# Linking Land Use and Water Quality: Guiding Development Surrounding Durham County's Drinking Watershed

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# Introduction

Cities and counties have an obligation to provide water to their citizens in the quality and quantity necessary to support a viable existence.  To meet these demands in 1929 Durham City dammed the Flat River, creating the reservoir named “Lake Michie” in the far northeastern part of its jurisdiction. Although Lake Michie is located in a primarily rural area, there are signs that the way land is being used in the Lake Michie Watershed (LMW) is affecting the reservoir. For example, Durham City estimates that the Lake Michie Reservoir has lost about 25% of the holding capacity due to sedimentation washing in from the surrounding land (Duke University 2012).

Besides lowering the holding capacity of the reservoir, land use is widely recognized as a leading cause of water quality decline (NRC 2009). The land use in the LMW can be divided into three broad categories, agriculture, forest and development. Each of these categories affects the water quality of the reservoir in unique ways. Development generally damages water quality, while forests are recognized as having a positive effect (NRC 2009). The effects of agriculture on water quality vary by cultural practice, ranging from highly detrimental to neutral or even slightly positive (Jung et al 2008).   The conversion of land from forest to development with its associated water quality issues will likely increase, as from 2000 to 2010 Durham County grew by over 19%, faster than the average across the state (U.S. Census Bureau 2012).

This increase in population, and subsequent development, has been noticed by Durham officials, and recognized in legislation. The joint Unified Development Ordinance (UDO) put together by Durham County and Durham City states that “Inappropriate development threatens the quality of natural resources.” The UDO contains codes which are specifically designed to protect environmentally sensitive lands and watercourses from pollutants and to minimize the impact of development by controlling the location, intensity, pattern and design of development (Durham City-County, 2011).

These codes apply broadly across Durham County and Durham city, but there are also codes which apply specifically to the Lake Michie Watershed.  To limit the amount of impervious surface in the watershed, the Unified Development Ordinance mandated that individual parcels may not contain more than 6% impervious surface.  To allow for some flexibility, owners may build more than 6% impervious surface in one area by preserving a comparable amount of land in another area. This would still result in the watershed containing less than 6% impervious surface over all, while allowing for more concentrated development.

In addition to the protection afforded by codes, Durham managers are interested in creating a unified conservation scheme, based on preserving parcels as forested areas.  Durham City and County, in cooperation with other public and private entities, have used parcel conservation plans for two other bodies of water in the county, the Eno River and New Hope Creek.  The plan to preserve forested buffers around the Eno River was formed in 1966 (ERA 2008) and the New Hope Creek Plan was finalized in 1992 (NHCCAC 2012). Both of these plans focused on conserving forested land directly surrounding local water bodies, following the idea that the land beside the water has the most effect on the water.

# Objectives

In this project, I worked for Durham County's Office of Real Estate and Open spaces to develop a geospatial modeling tool to help prioritize conservation and guide development in the Lake Michie watershed. Officials had two objectives: they wanted an over view on how different land uses affected water quality, and they wanted easy to interpret maps to use when making policy decisions about where to develop and where to put conservation resources.

To meet these goals I did two things. First I performed a literature review on the subject, reading over past literature reviews, books, and scientific and publically produced articles. From this information I created easy to read summaries of the current knowledge about how land use affects water quality. Secondly I created a series of maps, which focused on both the whole watershed as well as the part of the watershed in the political boundaries of Durham County. After determining how much areas impact the reservoir, I created maps that prioritize land ownership parcels for conservation, and show how much parcels impact water quality.

These two products, summaries and maps, give officials the information they need to meet both the letter and the spirit of the law when making decisions about the Lake Michie Watershed.

# Land Use and Water Quality

High value water systems are characterized in two main ways: by the quality of water, based on a variety of physical components, and by the quantity of water, based on the amount and flow of water running through the system. Point source pollution, which comes from a discrete place, is regulated by the Clean Water Act based on the amount of chemical or physical additives being put into a water body. Non-point source pollution, defined by the Clean Water Act, is everything that is not point source pollution (US EPA 2012) and includes both natural and manmade pollutants that wash into a water body. Non-point pollution is carried by water flowing over land into streams, along ditches and through storm water drainpipes. This type of pollution is linked to specific land uses. This is what Durham County is addressing through the use of planning regulations.

Non-point source pollution, often referred to as storm water discharge, carries a variety of chemical and physical pollutants and substantially alters the flow regime of surrounding water bodies. It is affected by the underlying physical properties of the land (topography, soils, weather, air quality and climate) (NRC 2009, Baker 2003, Brabec et al 2002, Guo et al 2011), the historical and present use of land (forest, farming, and developments) (Diebel et al 2009, Guo et al 2011, Lee et al 2009, Misztal and Kuczera 2008, Tong and Chen 2002), and the cultural use of the land (farming practices, traffic regimes, and cultural choices) (Jung et al 2008). All of these factors affect storm water pollution, coming together to dictate the quality of the water flowing through a watershed.

Much research has been done on how each land use contributes positively or negatively to water quality in a watershed. Land use types can be broadly divided into three categories: development, farms, and forests. Each of these land use categories presents a unique set of characteristics which influence quality in the water bodies downstream (Lee et al 2009, NRC 2009). Understanding the characteristics of each type of land use allows policy makers and models to be more accurate when predicting water quality.

# Urbanization

Urbanization describes how development alters the physical properties of the land (e.g. through an increase of impervious surface), and how cultural choices affect the use of the land (e.g. through maintenance of sewage systems, increase in traffic, additions of yard fertilizers and biocides). Often planners use percent impervious surface as a proxy for urban development. High percent impervious surface has been linked to increased density of urbanization and a decrease in surrounding water quality (Brabec 2002, NRC 2009).

Much research and discussion has gone into the effects of impervious surface on water quality. Impervious surface dramatically alters the hydrologic cycle in two ways: the removal of vegetation and soil, leading to a loss of evapotranspiration and storage and hindering water infiltration into the soil (Brabec 2002, NRC 2009). This increases the amount and energy of the water reaching nearby streams and decreases the time it takes to reach it.

As a result, streams in areas with high amounts of impervious surface often suffer from "urban stream syndrome". Characteristics are flashy hydrographs (high flow during/immediately after a storm or low/no flow at other times), deeply incised banks, and highly disrupted biotic communities (Walsh et al 2005). Impervious surface draining directly into receiving water bodies, such as storm water drainage pipes, are a particular concern as they quickly convey water thus aggravating flow problems.

Besides altering the hydraulic flow, impervious surface is linked to increases in the amount of pollutants delivered to nearby streams. In some cases, the pollutants are generated by the impervious surface itself, such as PAHs from asphalt sealant or copper running off of roofing tiles (NRC 2009). In other cases, this link is due to the impervious surface preventing infiltration of water, bypassing systems which may naturally remove pollutants (Walsh et al 2005). As the amount of impervious surface in an area increases, so does its detrimental effects. One model predicted 55 percent more water running off of impervious surface than pervious surfaces such as fields and forests (Tong and Chen 2002). Clearly, impervious surface is an important characteristic of development.

Impervious surface may alter the amount of water reaching a stream but the cultural use of developed areas is what defines the types of pollutants it delivers. In a general sense, water quality decreases as population density increases (Coskun et al 2008). For example, construction sites generate large amounts of sediments and may be significant sources across the watershed (NRC 2009). Along with generating a large per capita amount of impervious surface (NRC 2009), rural home sites can contribute nitrogen or phosphorus through leaky sewage systems (Jung et al 2008). Residential land use in general has been linked to increased nutrients, *E. coli*, sedimentation, and heavy metals (Arismendez et al 2009, Jung et al 2008, Tong and Chen 2002). Roads, particularly freeway sites, can be sources of oil, grease, nutrients, heavy metals, rubber fragments and dissolved solids (Han et al 2006, NRC 2009, Tong and Chen 2002). Studies have found variable amounts and types of pollutants generated on developed site across the world.

The variability in the amount and type of pollutants accumulating from urbanization depends strongly on cultural influences. In some underdeveloped countries, rural development contributes biological and nutrient pollutants due to a lack of waste treatment (Misztal and Kuczera 2008). In developed areas nutrients are generated through improper use of fertilizers or leaky septic systems (NRC 2009). Some areas with ostensibly higher impervious surface may generate less runoff if the impervious surface leads to pervious areas where water can be infiltrated before exiting the site. Conversely, areas which seem pervious may be compacted from past construction practices thus water is prevented from infiltrating onsite. Because of the varying cultural and historical factors, urbanization has significant and unique effects on water quality

# Farms

Although often lumped together in one land class, the characteristics of farmland vary widely across the state, the country, and the world. As a result, the types of pollutants generated by farmland depend on the type of product produced and the cultural practices used to produce it.

Generally, planting only one type of crop in a field ("monocropping ") is bad for water quality. Of all the typical monocropping in our country, corn is both the widespread and most detrimental for water quality (Broussard and Turner 2009). Industrial corn and industrial farming in general is linked to high amounts of fertilizer and sediment runoff. Traditional industrial agricultural practices, such as row-cropping and continuous grazing, leads to decreased vegetation cover, increased erosion and associated pollutant transport (Zaimes and Schults 2011). Farming right next to streams leads to stream bank erosion. This type of farming can leave a legacy, affecting the ability of future vegetation to buffer out pollutants (Zaimes and Schults 2011).

While industrial farming has been repeatedly linked to declining water quality, the same is not true for all types of farms. Small, intensively managed farms growing a variety of foods have been shown to have little to no detrimental effect on water quality in several areas (Lee et al 2009) Small rice paddies have also shown little detrimental effect and in some cases actually act as wetland buffers, demonstrating small positive effects on water quality (Jung et al 2008). These results are promising: they show that farming can be sustainably integrated into even highly protected watersheds.

Other kinds of farm activities, such as pastures and animal lots, have varying effects on water quality. One study showed that pastures did export nutrients, particularly during calving times, although in this case the amount was greatly dictated by the rainfall patterns (Endale et al 2011). Historically pastures have been linked to declining water quality. Although this has been mitigated some by fencing which keeps livestock out of steams, animal lots lead to problems with nutrient runoff as well as fecal coliform contamination. Concentrated Animal Feed Operations (CAFOs) are particularly problematic, causing chronic and acute water problems across the nation (I. EPA 2012).

Although generally linked to nutrient and biological contamination, farming does not necessarily lead to degraded water if farming is done on a scale and with practices that minimize nutrient, sediment, and biological export.

## Forests

As opposed to the previous two land use categories, which are often associated with declining water quality, forests are generally associated with improved water quality (Brabec et al 2002, NRC 2009). Forests offer mechanisms for water cleaning and stabilization. (Abumozhi et al 2005, Lee et al 2009, Misztal and Kuczera 2008). Riparian forests, in particular, seem to improve water quality (Tomer et al 2009). Because of their heightened ability to improve water quality, forested sites along water ways are referred to as "buffers" because they moderate and improve water conditions.  Although some studies have shown that forests release small amounts of phosphorous and nitrogen, particularly during the fall, over-all they have a positive effect on water quality (Jung et al 2008, Misztal and Kuczera).

Other types of natural areas are generally pervious and allow for infiltration but do not infiltrate as well as forests (Brabec et al 2002). Grasslands, in particular, help to filter out sediments and the associated nutrients (Lee et al 2000), therefore provide an essential and unique way of improving water quality.

On a landscape scale large blocks of forests improve water quality. Some authors suggest the characteristics of water exiting a totally forested landscape should be taken as a baseline of water quality (Brabec et al 2002), although this standard would be very difficult to maintain if there were to be any development in the region.

# Study Area

Lake Michie, Durham City's drinking water reservoir located on the Flat River, was built in 1926, and expanded in the 1950s (Archibald et al 2004). The Lake Michie Watershed (LMW) spans across 4 counties, but is primarily located in Person and Durham County (Figure 1).

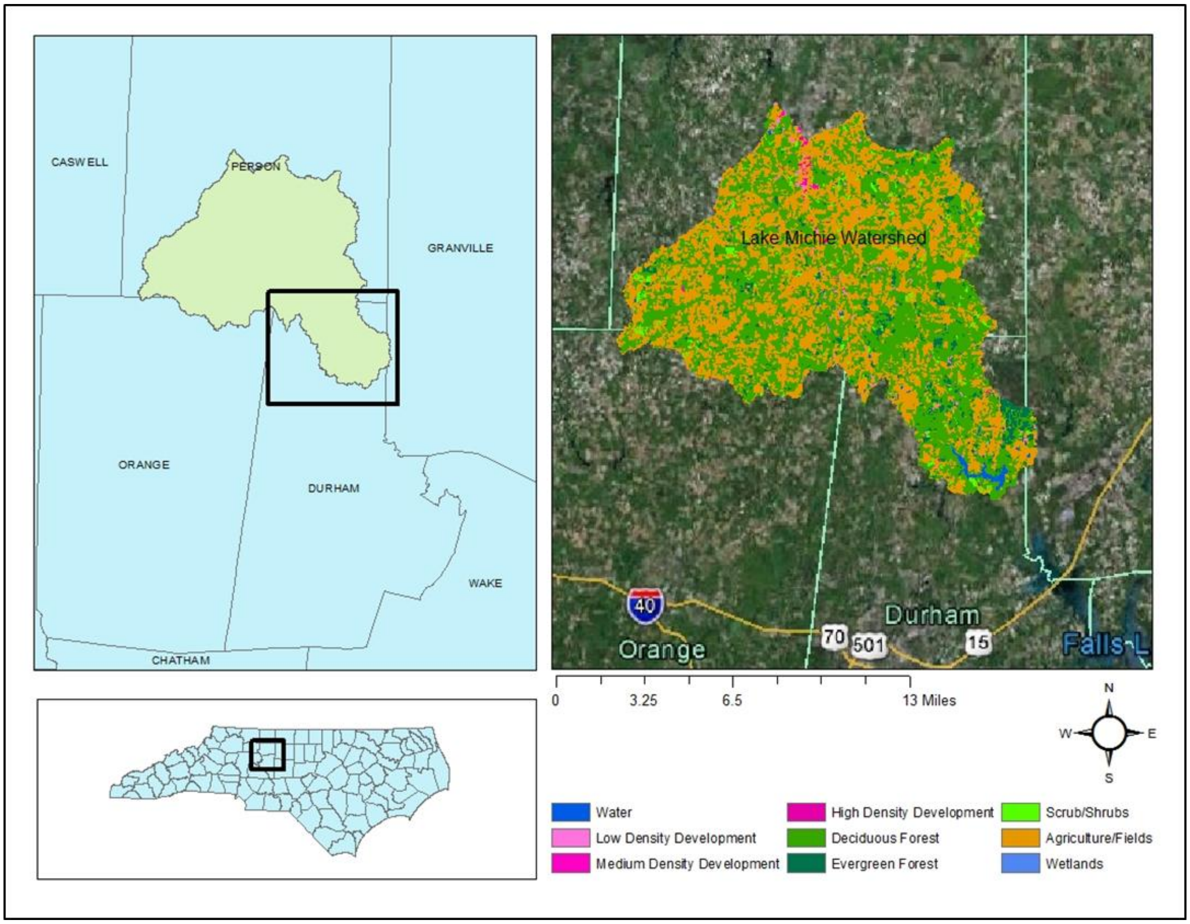
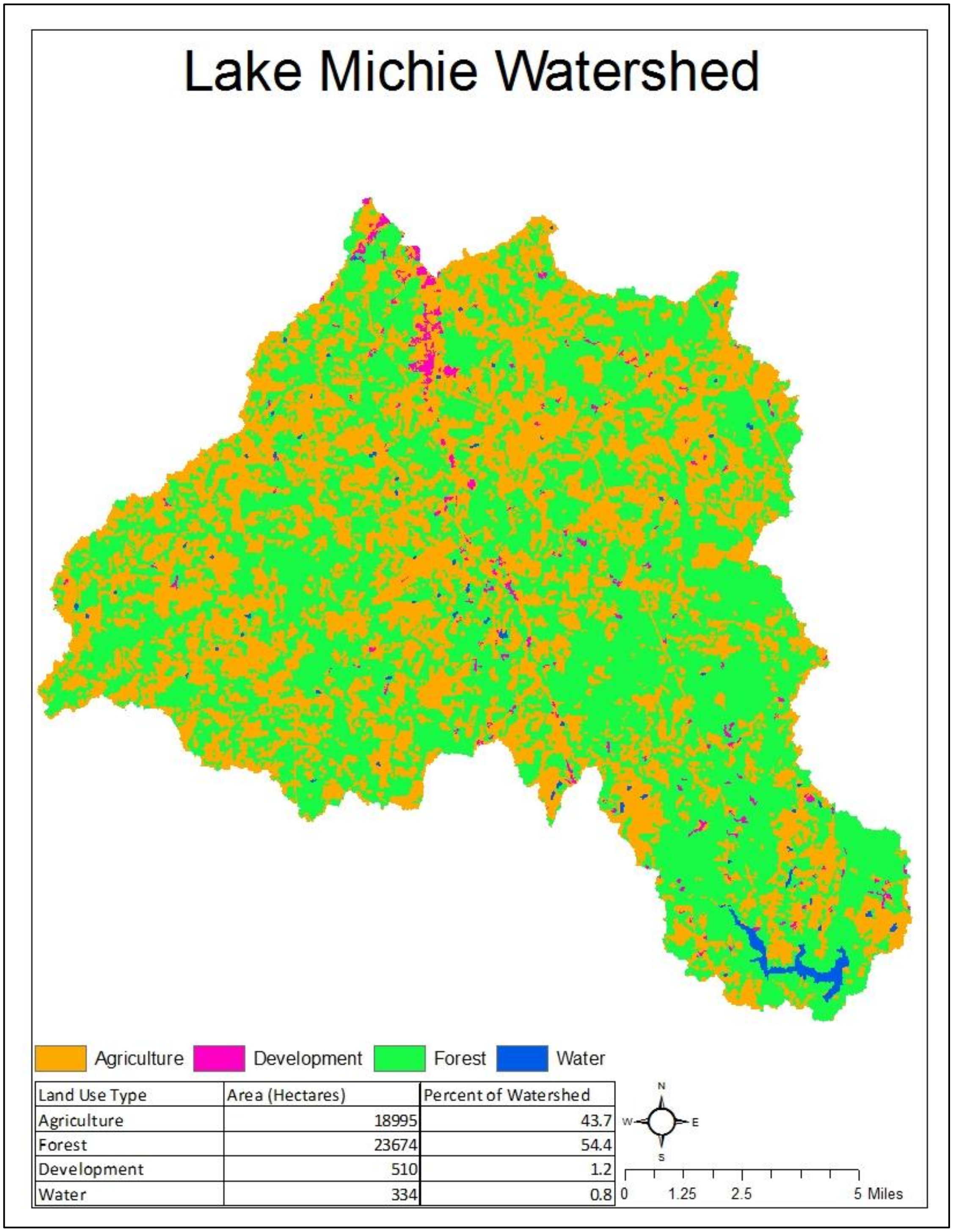



**Figure 1: Location of Lake Michie Watershed**

At 43,500 hectares, the land is primarily in forests and agriculture, with some development running up the center of the watershed (Figure 2).




| Land Use Type | Area (Hectares) | Percent of Watershed |
|---|---|---|
| Agriculture | 18995 | 43.7 |
| Forest | 23674 | 54.4 |
| Development | 510 | 1.2 |
| Water | 334 | 0.8 |

**Figure 2: Land use composition in the Lake Michie watershed**

# Methods

## Mapping Land Use and Relative Impact

To calculate the effect that land use has on water quality, a variable which combines the soil hydrologic properties, the land use infiltration capacities, and the distance from the water body was calculated following Somers et al (*In review*). The method is described below.

First, the 2006 National Land Cover Dataset was used to assess the current land cover data in the watershed. In order to evaluate the hydrology, the various land use categories were collapsed into four main categories: water, forest, agriculture, and development (Table 1).

| Land Cover Number | Land Cover Type | New Category |
|---|---|---|
| **11** | Water | Water/Wetlands |
| **22** | Developed (Low) | Development |
| **23** | Developed (Med) | Development |
| **24** | Developed (High) | Development |
| **41** | Forest (Evergreen) | Forest |
| **42** | Forest (Deciduous) | Forest |
| **52** | Shrub/Scrub | Forest |
| **80** | Field | Agriculture |
| **95** | Marsh | Water/Wetlands |

**Table 1: Land Cover Conversion; Conversion of the NLDC landcover (Fry et al 2011) to the definition used in this analysis.**

As of 2006 the LMW was very rural: composed primarily of agricultural fields and forests, with little development (Figure 2, Table 2).

| Land Use Type | Area (Hectares) | Percent of Watershed |
|---|---|---|
| **Agriculture** | 18995 | 43.7 |
| **Forest** | 23674 | 54.4 |
| **Development** | 510 | 1.2 |
| **Water** | 334 | 0.8 |

**Table 2: Land Cover in the Lake Michie Watershed; Evaluation of area and percent watershed**

The Soil Survey Geographic (SSURGO) soil hydrologic soil groups were obtained for the area. This database provides detailed information on soil characteristics, and is explicitly meant to be used for natural resource management and planning (USDA 1995). Areas in the watershed with the same combination of land use and SSURGO hydrologic group were grouped together based on this individual combination. The unique groupings were used for the evaluation.

In order to estimate the stormwater runoff of each unique combination of land cover and soils, the infiltration curve number of each was first calculated based on Halley et al (1990) (Table 3).

| Landcover Number | Landcover Type | Landcover Type for Curve Number Analysis | CN C | CN B | Water | CN C/D (Average of C and D) | CN D |
|---|---|---|---|---|---|---|---|
| 11 | Water | Water/Wetlands | 100 | 100 | 100 | 100 | 100 |
| 22 | Developed (Low) | Residential (High Density) | 90 | 85 | 100 | 91 | 92 |
| 23 | Developed (Med) | Commercial | 94 | 92 | 100 | 94.5 | 95 |
| 24 | Developed (High) | Industrial | 91 | 88 | 100 | 92 | 93 |
| 41 | Forest (Evergreen) | Forest (Thick Cover) | 70 | 55 | 100 | 73.5 | 77 |
| 42 | Forest (Deciduous) | Forest (Thick Cover) | 70 | 55 | 100 | 73.5 | 77 |
| 52 | Shrub/Scrub | Forest (Thin Cover) | 76 | 65 | 100 | 79 | 82 |
| 80 | Field | Agriculture | 83 | 77 | 100 | 85 | 87 |
| 95 | Marsh | Water/Wetlands | 100 | 100 | 100 | 100 | 100 |

**Table 3: SSURGO conversion numbers. The letters represent hydrological soil group infiltration capacity, with the A group being the most efficient at water transmission, and D the least. The curve combines the land cover with the hydrological group infiltration capacity. The smaller the curve number, the more water will infiltrate, and the less runoff (Halley et al 1990)**

This infiltration capacity was then converted into a “cost” index reflecting effective distance. In this, a parcel with high infiltration capacity can be envisioned to have longer effective distance in that more water would infiltrate while flowing over that area. By contrast, an area of low infiltration capacity is a shorter effective distance. This logic allows for the creation of a relative cost surface, which in turn provides a means to estimate the effective distance from the water for any point in the watershed. The longer the effective distance, the more water infiltrates, while the shorter effective distance, the less water that infiltrations. The cost number for the cost surface was calculated using the following equation:

$$\text{Cost} = \text{INT}((100\text{-curve number })/10). \quad (1)$$

This scored the relative cost of water moving across the landscape, assigning low values to those areas with high stormwater movement and generation, and high costs to highly permeable, low generating areas.

This cost surface was combined with the hydrologic flowpath of water moving through the Lake Michie watershed to create a relative flow distance surface. To account for the decrease in hydrologic impact with increasing distance from the water, relative flow distance was attenuated using negative exponential decay:

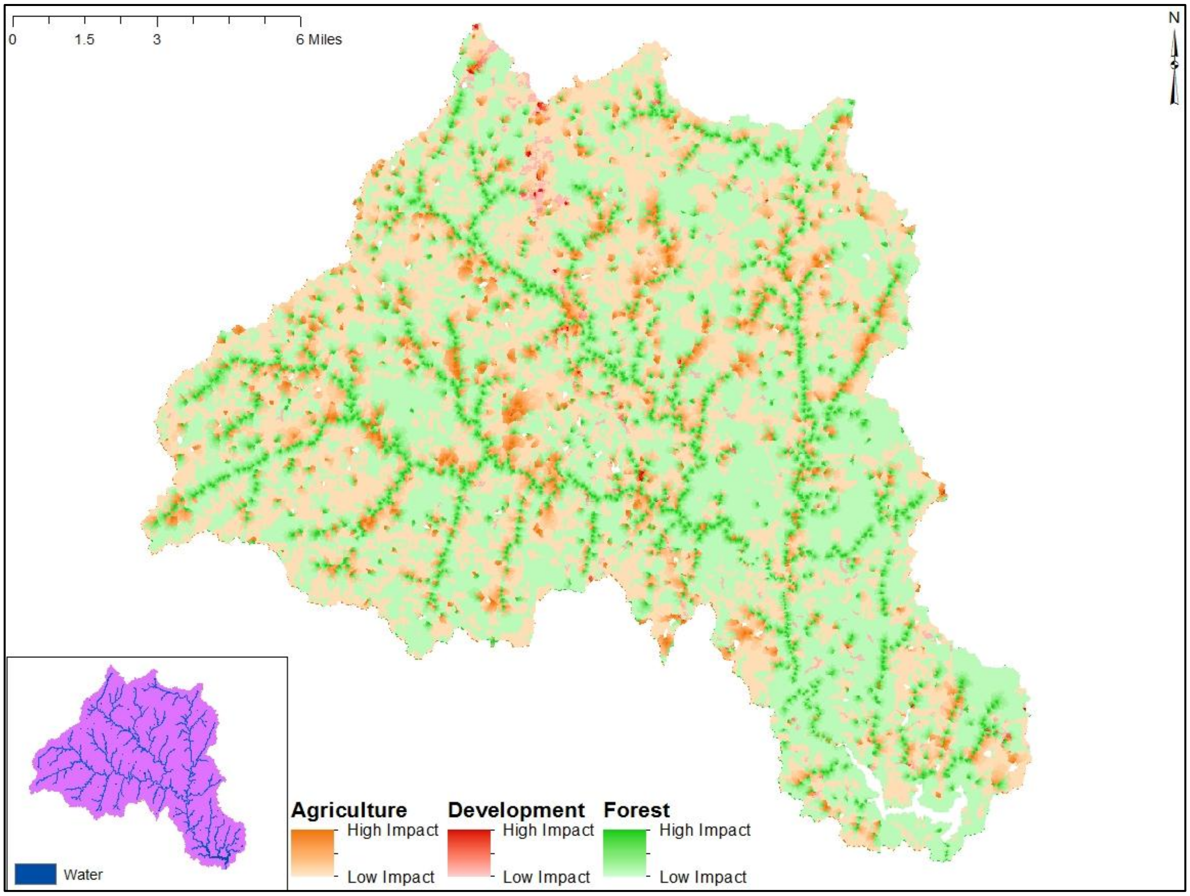
$$F = \text{EXP}(k*FD) \quad (2)$$

where *F* is inverse-weighted relative flow distance and *FD* is relative flow distance. The decay coefficient *k* was calculated using a maximum decay distance of 2000 m, which is the distance that Somers et al (*in review*) calibrated empirically in their evaluation of land use and streams in the Piedmont.

The result of the above calculations was a surface which showed the relative hydrologic contribution of any point in the watershed, as inverse-weighted distance along hydrologic flow paths and weighted by the relative infiltration capacity of land cover and soils between that point and the water. This surface shows that an area close to the water has more hydrologic impact than an area far from the water, and pervious land covers or soils can mitigate hydrologic impacts as water travels over then land.

The cost surface shows the relative impact of each area. So the larger the number, the higher the hydrological impact on the nearby water body. When combined with land use, the cost surface shows much each area affects the water quality nearby. For example, forests near the water show a large impact, while those away from the water show a smaller hydrological impact. Both these impacts are positive, and the higher the impact, the most positive the effects. Likewise, development near the water shows a large impact, while development isolate from the water, or surrounded by forests that infiltrate runoff, shows a smaller impact. In this case the impact is negative, with the larger value showing a larger negative impact.

This cost surface was created both for the entire watershed (Figure 3), and with a special



focus on Durham County (Figure 4).

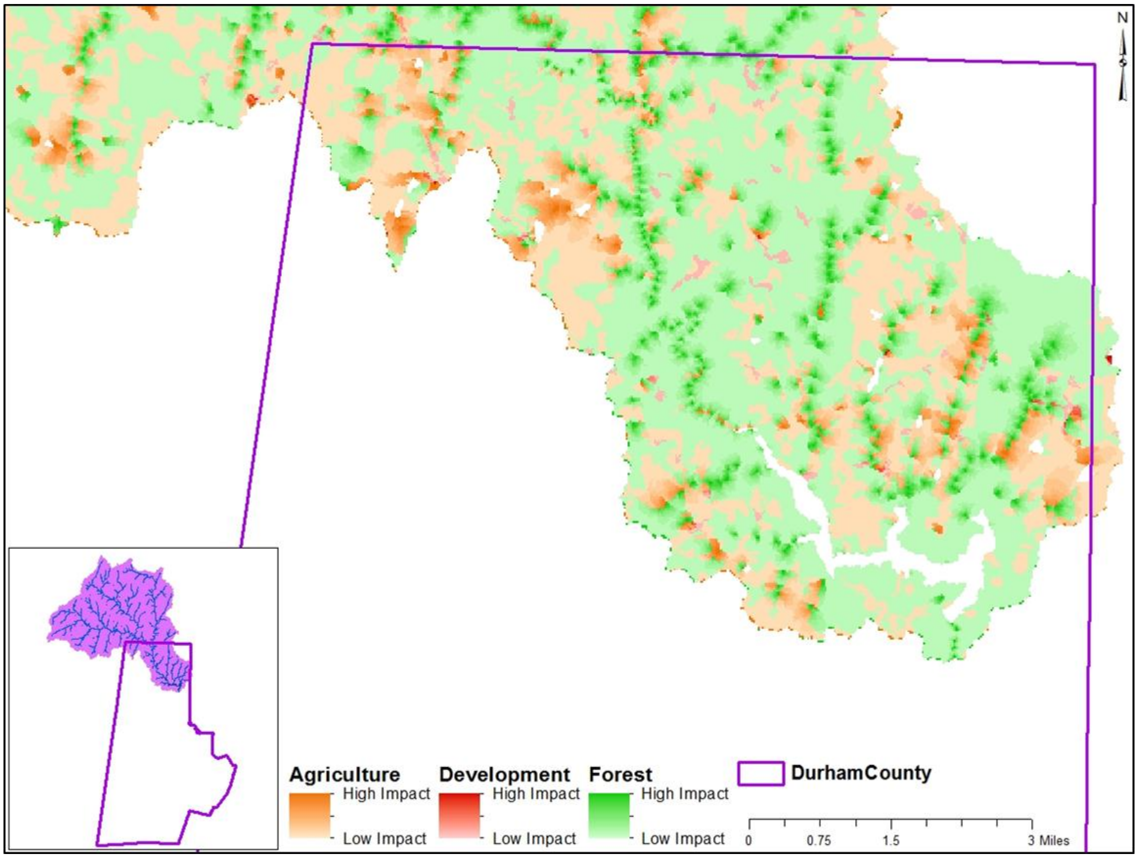



Figure 4: The hydrological impact cost surface for the Durham County area of the Lake Michie Watershed

The areas with higher values, shown with darker colors, indicate areas which have a larger effect on water quality nearby. Dark green areas show forests with large impacts on the water system, while light green areas show forests with little impact. Since forests have primarily positive impacts, the darker the green, the larger the positive impact the forest has in that area.

Conversely, since development has primarily negative impacts, the areas of dark pink represent areas where development is having a large detrimental impact on water quality, which areas of lighter pink show less of an impact. The dark brown areas show where agriculture is having a large impact on water quality, the light brown areas, less so.

To use these results, the relative hydrologic impact index was combined with ownership parcels, as most land use decisions are made at the parcel level. Parcels containing forests which show high hydrological impact will need to be preserved, as these forests greatly benefit water quality. Parcels containing high impact development need to be restored, to lessen the impact this development has on the water.

Parcels containing high impact agriculture may either converted into forests, or targeted for soil conservation plans to mitigate the negative impact of agriculture.

All analyses were conducted in ArcGIS version 2.9.3 and 2.10 (ESRI, Redlands, CA).

# Results

## Maps for Decision Makers

The following maps were created for officials in Durham to help visualize the impact that land use decisions will have on the water quality of Lake Michie. These maps combine the scientific evaluation of land use effects with the political boundaries of parcel ownership. This allows officials to easily translate science into the politics of conservation and development.

## Guiding Conservation: Parcel Prioritization

This map shows which parcels are the most important to preserve, as they have the highest impact on water in Lake Michie (Figure 5).

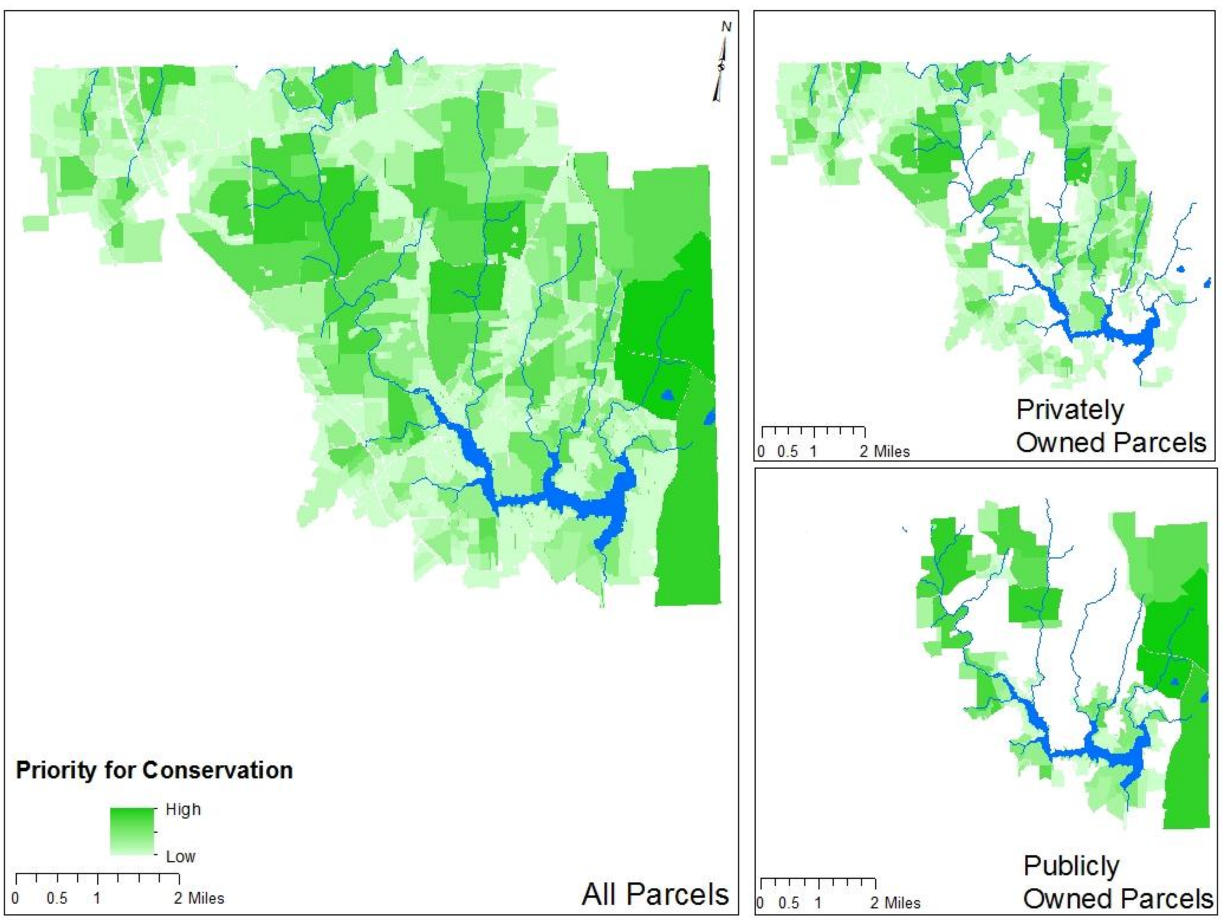



**Figure 5: Priority parcels in Durham County for conserving Lake Michie's water quality**

The dark green parcels are those that are most important to preserve, as they have the highest impact. The large frame shows the entire maps in full, with all parcels included. The two smaller frames show the parcels split based on ownership: all the publicly owned parcels are shown on the bottom right and the privately owned parcels are shown on top right.

These maps were created by summing how much the land in each parcel influences water quality nearby. Parcels with large areas of high impact land uses are rated higher than parcels with little or no high impact land. For example, a parcel lots of with 100 acres of high impact forests and agriculture would be more important that a parcel with 50 acres of high impact forest.

This method prioritizes larger parcels and parcels in particularly sensitive zones. Focusing on the larger and more sensitive zones allows conservationists to be more efficient with limited resources. When working on conservation easements or buying land, focusing on larger parcels allows agencies to minimize the number of land owners and paperwork needed to preserve large amounts of area.

Fortunately for Durham County, many of the lands which are high priority for conservation are already owned by public entities, either the state of the county. This creates a great backbone for Durham to build upon when creating a comprehensive conservation landscape.

## Guiding Development: Relative Parcel Impact

Durham County has limited impervious surface on any one lot in the Lake Michie Watershed to 6%. In order to allow for more concentrated development and to decrease suburban sprawl, Durham allows people to preserve land in one place, and move the unused impervious development onto a separate lot for use there. This allows people to develop more than 6% in one lot, but seeks to keep the watershed under 6% impervious surface as a whole.

However, different areas can have different impacts on water quality, and so the impact of impervious surface may not be the same in each area. In order to show the impact of developing land in one compared to another, the average land use impact was calculated in each parcel.

This produced a map of parcel categories, where parcels in the same category have the same average impact on local water quality (Figure 6).

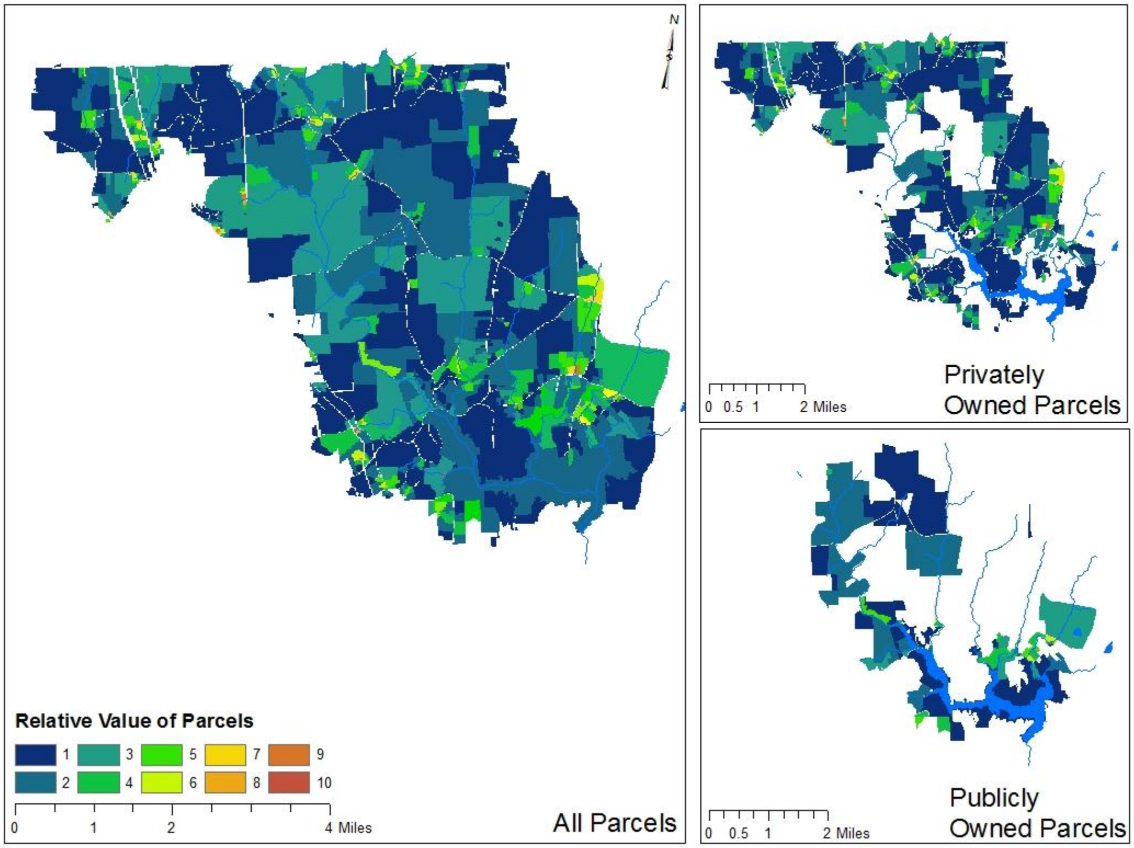



Figure 6: Relative impact of Durham County parcels on water quality of Lake Michie

In other words, developing one acre of impervious surface in one blue parcel should on average have the same impact as developing an acre in another dark blue parcel. However, developing an acre in a red area would be about equivalent to developing ten acres in a red parcel. This is because the dark blue parcel infiltrates about ten times the amount of water that the red parcel does, having a much lower impact on Lake Michie.

This map can be used to guide development decisions. When a developer conserves ten acres in a dark blue parcel, they can develop ten acres in another parcel without altering the net impact of their development. However, if they conserve ten acres in a blue parcel then they could only develop one acre in the red parcel if the goal is to maintain the same net impact. Alternatively, preserving ten acres in a red parcel would allow the development of one hundred acres in a blue parcel, producing, on average, the same net impact.

When seeking to preserve water quality, it is be preferable to preserve and restore land in higher impact areas and while allowing development to take place in lower impact areas.  Knowing these relationships between parcels allows county officials to be fully informed about development decisions.

# Discussion

These maps provide guidance for decision makers now, but there is more than can be done. The maps can be improved with a more detailed analysis and optimization, which will provide an even more effective structure for water quality conservation. But conservation is a political process, and the maps provided here are just one tool that can be used to preserve water quality.

## Improved Models

These maps generated here provide powerful information for planning land use focused around water quality. However, like all models, they have limitations.  First, these maps show the relative impact of parcels based on current land use. If areas are developed, converted to more intensive agriculture, or planted into forests, their impacts on Lake Michie will change. Secondly, the map showing the relative impact of parcels shows only the impacts between different locations for the same level of development, not the cumulative.  Since this is an index, not an actual hydrological model, this provides an important first step in conservation planning, but not the final one.

As indices, the maps presented consider how the location of each land use in isolation affects water quality. They do not look at the spatial configuration of the whole watershed, nor at proportion of the watershed each land use comprises.  Research increasingly reveals that these two factors, spatial configuration and proportion of land uses, can have large effects on water quality (Guo et al 2011, Lee et al 2009, Mehaffey et al 2005, Tormos et al 2011)

Science and citizens both have long acknowledged that the spatial configuration of land use has an effect on water quality, hence the popularity of buffers.  Buffers of various kinds have been shown to be effective at removing pollutants and improving water quality (Mander et al 1997, Tomer et al 2009, Tomos et al 2011, Weller et al 1998), and it is not just the main body of waters that should be buffered. Buffering first order streams may be critical in maintaining water quality, as headwater streams may have better opportunities to intercept pollutants than larger stream riparian zones do (Zaimes and Schultz 2011).  In fact, many nutrients which cause eutrophication and hypoxia may originate far up in the watershed, in headwaters and small streams (Endale et al 2011). Future conservation maps could include buffers which prioritize small streams, accounting for their oversized impact on water quality.

Not only should land beside the stream preserved, as the spatial arrangement of land uses across the watershed are important. Aggregated land uses, with large areas of forest, agriculture, and development, promote higher water quality than diffuse land use across the watershed, which leads to more degradation (Guo et al 2011). These sorts of spatial characteristics may make the difference in water quality between in two watersheds with otherwise the same amount of development and farming in total (Lee et al 2009).

Beyond the spatial arrangement, the total amount of each land use makes a difference in the water quality. Large scale evaluations show strong correlation between the proportion of land uses across the watershed and water quality (Lee et al 2009, Mehaffey et al 2005). Many researchers have concluded that despite the installation of best management practices for stormwater mitigation and extensive buffers, high amounts of development and agriculture within a watershed will inevitably result in water quality degradation (Brabec et al 2002, Guo et al 2011). As development and agriculture are necessary, planners must decide which areas are important to conserve, and how clean the water must be to meet desired uses.

There are many decisions which must be made when creating models and planning for conservation. As technology improves and more information becomes available, these models will continue to improve.

## Model Application

Durham County, in cooperation with other public and private entities, has used parcel prioritization plans for two other bodies of water in its border. The plan to preserve forested buffers around the Eno River was formed in 1966 (ERA 2008) and the New Hope Creek Plan was finalized in 1992 (NHCCAC 2012). Both of these plans involve cooperation between public and private organizations rallying around an agreed upon plan for conservation.

Using these maps Durham County can involve other organizations to begin a similar conservation plan for Lake Michie. Having an official map for conservation prioritization provides a centrally agreed upon plan for many different organizations to act upon, coordinating their efforts and pooling resources towards a common goal. Conservation is a highly political process, so the more coordination of groups involved, the better.

# Conclusion: Land Use and Water Quality

Land use can have a large effect on water quality. Legislators in Durham have already taken the first steps to protecting their drinking water reservoir by limiting the amount of development allowed within the watershed. Now they have the information and tools to intelligently protect the land that matters most, and ensure that the water of Lake Michie remains in high quality for the people of Durham for years to come.

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