# INVESTIGATION OF FRESHWATER CONSERVATION STRATEGIES USED BY LOCAL GOVERNMENTS

By

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## ABSTRACT

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Freshwater resources globally are facing various challenges as a result of direct and indirect human activities, highlighting the influence of land on aquatic resources. Activities such as urban expansion, agricultural runoff and recreational activities have led to point and non-point source pollution, spread of non native species and aquatic habitat degradation. Solutions to some of these threats and challenges can be found at the local government level in the form of land use planning and zoning, implementing best management practices, enforcement of policies and ordinances, having environmental capacity and participating in communication/outreach efforts.

In order determine the diversity of planning, zoning and management strategies of local governments with regards to freshwater conservation, we surveyed local governments located in six large river watersheds located in the Lower Peninsula of Michigan and drained into Lake Michigan. We obtained land use/cover data from the state of Michigan and socioeconomic data from the United States census bureau.

Chapter 1 explored both the management strategies and policy supporting measures in place by local governments to protect freshwater resources in Michigan. Results show that while the issue of water pollution was found to be important, there was a disconnect between the stated importance of water pollution and local governments taking a proactive approach by implementing policies and supportive actions to minimize pollution and non-native species.

While most governments had in place their own planning and zoning, there was limited policy and best management practices mandated or incentivized, less than 7% of responding governments addressed the issue of small wetlands, capacity and communication/outreach actions taken by local governments was found to be absent in some governments.

Results from chapter 2 show evidence of a relationship between the type of policy, planning and zoning used by local governments with some land use/cover and socioeconomic factors. Results also show that the amount of water located within cities and townships is an important factor when it comes to determining which types of governments have implement strong water policy initiatives.

Chapter 3 found evidence showing a relationship between the type of local government capacity, enforcement, outreach, education, watershed management plan participation with some land use/cover and socioeconomic factors. Percent of water and population size were two factors that were identified as being important when trying to predict what factors drive policy supporting measures.

Local governments play an important part in managing land use in the state of Michigan. Results from this study indicate that water conservation practices are not uniform across the study area. Policy supportive actions such as policy enforcement, presence of environmental staff, and outreach/communication actions are limited in communities having smaller populations and less percentage of water. This research contributes to the understanding of what local governments are doing to protect water, and the factors that influence the presence of freshwater conservation planning, zoning, best management practices and policy supporting actions.

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## PREFACE

Each chapter is prepared as a separate standalone manuscript to be submitted for publication. Hence, there is some repetition between chapters in the study site description and methods section.

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## INTRODUCTION TO THE DISSERTATION

Many of our freshwater resources are facing various challenges such as nutrification (nitrogen and phosphorus), riparian zone disturbance, and streambed sedimentation (U.S EPA, 2006). In addition to pollution, the spread of non-native species is also of concern. In the state of Michigan, two more non-native species have recently been spotted, adding to the estimated 180 aquatic species already thought to be reproducing in the Great Lakes region, some negatively impacting the environmental health of the region (DEQ, 2015; NOAA, 2012; GLC, 2016). These challenges, coupled with the drainage of wetlands, sand bar removal, and siltation result can alter the landscape, thus contributing to the decline of various aquatic organisms. Some of these challenges can be partially addressed by implementing a variety of best management practices and including measures in comprehensive planning and zoning documents at the local government level.

### *Local governance*

When looking at the provisioning of public services, according to the basic principle of fiscal decentralization, it should be done so at the lowest level of government, and that "each public service should be provided by the jurisdiction having control over the minimum geographic area that would internalize benefits and costs of such provision" (Oates, 1999; Oates, 1972). One reason being that local governments can understand the concerns of local constituents and in theory, make decisions that are fiscally responsible and efficient regarding the services to the intended people (Oates, 1972; Shah and Shah, 2006). When the public services pertain to environmental resources, states are not well equipped to deal with the provisioning of natural resources, and that regional governments presiding over the singular jurisdiction such as watersheds would be more logical (Oates, 1999). We seek to focus on what local governments

are doing in terms of protecting freshwater resources within the confines of planning and zoning, to examine the level of environmental capacity and outreach / communication of environmental related information regarding freshwater resources and issues, and how many local governments are participating in a watershed based management plan.

*Existing political structure in Michigan*

The responsibilities and duties of municipalities and/or counties varies amongst states within the United States. In the state of Michigan, all municipal governments are entitled to home rule. In a "home rule" system, the state gives smaller units of governments more influence on how they plan, grow and develop their jurisdiction. Home rule brings forth the idea that local governments are better suited to understand and respond to the needs of its local population. Counties (a political subdivision of the state containing multiple municipalities) can create a county wide master plan and/or zoning (which local governments within that county can implement if they so choose), however they do not have the authority for their planning and zoning to supersede local municipal planning and zoning. Because local governments have the ability to do a lot of self-regulation, this can result in a wide array of policies and ordinances with the end result being the lack of policy in some areas negating the positive effects of policies in neighboring local areas within the same watershed.

*Managing common resources*

When you have many local governments managing the land in different ways, common resources shared by those local governments may be affected. Tragedy of the commons is a theory referring to the shared use of a common resource, where users can act in their own best interest, contrary to acting in a manner that is for the common good of all users. The original

idea was introduced by Lloyd (1980) in 1832 where he introduced the idea of cattle grazing in a common area, with that common reaching a saturation point (Lloyd, 1980). In a commons situation, when one person (in our case a local government) introduces an extra burden, the rest of the users will share in the negative utility, potentially resulting in them introducing their own burden (Hardin, 1968) which could include a variety of impacts to water resources.

Ostrom (1990) places importance on the local factor of governance when she discusses the "Eight principles for Managing a Commons", where it is important to "Match rules governing use of common goods to local needs and conditions". Local governments not only can address the needs of their constituents, but can implement and test new solutions geared towards local situations, making them an appropriate level to deal with commons issues (Homsey, 2016). Assessments of local governance can be helpful in identifying gaps and limitations regarding the implementation of policy, capacity building needs and capacity building efforts, and can help build accountability of locally elected leaders (UNDP, 2016). Understanding what local governments are doing from an environmental standpoint is important, as what we do on land impacts water resources, "the valley rules the streams" so to speak (Hynes, 1975). Local governments are also the first line of environmental defense due to their responsibilities in planning and organizing how the land is used.

Literature has identified tools and management strategies that local governments can use to address pollution, the spread of non-native species, and habitat degradation concerns (Allan, 2004; Allan, 1997; Sweeney and Newbold, 2014; Ardizone and Wykoff, 2010; Richardson, Naiman and Bisson, 2012). Literature also suggests poor capacity as a reason for not being able to implement various practices or enforcement and a push for capacity development (Russell, 1990; Bruce and Barnes, 2008; Tropp, 2007). Water governance must contend with demands

made from environmental, socioeconomic and health sectors and take on a more coordinated, integrated and inclusive decision making approaches, including themes of integrated water resource management and river basin management (Tropp, 2007; Wang, 2001; Park et al, 2010). Our research seeks to further the literature in how local governments manage shared resources, specifically in the field of freshwater conservation with a goal in minimizing the degradation of freshwater resources.

We seek to understand what local governments are doing in the context of managing common aquatic resources from a broad based perspective, looking at multiple issues as opposed to traditional studies that focus on one aspect of freshwater conservation (storm water, water quality monitoring…) often through the use of very localized case studies. We also seek to further understand the capacity level of local governments to address freshwater conservation, if the calls for a more integrated and coordinated water governance approach is being heeded by local governments. The three chapters presented in this dissertation are as follows:

- *Chapter 1: Investigation of Freshwater Conservation Strategies Used by Local Governments*
- *Chapter 2: The Influence of Land Use /Cover and Socioeconomic Factors on Policy and Management*
- *Chapter 3: The Influence of Land Use/Cover and Socio Economic Factors on Capacity, Enforcement, Communication and Watershed Based Management Actions Taken by Local Governments*

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# CHAPTER 1: INVESTIGATION OF FRESHWATER CONSERVATION STRATEGIES USED BY LOCAL GOVERNMENTS

## Introduction

Freshwater resources world wide are facing various challenges as a result of direct and indirect human activities (Halpern et. al., 2008; Maybeck, 2003), lending credence to the idea "the valley rules the stream", coined by Hynes (1975), highlighting the influence of land on aquatic resources. Many studies have pointed to the importance of human activity and the surrounding landscape to the ecological integrity of a stream (Allan, 2004). Activities such as urban expansion, agricultural runoff have led to point and non-point source pollution that contains nutrients, pesticides, herbicides, sediments, that when coupled with riparian zone disturbance, overfishing, dams, invasive species, drainage of wetlands, agricultural runoff, sand bar removal, and siltation have resulted in the decline of aquatic organisms such a fish, amphibians, reptiles and molluscs (Hernández et al. 2016; Hayes et al., 2010). In order to address issues like nonpoint source pollution, loss of ecosystem services and aquatic habitat, effective management strategies and policies are needed.

### *How is water managed?*

Managing water resources across the United States is a complicated task, requiring coordination across federal, tribal, state, county and local government levels, as well as coordination within each level of government. Both the Federal Water Pollution Control Act (FWPCA) and the Safe Water Drinking Act (SWDA) are enforced by the Environmental Protection Agency (EPA) and currently shape how water is managed in the United States. The FWPCA underwent significant amendments and ultimately became known as the Clean Water Act (CWA) and is the basis for regulating pollutant discharge and water quality standards for

surface water, while instituting a permitting system for point source pollution. Congress had tasked the federal government with primary authority in 1972 during a period "where states had long held primacy" (Andreen, 2007). In essence, it allowed the federal government, specifically the EPA, to intervene in cases where the State could not, or would not enforce the regulatory portions under the CWA, and for the EPA to work with tribal groups when dealing with tribal lands. The EPA now became the "gorilla in the closet" a phrase coined by EPA Administrator William Ruckelshaus where he stated:

> *"Unless the states have a gorilla in the closet, they can't do the job. And the gorilla is EPA…The states can't enforce these laws by themselves. They need us. They'll complain and scream, but if they don't have us, they are dead" (Andreen, 2007; Stanfield, 1984).*

In addition to the CWA and SWDA, the Endangered Species Act (ESA) also helps water conservation efforts by regulating point source pollution discharge, water quality and habitat degradation in regards to endangered/at risk species. Wetlands are another resource covered under the CWA; those connected to the Great Lakes/Lake St. Clair or connected indirectly or close to the Great Lakes are managed federally under section 404 of the CWA. Within many of these laws, state and local governments can be tasked with enforcement or administration of some sections. One such example is the National Pollutant Discharge Elimination System (NPDES) permitting program within the CWA where states can apply to administer part of the NPDES program.

States can create standards, but they must be equally strict or more stringent than federal standards. States are not only tasked with enforcing legislation, but also developing policy of

their own, allocating resources and money (from federal and state sources) within their state, having state level permitting and must coordinate emergency action. The state also oversees public water supplies, monitors for water quality, industrial and municipal wastewater discharge and health of aquatic communities (DEQ, 2016a). With regards to wetlands, those connected to or near inland lakes/ponds/rivers/streams, are larger than five acres, or are classified as being "essential to the preservation of the state's natural resources" fall under state jurisdiction (DEQ, 2016b), with the state of Michigan being one of two states authorized by the federal government to run the federal wetland protection program in their own state.

Home rule states like Michigan allow smaller units of governments more influence on planning, growth, and development, bringing forth the idea that local governments are better suited to understand and respond to the needs of its population. The Michigan Planning Enabling Act part 33 of 2008 describes how the master plan can address land use, infrastructure issues, the direction, goals, and vision of the community while the zoning document is a set of enforceable rules and ordinances put into action that reflects the contents of the master plan. Regarding wetlands, local governments can manage wetlands less than 5 acres (not covered under state protection) under section 303 of Michigan's Natural Resources and Environmental Protection Act.

When coupled with federal and state laws, policy fragmentation can occur with regards to freshwater conservation, especially since water is dynamic in nature and crosses political borders. Fragmentation can be substantive ("separate agencies holding responsibility over different but often closely related substantive issues") and geographical ("a single watershed or water basin often crisscrossed by multiple geopolitical boundaries") (Thompson, 2012). Lubell and Lippert (2011) identify "geographic interdependence, localism and the political power of

water supply economic interests" as main factors driving fragmentation in water management. Under home rule, a wide variety of policies and management practices could potentially be used by local governments to plan and zone their jurisdictions leading to a spatial disconnect of conservation practices across a landscape.

We seek to understand what type of management strategies are used and implemented by local governments themselves to protect and manage freshwater resources. This study examines the variation in local policy and management activities in three main areas: 1) the differences in local policies and best management strategies related to aquatic resources conservation and how congruent those policies are across a geographic area; 2) online visibility and dissemination of policy, zoning and environmental information with members of their community; and 3) local governments' capacity to address aquatic resource problems.

## Methods

### *Study region*

Michigan contains 63 large river watersheds which drain into the Great Lakes, linking inland Michigan activities and landscapes with Great Lakes waters via run off and water drainage. Seventeen percent of Michigan is also covered by a variety of wetland types (Fizzell, 2014). Our research focussed on local governments in the state of Michigan, specifically located in the Central Lake Michigan Management Unit and Grand River watershed which contain six large river watersheds and 460 local units of government (i.e. townships and cities – figure 1.1). Watershed data at the HUC 8 level (Seaber et al., 1987) and municipal data was obtained from the state of Michigan CGI database (MCGI, 2010; MCGI, 2009). The river watersheds are the Betsie-Platt, Manistee, Muskegon, Pere Marquette, Pine, and Grand (Upper and Lower). This

region also contains the Manistee National forest, which is 540,187 acres in size, spanning nine counties.

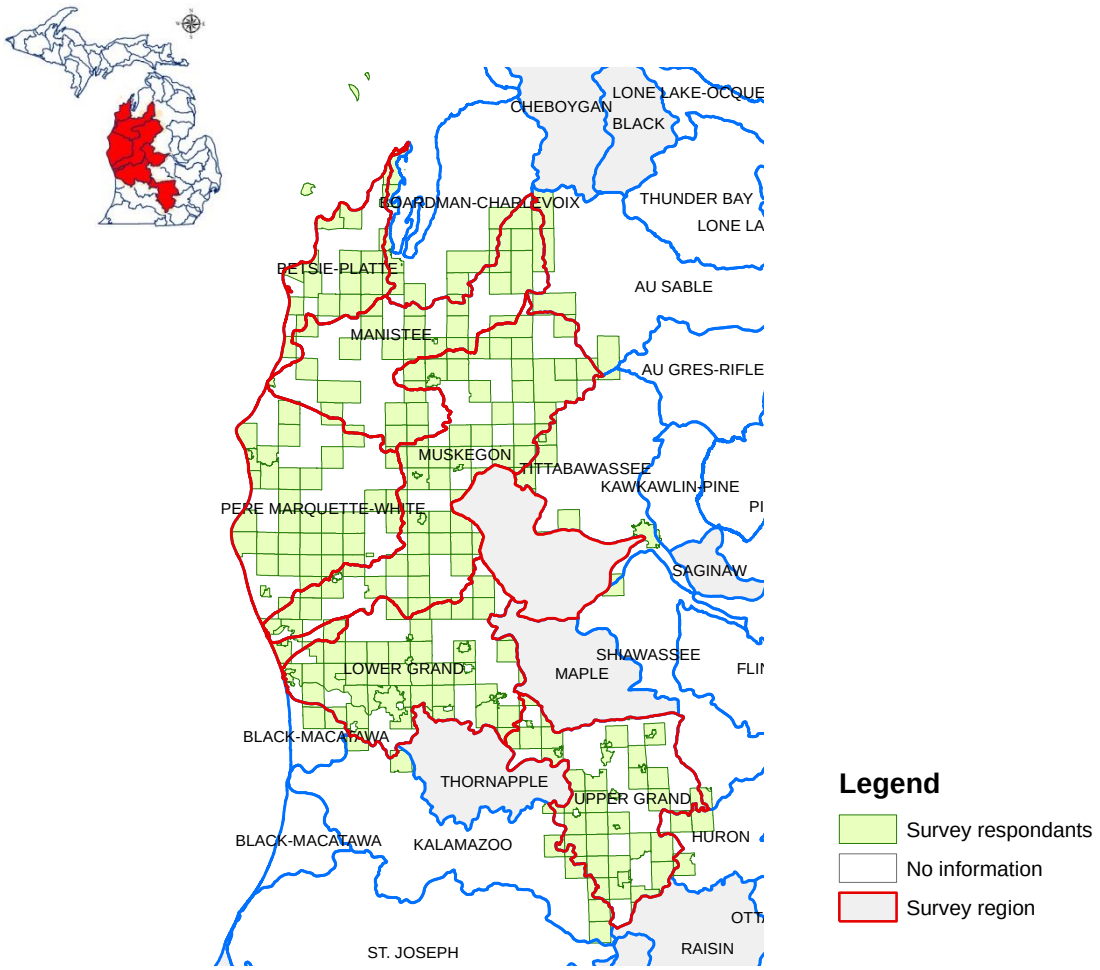


**Figure 1.1.** Location of study area within the Lower Peninsula of Michigan (watersheds outlined in red).

The Central Lake Michigan Management Unit, formerly an industrial area, is now being promoted as a tourist destination, recognized for its cold water trout streams and thus importance to Michigan's recreational fishing industry. The Grand River watershed is the second largest

river basin in Michigan. This region contains areas of intense agricultural activity and dense urban areas. With the mouth of the river emptying into Lake Michigan, there are also many recreational areas in the watershed which are increasingly threatened by turbidity, nutrient inputs and water quality degradation. Of the 100 EPA approved TMDL plans listed in Michigan, 23 were plans located in our study region for issues of sedimentation, phosphorus, Polychlorinated biphenyl (PCB), *Escherichia coli* or dissolved oxygen.

*Survey distribution*

To determine the diversity of planning, zoning and management strategies of local governments with regards to freshwater conservation, we surveyed local governments within our study region described above. The survey was administered using two methods, online and a mailed hardcopy. The survey was administered between March 2013 and December 2014. We sent the online survey to one member of each local government, either the clerk, supervisor, planning or zoning official. The first recipient was allowed and encouraged to forward the online survey link to others in the township when appropriate. At the end of the online survey period, we mailed paper copies of the survey with pre-addressed and stamped return envelopes, followed by a reminder postcard three weeks later, and one last mailing of the paper survey to non-responding governments. We used ArcGIS version 10 to map each survey response variable by government and HUC8 watershed (Michigan Geographic Data Library).

Including both electronic and mailed survey responses, we obtained 264 partial and/or completed surveys out of a total of 461 local governments in our study region (indicated in green in figure 1), a response rate of 57.27%. We received 137 responses via postal mail and 127 responses using the online survey. One township opted out of the online survey and seven

returned blank surveys. In order see if a non-response bias existed, three questions were selected out of the survey and asked to 10% randomly selected non responding municipalities. Questions asked were presence of a comprehensive land use planning document, zoning ordinance document and a website. Results reflected the trends found in the responses of responding local governments.

*Statistical analysis*

When examining differences between watersheds, governments that straddled multiple watersheds in the study region were grouped in one watershed based on majority of coverage. Governments that appeared to straddle two watersheds equally or almost equally were excluded from statistical analysis when comparing watersheds to each other. This was done to avoid duplicate usage of data points within the same analysis. In order to determine if watersheds differed in the importance of water pollution, an ANOVA analysis was used, while a chi square analysis was performed to determine if differences existed with regards to policy and practices. In order to determine which watersheds were significantly different from each other with regards to having a master plan, zoning document, setback ordinance or vegetative riparian buffer width requirement, a logistic regression model was run. To see if a difference existed between watersheds with regards to storm water ordinances, a multinomial regression model was run to account for a third option response. Tukey's Honest Significance Difference (HSD) analysis was performed to determine which watersheds were significantly different from each other. Due to low sample sizes, a descriptive approach was taken to see if there were differences within each watershed regarding having a master plan, zoning document, setback ordinance or vegetative riparian buffer width requirement.

## Results

*Time, effort and priorities of local governments*

In general, environmental issues were not the top priority of local governments but still ranked in the top three. When asked about environmental issues, water pollution was identified as an issue of importance and ranked first of all the issues.

When comparing time and effort local governments spent on environmental issues compared to non environmental issues, environment ranked third with a score of 3.93 (where on a scale of one to seven, seven indicating "not much time/effort at all). Average scores for the seven issues ranged between 3.65 and 4.92. Environment ranked behind transportation/infrastructure (3.65) and crime/justice/public safety (3.74). Twenty-three out of 254 local governments (proportion of 0.09) felt that time and efforts expended towards environmental issues was not applicable. When asked about the importance of commonly discussed aquatic and environmental issues, on a scale of one to seven, water pollution was deemed most important with a score of 2.81 (where a value of one indicated that the issue was "extremely important" to their government while seven was "not important at all"). Following water pollution was water availability (3.05), land and/or soil degradation (3.30), and waste management and disposal (3.44). Climate change ranked the least important (4.88) with 54 of 259 respondents identifying climate change as not applicable to them. Just above climate change was ecosystem services (4.33) and the management of aquatic species (4.14).

Water pollution was further examined, comparing average local government response within watersheds. Governments located within the Pine River scored water pollution the most important out of all the watersheds with an average of 2.35 out of seven (table 1.0), the average

score ranging between 2.35 to 3.10 for all watersheds. No difference with respect to importance was observed between watersheds ($p>0.05$).

**Table 1.1**. How local governments rank the importance of water pollution within each watershed. Average score of each watershed regarding the "importance of water pollution". within each watershed* (1 being "Extremely important", 7 "Not important at all").

| Watershed | Average score | (n) |
|---|---|---|
| PINE | 2.35 | 20 |
| BETSIE-PLATTE | 2.55 | 20 |
| LOWER GRAND | 2.60 | 57 |
| PERE MARQUETTE-WHITE | 2.80 | 46 |
| MUSKEGON | 2.84 | 75 |
| MANISTEE | 2.94 | 33 |
| UPPER GRAND | 3.10 | 50 |

**note: governments located in multiple watersheds had their choice included in each of the watersheds they are located when calculating the average score.*

*Watershed management plan, planning and zoning*

Of the 235 responding governments, 72 (30.64%) indicated they were a part of a Department of Environmental Quality (state agency) approved watershed management plan. Forty (17.02%) responded that they were part of plan approved by another organization, ten (4.25%) governments were either "in the process of coming up with a management plan" or the plan was in "the process of being reviewed". Twenty-nine out of 264 (11.0%) of the local governments did not answer the question. The Betsie-Platte watershed had the highest percentage of townships participating in a watershed management plan (66.67%) while the Pine watershed had the lowest (27.27%) (table 1.2).

**Table 1.2**. Percentage of local governments who are part of a watershed management plan.

| Watershed | Part of a watershed management plan (%) | Number of governments that returned survey |
|---|---|---|
| BETSIE-PLATTE | 66.67 | 21 |
| LOWER GRAND | 55.17 | 58 |
| PERE MARQUETTE-WHITE | 45.28 | 53 |
| UPPER GRAND | 44.23 | 52 |
| MUSKEGON | 32.50 | 80 |
| MANISTEE | 28.21 | 39 |
| PINE | 27.27 | 22 |

**note: governments straddling multiple watersheds had their response included in each of the watersheds they are located in.*

Planning and zoning

Most townships had a master plan and zoning document (figure 1.2). Slightly more governments had a master plan (77.73%, figure 1.2a) than a zoning ordinance (76.14%, figure 1.2b). Chi square analysis found differences existed between watersheds regarding local governments having a comprehensive planning document ($p<0.05$). Chi square analysis found that watersheds also differed regarding local governments that had a zoning document ($p<0.05$).

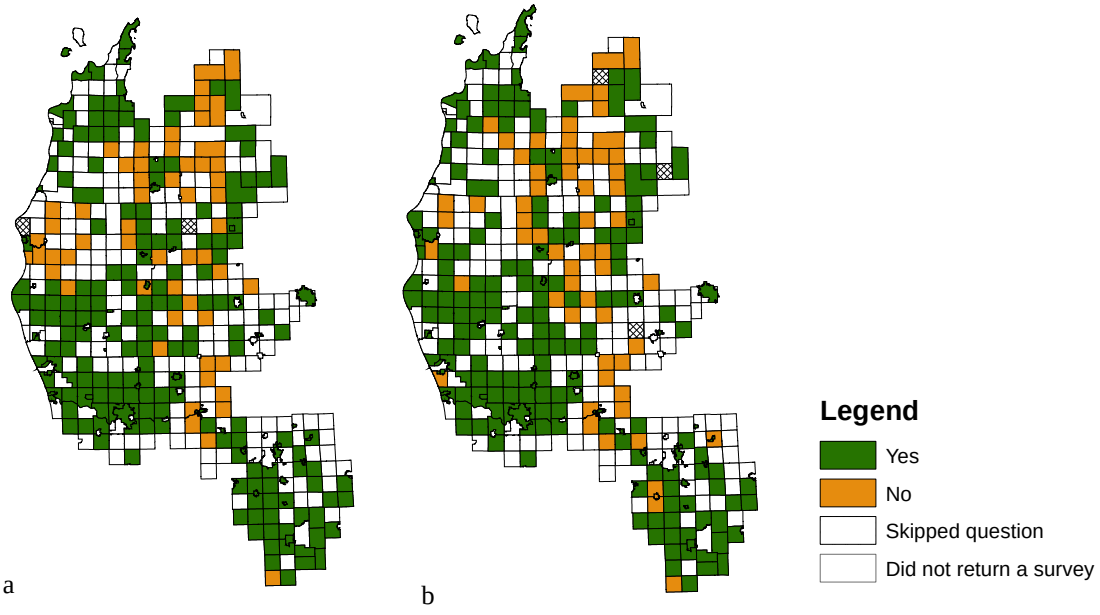


**Figure 1.2**. Governments with a) comprehensive planning document, and b) zoning document

All respondents in the Betsie-Platte watershed indicated that they had a comprehensive planning document (therefore no variation within the watershed) in figure 1.3. Results showed that the Manistee watershed differed from all the watersheds except for Pine watershed ($p<0.05$). Pine watershed differed from Lower Grand and Upper Grand watersheds ($p<0.05$). Upper and Lower Grand showed no differences ($p>0.05$) and showed similar results to Betsie-Platte watershed. Figure 1.3 showed three watersheds that had high proportions of respondents answering yes to having a planning document (above 0.75), indicating less variation within those watersheds (Betsie-Platte, Lower Grand, and Upper Grand). Local governments in three watersheds had response proportions of 0.5 to <0.75 regarding having a planning document. The Manistee watershed had less than half of responding townships answering yes to having a planning document (proportion =0.46). Variability was seen within most watersheds regarding having a planning document, with the exception of Betsie-Platte watershed which was homogeneous.

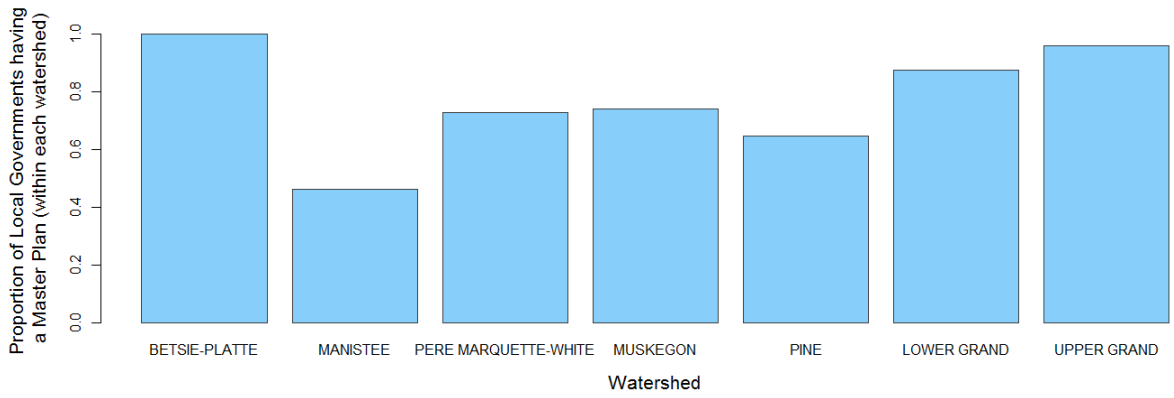


**Figure 1.3**. Proportion of local governments within each watershed (watersheds ordered north-west to south-east of the study region) who responded "yes" to having a master plan.

With regards to having a zoning document, Manistee and Pine watersheds were similar to each other ($p>0.05$), and both significantly differed from Lower Grand, Upper Grand, Pere Marquette-White and Betsie-Platte watersheds ($p<0.05$). Muskegon was in the middle of the groups, differing from the Lower Grand watershed ($p<0.5$). Figure 1.4 displays the proportion of responding governments indicating whether or not they have a zoning document. When looking at differences within watersheds, four watersheds had proportions higher than 0.75 when responding yes to having a zoning document (Betsie-Platte, Lower Grand, Pere Marquette-White and Upper Grand). Muskegon and Pine watersheds had a response proportion ranging between 0.5 and <0.75. Manistee had a proportion of 0.48. These results show variability existed within watersheds.

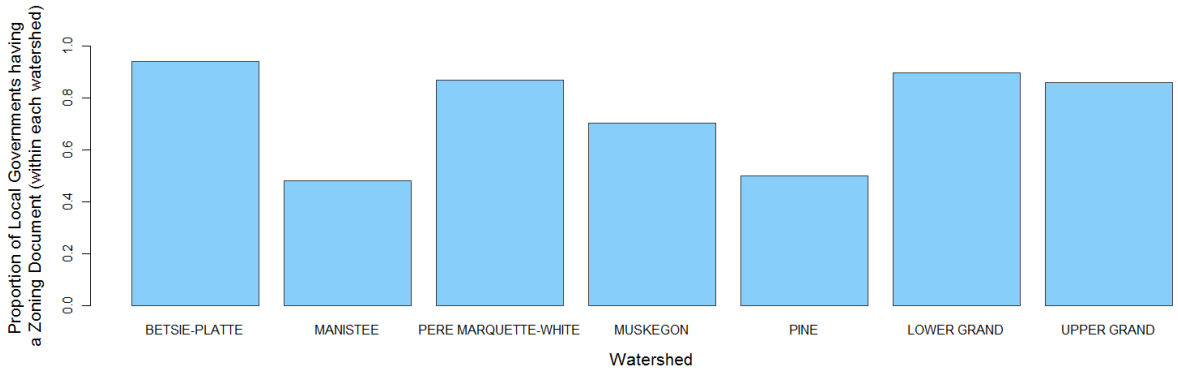


**Figure 1.4**. Proportion of local governments within each watershed (watersheds ordered north-west to south-east of the study region) who responded "yes" to having a zoning document.

Setbacks, riparian buffer and stormwater management ordinances

Summary of what kind of policies and best management practices used by local governments are as follows. Of the three commonly suggested ordinances asked about, setbacks

were identified as being implemented the most by local governments. Less than half of commonly suggested best management practices were utilized by local governments, with soil erosion/sediment control being a practice selected most often. Few local governments took measures regarding wetland protection and non native species.

More governments indicated they had aquatic setback requirements (proportion = 0.57) than vegetative riparian buffer width restrictions (proportion = 0.27) and storm water ordinances (proportion = 0.24). Governments having setback requirements for development near lakes, rivers, streams, wetlands or high risk erosion areas tended to be spread throughout the study region with small clusters of neighbouring townships and cities occurring in the Lower Grand River watershed and the southern portion of the Pere Marquette-White watershed (figure 1.5b). Chi square analysis showed watersheds to be a significant predictor of local governments having setback requirements ($p<0.05$), vegetative riparian buffers width requirement ($p<0.05$) and a storm water ordinance ($p<0.05$). General trends found that local governments in the Betsie-Platte and Lower Grand watersheds consistently tended to have a higher proportion of local governments having setback requirements, vegetative riparian buffers and storm water ordinances. Generally, Pine watershed tended not to have high proportions of governments of local governments having setback requirements, vegetative riparian buffers and storm water ordinances.

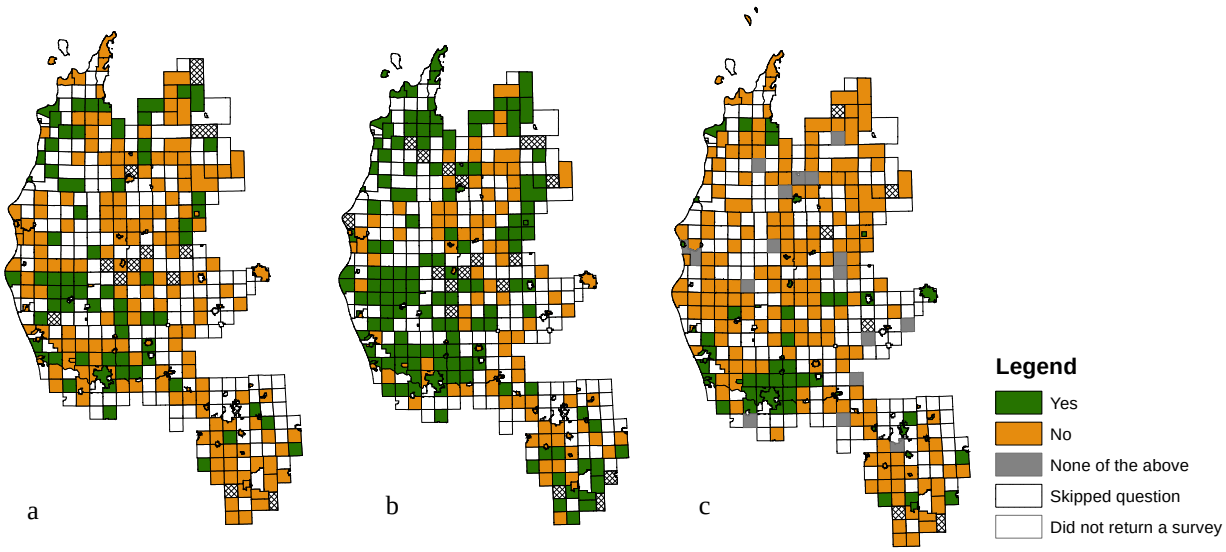


**Figure 1.5**. Governments having a) vegetative riparian buffer ordinance, b) setback requirements for development near natural features, and c) storm water ordinance.
** "none of the above" was an option for the storm water ordinance question*

No variation was found among respondents in the Betsie-Platte watershed with regards to having a setback requirement (all respondents answered "yes"). Other watersheds showed some degree of variability within their watersheds in regards to having a setback requirement (figure 1.6). Pine watershed was significantly different than all other watersheds barring Upper Grand ($p<0.05$). Pere Marquette-White was significantly different than Pine and Upper Grand watersheds ($p<0.05$) but not Lower Grand, Muskegon, and Manistee ($p>0.05$).

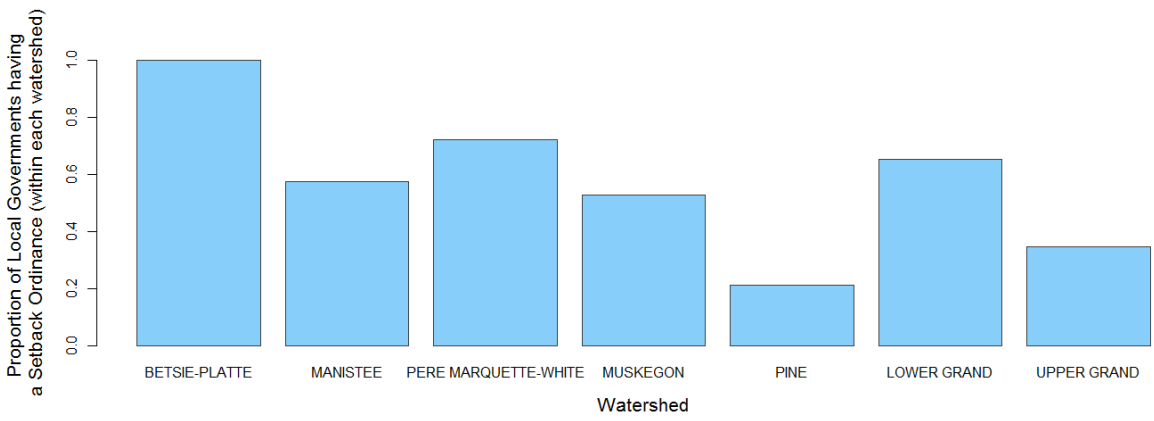


**Figure 1.6.** Proportion of governments (watersheds ordered north-west to south-east of the study region) having a setback requirement for development near natural features.

There were varying degrees of variation among local governments who responded to having a vegetative riparian buffer width requirement within each watershed (figure 1.7), barring the Pine watershed which had no variation among responses. All respondents in the Pine watershed answered "no" to having a vegetative riparian buffer width requirement. Upper Grand watershed significantly differed from all watersheds ($p<0.05$). Pine watershed differed from all other watersheds, but results cannot distinguish if there was a difference between Pine and Upper Grand watershed. Muskegon watershed was not significantly different than Upper Grand and Manistee watersheds ($p>0.05$), Manistee watershed was significantly different compared to the Upper Grand watershed ($p<0.05$).

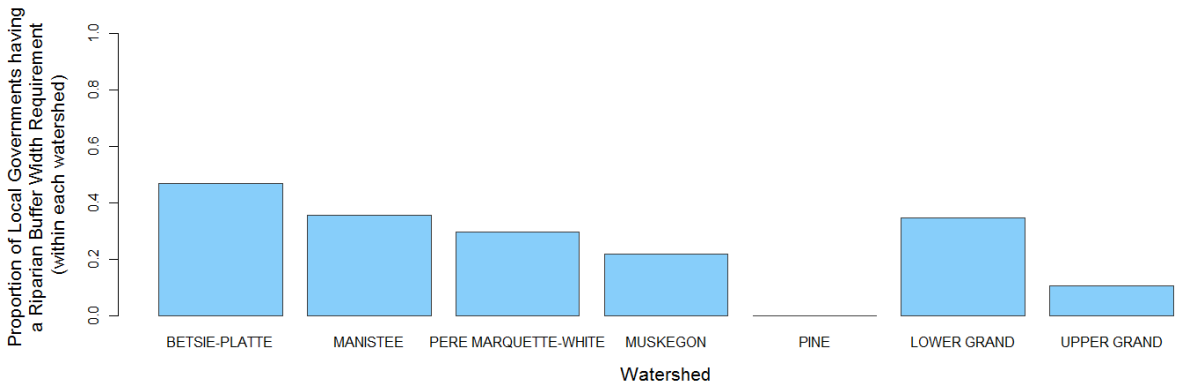


**Figure 1.7.** Proportion of governments (watersheds ordered north-west to south-east of the study region) having a vegetative riparian buffer width requirement.

In general, there was not much variation within watersheds, with local governments tending to not have a stormwater ordinance (figure 1.8). When examining how many watersheds replied "yes" to having a stormwater ordinance, the Lower Grand watershed significantly differed from Manistee, Muskegon, Pere Marquette-White and Upper Grand watersheds ($p<0.05$). Betsie-Platte and Pine watersheds were not different from Lower Grand or the other watersheds, placing them in the middle ($p>0.05$). Pine watershed had 16 responses with one local government who indicated they had a stormwater ordinance, however, four of the governments selected none of the above, indicating that they had something in place to address stormwater.

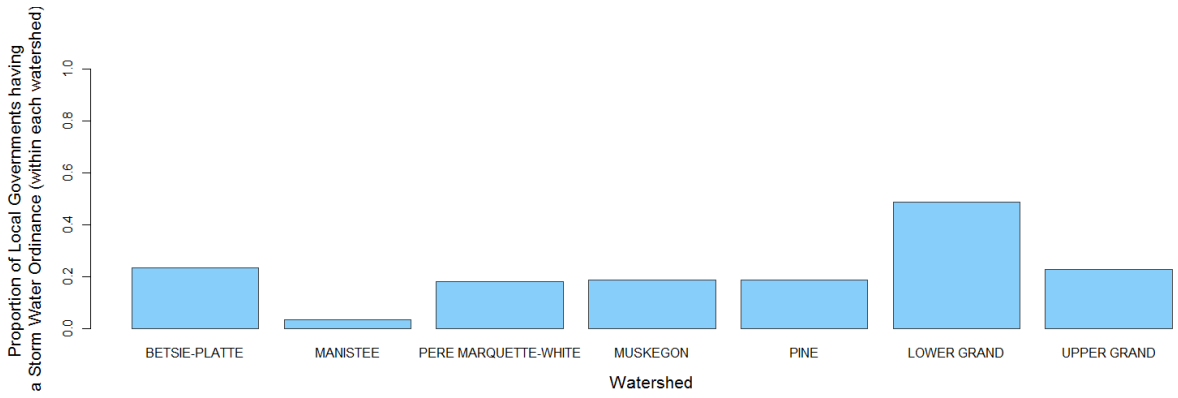


**Figure 1.8**. Proportion of governments (watersheds ordered north-west to south-east of the study region) having storm water ordinance.
**"none of the above" was an option for the storm water ordinance question*

From a list of 18 commonly used practices designed to minimize water pollution, we asked governments which practices they mandated or offered incentives for. There were 251 governments that responded to the question, with all options selected by multiple governments. Responses ranged from 0 practices (34.66% of respondents) to 16 practices (0.80% of respondents) with a mean of 2.952 (SD=3.368). The highest frequency of items chosen was 2 (11.554% governments) followed by 1 (9.96% governments). Most governments selected less than half of the 18 practices. Ninety-nine (39.44%) selected between one and four items on the list, 43 (17.13%) governments selected between five and seven options, 22 (8.77%) governments checked off eight or more of the items from the list. Results for both the top and least selected practices are presented with the number of governments selecting the practice with the percentage in parenthesis. Top three practices selected were soil erosion and sedimentation plans (97, 38.65%), stormwater management plan for parking lot runoff (90, 35.86%) and cluster development (88, 35.06%). Least selected practices selected were rain barrels (10, 3.98%), green roofs (10, 3.98%) and retrofitting older buildings/low impact design of existing buildings (15, 5.98%). Most governments did not have open space requirements in their planning and

zoning ordinances (158, 59.85%) while 35 (13.26%) had in both planning and zoning ordinances, 49 (18.56%) in zoning ordinances and 11(4.16%) in their master plans.

*Wetlands*

Few responding governments had stricter wetland policies than the state of Michigan (4.55% - figure 1.9a). Eleven of twelve governments who responded "yes" were located in either the Upper or Lower Grand River watersheds, the twelfth was located in the Betsie-Platte watershed. When asked if they had a goal of "no net loss" of wetland number or acreage within their comprehensive master plan, 6.41% governments answered yes (figure 1.9b). When asked if an ordinance of "no net loss" of wetland number or acreage was present, seven (2.98%) answered "yes" and were located in the Upper or Lower Grand River watershed (figure 1.9c). When asked if they had a wetland restoration plan, 3.40% of governments selected "yes". Six out of eight governments were located in the Upper and Lower Grand River watershed (figure 1.9d).

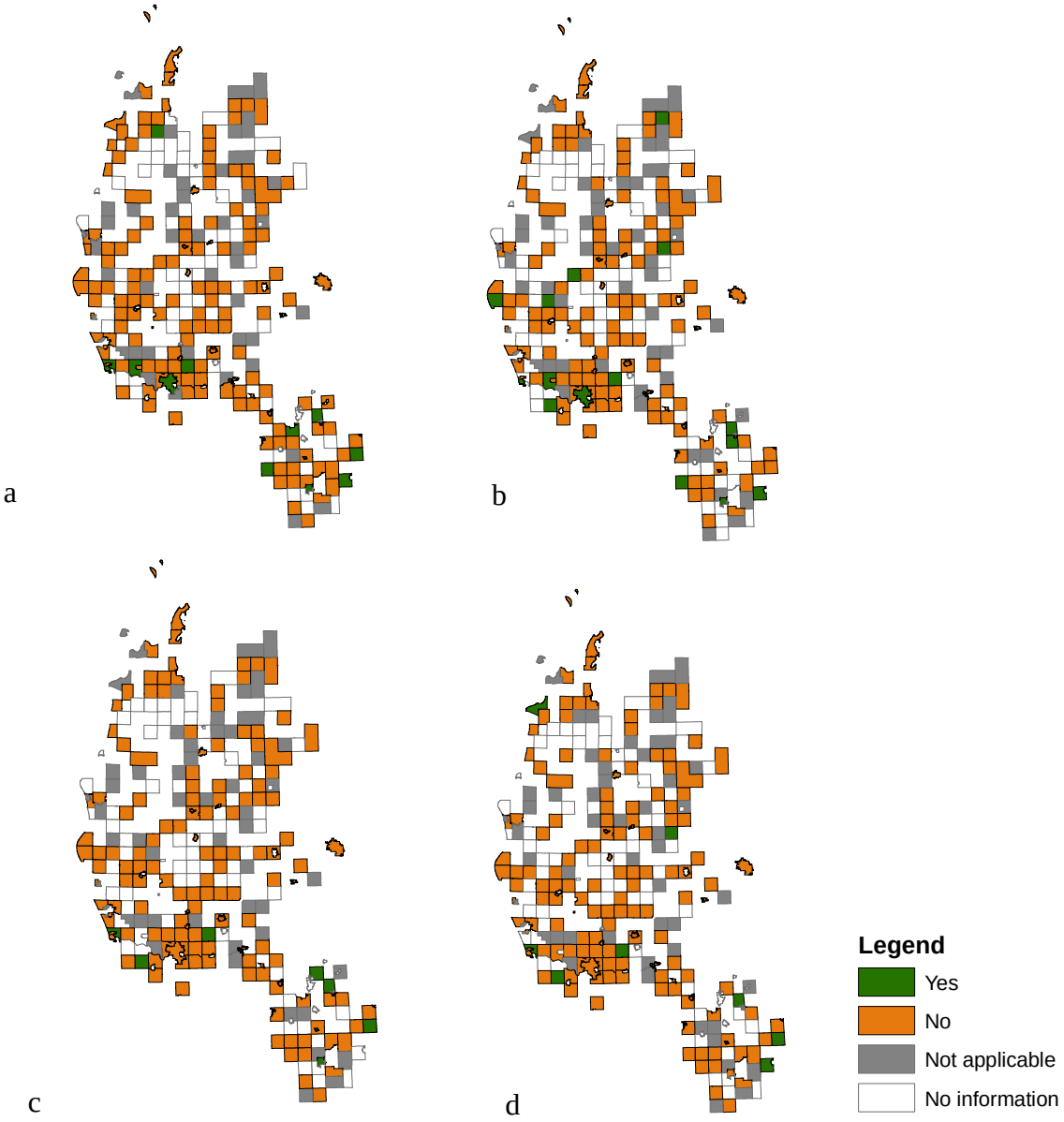


**Figure 1.9.** Different policies used to protect wetlands less than five acres in size such as a) ordinance stricter than the state, b) “no net loss” goal in the master plan, c) “no net loss” ordinance, and d) wetland restoration plan in either the master plan or zoning documents

*Aquatic non-native species prevention*

Local governments were asked to identify actions they took to minimize the spread of invasive aquatic species, educational tools used to identify these species, if they recorded and maintained records regarding invasive species found within their jurisdiction. Results are presented with the number of governments using the method and the percentage in parenthesis. The top three methods used by governments to minimize the spread of invasive species were educational fact sheets (48, 19.92%), posted signs (42, 17.25%) and a regionally linked database containing local monitoring data (22, 5.79%). Less than 5% of local governments used boat washing stations, volunteers at boat launches, had live bait use/release restrictions stricter than the state, or maintained a local database.

*Education, communication and outreach*

Summary of education, communication and outreach results are as follows: More governments maintained an online presence, and posted informational documents such meeting minutes and zoning documents. Few utilized online platforms to encourage discussion and engagement via social media.

Roughly 66.13% (164) of responding governments had a website, most located in the Upper and Lower Grand River watersheds and along the coast of Lake Michigan. Figure 1.10 displays the responses by governments when asked what they had on their website. Of the governments having a website, items selected most were meeting minutes (150, 90.36%, figure 1.10a) followed by zoning documents (137, 82.53%, figure 1.10c), public notices (120, 71.86%, figure 1.10g), planning documents (111, 66.87%, figure 1.10b) and feedback forms or emails for elected officials (101, 60.48%, figure 1.10i). The least selected item was discussion forum (14,

8.91%, figure 1.10h) followed by information on environmental issues (23, 13.86%, figure 1.10e), social networking page (38, 22.75%, figure 1.10f) and links to other organizations/partners (39, 23.50%, figure 1.10d). Some governments had websites but none of the nine specific items we asked in the survey. Five governments had all nine items, but were scattered throughout the study region. On average, townships selected about 50.55% of the nine items.

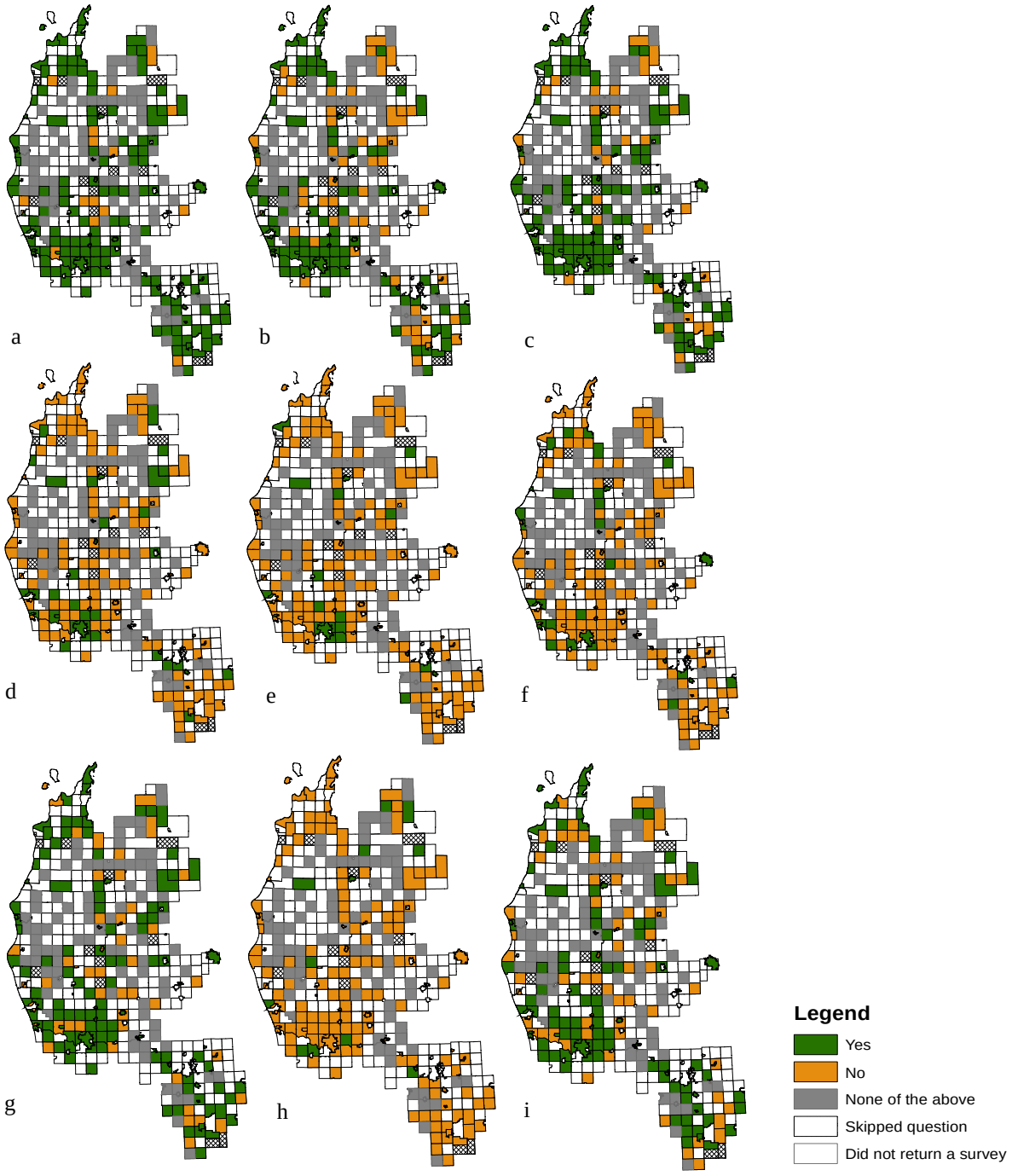


**Figure 1.10**. Items appearing on government websites. Items asked included a) meeting minutes, b) planning documents, c) zoning documents, d) links to watershed groups and partners, e) environmental information, f) social network links, g) public notices, h) discussion forums, and i) feedback forms and email addresses.

*Environmental capacity*

Summary of governmental capacity is as follows: Few governments had environmentally focused staff and sought external funding for environmental monitoring and investigation studies. Those that did seek external funding, were generally successful.

Few environmental staff such as environmental compliance officers, environmental scientists or other environmental positions were employed by local governments. Of the responding governments, nine (3.66%) governments had either a full or part time environmental compliance officer; two (less than 1%) had a full or part time environmental scientist and 11(4.68%) had some other environmentally based position including but not limited to "watershed treatment staff", "compliance manager for sanitary sewage client discharge" and "wetland officer".

More local governments indicated that they had planning and zoning professionals compared to environmental staff positions. Zoning officers were present in 175 (70.85%) of the governments with 78 (31.84%) having a planning professional. Responding governments that had planning officers were located throughout the study region with higher concentrations in the Lower & Upper Grand and Betsie-Platte Watersheds. There was overlap between those having zoning officials and those having planning professionals.

More governments sought funding for water quality (40, 16.13%) compared to hydrological studies (20, 8.1%) and habitat quality assessment (16, 6.53%). Out of the governments that applied for funding, 95% were successful in securing funds for initiating hydrological studies, 87.5% for water quality monitoring and 87.5% for habitat quality

assessment studies with 20, 40 and 16 applying respectively. In all three cases, over 200 governments (83.87%) did not seek external sources of funding for monitoring and assessment.

Local governments were asked if they set aside funds for education and outreach with regards to water conservation efforts. Out of 250 responding governments, 15 (6.0%) governments responded "yes". Nine of those governments were located in either the Upper or Lower Grand River watersheds. When asked if governments had funds for small grant programs (for nongovernmental organizations, citizens and/or businesses), 5 (2.04%) out of 245 responding governments answered "yes". These governments were spread across the study region.

Geographic information system

Of the 244 respondents, 126 (51.64%) responded "yes" to utilizing GIS to inform decision making when creating, updating, or enforcing land use planning documents and zoning ordinances (shown in green in figure 1.11) while 59 (24.18%) did not use GIS (shown in orange). Most local governments that used GIS were located within the Betsie-Platte, Lower and Upper Grand River watersheds. A small cluster of local governments was found near and at the mouth of the Muskegon River within the Muskegon watershed.

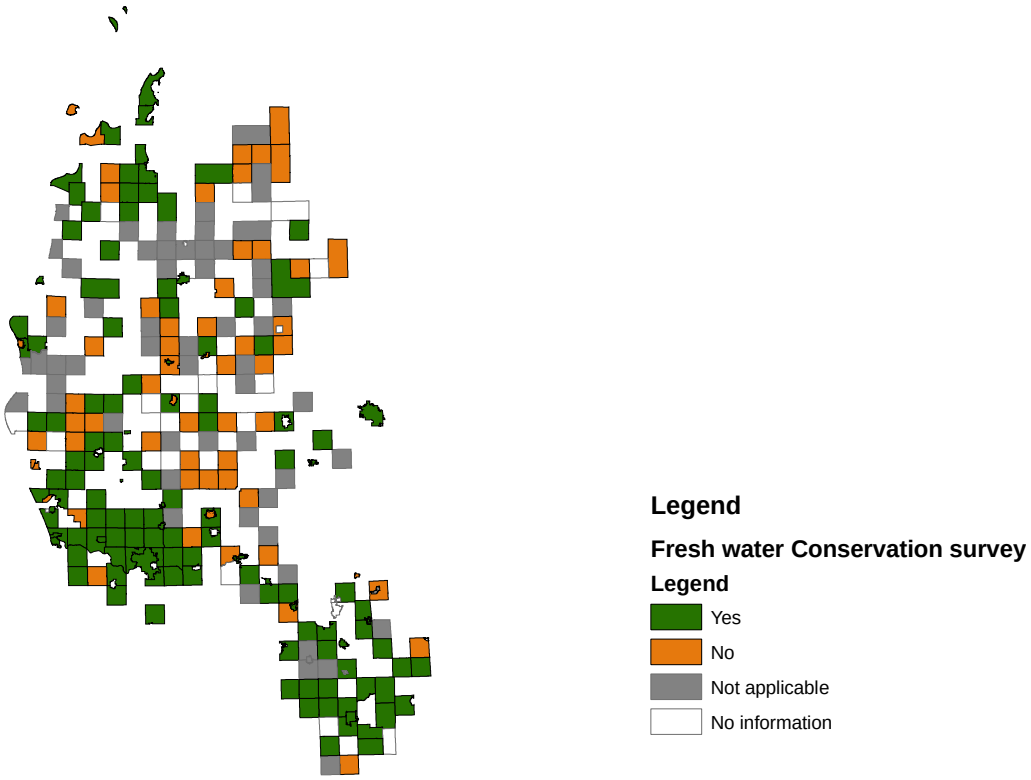


**Figure 1.11**. Governments who use GIS to inform decision making

**Discussion**

This study explored both the management strategies and policy supporting measures in place by local governments to protect freshwater resources in Michigan. Results showed that while the issue of water pollution was found to be important, gaps were found to exist between the stated importance of water pollution and the policies and supportive actions taken to address issues like pollution and non native species.

While most governments had in place their own planning and zoning, there was limited policy and best management practices mandated or incentivized. Less than 7% of responding governments addressed the issue of small wetlands within their planning and zoning documents. Lack of environmental policy could be a result of limited time and resources available for local governments. It is suggested that richer communities might have more resources, time and support for sustainable planning, growth control, environmentally sustainable policies and planning in general (Conroy and Jun, 2016; Tang and Brody, 2009). The number of planning staff as well as the quality of planning staff can increase the quality of environmental policy in a plan (Tang and Brody, 2009). Due to lack of resources, townships sometimes "outsource planning efforts" (Jun and Conroy, 2014; Conroy and Jun, 2016). By outsourcing planning, local knowledge and environmental needs may not be reflected in those plans. One example could be related to wetlands, as wetlands not only provide many ecological services, but function under specific hydrologic and ecological conditions (Zacharias, Dimitrious and Koussouris, 2005). Those specific conditions may not be met or considered in an outsourced plan. Free-riding could also account for some degree absent policy and management strategies, however. Free-riding is a concept discussed by Ostrom (1990) which involves a member of a group who cannot be excluded from a benefit, even when they do not participate in a joint effort in gaining that

benefit. In our study, this refers to local governments free riding on the efforts of other local governments within the same watershed.

Just over half of responding governments were part of a watershed based management plan. Reasons for groups not participating in an integrated, regionally organized water management group maybe due to perceived negative views regarding participation. Evidence shows that stakeholders had negative views towards water policy after participating in "Integrated Regional Water Management" program (Lubell and Lippert, 2011). Lack of trust, appropriate trust building opportunities and social network type (referring to actors within a network such as local stewards…) between local governments could factor into local governments opting to forgo participation in watershed based management plans. Trust is more likely built in less restrictive informal networks, and thus contributing positively towards water management outcomes, stimulating collaboration amongst different groups and result in new ideas (Folke et al, 2005; Edelenbos and van Meerkerk, 2015). Trust is important when dealing with unpredictable and high risk scenarios (Klijn et al., 2010), lack of trust might turn off officials from thinking collaborative approaches will address their needs. Social networks were found to be important for ecosystem management initiatives as they can build social memory and capital; contribute legal, political and financial support (Hahn et al., 2006) and could induce governments to join watershed management plans to tap into these benefits.

Governments have been investing in online interactions with their citizens and businesses (Andersen et al., 2011). This is reflected in our study as approximately two thirds of local governments in this study indicated having a webpage, with those governments using the internet to post information containing documents such as planning, zoning and minutes of meetings. Few governments utilized online methods to inform citizens on environmental issues or utilize

social networking pages. Reasons for not using online methods could be indicative of population characteristics such as size and age. Generally, people who are younger, with higher levels of education, higher income and online use for other tasks are more likely to use e-governmental services (Bélanger and Carter, 2009). Research shows that officials in larger communities were found to be more active on social media platforms (Djerf-Pierre and Pierre, 2016). Government officials might be offering online services based on demand for such services by their constituents and/or be reflective of their need to reach out to many people in an effective manner. Finally, age of government officials themselves could influence online presence and use of social media platforms like facebook and twitter. Research has shown younger government officials to be more likely to use social media (Djerf-Pierre and Pierre, 2016).

In our study region, many local governments had either planning or zoning professionals, however, less than five percent of local governments had environmentally related staff members. Lack of environmentally related staff members could be related to population size of the municipality. Municipalities having a large population size could have higher capacity to be able to do environmental planning (Tang and Brody, 2009). Larger communities could have the funds to hire environmental staff. Another factor influencing the presence of environmentally related staff could be personal characteristics of other government officials and land cover characteristics. It was found that mayors with more years of education and more forest cover invested in more forestry personnel (Gibson and Lehoucq, 2003).

## Conclusions

Our results reinforced the idea of local policy variation in comprehensive planning and zoning documents across the landscape and within watersheds, and found a limited amount of capacity available to address freshwater concerns. Because water is dynamic resource, moving across different regions, gaps in protection in one area can affect water and aquatic habitat quality both downstream and upstream. In order to effectively minimize challenges like non point source pollution, local governments need to be on the same page regarding having effective policy and measures in the zoning ordinances. Using the a telecoupling framework to address water challenges can be beneficial as it not only integrates socioeconomic and environmental interactions, but does so by factoring in distance between systems, all of which are relevant when managing aquatic resources across large spatial regions (Liu et al., 2013). Results show that local governments within a watershed are not on the same page regarding freshwater conservation, with many governments not utilizing suggested best management practices and ordinances. This can lead to overall degraded water quality in the watershed over time. This represents a somewhat lost opportunity for strengthening environmental conservation efforts within those communities in a manner that leads to accountability and enforcement. In addition to policy gaps found within a watershed, policy gaps existed between watersheds which can lead to water quality impairments on a larger scale as all watersheds in the study region drain into Lake Michigan.

Sufficient capacity is needed by local governments to help create policy, enforce and offer some type of outreach and education service to the community. Capacity building and integrated water resource management should go hand in hand with each other, and were found

to be “targeted and coordinated” within in successful integrated water resource management programs (Leidel et al., 2011; Borchardt and Ibisch, 2013).

This research offers a tool other Great Lakes or international governments can use (or adapt) in order to identify policy gaps within their region. It can also be used as a stepping stone for comparing water protection strategies in place, ultimately working towards building a more coordinated approach towards water management within the Great Lakes basin. Results from this type of research can also be integrated into frameworks designed to identify and implement freshwater protected areas. More work is needed in furthering our understanding of local government management strategies to fully address the questions of “Are local governments equipped to deal with challenges facing freshwater resources?” and “Does fragmentation matter?”, especially in the wake of climate change, non native species and increased incidences of water impairment.

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## CHAPTER 2: THE INFLUENCE OF LAND USE /COVER AND SOCIOECONOMIC FACTORS ON POLICY AND MANAGEMENT

### Introduction

Freshwater resources are increasingly facing a variety of threats and challenges due to the complex relationship between human interactions and the environment. There are five categories of threats to freshwater biodiversity identified, that being pollution, over exploitation, habitat destruction/degradation, flow alteration and non native species (Dudgeon et al., 2006). Intensive human activities resulting in both point and non-point source pollution, habitat loss, loss of connectivity, unsustainable withdrawal practices have altered coastal and marine environments (Bunn, 2016; Vorosmarty et al., 2013; Halpern et al., 2008). Of the Great Lakes, moderate to high levels of cumulative stress have been shown in Lake Erie, Lake Ontario and along the shoreline of Lake Michigan (Allan et al., 2013). With over 180 non-native species considered established in the Great Lakes and Chesapeake Bay, non-native species remain a concern for freshwater mangers as aquaculture, recreation, fishing bait release, and shipping can facilitate the spread of non native species (GLC, 2016; Ruiz and Reid, 2007; Naylor et al., 2001; Walsh, Carpenter and Vander Zanden, 2016), potentially limiting ecological services and reducing aquatic biodiversity (Zhang and Boyle, 2010; Walsh, Carpenter and Vander Zanden, 2016). Solutions to some of these threats and challenges can be found in the form of strong land use policies and conservation efforts. While there are many international, federal and state policies, local governments quite often are the first line of defence when meeting these challenges and threats.

Local governments generally interact with federal, state and regional governments when addressing policies and management strategies related to the environment such as those in the Clean Water Act, Safe Drinking Water Act etc... However, in order for high level polices to be

meaningful, they should be "informed by and responsive to local and regional contexts" and "support local and regional interests, efforts and policies" (Hering et al., 2015). Large scale governance is more focused on "transboundary surface water" issues, failing to mitigate the challenges arising from the disparity between river basins and political boundaries (Vörösmarty et al., 2015). Top down policy approaches may increase friction and delay policy development. Swedish local governments, like those in Michigan, are responsible for planning and water policy, but must adhere to national regulations. In the case of climate change and local government planning in Sweden, when regional government tried to control the direction of local planning, there seemed to be roadblocks and slowed progress (Antonson et al., 2016). This illustrates the challenges with each level of interaction, potentially slowing down progress towards developing policies and planning strategies in reducing pressures placed on the environment by humans.

There is a recognisance that water issues arise locally, and are best solved at the local level (Hering et al., 2015). In addition to local problem solving, there is a growing call to recognize the importance of local action and "local to global" link in water management (Vörösmarty et al., 2013), where water issues are linked to global mechanisms such as climate and world economy patterns of water use (Vörösmarty et al., 2015). Part of this movement is for local governments to take a growing responsibility in management of their resources in order to minimize global cumulative impacts.

Local governments have many tools and measures they can use to manage and protect freshwater resources. Local governments can employ measures such as low impact design (LID) and best management practices (BMP). Tools such as rain gardens, green roofs, bio-retention units, and rain barrels can be used during development, re-development and retrofits to existing

developments in order to achieve those goals. Local governments can use zoning to minimize the amount of high density housing, and implement development modifications (Ardizone and Wykoff, 2010). Riparian zones, maintaining riparian buffer widths, riparian corridors, retention ponds, live stalk exclusion, and maintaining intact riparian corridors have been identified in literature as measures to minimize various types of pollution including stormwater and agricultural runoff, impacts from the forestry industry, as well as habitat degradation (Allan, 2004; Allan, 1997; Sweeney and Newbold, 2014; Ardizone and Wykoff, 2010; Richardson, Naiman and Bisson, 2012).

Local governments also have a role to play in protecting wetlands and non-native species. While most national policies have included wetland protection, at the local level, local economic development often occurs at the expense of wetlands with a "behavioural change at the local level" needing to occur (Turner et. al., 2000). Including "no net loss" of wetlands or wetland acreage in planning and zoning documents, stricter site plan reviews, natural features setbacks, unavoidable use mitigation, restoration, permanent protection, planting native vegetation, presence of buffer strips have been suggested in literature and published documents as ways to protect wetlands (Tomassey, 2007; Ardizone and Wyckoff, 2010. In order to slow the spread of non-native species, prevention is cited as being critical and the best way to reduce their impacts (Keller, Frang and Lodge, 2008; Lodge et al., 2006). There are many strategies that have been suggested to help prevent the arrival and translocation of non native species such as posting signs that identify or provide instructions for recreationalist, mandatory washing of boats and equipment, boat washing stations, hiring/volunteer boat inspectors, and using hot water sprays (Vander Zandon and Olden, 2008; Morse, 2009). With the many different options available to

minimize landscape influences and human activities on freshwater resources, not only is it critical that these measures are implemented, but that they are implemented properly.

Land use and cover play a role in environmental decision making, with the amount of natural resource of interest potentially driving how much is being done, along with socioeconomic factors such as income, population, race etc…With regards to forest canopy over in urban areas, we know a positive relationship exists with urban forest canopy cover and median household income, tracts inhabited by non-Hispanic whites; a negative relationship with housing vacancy and Hispanic residents (Heynen, Perkins and Roy, 2006). In the area of energy conservation, conservation sites have been selected based on ease of fulfilling conservation targets with little indication of genuine ambition (Hoppe, Bressers and Lulofs, 2011). Homsy (2015) found that a positive correlation with cities with municipal power companies and the number of sustainable energy policies. Unlike the forestry and energy sectors, not much is known regarding what factors that drive local government water resource management.

Some research has looked at land use/cover and socioeconomic factors and some aspects of water conservation. A relationship was found between land use and population density and the presence of water quality monitoring stations, indicating that environmental pressure leads to increased public demand for stricter environmental policies (Beck, Bernauer and Kalbhenn, 2010). Bruce and Barnes (2008) found significant differences in how local governments "oversee the planning, installation, and monitoring of BMPs" regarding BMP of stormwater, concluding it could be a function of being a smaller city or population growth. Martinez-Santos et. al. (2008) concluded when agricultural policy "plays the leading role in user's minds", water policy can become "almost irrelevant" in certain situations, as agricultural policy is an important economic factor and cannot be offset by water management. This is important as both

agricultural activities and urbanization can directly influence water resources (Allan, 2004; Arnold and Gibbons., 1996). Free riding by states (when authorized by the federal government to take responsibility for implementation and enforcement of regulations) has been shown to lower the water quality index by 4% downstream across state borders with an environmental cost of $17 million in 1983 (Sigman, 2005). Our study furthers these findings by examining several different aspects of water management, ranging from best management practices to planning and zoning measures to non-native species. We also seek to determine what factors explain why some areas have measures in place to address water resource management.

Previous results in chapter 1 show that there is a lot of variability in the measures local governments have in place to manage freshwater. More understanding is needed in determining what factors influence local governments into implementing more sustainable water policy and/or encourage best management practices from both a land scape and socioeconomic perspective. This research seeks to determine if and how much socioeconomic, land cover, and land use can explain 1) number of management strategies used for freshwater water conservation 2) Presence of wetland conservation strategies 3) Measures preventing the spread of aquatic non native species and 4) Presence of planning, zoning and commonly suggested ordinances to minimize storm water and non-point source pollution.

## Methods

*Study region*

Michigan contains 63 large river watersheds which drain into the Great Lakes, linking inland Michigan activities and landscapes with Great Lakes waters via run off and water drainage. Seventeen percent of Michigan is also covered by a variety of wetland types (Fizzell, 2014). Our research focussed on local governments located in the Central Lake Michigan Management Unit and Grand River watershed which contain six large river watersheds and 460 local units of government (i.e. townships and cities – figure 2.1). The river watersheds are the Betsie-Platt, Manistee, Muskegon, Pere Marquette, Pine, and Grand (Upper and Lower). The Central Lake Michigan Management Unit, formerly an industrial area, is now being promoted as a tourist destination, recognized for its cold water trout streams and thus importance to Michigan's recreational fishing industry. The Grand River watershed is the second largest river basin in Michigan containing areas of intense agricultural activity and dense urban areas.

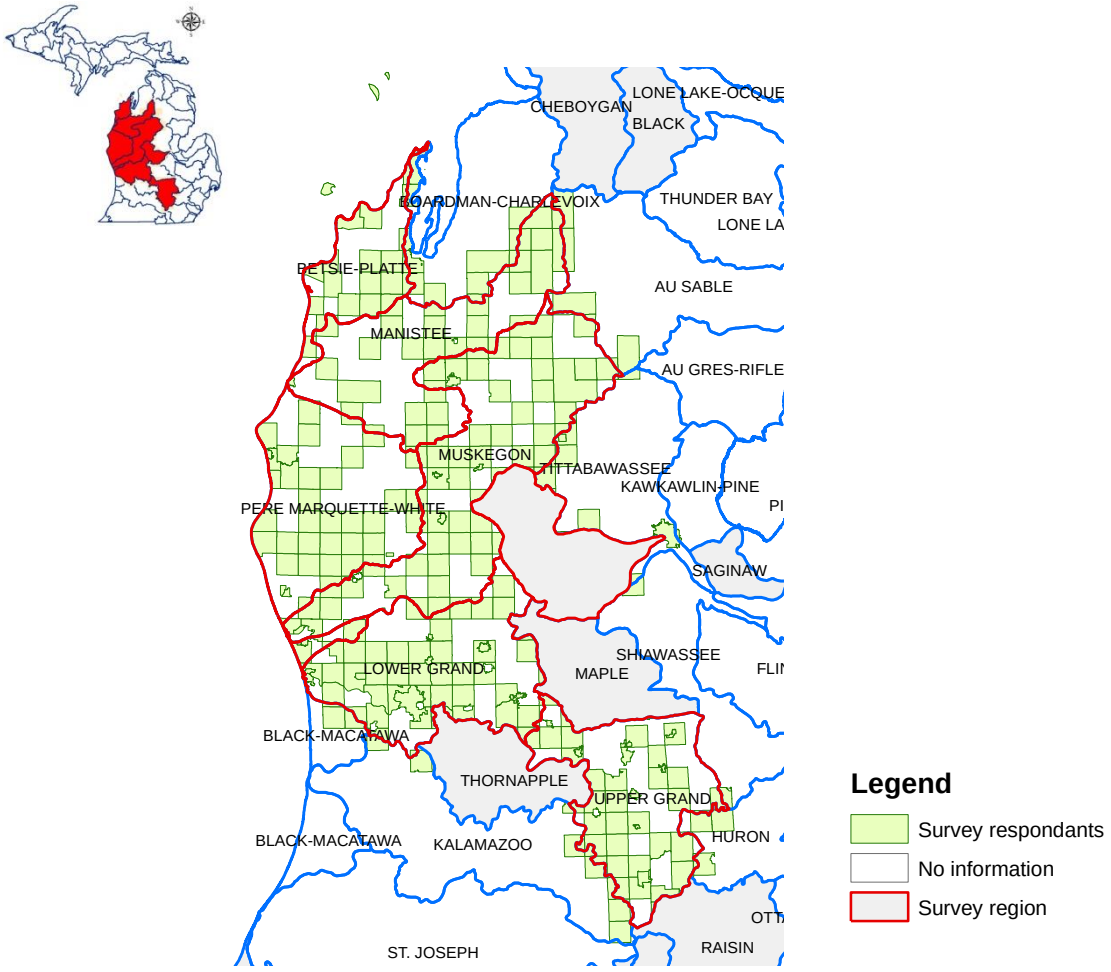


**Figure 2.1.** Location of study area within the Lower Peninsula of Michigan (watersheds outlined in red).

*Survey distribution*

To determine the diversity of planning, zoning and management strategies of local governments with regards to freshwater conservation, we surveyed local governments within our study region described above. The survey was administered using two methods, online and a mailed hardcopy. The survey was administered between March 2013 and December 2014. We sent the online survey to one member of each local government, either the clerk, supervisor, planning or zoning official. Primary recipient of the email was the person most familiar with their governments planning and zoning ordinances (planning or zoning official) followed by the clerk and supervisor. The first recipient was allowed and encouraged to forward the online survey link to others in the township when appropriate. At the end of the online survey period, we mailed paper copies of the survey with pre-addressed and stamped return envelopes, followed by a reminder postcard three weeks later, and one last mailing of the paper survey to non-responding governments. Including both electronic and mailed survey responses, we obtained 264 partial and/or completed surveys out of a total of 461 local governments in our study region (indicated in green in figure 1), a response rate of 57.27%. We received 137 responses via postal mail and 127 responses using the online survey. One township opted out of the online survey and seven returned blank surveys.

*Statistical analysis*

A negative binomial generalized linear model was used to analyze the number of best management practices selected by local governments. Local governments were asked to select the number of BMP's mandated or where they offered incentives for. Binomial logistic regressions were used to compare wetland policy measures (if they had an ordinance/protection plan stricter than state regulations, a goal of no net loss of wetland number/acreage in their

master plan and zoning document, or a wetland restoration plan). Binomial logistic regression was also used to compare if any proactive measures was taken against invasive species (fact sheets available or posted online, local monitoring database, linked monitoring data base, live bait use/release restrictions, posted signs, boat washing stations or volunteers at boat launches for educational or inspection purposes). A poisson model was used to analyse the planning and zoning tools used (having planning, zoning, vegetative riparian buffers, setbacks and stormwater ordinances). Model variables are summarized in table 2.1.

Statistical analysis was performed by using R v. 3.2.3 (R core team, 2015). Municipal boundary data was obtained from the state of Michigan CGI database (MCGI, 2009). Land use and cover data for each local government was obtained from the state of Michigan (MDNR, 2001) and analyzed using ArcGIS version 10 (summarized in table 2.2). Socioeconomic and population data were collected from the United States Census Bureau (2010) and are summarized in table 2.2. Land use/cover factors are also described in table 2.2. In order to address collinearity between factors, a step wise model was run with all factors, sequentially dropping the factor with the highest variance inflation factor (VIF), and recalculating the values until all VIF's had a value less than three (Zuur, Ieno and Elphick, 2010). Using calculated model weights using Akaike Information Criteria for small samples (AICc). We used a model averaging approach (Burnham and Anderson, 2002) where we calculated model averages across the 95% confidence interval, and where the smallest number of models whose cumulative weights added up to 0.95. Akaike weights ($w_i$) for the top resulting model are presented in the results. The package used to calculate the model average in R was "MuMin" (Barton, 2016). The relative importance (RI) of each factor was calculated by adding up the Akaike weights for

each covariate from each of the models it appears in using the package "GlMulti" in R (Calcagno, 2013).

**Table 2.1.** Description of the four dependent variables compared to land use/cover and socioeconomic variables.

| Dependent variables | Description |
|---|---|
| Management strategies | Number of management strategies that are mandated or have incentives given from a list of 18 options |
| Wetland conservation | Presence or absence of some type of wetland conservation practice |
| Non-native species | Presence or absence of non-native species prevention techniques, database and educational materials |
| Number of policy/zoning options | Number of items selected from having a land use plan, zoning document, storm water ordinance, open space, vegetative riparian buffer width requirement and setback for development near aquatic natural features |

**Table 2.2**. Description of land use/cover and socio economic at the city and township level.

| Variable | Min-Max | Average | Std. | Description |
|---|---|---|---|---|
| Urban (%) | 0.532 - 72.92 | 8.724 | 12.924 | Land areas greater than 10% man-made structures (includes low intensive, high intensive, roads and airports) |
| Row Crop (%) | 0 - 56.072 | 11.041 | 13.970 | Vegetation of annual crops planted in rows (e.g. soybeans, corn) |
| Forage/Non-tilled (%) | 0 - 50.976 | 17.520 | 12.372 | Vegetation for fodder production (e.g. hay), pasture or non tilled herbaceous agriculture. |
| Upland Forest (%) | 2.072 - 84.521 | 31.957 | 19.741 | Where the proportion of trees greater than 60% of canopy |
| Water (%) | 0 - 55.082 | 2.783 | 5.335 | Where proportion of open water greater than 75% of land area |
| Wetland (%) | 0.166 - 28.688 | 5.658 | 4.019 | Non forested wetlands including floating aquatic, lowland shrub, emergent wetland and mixed non-forested wetlands |
| Total Population | 163 - 188040 | 4984.537 | 12389.65 | Total population of the township or city. |
| Median Age | 21.1 - 64.3 | 42.456 | 6.379 | Median age of the population |
| Per White | 16 - 100 | 94.348 | 6.853 | Percent of the population that were one race white. |
| Per Owner Occ (%) | 33.36 - 96.1 | 82.826 | 10.691 | Owner occupied housing units |
| Per HS 18_24 (%) | 0 - 100 | 36.451 | 16.109 | Percent of high school graduates (including equivalency) between the ages of 18 and 24 |
| Median Earnings ($) | 8452 - 58558 | 29261.04 | 7064.86 | Median earnings for population 25 years and over with earnings (in American $, adjusted for inflation) |
| Per HS 25≥ (%) | 39.7 - 99.5 | 87.387 | 6.181 | Percent high school graduates 25 years and over |
| Per Bach. 25≥ (%) | 0.6 - 77.3 | 17.729 | 11.025 | Percent who are 25 years and older holding a bachelor's degree or higher |

## Results

*Best management strategies*

With regards to best management strategies, of all factors examined, the variable with the lowest p-value was percent of those who are 25 years of age or older and having a high school degree (table 2.3). Cities and townships having higher percentages of high school graduates also had more of the management practices ($p<0.001$). There was a positive significant relationship,

with management strategies selected with the amount of water ($p<0.05$). Results also showed a positive relationship with total population ($p<0.05$). A negative relationship was found with number of options selected and percent row crop present ($p<0.1$), governments having less amounts of row crop selected more of the options. Model averaging did not produce a highly supportive model for predicting best management practices ($w_i$ =0.029). The top three factors in the relative importance analysis were percent high school graduates 25 years and older (RI >0.8) followed by total population (RI >0.8) and percent water (RI>0.8).

**Table 2.3.** Negative binomial model results of management strategies local governments mandated or offered incentives for.

| | **Estimate** | **SE** | **Pr(>\|z\|)** | **VIF** | **Model Average Estimate** | **Model Average SE** | **Model Average Lower CI** | **Model Average Upper CI** |
|---|---|---|---|---|---|---|---|---|
| Intercept | -3.554e+00 | 1.665e+00 | 0.033 * | | -4.725 | 1.661 | -7.980 | -1.469 |
| Row Crop | -1.430e-02 | 7.800e-03 | 0.067 • | 2.012 | -0.010 | 0.007 | -0.025 | 0.004 |
| Forage/Non-tilled | 1.041e-02 | 8.989e-03 | 0.247 | 2.124 | 0.005 | 0.009 | -0.013 | 0.023 |
| Water | 3.386e-02 | 1.358e-02 | 0.013 * | 1.431 | 0.029 | 0.013 | 0.003 | 0.055 |
| Wetland | -7.382e-03 | 1.941e-02 | 0.704 | 1.098 | -0.011 | 0.019 | -0.048 | 0.027 |
| Total Population | 1.146e-05 | 5.553e-06 | 0.039 * | 1.343 | 1.40e-05 | 5.43e-06 | 3.35e-06 | 2.47e-05 |
| Median Age | -7.085e-03 | 1.731e-02 | 0.682 | 2.292 | -0.011 | 0.015 | -0.040 | 0.018 |
| Per White | -1.169e-02 | 1.227e-02 | 0.341 | 1.558 | -0.014 | 0.013 | -0.039 | 0.012 |
| Per Owner Occ | -8.568e-04 | 9.928e-03 | 0.931 | 2.355 | -0.004 | 0.008 | -0.020 | 0.012 |
| Per HS 18_24 | -3.807e-03 | 5.087e-03 | 0.454 | 1.069 | -0.003 | 0.005 | -0.013 | 0.007 |
| Median Earnings | 1.388e-05 | 1.570e-05 | 0.377 | 2.327 | -0.011 | 0.015 | -0.040 | 0.018 |
| Per HS 25≥ | 6.336e-02 | 1.837e-02 | 0.0005 *** | 1.858 | 0.071 | 0.017 | 0.038 | 0.104 |
| AIC: 1094.2 N=251 | | | | | | | | |

Level of significance: *** 0.001, ** 0.01, * 0.05, and • 0.1

*Wetlands*

Less than seven percent of local governments answered "yes" to any of four options asked in the survey regarding wetland conservation strategies, and over ten percent governments did not know their position on the wetland policy question. One factor was found to be statistically significant when examining governments that selected "yes" to at least one of the wetland policy items (table 2.4). A positive relationship was found with median age, with townships with greater older populations more likely to have some sort of wetland protection plan located either in their planning or zoning document ($p<0.05$). Model averaging did not produce a highly supportive model for predicting wetland protection ($w_i$ =0.018). The top three factors in the relative importance analysis were total population (RI >0.8) followed by median age (0.6<R<0.8) and percent high school graduate 25 years and older (0.6<R<0.8).

**Table 2.4**. Logistic regression model results of wetland conservation practice

| | **Estimate** | **SE** | **Pr(>\|z\|)** | **VIF** | **Model Average Estimate** | **Model Average SE** | **Model Average Lower CI** | **Model Average Upper CI** |
|---|---|---|---|---|---|---|---|---|
| Intercept | -1.262e+01 | 6.121e+00 | 0.039 * | | -12.022 | 5.904 | -23.594 | -0.450 |
| Row Crop | 4.033e-03 | 2.489e-02 | 0.871 | 2.126 | 0.004 | 0.022 | -0.038 | 0.047 |
| Forage/Non-tilled | -4.486e-03 | 3.290e-02 | 0.892 | 2.388 | -0.016 | 0.028 | -0.070 | 0.039 |
| Water | -8.752e-03 | 4.107e-02 | 0.831 | 1.516 | 0.003 | 0.039 | -0.074 | 0.079 |
| Wetland | 7.305e-02 | 5.418e-02 | 0.178 | 1.168 | 0.069 | 0.052 | -0.033 | 0.172 |
| Total Population | 3.291e-05 | 2.035e-05 | 0.106 | 1.531 | 3.80e-05 | 2.26e-05 | -6.26e-06 | 8.23e-05 |
| Median Age | 1.115e-01 | 5.666e-02 | 0.049 * | 2.767 | 6.81e-05 | 4.34e-05 | -1.69e-05 | 0.0001 |
| Per White | -2.332e-02 | 4.348e-02 | 0.592 | 1.716 | -0.024 | 0.039 | -0.100 | 0.053 |
| Per Owner Occ | -2.009e-02 | 3.672e-02 | 0.584 | 2.657 | -0.012 | 0.036 | -0.083 | 0.058 |
| Per HS 18_24 | -9.461e-03 | 1.636e-02 | 0.563 | 1.089 | -0.010 | 0.016 | -0.042 | 0.021 |
| Median Earnings | 5.034e-05 | 4.706e-05 | 0.285 | 2.603 | 6.81e-05 | 4.34e-05 | -1.69e-05 | 0.0001 |
| Per HS 25≥ | 8.441e-02 | 6.655e-02 | 0.205 | 1.974 | 0.107 | 0.061 | -0.013 | 0.227 |
| AIC: 152.35 N=239 | | | | | | | | |

Level of significance: *** 0.001, ** 0.01, * 0.05, and • 0.1

*Aquatic non-native species*

There was a negative relationship found between presence of non-native species prevention strategies with percent row crops, where less row crop present in municipalities were more likely to include one or more measures to prevent the spread of non-native species ($p<0.05$) as shown in table 2.5. A positive relationship was found with percentage of water, with higher percentage of water in a municipality meant they were more likely to include one or more measures ($p<0.05$). No significant relationship was found with any of the socio-economic factors ($p>0.05$). Model averaging did not produce a highly supportive model for predicting preventative measures to avoid non-native species ($w_i$ =0.018). The top three covariates in the relative importance analysis were total population (RI >0.8) followed by median age (0.6<R<0.8) and percent high school graduate 25 years and older (0.6<R<0.8).

**Table 2.5**. Logistic regression model results of measures to avoid non-native species

| | **Estimate** | **SE** | **Pr(>\|z\|)** | **VIF** | **Model Average Estimate** | **Model Average SE** | **Model Average Lower CI** | **Model Average Upper CI** |
|---|---|---|---|---|---|---|---|---|
| Intercept | -3.864e+00 | 4.021e+00 | 0.337 | | -12.022 | 5.904 | -23.594 | -0.450 |
| Row Crop | -5.453e-02 | 2.283e-02 | 0.017 * | 1.808 | 0.004 | 0.022 | -0.038 | 0.047 |
| Forage/Non-tilled | -6.182e-03 | 2.129e-02 | 0.772 | 1.906 | -0.016 | 0.028 | -0.070 | 0.039 |
| Water | 1.121e-01 | 4.412e-02 | 0.011 * | 1.364 | 0.003 | 0.039 | -0.074 | 0.079 |
| Wetland | 6.399e-02 | 4.133e-02 | 0.122 | 1.213 | 0.069 | 0.052 | -0.033 | 0.172 |
| Total Population | 2.845e-05 | 2.423e-05 | 0.240 | 1.619 | 3.80e-05 | 2.26e-05 | -6.26e-06 | 8.23e-05 |
| Median Age | 5.311e-02 | 3.623e-02 | 0.143 | 1.904 | 0.090 | 0.046 | 0.000 | 0.181 |
| Per White | -3.871e-02 | 2.456e-02 | 0.115 | 1.539 | -0.024 | 0.039 | -0.100 | 0.053 |
| Per Owner Occ | 2.625e-02 | 2.276e-02 | 0.249 | 2.043 | -0.012 | 0.036 | -0.083 | 0.058 |
| Per HS 18_24 | -1.249e-02 | 1.094e-02 | 0.253 | 1.069 | -0.010 | 0.016 | -0.042 | 0.021 |
| Per HS 25≥ | 2.096e-02 | 4.311e-02 | 0.627 | 2.455 | 0.107 | 0.061 | -0.013 | 0.227 |
| Per Bach. 25≥ | 2.283e-02 | 2.194e-02 | 0.298 | 2.405 | 6.81e-05 | 4.34e-05 | -1.69e-05 | 0.0001 |
| AIC: 251.84 N=244 | | | | | | | | |

Level of significance: *** 0.001, ** 0.01, * 0.05, and • 0.1

*Planning and zoning*

Table 2.6 shows a positive and significant relationship was found with having planning and zoning documents as well as measures included in those documents ($p<0.05$), with governments having a higher percentage of water selecting more of the above options. There was also significant relationship found ($p<0.05$) with median earnings of the population of the local township or city, high earnings were positively related to the number of planning/zoning options. A significant and positive relationship was also found with percentage of those 25 years or older having a high school degree ($p<0.1$), with municipalities with higher percentages of graduates more likely to have planning and zoning, and conservation strategies within those documents. Model averaging did not produce a highly supportive model for predicting wetland protection ($w_i$ =0.011). The top three factors in the relative importance analysis were percent water (RI >0.8) followed by median earnings (RI>0.8) and percent high school graduate 25 years and older (0.6<R<0.8).

**Table 2.6**. Poisson model results of having planning, zoning, vegetative riparian buffers, setbacks and stormwater ordinances.

| Factors | Estimate | SE | Pr(>\|z\|) | VIF | Model Average Estimate | Model Average SE | Model Average Lower CI | Model Average Upper CI |
|---|---|---|---|---|---|---|---|---|
| Intercept | 4.487e-01 | 7.620e-01 | 0.556 | | 0.491 | 0.927 | -1.326 | 2.308 |
| Row Crop | -4.702e-03 | 3.941e-03 | 0.233 | 2.016 | -0.005 | 0.004 | -0.012 | 0.002 |
| Forage/Non-tilled | -4.750e-04 | 4.548e-03 | 0.917 | 2.154 | -0.003 | 0.004 | -0.011 | 0.006 |
| Water | 1.369e-02 | 5.881e-03 | 0.020 * | 1.414 | 0.015 | 0.006 | 0.004 | 0.026 |
| Wetland | -1.271e-02 | 9.927e-03 | 0.201 | 1.111 | -0.014 | 0.010 | -0.034 | 0.005 |
| Total Population | 2.855e-06 | 2.248e-06 | 0.204 | 1.403 | 3.98e-06 | 2.25e-06 | -4.28e-07 | 8.38e-06 |
| Median Age | -2.744e-03 | 8.518e-03 | 0.747 | 2.530 | -0.005 | 0.008 | -0.021 | 0.010 |
| Per White | -8.118e-03 | 5.330e-03 | 0.128 | 1.630 | -0.010 | 0.005 | -0.020 | 0.000 |
| Per Owner Occ | -2.855e-03 | 4.760e-03 | 0.549 | 2.660 | -0.006 | 0.004 | -0.014 | 0.002 |
| Per HS 18_24 | -1.148e-03 | 2.528e-03 | 0.650 | 1.092 | -0.002 | 0.003 | -0.007 | 0.003 |
| Median Earnings | 1.823e-05 | 7.608e-06 | 0.017 * | 2.300 | 1.91e-05 | 7.81e-06 | 3.76e-06 | 3.44e-05 |
| Per HS 25≥ | 1.453e-02 | 8.472e-03 | 0.086 •. | 1.853 | 0.017 | 0.009 | -0.001 | 0.035 |
| AIC: 1010.5 N=264 | | | | | | | | |

Level of significance: *** 0.001, ** 0.01, * 0.05, and • 0.1

## Discussion

Results from this study show evidence of a relationship between the type of policy, planning and zoning used by local governments with some land use/cover and socioeconomic factors. Results also show the percentage of water located within municipalities is an important factor when it comes to determining which types of governments have implement strong water policy initiatives. This study supports the idea that local governments differ in what type of environmental policies they have, as found by Bruce and Barnes (2008) who looked at stormwater best management practices.

Percentage of row crops were found to have a negative association with the amount of management strategies local governments mandated or offered incentives for. In addition to a lack of BMP's, this study found a negative association with row crop regions and invasive species preventative action. In the context of water resource allocation, when agricultural policy

plays “a leading role in user’s minds”, then “water policy can be come irrelevant” (Martinez-Santos et al., 2008). Michigan also has a strong agricultural lobby group which may exert some pressures on local and state officials during policy drafting periods. The Michigan Farm Bureau (representing over 45000 farmers) previously joined a law suit that challenged the EPA’s Clean Water Rule, with the position that their member’s livelihoods could be affected by the new guidelines (Spangler, 2015). In addition to lobbyists, Michigan also has a “Right to Farm Bill” that is designed to protect farmers from nuisance law suits. While state and federal laws must be adhered to, some local laws may be circumvented. Implementing agricultural best practice approach (or “code of practice”) in rural communities is met with limited success as there is no statutory backup, codes are too general, and in some cases are too expensive for farmers to implement (thereby risking bankruptcy) as evidenced in the United Kingdom (D’Arcy and Frost, 2001).

This study found a direct and significant positive relationship with policy/best management strategies with the amount of water in three of the four models. These results show the importance of water amount in developing strong and proactive policies aimed at minimizing non point source pollution and preventing the spread of non-native species. Potential explanations for these trends could include economic benefits derived from aquatic resources such as recreation, property value and tourism. From an international perspective, tourism is one of the fastest growing economic sectors (Rico-Amoros, Olcina-Cantos and Sauri, 2009). Water rich regions may rely on industries such as recreational fisheries for economic benefits. Invasive species can affect recreational fisheries (Horsch and Lewis, 2009) which can be important economic draw for local governments with lots of water, and species like Eurasian watermilfoil not only reduces biodiversity, but limits recreational activities such as swimming and boating,

compromises water quality, affects fish abundance, impact tourism and can decrease lake front property values by up to 16% (Zhang and Boyle, 2010; Horsch and Lewis, 2009). Water rich regions may also have dealt with historical pollution that triggered mandated action be taken. According to the Clean Water Act, states are required to submit a list of water bodies unable to meet water quality standards. This results in managers and government officials having to develop total daily maximum load plans, essentially a pollution budget, that over time will allow the water body to meet those standards.

Factors such as high school education could indicate higher level of environmental knowledge capacity within the constituent population. This could mean more support for stronger freshwater policies. More and more people are moving from urban areas, trading in urban sprawl for less populated areas, clean air and water (known as green migrants). Jones et al. (2003) found that migrants tended to be older, more educated, more affluent, had more concern and placed higher priority on environmental issues. Our results take this a step further and linked education to direct action (best management strategies, planning and zoning ordinances implemented) taken towards water conservation. The results from this study somewhat parallel what Gibson and Lehoucq (2003) found in Guatemala where mayors tended to place staff for forest protection when they have more education (in our case, education was of the community, not the officials) and the municipality has larger amounts of forested area. Thus, supporting the idea of more natural resources, more policy actions taken to protect those natural resources.

## Conclusions

There is an assumption that local governments want to succeed in attaining newly decentralized environment goals but fall short due to lack of technical ability and/or financial resources as surmised by Gibson and Lehoucq (2003). Bunn (2016) states that we over-estimate water literacy of the public and politicians and there is a need to better communicate causes and consequences of freshwater problems, solutions and in quantifying full costs/benefits of management action. Some of these assumptions could be at play here in Michigan.

Our research contributes to the field of freshwater conservation by increasing the understanding of factors influence what types of local governments implement freshwater conservation efforts. We find that water rich and large populated cities and townships tend to have more management strategies in place. Further understanding is needed in determining why smaller communities are not implementing management strategies, and further investigation is needed in identifying factors to strengthen model results.

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# CHAPTER 3: THE INFLUENCE OF LAND USE/COVER AND SOCIO ECONOMIC FACTORS ON CAPACITY, ENFORCEMENT, COMMUNICATION AND WATERSHED BASED MANAGEMENT ACTIONS TAKEN BY LOCAL GOVERNMENTS

## Introduction

Freshwater resources are facing many challenges stemming from human activities such as non-point source pollution, habitat degradation, and non-native species. Population growth coupled with technological advancements are changing the environment, including rivers and moving us towards the Anthropocene period (Poff, 2014; Steffen, Crutzen and McNeill, 2009; Crutzen, 2002) with trickle down effects will be felt on aquatic resources resulting from climate and land use change (Thompson et al., 2013). Local governments are on the front lines of these environmental changes and need address these challenges. However, questions remain whether or not local governments have the environmental capacity to identify those challenges, implement effective policies, enforce policies and engage with their constituents on issues relating to aquatic resources.

Historically, water resource management has been reactionary, with a call for both science and management to make a shift towards "strategic problem solving, with sufficient knowledge to avoid problems or address them properly should they arise" (Likens et. al., 2009). Literature points to a wide array of policies, planning and zoning needed to preserve freshwater resources, but knowledge and policy alone does not lead to proper planning and or effective action (Alaerts and Kaspersma, 2010). Water resource managers need to build social-ecological resilience and adaptive capacity to meet unexpected challenges to water resources (Rockström et al., 2014). Environmental policy and management strategies, no matter how strong and proactive, cannot be effective unless implemented properly, enforced, and outreach/education tactics are utilized to communicate with various stakeholder groups what the issues are and

resulting actions being taken. Lack of resources was cited as a reason for a lack of policy enforcement (Sisser et al. 2016). Strong enforcement strategies are an important step towards making sure policy is having the intended effect. Best management practice implementation can have limited success from a lack of statutory backup (D'Arcy and Frost, 2001). Fines and legal consequences give teeth to policy, acting as a deterrent towards violating policies as residents knowingly violate or modify ordinances to suit personal preferences (Savenije and van der Zaag, 2002). In essence, governments and policy making groups need to have sufficient amounts of capacity to effectively support existing water conservation policies and practices.

Capacity is the ability of "a community to identify and understand its development issues, to act to address these, and to learn from experience and accumulate knowledge for the future" (Alaerts and Kaspersma, 2010). In order to address complex environmental issues, such as land and water interactions, it is important to have the knowledge to identify the issue, communicate it, confirm with experts, colleagues and decision makers followed by proper policy and administrative action (allowing for financial and other relevant resources); many citizens and policy makers are not well informed regarding the health of water resources and link health to social and economic institutions; nor are they concerned about it (Alaerts, 2009; Bjorkland and Pringle, 2001). Local governments are at risk for not having adequate capacity needed to anticipate and react to environmental changes in an effective manner as a result of a lack of knowledgeable personnel and/or funding (Aaerts and Kaspersma, 2010).

Public education, broad based educational strategies that incorporates citizen participation is needed for water conservation to be effective (Bjorkland and Pringle, 2001). Education programs and methods that address the relevancy of proposed water pollution policies and ordinances to residents and stakeholders, result in decreased pollution and water use

(Campbell, Ibeanusi, and Comer, 2016; Savenije and van der Zaag, 2002). However, citizen awareness of policy does not necessarily mean policy adherence, as was found in the case of water irrigation ordinances (Campbell, Ibeanusi, and Comer, 2016; Sissers, et. al. 2016). In order to increase awareness of policies and ordinances, alternative and effective methods of communications is needed.

Online venues can be an efficient way to remedy this problem as adult online users are turning to the internet to get information about their government, and use the internet to search for information regarding a public policy or local, state or federal government issues (Smith, 2010). Local governments not having social media presence still were spoken about on social media, and missed an opportunity to hear "grass roots opinions and feelings about local policy, public services, and daily life in their municipalities" (Bonsón et al., 2012). Even though some countries that have "high level of e-government readiness", letters, phone calls and in person meetings formed the majority of communication practices (Berger, Hertzum and Schreiber, 2016).

As found in chapter 1 and chapter 2, local governments differ in how they support water conservation policies, with capacity varying amongst local governments. Local governments also need revenue raising and institutional capacity to apply local regulations that allow for minimum government functions (Wallis and Dollery, 2002). Capacity levels related to environmental work, have been found to vary significantly between local governments (Wild-River, 2006). For example, municipal governments rarely sought out code violations, with enforcement being "complaint driven" due to lack resources on the part of the government (Sisser et. al., 2016). On the issue of online presence by governments, governments are using the internet to communicate with their citizens, especially in larger cities, where one study found

over 80% of the cities with a population size larger than 50,000 used the internet to communicate with their citizens (Sisser et. al., 2016; Wang, 2001a). Social media is being used by local governments in the European Union where twitter was used by 32% of local government surveyed and had on average 823 followers (Bonsón et al., 2012). On the issue of watershed based management, watersheds as a spatial unit for planning and water resource planning is gaining traction, but has not received as much attention in the land-use planning field as in other biological and environmental contexts (Wang, 2001b).

While our previous research has shown that local governments do vary when it comes to capacity, enforcement, outreach/communication and participation in watershed based management, more understanding is needed in determining what factors influence the presence of the above those actions. This research seeks to determine if and how much socioeconomic, land cover, and land use can explain 1) Presence or absence of environmentally focused capacity 2) enforcement of water-related local ordinances 3) Outreach, information distribution and educational opportunities and 4) Participation in a watershed based management plan.

## Methods

### *Study region*

Michigan contains 63 large river watersheds which drain into the Great Lakes, linking inland Michigan activities and landscapes with Great Lakes waters via run off and water drainage. Seventeen percent of Michigan is also covered by a variety of wetland types (Fizzell, 2014). Our research focussed on local governments located in the Central Lake Michigan Management Unit and Grand River watershed which contain six large river watersheds and 460 local units of government (i.e. townships and cities – figure 3.1). The river watersheds are the Betsie-Platt, Manistee, Muskegon, Pere Marquette, Pine, and Grand (Upper and Lower).

The Central Lake Michigan Management Unit, formerly an industrial area, is now being promoted as a tourist destination, recognized for its cold water trout streams and thus importance to Michigan's recreational fishing industry. The Grand River watershed is the second largest river basin in Michigan containing areas of intense agricultural activity and dense urban areas.

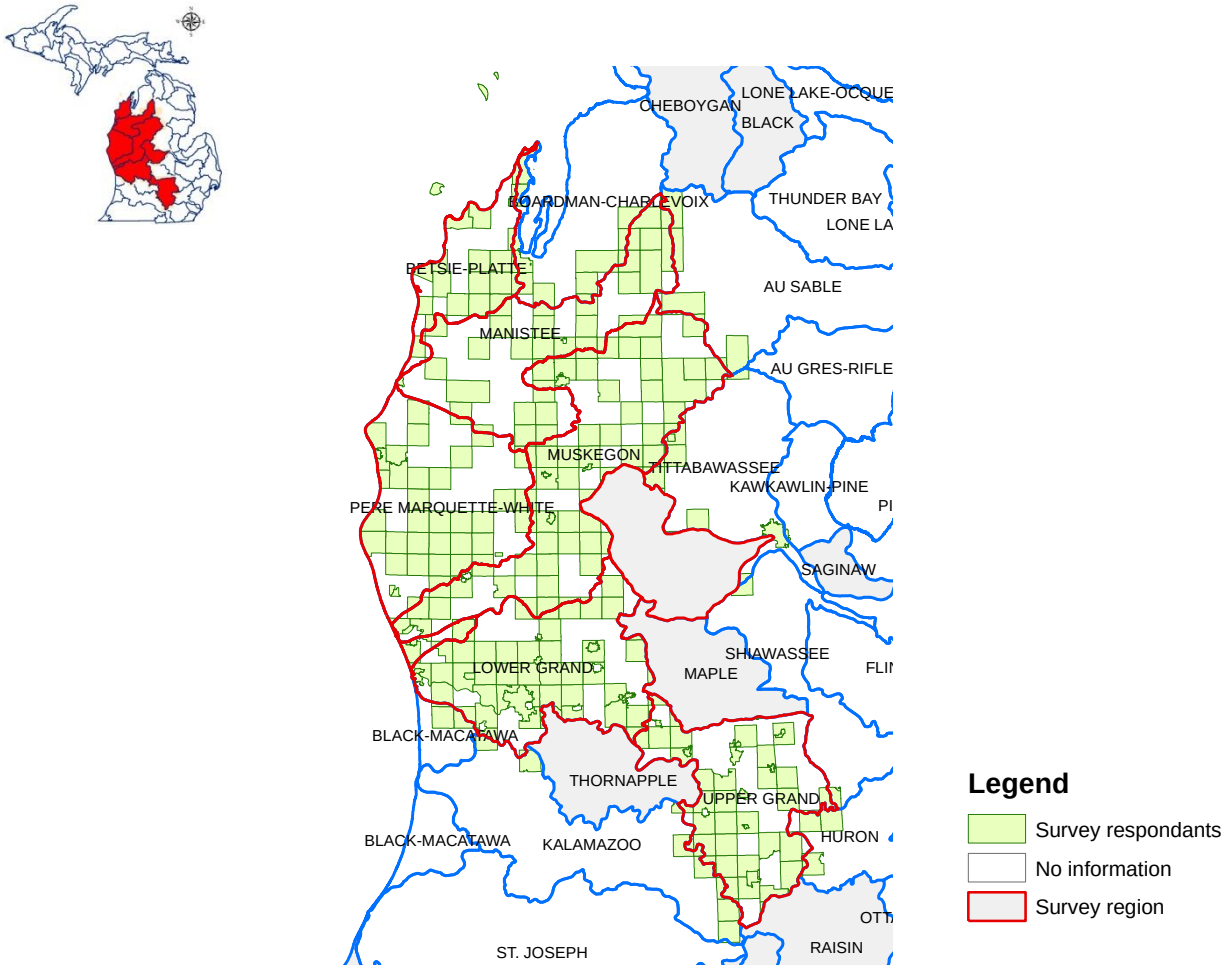


**Figure 3.1.** Location of study area within the Lower Peninsula of Michigan (watersheds outlined in red).

*Survey distribution*

To determine the diversity of planning, zoning and management strategies of local governments with regards to freshwater conservation, we surveyed local governments within our study region described above. The survey was administered using two methods, online and a mailed hardcopy. The survey was administered between March 2013 and December 2014. We sent the online survey to one member of each local government, either the clerk, supervisor, planning or zoning official. Primary recipient of the email was the person most familiar with their governments planning and zoning ordinances (planning or zoning official) followed by the clerk and supervisor. The first recipient was allowed and encouraged to forward the online survey link to others in the township when appropriate. We mailed paper copies of the survey with pre-addressed and stamped return envelopes, followed by a reminder postcard three weeks later, and one last mailing of the paper survey to non-responding governments. Including both electronic and mailed survey responses, we obtained 264 partial and/or completed surveys out of a total of 460 local governments in our study region (indicated in green in figure 3.1), a response rate of 57.27%. We received 137 responses via postal mail and 127 responses using the online survey. One township opted out of the online survey and seven returned blank surveys.

*Statistical analysis*

Logistic regression models were used to look at environmental capacity, enforcement, engagement and participation in a watershed based management plan (table 3.1) with respect to land use, land cover and socio-economic factors. To address environmental capacity, presence of any environmentally based staff was examined in one model, and successful funding obtained from external funding sources to investigate hydrological studies, water quality monitoring or habitat assessment in a second model. Local governments were asked if they enforced

ordinances regarding water resources (using any of the following methods: they investigated after a negative outcome such as a fish kill or algal bloom, self reporting, citizens reporting on others, via permitting, scheduled or unscheduled visits or as a result of state notification of a problem. In order to examine if any outreach, communication and engagement occurred, local governments were asked if they engaged with farmers, maintained a website, had money for educational and/or outreach activities, and small grant programs for non-governmental organizations, citizens or businesses.

Statistical analysis was performed by using R v. 3.2.3 (R core team, 2015). Municipal boundary data was obtained from the state of Michigan CGI database (MCGI, 2009). Land use and cover data for each local government was obtained from the state of Michigan (MDNR, 2001) and analyzed using ArcGIS version 10 (summarized in table 3.2). Socioeconomic and population data were collected from the United States Census Bureau (2010) and are summarized in table 3.2. Land use/cover and socioeconomic variables are described in table 3.2. In order to address collinearity between factors, a step wise model was run with all factors, sequentially dropping the variable with the highest variance inflation factor (VIF), and recalculating the values until all VIF's had a value less than three (Zuur, Ieno and Elphick, 2010), we refer to this as the global model. Using calculated model weights using Akaike Information Criteria for small samples (AICc). We used a model averaging approach (Burnham and Anderson, 2002) where we calculated model averages across the 95% confidence interval, and where the smallest number of models whose cumulative weights added up to 0.95. Akaike weights ($w_i$) for the top resulting model are presented in the results. The package used to calculate the model average in R was "MuMin" (Barton, 2016). The relative importance (RI) of

each covariate was calculated by adding up the Akaike weights for each covariate from each of the models it appears in using the package "GlMulti" in R (Calcagno, 2013).

**Table 3.1.** Description of the five dependent variables compared to land use/cover and socioeconomic variables.

| Dependant Variable | Description |
|---|---|
| Environmental Staff | The presence or absence of staff dedicated to environmental issues (either full or part time) |
| Funding for environmental investigation | Funding from external sources for hydrological, water quality and habitat assessment studies |
| Enforcement | Presence or absence of water related ordinance enforcement. |
| Outreach and Information | Presence or absence of any type of farmer engagement, website, education/outreach and small grant programs regarding water conservation. |
| Watershed Management | Local governments who are part of a watershed based management plan. |

**Table 3.2**. Description of land use/cover and socio economic factors at the local government level.

| | Min-Max | Average | Std. | Description |
|---|---|---|---|---|
| Urban (%) | 0.532 - 72.92 | 8.724 | 12.924 | Land areas greater than 10% man-made structures (includes low intensive, high intensive, roads and airports) |
| Row Crop (%) | 0 - 56.072 | 11.041 | 13.970 | Vegetation of annual crops planted in rows (e.g. soybeans, corn) |
| Forage/Non-tilled (%) | 0 - 50.976 | 17.520 | 12.372 | Vegetation for fodder production (e.g. hay), pasture or non tilled herbaceous agriculture. |
| Upland Forest (%) | 2.072 - 84.521 | 31.957 | 19.741 | Where the proportion of trees greater than 60% of canopy |
| Water (%) | 0 - 55.082 | 2.783 | 5.335 | Where proportion of open water greater than 75% of land area |
| Wetland (%) | 0.166 - 28.688 | 5.658 | 4.019 | Non forested wetlands including floating aquatic, lowland shrub, emergent wetland and mixed non-forested wetlands |
| Total Population | 163 - 188040 | 4984.537 | 12389.65 | Total population of the township or city. |
| Median Age | 21.1 - 64.3 | 42.456 | 6.379 | Median age of the population |
| Per White | 16 - 100 | 94.348 | 6.853 | Percent of the population that were one race white. |
| Per Owner Occ (%) | 33.36 - 96.1 | 82.826 | 10.691 | Owner occupied housing units |
| Per HS 18_24 (%) | 0 - 100 | 36.451 | 16.109 | Percent of high school graduates (including equivalency) between the ages of 18 and 24 |
| Median Earnings ($) | 8452 - 58558 | 29261.04 | 7064.86 | Median earnings for population 25 years and over with earnings (in American $, adjusted for inflation) |
| Per HS 25≥ (%) | 39.7 - 99.5 | 87.387 | 6.181 | Percent high school graduates 25 years and over |
| Per Bach. 25≥ (%) | 0.6 - 77.3 | 17.729 | 11.025 | Percent who are 25 years and older holding a bachelor's degree or higher |

## Results

### *Environmental capacity*

Results for local governments having environmentally related staff are shown in table 3.3. The only significant relationship found between environmentally related positions was with total population ($p<0.1$). There was a positive relationship found, with larger populations more likely to have an environmentally focused staff member. When asked about having funding for

monitoring and assessment studies, a significant ($p<0.1$) relationship was found with percent high school graduates who were 25 years of age and older (table 3.4). Model averaging did not produce a highly supportive model for either predicting environmental staff ($w_i$ =0.031) or funding acquired for further environmental studies ($w_i$ =0.030). For environmentally focused staff, the top three covariates found in the relative importance analysis were total population (RI >0.8) followed by percent forage/non-tilled land (0.6<RI <0.8) and percent row crop (0.4<RI<0.6). For funding, the top three covariates found in the relative importance analysis were total population (RI >0.8) followed by percent high school graduates over the age of 25 (RI >0.8) and percent row crop (0.6<RI <0.8).

**Table 3.3**. Logistic regression model results of local governments have environmentally related staff positions (full or part time).

| | **Estimate** | **SE** | **Pr(>\|z\|)** | **VIF** | **Model Average Estimate** | **Model Average SE** | **Model Average Lower CI** | **Model Average Upper CI** |
|---|---|---|---|---|---|---|---|---|
| Intercept | -1.815e+00 | 5.642e+00 | 0.748 | | -1.960 | 3.244 | -8.318 | 4.396 |
| Urban | -3.865e-03 | 2.474e-02 | 0.876 | 2.648 | 0.006 | 0.022 | -0.038 | 0.049 |
| Row Crop | -3.251e-02 | 4.694e-02 | 0.489 | 2.055 | -0.045 | 0.044 | -0.132 | 0.041 |
| Forage/Non-tilled | -6.447e-02 | 4.517e-02 | 0.154 | 2.231 | -0.068 | 0.036 | -0.140 | 0.003 |
| Water | 4.206e-03 | 4.126e-02 | 0.919 | 1.305 | 0.004 | 0.040 | -0.074 | 0.082 |
| Wetland | 2.159e-02 | 6.463e-02 | 0.738 | 1.176 | 0.022 | 0.064 | -0.103 | 0.146 |
| Total Population | 5.834e-05 | 3.087e-05 | 0.059 • | 1.767 | 6.68e-05 | 2.75e-05 | 1.28e-05 | 0.0001 |
| Median Age | -6.550e-02 | 5.574e-02 | 0.240 | 1.889 | -0.055 | 0.051 | -0.155 | 0.045 |
| Per White | 1.070e-02 | 3.756e-02 | 0.776 | 1.739 | 0.007 | 0.033 | -0.058 | 0.073 |
| Per HS 18_24 | 1.334e-03 | 1.972e-02 | 0.946 | 1.119 | -0.0004 | 0.019 | -0.037 | 0.037 |
| Median Earnings | 8.633e-06 | 5.281e-05 | 0.870 | 2.054 | 1.29e-05 | 4.60e-05 | -7.72e-05 | 0.0001 |
| Per HS 25≥ | 1.418e-02 | 6.265e-02 | 0.821 | 2.000 | 0.014 | 0.052 | -0.087 | 0.116 |
| AIC: 127.46 N=245 | | | | | | | | |

Level of significance: *** 0.001, ** 0.01, * 0.05, and • 0.1

**Table 3.4**. Logistic regression model results of local governments having successfully received funding for hydrological studies, water quality monitoring or habitat quality assessment from external sources

| | Estimate | SE | Pr(>\|z\|) | VIF | Model Average Estimate | Model Average SE | Model Average Lower CI | Model Average Upper CI |
|---|---|---|---|---|---|---|---|---|
| Intercept | -7.351e+00 | 4.363e+00 | 0.092 • | | -7.482 | 4.106 | -15.529 | 0.566 |
| Urban | -4.991e-03 | 1.817e-02 | 0.784 | 2.361 | 0.007 | 0.017 | -0.026 | 0.039 |
| Row Crop | -3.316e-02 | 2.279e-02 | 0.146 | 1.972 | -0.036 | 0.020 | -0.074 | 0.004 |
| Forage/Non-tilled | -1.915e-02 | 2.483e-02 | 0.441 | 2.246 | -0.026 | 0.023 | -0.071 | 0.020 |
| Water | 2.627e-03 | 3.011e-02 | 0.931 | 1.374 | 0.006 | 0.030 | -0.054 | 0.065 |
| Wetland | 1.195e-02 | 4.753e-02 | 0.801 | 1.174 | 0.012 | 0.047 | -0.080 | 0.103 |
| Total Population | 3.183e-05 | 2.438e-05 | 0.191 | 1.610 | 4.17e-05 | 2.43e-05 | -5.92e-06 | 8.93e-05 |
| Median Age | -4.134e-02 | 3.634e-02 | 0.255 | 1.817 | -0.036 | 0.033 | -0.102 | 0.029 |
| Per White | -5.818e-04 | 3.012e-02 | 0.985 | 1.579 | -0.003 | 0.029 | -0.059 | 0.053 |
| Per HS 18_24 | -7.847e-03 | 1.308e-02 | 0.548 | 1.081 | -0.009 | 0.013 | -0.034 | 0.016 |
| Median Earnings | 7.018e-06 | 3.580e-05 | 0.845 | 2.185 | 2.07e-05 | 3.87e-05 | -5.51e-05 | 9.65e-05 |
| Per HS 25≥ | 9.050e-02 | 5.010e-02 | 0.071 • | 2.060 | 0.089 | 0.041 | 0.089 | 0.041 |
| AIC: 123.53 N=247 | | | | | | | | |

Level of significance: *** 0.001, ** 0.01, * 0.05, and • 0.1

*Ordinance enforcement*

With regards to local governments having any type of enforcement of ordinances pertaining to water resources, two factors showed a significant relationship. Results are shown in table 3.5. A negative relationship was found between enforcement and percent row crop, and was found to be slightly significant ($p<0.1$). A negative relationship was also found between enforcement and the amount of wetland with the relationship being slightly significant ($p<0.1$). Model averaging did not produce a highly supportive model for predicting enforcement of water related ordinances ($w_i$ =0.007). The top three covariates found in the relative importance analysis were total population (0.6<RI <0.8) followed by percent wetlands (0.6<RI <0.8) and percent row crop (0.4<RI <0.8).

**Table 3.5**. Logistic regression model results of local governments that have some type of enforcement of ordinances regarding water resources.

| | Estimate | SE | Pr(>\|z\|) | VIF | Model Average Estimate | Model Average SE | Model Average Lower CI | Model Average Upper CI |
|---|---|---|---|---|---|---|---|---|
| Intercept | -6.128e-01 | 3.597e+00 | 0.865 | | -0.397 | 2.607 | -5.507 | 4.712 |
| Urban | -1.750e-02 | 1.623e-02 | 0.281 | 2.111 | -0.004 | 0.015 | -0.034 | 0.027 |
| Row Crop | -2.467e-02 | 1.496e-02 | 0.099 • | 2.182 | -0.017 | 0.014 | -0.044 | 0.010 |
| Forage/Non-tilled | 9.413e-03 | 1.757e-02 | 0.592 | 2.193 | 0.008 | 0.017 | -0.025 | 0.040 |
| Water | 4.770e-02 | 3.627e-02 | 0.189 | 1.531 | 0.036 | 0.033 | -0.029 | 0.101 |
| Wetland | -6.849e-02 | 3.764e-02 | 0.069 • | 1.215 | -0.063 | 0.035 | -0.132 | 0.007 |
| Total Population | 5.321e-05 | 3.931e-05 | 0.176 | 1.724 | 5.87e-05 | 3.72e-05 | -1.43e-05 | 0.0001 |
| Median age | -3.638e-02 | 3.185e-02 | 0.253 | 2.107 | -0.032 | 0.028 | -0.086 | 0.022 |
| Per White | -1.204e-02 | 2.568e-02 | 0.639 | 1.471 | -0.009 | 0.027 | -0.061 | 0.043 |
| Per HS 18_24 | -8.123e-03 | 9.079e-03 | 0.371 | 1.050 | -0.008 | 0.009 | -0.026 | 0.009 |
| Median Earnings | 3.782e-05 | 3.343e-05 | 0.258 | 2.604 | 3.18e-05 | 2.99e-05 | -2.69e-05 | 9.05e-05 |
| Per HS 25≥ | 4.092e-02 | 3.462e-02 | 0.237 | 2.220 | 0.037 | 0.029 | -0.0202 | 0.095 |
| Per Bach. 25≥ | -1.246e-02 | 2.300e-02 | 0.588 | 2.890 | 0.015 | 0.020 | -0.024 | 0.054 |
| AIC: 316.36 N=237 | | | | | | | | |

Level of significance: *** 0.001, ** 0.01, * 0.05, and • 0.1

*Outreach and information*

Results examining outreach, education and are shown in table 3.6. Two factors were shown to be significant, percent of water and total population size. Percent water had a significant ($p<0.05$) and positive relationship, the more water present within the city or township indicated a higher likelihood of the government practicing some type outreach, education or information dissemination. A slightly significant and positive relationship was also found with population size ($p<0.1$). Model averaging did not produce a highly supportive model for predicting presence of outreach and education ($w_i$ =0.005). The top three factors found in the relative importance analysis were percent water (RI >0.8) followed by total population (RI >0.8) and percent urbanization (0.4<RI <0.6).

**Table 3.6**. Any type of outreach or information distribution (farmer, website or education/outreach and small grant programs) regarding water conservation.

| | Estimate | SE | Pr(>\|z\|) | VIF | Model Average Estimate | Model Average SE | Model Average Lower CI | Model Average Upper CI |
|---|---|---|---|---|---|---|---|---|
| Intercept | 9.641e+00 | 6.484e+00 | 0.137 | | 4.316 | 5.491 | -6.446 | 15.077 |
| Urban | 6.135e-02 | 5.847e-02 | 0.294 | 1.980 | 0.071 | 0.055 | -0.037 | 0.178 |
| Row Crop | 2.568e-02 | 1.804e-02 | 0.155 | 2.223 | 0.021 | 0.015 | -0.010 | 0.051 |
| Forage/Non-tilled | 4.811e-03 | 2.012e-02 | 0.811 | 1.938 | 0.016 | 0.018 | -0.020 | 0.052 |
| Water | 3.661e-01 | 1.463e-01 | 0.012 * | 1.409 | 0.302 | 0.132 | 0.044 | 0.560 |
| Wetland | -5.278e-02 | 4.650e-02 | 0.256 | 1.208 | -0.063 | 0.046 | -0.152 | 0.026 |
| Total Population | 2.591e-04 | 1.481e-04 | 0.080 • | 1.771 | 0.0003 | 0.0001 | 3.54e-05 | 0.0006 |
| Median age | -3.655e-02 | 4.720e-02 | 0.439 | 2.182 | -0.047 | 0.043 | -0.130 | 0.037 |
| Per White | -5.103e-02 | 6.233e-02 | 0.413 | 1.172 | -0.066 | 0.062 | -0.188 | 0.056 |
| Per Owner Occ | 8.062e-03 | 4.542e-02 | 0.859 | 2.358 | -0.018 | 0.040 | -0.096 | 0.061 |
| Per HS 18_24 | -6.933e-04 | 1.025e-02 | 0.946 | 1.042 | -0.002 | 0.010 | -0.022 | 0.018 |
| Median Earnings | -1.591e-05 | 4.768e-05 | 0.739 | 2.637 | 9.40e-06 | 4.38e-05 | -7.64e-05 | 9.52e-05 |
| Per HS 25≥ | -5.336e-02 | 3.885e-02 | 0.170 | 1.813 | -0.038 | 0.039 | -0.115 | 0.038 |
| Per Bach. 25≥ | 5.192e-02 | 3.457e-02 | 0.133 | 2.113 | 0.046 | 0.032 | -0.017 | 0.109 |
| AIC: 229.96 N=253 | | | | | | | | |

Level of significance: *** 0.001, ** 0.01, * 0.05, and • 0.1

*Watershed based management plan*

Results looking at local governments participating in a watershed based management plan are shown in table 3.7. Percent urbanization was found to have a significant relationship with watershed management plan participation ($p<0.05$). A positive relationship found that the more urbanized the area was, the more likely those governments were in a watershed based management plan. A negative but significant relationship was found between the percent of the population between the ages of 18 to 24 having graduated high school ($p<0.05$) and watershed management plan participation. Model averaging did not produce a highly supportive model for predicting participation in a watershed based management plan ($w_i$ =0.011). The top three

factors in the relative importance analysis were percent urbanization (RI >0.8) followed by percent high school graduates between the ages of 18 to 24 (0.6<RI <0.8) and median earnings & percent 25 years and older with a bachelor's degree being similar (0.4<RI <0.6).

**Table 3.7**. Local governments part of a watershed based management plan.

| | **Estimate** | **SE** | **Pr(>\|z\|)** | **VIF** | **Model Average Estimate** | **Model Average SE** | **Model Average Lower CI** | **Model Average Upper CI** |
|---|---|---|---|---|---|---|---|---|
| Intercept | -1.879e+00 | 3.778e+00 | 0.619 | | -1.457 | 2.249 | -5.865 | 2.951 |
| Urban | 4.846e-02 | 1.980e-02 | 0.014 * | 2.057 | 0.049 | 0.017 | 0.016 | 0.081 |
| Row Crop | -1.298e-02 | 1.506e-02 | 0.389 | 2.087 | -0.005 | 0.014 | -0.031 | 0.022 |
| Forage/Non-tilled | 1.993e-02 | 1.737e-02 | 0.251 | 2.185 | 0.010 | 0.015 | -0.019 | 0.038 |
| Water | 2.614e-02 | 3.491e-02 | 0.454 | 1.526 | 0.025 | 0.032 | -0.038 | 0.088 |
| Wetland | 5.161e-02 | 3.744e-02 | 0.168 | 1.156 | 0.048 | 0.036 | -0.023 | 0.119 |
| Total Population | 1.617e-05 | 3.315e-05 | 0.626 | 1.694 | 2.46e-05 | 3.46e-05 | -4.33e-05 | 9.25e-05 |
| Median age | 4.892e-03 | 3.207e-02 | 0.879 | 2.015 | 0.0002 | 0.029 | -0.057 | 0.057 |
| Per White | 8.752e-03 | 2.979e-02 | 0.769 | 1.485 | 0.013 | 0.030 | -0.047 | 0.072 |
| Per HS 18_24 | -1.931e-02 | 9.488e-03 | 0.042 * | 1.062 | -0.018 | 0.009 | -0.037 | 1.17e-05 |
| Median Earnings | 2.859e-05 | 3.215e-05 | 0.374 | 2.492 | 3.42e-05 | 2.61e-05 | -1.70e-05 | 8.55e-05 |
| Per HS 25≥ | -6.245e-03 | 3.445e-02 | 0.856 | 2.138 | 0.014 | 0.033 | -0.050 | 0.079 |
| Per Bach. 25≥ | 1.117e-02 | 2.246e-02 | 0.619 | 2.873 | 0.022 | 0.017 | -0.011 | 0.056 |
| AIC: 310.73 N=231 | | | | | | | | |

Level of significance: *** 0.001, ** 0.01, * 0.05, and • 0.1

## Discussion

This study explores what factors influence local governmental capacity, enforcement, outreach and education, and participation in a watershed management plan. Based on the results from this study, there is evidence showing a relationship between the type of local government capacity, enforcement, outreach, education, watershed management plan participation with some land use/cover and socioeconomic factors. Results show that factors indicating environmental pressure and educational attainment influence what steps local governments take in supporting their policies and in increasing awareness regarding freshwater conservation policies, practices and online presence.

As defined earlier, capacity includes being able to identify issues and being able to act to address those issues. We compared land use/cover and socio economic factors to whether or not local governments had environmentally focused staff positions and found total population to be positively related. First, it is plausible that population is related to governments hiring environmental staff, as population growth often is attributed to environmental degradation (Cropper and Griffiths, 1994) and staff is needed to identify impacts of population related pressure on water resources. These results support other findings that population was related to capacity, and that larger more metropolitan cities were also more likely to have increased numbers of staff dedicated to environment and sustainability work (Wild-River, 2006; Thomas and Millar, 2016). Second, larger populations, such as those found in capital cities and those governments in urban areas have a stronger resource base that "allows them to hire environmental specialists, initiate environmental programs, and take part in other external environmental initiatives" (Wild-River, 2006). Some of the smaller cities and townships located in our study region were run by part time government officials who had full time jobs in addition

to their government duties (determined through the course of initial phone conversations), leaving them with limited time to seek out alternative sources of capacity. This sentiment has been found in other environmental sectors such as sustainable energy policy, where at the local government level, smaller cities and towns felt they lacked both fiscal capacity and/or technical expertise to implement environmental protection policies (Homsy, 2015).

When comparing land use/cover and socio economic factors to whether or not local governments successfully obtained funds for hydrological studies, water quality monitoring and habitat assessment studies, we found that that educational attainment was positively related. Longer education means more knowledge about environmental issues and is thought to be one of the first steps taken to improve people's perception about conservation (Kollmuss and Agyeman, 2002; Xu et al., 2006). More knowledge about environmental issues could increase public support for monitoring and assessment programs. A more educated public could see the value of such programs to get a better idea of what is going on in their jurisdiction and encourage officials to seek funding. Additional barriers to sustainable efforts and environmental initiatives include lack of adequate funding, elected official's apathy, lack of knowledgeable staff, lack of public demand and acceptance, and opposition from the developer and business community (Saha and Paterson, 2008).

In the case of enforcement, a negative relationship was found with row crop and percent of wetlands. Enforcement of environmental policies by local governments can be beneficial as they might have more local and direct knowledge of activities, however, in an effort to seem business friendly, enforcement can take a softer, laxer approach to appear business friendly (Sjöberg, 2016; Johannesson and Johansson, 2000) which may be occurring in our study region. The negative relationship with enforcement could potentially be explained by local governments

using a more cooperative approach of enforcement. However, in agricultural regions where a more cooperative approach is taken with various local farmers' associations, working with consultants having ties to the agricultural communities could result in the process of enforcement being hijacked by those farmers' organizations (May and Winter, 1999). Our results regarding wetlands may be explained as occurring out of necessity as wetlands have historically experienced serious declines as a result of human activities such as agricultural and urban expansions, their economic importance is now being realized (Millennium Assessment, 2005). In order to preserve the ecosystem services derived from wetlands, local governments that do not have many wetlands may be enforcing ordinances to minimize direct and indirect negative impacts that could destroy wetlands and/or disrupt ecosystems services derived by the wetlands that they do have.

We found that the percentage of water within a local government had a positive relationship with governments practicing some type of outreach, information dissemination and educational programs. Our results also showed a positive relationship with total population size. Results might be related to water rich places relying on tourism and recreation to stimulate their local economies and wanting to protect those resources. In addition to traditional roles fulfilled by local governments such as infrastructure, trash and recycling, local governments are increasingly taking on roles such as environmental management as well as looking to deploy deploying public and common property resources in order to tap into the tourism sector (Shone, Simmons and Dalziel, 2016). In 2014, $22.8 billion was spent throughout the state by visitors (MDEQ, 2015), and our study region contains many beaches and parks along rivers, inland lakes and Lake Michigan shorelines. Outreach and engagement activities by the local government could be a way to harmonize both environmental management and conservation efforts with

coordinating and supporting economic interests. Residents in water rich regions are also more likely to be directly affected by things like poor water quality and invasive species, therefore more likely to take proactive steps towards conservation and seek out more information on the issues and how to be more proactive in conservation practices. Fixing water quality and invasive species problems can be more expensive than preventative measures, and local governments may be investing in education opportunities to increase awareness about the issue to minimize future mitigate expenses. In order to encourage the use of best management practices regarding water quality and protection, it is important to engage farmers, landowners and various other stakeholders (Prokopy and Genskow, 2016). Results could reflect the need to utilize different techniques needed to take a proactive approach within municipalities with large populations, including both reaching out to stakeholders and having an area where stakeholders can access information as needed, such as maintaining an online presence and having resources available citizens.

When looking what type of local governments participate in some type of watershed based management plan, we found a positive relationship with participation and percent urbanization, however a negative relationship with education. Evidence exists that environmentalism does have a powerful influence on urban growth politics (While, Jonas and Gibbs, 2004) which may be reflected in our study area. Urban areas also tend to have more community, activist and non-profit groups which encourage local governments to seek out collaborative and holistic management opportunities with other governments and stakeholder groups. Researchers found that in the field of forestry, mayors were more likely to carry out environmental legislation when the number and density of community organizations increased, due to minimal costs incurred to the government (Gibson and Lehoucq, 2003). In addition to

creating a more uniform plan of action to deal with water management, working within a watershed based management plan allows governments to share resources and knowledge with one another. Communities having a decreased education base may not have the professional connections to manage water issues or be able to identify what steps need to be taken towards understanding the health status of their water resources, and thus seek collaborative avenues as evidenced in our study. By planning on a watershed based unit, watershed contacts surveyed perceived a positive effect on public awareness of watershed concerns, interagency coordination and data availability (Durham and Brown, 1999). Reasons why some local governments may not participate in common resource management could be due to the lack of autonomy to make changes and/or not enough time to make adjustments to their internal structures (Ostrom, 1990).

Model averaging did not yield any strong supportive models for environmental capacity, enforcement, outreach/education or watershed based management planning participation. However, total population came up as important in four of the five models and three models had percent row crop as one of the top three important factors. While results show some degree of land use/cover and socioeconomic influence when it comes to implementing policy supportive actions, further research is needed in identifying factors that may increase support for these models presented.

**Conclusions**

Freshwater resources are facing many different types of threats ranging from water pollution to invasive species to habitat degradation. In order to mitigate these challenges, not only are strong and proactive policies needed, but support for those policies are needed via capacity, adequate enforcement, public awareness and coordination between multiple

stakeholder groups and agencies, particularly at the local level who are often the first line of defence regarding freshwater conservation methods.

We found that policy supporting actions varied across different land use/cover and socioeconomic conditions, with larger populated areas taking a more being proactive in supporting freshwater conservation measures and was. Informal enforcement styles that are currently being used, not invoking threats, will not result in action unless there is a strong commitment for compliance (May and Winter, 999). State funding is necessary to allow for stricter local water policy enforcement which is needed to increase citizen compliance (Campbell, Ibeanusi, and Comer, 2016), and would benefit smaller communities with limited resources and capacity to carryout policy enforcement on their own. In addition to capacity and enforcement, local governments need adapt to changing preferences in how people are seeking information, to diversify how they communicate with their constituents. While most governments do have an online presence, many local governments still rely on face to face/meetings to communicate with their constituents which may not be as effective.

Politicians not only influence environmental policy but affect how successful that policy via implementation and enforcement (Sjöberg, 2016). Further investigation is needed in how local governments support existing water conservation policies. While our results show the influence of several land use/cover and socio-economic factors on policy support, more consideration is needed in identifying further factors, beyond traditional land use/cover and socioeconomic variables, to enhance the understanding and to better predict what is driving local government action. Perhaps a broader perspective needs to be taken, including but not limited to policy maker personal characteristics, social and professional networking groups and political factors.

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## SYNTHESIS OF THE DISSERTATION

This research examined what types of freshwater conservation strategies are being used by local governments in Michigan, and if land use, land cover and socioeconomic factors influence whether or not local governments employ these strategies. We also examined what type of environmental capacity local governments had, and if they had any outreach, communication and educational mechanism in place regarding water conservation issues; we also looked at the influence of land use, land cover and socioeconomic factors on those factors.

In chapter one, we explored both the management strategies and policy supporting measures in place by local governments to protect freshwater resources. While the issue of water pollution was found to be important, gaps existed between the stated importance of water pollution and the policies and supportive actions taken to address issues like pollution and non-native species. While most governments had in place their own planning and zoning, there was limited policy and best management practices mandated or incentivized (almost 35% of the responding did not select any of the commonly suggested best management practices listed). There were geographical gaps in policy, where some governments within a watershed had policy and best management practices, and others did not. Only 27% of local governments had vegetative riparian buffer requirements in their zoning documents, 24% had storm water ordinances and 57% had an aquatic setback requirement. Watersheds proved to be a significant predictor of these ordinances. Less than 7% of responding local governments addressed wetlands smaller than five acres in size. With regards to environmental capacity, few local governments had environmentally based staff, or sought funding for water based inquiry such as water quality monitoring, hydrological studies and habitat quality assessment.

Results from chapter two show evidence of a relationship between the type of best management strategies, policy, planning and zoning used by local governments with some land use/cover and socioeconomic factors. We found that that the percentage of water within a municipality is an important factor when it comes to implementing best management strategies, addressing non-native species, and having water conservation related planning and zoning ordinances. There was a negative relationship found between the percentage of row crop in an area with addressing both non-native species and implementing best management strategies.

In chapter three, we explored what factors influence local governmental capacity, enforcement, outreach and education, and participation in a watershed management plan. Based on the results from this study, there is evidence showing a relationship between the type of local government capacity, enforcement, outreach, education, watershed management plan participation with some land use/cover and socioeconomic factors. Percent total population was found to have a positive and significant relationship with the presence of environmentally based staff and informational distribution. Policy enforcement was found to have a negative and significant relationship with percent row crop and percent wetland. Further examination is needed in determining what factors influence policy supporting actions as our model averaging results did not show high support for the models, even though total population came up as important in four of the five models presented, and three models had percent row crop as one of the three important factors. This indicates that there are there other factors that are important that were not included in our study.

As human induced pressures to the land scape increase, local governments will need to act in a manner not only to address the resulting challenges faced by freshwater systems, but to be able to support existing policy by having sufficient capacity and informational services in

place. Capacity building and integrated water resource management were found to be "targeted and coordinated" within in successful integrated water resource management programs (Leidel et al., 2011; Borchardt and Ibisch, 2013). This research is a first step in understanding what local governments are doing to protect water resources from a landscape perspective. More work is needed in furthering our understanding of local government management strategies to fully address the question of "Are local governments equipped to deal with challenges facing freshwater resources?" and "Does policy fragmentation matter?", especially in the wake of climate change, non-native species and increased incidences of water impairment.

*Management and policy suggestions*

Results of this research indicates that local governments are not on the same page with regards to including water conservation strategies in their comprehensive planning documents and zoning ordinances. Results also indicate local governments do not have high environmental capacity with regards to staff and personnel, policy enforcement and an online presence. Just over half of responding governments indicated that they were part of a watershed based plan. Based on these results, some suggested recommendations are as follows:

- *Encourage participation in a watershed based management plan, especially smaller communities and those with limited environmental capacity*
- *Increase local government awareness regarding best management practices used to prevent non-point source pollution*
- *Encourage the inclusion of wetland protection measures for wetlands less than five acres in planning and zoning policies*

- *Increased collaborations with local governments and state, university and non-governmental organizations, especially targeting rural and less populated regions*
- *Federal, State and Non-governmental organizations should seek ways to help increase environmental capacity among local governments including environmental knowledge and funding*
- *Implement a formal email or internet structure for all local governments to use for communication and informational purposes*

These recommendations can help decrease the amount of non-point source pollution, the spread of non-native species and decrease the rate of wetland loss and degradation. It can also improve communication efforts between local governments and citizens. Each recommendation should be implemented on a case by case basis, and may have certain costs related to its implementation that will need to be considered by all parties involved.

# REFERENCES

## REFERENCES

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