CENTRAL INDIANA

CENTER FOR URBAN POLICY AND THE ENVIRONMENT MAY 2003

New Model Predicts Growth Patterns in Central Indiana

The Land Use in Central Indiana model (LUCI) is now available. Designed to be user friendly, this new computer simulation tool allows planners, policymakers, and citizens in the 44-county Central Indiana region to explore the implications of policy choices and alternative assumptions on future development patterns. By generating a series of scenarios, users can test, for example, the effects of restricting development along streams or in wetlands, policies to preserve agricultural land, and new transportation projects. For each scenario, LUCI produces maps that show regional changes in urbanization and overall patterns of development and an extensive set of summary statistics, including overall land consumption, the availability of water and sewer utilities, and the estimated average journey to work. The model also produces selected statistics at the county level.

LUCI already is being used to address an array of real-world planning issues. The Indianapolis Metropolitan Planning Organization has used LUCI (in beta version) to assess patterns of urbanization in the Indianapolis Metropolitan Statistical Area (MSA). Contractors to the Indiana Department of Tranportation recently retained the Center for Urban Policy and the Environment (Center) to develop a customized version of LUCI to forecast population and employment location for the Central Indiana Transportation Mobility Study. The Center also is using LUCI to forecast land use change in urbanizing watersheds.

Model Basics

LUCI predicts the conversion of non-urban land to urban use and the resulting population density in successive five-year increments through 2040. The model uses 17,369 one-mile square grid cells as the units of analysis. It covers the 44 Indiana counties defined by the U.S. Bureau of Economic Analysis as the Indianapolis Economic Area and includes six MSAs (Indianapolis, Bloomington, Terre Haute, Lafayette-West Lafayette, Kokomo, and Muncie).

The model is based primarily on interpreted LandSat satellite imagery for 30 square-meter pixels showing land cover types in 1985, 1993, and 2000,[1] that have been generalized to better estimate actual urban *land use*. A geographic coverage of publicly managed lands and major institutional facilities also was used to better estimate the land available for future development. Additional data about population density, employment by ZIP code, proximity to transportation and potable water and wastewater infrastructure, and school quality support the prediction functions of the model. Data about wetlands, water bodies, agricultural land, and slope support various model scenarios.

LUCI uses a statistical model[2] to predict the probability of development within each grid cell. The model correlates the probability of future development with factors that have been shown to affect the probability and location of development in the past. Data about the proportion of land in each grid cell converted from nonurban to urban use from 1993–2000 were used to estimate the model.

The model uses the following variables to predict probabilities of development:

- accessibility to employment,
- distance to nearest interstate,
- distance to nearest interstate or four-lane highway,
- availability of sewer service,
- availability of water service,
- ISTEP[3] total battery scores by school district (1999-2000),
- proportion of land converted to urban use in the preceding period, and
- proportion of urban land within adjoining grid cells.

The model uses accessibility to employment and availability of water and sewer service to predict the population density of *new* development; the relationship was estimated using population densities in the year 2000. The model uses these predicted probabilities and population densities to allocate regional population growth and urban development to the grid cells.

Scenario Options

The fundamental objective of the model is to allow users to test the effects of alternative assumptions and policy choices on the pattern of urbanization in Central Indiana. The model permits users to define a wide range of scenarios by specifying more than 50 parameters in 13 categories that are described briefly below. When users do not specify particular parameters, the model uses a default that reflects the projection of current trends into the future. Specifications for a complete Current Trends scenario are shown in Table 1.

Scenario Target Year

The target year for a scenario can be specified using any year from 2005 to 2040. This lets users create scenarios for different time horizons and compare otherwise identical scenarios for intermediate years.

Population Growth

The rate of population growth can be specified in three different ways. The model allows users to choose among the actual five-year compounded growth rate for the region for 1990 to 2000 (5.549 percent); the forecasts created by the Indiana Business Research Center (IBRC) to 2025, using the 2020–2025 projected growth rate for the remaining five-year periods; and a specific growth rate chosen by the user.

Land Development Restrictions

The model allows users to place development restrictions on land classified as wetlands, riparian buffers, steep slopes, or agriculture. For the first three conditions, users may exclude some or all of these lands from development. The restriction on the development of agricultural land may be applied to the region or only to non-MSA counties, and can be further specified by choosing the percentage of agricultural land use that must exist to apply any restriction and the percentage of agricultural land to be restricted.

Water and Sewer Infrastructure

The model also permits users to specify the relationship of water and sewer infrastructure to development in three ways: by restricting development to areas served by water or sewer service; by specifying the rates of expansion per five-year period for utilities in the areas around major urban centers and for areas around all other utilities; or by specifying the level of urbanization required to expand current utilities to adjacent grid cells.

Transportation Improvements

The model lets users consider the development and timing of selected major transportation improvements, including eight options for the extension of Interstate 69 from Indianapolis to Evansville, construction of an interstate highway north from Indianapolis along the alignment of U.S. 31 from Indianapolis to South Bend, and construction of a light rail line from Indianapolis to Noblesville.

School Quality

The model allows users to reduce or eliminate differences in school quality, as measured by mean ISTEP scores by school district, and thereby reduce the effect of differences in school quality on location of development.

Density of Development

The model permits users to adjust the density of development predicted by the model by specifying a minimum or maximum number of units allowed per acre or increasing or reducing density by a specific percentage.

Employment Distribution and Accessibility

The model allows users to allocate new employment to ZIP codes in three ways: proportional to the distribution of employment within each ZIP code in 2000; proportional to the employment growth by county from 1990 to 1999; and proportional to the employment growth by ZIP code from 1994 to 1999.

The model also allows users to simulate changing preferences about proximity to work by adjusting the importance of accessibility in predicting the location of development relative to other factors. These preferences can be affected by increases in congestion or the price of gasoline and by options for telecommuting.

New Employment

The model permits users to add one large block of employment to one county within the region, simulating the location of one large employer. Users must specify the location of the employment, the year, and number of jobs that would be generated.

Dispersal

Dispersal refers to whether development occurs adjacent to existing development or whether it is spread throughout the county and the region. The model lets users adjust the pattern of development that occurs to be more or less dispersed than would normally be predicted by the model.

Demand from Current Residents

Because some of the demand for new urban development comes from existing residents who seek new housing to replace their existing housing, the model allows users to adjust the percentage of existing residents who demand new development.

Maximum Development

Examination of development in urbanizing grid cells has shown that it is extremely unlikely that 100 percent of the land in any cell will become developed. The random character of the development process can leave isolated parcels of vacant, undeveloped land in areas long after the area has otherwise reached full development. Alternatively, the methodology for establishing areas of urbanization using satellite imagery probably underestimates actual land uses by failing to interpret certain types of land as urbanized, including common recreational areas, drainage retention areas, and even very large yards in low-density residential developments. The model allows users to adjust the maximum percentage of land available for urban development in each cell.

Area Growth

The model lets users raise or lower the probabilities of development produced by the model for any of the six Central Indiana

Table 1: **Specifications for Current Trends Scenario**

Scenario Options	Model Default
Target year	2040
Population growth	5.549%;5-year compounded population growth rate established for Central Indiana between 1990 and 2000
Land development restrictions	No restrictions for wetlands, riparian buffers, steep slopes (>15%),or agricultural land
Water and sewer infrastructure	Water and sewer infrastructure extended to adjacent cells when they become 20% urbanized
Transportation improvements	Uses the current system of 4-lane and interstate highways
Education quality	Uses relative differences in quality based on mean ISTEP scores for school districts from the 1999–2000 school year
Density of development	As predicted by the model
Employment distribution and accessibility	Allocates growth based on proportional growth by county between 1990 and 1999 and assumes current preferences for accessibility
New employment	No new employment
Dispersal of development	Uses dispersal predicted by the model based on the probability of development and vacant land in each cell
New housing demand from current residents	1.345%;estimated from U.S. Census data for 1990 and 2000
Maximum development per cell	90%
Probability of urbanization for MSAs and area outside MSAs	As predicted by the model

CENTER FOR URBAN POLICY AND THE ENVIRONMENT

Figure 1: **Change in Urbanization for Current Trends and IBRC Scenarios**

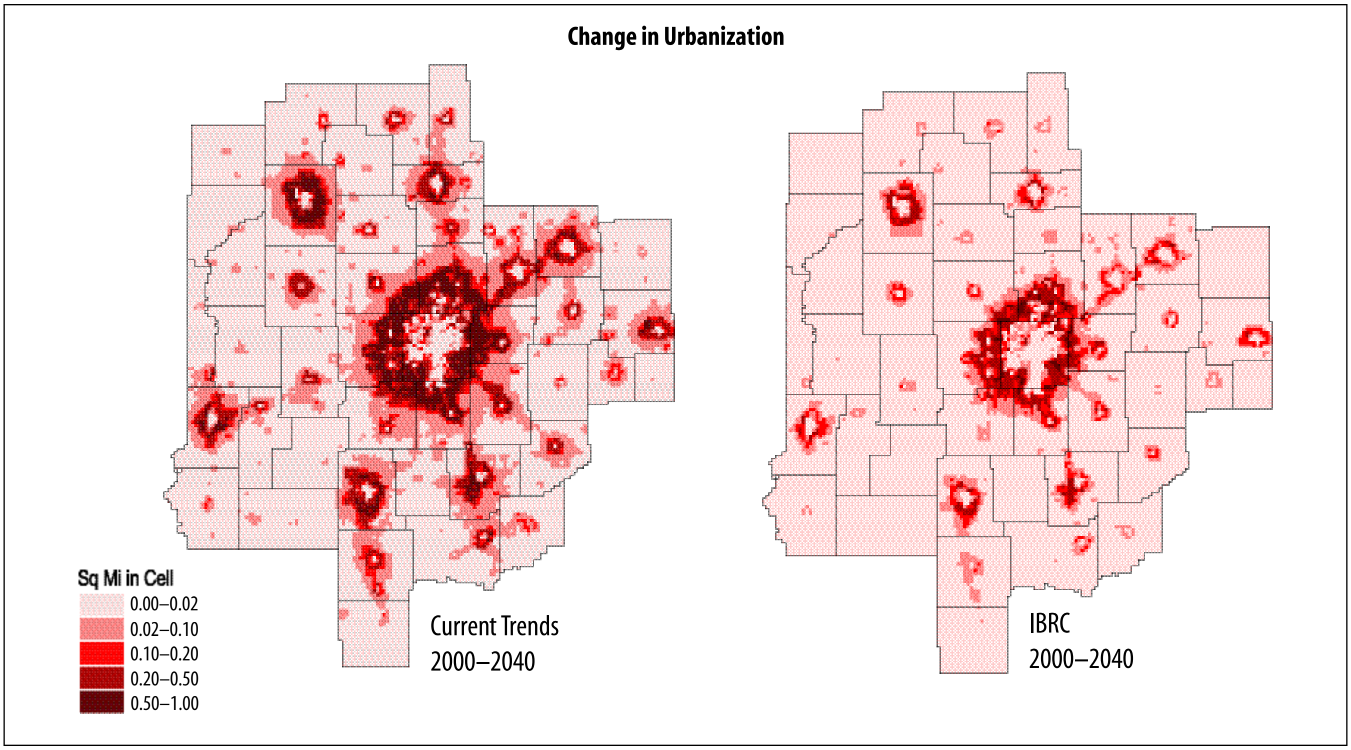
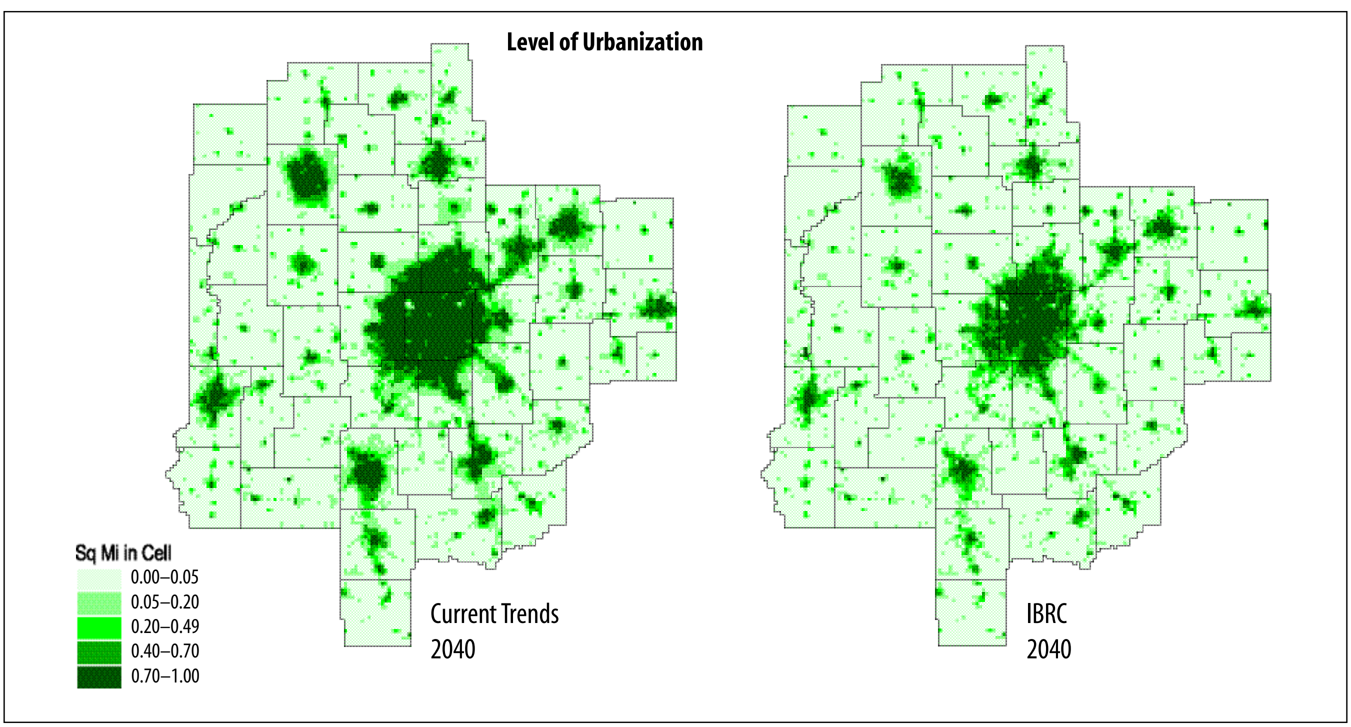


Figure 2: **Level of Urbanization for Current Trends and IBRC Scenarios**



CENTER FOR URBAN POLICY AND THE ENVIRONMENT

MSAs (Indianapolis, Bloomington, Muncie, Kokomo, Terre Haute, Lafayette-West Lafayette) or for the entire area outside the six MSAs.

Model Outputs: Comparing Alternate Population Projections

As an illustration, the outputs associated with two scenarios using very different rates of population growth are presented in Tables 2–4 and Figures 1 and 2. Both scenarios simulate development in the Central Indiana region from 2000 to 2040. The Current Trends scenario uses the five-year compounded population growth rate experienced from 1990–2000. The second scenario uses the much slower rates that were forecast by the IBRC (see Table 2). Both scenarios assume that all other parameters are the same.

Table 2: **Five-Year Population Growth Projections**

Simulation Period	Current Trends	IBRC
2000–2005	5.549%	1.39%
2005–2010	5.549%	1.70%
2010–2015	5.549%	1.39%
2015–2020	5.549%	1.24%
2020–2025	5.549%	1.43%
2025–2030	5.549%	1.43%
2030–2035	5.549%	1.43%
2035–2040	5.549%	1.43%

Figure 1 shows where new development is predicted to occur under the Current Trends and IBRC scenarios, respectively. The darker shaded areas represent higher proportions of land changed from non-urban to urban use. In both cases, new urban development occurs in areas surrounding major cities. As might be expected, the Current Trends scenario uses more land and expands existing urban areas to a greater extent than the IBRC scenario.

Similarly, Figure 2 shows the aggregate level of urbanization in Central Indiana that results under these two scenarios. Again, the darker shades represent higher proportions of urban land that are predicted to be urbanized by 2040.

Table 3 shows selected tabular results from the two scenarios for the entire region. These results show, in numeric terms,

Table 3: **Selected Regional Results for Current Trends and IBRC Scenarios**

	Current Trends	IBRC
Population (persons)		
Population at the start of simulation	3,049,461	3,049,461
Population at the end of simulation	4,697,384	3,416,034
Population growth	1,647,923	366,573
Percent change	54.0%	12.0%
Urbanization (sq mi)		
Land area urban at start of simulation	1,076	1,076
Land area urban at end of simulation	2,243	1,450
Land area developed/urbanized	1,167	374
Percent change	108.5%	34.8%
Population density of new development	1,412	979
Sewer Utilities (sq mi)		
Land area served by sewer at start	2,484	2,484
Land area served by sewer at end	3,296	2,810
Change in land area served by sewer	812	326
Percent change	32.7%	13.1%
Percent of new development served at the time of development	71.1%	76.9%
Percent of new development served at end	80.1%	81.2%
Water Utilities (sq mi)		
Land area served by water at start	4,433	4,433
Land area served by water at end	5,082	4,680
Change in land area served by water	649	247
Percent change	14.6%	5.6%
Percent of new development served at the time of development	77.1%	82.5%
Percent of new development served at end	83.8%	84.6%
Agricultural land (sq mi)		
Agricultural land at start (sq mi)	9,046	9,046
Agricultural land at end	8,429	8,863
Estimated agricultural land urbanized	-617	-183
Percent change	-6.8%	-2.0%
Mean Estimated Journey to Work (minutes)		
Journey to work at start	20.5	20.5
Journey to work at end	23.1	21.6
Change	2.6	2.6
Percent change	12.7%	5.4%

Table 4: **Selected County Results for Current Trends and IBRC Scenarios**

County	Land Area Developed/Urbanized (sq mi)		Percent Change in Urban Land	
	Current Trends	IBRC	Current Trends	IBRC
Bartholomew	49.1	14.5	165.8%	48.9%
Benton	1.5	0.4	42.5%	10.2%
Boone	52.1	17.0	276.7%	90.2%
Brown	4.1	0.9	74.1%	16.6%
Carroll	4.4	1.0	63.8%	13.8%
Cass	10.4	2.6	74.0%	18.4%
Clay	6.6	1.5	71.1%	16.6%
Clinton	8.8	2.0	92.4%	20.7%
Decatur	13.0	2.7	125.7%	26.1%
Delaware	43.3	11.6	104.9%	28.1%
Fayette	4.7	1.2	59.0%	15.2%
Fountain	3.1	0.7	48.9%	11.1%
Greene	3.1	0.7	26.8%	6.3%
Hamilton	118.0	49.4	169.8%	71.0%
Hancock	74.2	21.9	346.6%	102.3%
Hendricks	101.0	40.0	205.1%	81.2%
Henry	13.1	3.2	70.3%	17.3%
Howard	35.0	9.2	108.9%	28.7%
Jackson	13.9	3.4	72.6%	17.6%
Jennings	5.4	1.2	41.7%	9.2%
Johnson	77.9	23.8	193.2%	59.1%
Lawrence	18.6	4.3	78.3%	18.2%
Madison	40.6	10.7	81.4%	21.5%
Marion	87.0	52.9	34.1%	20.7%
Miami	8.4	2.0	49.6%	11.8%
Monroe	59.2	16.8	130.4%	36.9%
Montgomery	18.9	4.7	133.8%	32.9%
Morgan	44.5	11.2	144.5%	36.3%
Orange	3.0	0.7	32.0%	7.4%
Owen	1.4	0.3	41.3%	9.2%
Parke	3.0	0.7	46.7%	10.6%
Putnam	11.0	2.3	88.1%	18.8%
Randolph	2.2	0.6	33.7%	8.7%
Rush	3.8	0.8	67.6%	14.8%
Shelby	36.0	7.1	250.6%	49.7%
Sullivan	2.8	0.7	31.2%	7.5%
Tippecanoe	91.1	25.5	228.2%	64.0%
Tipton	11.9	2.3	236.1%	45.4%
Union	0.8	0.2	37.2%	8.8%
Vermillion	3.6	0.8	41.4%	9.2%
Vigo	42.3	11.9	109.2%	30.6%
Warren	1.6	0.4	62.3%	14.1%
Wayne	26.7	7.3	105.1%	28.7%
White	6.0	1.3	51.2%	10.9%

that urbanization is significantly greater in the Current Trends scenario than in the IBRC scenario. Both scenarios show that the increase in urbanized land is proportionately greater than the increase in population. The Current Trends scenario, however, uses proportionately less new land per person. In other words, the Current Trends scenario indicates somewhat higher densities for new development. These results are not surprising because higher population growth increases demand for accessible land served by utilities.

Table 3 also shows a number of other measures available, including land area served by water and sewer, change in the amount of agricultural land, and estimated average journey to work. Interestingly, the model predicts that the proportion of development served by water and sewer at the time of development is greater in the IBRC scenario than the Current Trends scenario, but that similar proportions of new development are served at the end.

Table 4 shows two of the four measures that are available for individual counties. The model predicts that more land area will be developed in each county under the Current Trends scenario than the IBRC scenario. Ordering counties by the amount of land area developed creates a similar list in both scenarios with a few minor exceptions. With slower growth, Marion County will retain a larger share of new development, and its share will be reduced with faster growth.

Model Limitations

Scenario results are not presented as accurate predictions about the future of Central Indiana, but rather as indicators of general development patterns. The model cannot predict the development of individual parcels or small areas. Similarly, the presentation of scenarios is not offered as policy prescriptions for the region. Scenarios will show, however, the direction of changes likely to be associated with different policy choices.

Technical Requirements and Availability

Designed to be user-friendly, the model requires no specific expertise. LUCI requires users to have Windows 95, 98, NT, 2000, ME, or XP, with at least a Pentium 200 MHz processor. It also requires at least 12 MB of free disk space for installation and at least 64 MB of RAM (96 MB is recommended).

The model is available for download at luci.urbancenter.iupui.edu. CD copies also are available on request. Questions and comments can be directed to LUCI@iupui.edu or to the staff at the Center for Urban Policy and the Environment (317/261-3000).

Endnotes

[1] Wilson, J.(forthcoming). *Land Cover in Indiana: 1985, 1993, and 2001*. Indiana University–Purdue University Indianapolis, School of Public and Environmental Affairs, Center for Urban Policy and the Environment.

[2] More specifically, LUCI uses an aggregated discrete choice (logit) model.

[3] The Indiana Statewide Test of Educational Progress (ISTEP) is a state-mandated test of student achievement administered in all Indiana school districts.

About LUCI's Creator

John R. Ottensmann, Ph.D., AICP, is associate director of the Center for Urban Policy and the Environment and a professor in the Indiana University School of Public and Environmental Affairs at Indiana University–Purdue University Indianapolis, where he has been a faculty member since 1978. Drawing on more than 25 years experience in planning in Indiana, Dr. Ottensmann developed LUCI to help citizens and policy makers in Central Indiana understand the effects of policy choices about land use.

Dr. Ottensmann received a B.A. from the University of Wisconsin at Madison and a Ph.D. in city and regional planning from the University of North Carolina at Chapel Hill in 1974. He is recognized nationally for his innovative work on computer applications in planning, including geographic information systems, use of planning tools in provision of public services, and studies of equity and racial change. In 2001, he received the Indiana Planning Association's Earl Franke Award for outstanding contributions to planning in Indiana.

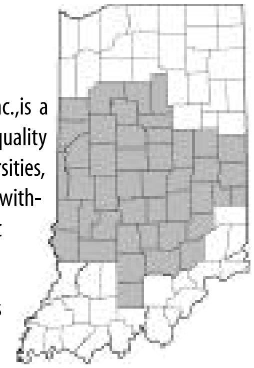
Dr. Ottensmann has worked with a number of public and nonprofit organizations, providing studies of the valuation of their services and analyses relating to the location of facilities. He also has served as a consultant to a number of planning and engineering consulting firms in Indianapolis, providing advice on forecasting and evaluation methods and performing reviews of comprehensive plans. He is responsible for the development of the Master of Planning (MPL) Program in SPEA at IUPUI where he teaches courses in urban planning and urban policy, geographic information systems, and management information systems.

Dr. Ottensmann has published three books and more than 25 articles in journals such as the *Journal of the American Planning Association, Environment and Planning, Journal of Planning Education and Research, Urban Affairs Review, Library & Information Science Research,* and *Library Quarterly*.

Dr. Ottensmann can be contacted via e-mail at jottensm@iupui.edu or at the Center for Urban Policy and the Environment, (317) 261-3000.

CENTER FOR URBAN POLICY AND THE ENVIRONMENT

Central Indiana's Future:
Understanding the Region and Identifying Choices



Central Indiana Region

Central Indiana's Future:Understanding the Region and Identifying Choices, funded by an award of general support from Lilly Endowment, Inc.,is a research project that seeks to increase understanding of the region and to inform decision-makers about the array of options for improving quality of life for Central Indiana residents. Center for Urban Policy and the Environment faculty and staff, with other researchers from several universities, are working to understand how the broad range of investments made by households, governments, businesses, and nonprofit organizations within the Central Indiana region contribute to quality of life. The geographic scope of the project includes 44 counties in an integrated economic region identified by the U.S.Bureau of Economic Analysis.

Concern about growth and development during the last decade has forced state and local officials to struggle to balance competing interests and to determine the best use of land for the future. The Center for Urban Policy and the Environment has undertaken a series of projects on land use intended to provide objective information to strengthen public discussion and decision-making on these issues. The Land Use in Central Indiana (LUCI) model forecasts future urban development through 2040 and allows users to generate and compare urban development scenarios reflecting different policy choices and assumptions about how development is likely to occur.

The Center for Urban Policy and the Environment is part of the School of Public and Environmental Affairs at Indiana University–Purdue University Indianapolis. For more information about the Central Indiana Project or the research reported here, contact the Center at 317-261-3000 or visit the Center's Web site at www.urbancenter.iupui.edu.

Authors:Jamie Palmer, policy analyst, and **John Ottensmann**, associate director, Center for Urban Policy and the Environment.

CENTER FOR URBAN POLICY
AND THE ENVIRONMENT

342 North Senate Avenue
Indianapolis, IN 46204-1708
www.urbancenter.iupui.edu

INDIANA UNIVERSITY SCHOOL OF PUBLIC AND ENVIRONMENTAL AFFAIRS
INDIANA UNIVERSITY–PURDUE UNIVERSITY INDIANAPOLIS

03-C11