Assessment of Land Cover Change & Water Quality in Oswego Lake & Basin, Oregon

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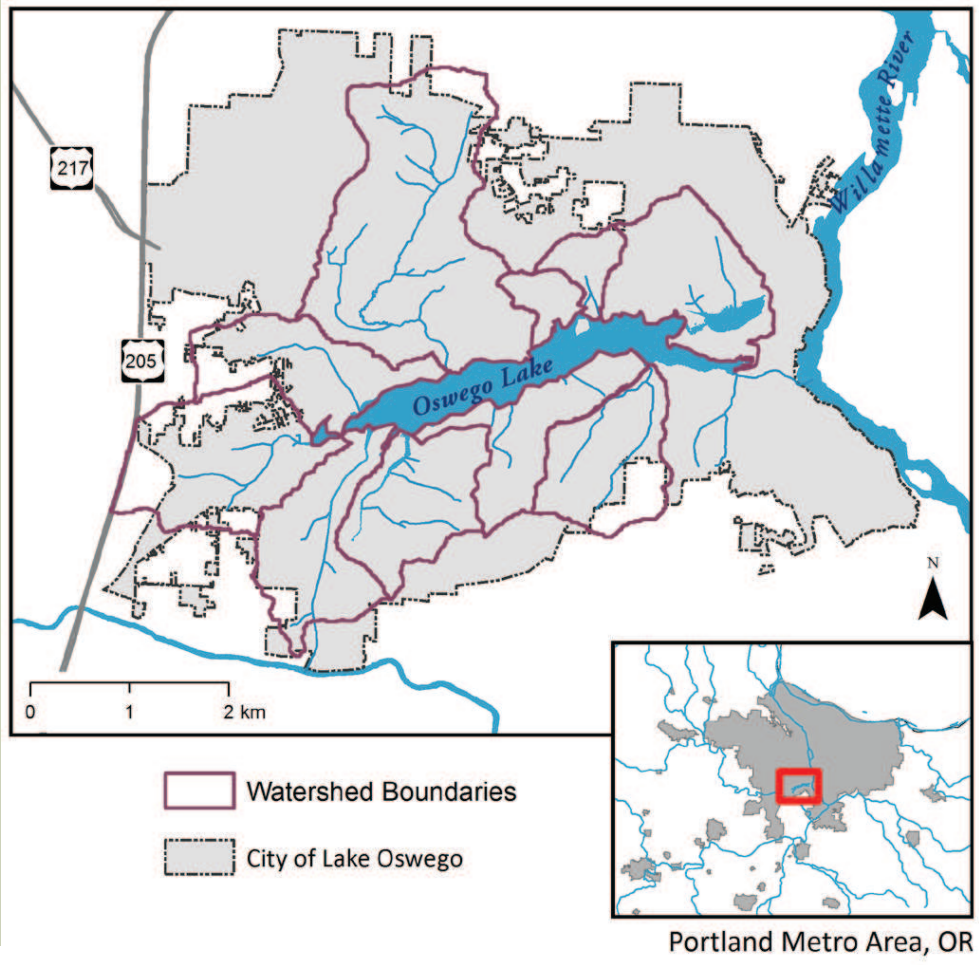
ROAD MAP

- Study area
- Problem statement
- Research questions
- Water quality trends
- Data and methods
  - Water quality
  - Land cover
- Results
- Resources

Study Area: Oswego Lake and Contributing Watersheds



PROBLEM STATEMENT

- Oswego Lake experiences periodic water quality problems associated with nonpoint source pollution and surface runoff.
- As this lake is used for recreation, poor water quality can be hazardous to human health and may prevent the lake's use.
- An increase in impervious area and low density residential developments surrounding the lake are characteristic of urban intensification, which is known to have detrimental effects on water quality in lakes and rivers.
- Land cover in the City of Lake Oswego have followed a trend of development since the end of World War II that may indicate a relationship between land use change and water quality.

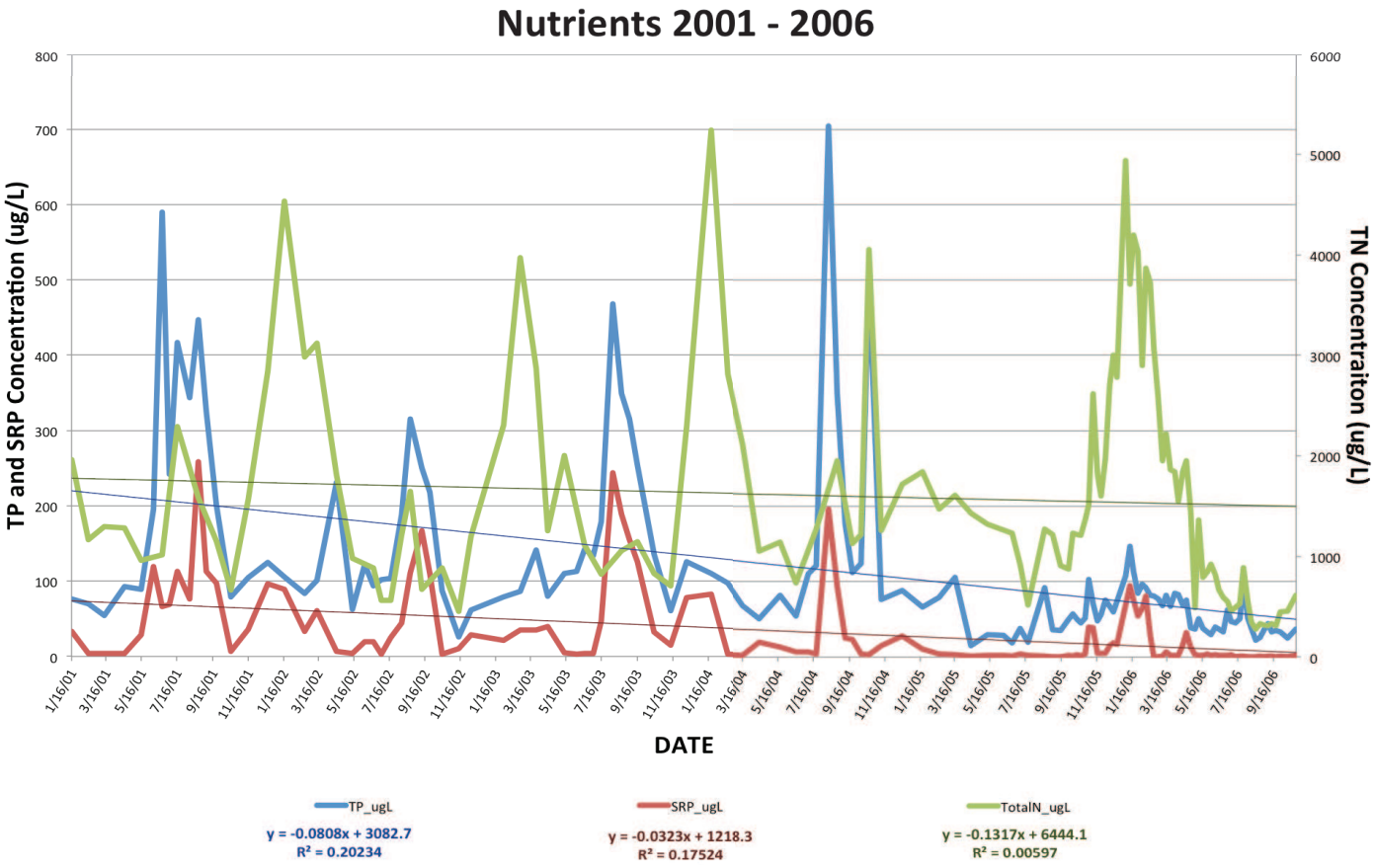
RESEARCH QUESTIONS

- What are the water quality trends in Oswego Lake between 2001 and 2006?
- What are the land cover changes in the Oswego Lake basin between 2001 and 2006?
- Is there a discernible relationship between land cover change metrics and water quality variables in Oswego Lake?

WATER QUALITY

- Background information
  - Urbanized watersheds characterized by high amounts impervious surface
    - Minimal opportunity for infiltration leading to flashy streams, stream bank erosion
    - Resulting in delivery of runoff high in nutrient concentration and sediment
  - Primary pollutant of concern is phosphorus
  - 2004 - hazardous algal bloom resulted in the closing of the lake
  - Subject to the water quality parameters outlined in the Tualatin Sub-basin TMDL and WQMP
- Data and sources
  - The Lake Oswego Corporation – weekly WQ monitoring

WATER QUALITY TRENDS WEST BAY



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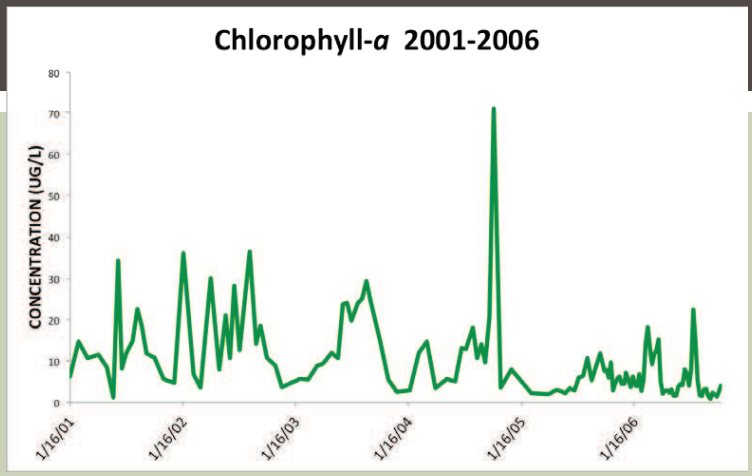
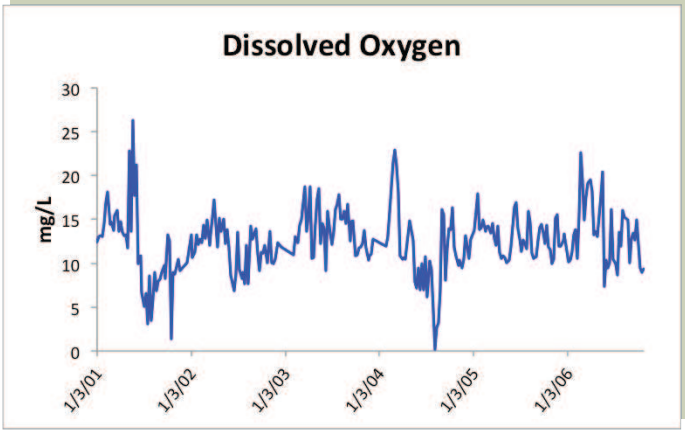
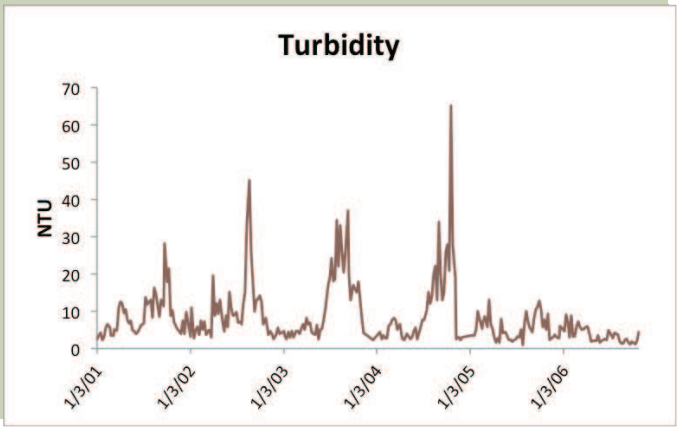
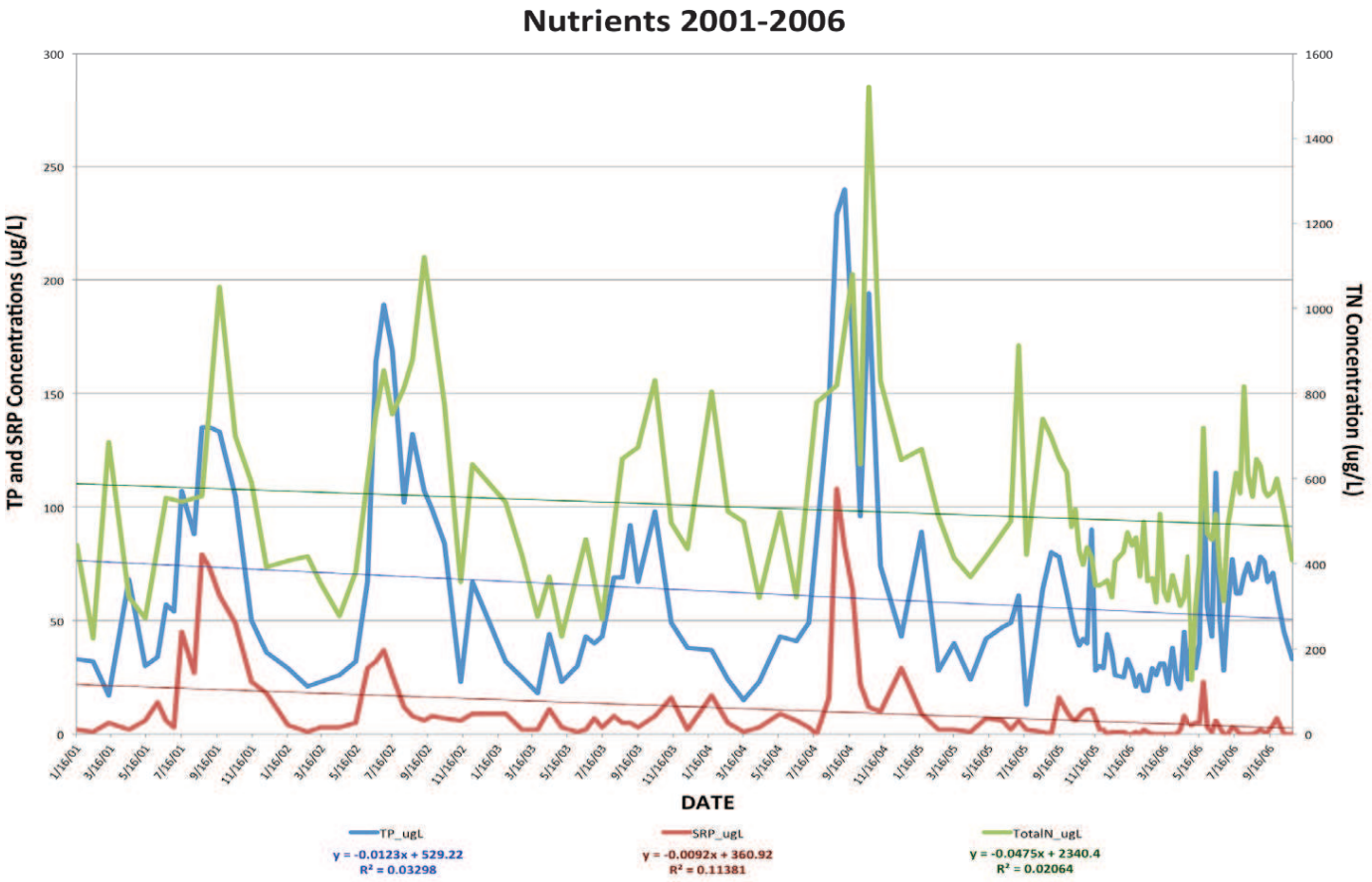






WATER QUALITY TRENDS LAKEWOOD BAY



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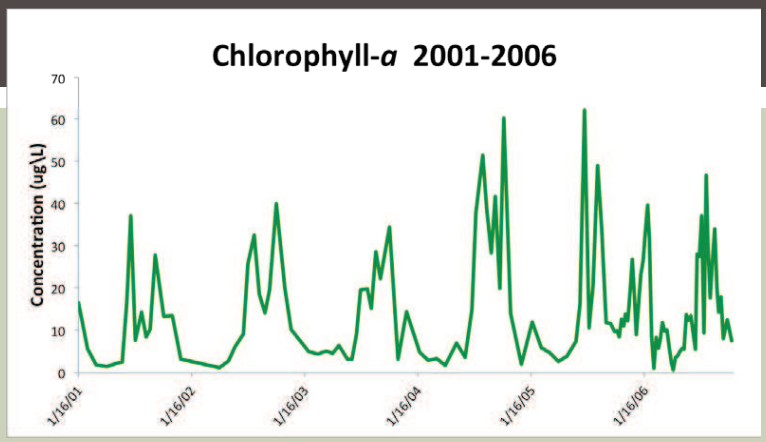
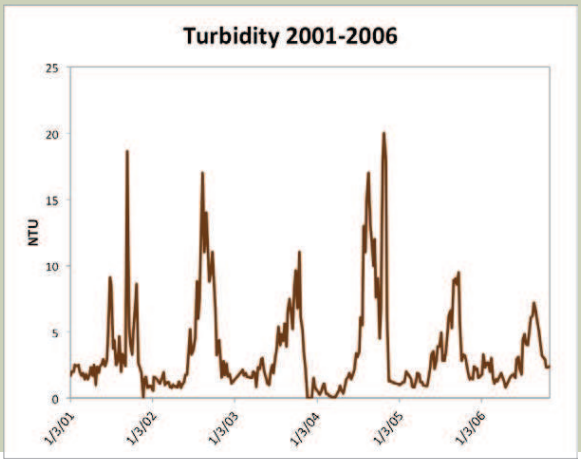
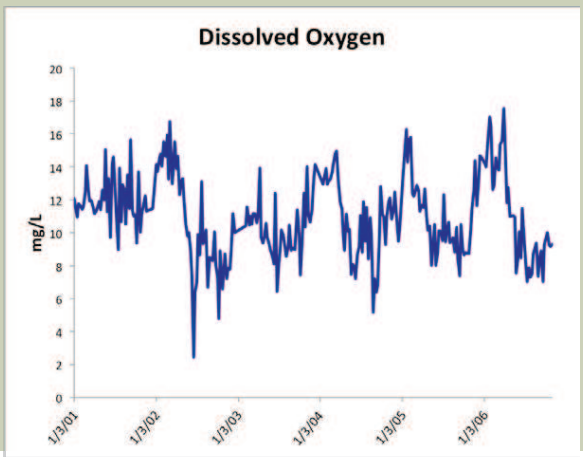


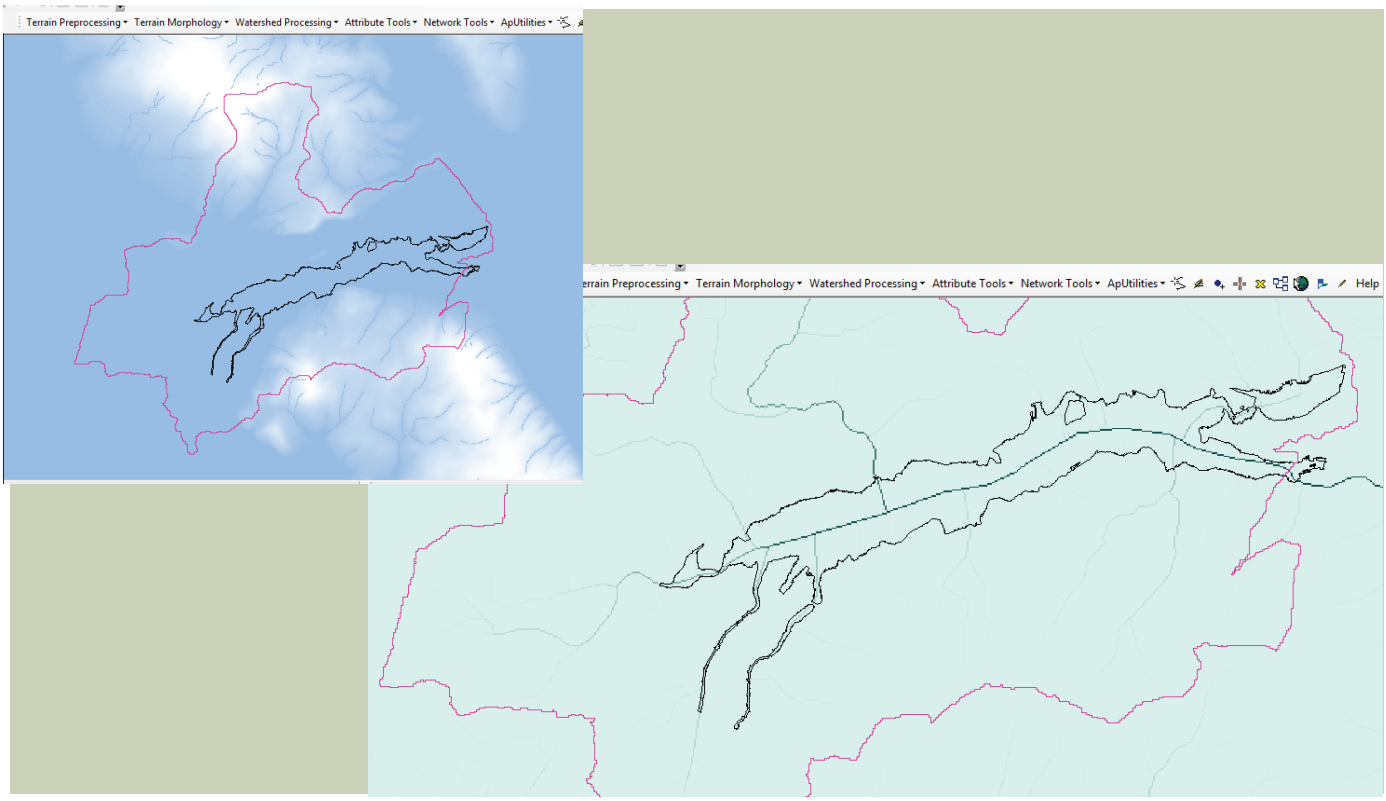




METHODS: WATERSHED DELINEATION

- ArcHydro Tools 2.0 extension for ArcMap v. 10
  - ArcInfo, Spatial Analyst Extension
- Project all layers into same projection
- DEM processing to delineate watershed basins & sub-basins
  - Uses enforcing techniques to ensure that DEM and streams line up
- Inputs:
  - 10m DEM (Oregon Geospatial Enterprise Office)
  - Streams (Portland Metro RLIS)
  - Oswego Lake Polygon (Portland Metro RLIS)

WATERSHED DELINEATION PROCESS



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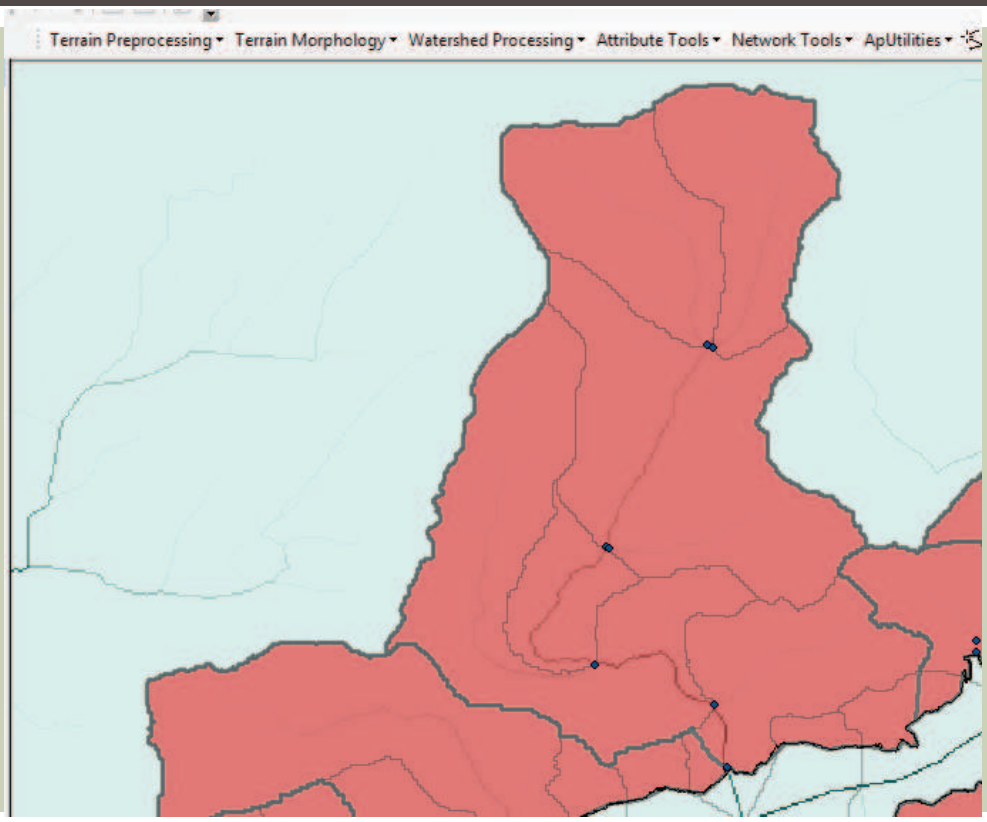
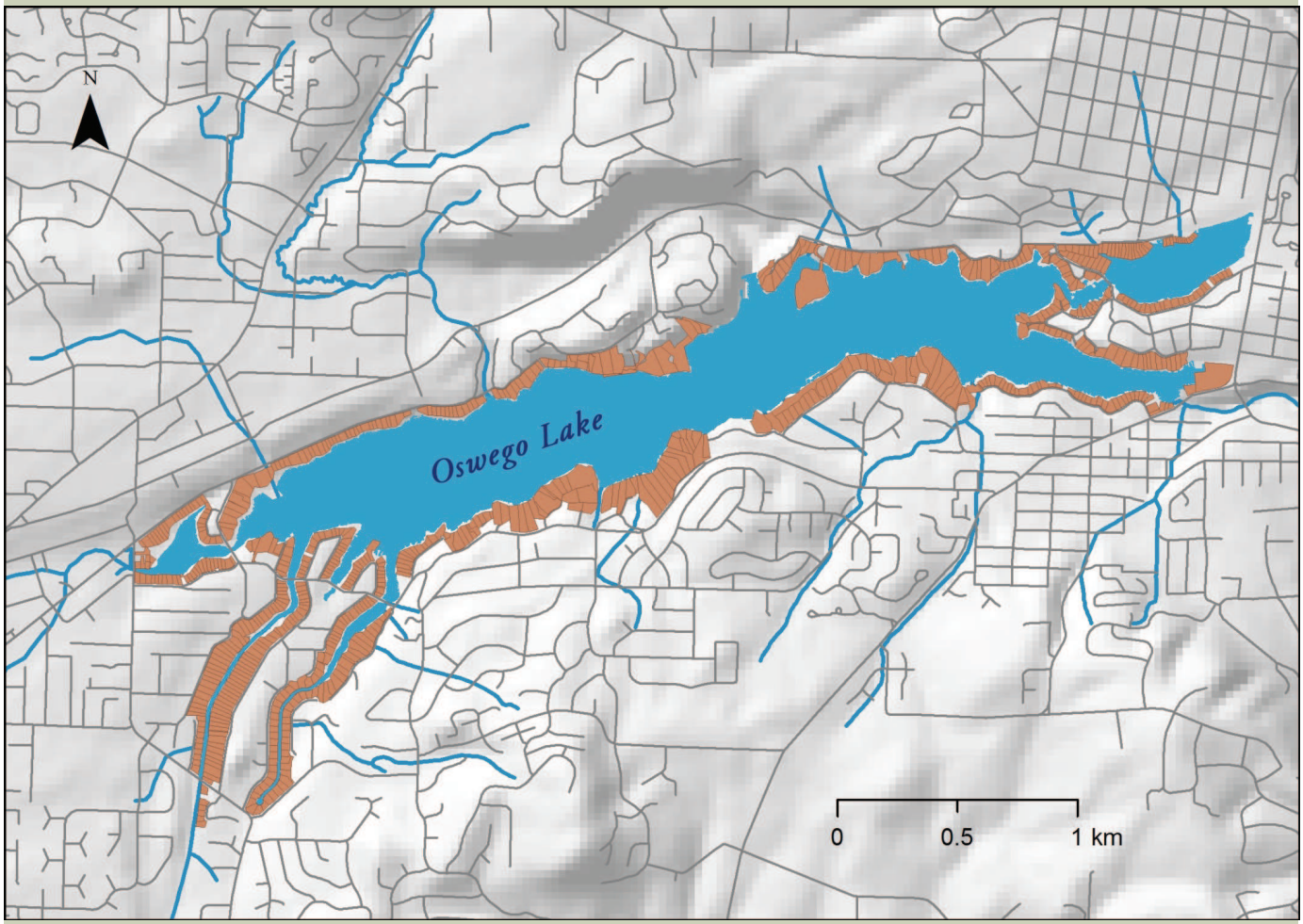


METHODS: LAND COVER CHANGE

- Justification
  - Different land use/cover types are associated with different levels of surface (nonpoint source) runoff
  - Urban intensification has been associated with increases in nonpoint source runoff
  - Planners need to know about land cover change and their spatial patterns to analyze their relationships to surface water pollution problems
  - From Yuan (2008); Rothenberger and Burkholder (2009)
- Use GIS to calculate change between 2001-2006
  - Spatial patterns
  - Tabular matrix



METHODS: LAND USE CHANGE

- USGS National Land Cover Dataset (NLCD)
  - 2001 (v2) and 2006
  - Collected from satellite imagery
  - 30m cell size
- Spatial extent of analysis
  - Contributing area
  - 500m buffer
  - 100m buffer

2006

METHODS: RECLASSIFYING LAND COVER

- Reclassify Tool
- Fewer classes are easier to understand and display
- After Jantz et al. (2005)

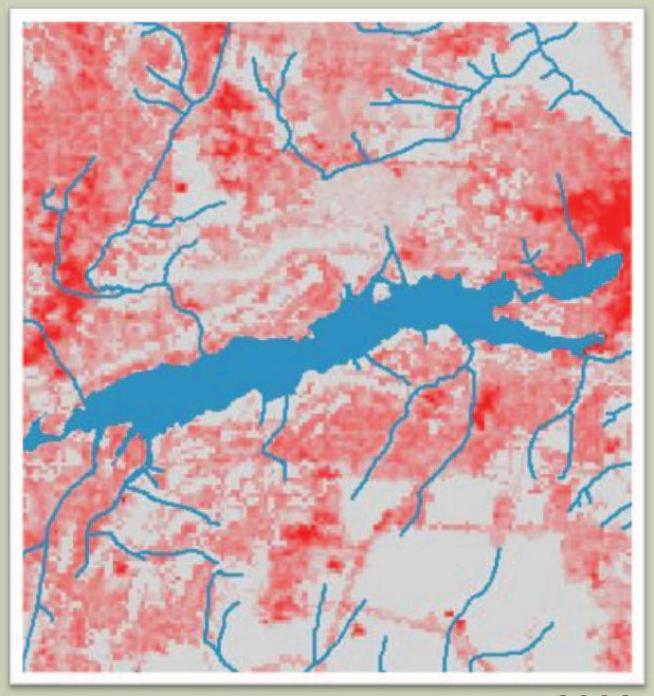
Old Legend	New Legend
Open Water	Open Water
Open Space	Open Space/Low Density Development
Low Density	
Medium Density	Medium/High Density Development
High Density	
Barren Land	Barren Land
Deciduous Forest	Forest
Evergreen Forest	
Mixed Forest	
Shrub/Scrub	Shrub/Grassland
Grassland/Herbaceous	
Pasture Hay	Agriculture
Cultivated Crops	
Woody Wetlands	Wetlands
Emergent Herbaceous Wetlands	

METHODS: CALCULATING LAND COVER CHANGE

- Combine Tool
  - Add attributes of input rasters, giving a unique value to each pair
  - Use NLCD codes to determine change classification
- Tabulate Area Tool
  - Calculate cell counts; multiply by cell size for area estimate
  - Create matrix of land use change
  - Separate tables for each spatial extent

METHODS: PERCENT IMPERVIOUS CHANGE

- USGS NLCD Percent Impervious
  - 2001 (v2) and 2006
  - Collected from satellite imagery
  - 30m cell size
- Spatial extent of analysis
  - Contributing area
  - 500m buffer
  - 100m buffer



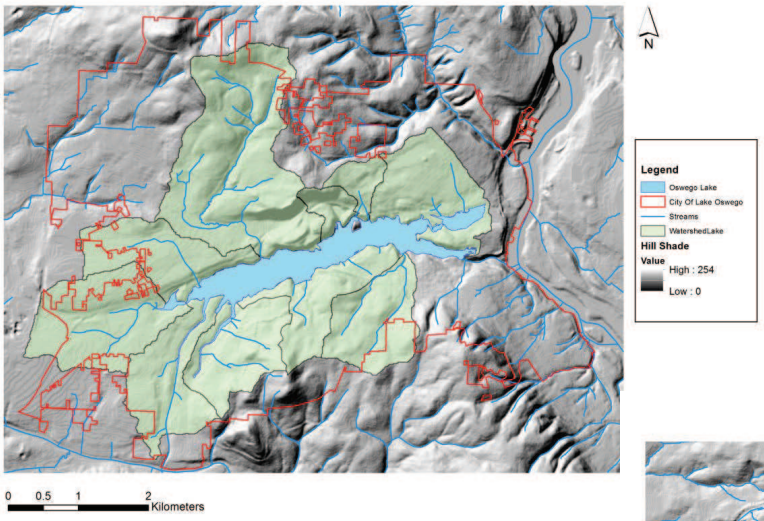
2006

METHODS: CALCULATING PERCENT IMPERVIOUS CHANGE

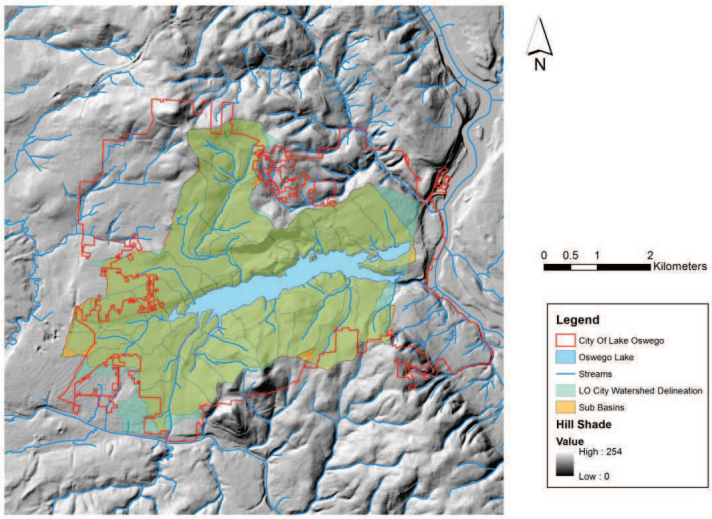
- Diff Tool
  - Subtract 2001 from 2006 to find imperviousness change
- Raster Calculator Tool
  - ImpDiff20 = Con("ImpDiff" >= 20, 1, 0)
  - Locate areas where imperviousness has increased 20% or greater
    - Goetz et al. (2010) found 20% threshold to be a “robust” measure of development
- Tabulate Area Tool
  - For each spatial extent

RESULTS: WATERSHED DELINEATION

Oswego Lake Watershed Basin Delineation



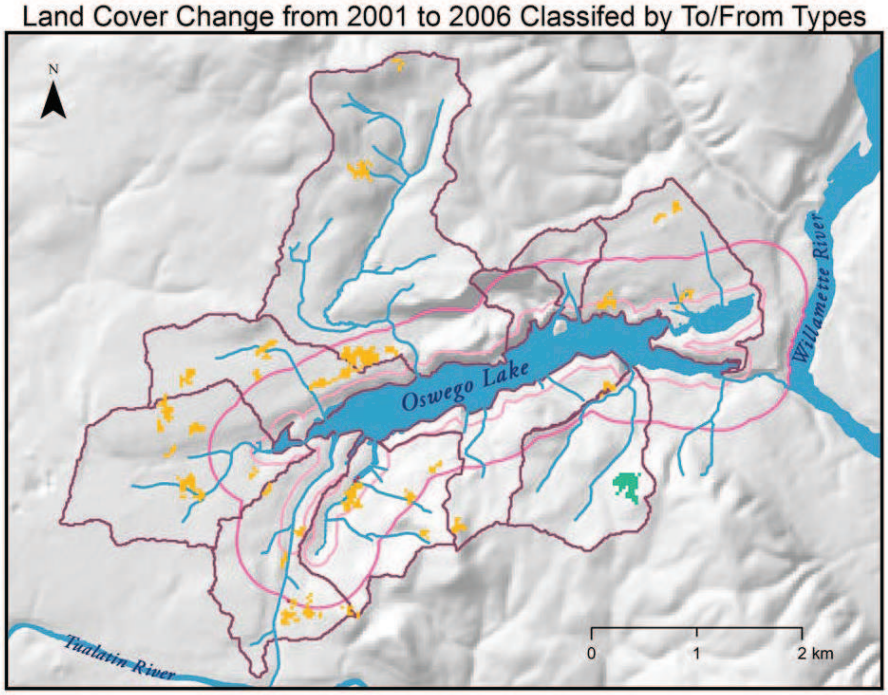
Oswego Lake Watershed SubBasin



RESULTS: LAND COVER CHANGE

Watershed Extent		2006 (Area in m^2)								
		Open Water	Open Space/ Low Density Development	Medium/High Density Development	Barren Land	Forest	Shrub/ Grassland	Agriculture	Wetlands	Percent Gain/Loss
2001 (Area in m^2)	Open Water	1,792,800	0	0	0	0	0	0	0	0.200%
	Open Space/Low Density Development	0	43,093,800	18,000	0	0	0	0	0	2.242%
	Medium/High Density Development	0	0	21,684,600	0	0	0	0	0	0.331%
	Barren Land	0	0	0	3,600	0	0	0	0	0.000%
	Forest	0	820,800	27,900	0	12,874,500	86,400	0	0	-6.771%
	Shrub/Grassland	0	41,400	0	0	0	466,200	0	46,800	24.619%
	Agriculture	0	124,200	26,100	0	0	231,300	2,886,300	6,300	-11.847%
	Wetlands	3,600	20,700	0	0	0	0	0	1,248,300	2.171%

Land Cover Change from 2001 to 2006 Classifed by To/From Types



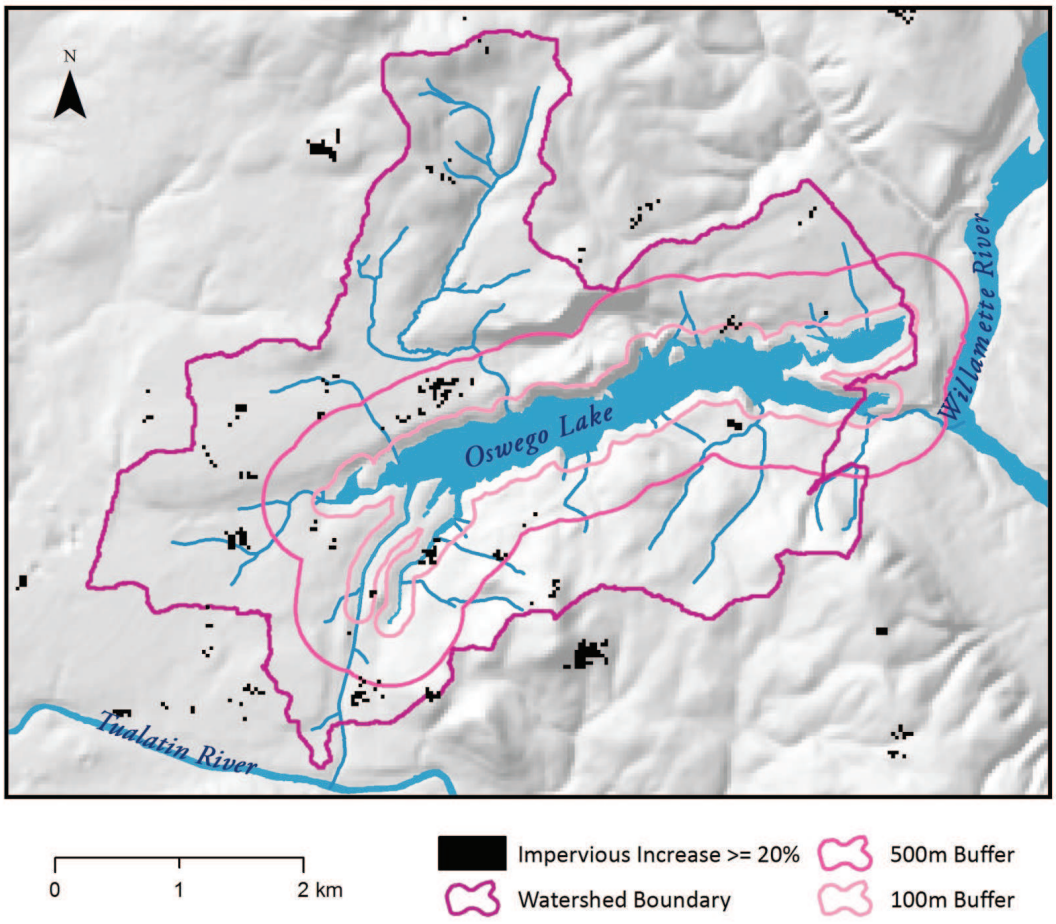
- Agriculture to Barren Land
- Agriculture to Forest
- Agriculture to Medium/High Density Development
- Agriculture to Open Space/Low Density Development
- Agriculture to Shrub/Grassland
- Agriculture to Wetlands
- Forest to Agriculture
- Forest to Agriculture
- Forest to Barren Land
- Forest to Medium/High Density Development
- Forest to Open Space/Low Density Development
- Forest to Shrub/Grassland
- Forest to Shrub/Grassland
- Open Space/Low Density Development to Medium/High Density Development
- Shrub/Grassland to Barren Land
- Shrub/Grassland to Forest
- Shrub/Grassland to Forest
- Shrub/Grassland to Medium/High Density Development
- Shrub/Grassland to Open Space/Low Density Development
- Shrub/Grassland to Wetlands
- Wetlands to Medium/High Density Development
- Wetlands to Medium/High Density Development
- Wetlands to Open Space/Low Density Development
- Wetlands to Open Water
- Wetlands to Open Water
- Wetlands to Shrub/Grassland

RESULTS: IMPERVIOUS CHANGE

Spatial Extent	m^2	Total m^2	Percent*
Buffer 100m	171,000	3,656,700	0.47%
Buffer 500m	81,000	9,486,900	0.85%
Contributing area	161,100	16,889,400	0.95%

* Percent of total area in spatial extent where imperviousness has increased ≥ 20% from 2001 to 2006

Imperviousness Change: Areas with Greater Than 20% Increase Between 2001 and 2006

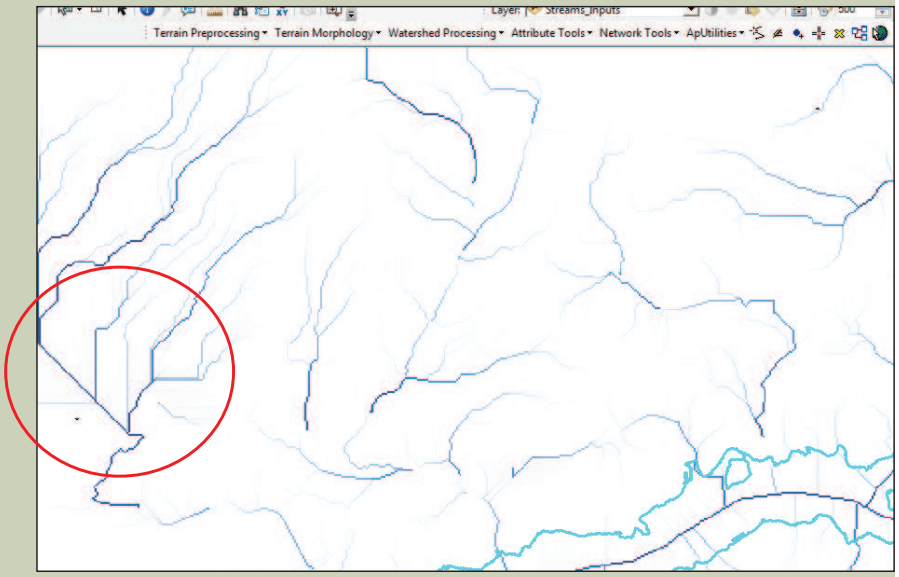


RESULTS: RELATIONSHIPS?

- Impervious area increased by <1% at all scales
  - Implication: Likely too low to have dramatic effects on an already urbanized watershed
  - This system is too complex to be explained by a single imperviousness metric
- Land cover changes (at watershed scale)
  - Loss of forest (-6.77%)
  - Loss of agriculture (-11.85%); gain of shrub/grassland (24.62%)
  - Gain of low density (2.24%) and wetlands (2.17%)
  - Conflicting results in regards to surface runoff potential
- Oswego Lake is heavily managed to ameliorate runoff associated problems which may mask the influence of land cover changes

LIMITATIONS: WATERSHED DELINEATION

- Engineered outflow of lake may have affected pour point locations
- Checked delineated watersheds against City of Lake Oswego's layers
  - Close match

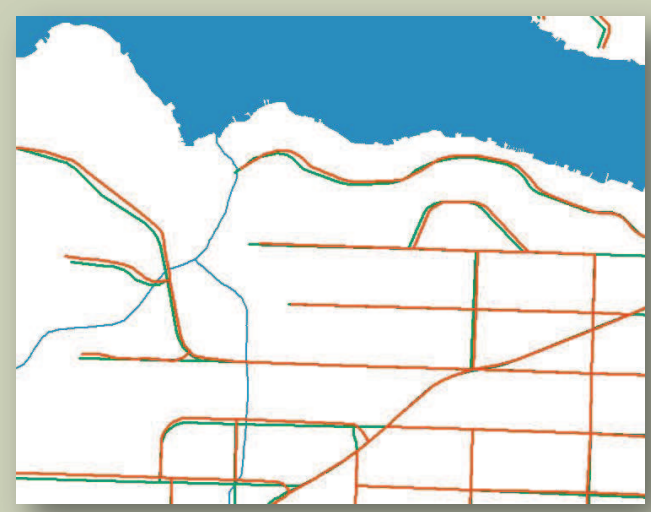


LIMITATIONS: LAND COVER AND IMPERVIOUS CHANGE

- Data resolution
- Classification errors
- Multiple land uses per cell
  - Example: large backyards with open space or forest
- Temporary land cover changes
  - Examples: agriculture, water
- Short time period
  - 10 year period is better!
  - When will the NLCD 2011 be released?

LIMITATIONS: OTHER METRICS

- Layers between 2000 and 2006 do not line up!
  - Same projection
  - Different surveying techniques?
  - Greater precision?
- Unable to use parks, streets, or developed/vacant as metrics ☹



RESOURCES

- Environmental System Research Institute (ESRI). 2011. *Arc Hydro Tools: Tutorial*. Version 2.0.
- Goetz, S. J. and G. Fiske. 2010. *PALMS Standard Operation Procedure: Estimating impervious cover change*. National Park Service, Fort Collins, CO.
- Hollenhorst, T. P., T. N. Brown, L. B. Johnson, J. J. H. Ciborowshi, and G. E. Host. 2007. Methods for generating multi-scale watershed delineations for indicator development in Great Lake coastal ecosystems. *Journal of Great Lakes Research*, 33(Special Issue 3):13-26.
- Jantz, P., S. Goetz, C. Jantz. 2005. Urbanization and the loss of resource lands in the Chesapeake Bay watershed. *Environmental Management* 36(6): 808-825.
- Rothenberger, M. B. and J. M. Burkholder. 2009. Long-term effects of changing land use practices on surface water quality in a coastal river and lagoonal estuary. Environmental Management 44(4): 505-523.
- Yuan, F. 2008. Land-cover change and environmental impact analysis in the Greater Mankato area of Minnesota using remote sensing and GIS modeling. International Journal of Remote Sensing 29(4): 1169-1184.


QUESTIONS?