Land Use Models

presented by

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Presentation Outline

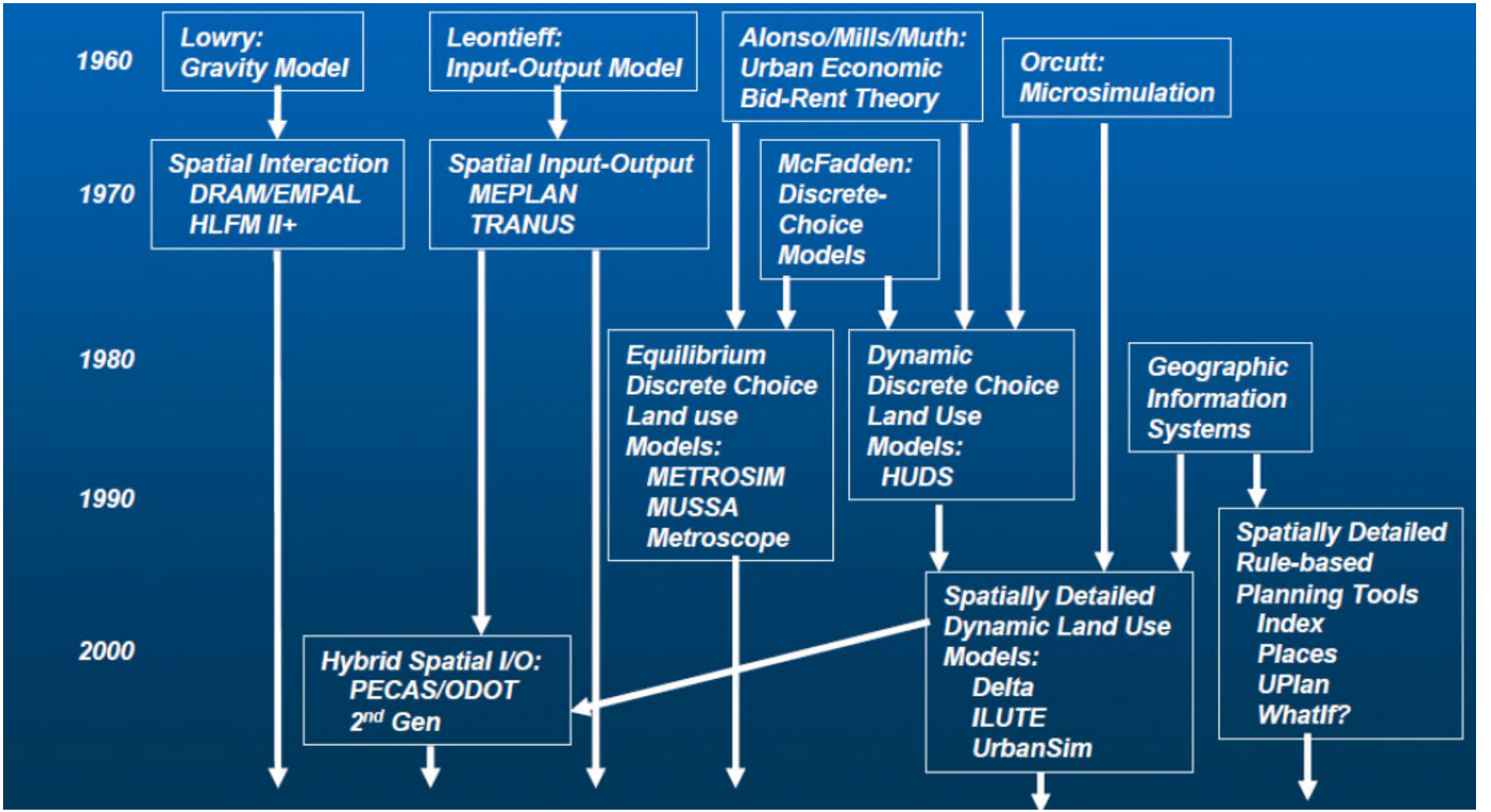

- Overview of various types of land use models
- Florida Land Use Allocation Model (FLUAM)
  - Model overview
  - Model structure
  - Model variables
  - Land use data inputs
  - Model execution
  - FLUAM input and output files
  - Travel Demand/Land Use Model Integration

Land Use Model Overview

Land Use Models:

- Use economic theories and simplified statistical methods to explain and estimate the layout of land uses
- Are quantitative methods used to predict future changes in land uses based on economic theories and social behaviors
- Can be integrated with transportation models to simulate the interdependent relationships between land uses and the transportation network
- Help determine the various impacts to the transportation network of various land use policies

General Categories of Land Use Models



Waddell, TRB Workshop 162, January 2005

Typical Base Year Data Sources


- Parcel data
  - Property appraiser data available from the Florida Department of Revenue
- Zoning/Existing Land Use
- Water/sewer service
- Building permits
- Bureau of Economic and Business Research (BEBR) and Census data
- InfoUSA or Bureau of Economic Analysis (BEA) data
- Environmental constraints
- Model data such as networks and skims

Additional Forecast Year Data Sources

- Future Lane Use Maps (FLUM)
  - Planned Unit Developments (PUDs)
  - Evaluation and Appraisal Reports (EARs)
  - Redevelopment plans
- BEBR and BEA forecasts
- Development of Regional Impacts (DRIs)
- Urban Service Areas
- Master/sector plans
- FSUTMS model future year data
  - Networks and skims

Overview of Florida Land Use Models


- Future Land Use Allocation Model (FLUAM) used by Metroplan Orlando and others
- Urban Land Use Allocation Model (ULAM)
- Land Use Conflict Identification Strategy (LUCIS)
  - LUCIS Trend
  - LUCIS Composite
- SLEUTH
- Florida Land Use Allocation Model (FLUAM) from Turnpike developed by RSG
- Others

Sampling of MPO Land Use Models


MPO/TPO	LUCIS Trend	LUCIS Composite	FLUAM	ULAM	SLEUTH	Other
Lake Sumter MPO			✓			
Ocala Marion County TPO	✓	✓	✓			
Northwest Florida Regional TPO						✓
Polk TPO			✓			
Metroplan Orlando			✓			
Palm Beach MPO						✓
Hillsborough County MPO						✓
Pinellas County MPO						✓
Pasco County MPO						✓
Martin MPO				✓		
Indian River MPO				✓	✓	
Florida's Turnpike						FLUAM*

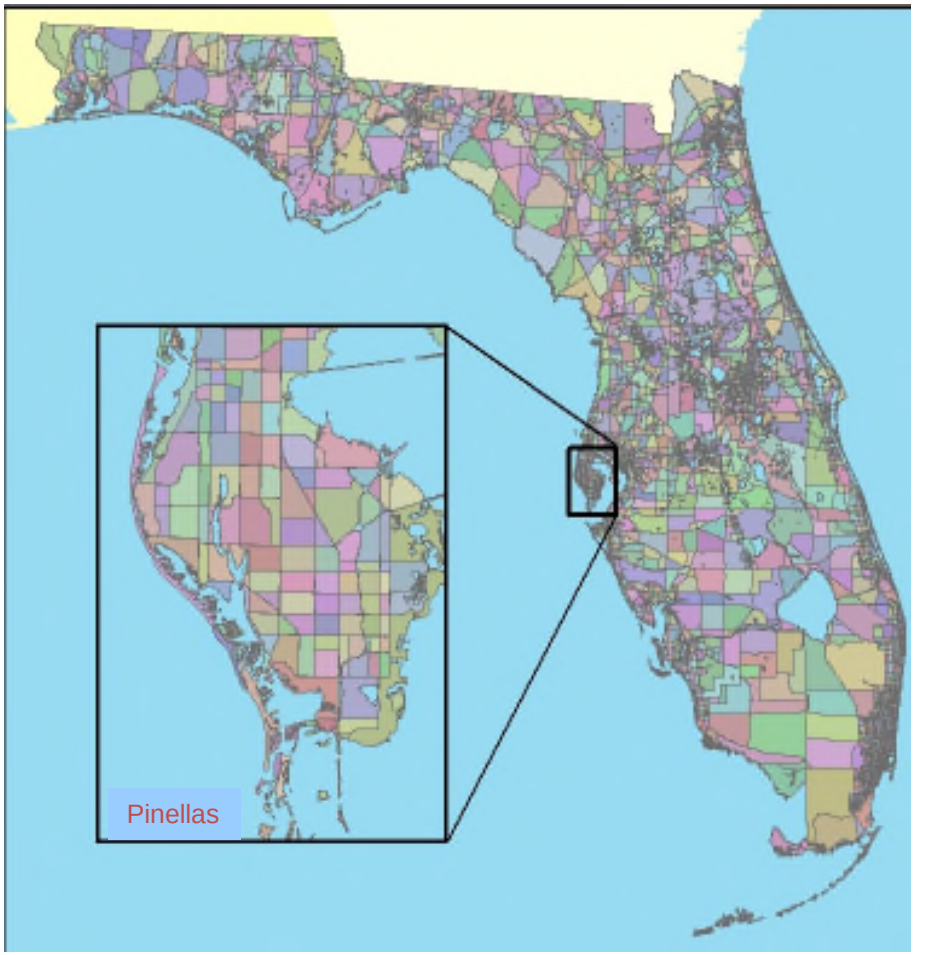
FDOT

Florida Land Use Allocation Model-FLUAM

- Originally developed by Resource System Group (RSG) in conjunction with AECOM for Turnpike applications
- Gravity model-based
  - In the same category as DRAM/EMPAL land use models
- Uses parcel data information
- Been in use for over 9 years
- Used in the Turnpike State Model (TSM)
- Used in the Turnpike Central Florida Model (TCFM)
- Potential for use in the Cube/Voyager FLSWM

FLUAM Introduction

- Growth centers can be geographically defined by the user
  - State, County, MPO, other.
- Allocates housing and employment growth at TAZ level
- Written in C++ and integrated with transportation models:
  - Currently integrated into Florida's Turnpike State and Central Florida Models
  - Built to allow integration into Cube/Voyager models
- FLUAM Model runs in 2-4 minutes



Overview of the FLUAM Process

Base Year Zonal Land Use
- Households
- Employment

Total Land Available

Legal & Physical Constraints

Determine Remaining Developable Land

Generate Travel Impedance Matrix

Accessibility and Overall Attractiveness

Florida - Calibrated Parameters

Allocate new Increment of Land Use

Future Growth Increment
- Households
- Employment

Forecasting Analysis Procedures

TAZ Land Use Forecasts
- Households
- Employment

5 Year Dynamic Land Use Lag

FLUAM Process – Key Inputs


- Households
  - An extension of the population forecasts
  - Uses BEBR forecasts
  - Guided by persons per household trends
  - Assumes relatively stable household sizes with some decay
- Employment
  - Uses Bureau of Economic Analysis (BEA) information
  - Historical data for all counties 1969 through 2009
  - Least squares trend analysis used to develop growth rates out to 2045
  - Housing to employment ratio used to check that the employment was sufficient to service the projected population growth

Model Structure – Two Stage Logit / Linear

1. What percent of the available land is consumed?

Logit Model Estimates:

$$P_{ij} = \Pr(Y_{ij} = 1 \mid X_{ij}) = \frac{e^{\beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_k x_k}}{1 + e^{\beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_k x_k}}$$

P_{ij} = Probability of TAZ i, land use j, being developed

2. What will be the additional households and employment on the consumed land?

Tobit Model Estimates:

$$\text{Density}_{ij} = \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_k x_k + \varepsilon$$

Density_{ij} = amount of land use j in TAZ i

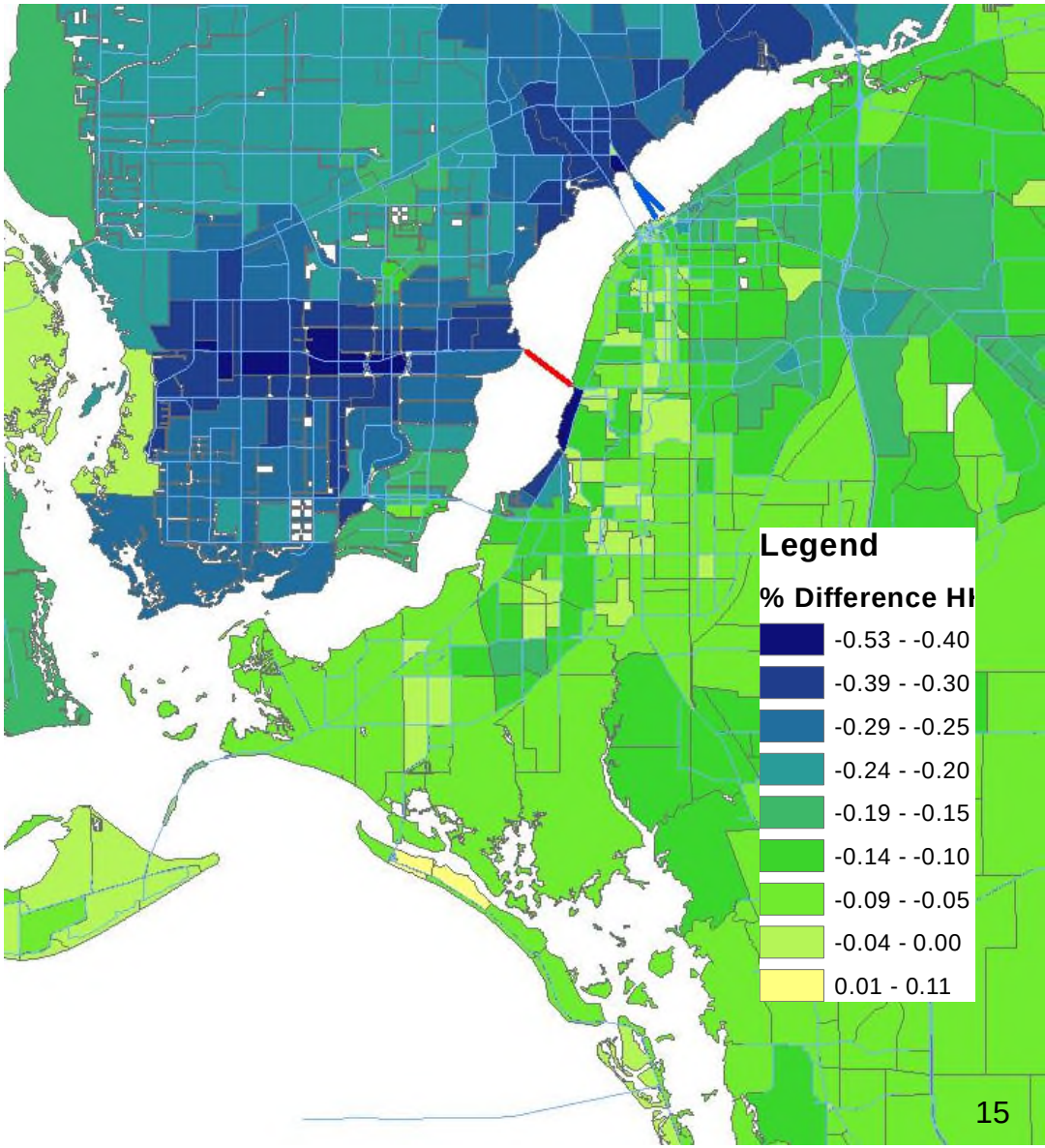
Model Variables

Variable	Source	Effect on Development
Accessibility	Travel demand model	Positive
Proximity to Coast	GIS layer	Positive
Distance from Arterials & Interchanges	Travel demand model	Negative
Urban Growth Boundary	GIS layer	Positive inside UGB; negative outside
Percent of Undeveloped/Vacant Land	Parcel	Positive
Density of Current Use	Parcel	Positive
Land Category	Parcel	Negative

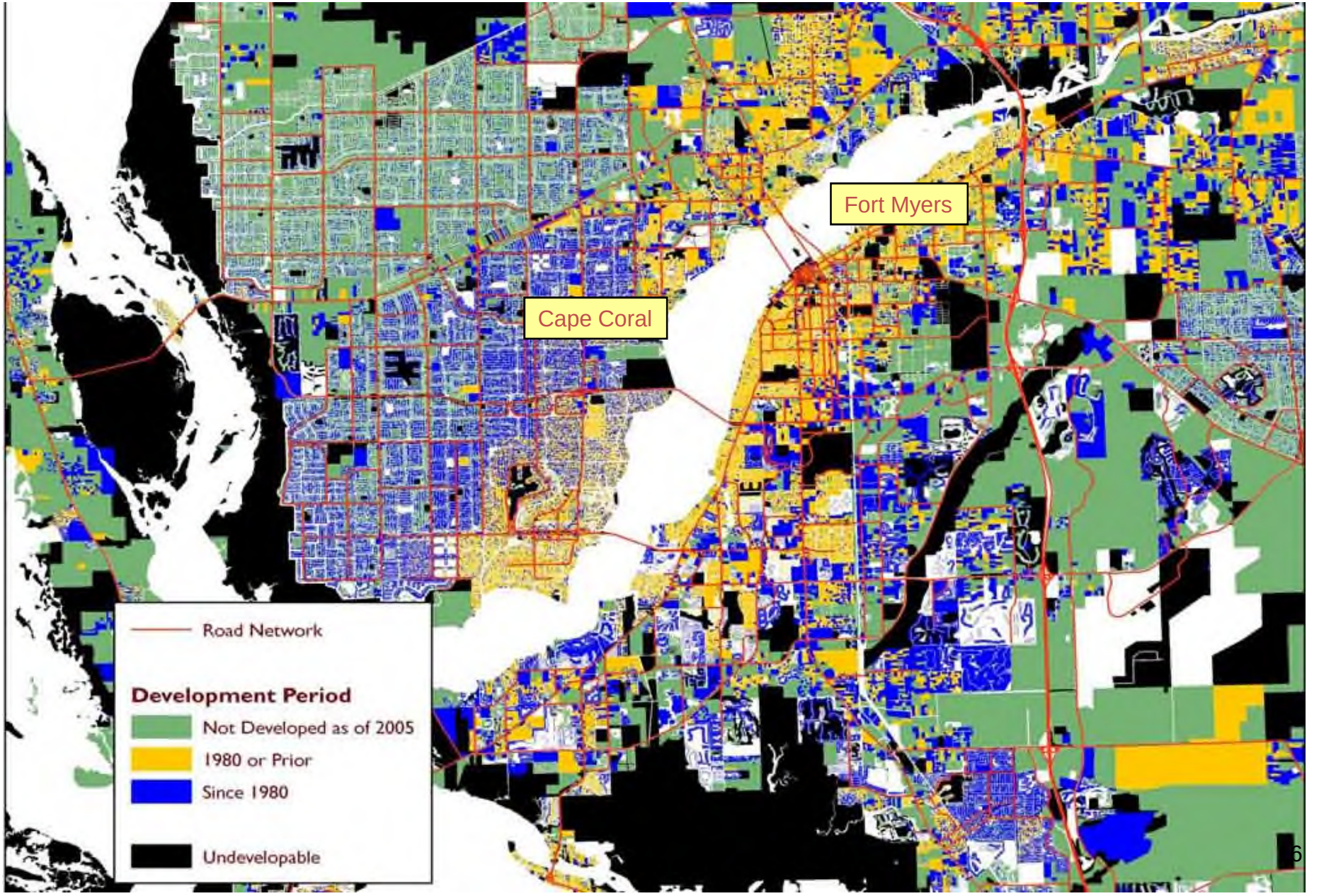
Sensitivity to Accessibility Example

- Approximate Population to Employment Ratio
  - Cape Coral: 3 pop to 1 emp
  - Fort Myers: 1 pop to 2 emp
- Doubling of bridge capacity during 1990s
- Large subsequent observed increase in development in Cape Coral
  - Population increase by 75% between ’95 – ’05
  - Twice the rate of growth in the 80s and early 90s

- Modeled removal of new bridge capacity
  - Population increase by 55% between ’95 – ’05 (as compared to 75% with the bridges)



Development of Land Use Parcel Data



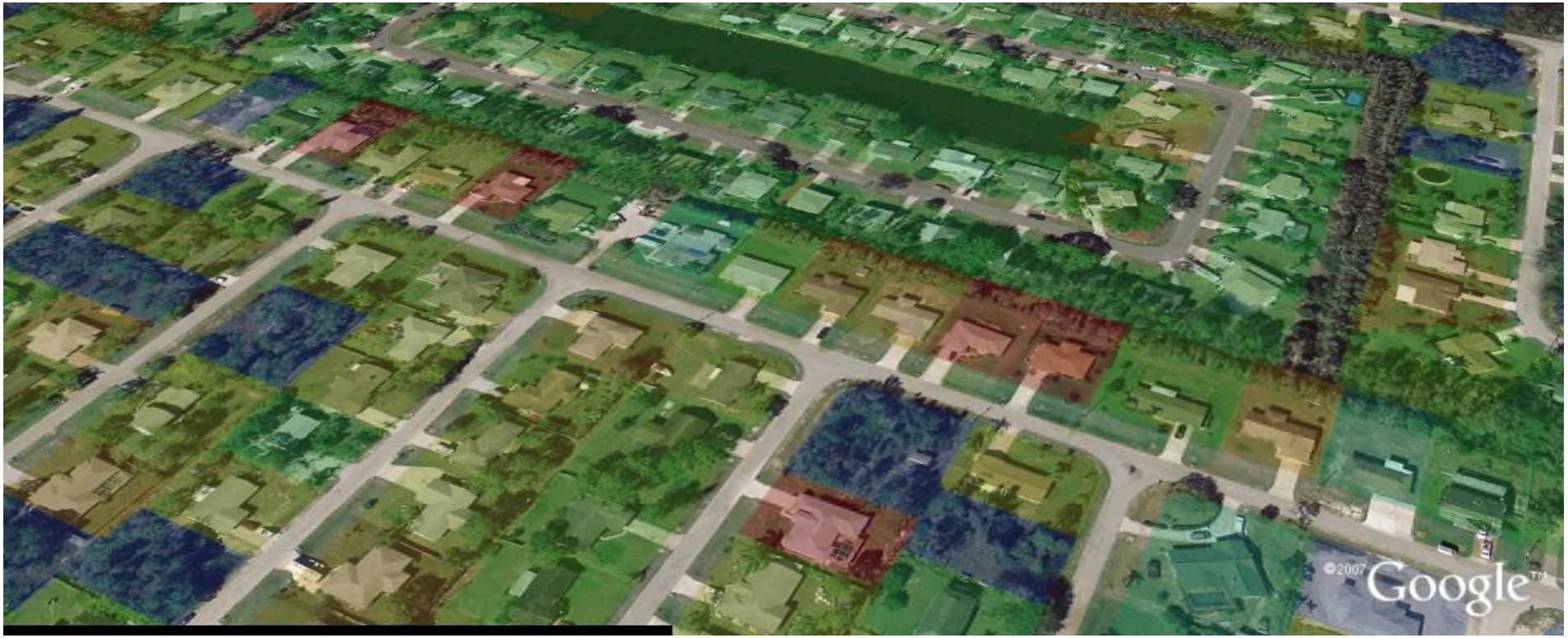
Parcel Data Development Details

Four key parcel data variables

- Land use codes
- Land value
- Building square footage
- Year built

Parcel Data Development Period

Parcel-level development over time

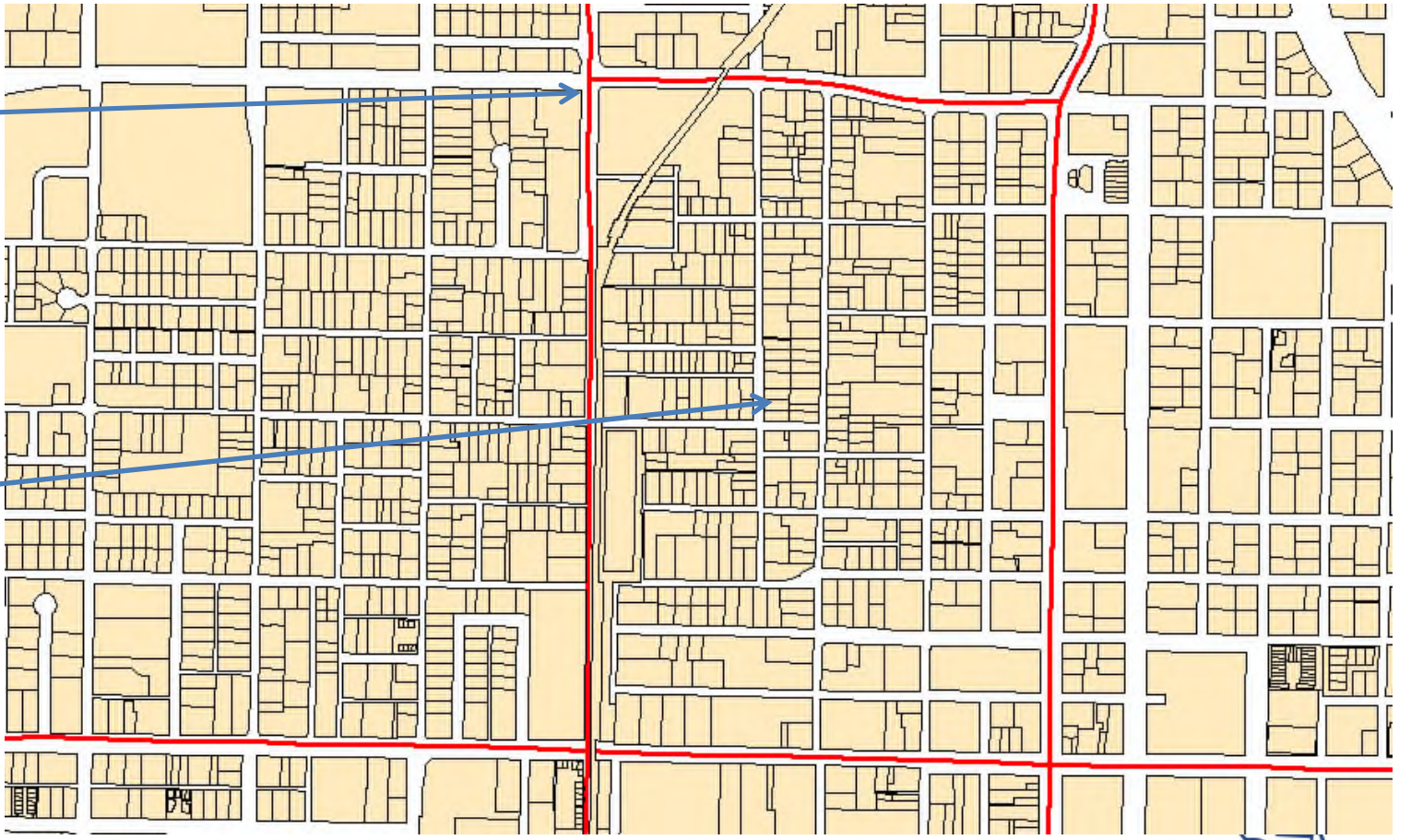


Parcel Data Aggregation

Roll-up of parcel information to the TAZ level

1 TAZ

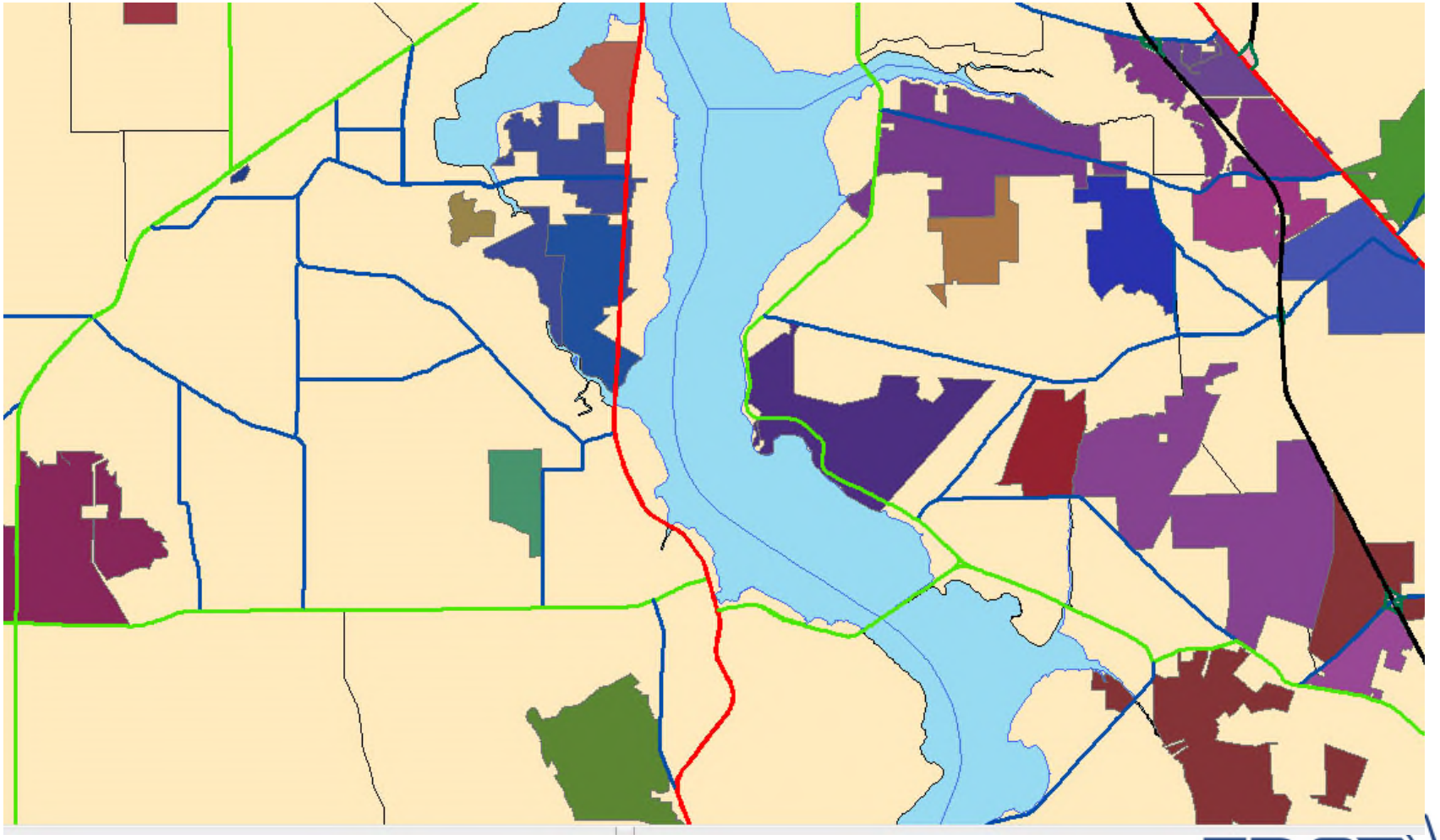
300+ Parcels



Aggregation of Land Categories

- Agricultural Land
- Developed Residential Land
- Developed Non-residential Land
- Vacant Residential Land
- Vacant Non-residential Land
- Undevelopable Land

Large developments and the FLUAM

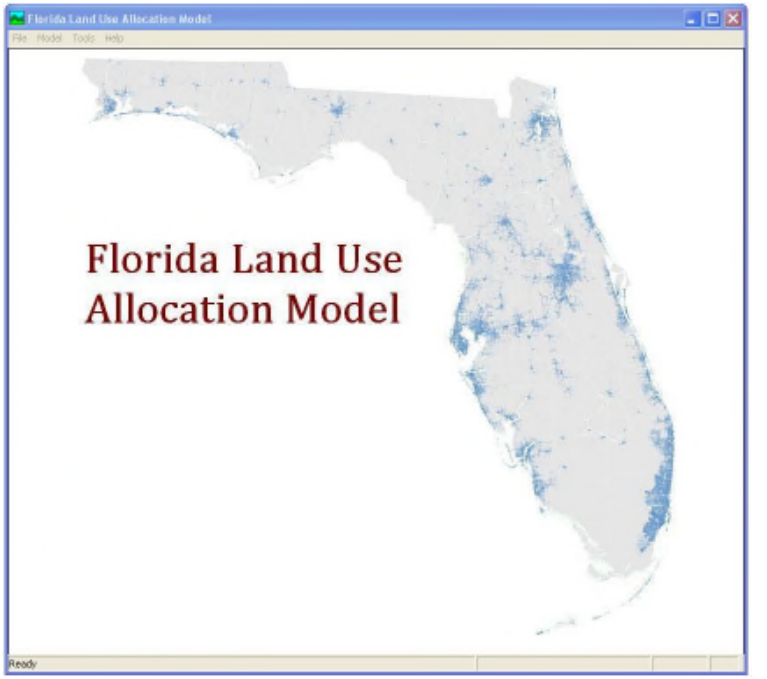


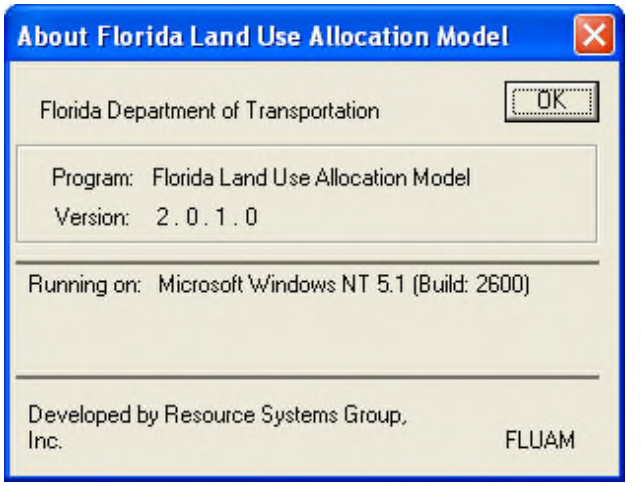
Agricultural Lands in the FLUAM

Underutilized Lands in the FLUAM

FLUAM Execution – Option 1

- Launched like any Windows Application
- File Menu:
  - Load Background – see screen capture
  - Exit – close the application
- Model Menu:
  - Run FLUAM - runs the model and reads an input file called FLUAM_ControlFile.txt located in the same directory as the executable
- Help Menu:
  - About - tells you which version of the FLUAM you are using





FLUAM Execution – Option 2


- When FLUAM is launched from the command line, the application starts, reads the input control file, runs, then automatically closes.
- Two parameters are required: the executable including path and the input control file including path.
- Two sample command lines are shown below (quotes are required around each parameter). An easy way to perform this step is through a batch file.

"C:\TSM\FLUAM.EXE" "C:\TSM\FLUAM_DATA\CONTROL_FILE.TXT"

Or

"fluam.exe" "ControlFile.txt"

Control File - Overview

- Consists of sections each defined by a header. Headers must be written exactly as shown below (must be upper case with the //**)

- //** VERSION
- //** GENERAL PARAMETERS
- //** FILE NAMES
- //** RESIDENTIAL LAND CONSUMPTION COEFFICIENTS
- //** NON-RESIDENTIAL LAND CONSUMPTION COEFFICIENTS
- //** RESIDENTIAL DENSITY COEFFICIENTS
- //** NON-RESIDENTIAL DENSITY COEFFICIENTS

Control File - Version Number

- The control file version number must be consistent with the application (which can be viewed from Help::About menu).

```
//** VERSION
2010                    // version 2.0.1.0 corresponding to the File::About menu
```

Control File - General Parameters

- General parameters define run flow and overall values.

```
//** GENERAL PARAMETERS
0                   // 1 = dump debug files, 0 = don't
0                   // 1 = new skim, 0 = skim represented in input TAZ file
0                   // 1 = new network, 0 = network is in input TAZ file
4837                // LastInternalZone
4874                // LastExternalZone
100                 // ClosestNTAZs
-1.7354             // TravelTimeAdjustment
```

Control File – Files Section

- This specifies the input and output files to be used in the model run

- //** FILE NAMES
- C:\FLUAM\DATA\travel_times_15.txt // INPUT: auto travel time skim
- C:\FLUAM\DATA\TAZ_15.txt // INPUT: TAZ input file
- C:\FLUAM\DATA\Growth_15_20.txt // INPUT: growth file (control totals)
- C:\FLUAM\DATA\Nodes_15.txt // INPUT: node file
- C:\FLUAM\DATA\Links_15.txt // INPUT: link file
- C:\FLUAM\DATA\TAZ_Out_15.txt // OUTPUT: current zonal output file
- C:\FLUAM\DATA\TAZ_OutIn_20.txt // OUTPUT: future zonal output file

Control File - Model Coefficients

- The remaining four sections specify the model parameters. These should not be changed. They are available simply to provide documentation and for access in future calibration efforts.

- //** RESIDENTIAL LAND CONSUMPTION COEFFICIENTS
- //** NON-RESIDENTIAL LAND CONSUMPTION COEFFICIENTS
- //** RESIDENTIAL DENSITY COEFFICIENTS
- //** NON-RESIDENTIAL DENSITY COEFFICIENTS

Travel Skim File


- Auto travel time file from the most previous transportation assignment.
- Exported via a script
- File structure: CSV file.
- Three columns (from TAZ, to TAZ, Time)

```
1,  2,  32
1,  3,  28
1,  4,  12
```

Node File

- Node File: Extracted from the model network.
- File Structure: CSV Format
- Sample File:

```
N, X, Y
1, 403760, 2987443
2, 378206, 2987949
3, 383076, 2989870
```

Link File

- Link File: Extracted from the model network
- File Structure: CSV Format
- Sample File:

a,b,district,distance,oneway,lane_05,ftype_05,atype_05,speed_05,cap_05,fftime_05

```
1,51493,1,2.21023,0,2,51,30,35,10000,3.78897
1,52148,1,1.22329,0,2,51,30,35,10000,2.09707
1,52163,1,1.27246,0,2,51,30,35,10000,2.18136
2,53485,1,1.3796,0,2,51,50,35,10000,2.36503
2,84608,1,.89797,0,2,51,50,35,10000,1.53938
```

Growth File

- Contains the housing and employment control totals for each "Growth Center"
- Each TAZ is assigned to a Growth Center in the TAZ file (described next). Growth Centers currently follow County boundaries
- File Structure: CSV Format
- Sample File:

67, Housing Units, Employment
1, 345, 262
2, 234, 834
3, 163, 256
…
67, 264, 526

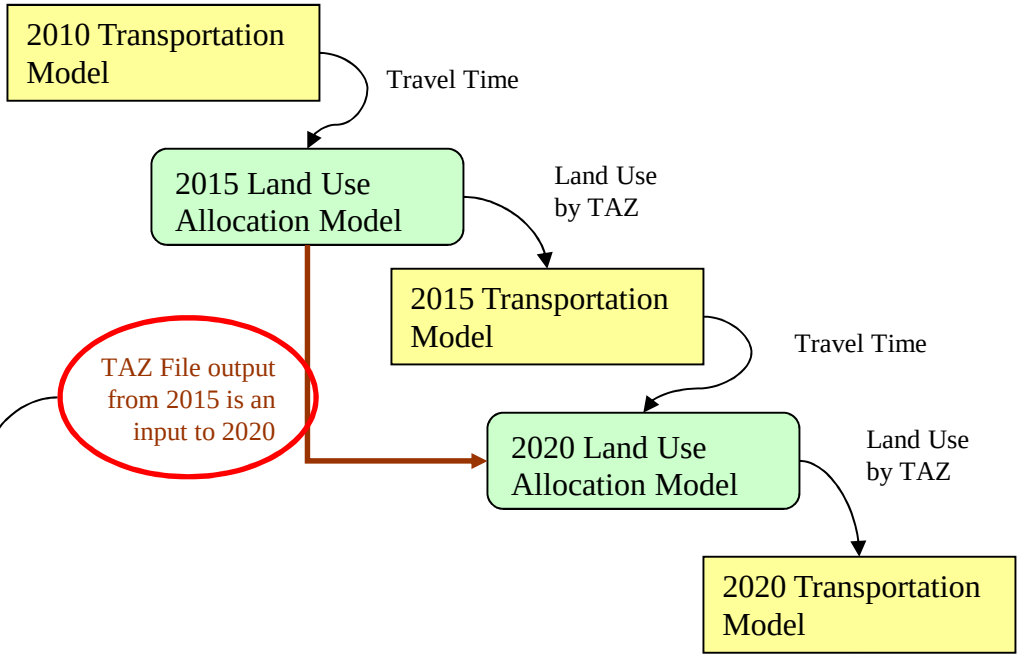
345 housing units will be assigned among the TAZ's designated in Growth Center 1

TAZ File

- TAZ File includes:
  - Input values: used as input to the model run
  - Temporary values: both input and output
  - Output values: results of the model run

Temporary values are intermediate variables calculated during the model run. These can be used as a starting point for a new model run (see the second and third values in the GENERAL PARAMETERS Section of the control file)

The TAZ file is used to hand output from one time step into the next time step



OUTPUT TAZ Files

//** FILE NAMES

- C:\FLUAM\DATA\travel_times_15.txt // INPUT: auto travel time skim
- C:\FLUAM\DATA\TAZ_15.txt // INPUT: TAZ input file
- C:\FLUAM\DATA\Growth_15_20.txt // INPUT: growth file (control totals)
- C:\FLUAM\DATA\Nodes_15.txt // INPUT: node file
- C:\FLUAM\DATA\Links_15.txt // INPUT: link file
- C:\FLUAM\DATA\TAZ_Out_15.txt // OUTPUT: current zonal output file
- C:\FLUAM\DATA\TAZ_OutIn_20.txt // OUTPUT: future zonal output file

This file contains the same inputs as were in the input TAZ file (second file listed in this section). It will have updated temporary and output values. This file is designed to be used as input to another run of the same time step.

OUTPUT TAZ Files continued

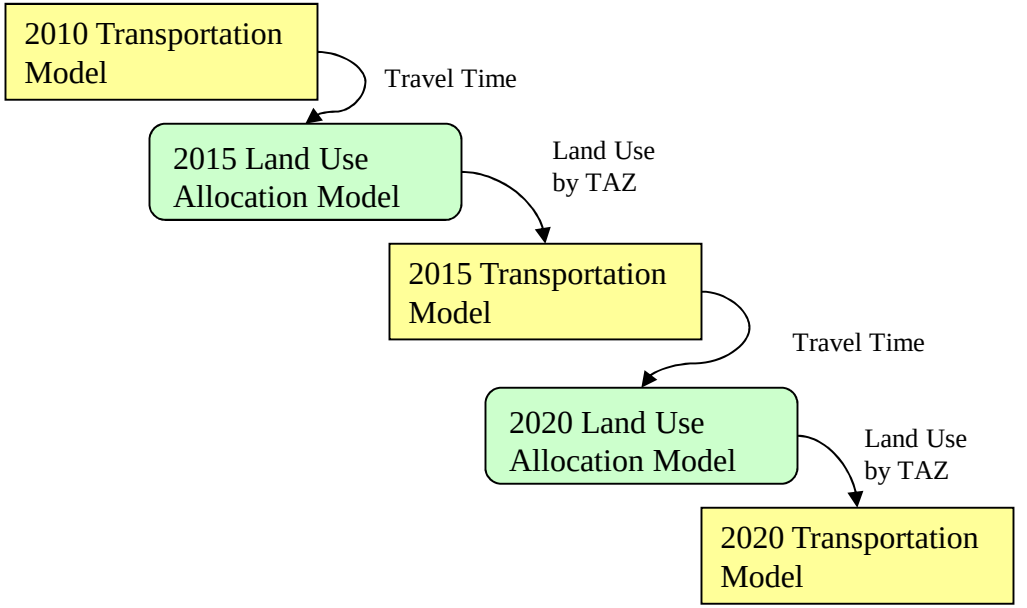
//** FILE NAMES

- C:\FLUAM\DATA\travel_times_15.txt // INPUT: auto travel time skim
- C:\FLUAM\DATA\TAZ_15.txt // INPUT: TAZ input file
- C:\FLUAM\DATA\Growth_15_20.txt // INPUT: growth file (control totals)
- C:\FLUAM\DATA\Nodes_15.txt // INPUT: node file
- C:\FLUAM\DATA\Links_15.txt // INPUT: link file
- C:\FLUAM\DATA\TAZ_Out_15.txt // OUTPUT: current zonal output file
- C:\FLUAM\DATA\TAZ_OutIn_20.txt // OUTPUT: future zonal output file

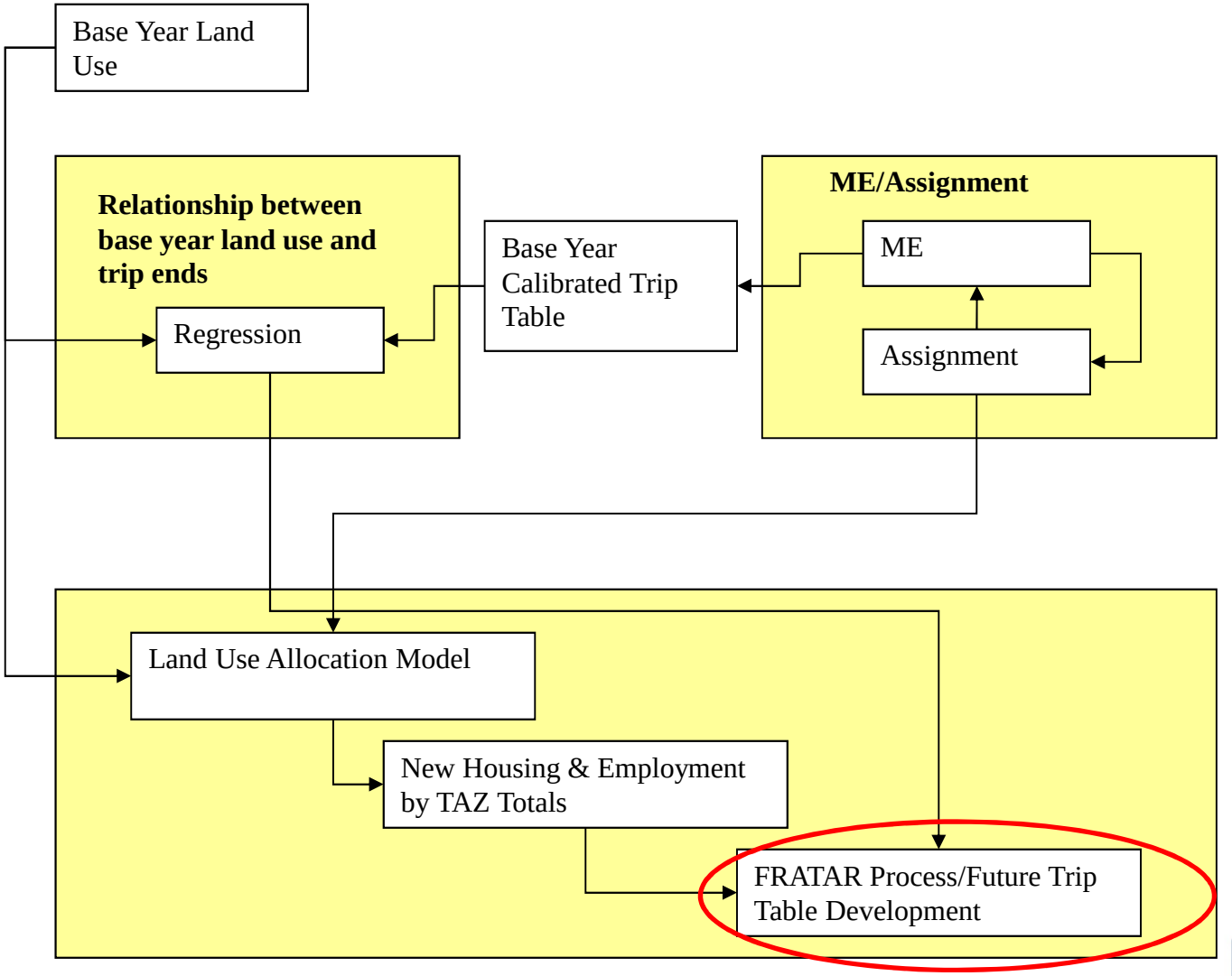
This file contains updated input data representing the results of the model run. It is designed as an input to the FLUAM run in the next time step.

FLUAM Integrated Forecasting Process

- Run traffic assignment for period (t)
- Run LUAM for (t+5) using period (t) skim values, period (t+5) control totals
- Calculate FRATAR factors for updating trip table to period (t+5)
- Repeat process for all forecast periods



FLUAM/Travel Demand Model Integration



FRATAR Process

- The future year trip ends are estimated based on a calculated relationship between the base year calibrated OD matrix trip ends and the base year land use.

$$TripEnds_i = 3.61 * Employment + 1.88 * Households \quad (rural\,TAZs)$$

$$TripEnds_i = 3.95 * Employment + 1.88 * Households \quad (transition\,TAZs)$$

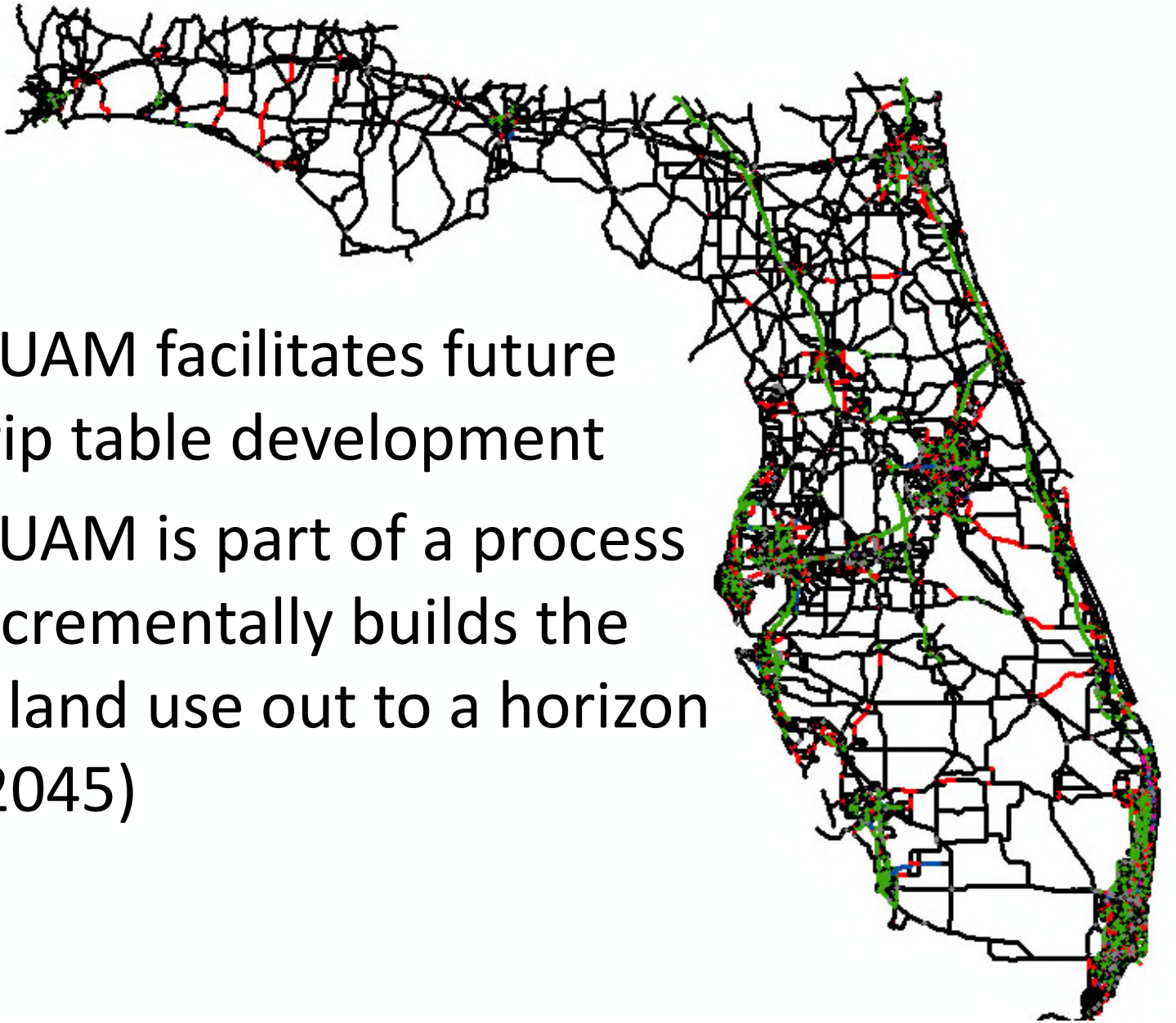
$$TripEnds_i = 3.02 * Employment + 1.88 * Households \quad (urban\,TAZs)$$

FRATAR Process continued

- A spreadsheet is used to generate the input to the FRATAR process.
- The spreadsheet:
  - Takes the future land use from FLUAM (yellow)
  - Estimates future trip ends based on this land use (blue)
  - Calculates the growth factor between the calibrated matrix (2010) and the future year (2015)
  - Generates the input to the FRATAR process (far right)

TPZONE	F2010HH	F2010EMP	F2015HH	F2015EMP		2010Est	2015 Est	2015 Fac		Year 2015 Fratar
1	511	97	524	107		2463	2520	1.02		FO 0001 1 0000102
2	1432	344	2957	415		5204	8360	1.61		FO 0002 1 0000161
3	392	243	900	398		4232	5659	1.34		FO 0003 1 0000134
4	900	549	1049	869		4826	6260	1.30		FO 0004 1 0000130
5	784	2156	1534	2867		10758	14319	1.33		FO 0005 1 0000133
6	690	256	1461	384		3458	5420	1.57		FO 0006 1 0000157
7	4578	1341	5341	2030		15439	18961	1.23		FO 0007 1 0000123
8	4318	884	5585	1330		13568	17304	1.28		FO 0008 1 0000128
9	225	250	337	711		2473	4351	1.76		FO 0009 1 0000176
10	232	105	318	366		3514	4466	1.27		FO 0010 1 0000127

End Results



- The FLUAM facilitates future year trip table development
- The FLUAM is part of a process that incrementally builds the future land use out to a horizon year (2045)

Using FLUAM with Cube Voyager


- The FLUAM is a stand alone process
  - Adaptable/flexible
  - Tool that is good at using many database layers
- Can be integrated into the Cube/Voyager platform
  - Customizable and able to be adapted to the Cube environment and variables
- Potential exists for use in the Florida Statewide Model (FLSWM)
  - Cube environment
  - Navteq integration

Questions

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