban population corresponding to the urban area defined by the Bureau of the Census;
Y = per capita personal income;
FARMVAL = value per acre of farmland and improvements;
RURPOP = rural population (which the Bureau of the Census defines as that not classified as urban);
UPOP7080 = total urban population change 1970–80.

Each equation was estimated with its intercept going through the origin. This follows from the expectation that developed uses such as urban areas will only arise with economic activity and the occurrence of human population. The six equations were estimated by the SAS regression package.

Impacts of zoning and differential assessment on the conversion of land to developed uses were not directly examined in our cross-sectional analysis for several reasons. First, local zoning varies so much that the urbanized area and state level data probably do not sufficiently reflect it. Second, previous research (e.g., Stoll, et al. 1984) has suggested that differential assessment does not appear to have been generally successful in forestalling the conversion of eligible land to noneligible uses.

[9] Attempts were made to use state level data dividing urbanized area population among central cities and suburbs, but the results were biased by very high multicollinearity. Such a division also would be affected by the fact that in some parts of the country, particularly the South, central cities can easily annex land that elsewhere would be incorporated as separate suburban towns.

[10] Changes between the 1970 and 1980 censuses noted in footnote 3 pertaining to the designation of urbanized areas preclude a meaningful division of urban population between urbanized and other areas for use as independent variables in a change equation. Farmland values used in the state level regressions were obtained from the U.S. Department of Agriculture, Economic Research Service, *Farm Real Estate Market Developments*.

TABLE 1

REGRESSION RESULTS FOR THE HYPOTHESIZED U.S. DEVELOPED AREA MODELS

Independent Variable	Dependent Variable (Area)					
	Central City	Urbanized Area Outside Central City	Census Urban	Change in Census Urban 1970–1980	NRI Total Built-up	NRI Small Built-up
Total urban population			0.20*		0.12*	
			(12.95)		(5.60)	
Central city population	0.15*					
	(22.25)					
(Central city population)^2	1.71E-8*					
	(−15.73)					
Urbanized area population outside central cities		0.26*				
		(37.61)				
(Urbanized area population outside central cities)^2		1.14E-8*				
		(−10.37)				
Change in urban population 1970–1980				0.27*		
				(8.54)		
Personal income	1.58*	2.45*	0.06*	0.03*	0.06	
	(4.93)	(3.10)	(2.50)	(2.78)	(1.86)	
Farmland value		−1.63	−0.02	0.03	−0.15	−0.01
		(−0.53)	(−0.16)	(0.69)	(−1.33)	(−1.01)
Rural population					0.67*	0.10*
					(6.36)	(14.20)
R^2	0.76	0.94	0.91	0.82	0.93	0.90
F ratio	373.2	1460.5	155.6	69.1	142.1	213.1
n	363	363	48	48	48	48

*Significantly different from zero at the 0.05 level. Numbers in parentheses are *t*-statistics.

Results

Results of the regression procedure are presented in Table 1. The explanatory power of the equations is high, with coefficients of determination ranging from 0.76 (for the central city equation) to 0.94 (for the equation for urbanized area outside central city) and F-values were all significant at the 0.01 level. As hypothesized, the most important determinants of built-up area were the population and personal income variables. Moreover, variation in type of settlement pattern did seem to make a difference in the amount of land consumed.

Results for the population variables were significant in all built-up area equations and appear to have coefficients of reasonable size. Multicollinearity problems precluded estimating separate coefficients relating land consumption to the populations of urbanized areas and "other urban" areas for the state level data.

Coefficients for the various population variables across equations are consistent in terms of per capita land consumption. Central city population has a coefficient (0.15 acre per person at the mean) that is about half of that for urbanized area population outside central cities (0.26). For the equations based on state level data, the urban population coefficient for census urban area (0.20) is larger than the one (0.12) for the corresponding urban population variable for the tighter NRI measure of urbanization. Within the NRI total built-up area equation, the same urban population coefficient is much lower than the rural population coefficient (0.67).

Personal income was significantly related

to built-up land area in cross section for the urbanized area equations and the state-level regressions for census urban area. The effect of income on land consumption for the state-level NRI total built-up equation may be attenuated by the inclusion of the rural built-up area, which appears to be shaped by somewhat different forces than are operating in urban areas.

The farmland price variable was not significantly related to land consumption in any of the regressions, at either the urbanized area or state levels. This finding appears to indicate that built-up uses are so dominant in general over agricultural uses in the land market that the level of farmland prices has no measurable influence on built-up land consumption. This contradicts Brueckner and Fansler's (1983) findings that agricultural rent had a negative impact on urban land consumption in 40 urbanized areas.

After this initial run, the model was reestimated to see whether any unique regional processes were at work in selected regions in determining built-up area (see Table 2). Two dummy variables were tested, one representing the Northeastern states, the other the Southern states. (In the reestimation, variables not significant at the 0.05 level in the first estimation of the model were dropped.) The South dummy was significant and positive in the equations, including explaining both the level and change in state-level census urban area. These findings tend to confirm our hypothesis that even when type of settlement is held constant, Southern states tend to have more built-up land per capita than do states in other regions. A notable difference is between the size of the coefficient for the Southern dummy in the census urban and NRI total built-up equations. This may be associated with the relatively greater reliance on incorporated area boundaries in the census measure of urban area and the relative ease with which towns and cities in many southern states can annex new territory. This implies that, given our interest in measuring interregional variations in actual built-up areas, the NRI estimate, with its relatively smaller South/non-South difference, may be the most relevant. The Northeastern states dummy was not significant.

Linear models out-performed log-linear models and nonlinear specifications. Interaction terms between income and population and between farmland values and population proved to be statistically insignificant.

Projecting Future Built-up Area

The regressions just described were used to simulate the impact on land consumption of alternative assumptions about future total population, settlement patterns, interregional distribution of the population, and personal income levels. Projected estimates of built-up area can then be factored into the many long-range projections of future supply and demand for crops, animal products, and forest products (e.g., U.S. Department of Agriculture, Forest Service 1982). The same regression coefficients for the independent variables were used for each scenario, with the levels of selected independent variables changing between scenarios.

Projections of total population to the year 2000 by state, prepared by the USDC Bureau of Census (1983), were used for the baseline built-up area projections for the census urban and NRI measures. National population is projected to increase by approximately 40 million people by the year 2000, equal to about a one-fifth increase over the 1980 population. This projected increase is 15% less than the U.S. population increase over the last twenty years. Populations in the South and West are projected to increase the most rapidly, with a projected increase of 31% for the South and 45% for the West by the year 2000.

Baseline projections of personal income were based on an annual real rate of change of 2.1% up to the year 2000. This is thought to be a conservative estimate, developed from an examination of different projections of economic activity in the U.S., including medium level projections of the GNP annual rate of growth in the range of 2.5 to 3.4% by the USDC Department of Commerce, Bureau of Economic Analysis. It is also lower than the real annual rate of income growth of approximately 3.4% between 1970 and 1980. At an annual real rate of growth of 2.1%, personal income levels would increase by approximately 37% over the next 15 years.

TABLE 2

REGRESSION RESULTS FOR THE FINAL VERSIONS OF THE U.S. DEVELOPED AREA MODELS

Independent Variable	Dependent Variable (Area)					
	Central City	Urbanized Area Outside Central City	Census Urban	Change in Census Urban 1970–1980	NRI Total Built-up	NRI Small Built-up
Total urban population			0.19* (17.06)		0.13* (6.01)	
Central city population	0.15* (23.23)					
(Central city population)^2	−1.69E-8* (−16.29)					
Urbanized area population outside central cities		0.26* (38.74)				
(Urbanized area population outside central cities)^2		−1.14E-8* (−10.55)				
Personal income	0.63* (1.82)	1.50* (3.42)	0.03* (2.80)	0.03* (5.84)		
Farmland value					0.63* (6.44)	0.10* (20.62)
Rural population						
Change in urban population 1970–1980				0.23* (7.78)		
South dummy^	16035.3* (5.70)	9294.3* (2.51)	0.57* (5.84)	0.19* (4.07)	0.34* (2.01)	
R^2	0.78	0.94	0.95	0.87	0.93	0.90
F ratio	312.5	1486.5	284.7	98.8	195.8	425.1
n	363	363	48	48	48	48

*Significantly different from zero at the 0.05 level. Numbers in parentheses are *t*-statistics.
^Dummy values for the urbanized area equations are in terms of acres, and the state-level Census Urban and NRI values are millions of acres.

The first projection to the year 2000 is based on the baseline projections of state populations and personal income. Distribution of total U.S. population among urban and rural components in the year 2000 is assumed to be the same as in 1980. Given these assumptions, census urban area for the 48 contiguous states is projected to increase from 46.9 million acres in 1980 to 56.1 million acres in 2000. The NRI measure of total built-up area is similarly projected to increase from 62.2 million acres in 1980 to 70.9 million acres by 2000.

In the next scenario, a change in the 1980 population settlement distribution was examined in relation to a revival of urban population growth relative to rural population growth. Currently, about three-quarters of the population lives in urban areas. During the 1950's and 1960's, urban population in the U.S. grew substantially, while rural population declined. But during the 1970's, the relative rate of population growth of urban and rural areas was quite similar (rural, +10.4%; urban, +11.9%). No data on urban versus rural growth are available since 1980, but there is evidence from county mobility data that urban population may again be growing relatively faster than rural population.[11] In this scenario, urban population as a percentage of total population was increased to 80%. The same regression coefficients as in the first scenario were used and the only change was in the distribution of future populations between urban and rural settings. In this scenario, the projected census urban area is 58.3 million

[11] Figures for 1980 to 1984 are from a Bureau of the Census geographical mobility report for 1984. Unfortunately, complete urban population growth data are unavailable for the period since 1980.

TABLE 3

CURRENT ESTIMATES OF URBAN AND BUILT-UP USES AS PERCENTAGES OF THE TOTAL LAND BASE IN THE CONTINENTAL UNITED STATES, AND AS PERCENTAGES OF THE CROPLAND BASE, WITH PROJECTIONS TO THE YEAR 2000.

Measure	Current Percentage	Projected Percentage of Total Land Base for the Year 2000			
		A[1]	B	C	D
Census urban (1980)	2.5	3.0	3.1	2.9	3.3
NRI (1982)	3.3	3.7	3.4	3.8	3.7
		Projected Percentage of Cropland Base for the Year 2000			
Census Urban	10.0	12.0	12.4	11.9	13.1
NRI	13.3	15.1	13.9	15.2	15.1

[1]A = Baseline projection
B = Projection with relative urban growth
C = Projection with change in assumed interregional population shifts
D = Projection with 50% increase in projected personal income

acres and the projected NRI built-up area is 65.1 million acres.

The third scenario involves the possibility of future interregional shifts in population different from those projected by the Bureau of the Census. In contrast to the Bureau of the Census's population projections of much faster growth in the South and West than in the East and Midwest, we assumed that, either as a result of deliberate policy or market forces, all regions of the United States will grow at the national average percentage rate. In this case, the projected census urban area figure is 55.8 million acres and the NRI measure is 71.3 million acres.

The fourth scenario involved increasing the baseline projection of personal income by 50 percent in each state. This is to test the sensitivity of census urban area to notably higher projected changes, compared to the projection baseline, for the personal income variable in the associated regression equation. The resulting projected census urban area is 61.6 million acres.

The ranges of the percentage of the total land base in the 48 contiguous states occupied by built-up uses for the three sets of projections are 2.9% to 3.3% for the census urban area measure and 3.4% to 3.8% for the NRI total built-up measure (Table 3). As a projected percentage of the current cropland base, the projected built-up areas in the year 2000 are also small, falling well below 20%. The ranges of projected percentages of land occupation are narrow relative to both the total land base and cropland base.

No urban area projections were available in published sources with which to compare against this study's projections. The projections indicate that assumptions regarding the distribution of people within a region are more important, in terms of impact on projected built-up area, than those for interregional growth in population. Projected census urban area is more sensitive to assumptions regarding personal income than the NRI measure. However, in terms of physical occupation of the land base, the projected built-up percentages are rather small.

CONCLUSIONS

Continued spread of "irreversible" built-up uses over the rural landscape in recent decades has led many observers to wonder about the degree to which their expansion was affecting the availability of land for agricultural and forestry commodity production and for recreation. Bureau of the Census figures for the first half of the 1980's indicate a reversal of the relative rural growth pattern of the 1970's. However, physical occupation of the land base by built-up uses is projected in this study to remain below 4% over the next two decades for the U.S.

Expansion of built-up uses into rural areas

has other important impacts besides the actual conversion of land from rural uses. Expectations of neighboring landowners about the future use of their land may be influenced, generally reflected in higher asking prices. Property taxes may also rise, reflecting the new, higher land values.[12] Composition of landownership may change, with an increasing proportion of landowners being primarily nonfarmers, although the land may still be used for farming, often on a rental basis. In addition, as expectations about future urban uses rise, land is typically divided into smaller parcels. This can have profound impacts on the economics of farming or forestry, even when the land is not physically altered in any major way (Healy and Short 1981; Row 1978). Aggregate studies such as this cannot identify the amount of higher quality rural land, including prime farmland, that may be converted to built-up uses. There are also "juxtaposition effects"—spatially bounded externalities that affect adjoining or nearby land (Healy 1985*a*). These effects may be either positive (e.g., a new reservoir raises recreational attractiveness of nearby land) or negative (e.g., new non-farm residents object to spraying of herbicides on farmland or to clearcuts or controlled burns on forest land) (Bradley 1984).

Existing measures of urbanization, particularly the U.S. Bureau of the Census, probably err on the side of overgenerous inclusion, by labeling as "built-up" some land that is still to some extent available for rural productive uses. Realistically, one might hope for good data on the extent of physical occupancy of land by the various built-up uses, but even physical occupancy is somewhat ambiguous. Although the term "paved over" has frequently been used to describe urban land, only a tiny fraction of the land so classified is literally paved. Many of our urban areas contain significant amounts of land used for agriculture, particularly for various high-value horticultural products. On the other hand, existing urbanization measures fail to measure impacts such as the impermanence syndrome and problems of juxtaposition through which urbanization affects land that is otherwise classified as forest, range, or some other nonurban category. One can not accurately estimate the net effects on the productivity of rural land for agriculture and forestry uses of these opposing impacts.

NRI data appear to be more useful to the resource analyst than census urban data, although the absence of a time series is a major shortcoming. It must be emphasized, however, that the tightness of the NRI measure also implies that it does not include the very considerable amount of land that is indirectly affected by development (e.g., reduced parcel size), even though it is not actually occupied by built-up uses.

Regional variations in the land settlement patterns include the relatively fast population growth in the South. This is occurring in a region where rural population is higher than on average and where urban densities are relatively low, so that relatively more land is consumed by urban population expansion (Healy 1985*b*). Relationships such as these among different sectors of the economy that are dependent, at least in part, on the land base should be examined carefully when exploring policy options related to agricultural and forest productivity, rural and urban development, and property and income taxes.

References

Alig, Ralph J. 1986. "Econometric Analysis of Forest Acreage Trends in the Southeast." *Forest Science* 32(1):119–34.

Alonso, William. 1964. *Location and Land Use: Toward a General Theory of Land Rent*. Cambridge: Harvard University Press.

Barron, J. C., and T. E. Dickinson. 1975. "Social, Economic, and Institutional Constraints Affecting Production and the Reservation of Agricultural Land in the U.S.A." *Agriculture and Environment* 2: 147–63.

Bradley, Gordon A., ed. 1984. *Land Use and Forest Resources in a Changing Environment: The Urban/Forest Interface*. Seattle: University of Washington Press.

Brown, David L., Michael F. Brewer, Robert F. Boxley, and Calvin L. Beale. 1982. "Assessing Prospects for the Adequacy of Agricultural

[12] Nearly all states, however, allow deferral or abatement of taxes based on use value assessment for land kept in agriculture or forestry.

Land in the United States." *International Regional Science Review* 7(3):273–84.

Brueckner, Jan K., and David A. Fansler. 1983. The Economics of Urban Sprawl: Theory and Evidence on the Spatial Sizes of Cities. *Review of Economics and Statistics* 50 (Aug.): 479–82.

Coughlin, Robert E., et al. 1977. *Saving the Garden: The Preservation of Farmland and Other Environmentally Valuable Land*. Philadelphia: Regional Science Research Institute.

Fischel, William A. 1982. "The Urbanization of Agricultural Land: A Review of the National Agricultural Lands Study." *Land Economics* 58(2):236–59.

Frey, H. Thomas. 1984. *Expansion of Urban Area in the United States: 1960–1980*. USDA Economic Research Service Staff Report No. AGES830615. Washington, D.C.

Frey, H. Thomas, and Roger W. Hexem. 1984. *Major Uses of Land in the United States: 1982*. U.S. Department of Agriculture, Economic Research Service, Washington, D.C.

Healy, Robert G. 1985*a*. "Population Growth in the U.S. South: Implications for Agricultural and Forestry Land Supply." *Rural Development Perspectives* 2(1):27–30.

———. 1985*b*. *Competition for Land in the American South*. Washington, D.C.: The Conservation Foundation.

Healy, Robert G., and James L. Short. 1981. *The Market for Rural Land: Trends, Issues, Problems*. Washington, D.C.: The Conservation Foundation.

Lee, Linda. 1985. "Urban and Built-up SCS Data: An Historical Perspective." In *Farmland Retention in the Southeast*, pp. 46–54. *Proceedings of the Conference on Land Retention in the Southeast*, Knoxville, Tenn., Mar. 22, 1984. State Coll., Miss.: Southern Rural Dev. Center.

Raup, Philip M. 1980. "Competition for Land and the Future of American Agriculture." In *The Future of American Agriculture as a Strategic Resource*, Sandra S. Batie and Robert G. Healy, eds. Washington, D.C.: The Conservation Foundation.

Row, Clark. 1978. "Economics of Tract Size in Timber Growing." *Journal of Forestry* 76:576–82.

Stoll, John R., et al. 1984. *Differential Assessment of Agricultural Lands in the South*. Mississippi State: Southern Rural Development Center.

Thamodaran, R., Burton English, and Earl O. Heady. 1981. *A Statewide Projection of Agricultural Land Losses to Nonagricultural Land Uses*. Working Paper, Iowa State University: Center for Agricultural and Rural Development.

U.S. Bureau of the Census. 1983. *Provisional Projections of the Population of States, by Age and Sex: 1980 to 2000*. Current Population Reports, Series P-25, No. 937. Washington, D.C.

U.S. Department of Agriculture and U.S. Council on Environmental Quality. 1981. *National Agricultural Lands Study. Final Report*. U.S. Government Printing Office, Washington, D.C.

U.S. Department of Agriculture, Forest Service. 1982. *An Analysis of the Timber Situation in the United States, 1952–2030*. USDA Forest Resource Report 22. Washington, D.C.

U.S. Department of Agriculture, Soil Conservation Service. 1984. *Natural Resources Inventory: A Guide for Users of 1982 NRI Data Files*. USDA Soil Conservation Service unnumbered report. Washington, D.C.

Zeimetz, Kathryn A., et al. 1976. *Dynamics of Land Use in Fast Growth Areas*. USDA, Economic Research Service, Agricultural Economic Report No. 325. Washington, D.C.