

Evaluation of Land Use/Land Cover Characteristics in Ohio Drainages to Lake Erie

Ohio Phosphorus Task Force
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Data Sources:

There are three main sources of data available for evaluating land use/land cover for large areas of Ohio and drainages extending beyond the borders of Ohio; one based on aerial photography and the other two based on satellite data.

Aerial Photography:

1976 GIRAS (Geographic Analysis and Retrieval System): During the mid 1970's and 1980's, the USGS produced nationally consistent maps of land use and land cover (LULC) for the conterminous U.S. and Hawaii. Polygons of land use and land cover were delineated manually from **aerial photography** and mapped following a two-level hierarchical classification system (table 1) as described by Anderson and others (1976). The minimum mapping unit used was 4-6 hectares. The USGS published these land use and land cover maps at USGS 1:250,000-and 1:100,000-scale for the conterminous United States and Hawaii.

For its time the GIRAS data was high-quality data generated using methods of interpreting aerial photographs. However, there are two key limiting factors for its usefulness in detecting land use change over time.

1. For current analysis of land use/land cover, the data is too old.
2. For change analysis, the methods are drastically different than those used to collect and interpret satellite data.

Satellite Data:

1992 NLCD (National Land Cover Data): NLCD 1992 was the first land-cover mapping project with a national (conterminous) scope based on **30m resolution satellite data** obtained from the Landsat 5 TM program. The target scene acquisition date was 1992, although cloud cover and other factors forced use of scenes from other years because of a lack of useable. Mapping was based on unsupervised clustering and logical modeling using a suite of ancillary data. NLCD 1992 was completed about December 2000, and is supported by a paper that describes the project and main results (Vogelmann et al. 2001).

2001 NLCD: NLCD 2001 was the second effort in developing a national land cover data based on **30m resolution satellite data**, but this time data was obtained from Landsat 7 TM. The 2001 NLCD effort had some slight differences to the 1992 NLCD that improved the classification of land use. Land use classes were determined using supervised (human-hand verification) classification methods Data was rectified for changes in elevation, and was based on three Landsat scene captures from spring , summer, and fall. The 2001 NLCD not only provides land use/land cover data, but also impervious land and tree canopy derivatives.

Current Conditions:

Table 1. shows the Level I and Level II classifications used in the 1992 and 2001 efforts, as well as the percent land-use values for Ohio tributaries draining to Lake Erie. Most classes are the same or similar enough to make a side by side comparison. However, in the 1992 Urban Recreational Grasses were classified under agriculture. For those studying the impacts of land use on water quality, it has become common practice to move that category up to the Level I Urban class.

According to the data, Ohio is drained to Lake Erie by almost 60% row-crop agriculture, 14% residential land, and 13% deciduous forest cover.

Table 1. Land Use / Land Cover Classifications for 1992 and 2001 National Land Cover Data (NLCD), and percentages for the Ohio tributaries draining to Lake Erie for the current 2001 NLCD data set.

Level I	Level II -1992 NLCD Classes	Level II - 2001 NLCD Classes	Ohio Lake Erie Tributaries
1. Water	11. Open water	11. Open water	1.5%
	12. Perennial Ice/Snow	12. Perennial Ice/Snow	
2. Urban Land	21. Low Intensity Residential	21. Developed, Open Space	8.4%
	22. High Intensity Residential	22. Developed, Low Intensity	5.6%
	23. Commercial/Industrial/Transport	23. Developed, Medium Intensity	1.7%
		24. Developed, High Intensity	0.7%
3. Barren Land	31. Bare Rock/Sand/Clay	31. Barren Land	0.1%
	32. Quarries/Strip Mines/Gravel Pits		
	33. Transitional		
4. Forest land	41 Deciduous forest land	41 Deciduous forest land	13.1%
	42 Evergreen forest land	42 Evergreen forest land	0.2%
	43 Mixed forest land	43 Mixed forest land	0.0%
5. Shrub land	51. Shrub land	52. Scrub/Shrub	0.2%
6. Orchards/Vineyards/Other	61. Orchards/Vineyards/Other		
7. Grass Land	71. Grassland/Herbaceous	71. Grassland/Herbaceous	1.4%
8. Agricultural Land	81. Pasture/Hay	81. Pasture/Hay	5.4%
	82. Row Crops	82. Cultivated Crops	59.1%
	83. Small Grains		
	84. Fallow		
	85. Urban/Recreational Grasses *		
9. Wetlands	91. Woody Wetlands	90. Woody Wetlands	2.0%
	92. Emergent Herbaceous Wetlands	95. Emergent Herbaceous Wetlands	0.6%

* Urban/Recreational Grasses from 1992 is included in the Level I Urban classification to match the 2001 classification #21. Developed, open spaces (parks, large residential grassy areas, golf courses).

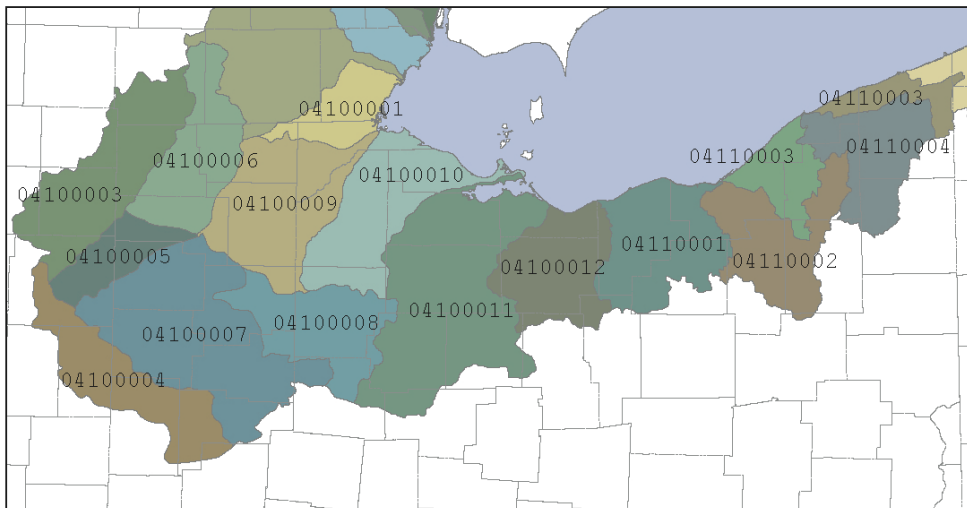
Table 2. shows percent land use/land cover is divided out for large watersheds (8-digit Hydrologic Unit Codes (HUCs)). In Northwest Ohio agricultural is dominate in watersheds such as the Auglaize, Blanchard, Sandusky, Tiffin, and Upper Maumee where agricultural accounts for 76-82% of the land-use; urban land accounts for 8-14%, and forest and wetland land cover accounts for 5-13%. Alternatively, urban dominated watersheds in Northeast Ohio, such as the Cuyahoga, Chagrin, Black, and Ashtabula are heavily influenced by commercial, residential and transportation land uses. Urban land in these watersheds accounts for 21-56%, forest and wetland cover accounts for 31-46% , and agriculture accounts for 28-36%.

Table 2. Land areas (square miles) and land use/land cover percentages from 2001 National Land Cover Data (NLCD) for 8-digit Hydrologic Unit Codes in Ohio draining to Lake Erie, and aggregated percentiles for the Maumee River Basin and Ohio Lake Erie tributaries.

NLCD 2001 Level I	Ohio Lake Erie Tribs	Maumee Basin	St. Joseph	St. Marys	Upper Maumee	Tiffin/Bean	Auglaize	Blanchard	Lower Maumee
	Aggregate of HUCs	Aggregate of HUCs	04100003	04100004	04100005	04100006	04100007	04100008	04100009
Area (sqmi)	13,643	6,587	1,074	823	383	782	1,666	786	1,074
Agriculture	65%	78%	70%	78%	78%	78%	82%	82%	76%
Urban	16%	11%	10%	13%	14%	8%	11%	10%	14%
Forest	13%	7%	11%	6%	5%	7%	5%	6%	7%
Wetlands	3%	2%	8%	1%	1%	6%	0%	0%	1%
Grassland	1%	1%	1%	1%	1%	0%	1%	2%	1%
Barren	0%	0%	0%	0%	0%	0%	0%	0%	0%
Shrub	0%	0%	1%	0%	0%	0%	0%	0%	0%

NLCD 2001 Level I	Ottawa	Toussaint/Portage	Sandusky	Huron +	Vermilion/Black/Rocky	Cuyahoga	Chagrin +	Grand	Ashtabula +
	04100001	04100010	04100011	04100012	04110001	04110002	04110003	04110004	04110003
Area (sqmi)	402	973	1,878	759	899	801	380	712	252
Agriculture	54%	76%	76%	69%	36%	16%	6%	33%	28%
Urban	32%	13%	10%	9%	31%	45%	56%	11%	21%
Forest	10%	4%	8%	19%	25%	31%	31%	43%	43%
Wetlands	2%	4%	2%	1%	6%	3%	1%	6%	3%
Grassland	1%	1%	1%	0%	1%	3%	5%	4%	3%
Barren	0%	1%	0%	0%	0%	0%	0%	0%	0%
Shrub	0%	0%	0%	0%	0%	0%	0%	2%	2%

Figure 1. 8-Digit Hydrologic Unit Codes (HUCs)



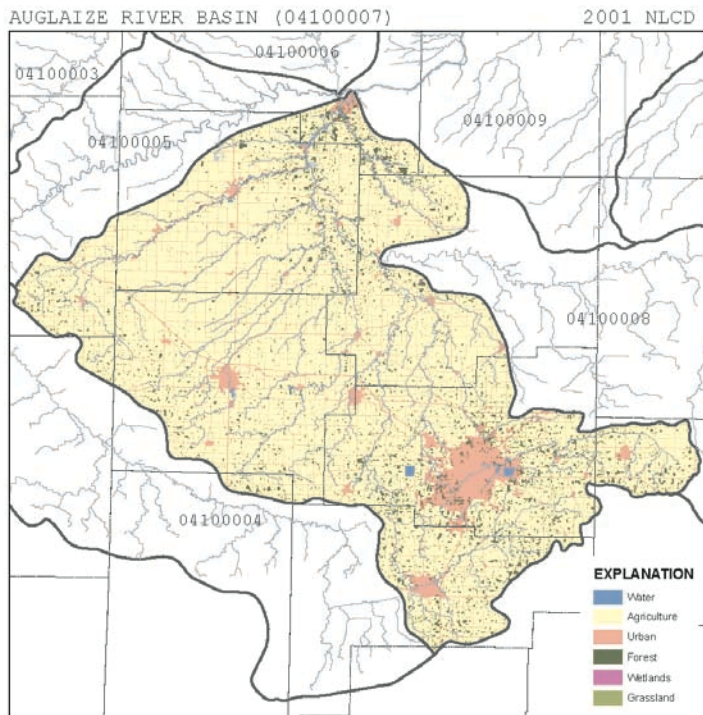
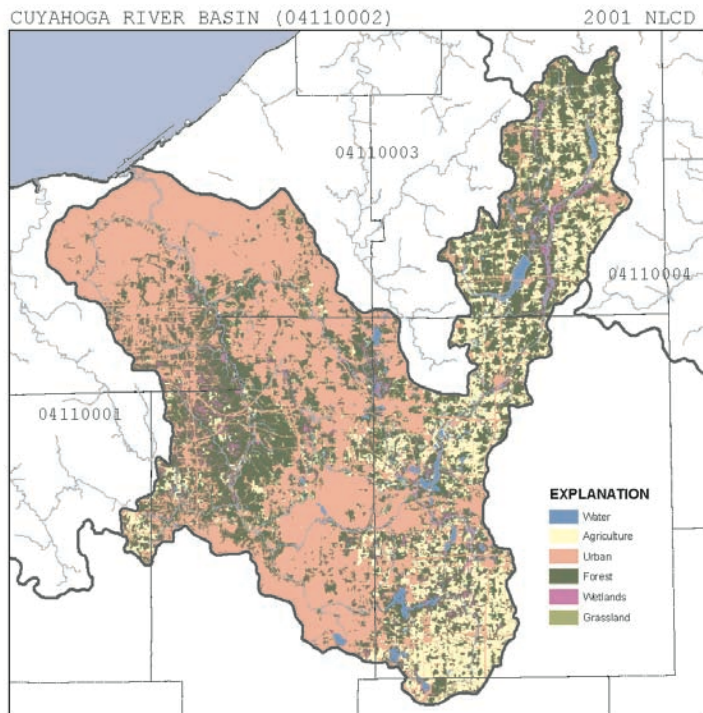


Figure 2. shows a graphic comparison between the Auglaize River, an agricultural use dominated watershed, and the Cuyahoga River, an urban land-use and forest cover dominated watershed.

In the Auglaize, Lima and its up-ground reservoirs are evident in the headwaters. The central part of the basin seems almost entirely void of any forest cover, where-as in the headwaters, the southwestern flanks, and areas near the mouth show spotty and occasional large clusters of forested land. This appears to be a function of soil type, surficial geology, and physiography.



The Cuyahoga River has a less-than moderate amount of agricultural production, but these areas are located in the headwaters of the Little Cuyahoga and the upper reaches of the main-stem. Any agricultural impact of the Cuyahoga to Lake Erie is likely masked by the more proximate Urban signature of residential, industrial, commercial, and transportation to the main-stem, mouth, and Lake Erie. The Cuyahoga River National Park and portions of the Cleveland Metro Park system is prominently depicted between Cleveland and Akron.

Table 2. Percent change in land use/land cover from 1992 to 2001 National Land Cover Data (NLCD) for 8-digit Hydrologic Unit Codes in Ohio draining to Lake Erie, the Maumee River Basin and Ohio Lake Erie tributaries.

NLCD 2001 Level I	Ohio Lake Erie Tribs	Maumee Basin	St. Joseph	St. Marys	Upper Maumee	Tiffin/Bean	Auglaize	Blanchard	Lower Maumee
	Aggregate of HUCs	Aggregate of HUCs	04100003	04100004	04100005	04100006	04100007	04100008	04100009
Agriculture	-9%	-9%	-10%	-9%	-9%	-8%	-8%	-9%	-9%
Urban	9%	8%	7%	9%	8%	7%	8%	8%	8%
Forest	-2%	-1%	-2%	-1%	0%	-3%	-1%	0%	0%
Wetlands	0%	1%	4%	0%	0%	3%	0%	0%	0%
Grassland	1%	1%	1%	1%	1%	0%	1%	2%	1%
Barren	0%	0%	0%	0%	0%	0%	0%	0%	0%
Shrub	0%	0%	1%	0%	0%	0%	0%	0%	0%

NLCD 2001 Level I	Ottawa	Toussaint/Portage	Sandusky	Huron +	Vermilion/Black/Rocky	Cuyahoga	Chagrin +	Grand	Ashtabula +
	04100001	04100010	04100011	04100012	04110001	04110002	04110003	04110004	04110003
Agriculture	-14%	-11%	-11%	-7%	-13%	-11%	-9%	-4%	-8%
Urban	15%	9%	8%	7%	15%	19%	23%	8%	14%
Forest	-2%	-1%	-1%	-1%	-5%	-7%	-13%	-2%	4%
Wetlands	1%	1%	0%	0%	3%	-3%	-3%	-7%	-14%
Grassland	1%	1%	1%	0%	1%	3%	5%	4%	3%
Barren	0%	0%	0%	0%	0%	0%	0%	0%	0%
Shrub	0%	0%	0%	0%	0%	0%	0%	2%	1%

Change Detection:

The Federal partners (USEPA, USGS, NOAA, USFWS, USFS, NPS, NRCS, DOI) that created the two NLCD data compilations (1992 and 2001) **do not recommend a pixel-by-pixel comparison of land use/land cover change between the two data sets.** However, a simple evaluation of land use/land cover change between the two time periods can be made by using the Anderson Level I classification aggregated to large areas such as the Ohio drainages to Lake Erie, or 8-digit Hydrologic Unit Codes (HUCs). Table 1. describes the Anderson Classification schemes as they have been adopted/modified by 1992 NLCD, and 2001 NLCD.

Overall for the Lake Erie tributaries, the data show a decrease of 9% agricultural land, and a subsequent increase of 9% of urban land. Moreover, the data suggest that forest cover over the same period of time has decrease by 2%. The same numbers are approximated in the Maumee River Basin and the individual tributaries contributing to the Maumee. Agricultural losses range from 8-10% and urban land increases range from 7-9%. Considering that just a small part of this large watershed contains significant urban areas (Ft. Wayne, Toledo, and Lima), and that the census data show a slight decrease in population density in this part of Ohio (www.census.gov), the 7-9% increase in urban land seems to be an exaggeration. Although, with any urban sprawl, low-density residential land is likely never converted back to a natural cover or agriculture. In the more urban-dominated watersheds, agricultural losses were a bit higher, ranging from 8-13%, and as can be expected urban land use increased over this 10-year time frame from 14-23%. This coincides well with census data showing that a few counties in Northeast Ohio saw population increases from 4-19%. According to the change detection analysis of Level I classes, the Chagrin River watershed lost 13% of its forest cover, and the Ashtabula

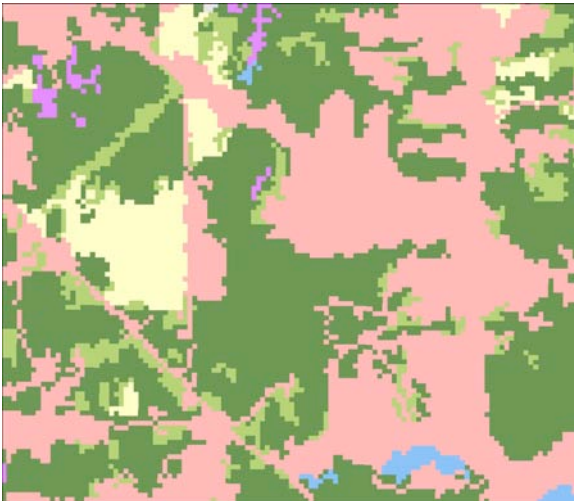
2006 Aerial Photograph



River lost 14% of its wetlands; likely to urban development which gained a subsequent percentage of land.

However the accuracy of the change detection numbers should still be questioned despite the data being generalized to a Level I classification and aggregated for large watershed areas. Figure 3. shows a bottom-to-top comparison of the raw 1992 NLCD, raw 2001 NLCD, and an aerial photograph of the same area taken in 2006. In the unsupervised classification of the 1992 Landsat data, the NLCD depicts a highly pixilated image where agricultural land sits side-by-side with urban-residential land, and residential neighborhoods have portions of their land categorized as forested. Likewise, portions of the golf course in the southeastern corner, and the right-of-way in the northwestern corner of the picture are incorrectly classified as agriculture, but properly classified in the 2001 NLCD as Developed Open-Spaces and Grass Land respectively.

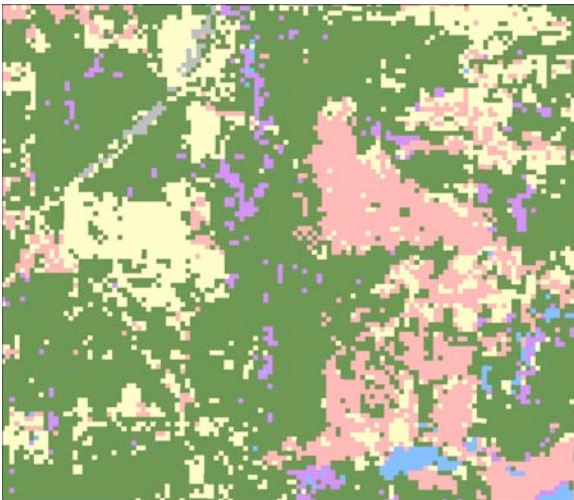
2001 NLCD



So, it is likely that **a portion** of the percent changes in land use from agriculture to urban and forest to urban is an artifact caused by the differences in the data, and not a true reflection of reality.

When compared to the 2006 aerial photograph of the same area, the 2001 NLCD does a better job of classifying land-use and land-cover overall. Wooded residential lands are not being depicted as forest-cover, which may have contributed to the extreme decrease in forested land cover in the Chagrin River watershed. Moreover, it appears from a comparison between the 1992 NLCD and 2006 aerial photograph that wetlands are more accurately depicted in the 1992 NLCD than in the 2001 NLCD., where the riparian wetlands down the center of the image are found in the 1992 NLCD, but not in the 2001 NLCD.

1992 NLCD



Therefore, change detection values shown in table 2. between 1992 and 2001 are likely not accurate, even though the relative percentages and concepts are inherently valid.