LAND USE CHANGE AND NON-POINT SOURCE POLLUTION MODELING IN AGRO-URBAN WATERSHEDS

LISA EMILI (Penn State University)
RICHARD GREEN (Northern Illinois University)

LAND USE CHANGE

- Land use is increasingly being recognized as a key driving force in global environmental change
- Over the last 50 years, the loss of nutrients from land to water and subsequent surface water degradation has been accelerated due to land development for agricultural and urban uses
- The greatest concern continues to be non-point source (NPS) pollution

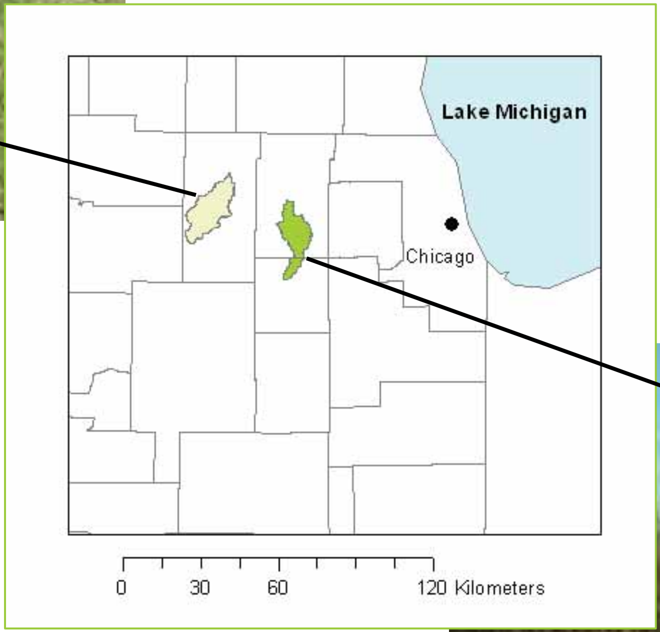
Non-point source pollution

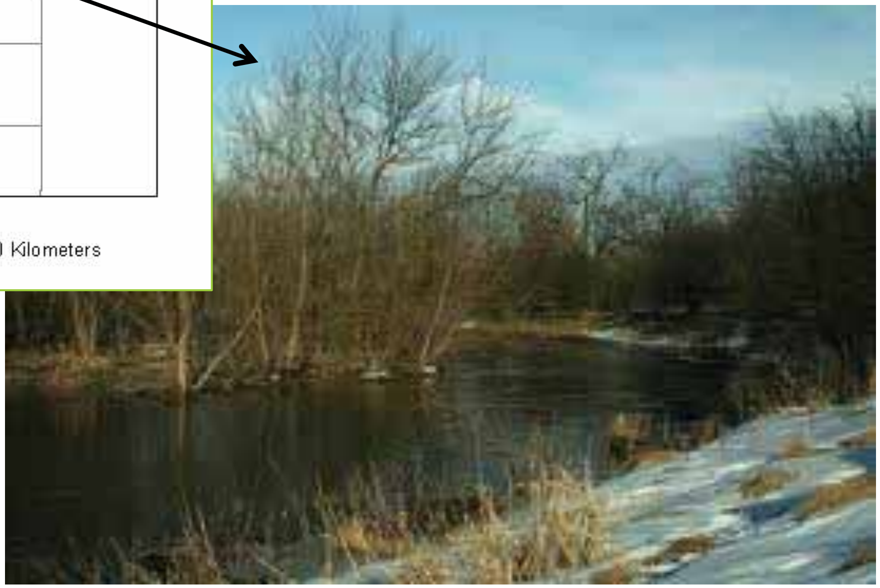
- NPS pollution is the leading source of water quality impacts to surface waters
- The primary pollutants are eroded sediments and nutrients, particularly phosphorus
- Excess phosphorus leads to cultural eutrophication and habitat and water quality degradation
- Despite advances in science and policy, eutrophication and algal blooms are one of the most common and serious threats to surface water resources

Urban to agricultural gradient (the urban fringe)

Study sites

Upper South Branch of the Kishwaukee River Watershed





Blackberry Creek Watershed

PHASE 1

Parcel-based
Land Use Change Model

⟺

PHASE 2

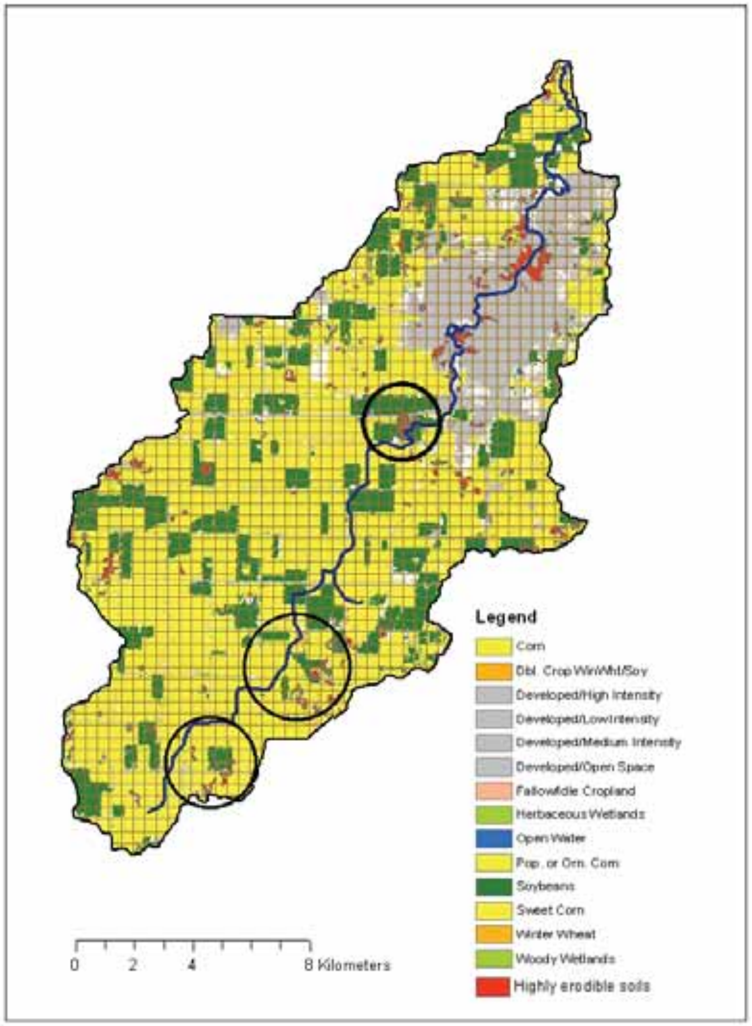
Pollutant Transport Model
- potential source areas
- runoff and sediment loading
- indices
- thresholds, rankings

⟺

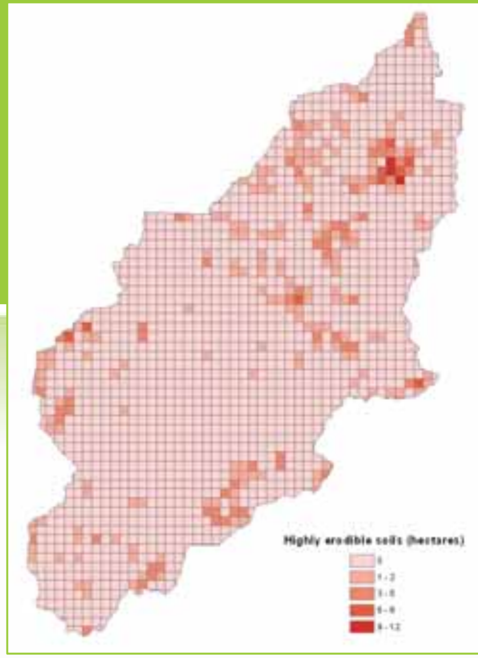
PHASE 3

Human Feedback Model
- participant centered analysis of best management practices
- interactive on-line public participation GIS model

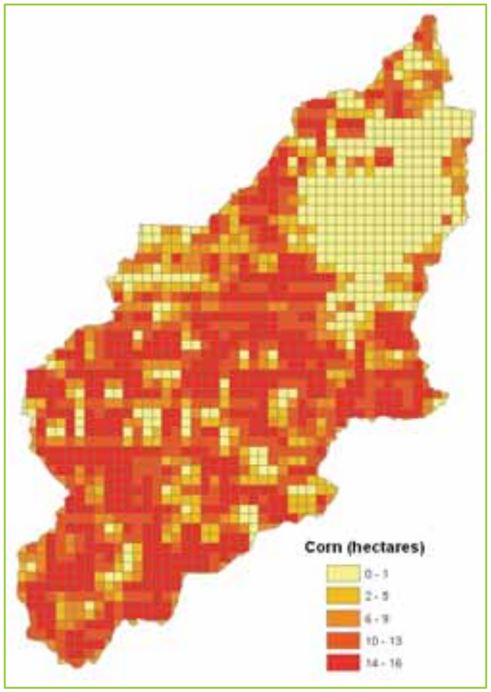
SOURCE AREAS



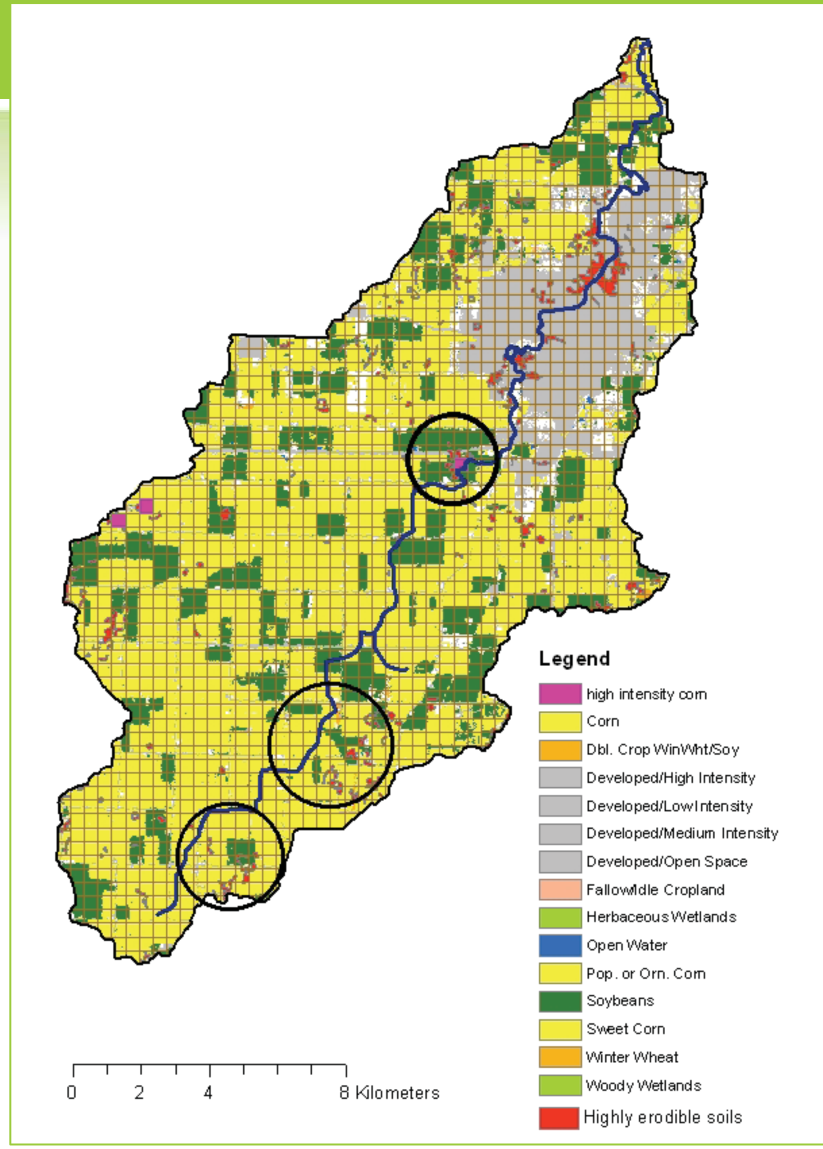
- Discrete grid/cell based data using GIS fishnet
- Based on land parcels



Highly erodible soils (hectares)
0
1 - 2

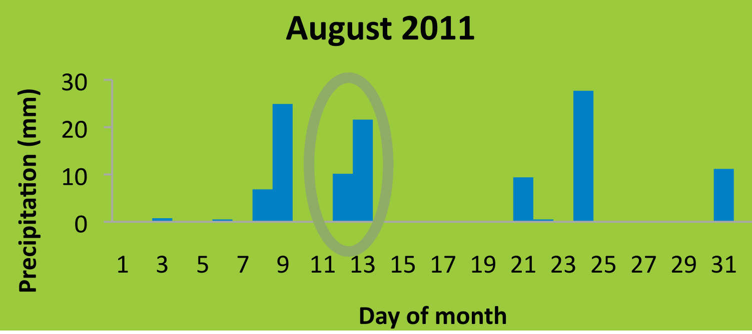


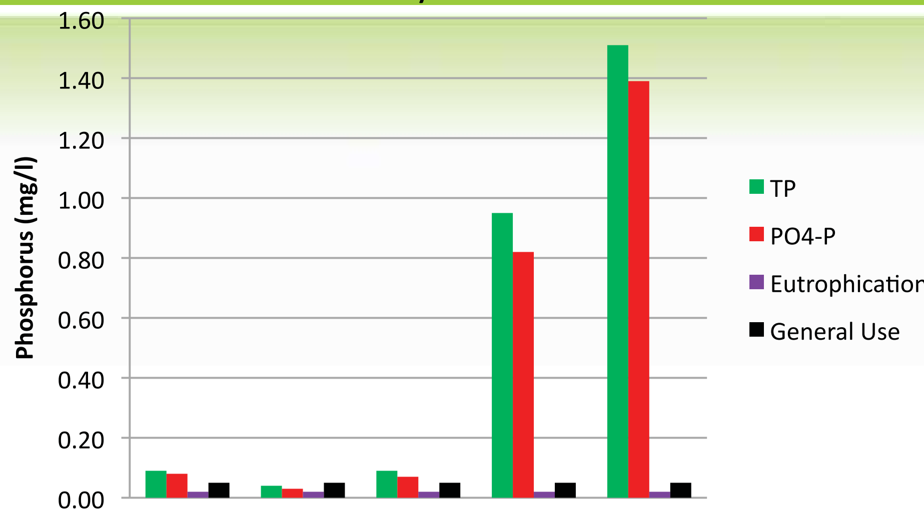
Corn (hectares)
0 - 1
2 - 5
6 - 9
10 - 13
14 - 16

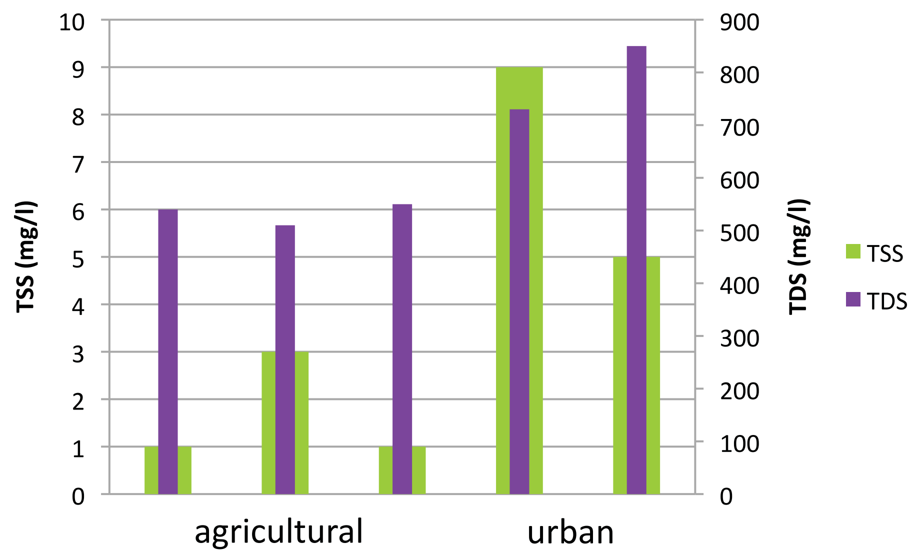


Legend
high intensity corn
Corn
Dbl. Crop WinWht/Soy
Developed/High Intensity
Developed/Low Intensity
Developed/Medium Intensity
Developed/Open Space
Fallow/Idle Cropland
Herbaceous Wetlands
Open Water
Pop. or Orn. Corn
Soybeans
Sweet Corn
Winter Wheat
Woody Wetlands
Highly erodible soils
0
2
4
8 Kilometers

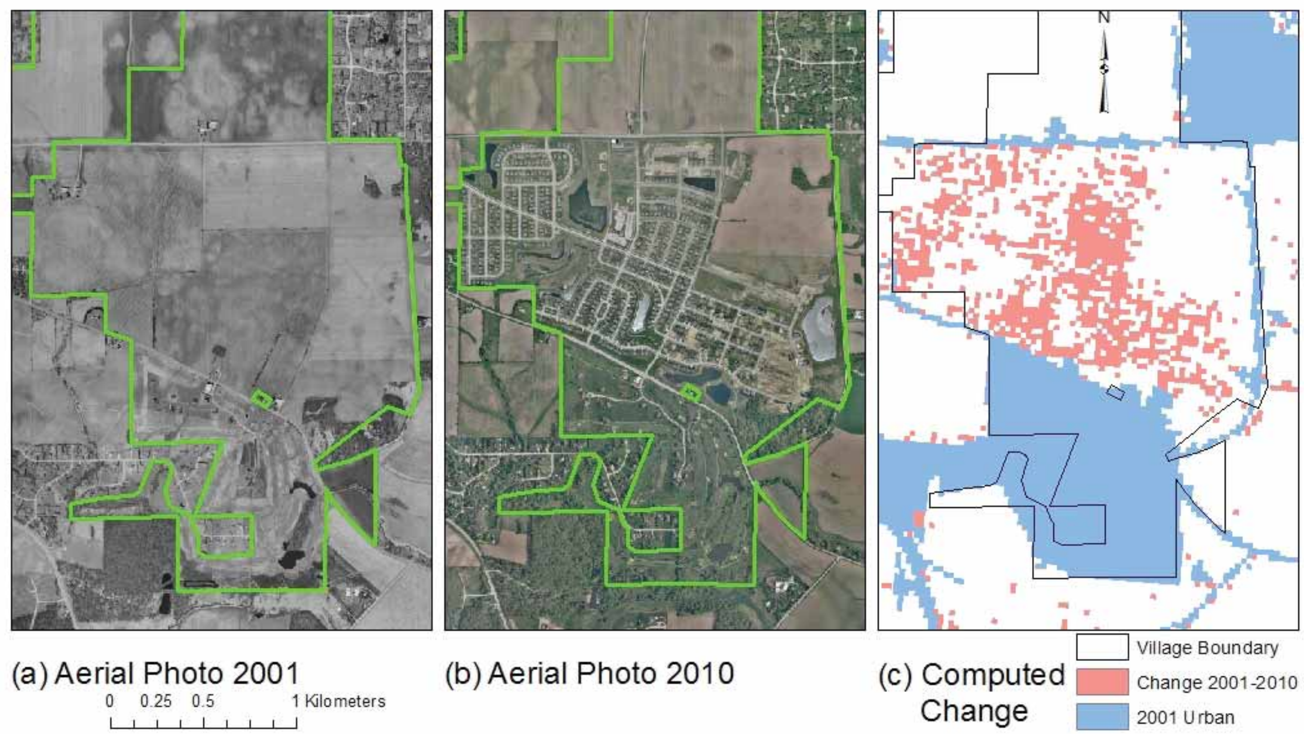
WATER QUALITY







URBAN CHANGE MODEL



NLCD 2001 NASS CDL 2010

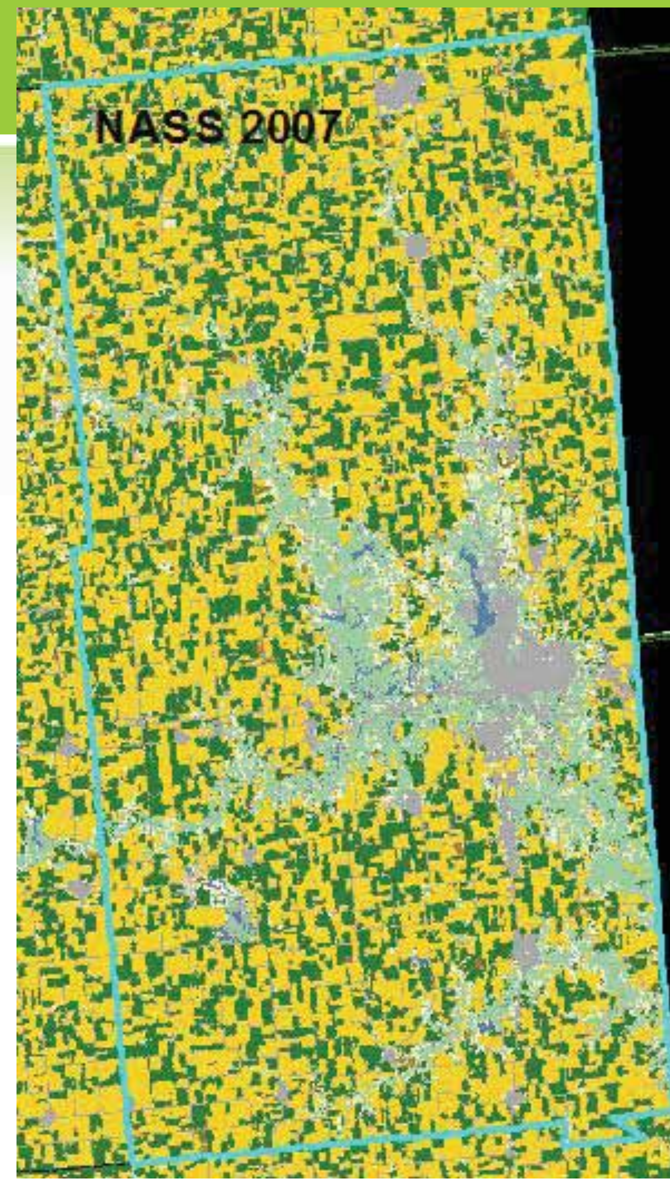
Table 1. Land Cover Classification Codes for NLCD 2001 and NASS 2007.

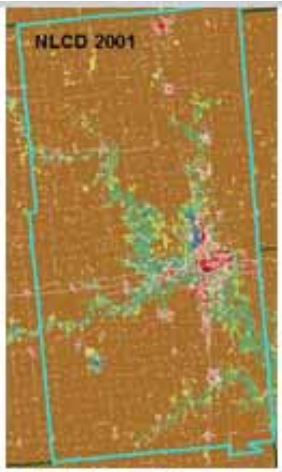
NLCD 2001	NLCD Name	GridCode07	CLASS_NAME07
11	NLCD - Open Water	1	Corn
12	Perennial Ice/Snow	4	Sorghum
21	Developed/Open Space	5	Soybeans
22	Developed/Low Intensity	21	Barley
23	Developed/Medium Intensity	23	Spring Wheat
24	Developed/High Intensity	24	Winter Wheat
31	Barren	26	Winter Wheat/Soybeans Double-Cropped
41	Deciduous Forest	27	Rye
42	Evergreen Forest	28	Oats
43	Mixed Forest	36	Alfalfa
52	Shrubland	42	Dry Beans
71	Grassland Herbaceous	43	Potatoes
81	Pasture/Hay	44	Other Crops
82	Cultivated Crops	47	Miscellaneous Vegetables & Fruit
90	Woody Wetlands	53	Peas
95	Herbaceous Wetlands	58	Clover/Wildflowers
		61	Fallow/Idle Cropland
		62	Grass/Pasture/Non-agricultural
		63	Woodland
		87	Wetlands
		92	Aquaculture
		111	NLCD - Open Water
		121	NLCD - Developed/Open Space
		122	NLCD - Developed/Low Intensity
		123	NLCD - Developed/Medium Intensity
		124	NLCD - Developed/High Intensity
		131	NLCD - Barren
		141	NLCD - Deciduous Forest
		142	NLCD - Evergreen Forest
		152	NLCD - Shrubland

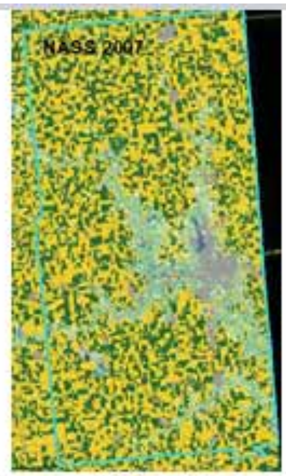
NASS 2007 Classification

GridCode07	CLASS_NAME07
1	Corn
4	Sorghum
5	Soybeans
21	Barley
23	Spring Wheat
24	Winter Wheat
26	Winter Wheat/Soybeans Double-Cropped
27	Rye
28	Oats
36	Alfalfa
42	Dry Beans
43	Potatoes
44	Other Crops
47	Miscellaneous Vegetables & Fruit
53	Peas
58	Clover/Wildflowers
61	Fallow/Idle Cropland
62	Grass/Pasture/Non-agricultural
63	Woodland
87	Wetlands
92	Aquaculture
111	NLCD - Open Water
121	NLCD - Developed/Open Space
122	NLCD - Developed/Low Intensity
123	NLCD - Developed/Medium Intensity
124	NLCD - Developed/High Intensity
131	NLCD - Barren
141	NLCD - Deciduous Forest
142	NLCD - Evergreen Forest
152	NLCD - Shrubland

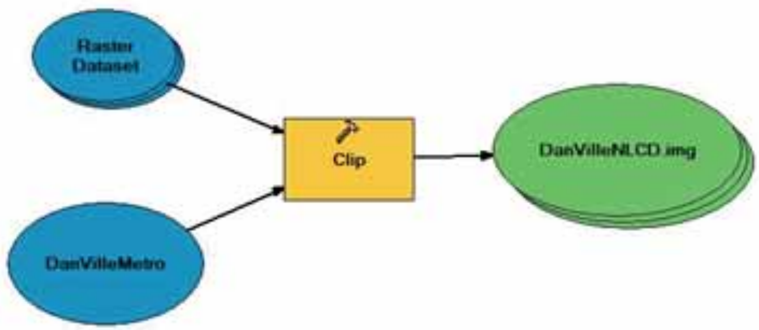
NASS Display







Model 1 – Raster Clip. Using model builder create a variable of type "Raster Dataset." Set the properties of the variable to be a "List of Values." Drag the "Raster Clip" tool into the model and connect the "Raster Dataset" variable and the DanVilleMetro layer to the tool.



Populate the "Clip" tool with the two "Input Rasters," the "Output Raster Datasets," the "Output Extent," and set the last box to be "true."

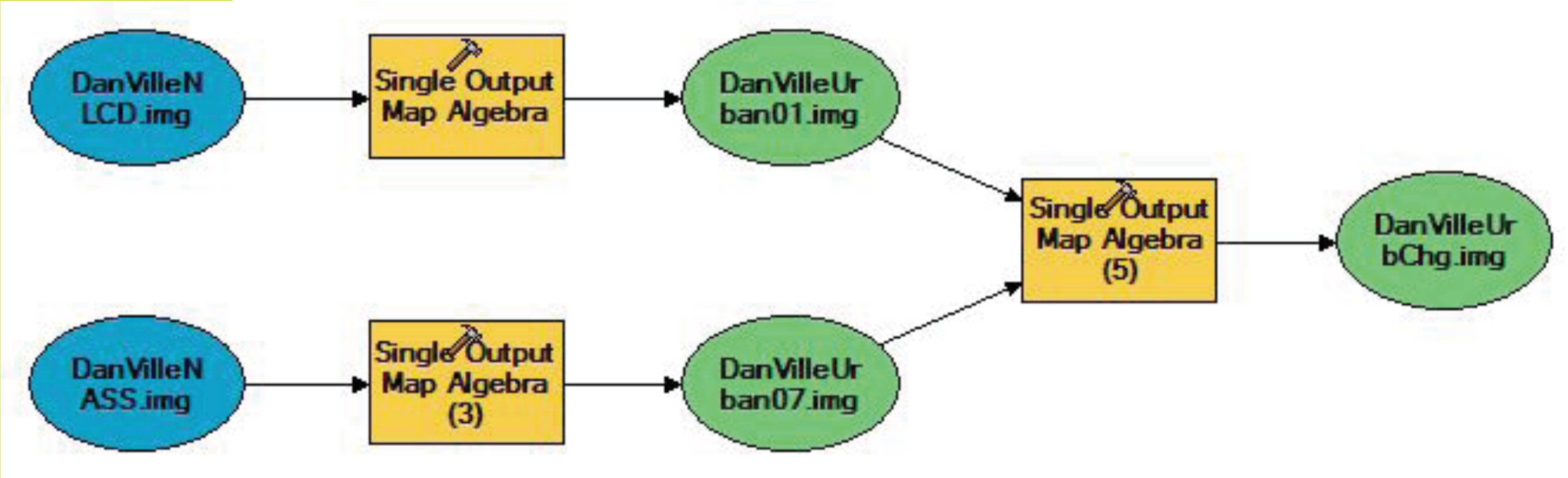
	Input Raster	Rectangle
1	MidwestNLCD01_Il.img	677001.216216322 1902485.12821108
2	cdl_awifs_r_il_2007.tif	

Output Raster Dataset	Output Extent
C:\GreeneProjects08\AFT_FOE4\FinalReport\DanVilleNLCD.img	DanVilleMetro
C:\GreeneProjects08\AFT_FOE4\FinalReport\DanVilleNASS.img	

NoData Value	Use Input Features for Clipping Geometry
	true

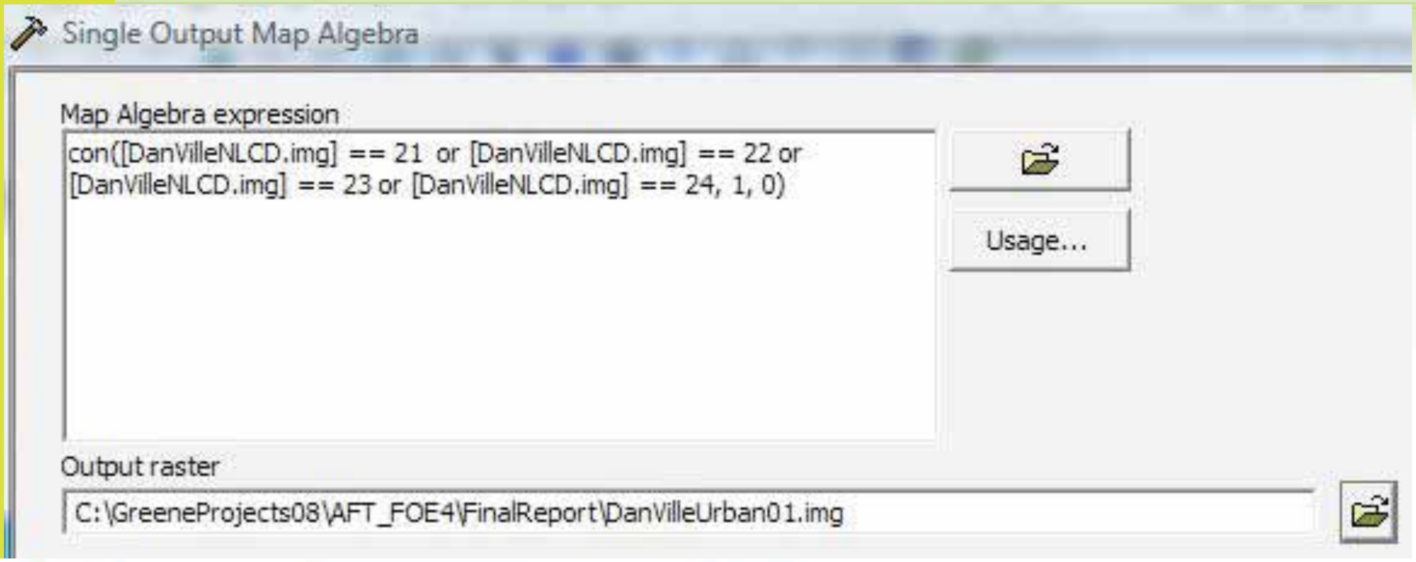
Model 2-urban change for 2001 to 2007

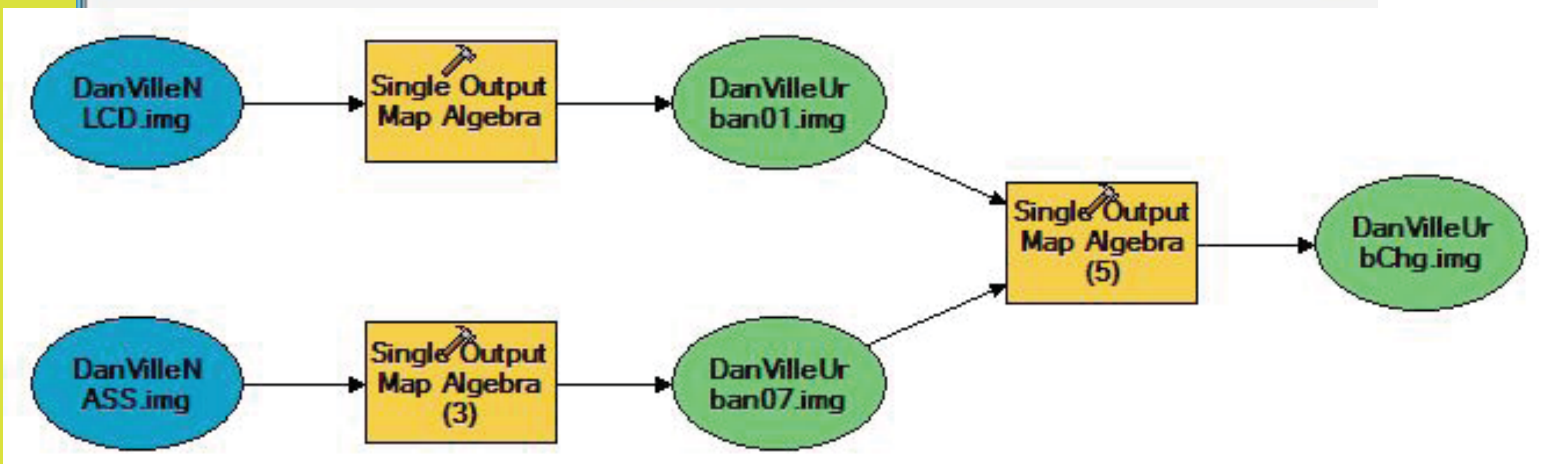
- Determine Urban Land Use Change
  - SingleOutput Map Algebra
    - Urban 2001 & 2007
  - Extract by Attribute
    - Land not urban 2001 but urban by 2007
  - Convert raster to a polygon for further processing
- Much urban change detected along roads is error



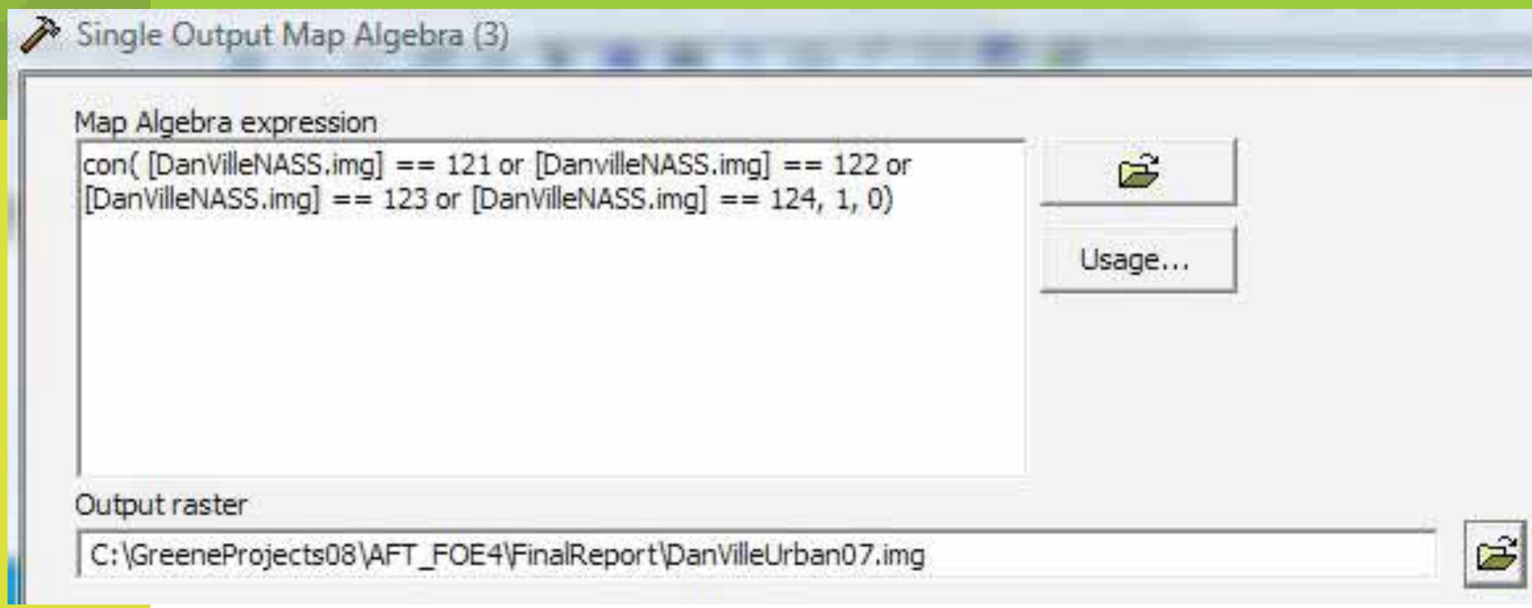
PART 1 OF MODEL 2: EXTRACT OUT URBAN

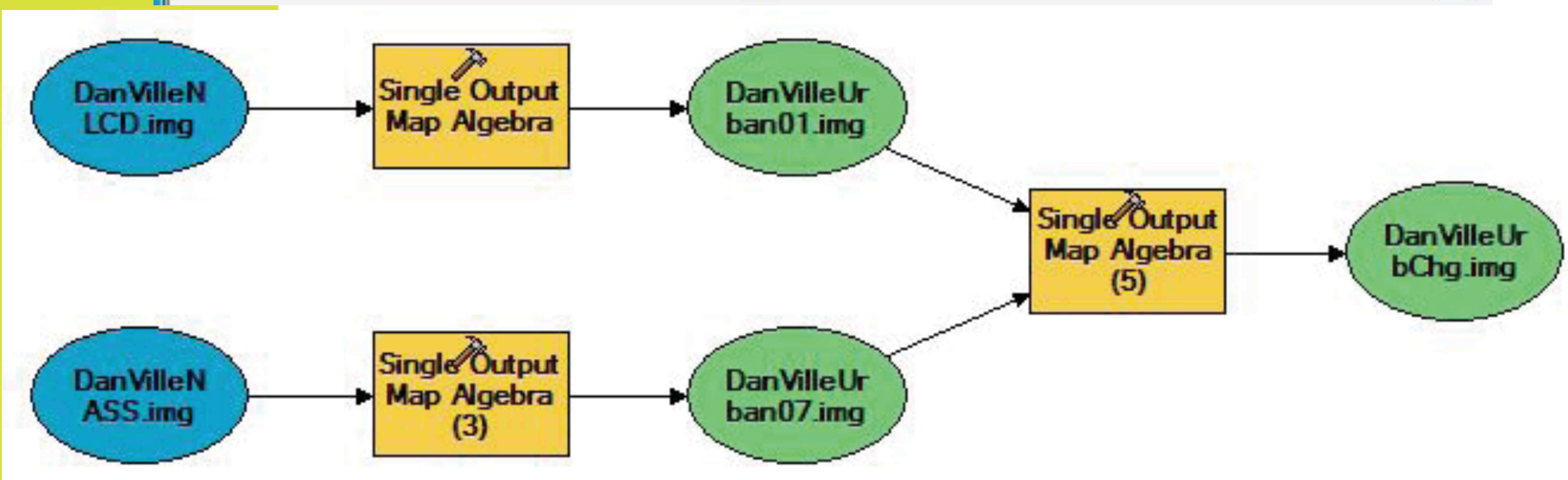
Process 1 (Top Yellow): Make DanVilleUrban01.img (top green) from input DanVilleNLCD.img (top blue) by querying developed codes 21-24. If the expression is true then assign 1 and 0 if it is not true.





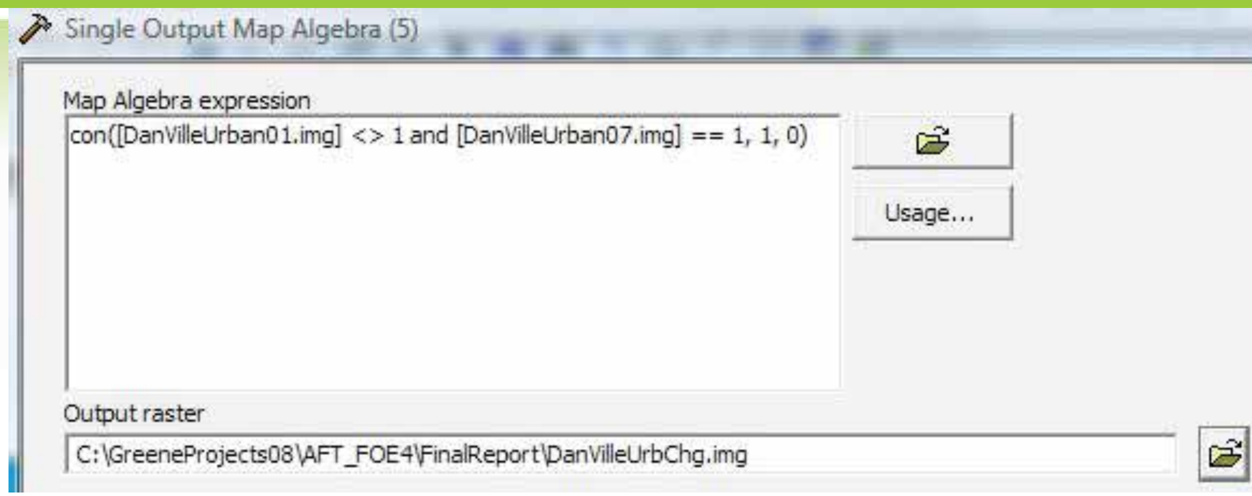
Process 2 (Bottom Yellow): Make DanVilleUrban07.img (bottom green) from input DanVilleNASS.img (NASS 2007) by querying developed codes 121-124. If the expression is true then assign 1 and 0 if it is not true.

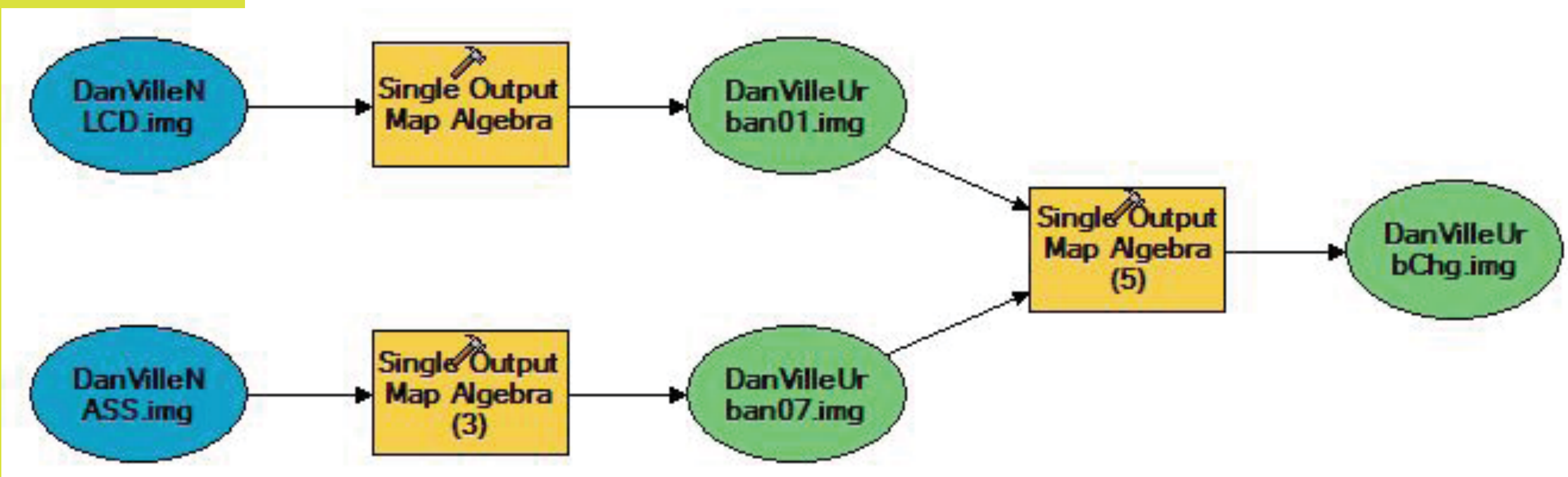




Part 2 of model 2: compute urban change

Process 3 (Yellow at end): Make DanVilleUrbChg (green at end) by Comparing inputs DanVilleUrban01.img and DanVilleUrban07.img and if it was not urban in 2001 and became urban by 2007 then assign a 1, otherwise assign a 0.





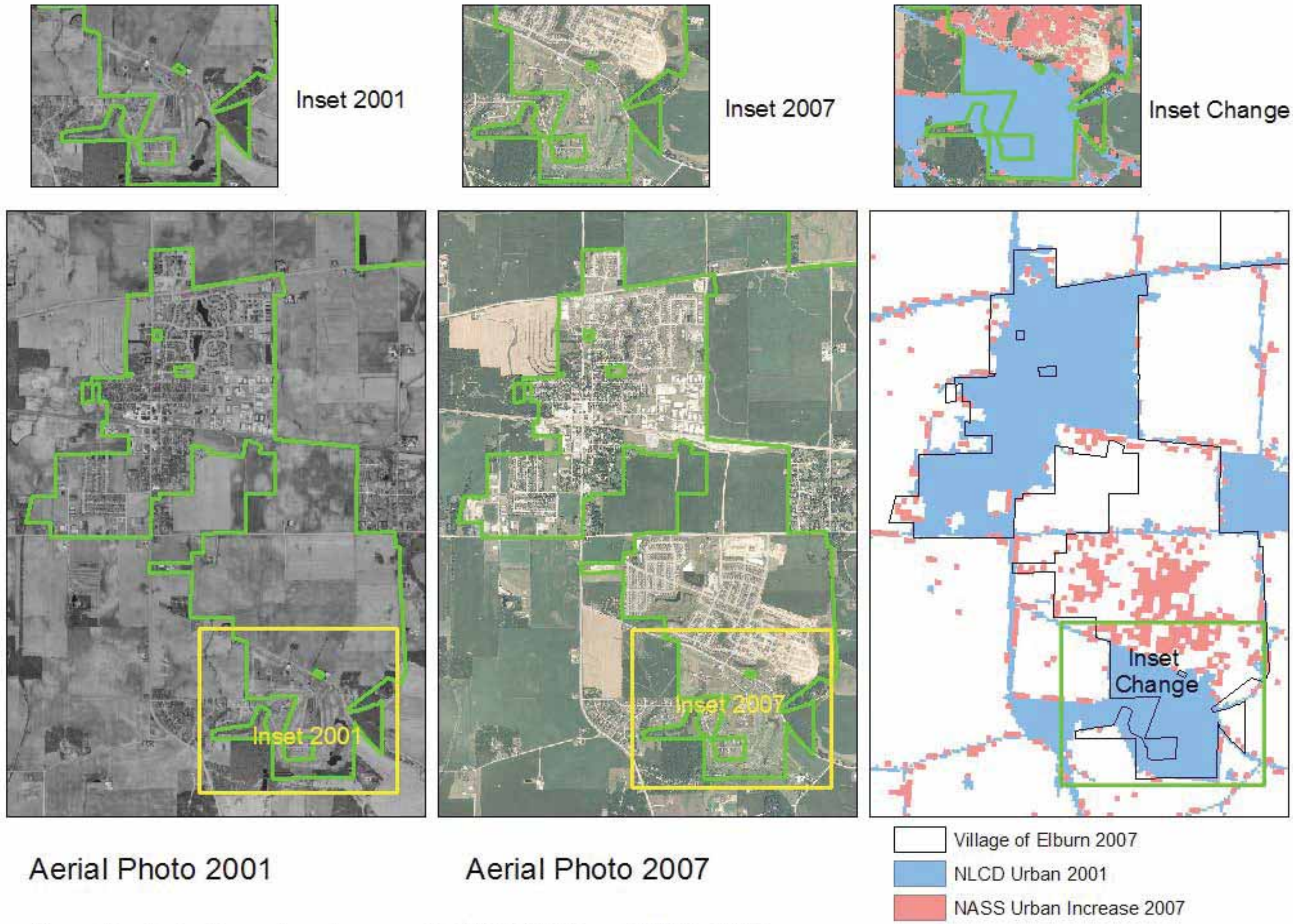


Figure 1 -- Detecting urban change with NLCD 2001 and NASS 2007.

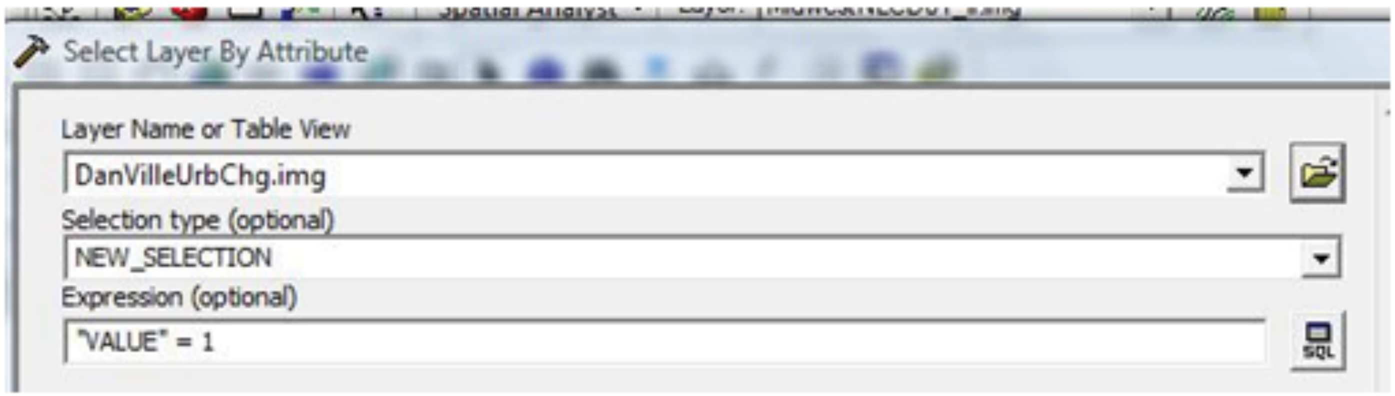
For other examples, see Maxwell, Alexis, "The Vanishing Farmland Myth: Tracking Farmland Loss to Urbanization through the use of Geospatial Data." M.S. Dept. of Geography, NIU 2010.

Model 3 – Select Change and Convert to Polygons.

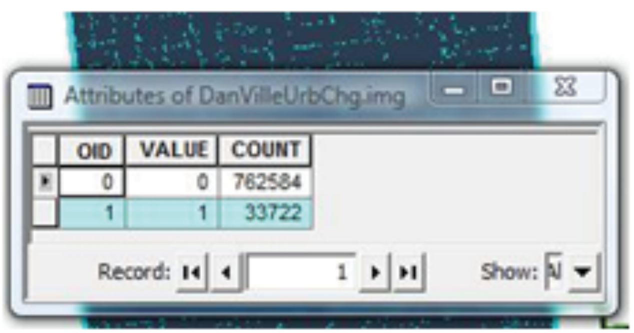
Open the Attribute Table of DanVille UrbChg and select Value =1

Part 1 of Model 3: Select just the change.

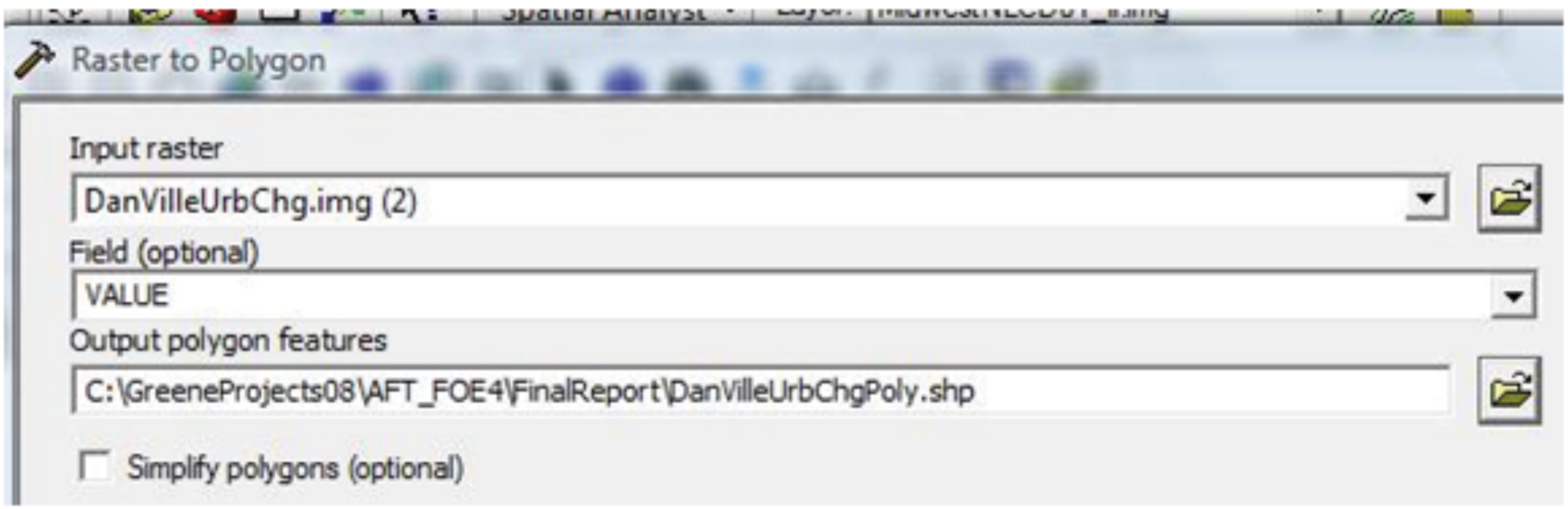
Process 1 (First Yellow): Select DanVilleUrbChg.img where Value is equal to 1.



Result

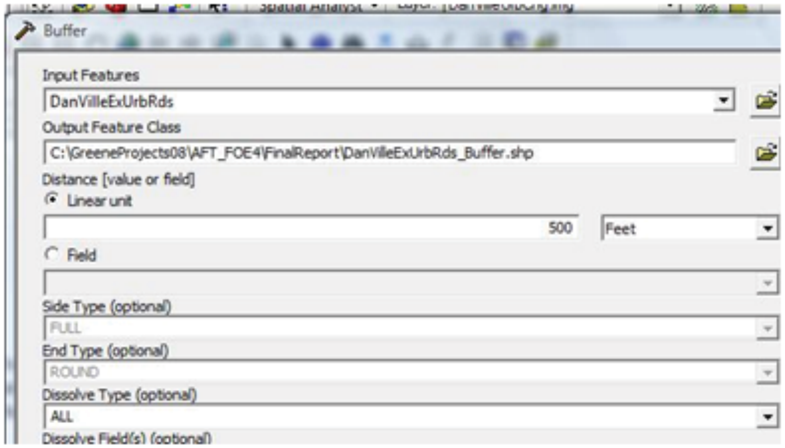


Process 2 (Second Yellow): Convert the selected raster cells to polygons using the "Raster to Polygon" tool. Very important to uncheck the "Simplify Polygons" box.

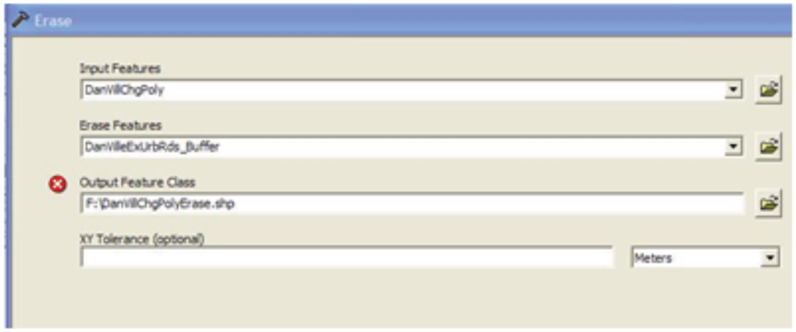


Model 4-buffer, erase and update

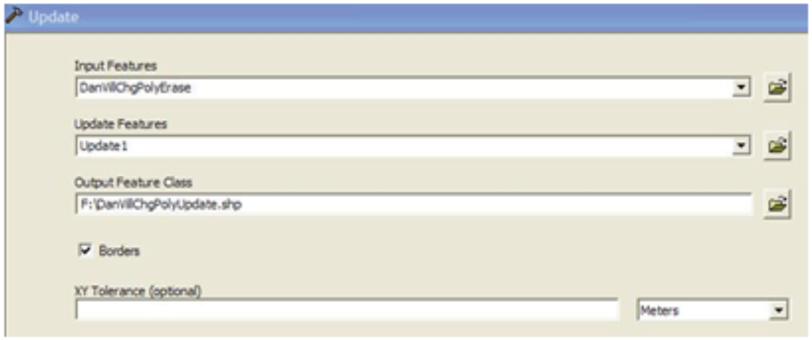
Buffer the Roads by 500 Feet



Erase the change polygons that fall within the 500 foot buffer.



Update the erase layer with legitimate change that was deleted.



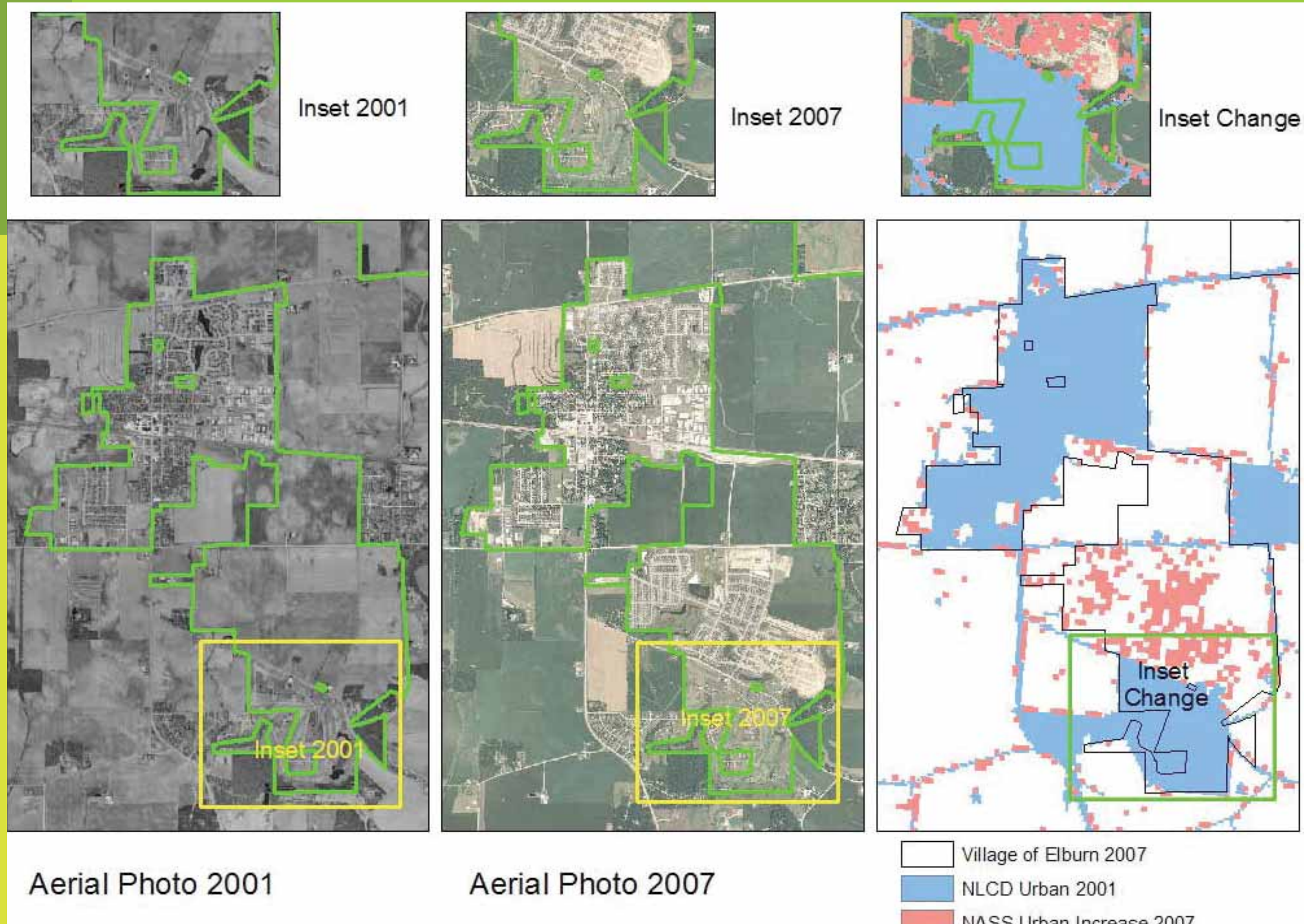
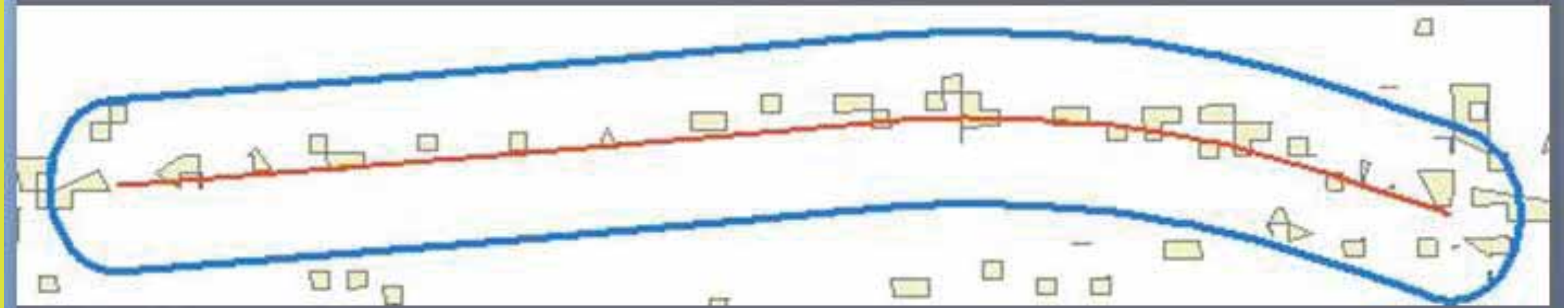


Figure 1 -- Detecting urban change with NLCD 2001 and NASS 2007.

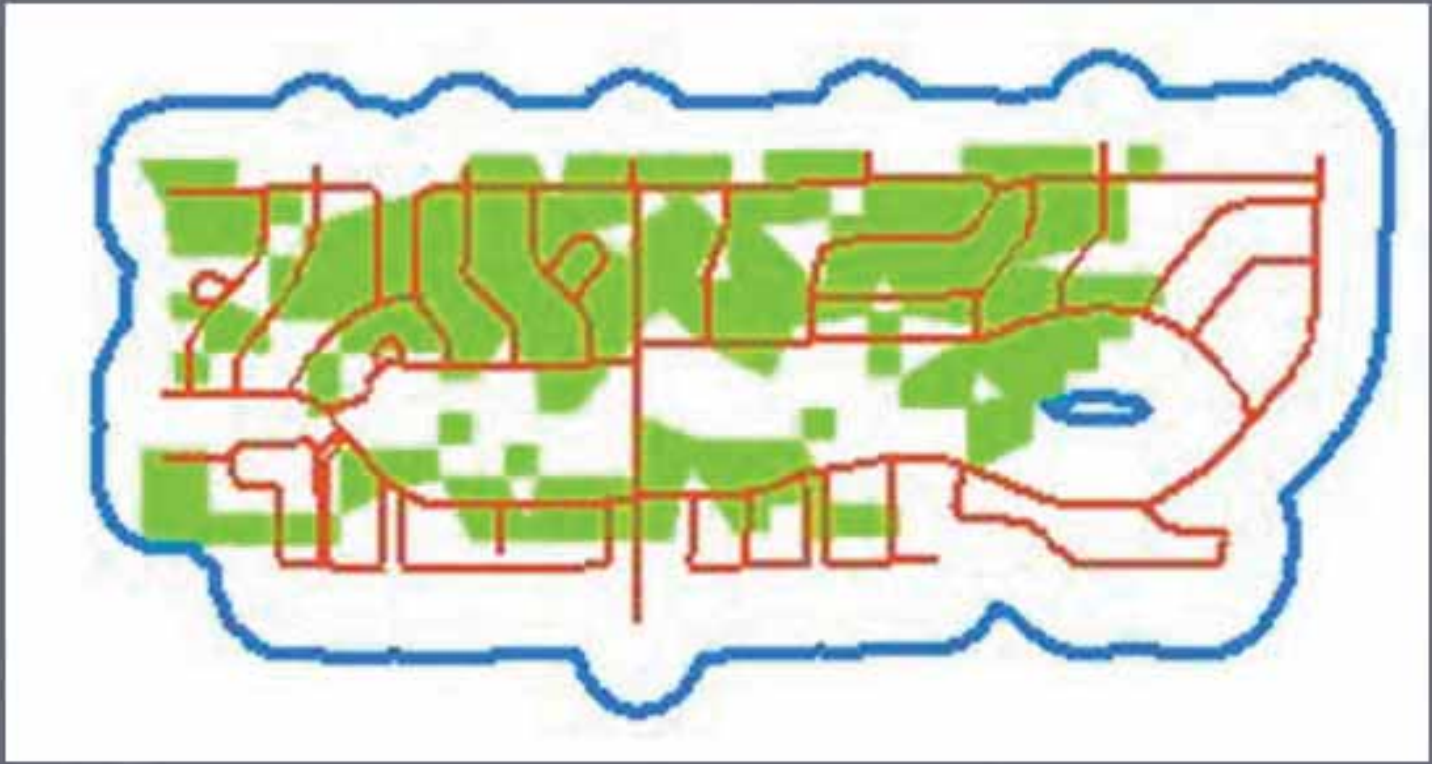
For other examples, see Maxwell, Alexis, "The Vanishing Farmland Myth: Tracking Farmland Loss to Urbanization through the use of Geospatial Data." M.S. Dept. of Geography, NIU 2010.

Buffer Roads by 500 Feet



Erase all Change inside the Buffer

Some Legitimate Urban Change will be Deleted by the 500 Foot Buffer because New Subdivisions have Roads within the 500 Foot Range



Solution was to Pan through the Road Buffer Erase Layer and Bring Change Back in for such Cases

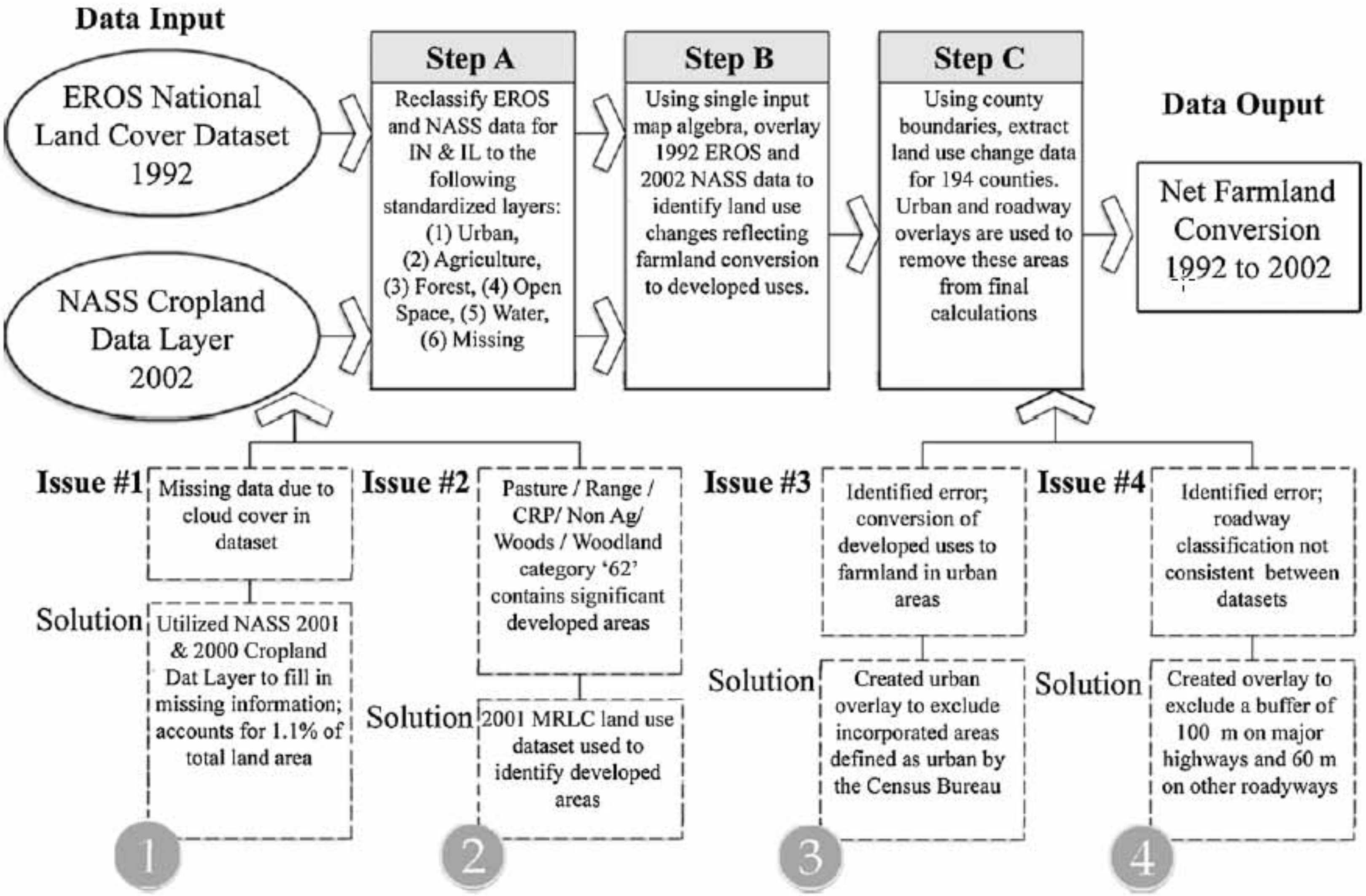
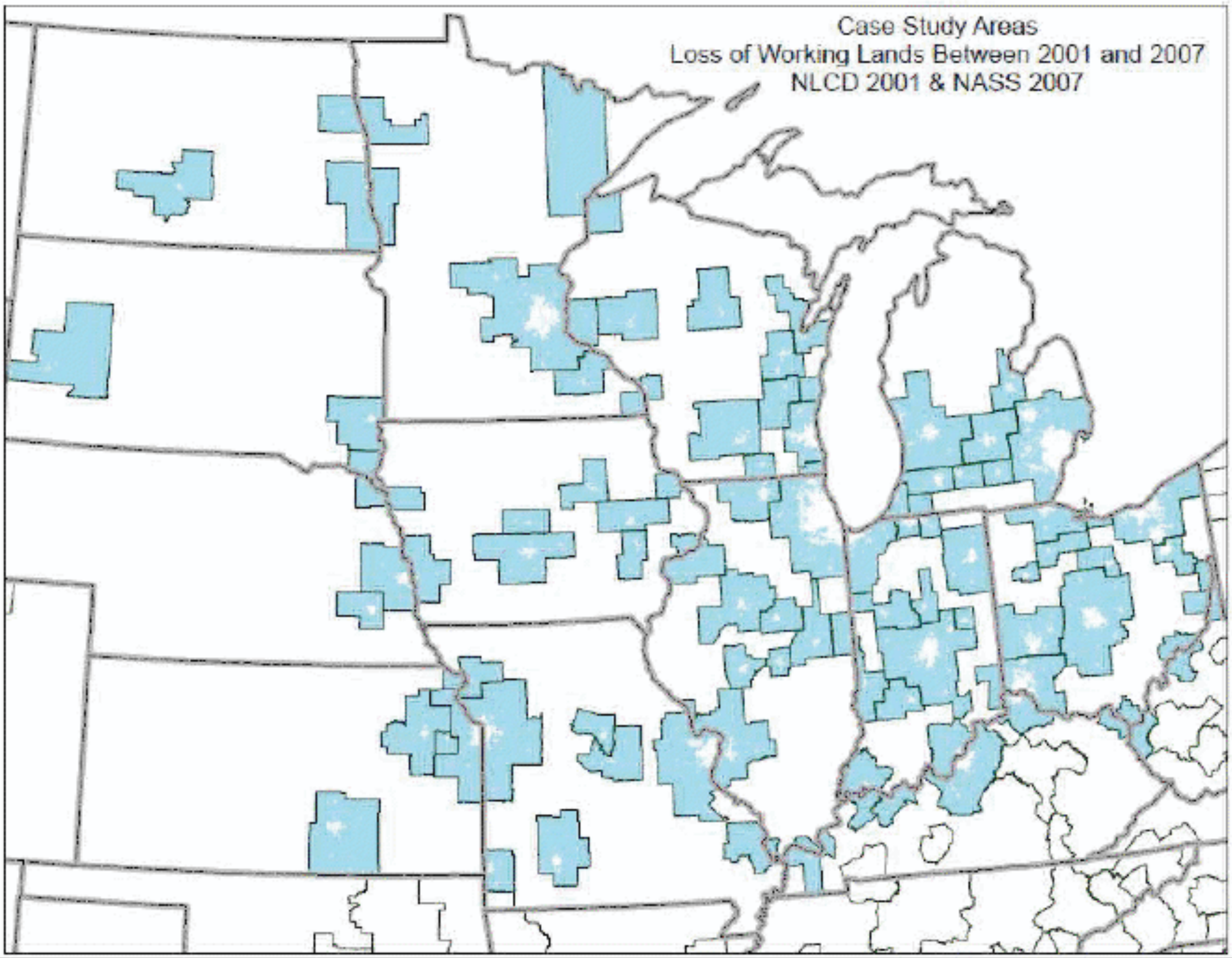
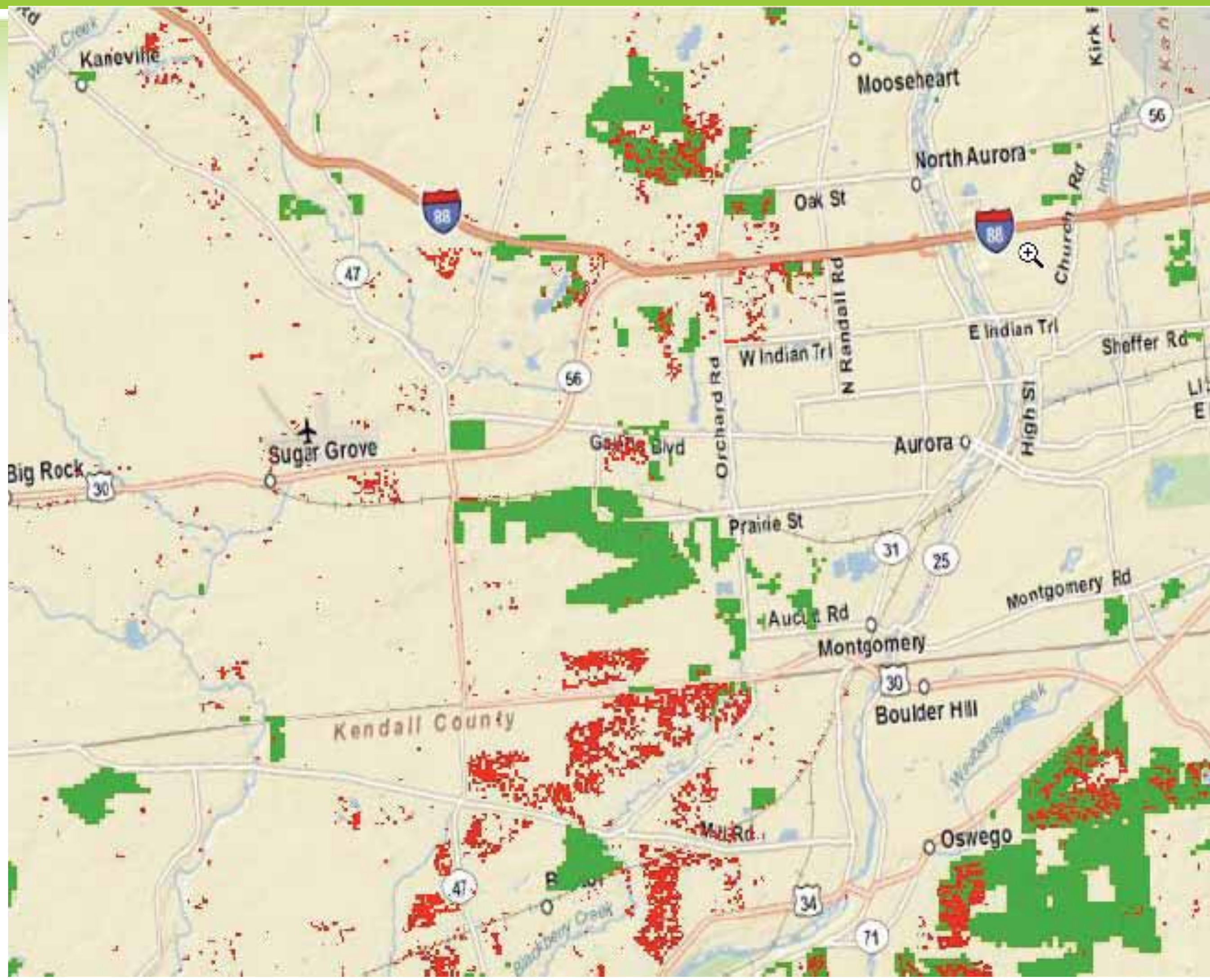


Fig. 2. Spatial analysis outline showing the three steps in the process, the issues identified with the spatial data, and the solutions used to correct these problems.

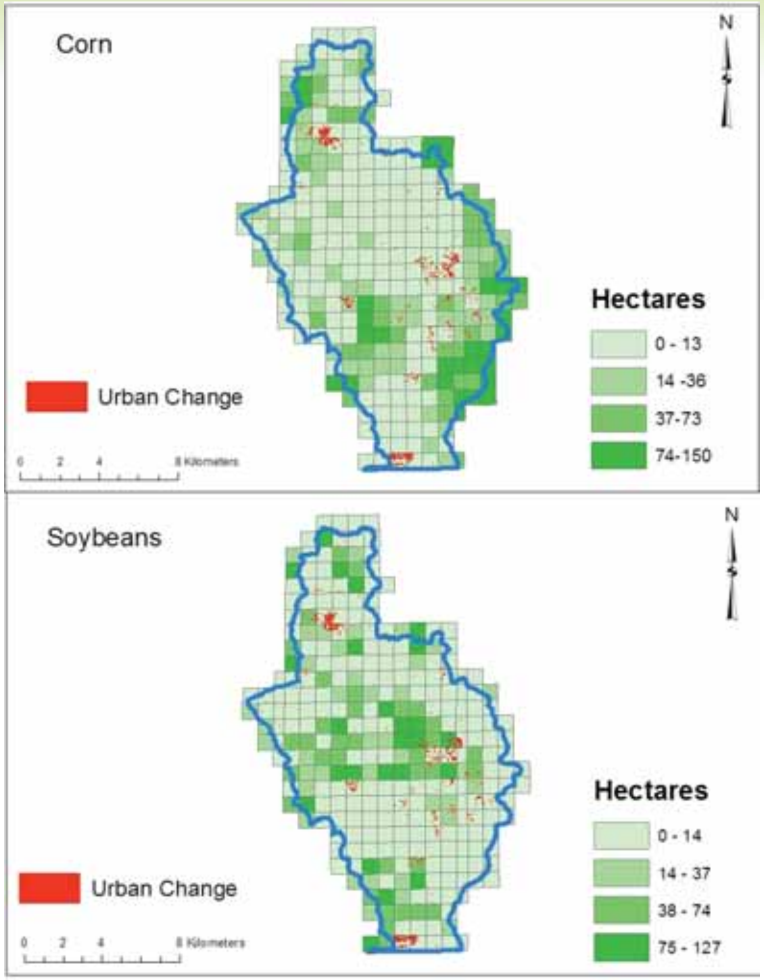
Study Area Shown in Blue
Defined as areas outside the Urbanized Areas of Metropolitan Areas



Here you see in red, working lands converted to urban between 2000 and 2007 shown in red and in green are theobalds's rural lands to be converted to a higher exurban/suburban/urban densities between 2000 and 2030.



URBAN CHANGE AND AGRICULTURAL ACTIVITY



PHASE 1

Parcel-based
Land Use
Change Model

PHASE 2

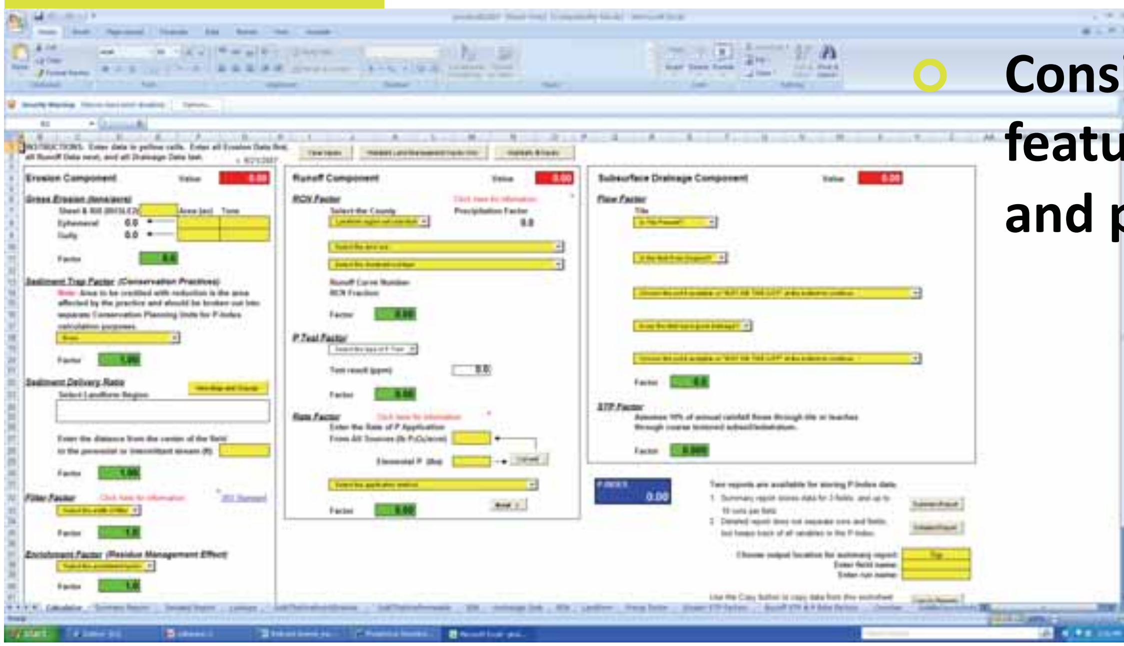
Pollutant Transport
Model
-potential source
areas
-runoff and
sediment loading
-indices
-thresholds,
rankings

PHASE 3

Human Feedback
Model
-participant
centered analysis
of best
management
practices
-interactive on-line
public
participation GIS
model

POLLUTANT LOAD

- **RUNOFF**
- **Phosphorus Index**
  - **Tool used to assess the potential to move phosphorus from agricultural fields to surface water**
  - **Considers soil and landscape features as well as soil conservation and phosphorus management**



OUTCOMES

- Decision support tools for water resource managers, government agencies, citizens
- Ability to model outcomes by identifying where allocated management strategies will have the greatest effect
- Scaling capability (spatial and temporal)

ACKNOWLEDGEMENTS

- Funding for this project was provided by a Research Development Grant

PENNSTATE
Altoona
1855