Enhanced Inputs for Travel Demand Modeling:

Using Census with Land Cover Data

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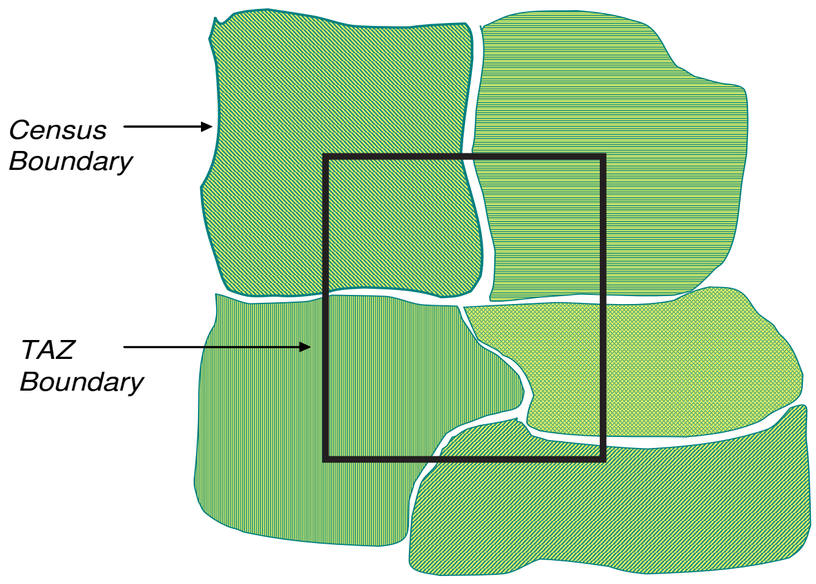
ABSTRACT

Travel demand models require as input the value of various demographic and economic variables at Traffic Analysis Zones (TAZs) level, the spatial unit of analysis. These values are derived from Census data in one of two ways. In one approach, TAZs can be drawn to closely match Census boundaries. Then the the value the variable takes is a combination of its value in one or more Census units all of which lie wholly within the TAZ. However, Census boundaries may not produce the most meaningful TAZs, and so in the second approach TAZs are drawn independent of Census boundaries. Here the values associated with portions of different Census units that lie wholly or partially within the TAZ are aggregated based on area. This unrealistically assumes that values are uniformly distributed across a Census unit given that the entire population may be concentrated only in a part of the Census unit.

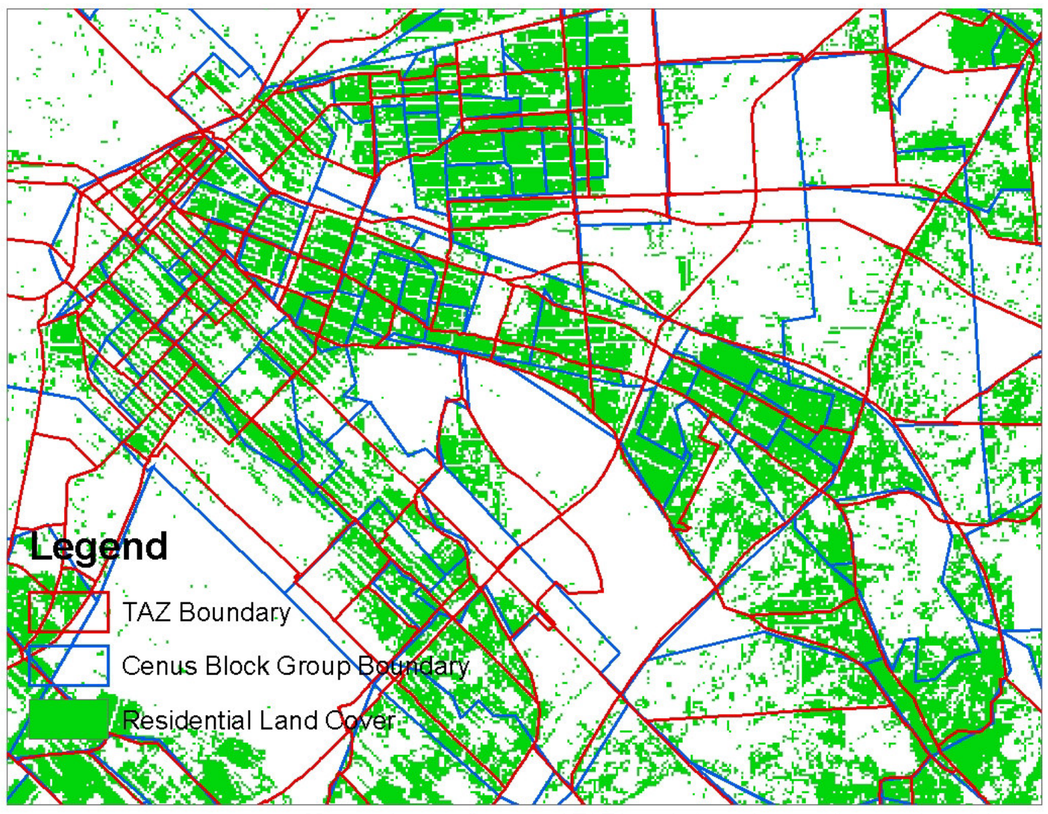
In this poster, we demonstrate how the above problem can be addressed using Land Cover Data to more effectively assign characteristics to portions of Census units. We show how demographic information for any configuration of TAZ can be derived from the Decennial Census. As a result, TAZs can be drawn without regard to Census geographies and the value of demographic variables can be computed on the basis of more realistic assumptions. This approach also serves as an effective way of linking transportation models with models of land-use change. We go on to demonstrate how the same method can be used with land-use change projected using the Land-use Evolution and impact Assessment Model (LEAM).

PROBLEM DEFINITION

Given that drawing TAZs according to more contextual guidelines is more appealing than following census boundary, we need a method that allows the same without compromising on data. Although, data from CTPP is available at TAZ level for metropolitan areas, some communities have TAZs that does correspond to CTPP boundary definition.



The problem can be abstracted to find the value of a variable at TAZ level when the data is available at some other spatial geometry (see figure on left below) without making assumptions about uniform density distribution.

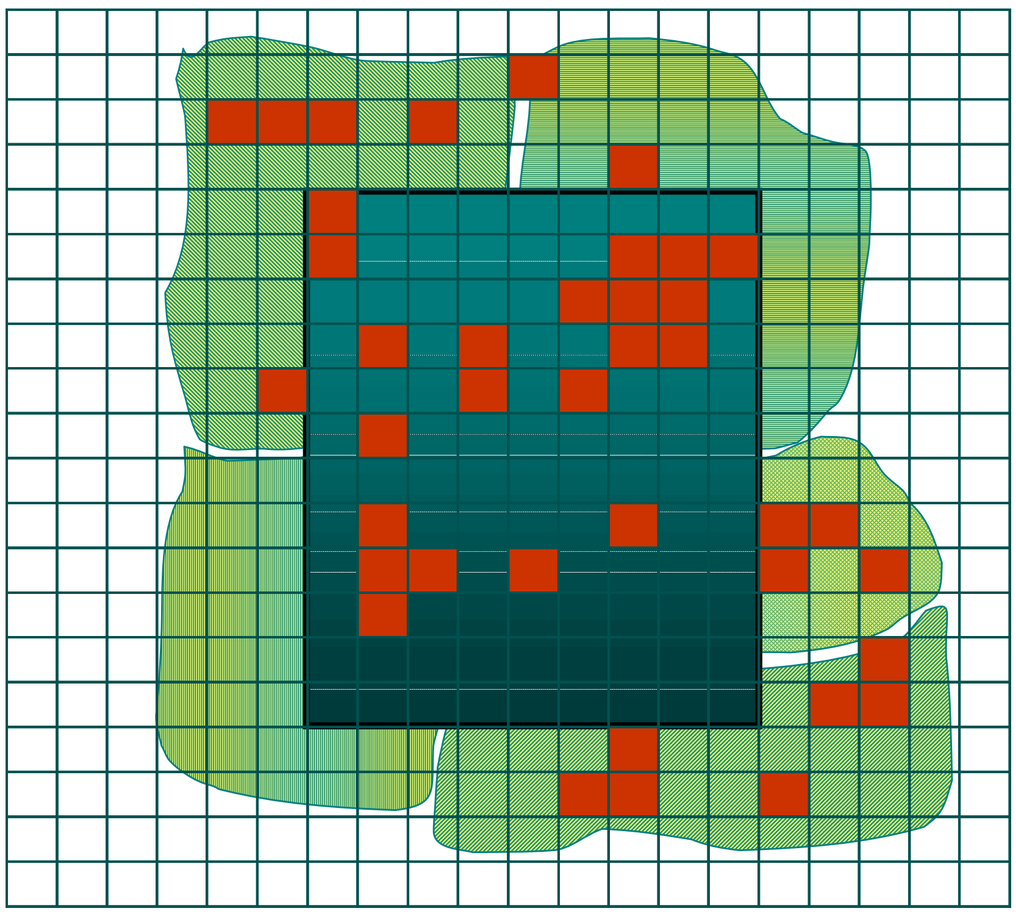


Non overlapping Census and TAZ boundaries and non uniform residential density

METHODOLOGY

The entire region into cells (30 m x 30 m) and each cell is assigned a land use (residential / industrial / commercial / etc.) using the National Land Cover Dataset (NLCD). The NLCD data is augmented by census data, aerial photography, information from local jurisdictions, etc to improve its quality. Next, the demographic information from the census is applied to each of the residential cells in the block. Information such as distributions can be also applied to each of residential cell. e.g., we can say that a cell has 1.4 households, with 0.2 people going to primary school, 0.8 engaging in workforce and 0.4 living a retired life. Or we can also compute that 30% of residential cells in a block are in income group A, 45% in group B and so on. Once each cell has been attached with a demographic attribute, we can aggregate information over all residential cells that lie within a given TAZ.

In the figure below, each red cell represents a residential land cover over 30 m x 30 m. They obtain their socio-economic attributes from Census data and are aggregated over TAZs in which they lie.



Notations: GU or the Geographical unit is the smallest unit (census blocks, block groups or tracts) at which data is available. Traffic Analysis Zones (TAZ) is the desired boundary over which data is desirable. Using elementary spatial analysis, the following two tables can be obtained.

GU id (g)	Total Residential cells (n_g)	Population (Pop_g)
1	n_1	Pop_1
2	n_2	Pop_2
…	…	…
g	n_g	Pop_g
…	…	…
G	n_G	Pop_G

A TAZ id (t)	B Constituents GU (g)	C = A ∩ B Total Residential cells in TAZ (t) which also lies in GU (g) (n_{tg})	Remarks
1	1	n_{11}	Parts of GUs 1-4 lie in TAZ 1
1	2	n_{12}	
1	3	n_{13}	
1	4	n_{14}	
2	2	n_{22}	Parts of GUs 2 & 4 lie in TAZ 2
2	4	n_{24}	
…	…		
t	…	$n_{t..}$	
t	g	n_{tg}	
…	…		
T	…	$n_{T..}$	
T	…	$n_{T..}$	
T	…	$n_{T..}$	

$$Pop_t = \sum_{g \in t} \frac{Pop_g}{n_g} . n_{tg} \qquad \forall \qquad t \in T$$

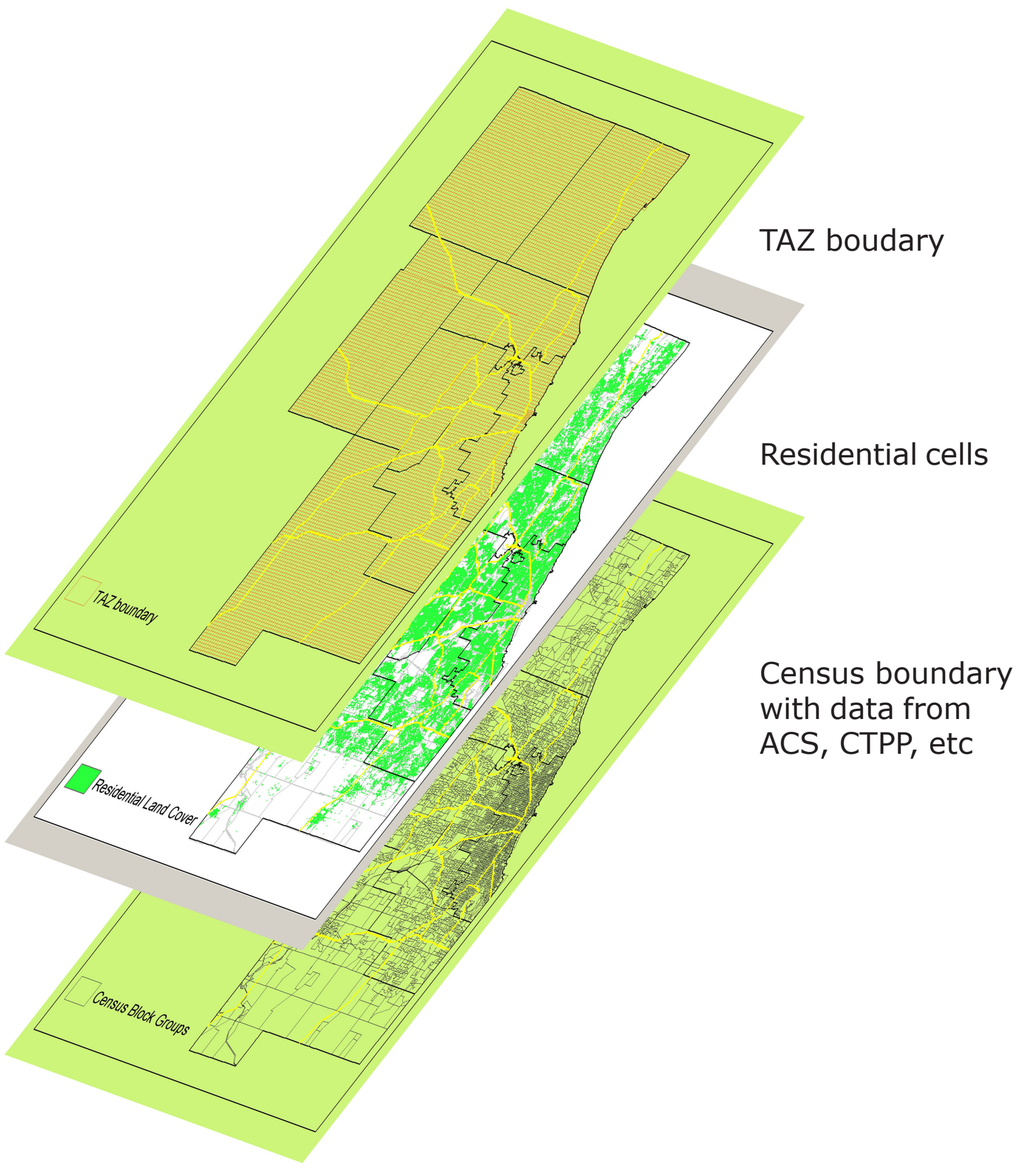
and

$$Inc_t = \frac{\sum_{g \in t} Inc_{tg} . n_{tg}}{\sum_{g \in t} n_{tg}} \qquad \forall \qquad t \in T$$

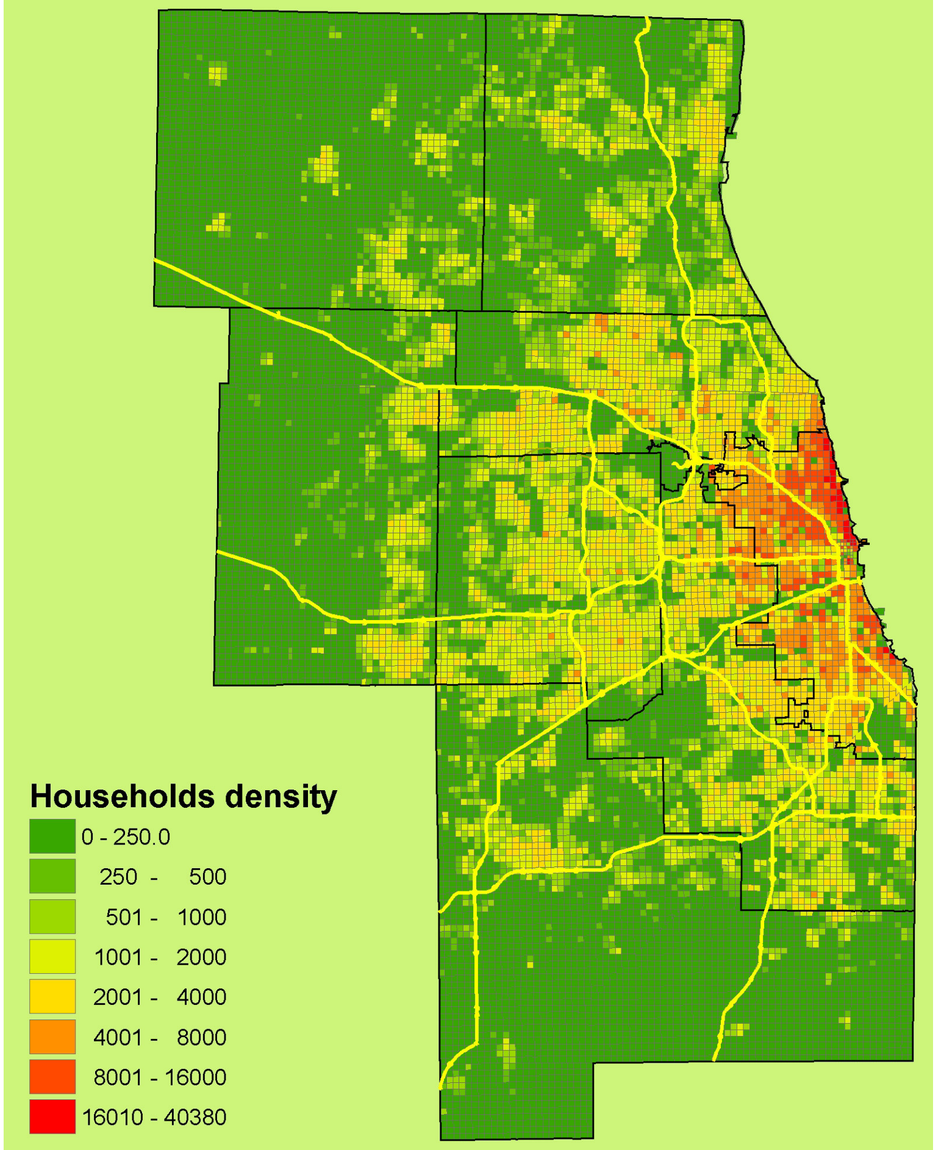
where $n_{tg} = 0$ if no parts of g does lie in t. The same approach can be used to convert GU level information to TAZ level for other variables like number of Households, Average HH income, School enrollment, Part time and full time workers, Age stratification (under 16, 20-50 working and retired), etc. For Age stratification and Households by income types, we can assign the distribution to each residential cell in a GU and then aggregate over the distributions of all residential cells in a given TAZ.

APPLICATION

Starting with information from multiple data sources, each available at a different spatial geometry, a single layer can be formed which is consistent with all other layers and allows for making comparisons that would not have been otherwise possible. This can be achieved by overlaying Census, Land-cover data and TAZ boundary using the methodology described in sheet 2.



Household density for TAZs using data from Census around Chicago



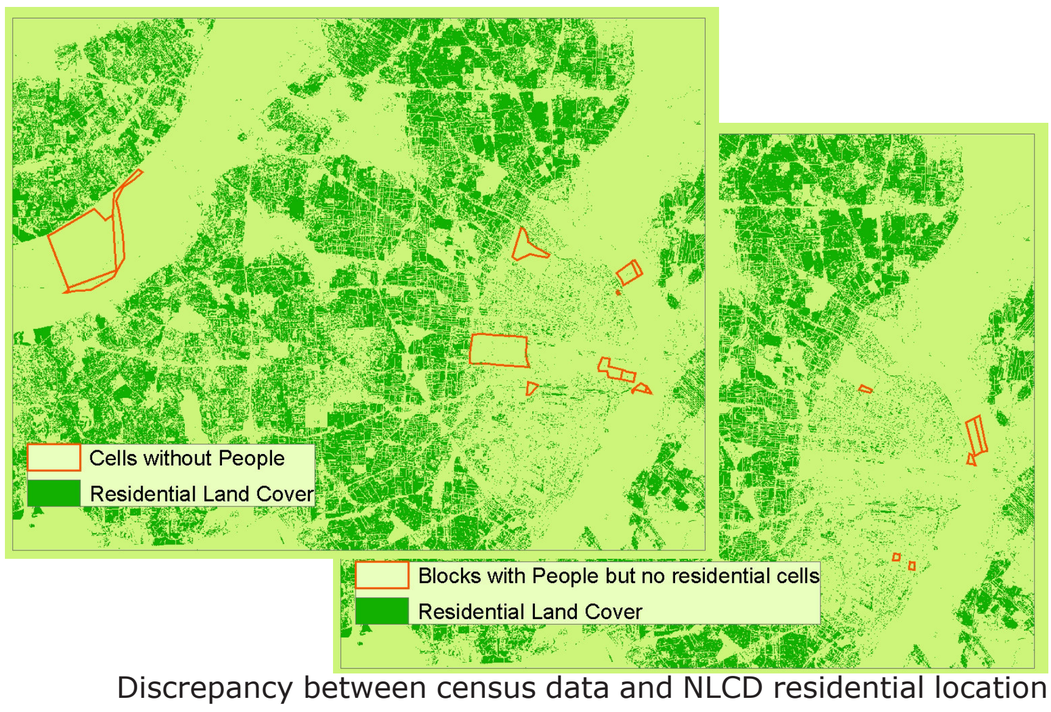
Census Data Used

We used census (ACS, CTPP) data to compute values of following variables at TAZ level.

- Total Population
- Number of Households
- Average Household Income
- School Enrollments at different level
- Age Stratification (Under 16, 17-65, 65 plus)
- Households by income groups
- Workers related data from CTPP, etc.

Approximations

Though, the census data is available at reasonable level of accuracy, the land cover data is not very accurate. There are some census blocks with people living there according to census, but no residential cells according to NLCD. There are also some blocks with residential cells but without anyone living there. Such errors, though very small in magnitude are difficult to overlook. In such situations, we went back to the traditional method of proportionate area approximations.

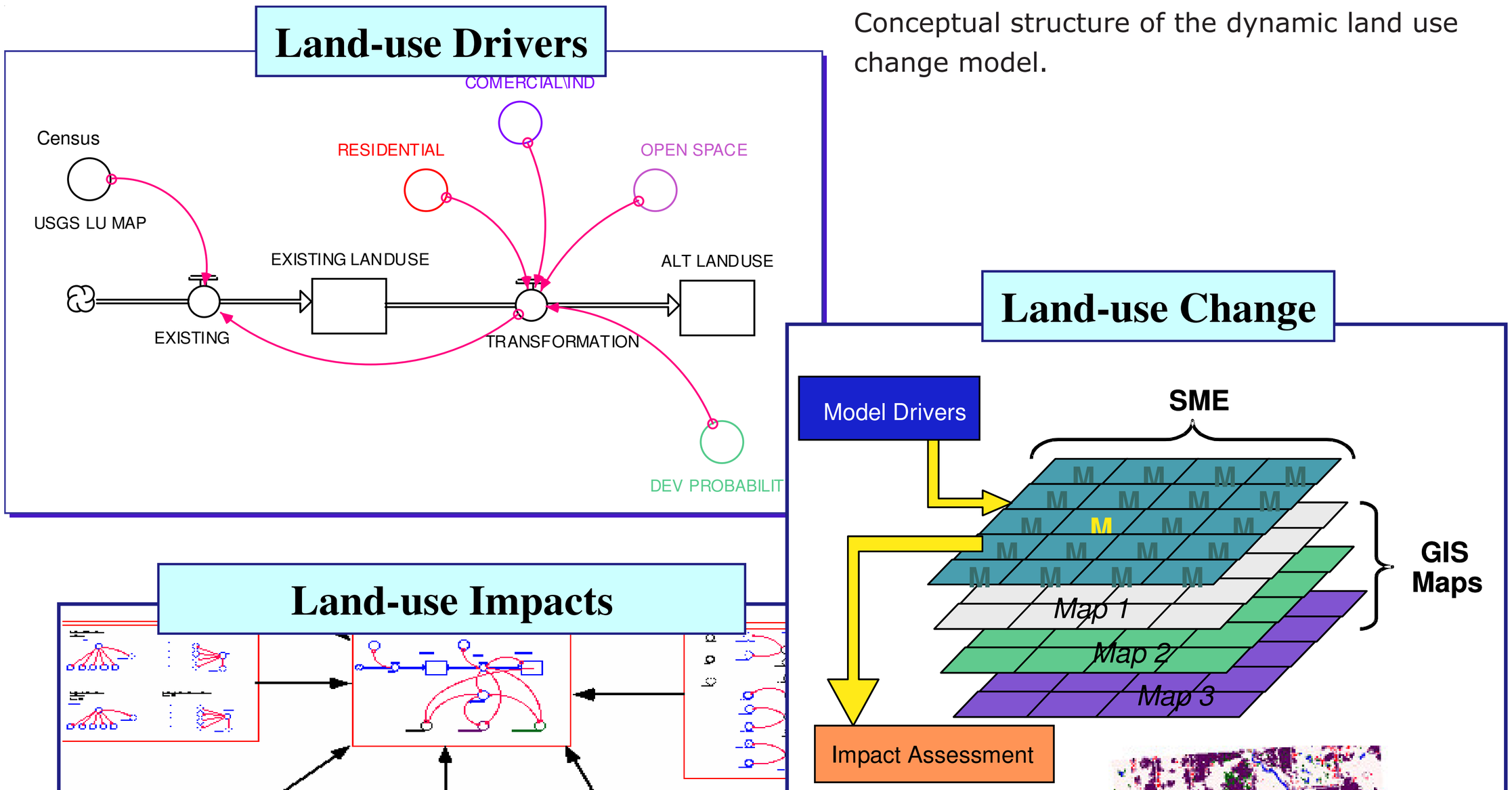


Discrepancy between census data and NLCD residential location

REMARKS

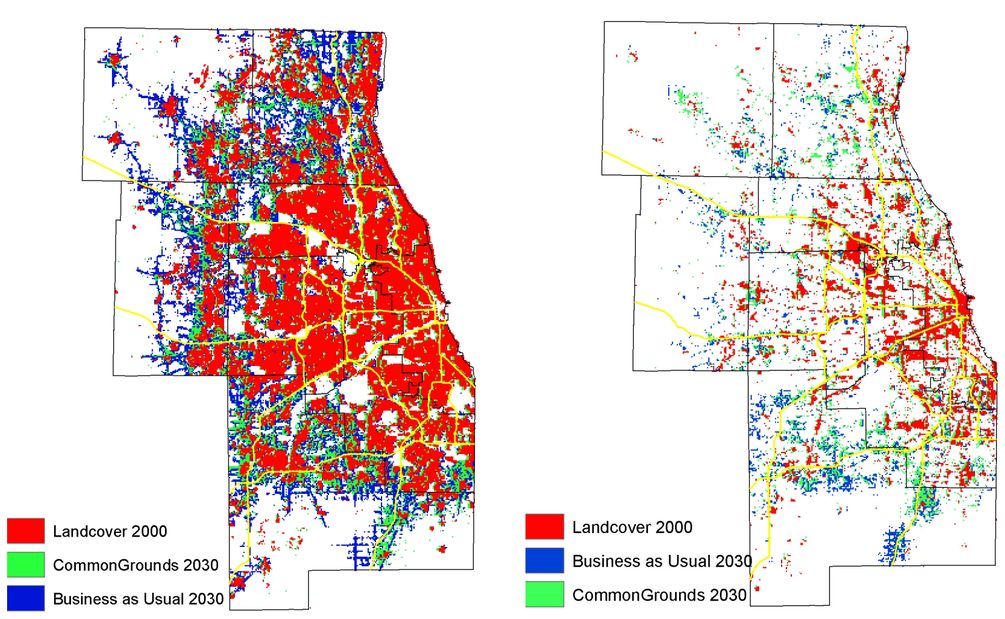
In the process described above, we developed a simple method to convert data from Census boundaries to TAZ boundaries for a variety of variables as needed to estimate and calibrate the transportation model. The process was validated by aggregating data over TAZs and cross evaluating the aggregated results from census table. **Thus, this process frees the transportation planner to delineate TAZs following the census boundary and allow the use of more contextual guidelines for the purpose, without worrying about the availability of data at the TAZ level. It also helps to make comparisons of data available at different spatial boundaries and input into the transportation model.**

INTEGRATION with Land-use Change Model

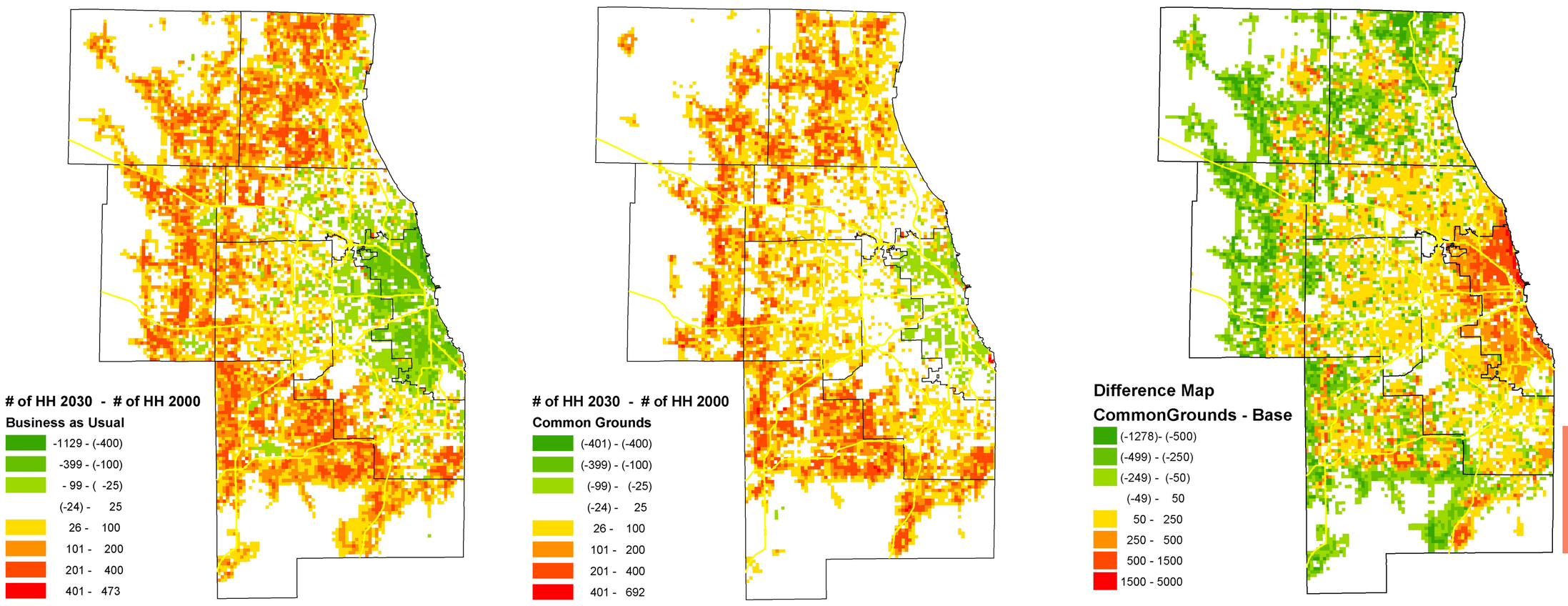


Conceptual structure of the dynamic land use change model.

The methodology described can be integrated with any raster based land use change model to derive TAZ level data for future years. We demonstrate this using the Land-use Change and Impact Assessment Model. We performed the analysis for the Northeastern Illinois Planning Commission under two scenarios - "Business as usual" and "Common Grounds". The later advocates for coordinated and high density development. Aggregating residential cells that lie within a TAZ, many of the socio economic variables can be computed for future years using the projected land use. The maps below show that in the "business as usual" scenario, the development will continue to occur at fringe, leading to hollowing of urban core. However, this can be averted under a coordinated development effort



Projected land uses for 2030 under two different scenarios



Distribution of changes in Household locations in Chicago region under alternative scenarios by TAZs