

LUCI Model Aids Planning for Transportation and Other Infrastructure

Efficient transportation. Clean water. Adequate public revenues. Effective intergovernmental cooperation. We read and hear about these issues every day in the news, and the future of Central Indiana depends on what we do about them. What do these seemingly unrelated issues have in common? Solutions to all of them depend on our ability to understand regional patterns of growth and land use. Historically, however, we have lacked the tools to forecast growth and understand the implications for these and other issues.

To help policymakers, planners, and citizens understand the effects of policy choices on patterns of urban development in the Central Indiana region, the Center for Urban Policy and the Environment (Center) sponsored development of a new, practical tool—the Land Use in Central Indiana (LUCI) model. The LUCI model is easy to use, requires no special expertise, and can be used to develop alternative growth scenarios and explore their implications.

Evidence of the need for the LUCI model lies in the demand for it. Since the Center introduced the LUCI model in spring 2003, more than 150 people have downloaded copies from the Web site (see <http://luci.urbancenter.iupui.edu>), and we have distributed more than 100 CD-ROM copies of the model at seminars.

The LUCI model already is changing how people analyze and understand the region. The Indianapolis Metropolitan Planning Organization (MPO) used the LUCI model to help delineate the federally-required transportation planning area. More recently, consultants to the Indiana Department of Transportation (INDOT) contracted with the Center to customize the LUCI model to forecast land use in the year

2025 for input into transportation models that are being used to explore the need for expansion of the region's highway network. In another project sponsored by IUPUI's Center for Earth and Environmental Science and USFilter, the private firm that manages Indianapolis's drinking water supply, Center researchers used the LUCI model to forecast land use change in watersheds that drain into the city's three drinking water reservoirs. Center researchers also have used the LUCI model in Tippecanoe County to identify potential urbanized areas that may be included in a new, intergovernmental stormwater finance project.

In this report, we present brief summaries of these four projects to illustrate how people can use the LUCI model to analyze important issues that affect us all. We conclude with a brief discussion of other potential applications and a description of future developments of the model.

Planners used the LUCI Model to define the transportation planning area for Indianapolis

The Indianapolis Metropolitan Planning Organization (MPO) is responsible for transportation planning for the Indianapolis area. By federal regulation, all transportation planning bodies are required to undertake their planning for a Metropolitan Planning Area that includes at least all of the areas surrounding the major city that are currently urbanized or are expected to become urbanized in the next 20 years (at a minimum). These areas must be updated at least every 10 years when data from a new census become available. The Indianapolis MPO must meet this federal mandate in order to maintain eligibility for federal transportation funds.



A Brief Introduction to LUCI

The LUCI model forecasts future urban development for a 44-county region in Central Indiana. This is an area defined by the U.S. Bureau of Economic Analysis and was selected to provide the broadest possible context for considering urban development in the region. The model predicts the quantities of land that were not urban in 2000 that will be converted to urban uses as far out as 2040.

Satellite images of the region for 1985, 1993, and 2000, were used to determine the locations and amounts of land in urban use and the changes over these periods. These data were used to estimate an equation to predict the probability of land being converted to urban use employing a set of variables associated with such conversion. These predictors of the probability of development included:

- a measure of accessibility to employment by ZIP code,
- the availability of water and sewer utility services,
- proximity to interstate and four-lane highways,
- ISTEP scores for school districts,
- the proportion of land converted to urban use during the previous period (reflecting the persistence of development patterns), and
- the level of urban development in the neighborhood of each grid cell (reflecting the fact that development typically starts out slowly in areas with little urban development, accelerates as development increases, and then tapers off as these areas become more fully developed).

A second equation predicts the density of development using employment accessibility and the availability of water and sewer utility services.

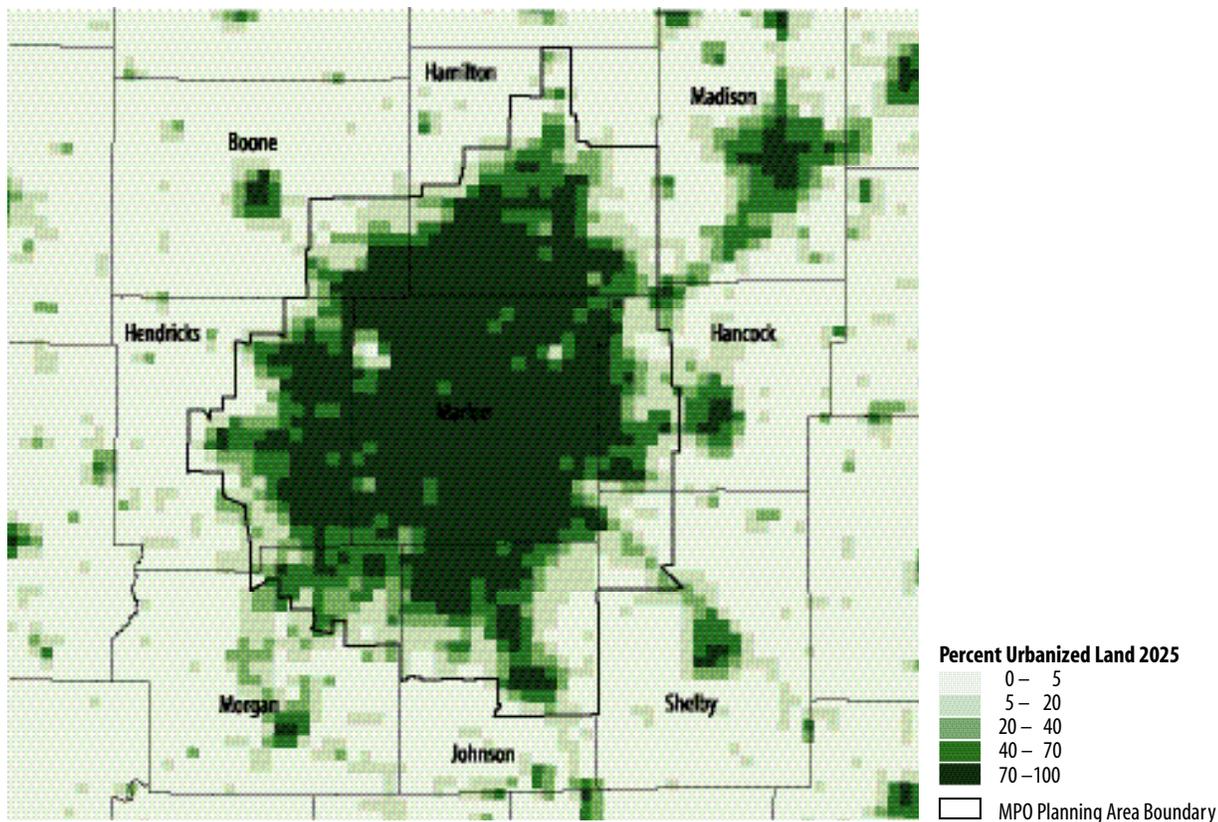
The LUCI model predicts future urban development in five-year increments. Each simulation period starts with a

specified amount of population growth for the entire region that must be accommodated. The model tentatively predicts the probability of development and density for each grid cell using the two equations. Final amounts of new urban development are then determined by adjusting these tentative predictions up or down to accommodate the specified population growth.

The model lets the user create different forecasts or scenarios that reflect varying policy choices and assumptions about future development. These scenarios can reflect, among other things, different rates of population growth, restrictions of development on agricultural or sensitive land, alternative policies for expanding and even requiring utility services, and higher or lower densities of development. The model displays the results from two scenarios side-by-side so that users can easily compare and understand the consequences of policy choices and assumptions.

More information on the LUCI model can be found in the report, *New Model Predicts Growth Patterns in Central Indiana* (available from the Center Web site at www.urbancenter.iupui.edu/) and on the LUCI Web site (<http://luci.urbancenter.iupui.edu>).

Figure 1: Indianapolis Metropolitan Planning Area and LUCI Forecast Percent Urbanized for 2025



In 2002, the Indianapolis MPO undertook the delineation of their updated planning area, using information from the Census on the current Indianapolis Urbanized Area for 2000. The issue, of course, involved the forecasting of the additional areas that could be expected to become urbanized by 2025 (the target year for their current long-range planning efforts). The Center provided the MPO with the forecast of urban development for 2025 produced with the LUCI model. The MPO used this information in its delineation of the updated Metropolitan Planning Area. Figure 1 shows a map of the new Indianapolis Metropolitan Planning Area and the LUCI forecasts of the percent of land in mile-square grid cells forecast to be urban in the year 2025.

LUCI/T predicts development patterns for planning transportation improvements

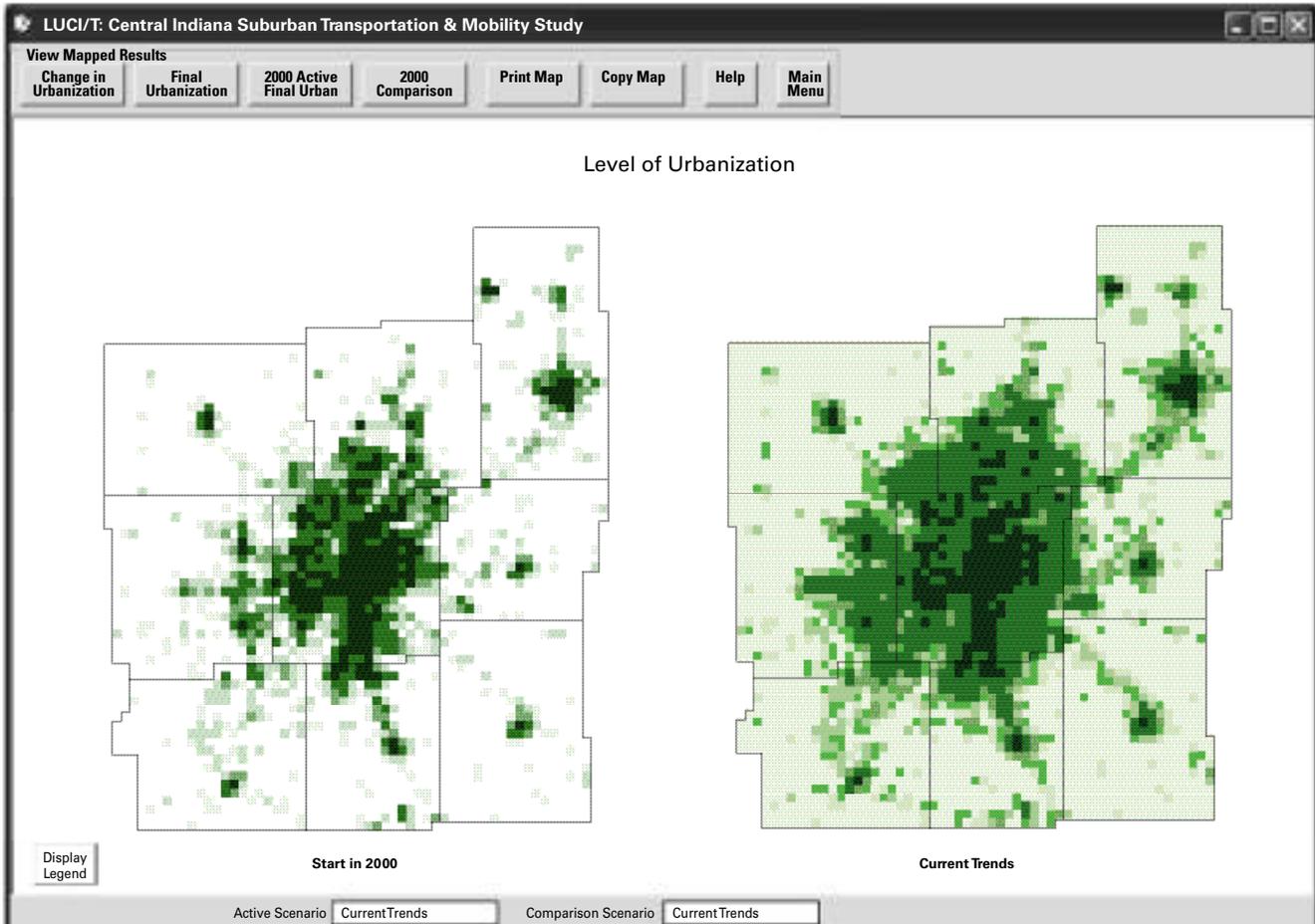
The Indiana Department of Transportation (INDOT) is undertaking the Central Indiana Suburban Transportation and

Mobility Study (CISTMS) to consider transportation alternatives for the outlying areas of the nine-county region centered on Indianapolis. (The study is being conducted by INDOT rather than by the Indianapolis MPO because much of the area of interest is outside the Indianapolis Metropolitan Planning area, just described, and also includes the planning area for the Anderson MPO. To ensure a cooperative and coordinated regional effort, a study management team including the Indianapolis and Anderson MPOs and INDOT provides oversight to the study.)

For this study, INDOT wanted the capability to effectively forecast urban development for two important reasons: First, future urban development is a critical input to the travel demand models that are used to forecast future travel patterns and to assess the need for and use that would be made of various transportation alternatives being considered. Second, not only does urban development affect travel, but new transportation facilities will affect future patterns of urban



Figure 2: The LUCI/T Program Showing 2000 and Baseline Forecast 2025 Levels of Urbanization



the different patterns of development that might be expected for various transportation alternatives.

While the original LUCI model could forecast future urban development in this area, it lacked some key capabilities for application in the transportation planning process. INDOT and their contractor on the study, Cambridge Systematics, contracted with the Center to develop a modified version of LUCI to meet the specific requirements of their study. This new model has been developed and is called the LUCI/T model, to reflect its intended use in the transportation planning study.

The original LUCI model uses distances from each grid cell to places of employment to calculate employment accessibility, a very important measure. It also incorporates the effects of the transportation infrastructure by using distances to interstates

use travel times across the existing and proposed transportation networks, which more accurately reflect differences among transportation alternatives being considered. The LUCI/T model was modified to focus on the nine-county study area, to use both current and forecast travel times produced by travel demand models, and to use existing and forecast employment levels for the smaller Traffic Analysis Zones used in transportation planning.

The travel demand modeling for the Central Indiana Suburban Transportation Planning and Mobility Study is being developed for the target year 2025. Different forecasts for employment for the Traffic Analysis Zones have been developed to reflect the baseline alternative without additional transportation improvements in the outlying area and an



alternative considering major improvements. LUCI/T will be used to produce forecasts of population and households for 2025 using these two forecasts of employment. These forecasts will be used as inputs to the travel demand models to predict travel patterns for the baseline and major improvement alternatives and assess the relative performance of those alternatives.

Because major transportation improvements in the outlying areas are not likely to be made before 2020, only limited effects of those improvements can be expected by the 2025 target year. So the LUCI/T forecasts will then be extended to 2040, using the different sets of travel times associated with the various alternatives. This will allow assessment of the possible long-term consequences of undertaking major improvements on the urban development patterns in the region.

Figure 2 shows the LUCI/T model, displaying urbanization in 2000 and a possible baseline forecast for urbanization levels

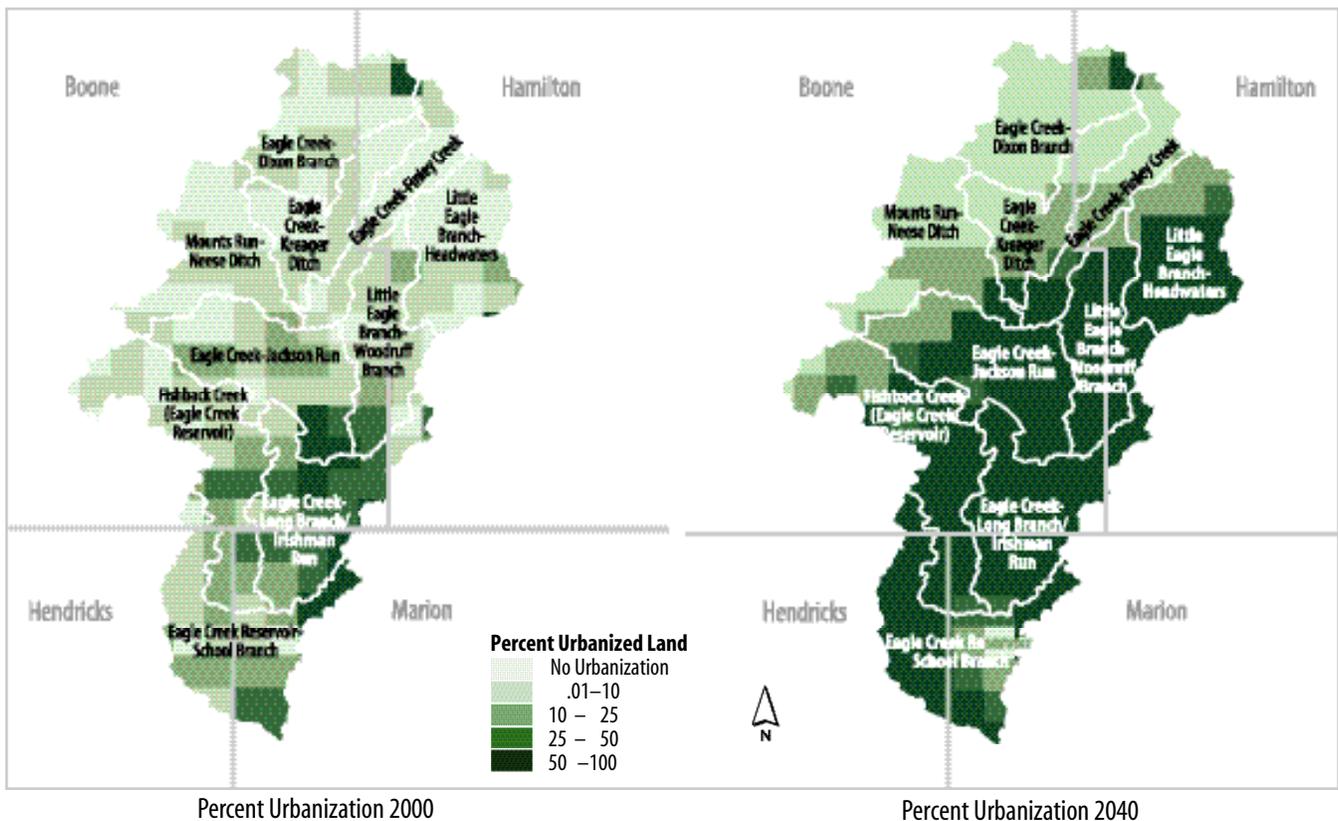
in 2025. This forecast assumes that major transportation improvements will not be developed in the outlying areas.

The LUCI Model forecasts of urban development in Indianapolis reservoir watersheds will help protect water quality

USFilter manages the Indianapolis Water Company for the city of Indianapolis. The Indianapolis Water Company gets much of its water from three reservoirs: Eagle Creek, Geist, and Morse. In response to periodic water quality issues with the water from these reservoirs, especially taste and odor problems, USFilter entered into a long-term research and development partnership with the Center for Earth and Environmental Science (CEES) at Indiana University–Purdue University Indianapolis (IUPUI). CEES is conducting research to understand the nature of the problems and provide possible solutions.

Types of land cover and land use and the levels of urban development in the reservoir watersheds all affect the quantity

Figure 3: Eagle Creek Watershed—Urbanized Land (2000–2040)





and quality of the stormwater runoff into the streams and, ultimately, the reservoirs. CEES contracted with the Center to analyze historical changes in land cover and land use and forecast changes in urban development levels for the Eagle Creek, Fall Creek, and Cicero Creek watersheds for the three reservoirs. The analysis of historical land cover change used the same land cover data derived from satellite images for 1985, 1993, and 2000, that were used in development of the LUCI model. LUCI was used to forecast future levels of urban development for the watersheds to 2040, assuming that urban development patterns continue as in the recent past. These forecasts were summarized for the watersheds and their sub-watersheds for use in further studies, such as the modeling of nutrient loading for the reservoirs.

The forecasts of future urban development provide a basis for understanding the possible effects on the reservoirs and water quality. Researchers can use these forecasts to develop strategies to enhance water quality for these reservoirs. These forecasts also suggest issues relating to the management of future urban development that might be used to protect and enhance water quality for these reservoirs.

To illustrate the changes predicted by the LUCI model for the watersheds, the maps in Figure 3 (page 5) show the percentages of land in the grid cells that were urbanized in 2000 and the forecasted levels of urbanization for the Eagle Creek watershed. The LUCI model produced similar forecasts for the Fall Creek and Cicero Creek watersheds for Geist and Morse reservoirs.

Tippecanoe County used the LUCI Model for stormwater planning

Under regulations adopted by the Indiana Department of Environmental Management in August 2003, counties, municipalities, and universities in urbanized areas are required to adopt new local programs to control pollutants in stormwater runoff. In 2002, the Tippecanoe County Project Team (including members from Tippecanoe County, the municipalities of Lafayette, West Lafayette, Battleground, and Dayton, and Purdue University and Ivy Tech State College) initiated a cooperative planning process to address these new regulations.

As part of this effort, the Project Team hired the Center to study financing options for new stormwater quality activities. The financial analysis included six tasks:

- determine funding currently available for stormwater quality related work by jurisdiction;
- determine the additional funds needed to comply with new regulations;
- assess the public's willingness to pay for new stormwater programs;
- identify alternative sources of funding;
- estimate potential revenues from preferred sources; and
- provide a summary of findings and recommendations.

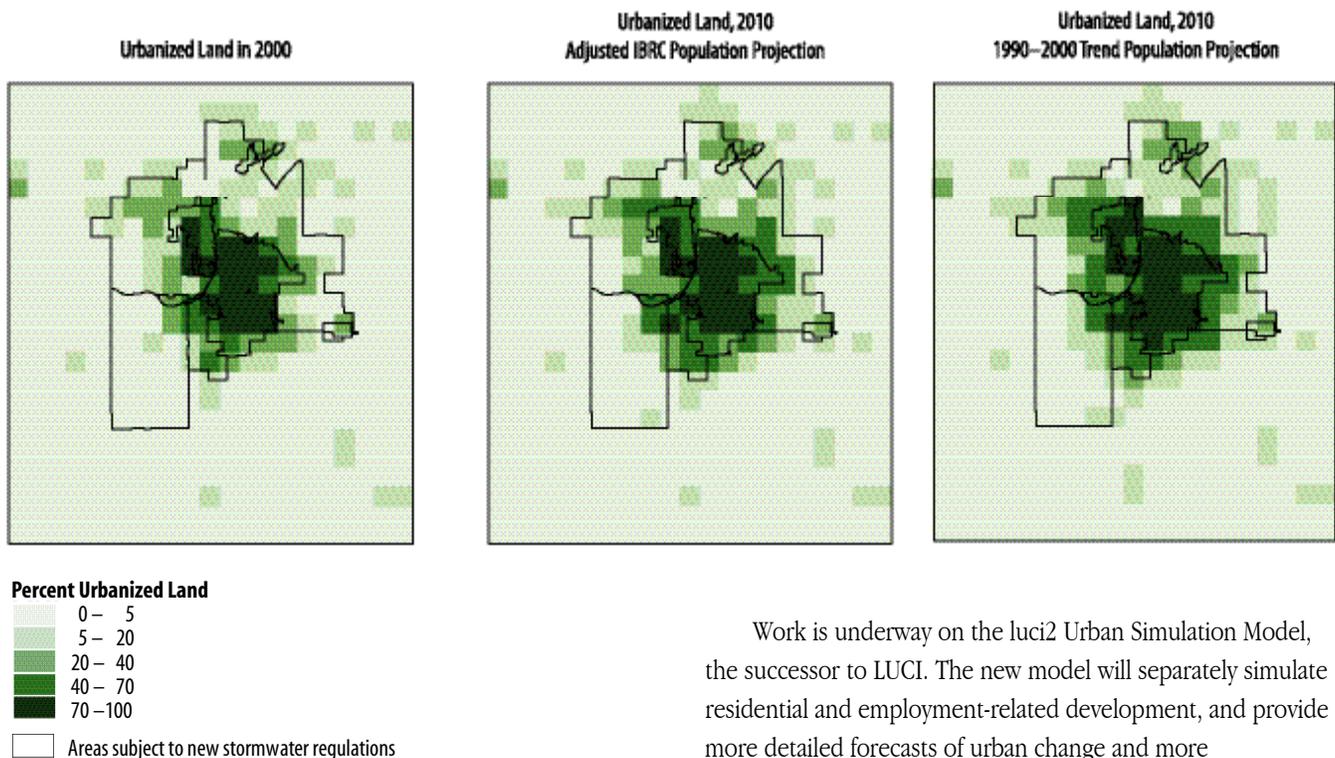
To estimate potential revenue from stormwater utility charges, analysts used estimates of residential and employment-related land use derived for use as inputs for a new version of the LUCI model that is being developed. They used estimates for residential uses to establish an Equivalent Runoff Unit (ERU), a measurement that often serves as the basis for stormwater utility fees. These data also were used to estimate the stormwater utility revenue that would be collected from nonresidential uses.

To develop recommendations for the formation of a stormwater utility, Center research staff used LUCI to estimate the urbanized area in Tippecanoe County in 2010. The results of these estimates are shown in Figure 4. Specifically, staff ran two scenarios, comparing each with a map showing urbanized land in the year 2000 (map on the left). The first forecast (center map), uses updated population projections from the Indiana Business Research Center (2.7 percent growth per 5-year period). The second forecast uses current trends (map on the right). This information will help the Project Team, particularly Tippecanoe County, in choosing boundaries for their new stormwater utility.

Future Applications and Future Directions

The four LUCI applications described in this report are only the beginning for the applications of this planning tool for Central Indiana. Several additional applications have begun or are under discussion, and we are developing a new version of the LUCI model that will expand its utility for an even wider range of applications.

Figure 4: Change in Urbanization in Tippecanoe County from 2000 to 2010



Researchers at Purdue University in West Lafayette are conducting long-term studies of ecological change in the Upper Wabash River Basin. Their work includes development and application of a variety of models to predict the ecological consequences of changes that are taking place in that region. Work is underway on initial efforts at linking LUCI with those models. Researchers will use forecasts of urban development produced by LUCI as inputs to other models to predict environmental effects of future urban change.

The Indiana Biodiversity Initiative is developing tools to help planners incorporate the protection of habitats and species in their work. Researchers are discussing using LUCI urban development forecasts to refine their work so that they can provide more effective recommendations to nurture biodiversity.

Also, the Indiana Livestock Alliance has asked about the possible use of LUCI to inform decisions about the siting of large-scale animal production facilities outside of the path of expected urban development.

Work is underway on the luci2 Urban Simulation Model, the successor to LUCI. The new model will separately simulate residential and employment-related development, and provide more detailed forecasts of urban change and more sophisticated forecasts of employment growth. The luci2 model also will include features that will enhance the ability to apply the model to a broader range of problems. New scenarios reflecting additional policy alternatives can be added easily to the model. And the luci2 model will have the flexibility to be used more easily to address different problems in areas beyond Central Indiana, using different sets of data.

The LUCI model already has demonstrated that a straightforward, easy-to-use model that simulates future patterns of urban development can be a useful tool in many ways. Future applications and model development will continue this work.



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

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.



Central Indiana Region

The Land Use in Central Indiana (LUCI) model forecasts 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. This report describes four recent projects that illustrate practical uses for the LUCI model in analyzing regional issues.

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: John R. Ottensmann, professor and associate director; Jamie L. Palmer, planner/policy analyst, 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