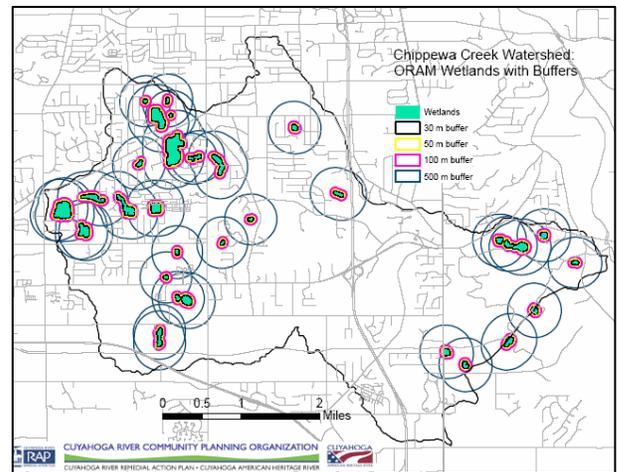


Prioritizing Restoration Opportunities in the Chippewa Creek watershed



February 15th, 2008

By:

Cuyahoga River Community Planning Organization

ABSTRACT

A goal of this project was to characterize wetland attainable condition as a function of watershed urbanization. A multilevel approach was used which incorporated assessments based on landscape (remote sensing) data, field investigated rapid and intensive assessment methods. These variables were analyzed to develop a model to predict the ecological condition of wetlands not sampled and best attainable condition. Land-use was characterized at various distances (30m, 50m, 100m, 500m, 1000m and within the wetland drainage area) beyond the wetland perimeter to investigate which buffer gave the best information on wetland condition. Land-use proportions were converted to a Landscape Development Intensity (LDI) index, which integrates the impacts of human land use on a given site. Two land use data sets (Cuyahoga Valley National Park and Ohio EPA Digital land-use databases) were calculated in each buffer distance, allowing us to check their predictive power. Landuse in the 30m buffer area had the strongest correlation and influence on wetland ecological condition. The cumulative distribution function (CDF) indicated that the best attainable condition for wetlands in the Chippewa basin is lower than in the other two study areas. Clearly the impacts of urbanization have downgraded the expectations for wetlands in this watershed.

PROJECT TIMELINE

1 st Quarter 2007	Finalize assessment data collected in the 2005 field assessment project for three tributary watersheds (complimentary project)
2 nd Quarter 2007	Identify criteria to be testes as predictors of ecological condition
3 rd Quarter 2007	Land use analysis in the varying buffer widths Creating wetland drainage areas
4 th Quarter 2007	Land use & road density analysis in the varying buffer widths & wetland drainage areas
1 st Quarter 2008	Landscape Development Index (LDI) assessment Determine Relationship Land Use & Wetland Conditions Soil Analysis & Results
2 nd Quarter 2008	Developed predictive model to be used in the entire Cuyahoga River Watershed (complimentary project)

CHIPPEWA MAP CONTENTS (included at end of report)

1. All Wetlands with Streams
2. Landcover Analysis Using the Cuyahoga Valley National Park data.
3. Landcover Analysis Using the Ohio EPA data
4. Randomly Selected Wetland Points Visited During the 2005 Field Assessment Project to Determine Wetland Quality.
5. Ohio Rapid Assessment Method (ORAM) Results.
6. Wetlands with Varied Buffer Sizes that were Analyzed- 30m, 50m, 100m, 500m.
7. Wetlands and drainage basins delineated for Analysis.

TECHNICAL REPORT

Project Overview

A probability-based survey of wetlands was conducted in the Cuyahoga River Watershed during the summer of 2005. Over 350 wetlands were assessed using the Ohio Rapid Assessment Method (ORAM). As part of this project, three “focus” subwatersheds were intensively sampled to ascertain the condition of wetlands along a gradient of increasing watershed urbanization (accounting for approximately 150 of the total sites). The focus watersheds include Chippewa Creek (highly urbanized), Tinkers Creek (rapidly urbanizing), and Breakneck Creek (a mix of agricultural and low density residential).

The Cuyahoga River flows from its headwaters in Geauga County, Ohio, south 80 km to Akron where it takes a sharp turn to the north and travels another 80 km through Cleveland before emptying into Lake Erie. Portions of the watershed are among the fastest growing regions in the U.S. The lower part of the basin, in and around Cleveland is industrialized and densely populated (represented in this study by Chippewa Creek subwatershed), while land use in the middle part of the basin is either urbanizing rapidly (Tinkers Creek) or is largely agricultural (Breakneck Creek).

The Chippewa Creek LEPF project is designed to build upon this data to evaluate the ecological condition of the wetlands that that were sampled and, along with newly updated land use data for the State of Ohio, will identify ecologically significant wetlands in the Chippewa Creek watershed. (i.e., advanced identification of priority wetlands).

This pilot will help determine the most reliable correlations of wetland restoration potential as it relates to land cover stressors such as road grid density, imperviousness and other factors. The study included “weeding out” the less relevant factors and refining the relationships and defining the most reliable methodology for use in establishing wetland restoration potential. The content of this project will form the basis for wetland analysis in all the Cuyahoga River tributaries and ultimately for content in the Cuyahoga River Delisting Report.

Main Activities

1. Identify and test criteria as predictors of ecological condition.
2. Land Use Analysis in the Chippewa Creek watershed
3. Incorporate Landscape Development Index (LDI)
4. Determine Relationship Land Use & Wetland Conditions
5. Soil Analysis & Results

Criteria Tested for Predictive Correlation of Ecological Condition

Criteria	Details
1. Patterns of Land Use- area surrounding each wetland	Buffers around each wetland at distances of 30m, 50m, 100m, 500m, 1000m
2. Wetland Drainage Basin	Calculated land use in each wetland's drainage basin
3. Land Use Data Sets	Two land use data sets were used to calculate the above buffer distances and wetland drainage area including detailed county data and the OEPA state landuse data. This allowed us to check their relative merits in terms of ease of use and predictive power
4. Landscape Development Index (LDI)	Calculate LDI scores for each buffer distance and wetland drainage basin using each land use data set
5. Road Density	The total length of roads were determined in each buffer distance and wetland drainage basin
6. Percent of Wetland Area	The % of the wetland area was used as a discrete variable. - wetland size - estimated maximum extent of water surface (if different from size and discernable) - distance to nearest stream - percent impervious surface - perimeter to area ratio of each wetland site (P:A ratio)
7. Soil Characteristics	Analyze soil samples gathered during the 2005 field assessments. Investigate the use of soil characteristics in the surrounding area, particularly the use of runoff coefficients for soils in the wetland drainage basin.

These variables were analyzed to develop a model to predict the ecological condition of wetlands not sampled. This will be done by testing the variables to determine their ability to predict wetland condition using the AIC multiple regression method.

Land Use Analysis

Land-use surrounding the wetland sites included in the Chippewa watershed was characterized using both the Cuyahoga Valley National Park and the Ohio EPA Digital land-use survey databases. Land-use was classified into general land-use categories, including:

- Forest: a combination of evergreen and deciduous forest cover;
- Pasture: Areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops;
- Crop: Areas used for the production of crops such as corn, soybeans, vegetables, tobacco, and cotton;
- Residential: Includes both heavily built up urban centers (high intensity residential) and areas with a mixture of constructed materials and vegetation (low intensity residential). Examples include apartment complexes, row houses, and single-family housing units;
- Commercial: Includes infrastructure (e.g. roads, railroads, etc.) and all highways and all developed areas not classified as residential;
- Wetland: a combination of wooded wetland and herbaceous wetland cover;
- Open water;
- Bare lands.

Landscape Development Intensity Index (LDI)

The LDI is a land use based index of potential human disturbance. It is calculated spatially based on coefficients applied to land uses within watersheds. The metric used for quantifying human activity is energy use per unit area per time.

Land-use was characterized at various distances beyond the wetland perimeter in order to investigate which buffer gave the best information on wetland condition. Buffer distances of 30m, 50m, 100m, 500m, and 1000m were calculated from the boundary of each wetland site. Land-use proportions were converted to a Landscape Development Intensity (LDI) index, which integrates the impacts of human land use on a given site (Brown and Vivas 2005).

The LDI scores are calculated based on assignment of land-use coefficients ranging from 0 for natural systems to 4.8 for business districts. The LDI_{total} is a simple weighted average, such that:

$$LDI_{total} = \sum \%LU_i * LDI_i$$

where, LDI_{Total} = the LDI score, $\%LU_i$ = percent of total area in that land use i , and LDI_i = landscape development intensity coefficient for land use i (Brown and Vivas 2004). What is unique to this calculation is that it integrates all land-uses into one score rather than looking at each land-use separately. By using this method (level 1 assessment) in combination with the ORAM (level 2 assessment), we can evaluate the response of wetland ecosystems as the human impact on surrounding land-use increases.

Results for the Chippewa Creek watershed

Using the ORAM scores and associated data for wetlands sampled in the three watersheds allows us to report on wetland condition along a gradient of urbanization (Chippewa > Tinkers > Breakneck). The number of wetlands sampled was roughly equivalent in the three watersheds, with 30 sampled in Chippewa, 41 in Tinkers, and 33 in Breakneck Creek. The fate of wetlands visited in the Chippewa Creek watershed is shown in Figure 1. In each watershed, most of the sites visited were wetlands that were able to be sampled. Chippewa Creek had the lowest success rate; of all the points visited, only 49% were wetlands that could be assessed. At over one-third of the sites (35%) no wetland was found (i.e., of the points visited, 35% were not wetlands), either due to mapping error inherent in the Ohio Wetland Inventory or recent conversion of an existing wetland. This was a much higher percentage than was found in the other two study watersheds.

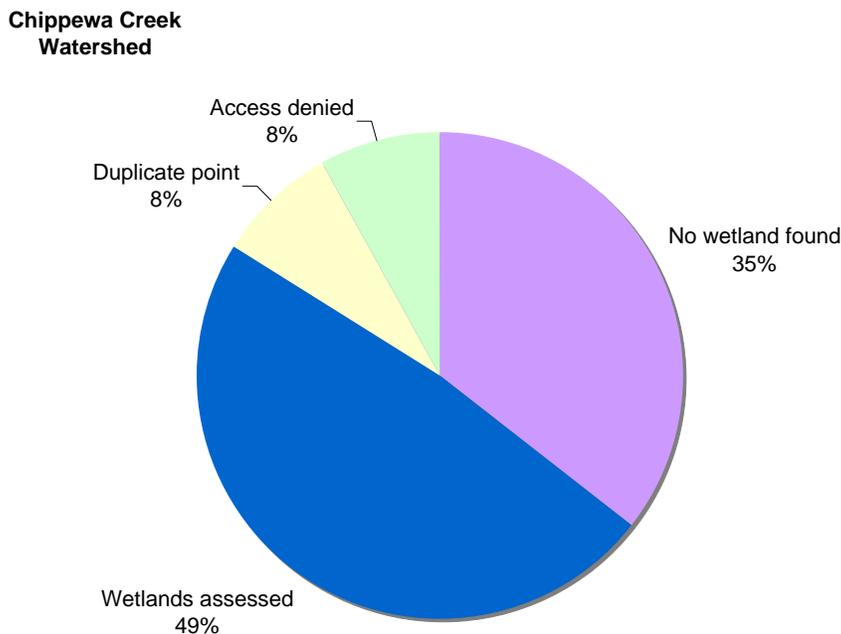


Figure 1. The fate of sample points visited in the Chippewa Creek watershed. Sample points determined using USEPA’s EMAP probabilistic sampling strategy in order to select a spatially balanced random sample of mapped wetlands points. Points were categorized as either a wetland that was assessed using ORAM, a point where no wetland was found, a point where landowners denied access, or a point that fell in a wetland that had already been sampled (duplicate point).

The ecological condition of wetlands in each watershed was evaluated by categorizing the ORAM scores using the State of Ohio's wetland antidegradation categories, including: Category 1 (poor plus modified Category 2, fair), full Category 2 (good), and Category 3 (very good to excellent). The percentage of wetlands in each watershed that would be considered degraded (Category 1 + modified Category 2) varied substantially, decreasing from a high of 38% in Chippewa, 24% in Tinkers, and 21% in Breakneck. This trend corresponds to the intensity of land use in the three watersheds. There was dramatic decline in the numbers of Category 3 wetlands moving from Breakneck (22%) to Tinkers (15%) to the Chippewa watershed (5%). The near disappearance of Category 3 wetlands in the Chippewa where only one site scored high enough to be considered a Category 3 wetland, indicates the chronic degradation of the entire wetland resource in the watershed. (See Figure 2)

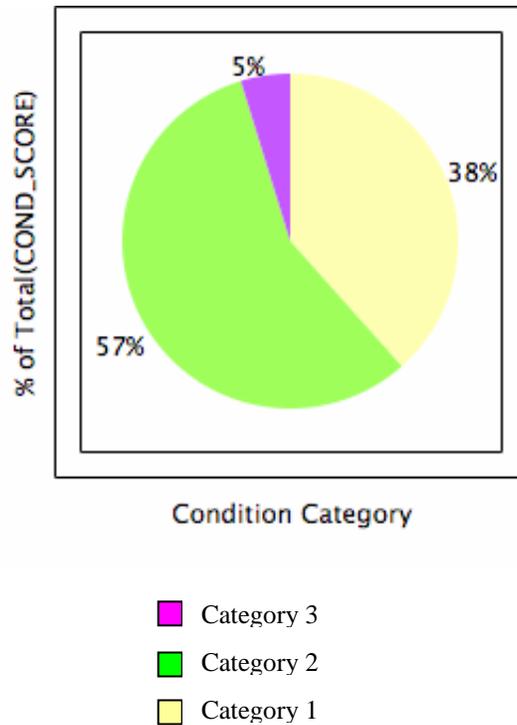


Figure 2. The proportion of wetlands in each condition category for the Chippewa Creek watershed (based on ORAM scores; Category 1 = poor to fair, Category 2 = good, and Category 3 = excellent).

A goal of this project was to characterize wetland attainable condition as a function of watershed urbanization. We did this by determining the distribution of ORAM scores for each watershed (Figures 3, 4), and from these calculating the cumulative distribution function (CDF) of scores in each watershed. CDF plots have become a standard way to report on the ecological condition of aquatic ecosystems (Whittier 2002). The CDFs for the 3 watersheds indicate that the *best attainable condition* for wetlands in the Chippewa Creek basin is lower than in the other two basins. For example, the data show that about 65% of all wetlands in the Chippewa Creek watershed have an ORAM score between 0 and 50. In addition, fully half of the wetlands in this watershed have ORAM scores lower than 44, the cutoff defined by ORAM that separates wetlands of poor to fair condition (Category 1 and low Category 2) from those considered in good condition. Only 2 wetlands (or 6% of the total) of those assessed as part of the watershed assessment in 2005 scored above 60, and as mentioned above, only 1 site (or 3% of the total) scored above 65 (Category 3 wetland). Clearly the impacts of urbanization (e.g. altered hydrology such as stormwater runoff or habitat fragmentation) have downgraded the expectations for wetlands in this watershed. This illustrates the need for a comprehensive restoration plan (such a plan will be developed via a complimentary project).

For the Tinkers and Breakneck watersheds, 55% of all wetlands scored above 50, thus the mean attainable condition is higher in these two areas. In contrast to the Chippewa, about 10-12% of all wetlands are expected to fall in Category 3 (excellent condition) in these two watersheds.

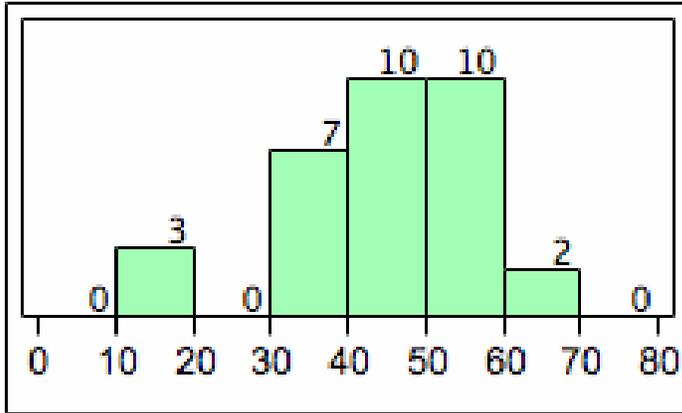


Figure 3. Distribution of ORAM scores in the Chippewa Creek watershed showing the number of sites in each scoring range,

CDF Plot

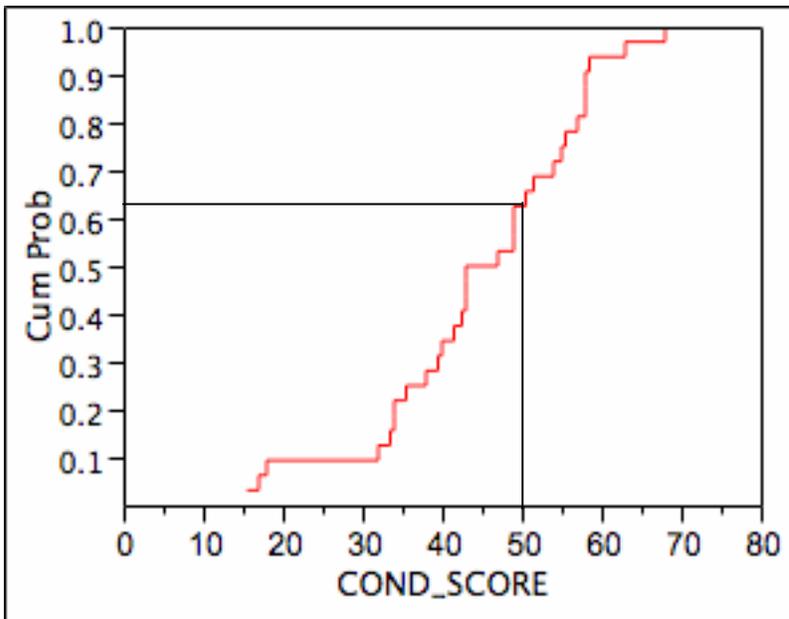


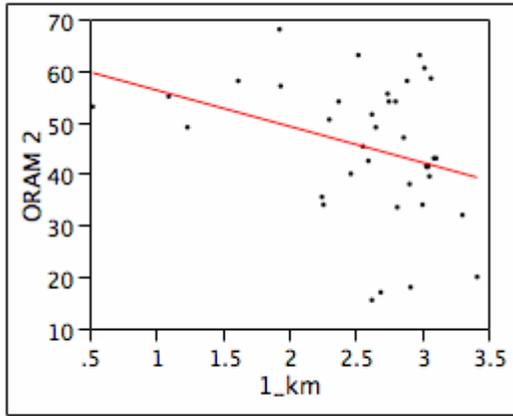
Figure 4. The cumulative distribution function for scores in the Chippewa Creek watershed. The graph indicates the probability of how a wetland will score. The line from an ORAM score of 50 indicates that 63% of all wetlands in the watershed will score below this point. This graph also indicates that 50% of all sites are likely to score below 45, and thus fall in Category 1.

Land Use and Wetland Condition

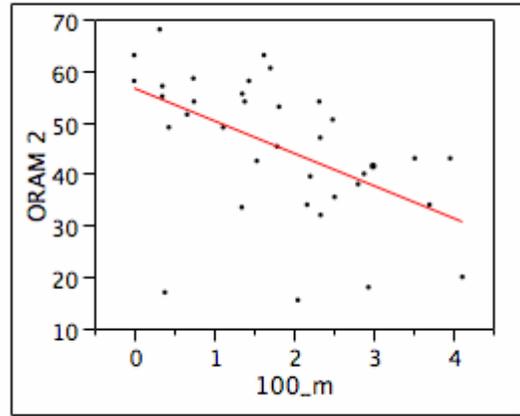
The land use analyses are first being performed for the Chippewa Creek watershed, allowing us to fully develop and streamline the methods that will then be applied to the Tinkers Creek and Breakneck Creek watersheds. We are particularly interested in the effects of land use on ecological condition in the buffer area surrounding a wetland. We used two different land use databases in this analysis in order to compare their usefulness: the Cuyahoga Valley National Park (CVNP) land use data, which is more precise since it is based on orthophotos (0.5 foot pixel resolution), but is not available throughout the entire Cuyahoga River watershed, and the Ohio EPA land use data, which has lower resolution (30m) but is available for the entire state.

Regression analysis of the LDI scores using the CVNP land use data for 5 different buffer distances versus ORAM score in the Chippewa Creek watershed shows that smaller buffer distances are better able to predict wetland condition (as measured by the r-squared values for the regressions; Figure 5 and 6). As we predicted, the buffer distance with the most power to predict wetland condition (ORAM scores) is the smallest we assessed, a 30m buffer. The r-squared values for the small buffers (30m and 50m) are both quite high for this kind of analysis (r-square values ranged from 0.42 to 0.55, indicating that between 42% and 55% of the variation in ORAM scores is explained by the LDI). Note that the LDI scores for the 30m buffer are better able to predict wetland condition than the 100m buffer (a standard buffer distance used in this type of analysis). The 1-km buffer, a standard buffer distance for landscape analysis, was a poor predictor of condition (with r-square values of 0.11 and 0.14 for the CVNP and OEPA data, respectively).

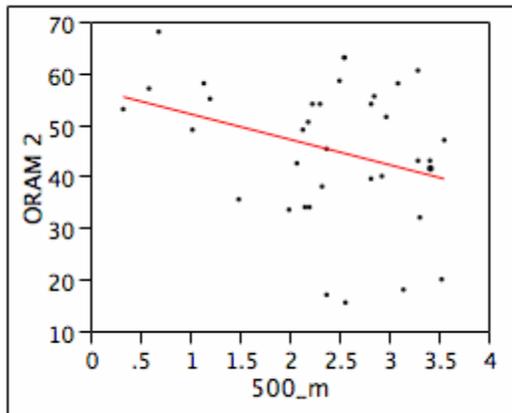
We also investigated land-use (using the Ohio EPA land use data) in the watershed draining to each wetland study area (Figure 7). Individual wetland watersheds were defined via a new method we developed using two tool sets in ESRI ArcGIS Spatial Analyst Extension 9.1: Interpolation to create a Digital Elevation Model, and Hydrology to determine the drainage basin of an entire wetland area instead of just a point. The correlation between land use (as measured by the weighted average, the LDI) was relatively high, although the size of the wetland watersheds varied greatly.



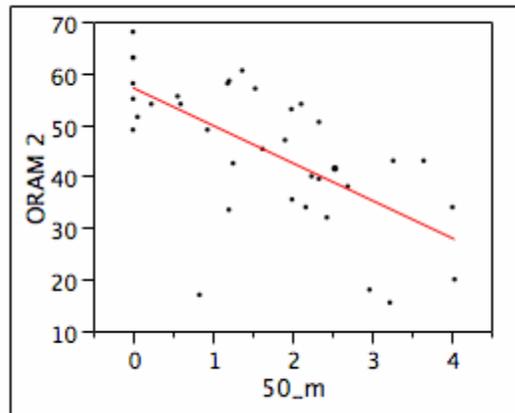
LDI scores for the 1 km buffer;
 $R^2 = 0.11$



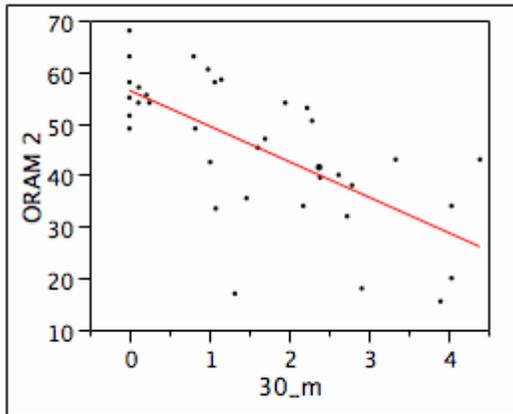
LDI scores for the 100m
buffer; $R^2 = 0.28$



LDI scores for the 500m buffer;
 $R^2 = 0.10$

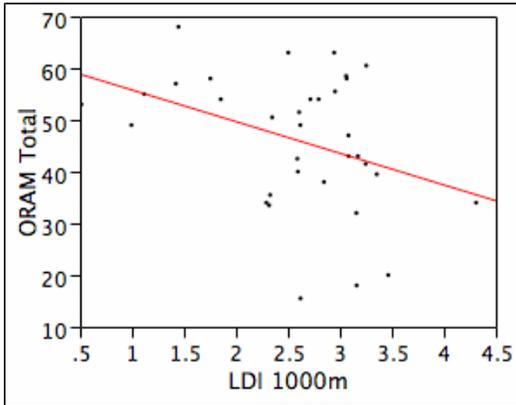


LDI scores for the 50m
buffer; $R^2 = 0.42$

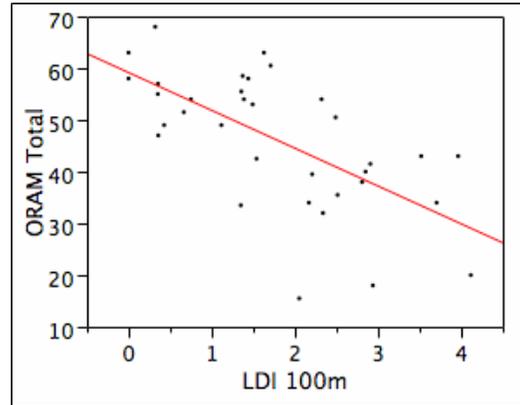


LDI scores for the 30m buffer;
 $R^2 = 0.46$

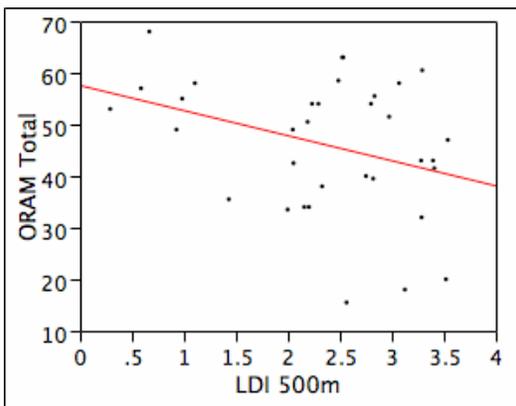
Figure 5. Regression analysis using the CVNP land use data to calculate the Landscape Development Index scores (a weighted average of the intensity of land use surrounding a site) for 5 different buffer distances versus ORAM in the Chippewa Creek watershed. Note the improving correlations as buffer distances get smaller (as measured by the r-squared values).



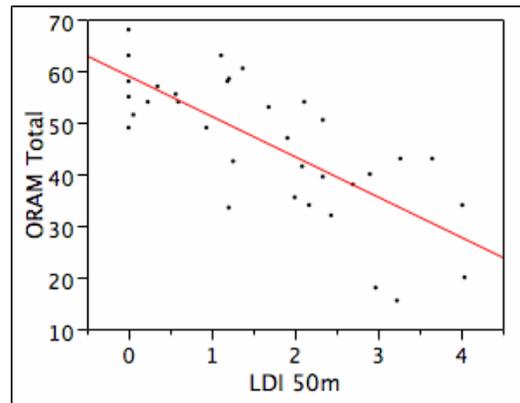
LDI scores for the 1km buffer; $R^2 = 0.14$



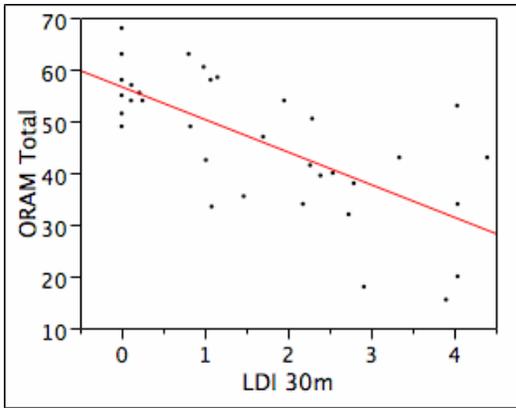
LDI scores for the 100m buffer; $R^2 = 0.42$



LDI scores for the 500m buffer; $R^2 = 0.11$



LDI scores for the 50m buffer; $R^2 = 0.55$



LDI scores for the 500m buffer; $R^2 = 0.47$

Figure 6. Regression analysis using the Ohio EPA land use data to calculate the Landscape Development Index scores (a weighted average of the intensity of land use surrounding a site) for 5 different buffer distances versus ORAM in the Chippewa Watershed. Note the improving correlations as buffer distances get smaller (as measured by the r-squared values).

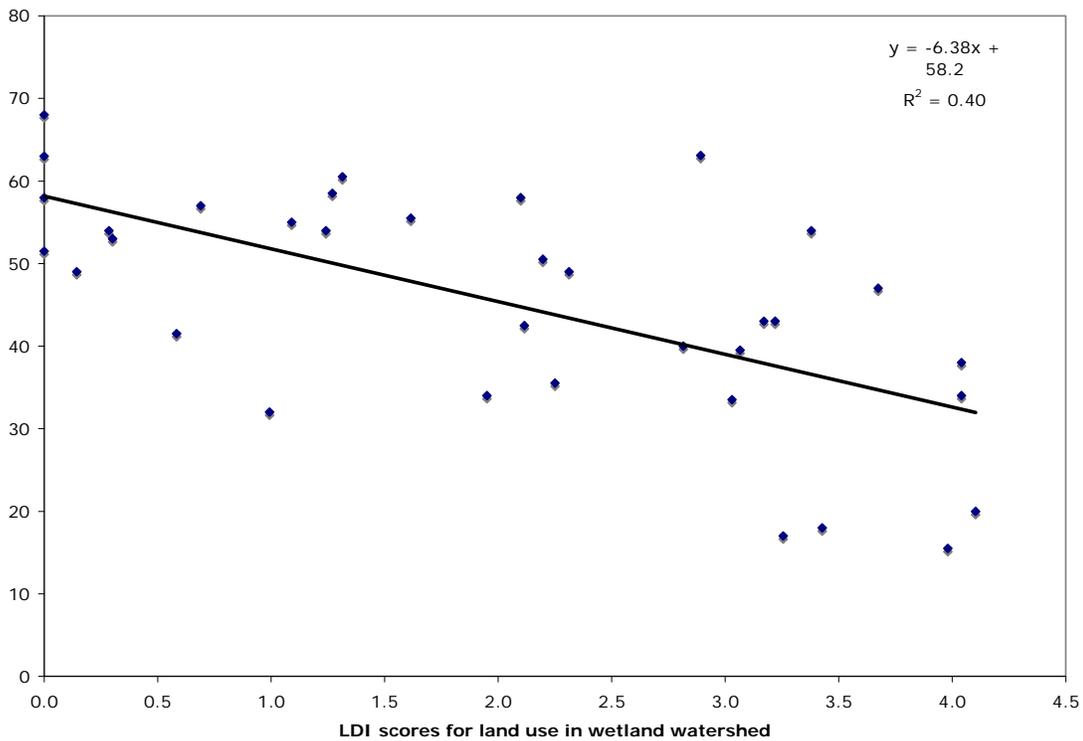
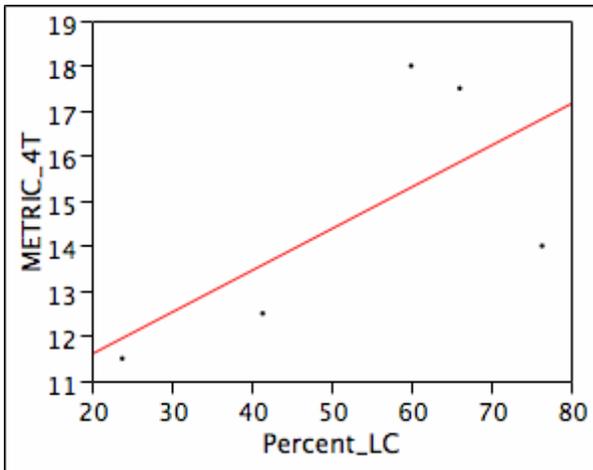


Figure 7. Regression analysis using the Ohio EPA land use data in the watershed draining to each wetland study site. The land use data were used to calculate the Landscape Development Index scores (a weighted average of the intensity of land use surrounding a site) in the Chippewa Watershed.

The relationship between ORAM scores and the percentage of individual land use types was also assessed (for example, how good a predictor is the percent of urban land use in a wetlands buffer area). Generally the correlation between individual land uses and ORAM scores were quite low, and significantly lower than the correlations using the LDI. The exception to this was the relationship between wetland condition and the percent of wetland area found in the buffer (Figure 8). In this case the ability of this land use type to predict wetland condition was as high as the total LDI scores. However, the vast majority of wetlands sampled did not have any wetlands in their buffer, thus the total number of sites included is only 5. This makes the usefulness of using the percent cover of wetlands in the buffer not practical in predicting wetland condition for sites not sampled.

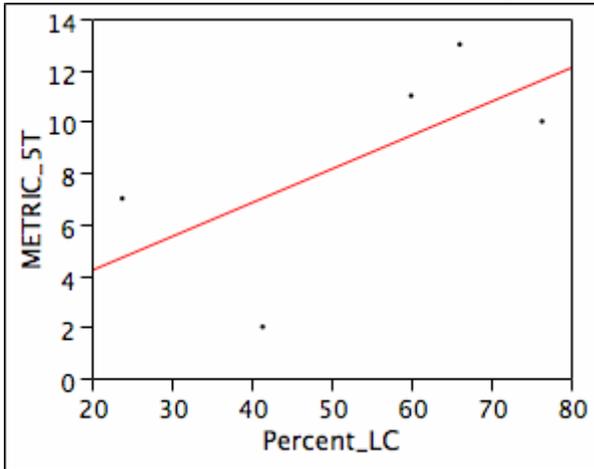
In sum, landuse in the smallest buffer areas measured has a strong influence on wetland ecological condition. Figure 9 shows the scores for wetlands in different land use settings. Condition declines significantly as land use in the buffer changes from natural (category 1 on this graph) to urban (category 4). This indicates that preservation of small buffer areas around wetlands can offer substantial protection and dramatically increase their conservation value.

METRIC 4 (total score): Habitat Value



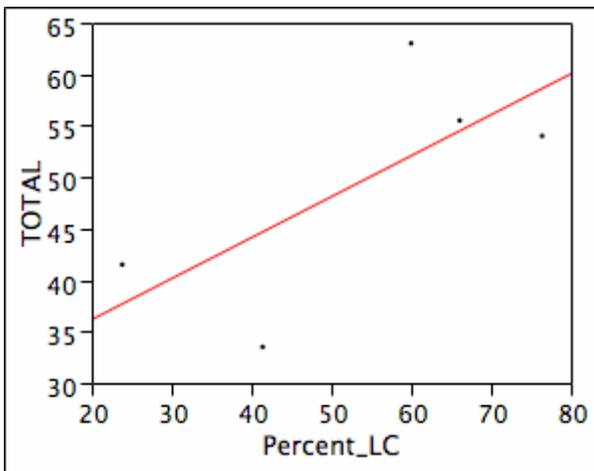
a) Scores for metric 4 of ORAM versus percent wetland land cover in the 50m buffer (R2 = 0.44).

METRIC 5 (total score): Vegetation Communities



b) Scores for metric 5 of ORAM versus percent wetland land cover in the 50m buffer ($R^2 = 0.41$).

Total ORAM Score



c) Scores for total ORAM scores versus percent wetland land cover in the 50m buffer ($R^2 = 0.49$).

Figure 8. Regressions between ORAM scores and the percent of wetland land cover in the 50m buffer surrounding a wetland. Note the sample size is only 5 of the total number of wetland assessed since the majority of sites did not have any wetland land cover in their buffer.

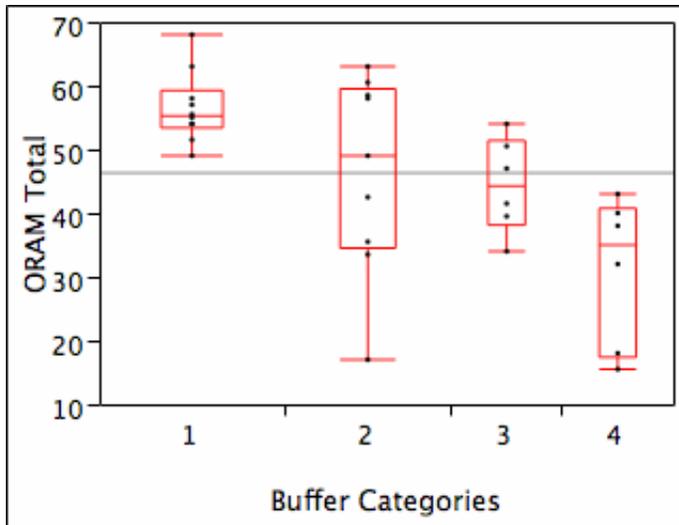


Figure 9. Average wetland condition as indicated by ORAM scores for different land use types in the 50m buffer where category 1 = natural, category 2 = pasture-agricultural, category 3 = agricultural –rural, 4 = urban.

Wetland Soils

Wetland soil nutrient levels tend to be higher than upland areas (Craft and Chiang 2002), storing significant quantities of nitrogen (N) and phosphorus (P). As land use in adjacent areas intensifies (as in the Chippewa), wetlands can absorb proportionately higher levels of nutrients and sediment, preventing downstream loading.

The soil data collected as part of the original survey of the entire Cuyahoga River watershed has been grouped by watershed and/or county (Table 1), illustrating differences in soil nutrient levels between the three areas. The largest differences were seen in the mean values of bulk density (higher in the Chippewa), and total phosphorus and total carbon concentrations (lower in the Chippewa).

Phosphorus retention is an essential ecological function of wetlands in a watershed, especially in watersheds (like the Chippewa) that are dominated by agricultural and urban land use, and so suffer the chronic degradation of water quality due to the influence of nonpoint source nutrient inputs and downstream eutrophication (i.e. Lake Erie). The annual load of phosphorus to Lake Erie is estimated to be 17,474 t/yr (Keddy 2000). The total phosphorus contained in the upper 10cm of the 14 wetlands that were sampled in the Chippewa watershed as part of the larger survey of wetlands in the Cuyahoga watershed was 1.4 metric tons (1.5 U.S. tons). This accounts for about 0.01% of the annual P load to Lake Erie. While this is a very small percentage, it should be noted that this potential to store P is due to only 14 wetlands sampled, with total combined acreage of only about 200 acres. The total amount of P currently held in the soil (based on soil P analysis) is 175 tons (193 U.S. tons).

Table 1. Soil Characteristics in the Chippewa watershed in comparison the sites in Portage and Summit counties. Note relatively high bulk density and the relatively low levels of carbon in the Chippewa. ¹

County	pH	Bulk Density (g/cc)	TP (mg/cc)	TN (mg/cc)	TC (mg/cc)	P-Sorption (ug/cc)
Chippewa	6.38	1.46	1.03	5.27	78.8	103.7
Portage	5.72	1.24	1.36	7.33	101.5	96.0
Summit	5.33	1.35	1.20	6.26	91.8	104.7

¹ Counties will be replaced with Breakneck and Tinkers watersheds for the final report when all sites in the three tributaries have been coded.

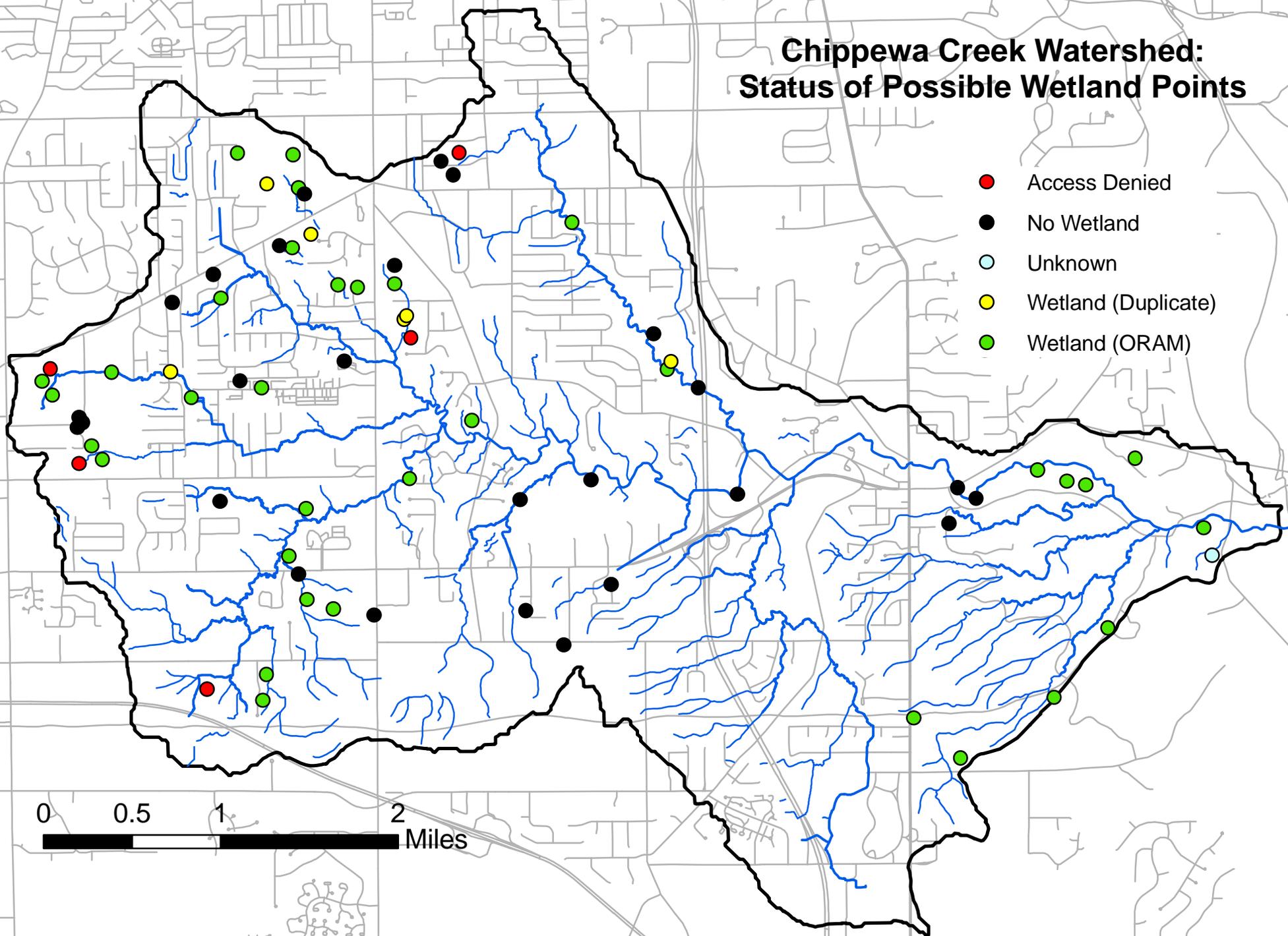
Conclusion

In conclusion, landuse in the smallest buffer areas measured has a strong influence on wetland ecological condition. Condition declines significantly as land use in the buffer changes from natural to urban. This indicates that preservation of small buffer areas around wetlands can offer substantial protection and dramatically increase their conservation value. The relationship between ORAM scores and the percentage of individual land use types was also assessed (for example, how good a predictor is the percent of urban land use in a wetlands buffer area). Generally the correlation between individual land uses and ORAM scores were quite low, and significantly lower than the correlations using the LDI.

More analysis needs to be conducted in determining correlations between ORAM scores and the percentage of individual land use types. A strong predictive model will allow basic wetland assessments and qualitative measurements to be done at the computer. A predictive model such as this would be useful to supplement traditional field assessments and will ultimately be extrapolated to the entire Cuyahoga River Watershed and tributaries.

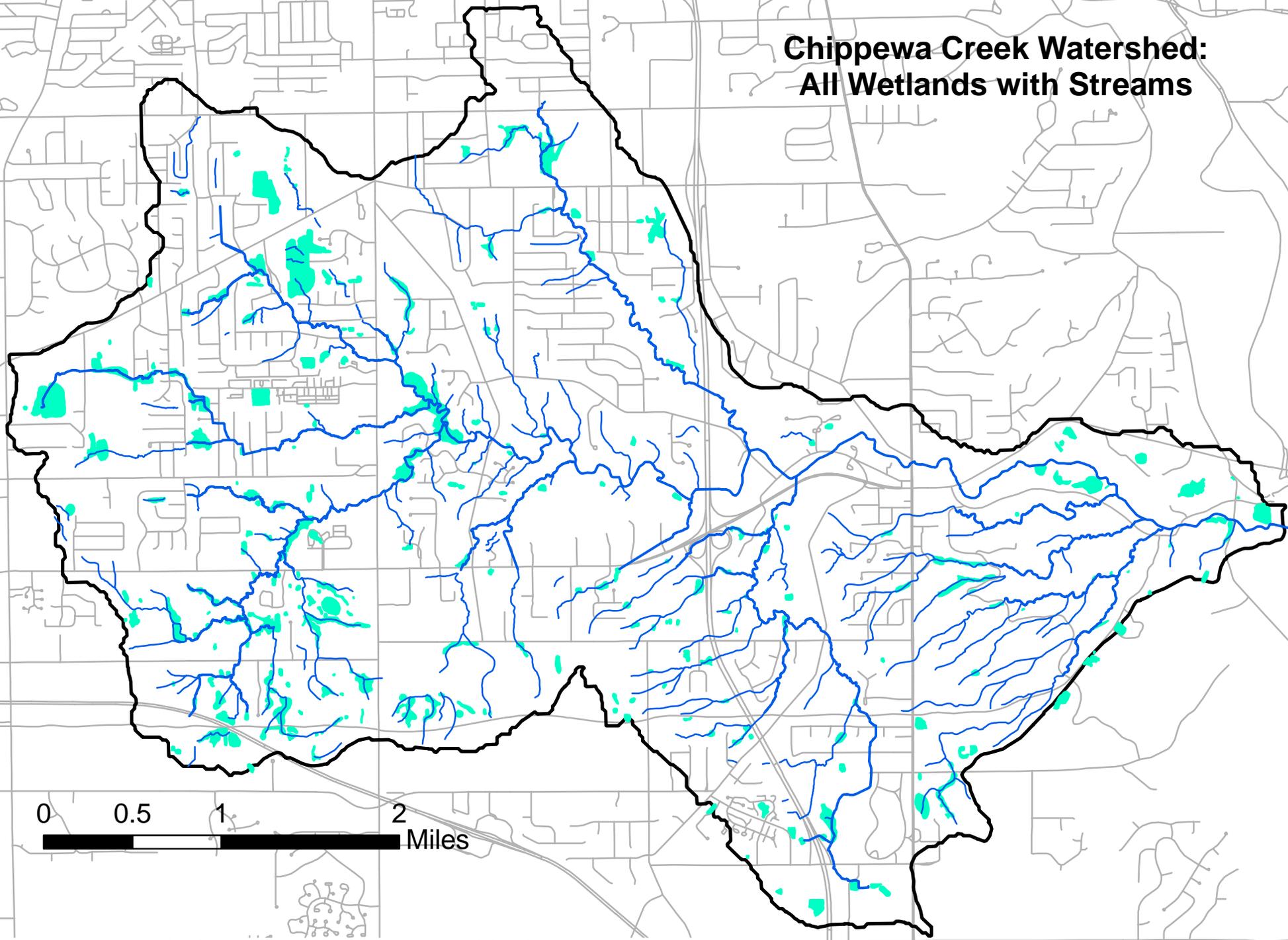
Chippewa Creek Watershed: Status of Possible Wetland Points

- Access Denied
- No Wetland
- Unknown
- Wetland (Duplicate)
- Wetland (ORAM)



0 0.5 1 2 Miles

Chippewa Creek Watershed: All Wetlands with Streams



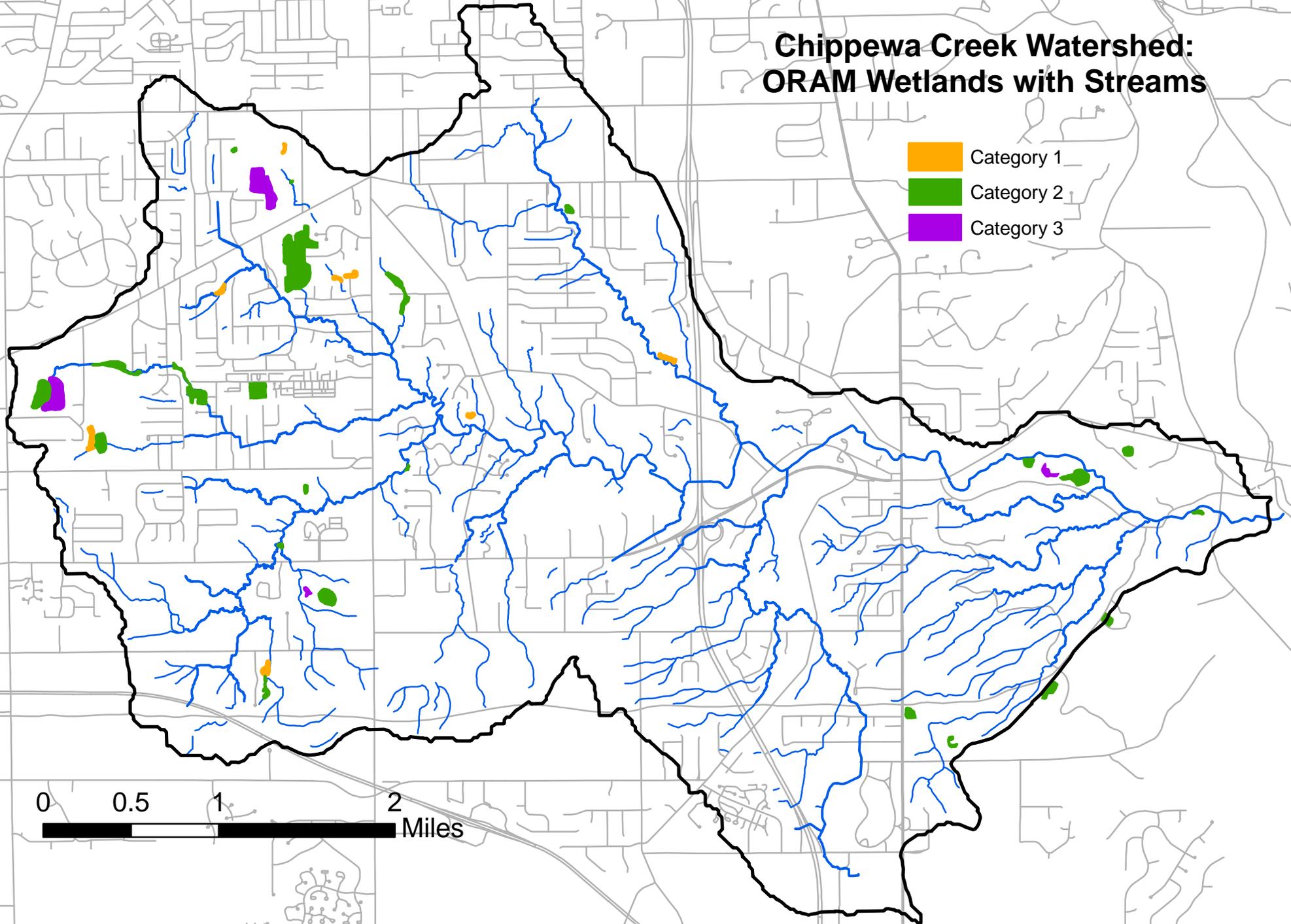
CUYAHOGA RIVER COMMUNITY PLANNING ORGANIZATION

CUYAHOGA RIVER REMEDIAL ACTION PLAN • CUYAHOGA AMERICAN HERITAGE RIVER



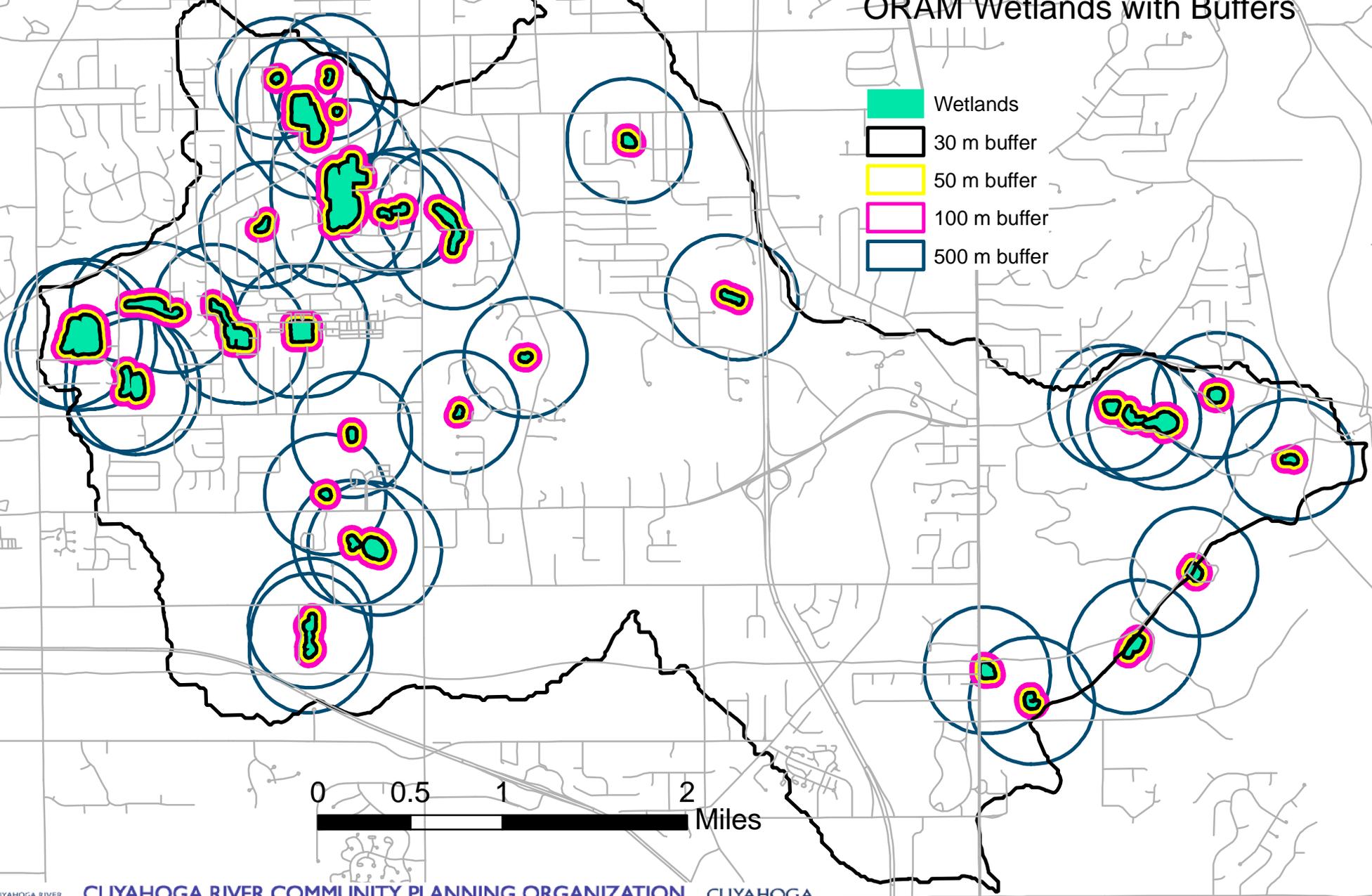
Chippewa Creek Watershed: ORAM Wetlands with Streams

-  Category 1
-  Category 2
-  Category 3



0 0.5 1 2 Miles

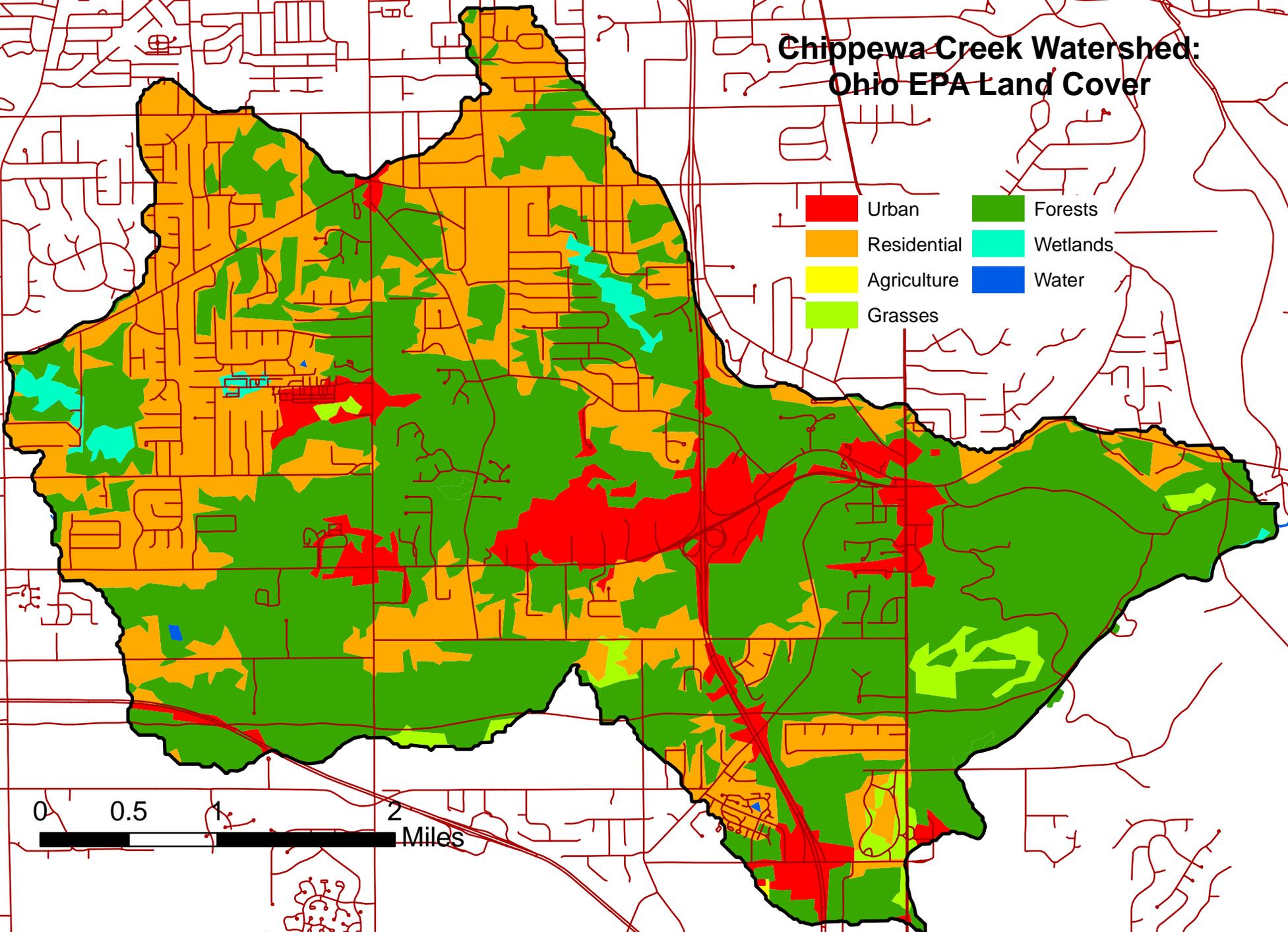
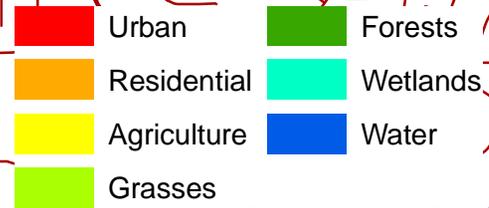
Chippewa Creek Watershed: ORAM Wetlands with Buffers



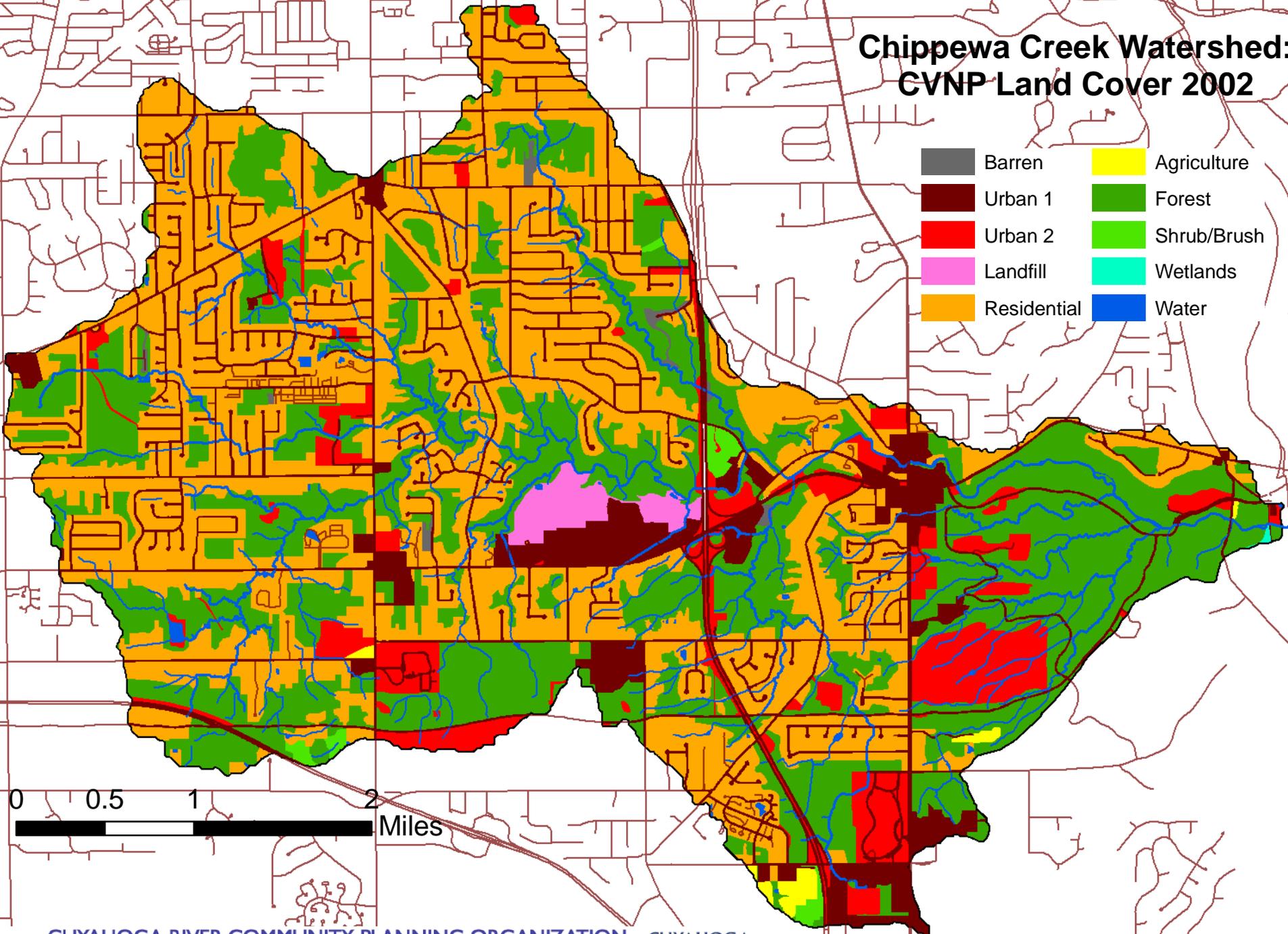
-  Wetlands
-  30 m buffer
-  50 m buffer
-  100 m buffer
-  500 m buffer



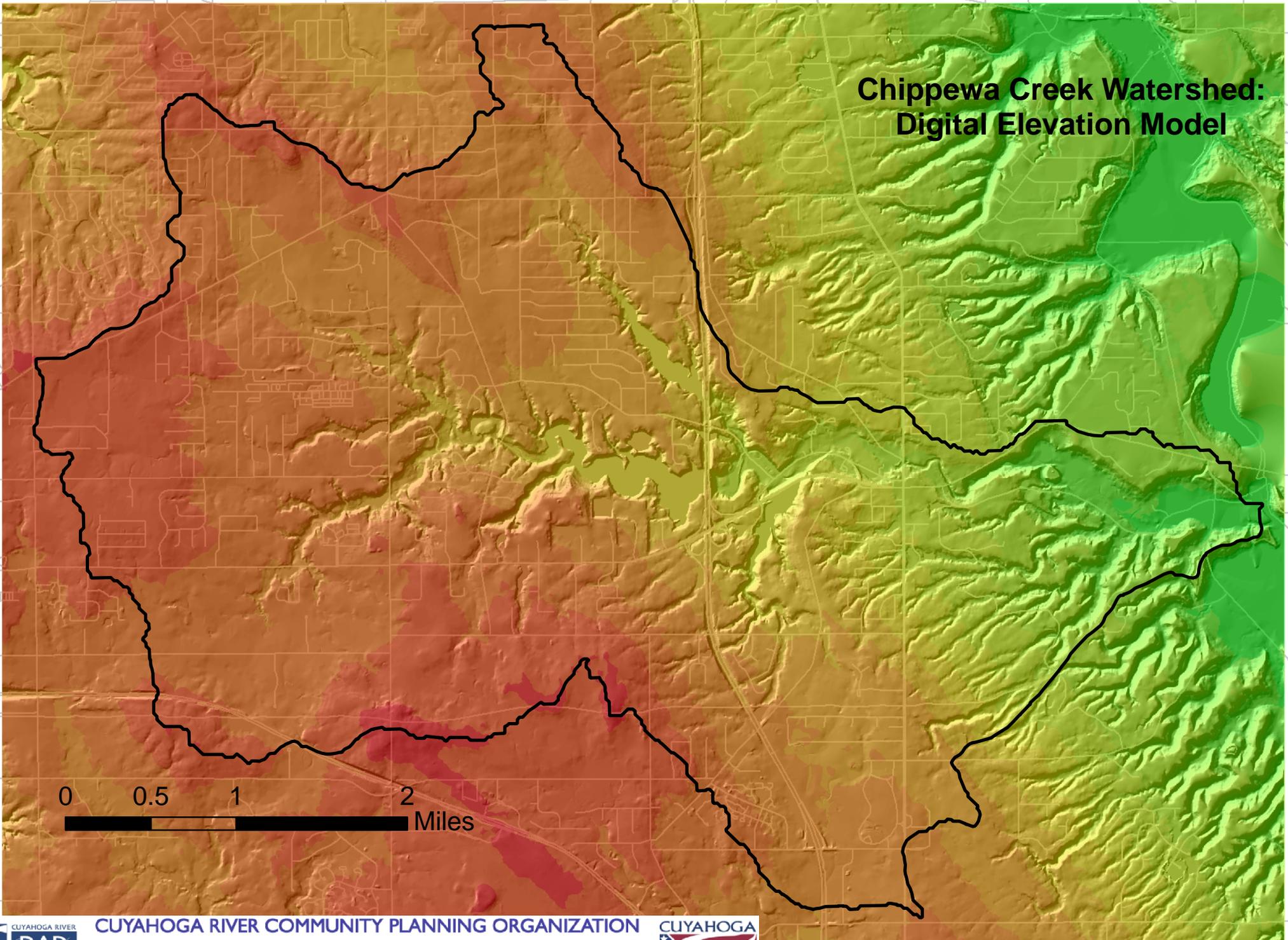
Chippewa-Creek Watershed: Ohio EPA Land Cover



Chippewa Creek Watershed: CVNP Land Cover 2002



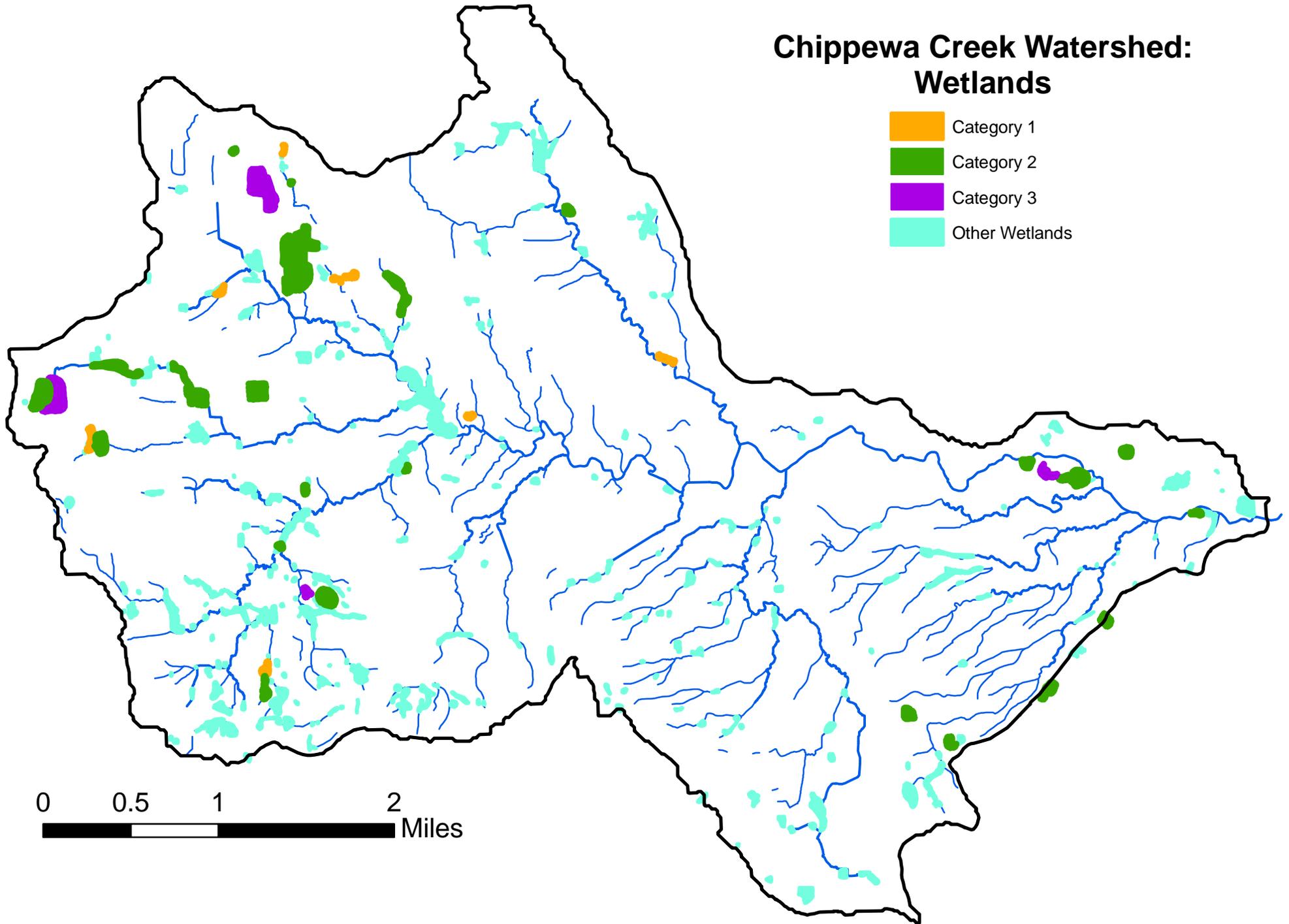
Chippewa Creek Watershed: Digital Elevation Model



0 0.5 1 2 Miles

Chippewa Creek Watershed: Wetlands

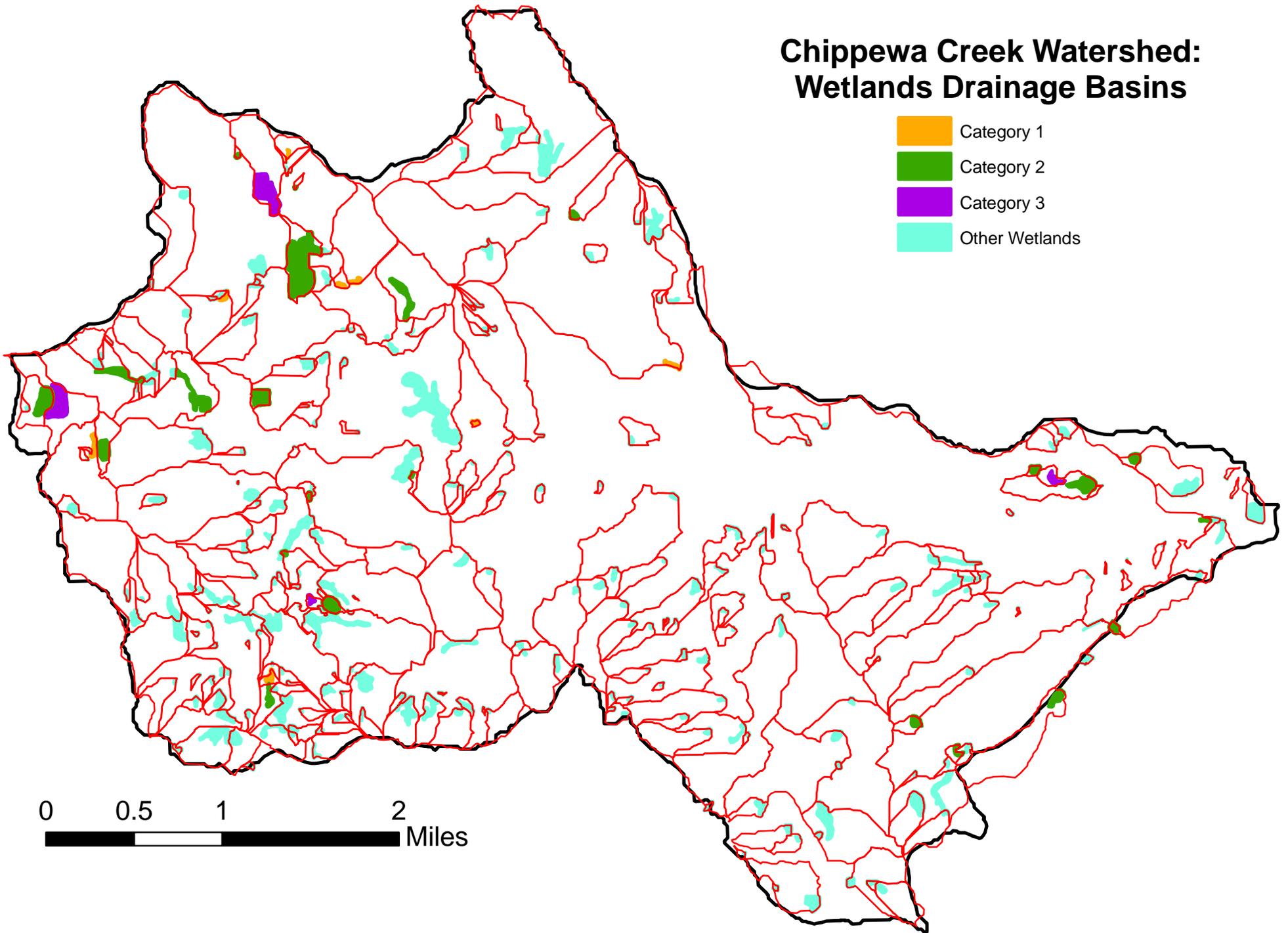
- Category 1
- Category 2
- Category 3
- Other Wetlands



0 0.5 1 2 Miles

Chippewa Creek Watershed: Wetlands Drainage Basins

- Category 1
- Category 2
- Category 3
- Other Wetlands



0 0.5 1 2 Miles