USGS
science for a changing world

Geographic Analysis and Monitoring Program

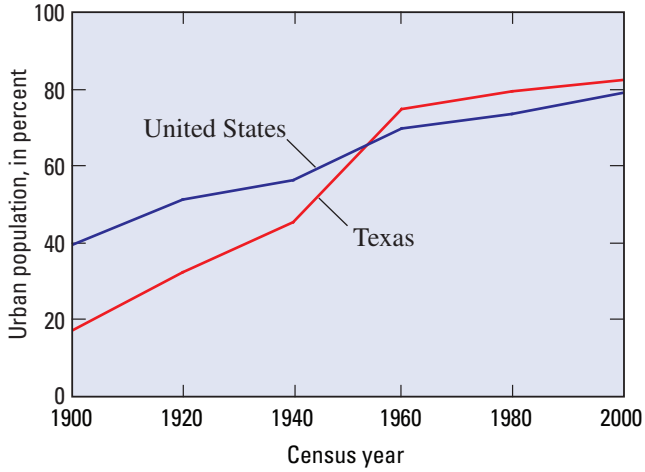
National Urbanization Monitoring Assessment (NUMA)

A core geographic science element of the U.S. Geological Survey's Geographic Analysis and Monitoring (GAM) Program is to monitor land-surface change for the Nation through time.

The Nation's land surface is dynamically evolving and transitioning in response to natural and human processes. The need to understand the transformations and locations where changes are taking place, their underlying causes, and the rate at which the transitions are occurring is fundamental to the health and viability of the Nation's natural and developed environments.

Development of a systematic urbanization monitoring capability is a fundamental requirement to increasing our understanding of human-induced land transformations that are occurring on the Nation's landscape and the possible consequences that may result in the future from continued urban land-use transitions.

Land-use policy decisions in both urban and rural landscapes influence and shape how these natural and human environments respond to landscape change processes. Thus, the GAM Program needs to have the capability to monitor, analyze, estimate, and forecast temporal states of the Nation's urban form in order to provide the scientific foundation for managing the Nation's land and natural resources.



Analysis of 20th century urban population composition for the United States and State of Texas.

Environmental and Societal Issues

The U.S. population has become more urban each decade through the 20th century. Most of the urbanization through time has occurred in suburban and exurban landscapes (that is, non-metropolitan counties) and is less a result of land-use development in metropolitan counties. As rural populations migrated to predominantly urbanized landscapes, metropolitan areas became the catalyst for urbanization driven by population and economic growth. The improvement in telecommunications and attraction to natural and cultural amenities has resulted in urban development spreading into regions where few inhabitants resided prior to 1990.

According to research by the Metropolitan Institute at Virginia Tech University, between 1960 and 2000 the Nation's urbanized population grew by about 80 percent, and the urbanized land area grew by about 130 percent. From 1985 to 2001, U.S. Housing and Urban Development and Census Bureau data quantify that about 40 percent of the 19 million new housing units built were on lots of

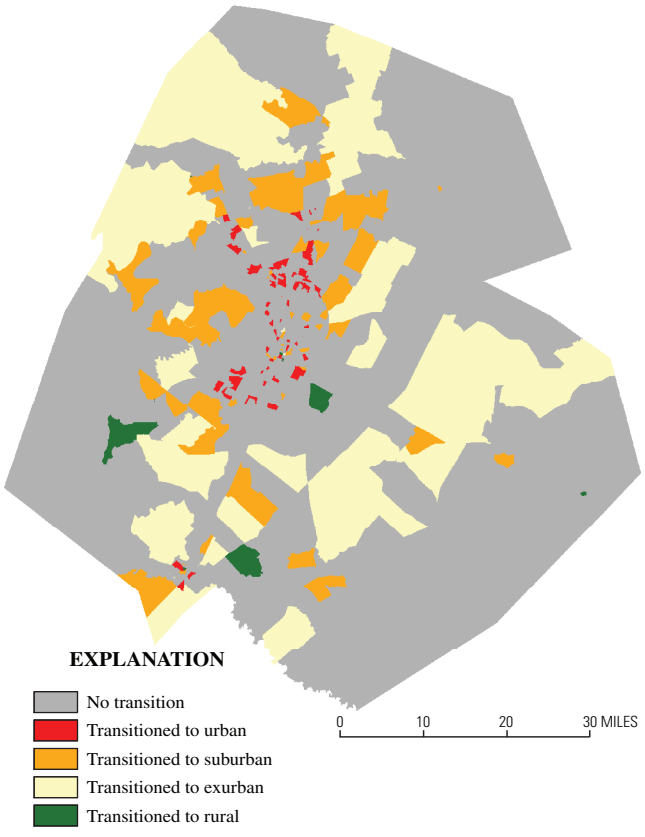
Land-use development near Berthoud, Colorado.

1 acre or larger. Each year the Nation converts more than 3,000 square miles of land to large-lot residential development. The suburbs of the 1970s now act as "anchors," according to research by the Brookings Institution Metropolitan Policy Program, and project population growth even farther away from urban cores. The more affordable land on the periphery of the urbanized area is encouraging low-density land-use development on the farthest edges of metropolitan areas.

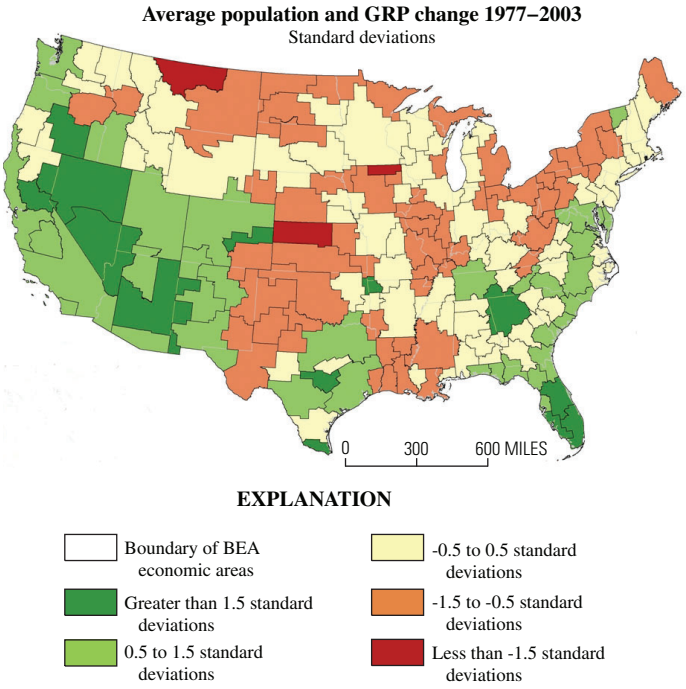
Research Assumptions

Metropolitan areas continue to be the economic engines driving regional urbanization, and urban growth follows economic growth.

Transformation of the natural land surface and subsequent urbanization tend to follow population and housing densification thresholds. Extension and improvement in the existing urban infrastructure enable this land transformation. Regions experiencing economic growth evolve from rural and exurban densities to suburban and urban land-use patterns.



Housing unit density transitions, 1990–2000, Austin–Round Rock metropolitan statistical area, Texas.



U.S. population and gross regional product (GRP) average growth rates computed for economic areas.

Low-density land-use development on the urban fringe and in unincorporated rural areas is occurring at a faster rate than urbanization in the denser urban and suburban environments.

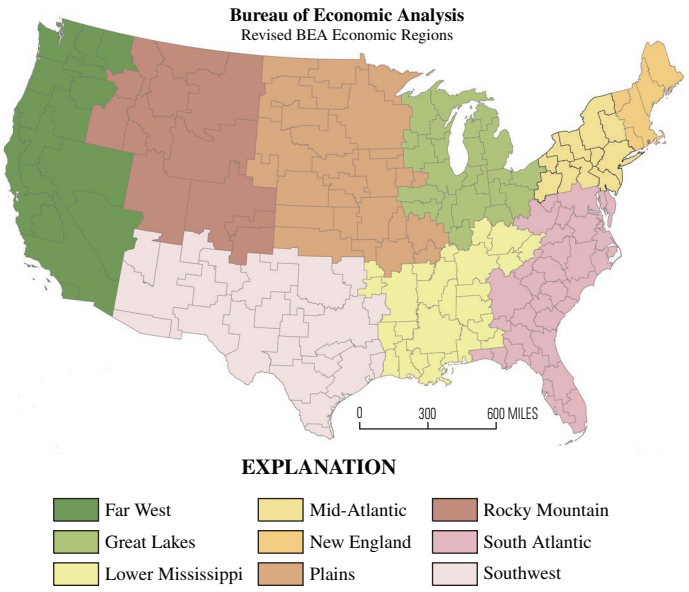
Local land-use policies and land-use zoning densities for unincorporated areas encourage low-density growth on the urban fringe, and these areas will eventually become "exclusion zones" to denser urbanized landforms.

Low-density land-use development on the urban fringe has an increased per capita demand for natural resources and urban services. This disproportionate increase in lower density development results in greater effects on landscape fragmentation, ecological and socioeconomic processes, and tax revenues.

Regions with the highest demographic and socioeconomic growth rates should be the areas in the Nation experiencing the most rapid urbanization. This research assumption should be verifiable by investigating parameters such as gross regional product and population.

Research Hypotheses

1. Do urbanization growth rates, urban-form patterns, land-use trends, and migration patterns vary between U.S. Department of Commerce



U.S. economic regions and areas.

Bureau of Economic Analysis (BEA) Economic Areas (EA) and Economic Regions?

2. Does the primary Core-Based Statistical Area (CBSA), acting as the economic engine, cause urbanization patterns, rates, and trends to vary between EAs?

3. Can temporal land-use transition probabilities be used to forecast when county-based Department of Agriculture Economic Research Service Rural-to-Urban Continuum Codes (RUCC) will change urban-form classification within each EA?

4. Are specific EAs and RUCC subregions within each EA placing greater urbanization demands on the environment and creating more societal pressures for those urbanizing regions?

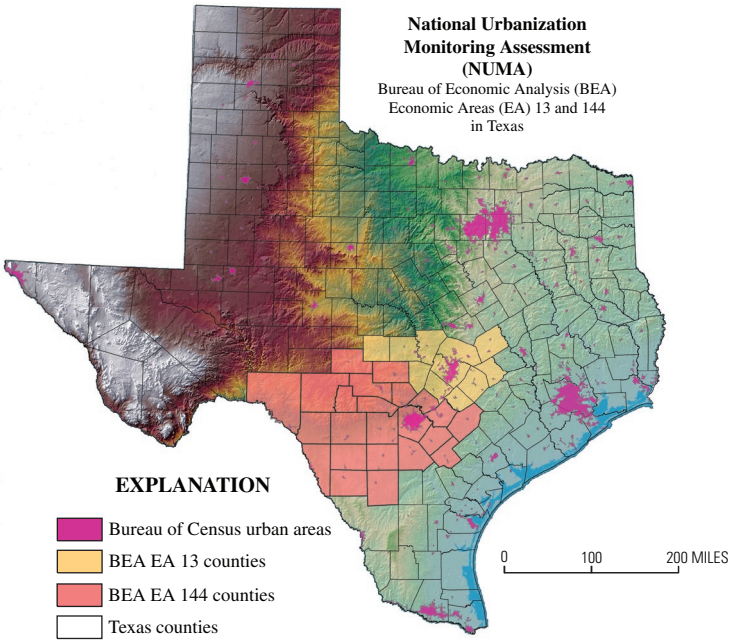
Canyon Ridge Springs planned urban development west of Austin, Texas.

Relevance and Effects

Land-use development affects how planners and resource managers address issues exacerbated by increased urbanization. Environmental and societal issues are being accelerated by human-induced land transformations. These issues include loss of ground-water recharge zones, increased traffic congestion, loss of arable land, increased air pollution and ozone levels, depletion of endangered and threatened species native habitat, and increased exposure of humans to catastrophic natural and man-made hazards.

Strategy and Approach

The research methodology entails classifying EAs using CBSA population threshold tiers and stratifying EAs with computed average population and gross regional product (GRP) growth rates from 1977 to 2003. This technique provides a systematic nationwide structure for sampling and monitoring urbanization within EAs.



Austin–Round Rock and San Antonio economic areas.

The short-term research approach was to select two economic areas experiencing rapid urbanization as prototype case studies. This selection was based on computed and ranked average population and GRP growth rates.

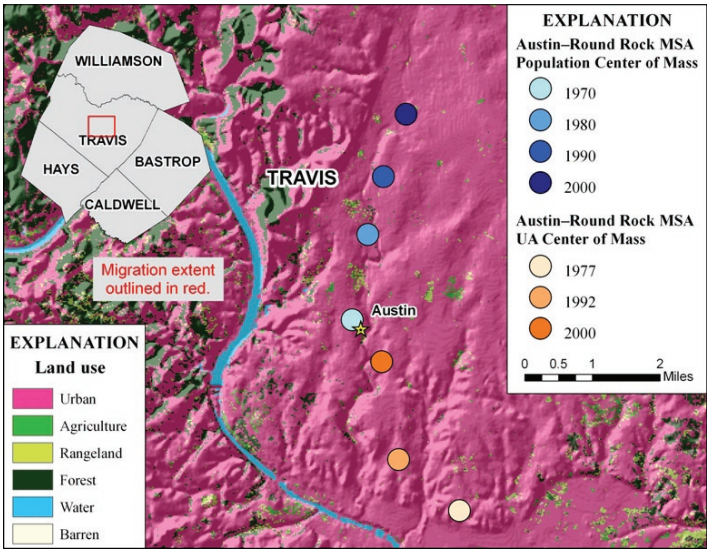
Prototype study sites selected were the Austin–Round Rock, Texas, and the San Antonio economic areas. These EAs were respectively ranked 3d and 34th nationally. Both of these economic areas in Texas are classified as major metropolitan CBSAs with a total population greater than 1 million residents by the University of Arizona.

The Austin and San Antonio EAs were subdivided into urban, suburban, exurban, and rural landscapes using the RUCC codes. To quantify urbanization rates, patterns, trends, and human migration paths, indicators were extracted from a USGS database as a potential standard template for monitoring human-induced land transformations.

Human migratory paths computed from decennial population information, and temporal land-use and land-cover (LULC) data were used in conjunction with land-use trends analysis (LUTA) metrics to understand the factors and causes influencing urbanization within an EA. Comparative analysis between RUCC subregions and EAs was conducted as a final step in the urbanization monitoring assessment.

Geographic Research Results

In order to characterize 1977 to 2000 urbanization for the Austin and San Antonio EAs, existing USGS Geographic Information Retrieval and Analysis System (GIRAS), National Land Cover Data (NLCD), and U.S. Census Bureau datasets provided the temporal foundation for LUTA metrics.



Comparative analysis between Austin–Round Rock MSA population and urbanized area migration paths.

urbanization in the Exurban subregion of the San Antonio economic area occurred at an annual rate of about 1.8 percent. In comparison, forest/woodland decreased at a rate of approximately 2.1 percent per year.

Human migration trends for population and urban area (UA) centers of mass were calculated respectively by using county-level population data from the U.S. Census Bureau and temporal USGS LULC datasets. The Austin–Round Rock and San Antonio Metropolitan Statistical Areas (MSAs) were used as migration case study sites.

Research results for the Austin–Round Rock MSA illustrate that population growth in Williamson County is the primary driver of northerly migration trends for the urban RUCC subarea within the Austin EA. In comparison, the direction of the Austin–Round Rock MSA temporal urbanized-area migration path demonstrates a northwesterly direction due to the influence of land-use development around U.S. Highways 281 and 183 transportation corridors.

LULC Transitions (in acres)
1977 to 2000
2000 LULC Class

1977 LULC Class	Water	Urban/ Developed	Barren Land	Forest/ Woodland	Grassland/ Shrubland	Agriculture	Wetlands	Unclassified	Total acres
Water	25,378	225	50	450	6,886	506	21	0	33,515
Urban/Developed	0	53,051	0	0	0	0	0	0	53,051
Barren Land	75	1,722	1,082	1,612	6,876	617	14	0	11,999
Forest/Woodland	2,461	3,838	7,151	745,892	713,581	32,232	758	0	1,505,912
Grassland/Shrubland	17,128	14,490	25,765	156,337	3,740,262	125,462	1,895	0	4,081,339
Agriculture	1,660	7,365	3,900	16,755	213,903	261,423	470	0	505,475
Wetlands	154	6	13	101	1,797	125	1,581	0	3,778
Unclassified	1,205	39	5	205	129	95	4	0	1,682
Total acres	48,060	80,736	37,964	921,353	4,683,434	420,459	4,743	0	6,196,751

Land-use transitions (1977 to 2000) for the exurban portion of the San Antonio Economic Area.

Analysis of the Exurban RUCC subregion for the San Antonio EA indicates that approximately 34 percent of the landscape transitioned to another LULC category from 1977 to 2000. The most frequent LULC category becoming urbanized was grassland/shrubland. Within this timeframe,

For More Information

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