EVALUATION OF RIPARIAN COMMUNITY CAPITALS AND THEIR RELATIONSHIP TO ADAPTIVE LAKE MANAGEMENT OUTCOMES

By

Jennifer Lynn Jermalowicz-Jones

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ABSTRACT

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While inland lakes in Michigan provide multiple community benefits, the aquatic ecosystems in many of these lakes are now significantly degraded, resulting in damages to ecological integrity, decreased utility by citizens and a decline in the municipal tax base due to loss in property values. Lake communities vary significantly in their capacity to identify problems and implement programs to improve lake water quality over time.

This study utilizes the Community Capitals Framework (CCF) to investigate what community capitals (assets) lead to better capacity and outcomes in terms of improved management of lake resources through implementation of Best Management Practices (BMPs). It also evaluates the Trophic State Index (TSI) of the lakes relative to the various community capitals. The exploration of this approach may be used in the future to specify which assets are most needed for improving water quality. This research increases our ability to understand capital resources and ultimately make recommendations to individual communities for optimal management capacity.

Statistically significant findings include a positive correlation between cultural capital and BMPs in riparian communities with active Lake Management Plans (LMPs) demonstrating that as cultural capital increased, communities were more likely to implement BMPs. Additionally, there were significant differences between BMPs and financial capital for the riparian communities. Communities with higher financial capital that had LMP’s were more likely to also implement

BMPs. Lastly, there were significant differences between human capital and BMPs for the LMP communities, indicating that higher human capital was associated with a greater ability to implement BMPs.

For Blue, who taught me the true meaning of persistence.

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PREFACE

This dissertation is meant to assist riparian communities with the assessment of community resources as a tool for better management outcomes. The proxy indicators developed as a part of this research are based on various community capital resources that exist in riparian communities. This dissertation may also be used to bring awareness to riparian communities relative to deficiencies in resources. Existing research on the direct influences of capital resources on environmental sustainability is quite limited. The purpose of this research was to measure the varying levels of capital and investigate the strength of relationships between the capitals and sustainable management outcomes (such as best management practices or BMPs). My research is not meant to replace larger-system model concepts since recognition of hydrologic and upstream influences on water quality are important for mitigation. This research aims to determine the types and relative abundance of community capitals that are available in various riparian communities as tools for enhancing implementation of Best Management Practices (BMPs) as components of adaptive lake management.

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KEY TO ABBREVIATIONS

BMP	Best Management Practices
CCF	Community Capitals Framework
EPA	Environmental Protection Agency
GDP	Gross Domestic Product
LMP	Lake Management Plan
NPS	Non-Point Source
SES	Socio-Ecological System
TSI	Trophic State Index
U.S.	United States of America

CHAPTER I: FRAMING THE INLAND LAKES WATER QUALITY PROBLEM

I.1 Introduction to Lake Ecosystems, Their Valuation, and Human Influence

Lakes are valuable resources that provide many ecosystem services to riparian (lake) communities and others who utilize them. Services may include recreational activities such as boating, fishing, and swimming, aesthetic opportunities, water supply, and dilution of pollutants (Postel and Carpenter, 1999). Furthermore, lakes uses differ, depending on their position in the landscape and how they provide services to the communities (Riera et *al.*, 2001). Naiman and Turner (2000) determined that water has become the key limiting factor for both environmental and human populations, inferring a fair and sustainable balance should be dispersed among the two groups. Lakes offer a multitude of ecosystem services as described above and thus are vulnerable to environmental changes that result from human behaviors which may ultimately compromise these services. Costanza et *al*., (1997) estimated that the value of global ecosystem services is around 33 trillion U.S. dollars which is higher than the value of the global annual Gross Domestic Product (GDP).

In addition to the intrinsic values that lakes provide for the organisms within them, they also provide value to communities that are located proximate to them. Stynes (2002) estimated that Michigan's 11,000 inland lakes (Fuller and Minnerick, 2008) support a recreational industry that is valued at approximately 15 billion dollars per year. Inland lakes also provide economic and aesthetic values to riparian waterfront property owners through increased residential lot values and scenic views. A survey of approximately 485 riparian land owners that represented five lakes in

Kalamazoo County, Michigan, USA, was conducted by Lemberg et *al*. (2002) and revealed that the most cited benefit of lakefront ownership was the view. Unfortunately, this benefit is coveted by so many citizens that it results in over-development of lake shorelines. Morton and Brown (2011) are quick to emphasize the paradox between humans and degraded waters since humans inherent both the ability to pollute waters and solve water degradation issues. They further explain that existing policies for addressing water quality also ignore human social components as they were originally developed for agricultural practices to reduce soil erosion.

A growing amount of literature attempts to explain the relationships between water quality of lakes and the associated property values. Scientists and economists have conducted these studies to assist policy makers with environmental decision-making and to help local economies through protection of municipal tax bases with lake improvements. The inclusion of local stakeholders involved in the conservation and management processes is desirable. Doss and Taft (1996) studied wetlands and lakes in Ramsey County, Minnesota, USA, and determined that the size of the living area and lake view were the most determinant variables on property values. Additionally, most riparian owners desire an open-water system or a scrub-shrub wetland over forested wetlands or those that contain predominantly emergent aquatic vegetation. Halstead et *al*. (2003) assessed the impacts of the invasive aquatic macrophyte, *Myriophyllum heterophyllum* on lakefront properties in New Hampshire, USA, and found that property values declined significantly for uninfested lakes. Additionally, Krysel et *al*. (2003) conducted a hedonic analysis of multiple water quality variables and how impaired states of these variables reduced lakefront property sales in the Mississippi Headwaters (USA) region. A major finding in their study was that water clarity reductions in area lakes would result in property value losses estimated at millions of dollars.

Other regions such as Chesapeake Bay, USA, have also been jeopardized by water quality degradation due to land use activities such as overdevelopment and agricultural runoff. A hedonic analysis by Leggett and Bockstael (2000) showed that homeowners were willing to make the necessary financial contributions to reduce concentrations of fecal coliform in area waters to protect human health and the water resource.

Lakes are complex ecosystems with metabolisms that drive the cycling of nutrients and sustain multiple forms of life (Smith and Prairie, 2004; Staehr and Sand-Jensen, 2007, among many others). These ecosystems are vulnerable to pollution and disruptions from the surrounding watersheds which usually include non-point source (NPS) pollutants such as nitrogen and phosphorus (Carpenter et *al*., 1998), and the introduction of invasive species (National Research Council, 1992; Bohn and Kerschner, 2002; Joyce et *al.*, 2006; Crowl et *al*., 2008). This idea of ecological connectedness is not new, and in 1969, Odum defined an ecosystem as a unit that is comprised of all organisms in a location which interact with the physical environment and results in energy fluxes and trophic structure within the system. The metabolism of the local area (urban metabolism) as initially defined by Wolman (1960), may also be subject to energy flows from outside the boundary of the natural resource (Huang et *al.*, 2010) and thus consideration of these extraneous flows can be critical.

The diffuse nature of NPS pollution makes mitigation of negative impacts challenging and sometimes impossible. Per the Millennium Ecosystem Assessment (2005), the major causes of lake degradation are overdevelopment, land use conversions, water withdrawal, anthropogenic eutrophication and pollution, invasive species introductions, and overexploitation and resource overuse. It is estimated that approximately 85% of the streams in the United States (U.S.) possess phosphorus concentrations that exceed U.S. Environmental Protection Agency (EPA) criteria for clean waters (Heinz Center, 2008). Thus, there is an inherent vulnerability of lake systems to the actions of humankind. Additional research is needed on the thresholds of aquatic ecosystems and the alternative stable states that can follow, since these states often possess less desirable water quality characteristics than the original state (Scheffer et *al*., 2001). Walker and Salt (2006) offer the term "resilience", which they define as: "The capacity of a system to absorb disturbance and still retain its basic function and structure." Although it can be argued that an alternative stable state, often precipitated by pollution events, allows an aquatic ecosystem to maintain a "basic structure and function", this is usually not the ideal goal since degradation leads to a decline in water quality and biodiversity as evidenced by computed indices of biotic integrity (Karr, 1991; Blockstein, 1992; Hughes and Noss, 1992). Vitousek et *al.* (1997) discusses the substantial impacts imparted by the human population on resource systems through multiple influential vectors that ultimately decrease biodiversity. Scheffer et *al*., (2001) concludes that construction and maintenance of ecosystem resilience through facilitation of the desired state is the recommended strategy for sound ecosystem management in an environment in constant flux.

Incentives for lake conservation and management are often large and impact the system on both economic and ecological scales. O'Riordan (1999) recommends that the economic valuation involved in the management of a natural resource be a participatory process with stakeholders so that all parties can weigh the costs and gains of the management outcome(s). This was especially important in the Oregon (USA) Plan for Salmon and Watersheds, which was designed to restore the populations of coastal salmon through the encouragement of residential property owners to grow riparian vegetation buffers that reduced streamside water temperatures and provided salmon spawning habitat. A hedonic pricing analysis of streamside property values before and after buffer implementation showed a reduction in property values after the buffers were installed (Mooney and Eisgruber, 2001). Conflicts between the use of water resources and the proper management are common in riparian habitats since financial resources are at stake. It is therefore important that incentives to protect both the lake resource and property values be projected to the residents to increase the probability of citizen support. It must be realized that even with the existence of "private" lakes, all lakes can be considered "common pool" resources since they are shared with other people either within or external to the riparian community.

I.2 Lakes as Common Pool Resources and Sense of Place

It is arguable that public-access lakes could be classified as "Common Pool Resources" (CPR's) since populations outside of the riparian community have access to the same resource, and the consumptive actions of the individuals reduce resource availability to others (Hardin, 1998). Hardin (1998) further warned that resource depletion beyond the carrying capacity of a commons system is inevitable if the system goes unmanaged. Alternatively, lakes held in completely private ownership by shoreline riparians are also vulnerable to resource depletion if consumptive rules and regulations are not in place. Privatization alone cannot guarantee protection of a natural resource. Libecap and Wiggins (1985) discussed the inherent challenges that privatized resources face due to the inability of the organization to agree on use regulations of the resource. Feeny et *al*., (1990) emphasized the need for the acknowledgement of a local property rights regime relative to the resource since this is an often-overlooked component of a Socio-Ecological System (SES). He describes the classification of property ownership in four groups including: 1.) Open access, where use of the resource is available to all and more likely subjected to overuse and degradation, 2.) Private property, where there is exclusive ownership, sometimes collectively, of the resource and where rational exploitation does not guarantee a sustainable outcome, 3.) Communal property where there is voluntary oversight and management of the resource, and 4.) State property where state ownership utilizes regulations for management of the resource but sustainability is not guaranteed and is dependent upon regulation enforcement and awareness of such regulations by external users. If open-pool resources (commons) and privatized systems are not exempt from resource exploitation, then it will be challenging to manage natural resources such as lakes to guarantee ecosystem services for future generations.

Another necessary component that cannot be overlooked is the sense of place that the riparian community has in relation to the water body. Jorgensen and Stedman (2006) surveyed 290 lakefront owners in Northern Wisconsin (USA) about their perceptions of sense of place for their waterfront properties and determined that owners with greater property development believed that the lake was the central focus of their perception of their properties. A study of multiple natural resources such as forests, streams, lakes, wetlands, prairies, and open fields was conducted by Wang et *al*. (2012) in southeast Michigan, USA, who found that lakes and streams had the highest level of importance to property owners. This finding emphasizes the importance of these water resource systems to riparian communities. How can riparians around the lake enjoy their sense of place and act in an environmentally responsible way? The solution will likely involve not only adequate knowledge of the ecosystem and its vulnerability, but incentives from the riparian community to preserve the resource for the entire lake community. A framework for governance and management would allow for consistent management of many inland lakes that could utilize similar resources with beneficial outcomes. At the heart of such a framework lies the concept of sustainability since it must be present to allow for long-term management of a commonly shared lake resource.

I.3 Elements of a Sustainable Lake Community

The concept of sustainability is likely an evolving concept that should be tailored to the specific locale under study to allow for maximum flexibility under changing conditions (Thompson, 2007). Thus, it is likely that a "universal model" for sustainability may not be achieved.

Meadows et *al.* (2004) cautioned that the ever-expanded global population will eventually be forced to reduce resource over-consumption through human behavior, organization, or technologies, or be compromised by inevitable resource limitations which could result in an unhealthy environment. Orr (2003) also warned us that: "A world of ever increasing economic, financial, and technological complexity cannot be sustained because sooner or later it will overwhelm our capacity to manage". He further elaborated that the major barriers to sustainability lie in social, political, and psychological forms, as opposed to purely technological forms. Lubchenco (1998) offered a concrete and functional definition of sustainable systems which would possess attributes of ecological soundness, economic feasibility, and social justice. In regards to these attributes, ecological soundness can be derived from careful management, economic feasibility can be assured through prioritization of improvement goals and corresponding cost analyses, and social justice can be obtained through inclusion of all stakeholders that have an association with the lake resource. Thus, it is synonymous to label a sustainable system as a derivation of an adaptive management process.

The scale of the community regarding the resource being exploited must also be considered for successful sustainable conservation measures (Dresner, 2002). For the conservation and management of lake systems, the riparian community combined with the local municipality seems appropriate in size for sustainable governance of lake resources. Clearly, this proposed community structure would involve only those that have a genuine stake in the lake resource and would lead to greater participation and ultimately conservation of the lakes. Flora (2004) discovered that communities need a shared vision of their future existence to drive change. It must not be ignored that lakes which span more than one municipal jurisdiction may be susceptible to more externalities and the riparian and municipal community may be larger in size. Everard (1999) cautioned that sustainable management of still water resources (i.e., lakes) must account for externalities that may complicate conservation efforts due to distant sources. An example of such an externality would include materials brought to the lakes from the watershed. Many watersheds in Michigan transcend multiple jurisdictional boundaries which make exclusive local governance of a lake resource more complicated.

How can we meet the demands of society in relation to development and ecosystem services without degradation of the resource in question? In the context of inland lakes and shoreline development, users and especially owners of the resources are often shocked when the ecosystem collapses in the form of hyper-eutrophication (as in the case of lake-wide Harmful Algal Blooms, or HAB's) or dramatically altered water levels (most commonly associated with excessive water withdrawals). Ostrom (2009) warned that the users may not be informed of the carrying capacity of the resource which ultimately results in resource commodity failures and ultimate destruction or depletion of the resource. This statement emphasizes the strong need for an understanding of the resiliency of the lake resource by all that benefit from it and its limits and thresholds to pollution sources, as well as accountability by the public to protect the lakes and gain services without exceedance of these thresholds. Ostrom also elaborated that there must be a thorough understanding of conditions specific to a certain region so that governance rules created by the users and governmental units remains sustainable. Information on thresholds for specific lakes is lacking, along with a sense of riparian lifestyle needs. Soranno et *al*. (2010) describe the model for landscape limnology which incorporates components of the lake ecosystem, land, and human land and water uses to effectively explain the landscape mosaic and allow for different variables to be used based on unique management goals. This model could be applied to any water body where land uses impact the water quality and are dependent on continuous changes. Barles (2010) elucidated that the interactions between society and the biosphere are completely inter-dependent and form the basis of sustainable development.

It becomes clear that knowledge of thresholds for each lake needs to be accurately understood, and the lake must be utilized in a manner favorable to support the local community and avoid depletion of the lake resources. Thus, we must have a sound idea of the capacity of the resource to support the local population, and of the population to manage the resource with sustainable methodologies. The capacity to manage can be increased through a thorough understanding of who is responsible for governing and managing the resource and what degree of management capacity they possess.

I.4 Elements for Sustainable Lake Management: Local Governance

Many inland lakes within Michigan, USA, are impaired and often rely on funds from Special Assessment Districts (SADs) established by local municipalities for improvements since external funding sources are scarce. Scheffer et *al*. (2001) suggest that prevention of catastrophic shifts in natural resource systems requires that an acceptable level of resilience be maintained. Such resilience may be evaluated with the community capitals framework (CCF) which could then be used to prevent ecological and economic losses of an ecosystem such as inland lakes. Once a catastrophic shift occurs the costs to mitigate the damages and restore an ecosystem to its original state may be excessive and impossible to attain. Holling (1973) was the first ecologist to define resilience as the time it takes post-disturbance for an ecosystem to return to a normal state of equilibrium.

The opportunities for local empowerment and governance in Michigan are high since there are 1,240 townships throughout the state. There is much concern about the ability of municipalities and riparian residents to effectively manage aquatic ecosystems due to limited knowledge of these complex ecosystems. Furthermore, management of these systems in the context of sustainability is uncertain if best management options of the natural, social, and economical components of the system are not well understood. Everard (1999) makes it clear that the high diversity among decision-makers requires a thorough understanding of the regional hydrological cycle so that upstream behaviors and impacts relative to specific water bodies are known. In other words, if the local lake system is considered as an isolated entity while outside or upstream factors influence its water quality, then a solution to mitigate impacts becomes nearly impossible. Inevitably, this will include stakeholders upstream of some water resources as well as additional water resources that may enter the local lake system. Morton and Wright (2011) explore the importance of multi-citizen stakeholder participation since everyone can bring unique perspectives, knowledge, and values to the forefront so that acceptance of solutions can be more widely understood.

A socio-ecological system (SES) framework is clearly needed to facilitate and govern the human roles in conservation and management of complex lake ecosystems. An SES may be defined as a highly integrative term that describes the nested variables such as resource sub-systems, resource units, users, and governance systems within the larger system (Ostrom, 2009). Ostrom also offers a framework to assist in the analysis of SES sustainability, which is undoubtedly crucial for optimum function of the system. Lake ecosystems must be viewed through the lens of an SES to begin to understand the human behaviors and activities that result in degradation since prevention is eventually needed for ecosystem sustainability.

Municipal governance was recommended by Burström and Korhonen (2001) as a means to reduce impacts of industry and society on natural resources (a.k.a, industrial ecology). They further cited that over the past three decades, municipalities have accumulated increased responsibilities for environmental actions. The responsibilities include the contributions of technical services, social services, infrastructure operations and management, purchasing of materials, employment of citizens, local planning, authoritative roles, and transference of information to residents. Undoubtedly, continued assurance of these services results in increased stability and resilience of the municipal community. The capacities of these municipal responsibilities can be determined through the recognition and measurement of community capitals present within the municipality.

Ostrom (2009) mentioned that although scientific knowledge (technical capital) is beneficial for solving complex resource management problems, there has been a disconnect between the ecological and social sciences. She mentions that SESs are necessary for addressing environmental issues but they must be sustainable. This would require some metrics to evaluate the sustainability of an SES. Ostrom offers many metrics that could be used as a framework for SES evaluations. However, in a riparian-lake SES, a possible web of metrics could include the community capitals framework proposed by Flora (2004).

Flora et *al*. (2004) recognized seven types of capital including natural, cultural, human, social, political, financial, and built capitals that are acknowledged by the most sustainable communities. Capitals are defined as existing resources that are used to develop new and stronger resources. Natural, cultural, and human capitals comprise the foundation of community composition. Mäler (2000) reminds us that natural capital often encompasses complex, non-linear systems that are difficult to predict. The behavior of these systems must not be overlooked since there exists an urgent need to measure the resilience of these systems and a thorough understanding of them is pivotal for successful conservation. Additionally, consideration of both the costs of conservation and the costs of a potentially damaged resource state are necessary to make sound and often sacrificial management decisions. Magis (2010) discusses the components of community resilience and emphasizes that in times of uncertainty a community strong in resources that are shared among members is more likely to thrive than one without ample resources. Pretty (2003) concluded that communities with higher social capital can participate more readily in collective activities and have more trust that results in increased cooperation. Precise evaluation metrics are needed to determine the magnitude of capitals present within a municipal community for water resource conservation and management. Increased cooperative efforts would likely result in achievement of common objectives and goals and lead to a successful conservation outcome.

Michigan riparian communities offer a unique opportunity for the study of these forms of capital and the inherent importance of them for the management of inland lakes because riparian communities often lie within one or a few municipalities and can be clearly delineated since the responsibilities of lake management activities rely almost entirely on the bordering riparian community and the local municipality (Jermalowicz-Jones, personal observation; Figure 1). Morton (2008) stated that a combination of regulation (policy) and scientific knowledge is not enough to solve a major environmental problem such as NPS pollution. Morton recommends that civic engagement is a necessary and effective tool for achieving complex goals. Civic groups need to have access to management tools such as those utilized by farmers in Iowa, USA and Ohio, USA since they rely on data from metrics such as the phosphorus index and soil condition index for data-driven management decisions to protect their yields.

Although riparian communities would need different tools than those utilized by farmers, they could benefit from a collection of various tools that assist them with the co-management of their unique lake resource. This is one advantage that riparian lake associations have in that they are a civic group of collective thoughts and actions that determine management outcomes. In reference to the CCF, policy would be in the political capital category, whereas scientific knowledge would lie in the technical capital category and civic engagement may fall into human and social capital categories. For purposes of this research, I will focus solely on riparian communities as a beginning approach to a broader SES model that may then encompass municipalities as an additional resource.

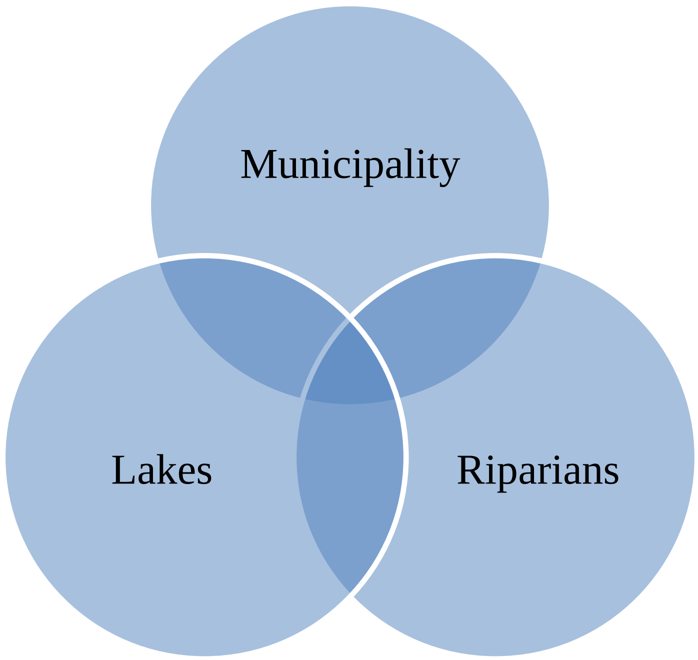

Figure 1. A diagram showing the interconnectedness and interdependence of lake resources, municipalities, and riparian communities.

A local framework for the conservation and management of inland lakes is lacking in Michigan, USA, and it is critical that one needs to be developed. In 1997, the Michigan Department of Environmental Quality (MDEQ) and the United States Geological Survey (USGS) formed the Lake Water-Quality Assessment Monitoring Program (LWQA) to assess the conditions of over 700 inland lakes by 2015 (Minnerick, 2004). Even though these efforts are critical to determine the baseline conditions of many recreational lakes in the state and recommend continued lake water quality monitoring, they do not establish a long-term process for the conservation and management of these systems. Environmental parameters and their responses to mitigation efforts (i.e., such as BMPs) are sometimes difficult to measure, especially in short time intervals, due to inherent "lag times” that may be present once an improvement effort is implemented (Meals et *al.*, 2010). Dobson et *al*. (2007) acknowledge that lake restoration methods require significant amounts of time to show intended improvements and thus recommended that restorative measures mimic the natural system to expedite any revelations. This finding further emphasizes the need for a framework that also supports long-term monitoring in addition to initial baseline water quality assessments to measure restorative efficacies.

Federal and state involvement in lake management is minimal, limited only to the issuance of lake improvement permits or regulatory oversight as required by the Clean Water Act of 1972 and the Natural Resources Environmental Protection Act (P.A. 451 of 1994), respectively and also to periodic fish stocking and surveys. The capacity is lacking for these regulatory levels to efficiently and effectively manage most of the lakes in the state. It can therefore be argued that lake conservation and management should be executed at the local level, with enhanced cooperation of the municipalities involved and the riparian communities. Kennedy (2003) reminds us of the relatively greater number of successes for local conservation through balancing of conservation objectives with recreational values compared to conservation management at the global scale. However, Birch and McCaskie (1999) cautioned that management of shallow urban lakes (London, U.K.) by local municipalities can be disadvantaged through the lack of knowledgeable experts to manage the lakes and to funding limitations. Because of this revelation, retention of environmental experts to effectively educate and guide the community is strongly encouraged. The expert could produce models that link together elements of local SES’s that would ultimately provide policy makers with a comprehensive view of their proposed actions, as recommended by Naiman (1996). The Sustainable Development Records (SDR) method proposed by Nilsson and

Bergström (1995) offers key indicators that measure the sustainability of an operational SES relative to the resource base and ecosystem services provided. A primary benefit of this method is that it allows stakeholders from different components of the system (i.e. policy makers, scientists, municipal leaders, etc.) to look at the system sustainability from an economic viewpoint, even given different foci relative to their fields of expertise or roles in society.

While involvement of the municipality is critical, we cannot undermine the importance of other stakeholder involvement. Riparians are lakefront property owners who have a direct stake in the conservation of lake resources. Many environmental management programs have failed because of a scarcity in stakeholder participation. Herath (2004) described the loss of wetlands in Victoria, Australia and attributed this to poor management that occurred without stakeholder input which was critical to the development of alternative objectives.

Ultimately, the fate of the lake resource depends on the coherency and decisions of the community and therefore requires robust community participation. To determine the components that comprise a well-structured community in regards to sustainable lake conservation and develop a functional framework, the concept of sustainability must be thoroughly investigated as it applies to riparian communities. Investigation of riparian communities allows for an initially simple model that incorporates a clearly defined community. In other words, there must be a thorough understanding of local level governance to understand what additional resources may be contributed from the municipalities.

I.5 Lake Management and Governance at the Local Scale: Components for a New SES Framework

Conservation scientists and policy-makers have uncertainties regarding the efficacy of local governance to manage inland lakes and other waterways. This phenomenon is not limited to lakes in the United States, as Europe also struggles to regulate lake eutrophication through the classification of lakes as Sites of Special Scientific Interest (SSSI's). The SSSI's are physical as well as legislative units where surrounding land is not included in regulations but may have devastating impacts to water quality through contributions of agricultural nutrient loads (Wilson, 1999). Certainly, such legal segregation of the natural resources (land and water) is not harmonious with the connectedness of these resources and makes potential management of non-point sources to the lakes nearly impossible. The water framework created by the European Union has clearly intended to remove nitrogen in addition to phosphorus as a regulatory mandate (Chave, 2001). The European Union Water Framework Directive (WFD) was adopted by the European Commission in 2000 for priority lakes that have the greatest benefit to cost ratio. The primary goal is to achieve good ecological health in these lakes by 2015. A study of recreation data by Vesterinen et *al*. (2010) determined that if a one-meter water clarity improvement was made for these lakes, then there would be a 6% increase in local swimming and 15% increase in local fishing activities. It is critical that lake improvements not only be effective but also do not contribute to overuse of the resource, although use by the local community would likely help support the local taxation base for the municipality. A thorough analysis of the European Union (EU) Life Programme for the management of urban lakes in the London Borough of Wandsworth yields a highly informative approach of the transference of ecological knowledge of specific lake systems to lake managers. The proposed management model allows for a tailored management process that addresses the use of each lake system (relative to the lake users) in a context that corresponds to compatible management or restoration methodologies (Birch and McCaskie, 1999). Holling and Meffe (1996) warned that a "command-and-control" management approach leads to a reduction in heterogeneity of an ecosystem, which inherently reduces its resilience due to loss of essential functions provided by biodiversity. Thus, this approach would not be ideal for the management of inland lakes.

Minnesota, USA, utilizes mandatory Watershed Management Organizations (WMO's) to manage surface waters within a watershed district. The WMO's lack the power of property taxation but can be funded by municipalities since they are governed by members appointed by municipalities. There have been difficulties, however, with the management of local waterways at a watershed scale due to observed differences in jurisdictional government and social structures, among other attributes. Furthermore, reliance on state and federal programs to manage inland waterways at the local level is unrealistic given the high quantities of these systems and their continuous need for effective management. White et *al*., (2009) elaborated on the importance of Critical Source Areas (CSA's) for the detection of specific environmental problem areas that could be addressed more readily and efficiently.

Even if local participation in lake conservation and management from riparian communities and municipalities is successfully executed, there exists a strong need for a framework with sustained funding mechanisms and environmental expertise. Furthermore, exclusion of the roles of property owners associated with the resource and heavy reliance on governmental representatives has been significantly linked to watershed planning failure. Differences in values as well as priorities between these two key groups have resulted in irresolvable conflict and thus the planning process should consider the entire watershed which includes all property owners and not predominantly ecological advocates (Woolley and McGinnis, 1999). Dietz et *al*. (2003) cautioned that governance at the local scale may also have to consider outside forces (such as externalities such as non-point source pollution) and thus it may be necessary for layered institutions to be involved to resolve possible resource use conflicts. Conflict over management regimes of CPR's likely arises from differences in knowledge, interpretation, pre-conceptions, and priorities about the resource in addition to material interests (Adams et *al*., 2003).

A sustainable management process should be adaptive in natural resource issues (Williams, 2011) where uncertainty and controllability are high (Allen et *al.*, 2011). The National Research Council (2004) identified adaptive decision-making as the formulation and sharing of objectives, identification of management alternatives, consideration of resource management consequences and possible uncertainties, along with monitoring procedures. There is indeed high uncertainty in the management of inland lake systems because they are not strictly ecological, but rather socio-ecological systems. However, the management potential of inland lake problems is significant since behaviors of riparians or those that utilize the lake resource can be readily altered, often when adequate knowledge of the resource is given. Allen et *al.*, (2011) also offered a structural recipe for the components of adaptive management which included a clear vision of the goals, flexibility with the determination of alternative management objectives and causative hypotheses, and methods for data collection which were amenable to evaluation and repetitive measurement. In addition, Allen and Gunderson (2011) described the nine most likely reasons for the failures of adaptive management programs. Such failures included a lack of consensus among stakeholders on the definition or ingredients of an adaptive management plan, lack of coordination between scientists and policy makers, lack of leadership, lack of metrics for determining adaptive management success, lack of funding for necessary continued monitoring, research goals dominated by research or biased interests, scientific overstatement of research capacities, and lack of shared decision making. Martínez de Anguita et *al*. (2008) emphasize the need for integration of stakeholder ethics into decision-making frameworks that aim to achieve sustainable and long-term environmental conservation objectives.

From the literature review above, it is apparent that a multitude of variables needs to be considered for the development of a sustainable inland lake conservation framework for Michigan. First, there needs to be a sound analysis of the capacity of a local municipality and the riparian community to effectively manage the resource. Second, there needs to be a clear understanding of the lake resource governance, how decision-making processes should be executed, and who is ultimately responsible for sustainable management of the lake ecosystem. It cannot be emphasized enough how critical the sociological component is to continued sustainability of any water quality improvement or conservation program (Gooch et *al*., 2012; Morton and Brown, 2011; Mascia et *al.*, 2003). For example, the sociological interaction of farmers in an agricultural watershed may allow for more successful performance-based goals for non-point source pollution reduction (Morton, 2008). Ultimately, the CCF may assist in the prediction of degree of success of costly experimental policies to minimize wasted costs and efforts (Walters, 1997). Third, adequate access to knowledge of the complex lake ecosystem (either contributed from experts or from local institutions), including critical thresholds, must be available and effectively relayed to all the stakeholders. Fourth, the compilation of any critical information for conservation of the resource (i.e., water quality monitoring, data collection, CSAs, modeling, etc.) should be participatory and involve citizens from both the riparian community and municipality, and if applicable include institutions from outside of the system that impact the lake resource. Lastly, the proposed framework should also engage an adaptive management strategy due to the rapidly changing conditions of the SES.

Since it is important that a proposed framework for sustainable inland lake conservation and management must be developed, I would offer the hypothesis that sustainable lake conservation and management is dependent upon sustainable and resilient communities that are, in turn, dependent on well-managed resources or municipal community capitals for continuous sustenance. A careful analysis of each of the components necessary for a sustainable and resilient community and lake resource is needed to generate predictive models that could determine the potential long-term benefits from the proposed framework. Huang and Xia (2001) mentioned that the myriad biological, physico-chemical, hydrological, socio-economic, and environmental management elements that comprise complex aquatic SES's cannot be considered separately but must rather be integrated in a system model. The model must be tested with inland lake riparian communities in Michigan to determine if the framework would have standing. The following chapter introduces critical components for the evaluation of management capacities of individual riparian communities and the theoretical rationale for the selection of these components.

CHAPTER II: DEVELOPMENT OF HYPOTHESES AND THEORY ON THE ROLE OF COMMUNITY CAPITALS IN INLAND LAKE MANAGEMENT

II.1 Community Capital Resources and Their Roles in Riparian Communities

There are seven major categories of community capitals that are used as resources for community function and sustainability. Flora (2004) defines capitals as “resources used to create new resources”. In reference to riparian communities, evaluation of available forms of capital will allow for the development of a sustainable capital resources tool to assist them with the co-management of their lake resource. Flora (2004) further demonstrates that there exists significant overlap of the capitals and that this overlap becomes pivotal for best management outcomes (Figure 2). In fact, Miller and Buys (2008) indicate that to date only a small amount of studies has investigated the relationship between social capital and sustainability. Furthermore, sustainable development is dependent upon future generations having access to at least the existing levels of capitals (Serageldin, 1996). Scholars have agreed on most of the definitions of these capitals, although some individual characteristics can be modified across disciplines. There is significant debate about the indicators for these capitals and how those indicators predict community functions and outcomes. Thus, careful analysis of all indicators that could be applied to community inland lake management are being pursued to assure the most precise measurements for future predictions and models. Additionally, collection of baseline values for each capital will allow for the determination of future community sustainability. A description of each form of community capital is discussed below.

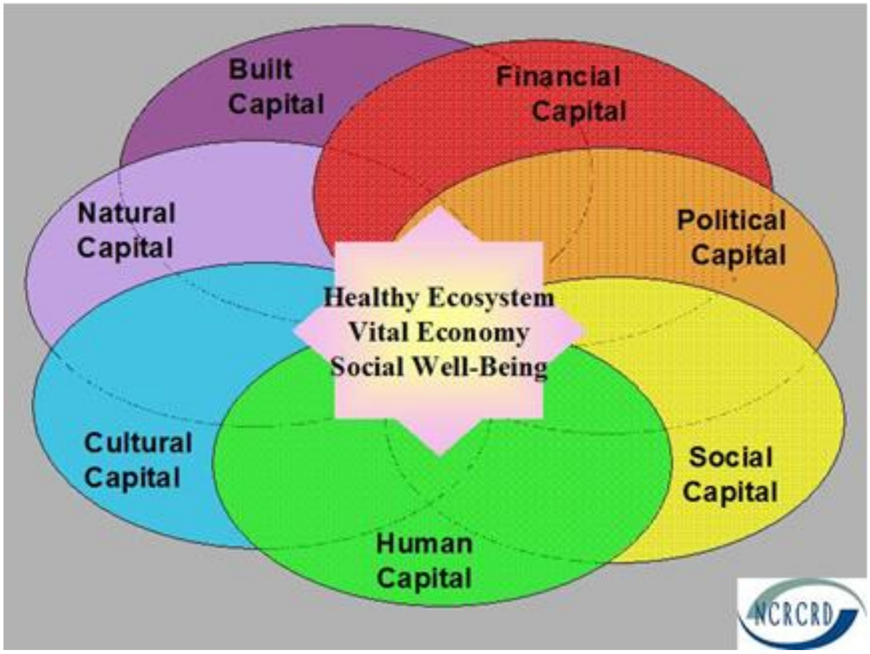

Figure 2. The overlapping of critical community capital forms and the positive shared outcomes of that relationship (Flora, 2004).

II.1.1 Social Capital

Social capital was first introduced to the literature by L.J. Hanifen in 1916 as he learned that community involvement was critical for successful education in rural schools. Social Capital was defined by Putnam (2000) as: “The social connectedness of a community or the glue that enables people, organizations, communities, and nations to work together collaboratively for mutual benefit.” Social Capital can be more broadly defined as the interactions among individuals and groups within a community (Flora, 2004). It includes attributes of trust, reciprocity, cooperation and membership, common visions and goals, acceptance of alternative views, leadership, and diverse representation and contributes to economic and social development. In fact, problem-solving capacities are generally higher in communities with high social capital (Cohen and Prusak, 2001), which is important for natural resource management efforts. This was evidenced in the case of the San Francisco Bay Plan which occurred post-Clean Water Act since social capital was the only form of capital initially available to drive conservation in the area. Putnam (2000) defined social capital as connection that allows community members to work together for mutual benefits. It is critical to realize that not all social capital results in positive outcomes and so special attention should be directed to the situation and context involved (Miller and Buys, 2008; Hogg et *al*., 2012). It can however, be a useful tool for policy makers since measurement of its capacity can determine the diversity in social capital, if any that may be useful for avoiding land use and natural resource management conflicts (Dale and Sparkes, 2007.)

Flora (2004) mentions that not all bonding social capital is constructive since divisions among community members and the formation of cliques may prevent unity among an entire community. Bridging social capital can help overcome this but by itself is also not effective (Hernandez, 2003). Bonding and bridging social capital are different in that the latter refers to social connections between heterogeneous groups whereas the former refers to the connections of homogenous groups. In fact, if when bonding social capital is high and bridging social capital is low, the community is less likely to accept "outsiders" that may be critical to solving a given problem. Alternatively, when bridging social capital is high and bonding social capital is low, the internal community is weak regarding external forces and ownership struggles may result. Furthermore, Woolcock (2000) introduced the term linking social capital as the relationship between community groups and power figures. Miller and Buys (2008) emphasize that not all social capital is "positive" and certain forms may not assist with the development of a sustainable community. They discuss favorable environmental behaviors and unfavorable forms of behavior. Unfavorable behavior may originate from socially proactive people that are more concerned with speaking out on an issue or appeasing neighbors than favoring what is best from a sustainability perspective. In reference to my research, this would be manifested by communities that refuse to implement BMPs not necessarily due to cost but due to a judgement that particular BMPs may not be aesthetically pleasing or may not be in their best interest (as opposed to nature).

II.1.2 Cultural Capital

Cultural capital refers to world views and it is usually cultivated over generations and includes language, behavior, recognition, celebration, world view, and values. Flora (2004) explains that cultural capital may influence natural capital since human behaviors can have marked impacts on natural systems. It is possible that different individuals within a given community can have unique world views due to their life history and experiences but still share a common goal or objective.

Cultural capital also encompasses the idea of legacy which is what a current generation passes on to the next or a previous generation passed on to an existing generation. This has a potentially important bearing on riparian communities since some of them have had several generations living on a specific lake. These people may have significant knowledge of the lake's history and therefore be more tuned in to current issues involving the lake's health. Conversely, some riparian communities have fast turnover of lake residents and this could potentially lead to confusion regarding the lake's issues since historical knowledge and baseline data on the lake may be limited or scarce. Legacy is associated with a sense of place. So if a lakefront home is passed down to younger generations, there could be a strong probability that those younger generations would inherit that same sense of place. Flora (2008) also points out that sometimes cultural capital can be reduced by the introduction of new governing policies or political capital. This is perhaps a good reason why there needs to be a thorough understanding of cultural capital within a community so that future policy change can take that into consideration and avoid the potential loss of valued cultural capital.

II.1.3 Natural Capital

Natural capital refers to natural geographic resources such as land, water, climate, scenery, living biota, and biodiversity. In other words, natural capital refers to natural geographic features. Additionally, natural capital may be considered a foundational form of capital since it is a resource which often determines human behavior and action. The maintenance of natural capitals in a community allows for sustainable resource use while populations increase if the stock is not substantially reduced. Sseguya et *al*. (2009) explain that reduced resources (such as natural) capital are often due to deficiencies in other community resources. This is one reason why protection of natural capital is complex and must investigate many different types of resources. Furthermore, understanding the costs that natural capitals provide also allows for better conservation efforts with a growing population (Costanza and Daly, 1992). Folke et *al*. (1994) remind us that natural capital depends on other forms of capital such as human and financial capital preservation and protection. This is crucial for the natural resource to continue with the contributions of ecosystem services. As described above, lakes are a form of natural capital as are other facets of natural landscapes. In reference to lake systems, this form of natural capital essentially creates financial capital in the form of waterfront properties and the associated tax revenue base. Of particular importance is the realization that natural capital is often non-renewable and thus these resources are highly vulnerable to depletion and degradation. Natural capital is thus susceptible to exploitation from the "commons" and a thorough understanding of its stock is critical for its preservation in a lake community. This is important to realize since natural capital must be present for economic development to progress in a community (Berkes and Folke, 1992). Jansson and Jansson (1994) discuss the importance of biodiversity for preservation of natural capital stock. In reference to lake systems, this would include protection of the fish, benthos, and other wildlife. Implementation of BMPs for the protection of lake biodiversity would thus conserve natural capital. This concept is discussed in further detail relative to the methodology executed by this study.

II.1.4 Built/Technical Capital

Built capital refers to infrastructure, buildings, hardware, housing, and utilities or producer goods. Technical capital may refer to learning resources and their availability. In riparian communities, this may include the lakefront properties, local libraries, GIS, and informational centers, schools, and other built structures. These forms of capital may also be limiting if other forms of capital such as social capital are low. In other words, the needs of local communities through open communication may best dictate the types of built capital for a given community as this is often need-based. One advantage that a riparian community may have with respect to abundant built capital is the ability to have roads altered or graded that may be contributing to runoff into the lakes. Many rural lakes have dirt roads that may sometimes wash into the lake and contribute sediment and nutrient loads which leads to water quality degradation. Abundant built capital may assist such communities with technologies that could improve the local environment.

II.1.5 Financial Capital

Financial capital includes debt and investment capitals, savings, tax revenues, donations, contracts, reallocation, loans, poverty rates, grants, and tax abatements. Financial capital may be closely linked to political capital when governmental entities are involved in the granting of funds. A natural resource such as land or a lake may also be considered as a component of financial capital if those resources yield new resources. In riparian communities, this would manifest itself in lakefront properties which have considerably higher value when on waterfront versus the same property not on a waterbody. This may also serve as an impetus for moving forward with a Lake Management Plan (LMP) since the plan itself requires significant financial capital to improve the lake resource and have it yield more financial benefits to the riparian community. Riparian communities with high financial capital would thus be able to implement more improvement methods since the costs could be paid. It is important to note that even with high financial capital, other forms of capital may be needed to drive change or implement solutions since human capital also contributes to financial capital through labor activities. Another significant source of financial capital may arise from the local municipalities since they may be able to contribute financial resources to riparian communities through the acquisition of grants or direct donations.

II.1.6 Human Capital

Human capital refers to the population, creativity, educational attainment, skills, health, and abilities of community individuals. Economists consider investments in the attributes as additions to human capital that cannot be separated from the individual the same way that physical or financial assets could be (Becker 2002). In general, smaller communities are less diverse and usually have lower human capital. However, that may not always be the case since a smaller community that is well educated may also have a high level of human capital. The type of training and education may be a significant contributor to the activities that would be implemented in a riparian community. For example, a riparian community with a high number of citizens educated in medicine would likely have different knowledge of lake issues relative to riparians trained in lake ecology.

Innovation is another attribute that lies within human capital and may also be an impetus for moving forward with new technologies for lake improvement such as Best Management Practices (BMPs). Human capital also refers to the "power in numbers" rule since more people can assume more roles and not be overtaxed for numerous duties. It also incorporates the concept of work ethic since laborers in the workforce are an example of strong human capital. In relation to riparian communities, a lake association with a higher number of participants would be expected to be able to execute more activities than a considerably smaller group. Flora (2004) explains that the trio of natural, cultural, and social capital form the community base and at least those forms of capital must be recognized before outside experts or resources can assist with water resource management issues.

II.1.7 Political Capital

Political capital refers to the mobilization of community resources through political proponents such as policy makers. The major components of political capital are connections, power, voice, ability of local governments to acquire resources for a community, and organization (Flora, 2004). For example, many small communities will directly contact a legislator to influence regulations rather than work together as a small group to create plans for themselves to request distribution of governmental resources.

II.2 Research Questions & Hypotheses

Research Question: How do we measure the capacity of lake associations to respond to water quality impairment?

Sub-question 1: Which community capitals influence lake association riparian community capacity to implement water quality best management practices (BMPs)?

Sub-question 2: Are there any significant correlations between community capitals and water quality?

Research Design: Use the community capitals framework (Flora, et *al*. 2012) to measure differences in capital assets (e.g. human, social, cultural, political, natural, built/technical, and financial capitals) among riparian communities and determine the relationships between these community capitals and BMPs and Trophic State Index (TSI) in sample populations with lake management plans (LMP) and without lake management plans (non-LMP).

II.2.1 Hypotheses

Hypothesis #1:

H_0: There are no significant differences in mean capital for LMP and non-LMP riparian communities.

H_A: There are significant differences in mean capital for LMP and non-LMP riparian communities.

Note: These hypotheses are tested for all seven forms of capital.

Hypothesis #2:

H_0: There are no significant differences in mean BMPs for LMP and non-LMP riparian communities.

H_A: There are significant differences in mean BMPs for LMP and non-LMP riparian communities.

Hypothesis #3:

H_0: There are no significant correlations between BMPs and each form of capital in LMP riparian communities.

H_A: There are significant correlations between BMPs and each form of capital in LMP riparian communities.

.Hypothesis #4:

H_0: There are no significant correlations between BMPs and each form of capital for non-LMP and riparian communities.

H_A: There are significant correlations between BMPs and each form of capital for non-LMP riparian communities.

Hypothesis #5:

H_0: There are no significant differences in mean TSI for non-LMP and LMP riparian communities.

H_A: There are significant differences in mean TSI for non-LMP and LMP riparian communities.

Hypothesis #6:

H_0: There are no significant correlations between TSI and community capitals for LMP riparian communities.

H_A: There are significant correlations between TSI and community capitals for LMP riparian communities.

Hypothesis #7:

H_0: There are no significant correlations between TSI and community capitals for non-LMP riparian communities.

H_A: There are significant correlations between TSI and community capitals for non-LMP riparian communities.

CHAPTER III: RESEARCH METHODOLOGY

III.1 Selection of Proxy Indicators for Assessing Community Capitals

Specific indicators for evaluating communities differ across the landscape, evaluate various attributes of a community and explain the existing functions of a community. One program that utilizes indicators representative of the environment, population and resources, economy, youth and education, and health and community is the Sustainable Seattle Model (Belesme and Mullin, 1997). These indicators are related to community health and sustainability but are most applicable to larger communities such as local municipalities.

To assess the degree of community capitals present within defined riparian communities, it was necessary to generate a survey instrument that measured community capitals in individual riparian communities. Development of this survey instrument consisted of methodical generation of proxy indicators that were specific to riparian communities and represented the community capitals present in the community capitals framework (CCF) developed by Flora (2004). Proxy indicators are defined as indirect measures that approximate an attribute in the absence of a direct measure.

It was critical to include all forms of capital, as Fey et *al*. (2006) emphasize that overlaps of various forms of capital are common and may be critical in explaining how they combine to create an outcome at the community level. For example, Alston (2004) showed that a decline in human capital was associated with a loss of economic and social capital. Due to this observed level of overlap, the designation of indicators to a specific form of capital is challenging. Thus, indicators that dominantly represent each form of capital were selected for this research. The textbook "Rural Communities (third edition, Westview Press)" by Flora and Flora (2008) was instrumental in the selection of proxy indicators specific to lake communities. Although the textbook did not have a section solely on lake indicators, the basic principles for each form of capital could be applied to many types of natural resource communities. Flora (2004) emphasizes that although scientific data and technical information may inform communities of infrastructure deficiencies that may highlight immediate needs for improvement, the information may not lead to a long-term, sustainable future improvement. It was important that the selection of riparian communities be used for subjects because having place-based communities allowed for a better understating of how these communities interact with the lake ecosystem using various forms of capital. Armitage (2005) emphasized the need for specific and place-based metrics for optimum natural resource management capacity. Additionally, Flora (2004) describes the individual forms of capital that may be evaluated for water resource sustainability. For this study, the community capitals to be evaluated included social capital, financial capital, political capital, natural capital, cultural capital, human capital, and built/technical capital. The proxy indicators were grouped by sections indicated by the capital form being measured for the sake of careful analysis.

III.2 Development of the Survey Instrument

In addition to the development of the proxy indicators for each form of capital to be evaluated, the survey questions were created to be closed-ended to assure that each respondent would be able to answer in a consistent manner. This was done to minimize any effects from myself as the interviewer and thus avoid interviewer bias. The respondents were individuals that were actively leading a lake association (such as an acting president or vice-chair). This was important since it reduced respondent bias which could have been a factor if the respondents could not provide accurate answers. Additionally, each question on the survey instrument had an opt-out answer that was stated as: "I do not know". Sixty lakes were randomly selected from a master list of lake associations. All of the respondents were mailed a complete survey with instructions and a letter explaining that the surveys were voluntary and would be used to develop a tool for management by inland lake riparian communities. A total of 33 survey instruments were returned and included in the data analysis. This represents a response rate of approximately 55% which is favorable for a mailed survey. Lake respondents were well scattered throughout the state of Michigan (Figure 3).

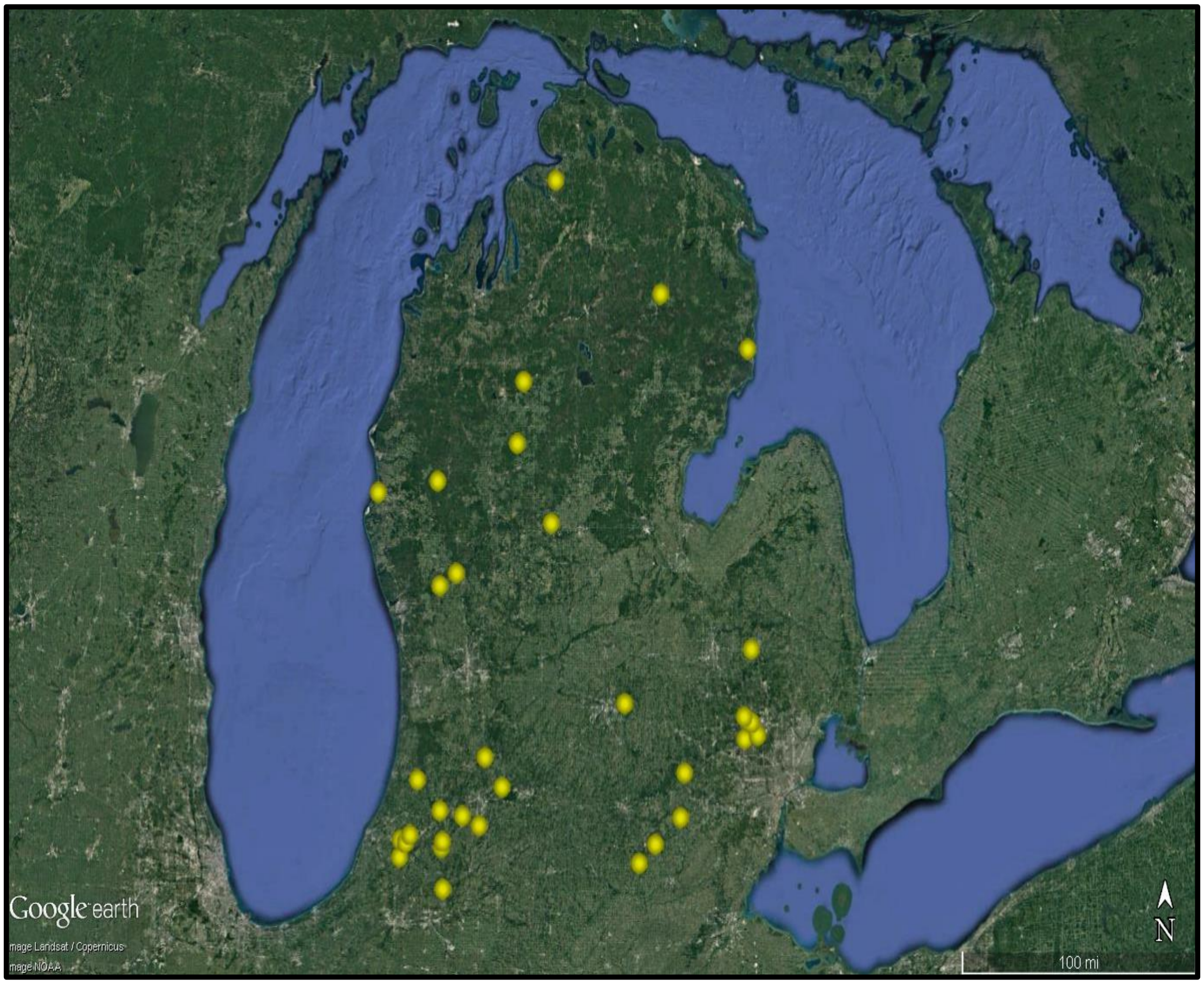

Figure 3. Randomly selected lake association sites included in this resource study. Note: The Upper Peninsula of Michigan is not represented here because there were no survey responses received from that region of the state.

III.3 Data Coding

After all surveys were received, the survey instruments were divided into two key groups to investigate the ability to implement BMPs and included lake associations with lake management plans (LMP) and those without lake management plans (non-LMP). Additional data on the number of BMPs implemented for the lakes returned was collected independently by gathering the data from lake association websites or reviewing lake management plans online or by directly contacting lake association board leaders for the information. A list of BMPs commonly implemented for riparian communities was created (Table 1) based on my experience with lake improvement projects and the various BMPs that are most often executed for such improvements. A total number of individual BMPs was calculated for each riparian respondent. Each form of capital had questions that ranged from 0 points to up to a maximum of 5 points. Community capital scores were calculated by adding up the total number of points for each capital measured and dividing that number by the total number of points possible for each type of community capital. Such quantitative data allowed for statistical analysis of the data. Each individual question in the capital categories was tallied for total points and added into an Excel spreadsheet. A total capital score was then generated for each respondent and each form of capital. If the answers were in the "I do not know" category, they were assigned a value of zero (0). Answers that included "I do not know" were assigned a value of zero since the survey instrument assessed overall abundance of each form of community capital and randomly selected subject lakes were associated with lake leaders that would have great knowledge of these local community resources. Respondents with high levels of capital had higher overall scores. This process was conducted for each type of capital and included social capital, natural capital, political capital, human capital, cultural capital, financial capital, and built/technical capital. The latter form of capital was combined since the survey instrument included questions pertaining to infrastructure as well as educational and informational (material) resources.

The use of a different dependent variable in place of BMPs was decided upon to see if action-oriented attributes such as BMPs would yield different outcomes from more static variables such as water quality. A Trophic State Index (TSI) provided a quantitative measure for scoring lakes based on three major parameters: 1) total phosphorus, 2) Secchi transparency, and 3) chlorophyll-*a*. Each parameter can have a separate index or a combination of the three parameters can be calculated to formulate a new index. The TSI was created by Carlson (1977) for use in categorizing lakes based on trophic status. The TSI scores range from 0-100 with the lowest scores referencing lakes with excellent water clarity, low nutrients, and low chlorophyll-*a* and those with the highest scores revealing lakes with higher nutrients concentrations, lower water clarity, and higher chlorophyll-*a*. In general, lakes with a score <30 are the most oligotrophic (nutrient-poor) and lakes with a score of >80 are the most eutrophic (nutrient-rich). A TSI index for each subject lake respondent was derived for all three parameters. Water quality data used to develop the TSI were collected from a combination of sources including existing lake management plans, the State of Michigan MiSWIM database, the MiCORPS Cooperative Lakes Monitoring Program database, or from the EPA Storet water quality database. The following equations (Carlson, 1977) were used to calculate the TSI Index for each water body:

TSI-Phosphorus (in $\mu g\ L^{-1}$) = 14.42*Ln [TP] + 4.15

TSI-Chlorophyll-*a* (in $\mu g\ L^{-1}$) = 30.6 + 9.81 Ln [Chl-a]

TSI-Secchi (in meters) = 60-14.41*Ln [Secchi]

Mean TSI = [TSI-Phosphorus + TSI-Chlorophyll-*a* + TSI-Secchi]/3

Table 1. Commonly implemented BMPs for riparian communities.

Best Management Practices	**Implemented? (Yes or No)**
Water Quality Monitoring	
Control of Submersed Invasive Exotic Plants	
Control of Submersed Nuisance Native Plants	
Control of Algae/Phytoplankton	
Control of Emergent Invasive Plants	
Riparian Education/Outreach/Seminars	
Muck Reduction (aeration or dredge)	
Watershed Plan/Monitoring	
Drain Sampling/Stormwater Control	
Tributary Sampling/Inlets to Lake	
Natural Shoreline Promotion/Preservation	
Reduction of Lake Nutrients	
Reduction of other aquatic invasives (i.e. zebra mussels)	
Fishery Study/Evaluation	
Fish Stocking	
Waterfront District Ordinance Development	
Boat Washing Station	

III.3.1 Proxy Indicators for Riparian Communities (Associations):

The questions below were derived to include representative proxy indicators for each form of community capital. Possible responses to the questions are available in Appendix A.

III.3.2 Social Capital:

1) How many years has your lake association been in existence?
2) How many times per year does your lake association hold meetings?
3) How many social media groups does the association belong to?

4) Estimate the degree of trust among lake Association residents:
5) How many times in the past year have you reached out to other lakes (Associations of other groups) for guidance or information on lake issues?
6) What percentage of your Association has turned over membership in the past 2 years?

III.3.3 Natural Capital:

1) How many lakes lie within five miles of your lake?
2) How many years has your lake been managed by your Association or a lake professional?
3) Is there a nature center within five miles of the lake?
4) What is the lake trophic status (i.e. nutrient-rich or poor or moderate)?
5) How many parks are within five miles of lake?
6) Percentage of green space/forest/wetlands/ within five miles of lake?
7) How many miles of walking (non-paved) trails are within five miles of lake?
8) What is the population density of your riparian community?
9) Does the lake have public access?

III.3.4 Cultural Capital:

1) How many unique items have been created as marketing products for your lake or association?
2) What is the average annual time investment (in hours) of the Association on lake projects?
3) How many lake-specific events are held in your lake Association community annually?

4) How many traditions exist that are specific to your lake Association?
5) Approximately what percent of the population around your lake is seasonal?
6) Approximately what percent of the population around your lake is generational or has relatives that once lived on the lake?

III.3.5 Human Capital:

1) What is the average age of a riparian in the Association?
2) What percentage of your Association has the following educational attainment:
3) How many riparians in the Association have skills that pertain to natural resources management or protection?
4) How many different civic associations do lake activities around your lake (i.e. Elks, Masons, Rotary, Schools, etc.)?
5) How many businesses donate time to lake activities each year?
6) How many businesses donate time to lake protection each year?
7) How many businesses donate time for lake monitoring each year?
8) How many small businesses/start-ups exist within your lake community?
9) What percentage of the lake population is in your Association?

III.3.6 Political Capital:

1) How many grants have been obtained by the Association in the past five years? (Grants can be municipal, private, non-governmental organization, state, county, national, or township)
2) On average, how many times have riparians worked annually with government or political groups?
3) How many riparians on the lake occupy a political office in the area or state?
4) Is there evidence of the ability of the Association to influence regulations (i.e. ordinances) due to the structure/composition of your lake community?
5) Is there evidence of the ability to implement regulations (such as ordinances) to benefit water quality due to the structure/composition of your lake community?

III.3.7 Built/Technical Capital:

1) How many homes are there around your lake?
2) How many of the homes on your lake are on a sewer system?
3) How many paved trails exist within five miles of your lake?
4) What is the percentage of homes with internet access on your lake?
5) Is there access to a local community center or library within five miles of your lake?
6) Is there a lake expert that manages your lake?
7) Is there access to scientific/technical information on your lake?
8) Is there access to GIS/maps on your lake (regarding your lake)?

9) How many industries or businesses are within five miles of your lake?

III.3.8 Financial Capital:

1) What is the average annual per capita income per riparian in the Association?
2) What is the annual amount of money received for annual lake Assoc. dues?
3) What is the annual amount of grant money received for lake improvement/watershed grants?
4) How much money is spent annually on lake management?
5) How much money is donated annually to the lake for management or preservation?
6) What is the approximate percentage of riparians on the lake at poverty level?
7) What is the average cost of housing on your lake?
8) What is the percentage of home ownership in your Association?
9) Would the Association have the ability to obtain a loan for lake improvements?

III.4 Data Analysis Methods

Data entered into Excel were analyzed first for correlations between each form of capital (the "x" independent variables) and implementation of BMPs (the "y" dependent variable). An "r squared" value and linear regression equation was obtained for each form of capital among all respondents separately in the lake management plan (LMP) and non-lake management plan (non-LMP) groups.

Additionally, another dependent variable (Trophic Status Index or TSI) was selected and graphed for correlations between the individual forms of community capitals also for both LMP and non-LMP populations. Tests of statistical significance on the correlations were then conducted using the Pearson correlation coefficient, two-tailed test with SPSS Version 22 (IBM® Corp.). The Pearson correlation coefficient measures "r" which measures linear dependence between x and y variables.

A comparison of the means (independent samples *t*-test; two-tailed) was conducted for all forms of capital for the LMP and non-LMP riparian community groups.

CHAPTER IV: RESULTS

The results presented below correspond to each hypothesis derived for this study. This section contains only the quantitative results which consists of graphs and tables. Analysis of qualitative answers was not executed for this study. If statistically significant results were found, then the table indicates these findings.

An independent samples *t*-test of the means was conducted on both data sets (non-LMP and LMP) relative to each form of community capital to determine significance differences of each form of community capital for both riparian populations. Table 2 shows the summary for differences in community capitals for Non-LMP and LMP riparian community populations.

IV.1 Social Capital with LMPs and Social Capital with non-LMPs

There were no significant differences in social capital for riparian community populations with and without LMPs (p=0.4; Tables B-1 and B-2; Appendix B). This finding indicates that there is not a significant difference in social capital for the two groups and therefore having a management plan does not necessarily mean higher social capital will be present within a riparian community. Thus, the null hypothesis for social capital was accepted.

IV.2 Financial Capital with LMPs and Financial Capital with non-LMPs

There were significant differences in financial capital for riparian community populations with and without LMPs ($p=0.04$; Tables B-3 and B-4; Appendix B). This finding indicates that there is a significant difference in financial capital for the two groups and riparian communities that had active LMP's also had more financial capital than communities without LMPs. Thus, the null hypothesis for financial capital was rejected.

IV.3 Political Capital with LMPs and Political Capital with non-LMPs

There were no significant differences in political capital for riparian community populations with and without LMPs ($p=0.6$; Tables B-5 and B-6; Appendix B). This finding indicates that there is not a significant difference in political capital for the two groups and therefore riparian communities that had active LMP's did not have more political capital than communities without LMPs. Thus, the null hypothesis for political capital was accepted.

IV.4 Natural Capital with LMPs and Natural Capital with non-LMPs

There were no significant differences in natural capital for riparian community populations with and without LMPs ($p=0.9$; Tables B-7 and B-8; Appendix B). This finding indicates that there is not a significant difference in natural capital for the two groups and therefore riparian communities that had active LMP’s did not have more natural capital than communities without LMPs. Thus, the null hypothesis for natural capital was accepted.

IV.5 Cultural Capital with LMPs and Cultural Capital with non-LMPs

There were no significant differences in cultural capital for riparian community populations with and without LMPs ($p=0.7$; Tables B-9 and B-10; Appendix B). This finding indicates that there is not a significant difference in cultural capital for the two groups and therefore riparian communities that had active LMP's did not have more cultural capital than communities without LMPs. Thus, the null hypothesis was accepted.

IV.6 Human Capital with LMPs and Human Capital with non-LMPs

There were significant differences in human capital for riparian community populations with and without LMPs (p=0.03; Tables B-11 and B-12; Appendix B). This finding indicates that there is a significant difference in human capital for the two groups and therefore riparian communities that had active LMP's had more human capital than communities without LMPs. Thus, the null hypothesis was rejected for human capital.

IV.7 Built/Technical Capital with LMPs and Built/Technical Capital with non-LMPs

There were no significant differences in built/technical capital for the two riparian community populations (p=0.2; Tables B-13 and B-14; Appendix B). This finding indicates that there is not a significant difference in built/technical capital for the two groups and therefore riparian communities that had active LMP's did not have more built/technical capital than communities without LMPs. Thus, the null hypothesis was accepted for built/technical capital.

Table 2: Summary statistical table for differences in community capitals for Non-LMP and LMP riparian community populations

Community Capital	Non-LMP Mean ± SD	LMP Mean ± SD	Diff. Non-LMP & LMP P-value
Social	0.65 ± 0.17	0.70 ± 0.20	0.4
Financial	0.42 ± 0.13	0.54 ± 0.18	0.04*
Political	0.29 ± 0.17	0.33 ± 0.18	0.6
Natural	0.59 ± 0.15	0.58 ± 0.15	0.9
Cultural	0.46 ± 0.15	0.48 ± 0.17	0.7
Human	0.31 ± 0.15	0.43 ± 0.13	0.03*
Built/Technical	0.31 ± 0.15	0.43 ± 0.13	0.2

SD= Standard deviation
* Denotes statistically significant result
LMP = lake management plan population
Non-LMP = non-lake management plan population

IV.8 Statistical analyses on BMPs in LMP and non-LMP Riparian Communities

There were no significant differences ($p=0.1$; two-tailed t-test; Tables B-15 and B-16; Appendix B) in BMPs for the LMP and Non-LMP riparian community populations. Thus, the null hypothesis for BMPs was accepted. This means that having a lake management plan does not necessarily guarantee that more BMPs will be implemented in riparian communities. Table 3 demonstrates the correlations between community capitals and BMPs for Non-LMP and LMP riparian community populations.

IV.9 Statistical analyses on correlations of BMPs and community capitals in LMP Riparian communities.

IV.9.1 Social Capital:

There was not a significant correlation between social capital and BMPs for riparian communities with an LMP (p=0.1; Figure 4 and Table B-17; Appendix B). Thus, the null hypothesis was accepted for the relationship between social capital and BMPs.

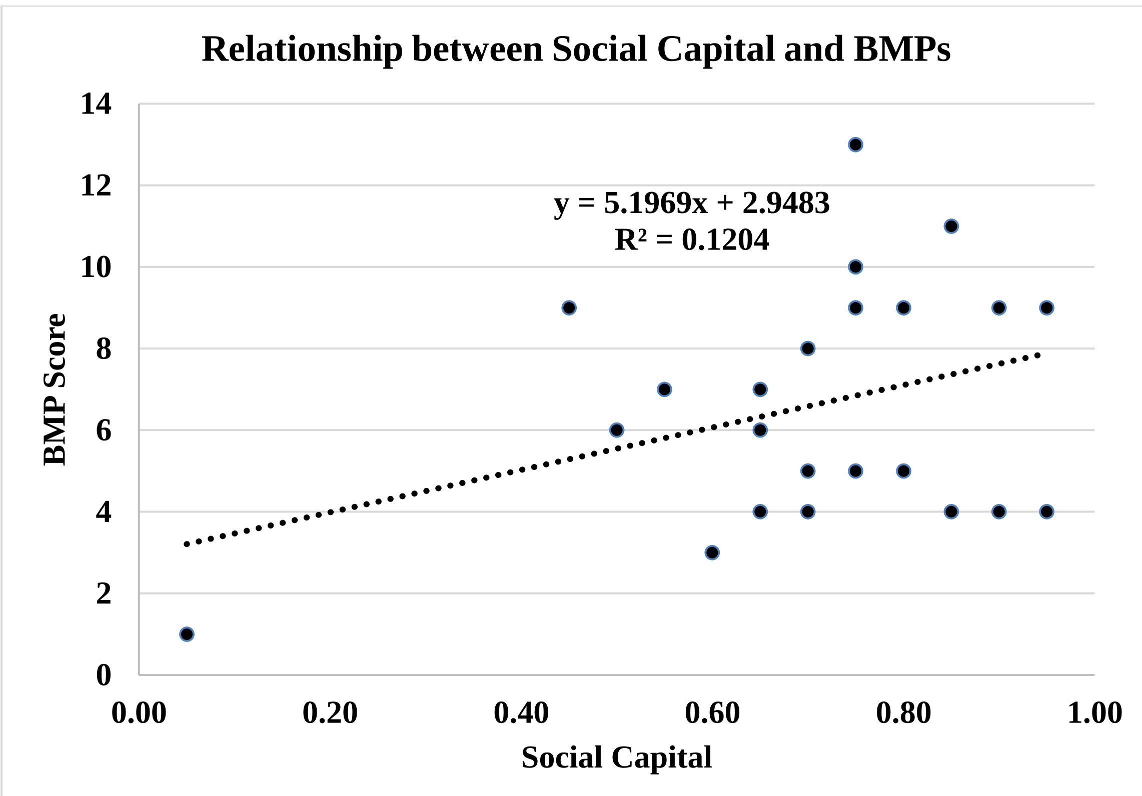

Figure 4. Relationship between social capital and BMPs in riparian communities with an LMP.

IV.9.2 Financial Capital:

There was not a significant correlation between financial capital and BMPs for riparian communities with an LMP (p=0.3; Figure 5 and Table B-18; Appendix B). The relationship between BMPs and financial capital was a positive one. Thus, the null hypothesis was accepted for the relationship between financial capital and BMPs.

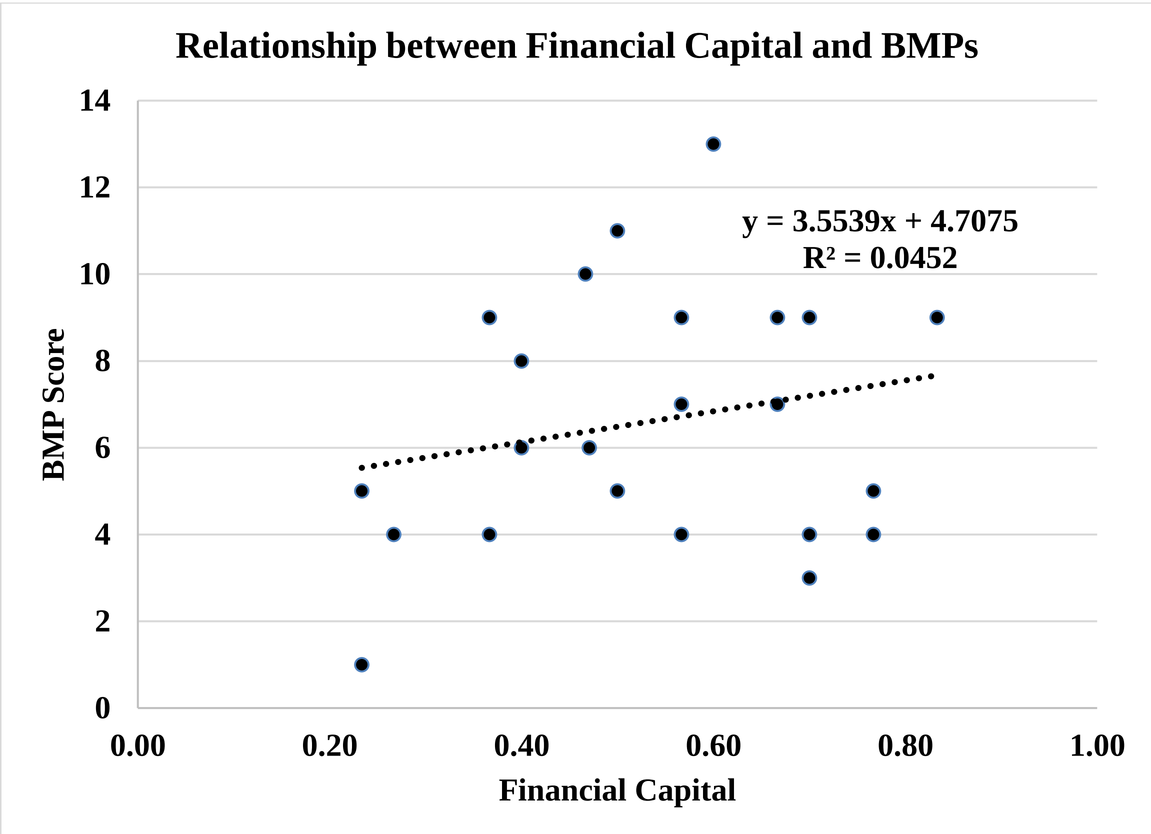

Figure 5. Relationship between financial capital and BMPs in riparian communities with an LMP.

IV.9.3 Political Capital:

There was not a significant correlation between political capital and BMPs for riparian communities with an LMP (p=0.2; Figure 6 and Table B-19; Appendix B). The relationship between BMPs and political capital was a positive one. Thus, the null hypothesis was accepted for the relationship between political capital and BMPs.

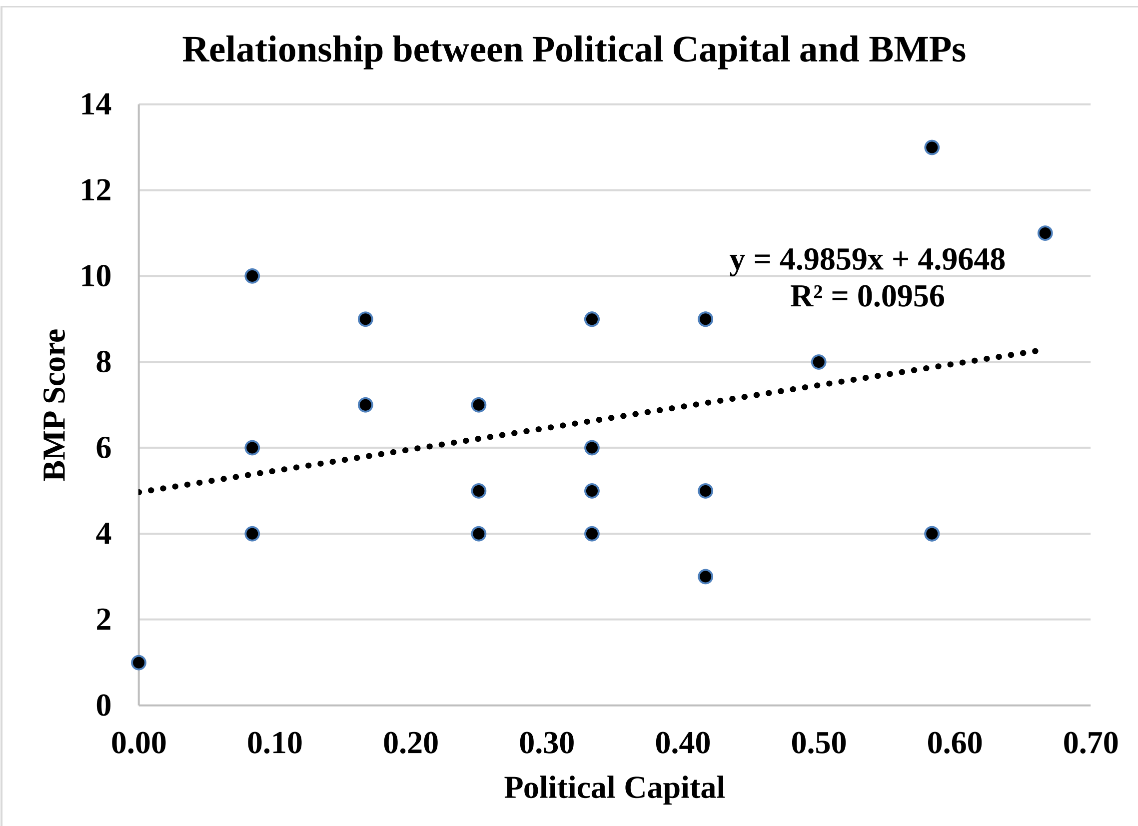

Figure 6. Relationship between political capital and BMPs in riparian communities with a lake management plan.

IV.9.4 Natural Capital:

There was not a significant correlation between natural capital and BMPs for riparian communities with an LMP (p=0.7; Figure 7 and Table B-20; Appendix B). The relationship between BMPs and natural capital was a negative one. Thus, the null hypothesis was accepted for the relationship between natural capital and BMPs.

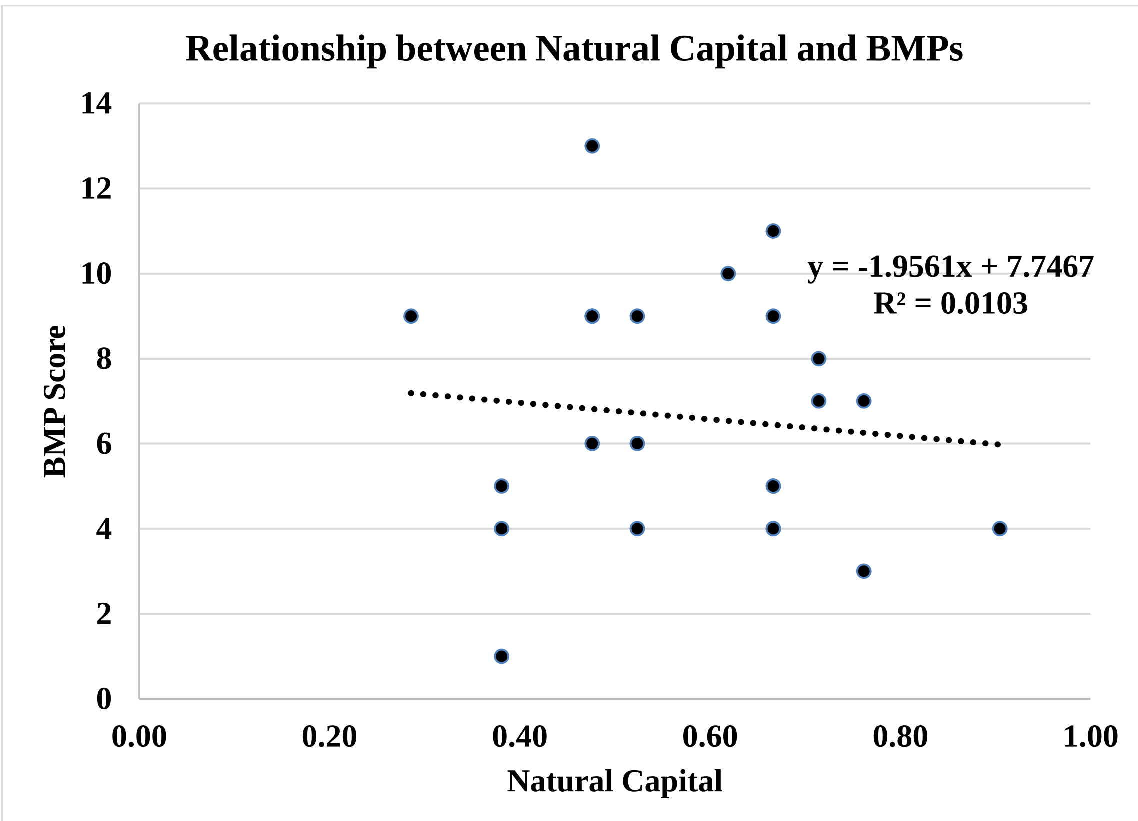

Figure 7. Relationship between natural capital and BMPs in riparian communities with an LMP.

IV.9.5 Cultural Capital:

There was a significant correlation between cultural capital and BMPs for riparian communities with an LMP (p=0.04; Figure 8 and Table B-21; Appendix B). The relationship between BMPs and cultural capital was a positive one. Thus, the null hypothesis was rejected for the relationship between cultural capital and BMPs.

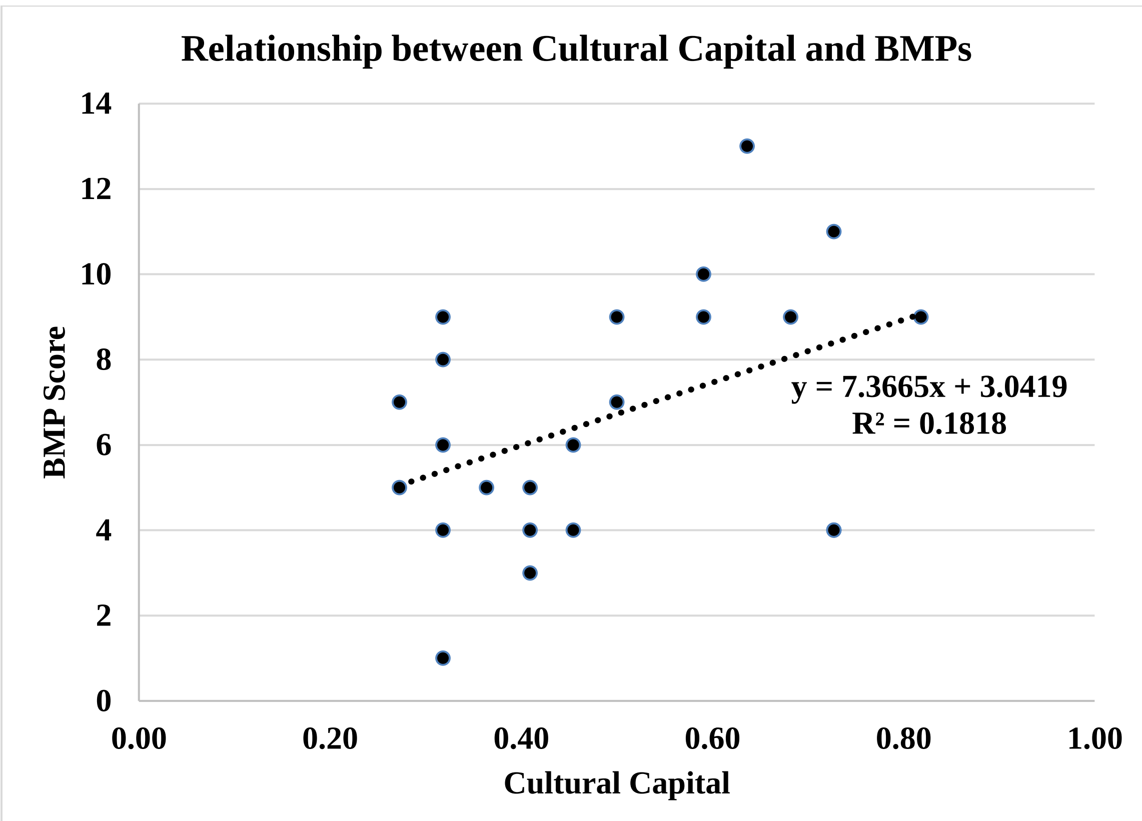

Figure 8. Relationship between cultural capital and BMPs in riparian communities with an LMP.

IV.9.6 Human Capital:

There was not a significant correlation between human capital and BMPs for riparian communities with an LMP (p=0.1; Figure 9 and Table B-22; Appendix B). The relationship between BMPs and human capital was a positive one. Thus, the null hypothesis was accepted for the relationship between human capital and BMPs.

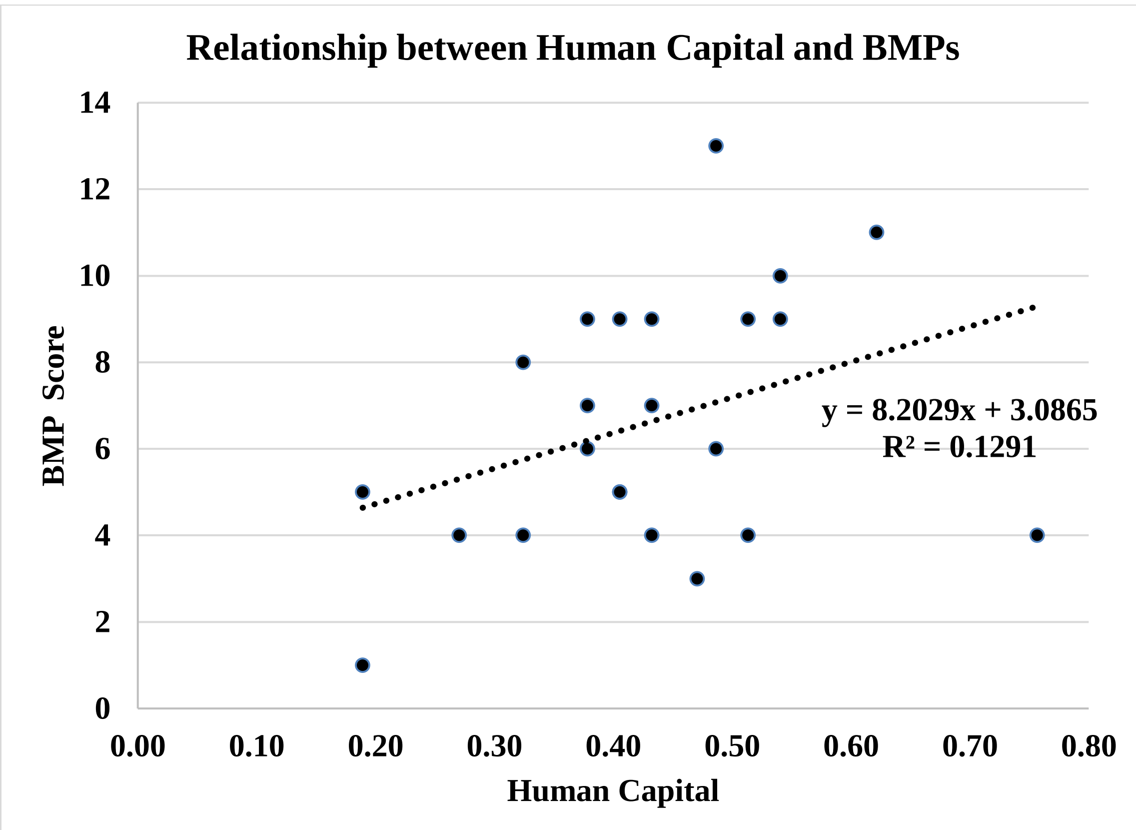

Figure 9. Relationship between human capital and BMPs in riparian communities with an LMP.

IV.9.7 Built/Technical Capital:

There was not a significant correlation between built/technical capital and BMPs for riparian communities with an LMP (p=0.9; Figure 10 and Table B-23; Appendix B). The relationship between BMPs and built/technical capital was a negative one. Thus, the null hypothesis was accepted for the relationship between built/technical capital and BMPs.

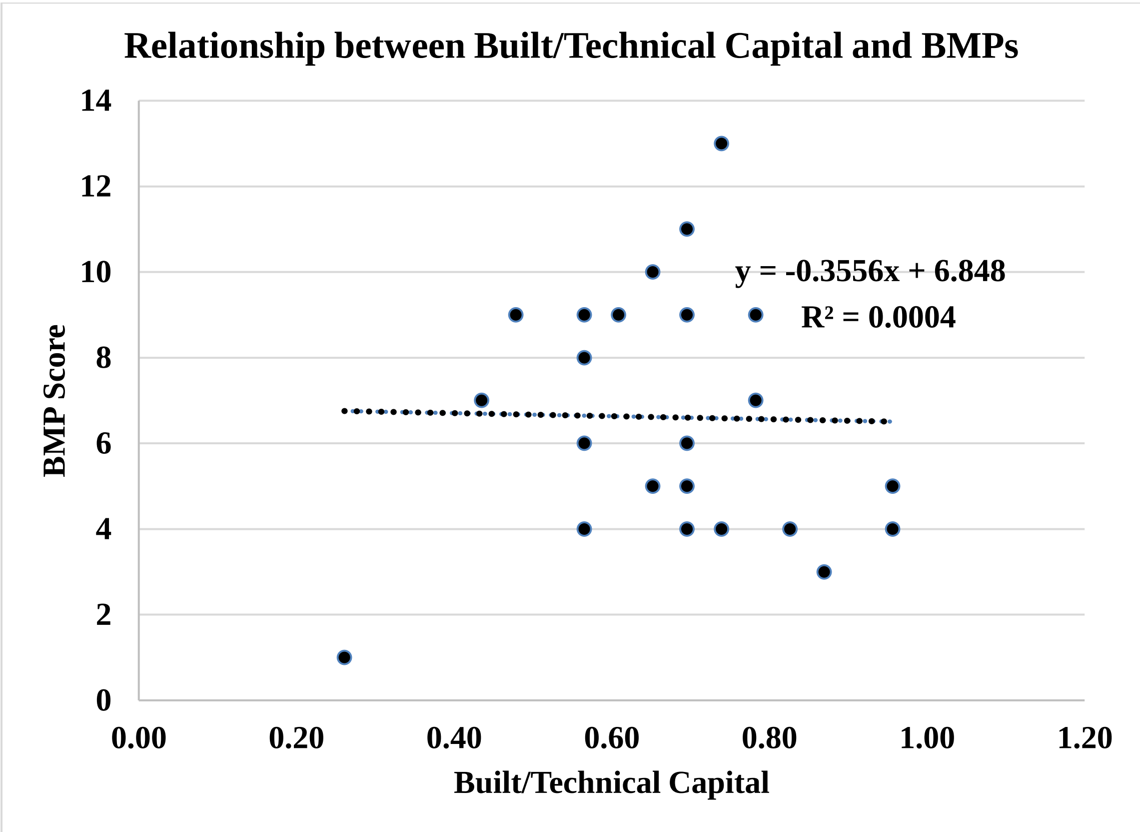

Figure 10. Relationship between built/technical capital and BMPs in riparian communities with an LMP.

IV.10 Statistical analyses on correlations of BMPs and community capitals in non-LMP riparian communities.

IV.10.1 Social Capital:

There was not a significant correlation between social capital and BMPs for riparian communities without an LMP (p=0.9; Figure 11 and Table B-24; Appendix B). The relationship between BMPs and social capital was a positive one. Thus, the null hypothesis was accepted for the relationship between social capital and BMPs.

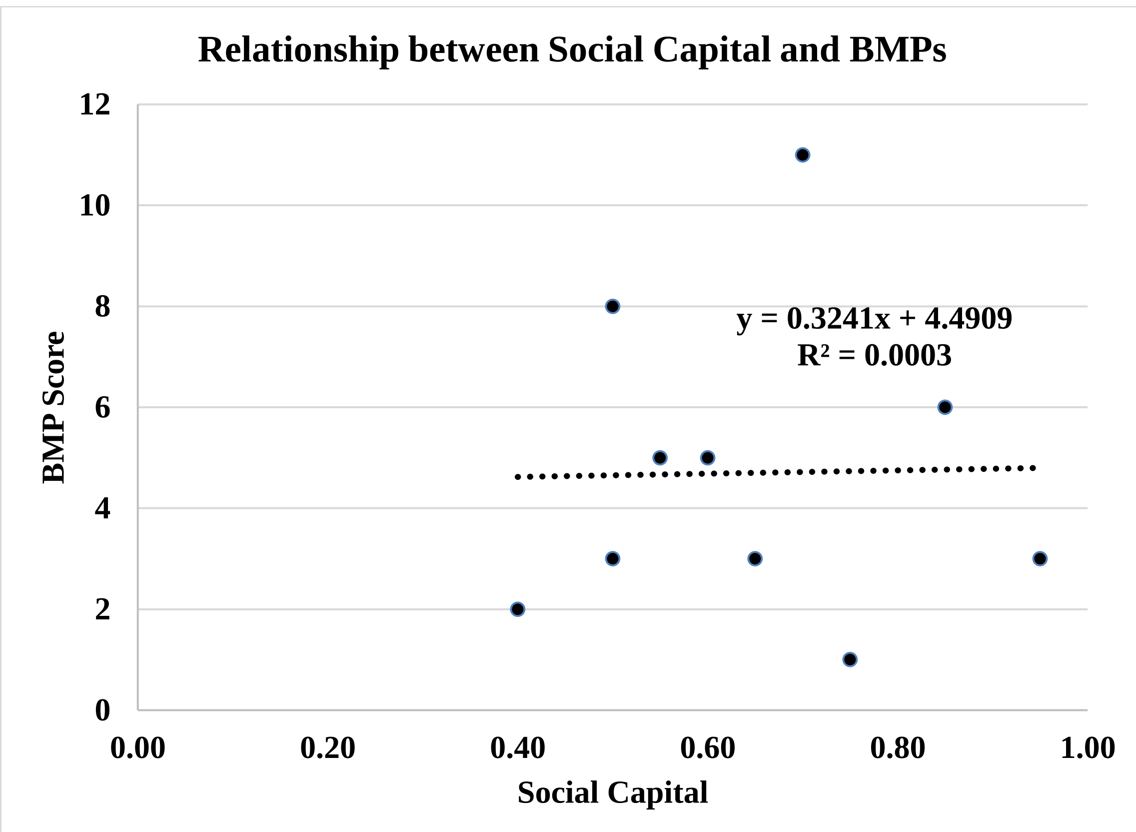

Figure 11. Relationship between social capital and BMPs in riparian communities without an LMP.

IV.10.2 Financial Capital:

There was not a significant correlation between financial capital and BMPs for riparian communities without an LMP (p=0.2; Figure 12 and Table B-25; Appendix B). The relationship between BMPs and financial capital was a positive one. Thus, the null hypothesis was accepted for the relationship between financial capital and BMPs.

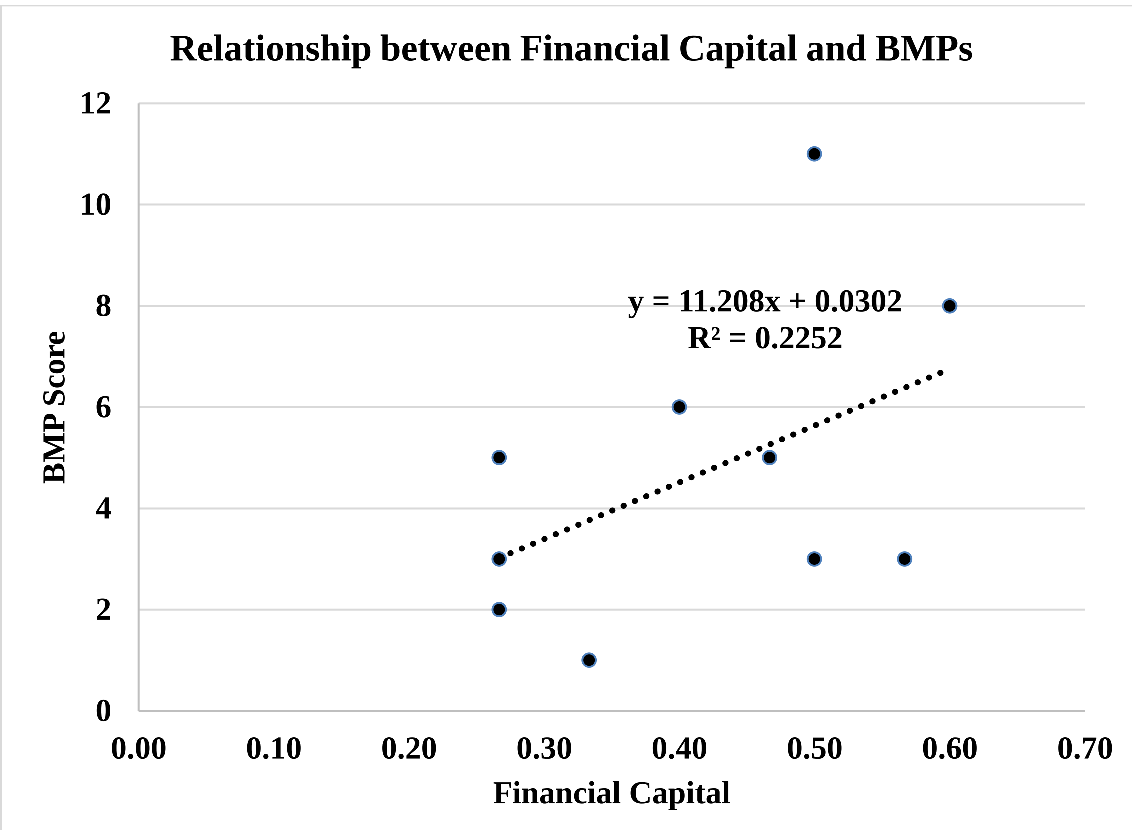

Figure 12. Relationship between financial capital and BMPs in riparian communities without a lake management plan.

IV.10.3 Political Capital:

There was not a significant correlation between political capital and BMPs for riparian communities without an LMP (p=0.8; Figure 13 and Table B-26; Appendix B). The relationship between BMPs and political capital was a positive one. Thus, the null hypothesis was accepted for the relationship between political capital and BMPs.

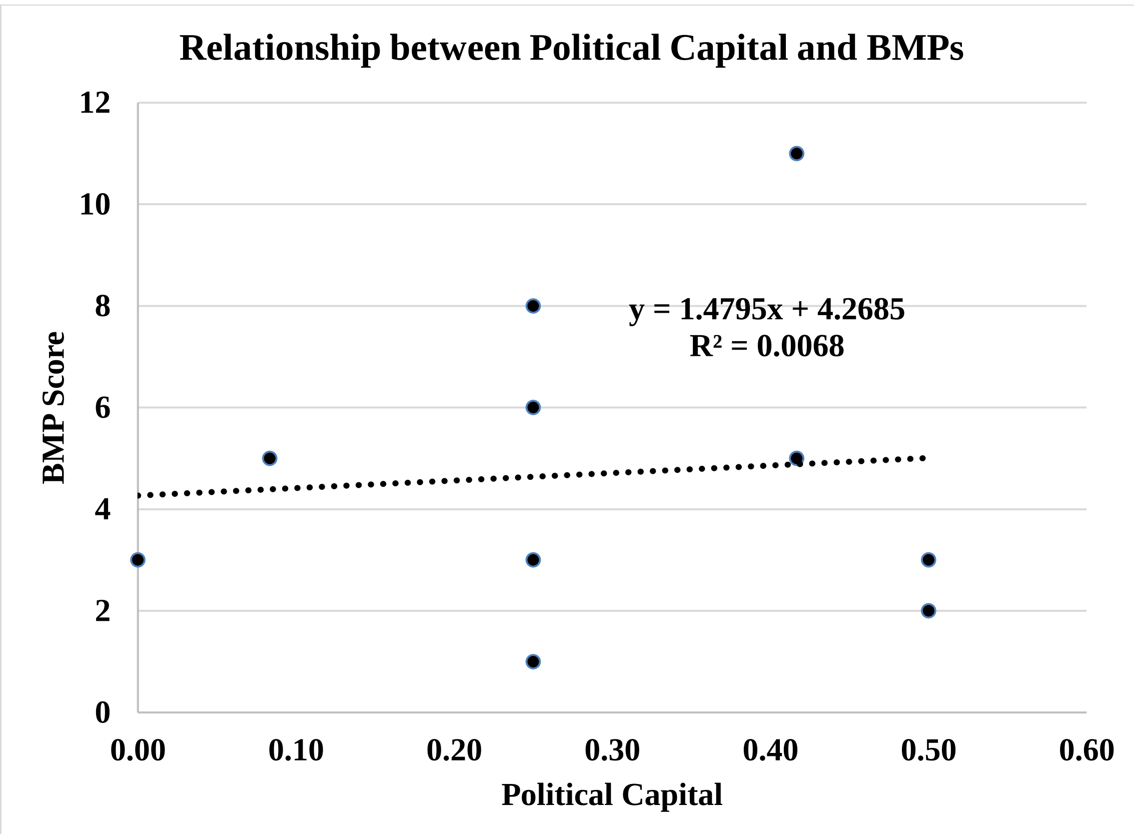

Figure 13. Relationship between political capital and BMPs in riparian communities without a lake management plan.

IV.10.4 Natural Capital:

There was not a significant correlation between natural capital and BMPs for riparian communities without an LMP (p=0.6; Figure 14 and Table B-27; Appendix B). The relationship between BMPs and natural capital was a negative one. Thus, the null hypothesis was accepted for the relationship between natural capital and BMPs.

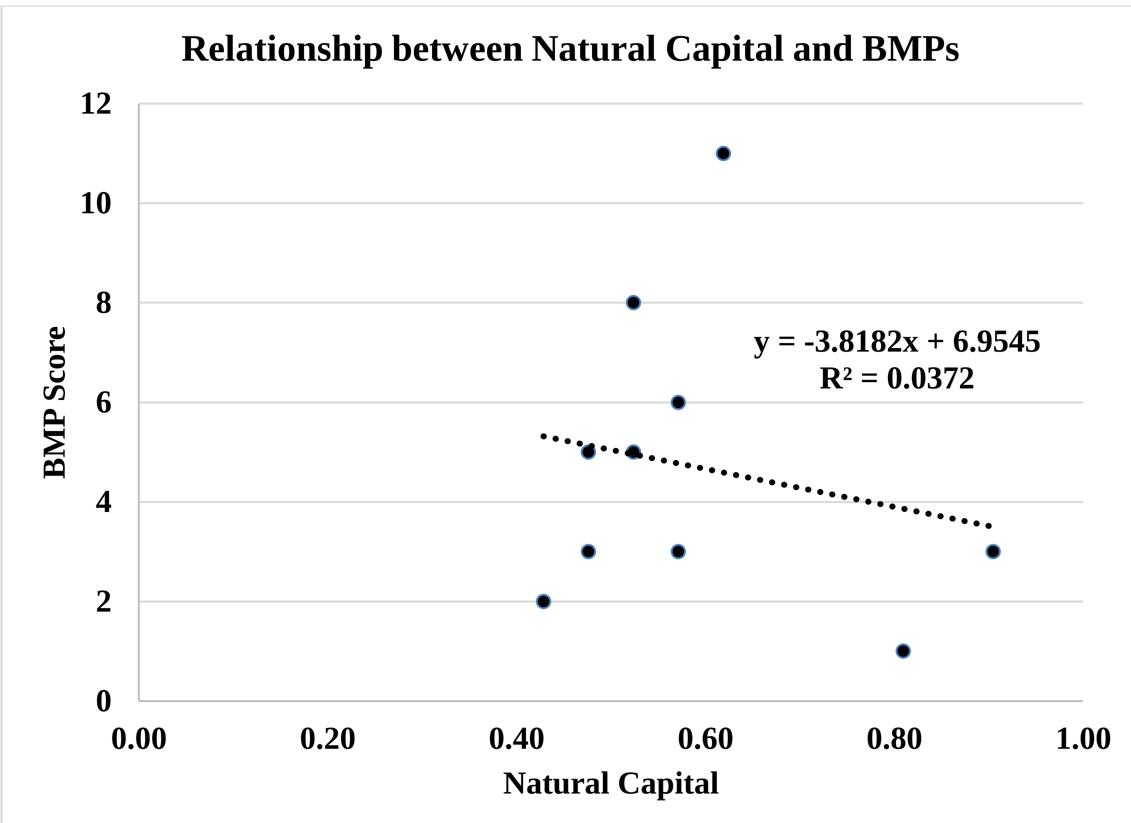

Figure 14. Relationship between natural capital and BMPs in riparian communities without a lake management plan.

IV.10.5 Cultural Capital:

There was not a significant correlation between cultural capital and BMPs for riparian communities without an LMP (p=0.7; Figure 15 and Table B-28; Appendix B). The relationship between BMPs and cultural capital was a positive one. Thus, the null hypothesis was accepted for the relationship between cultural capital and BMPs.

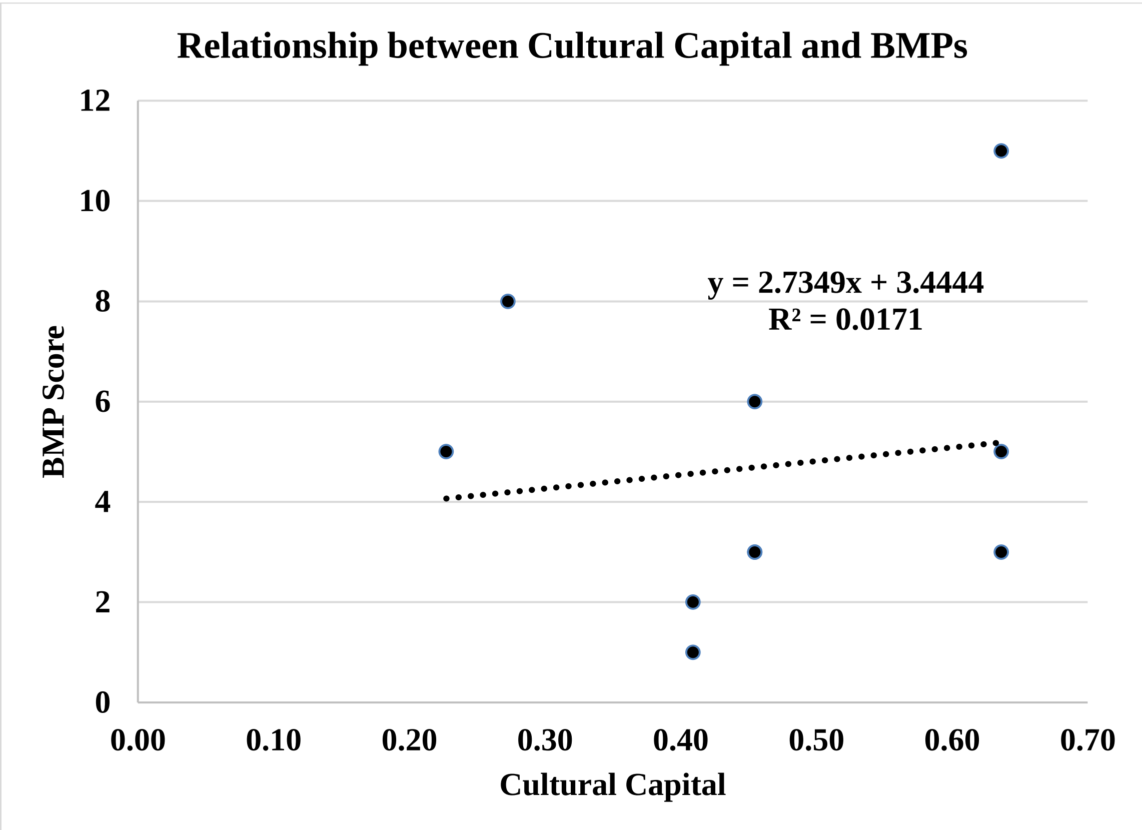

Figure 15. Relationship between cultural capital and BMPs in riparian communities without a lake management plan.

IV.10.6 Human Capital:

There was not a significant correlation between human capital and BMPs for riparian communities without an LMP (p=0.3; Figure 16 and Table B-29; Appendix B). The relationship between BMPs and human capital was a positive one. Thus, the null hypothesis was accepted for the relationship between human capital and BMPs.

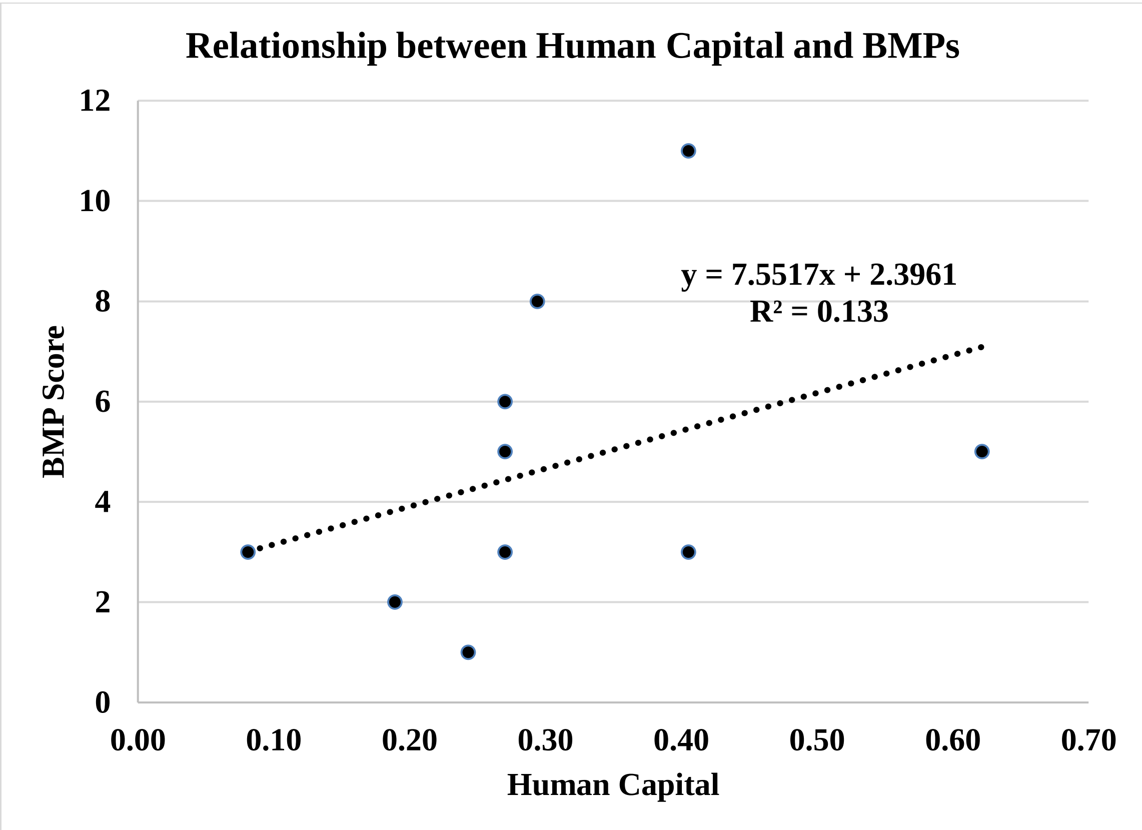

Figure 16. Relationship between human capital and BMPs in riparian communities without a lake management plan.

IV.10.7 Built/Technical Capital:

There was not a significant correlation between built/technical capital and BMPs for riparian communities without an LMP ($p=0.2$; Figure 17 and Table B-30; Appendix B). The relationship between BMPs and built/technical capital was a negative one. Thus, the null hypothesis was accepted for the relationship between built/technical capital and BMPs.

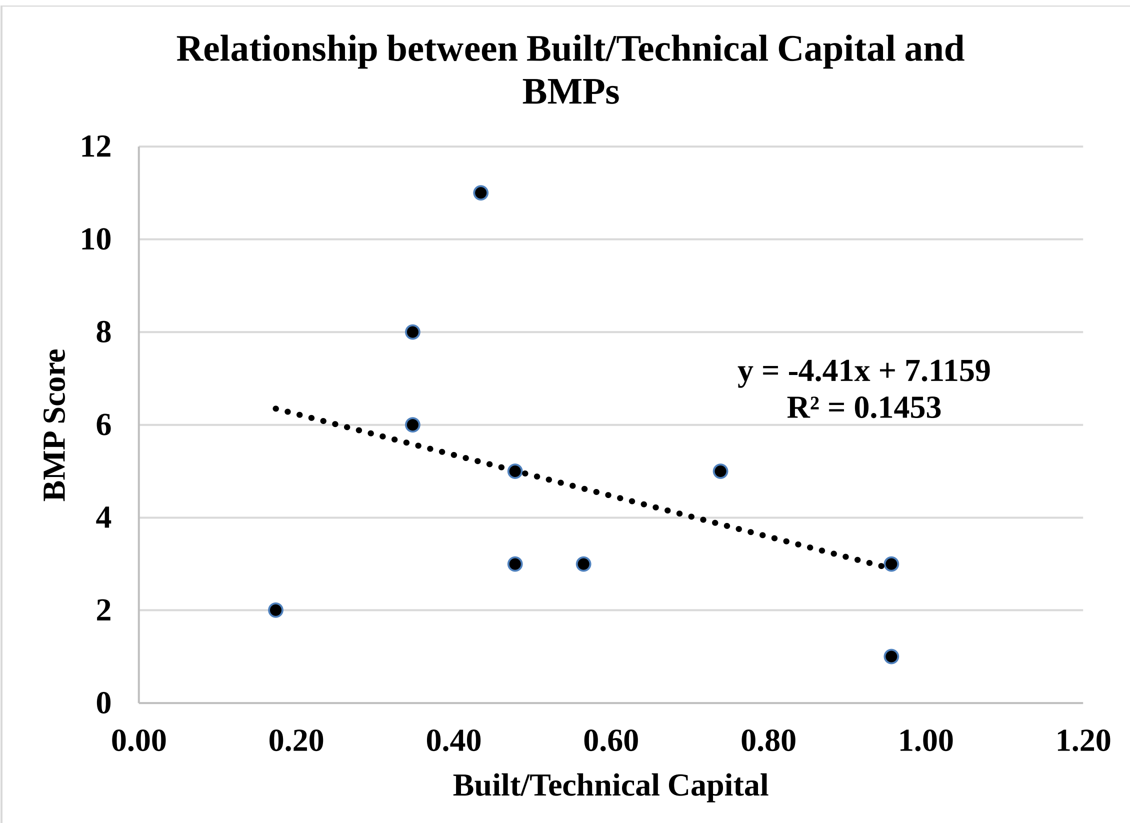

Figure 17. Relationship between built/technical capital and BMPs in riparian communities without a lake management plan.

Table 3. Summary statistical table for correlations between community capitals and BMPs for non-LMP and LMP riparian community populations

Community Capital	**Non-LMP Correlation P-value and R^2**	**LMP Correlation P-value and R^2**
Social	0.9; $R^2 = 0.000$	0.1; $R^2 = 0.120$
Financial	0.2; $R^2 = 0.225$	0.3; $R^2 = 0.045$
Political	0.8; $R^2 = 0.007$	0.2; $R^2 = 0.096$
Natural	0.6; $R^2 = 0.037$	0.7; $R^2 = 0.010$
Cultural	0.7; $R^2 = 0.017$	0.04*; $R^2 = 0.182$
Human	0.3; $R^2 = 0.133$	0.1; $R^2 = 0.129$
Built/Technical	0.2; $R^2 = 0.133$	0.9; $R^2 = 0.000$

* Denotes statistically significant result
LMP = lake management plan population
Non-LMP = non-lake management plan population

IV.11 Statistical analyses on means of TSI in LMP and non-LMP riparian community populations.

Independent samples *t*-tests at the 95% confidence interval ($\alpha=0.05$) were applied to each TSI parameter for both non-LMP and LMP populations and no significant differences were found between the two groups for TSI-phosphorus ($p=0.7$), TSI-chlorophyll-*a* ($p=0.2$), and TSI-Secchi transparency ($p=0.8$; Tables B-31-B-36; Appendix B).

IV.12 Statistical analyses on correlations of TSI and community capitals in LMP riparian community populations.

To determine if any correlations existed between TSI and the community capitals, a correlation regression was performed for each community capital type for the LMP population. A correlation test of significance was then conducted using the Pearson Correlation Coefficient which is a measure of "r" or the linear dependence (correlation) between the dependent (TSI) and independent variables (community capitals). The test was conducted at the 95% confidence level (α=0.05). No statistically significant findings were found for these correlations (Tables B-37-B-43 and Figures 25-31).

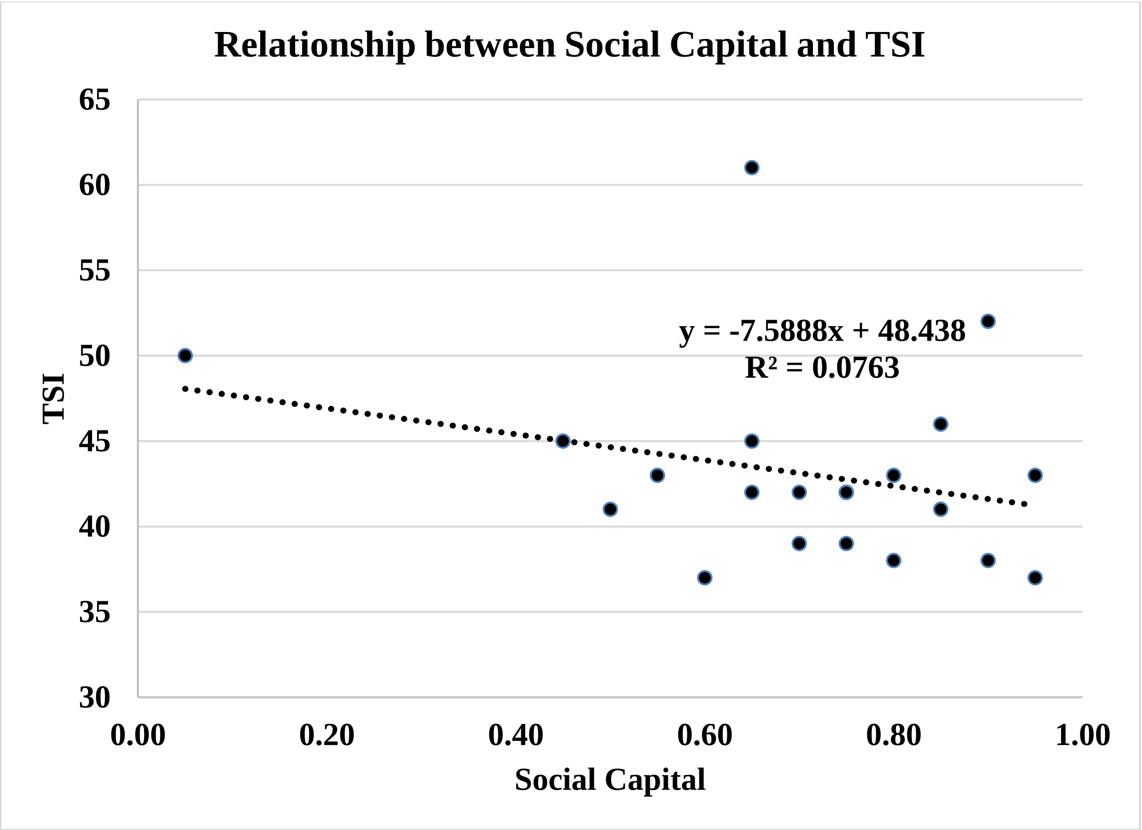

Figure 18. Relationship between social capital and TSI in riparian communities with an LMP.

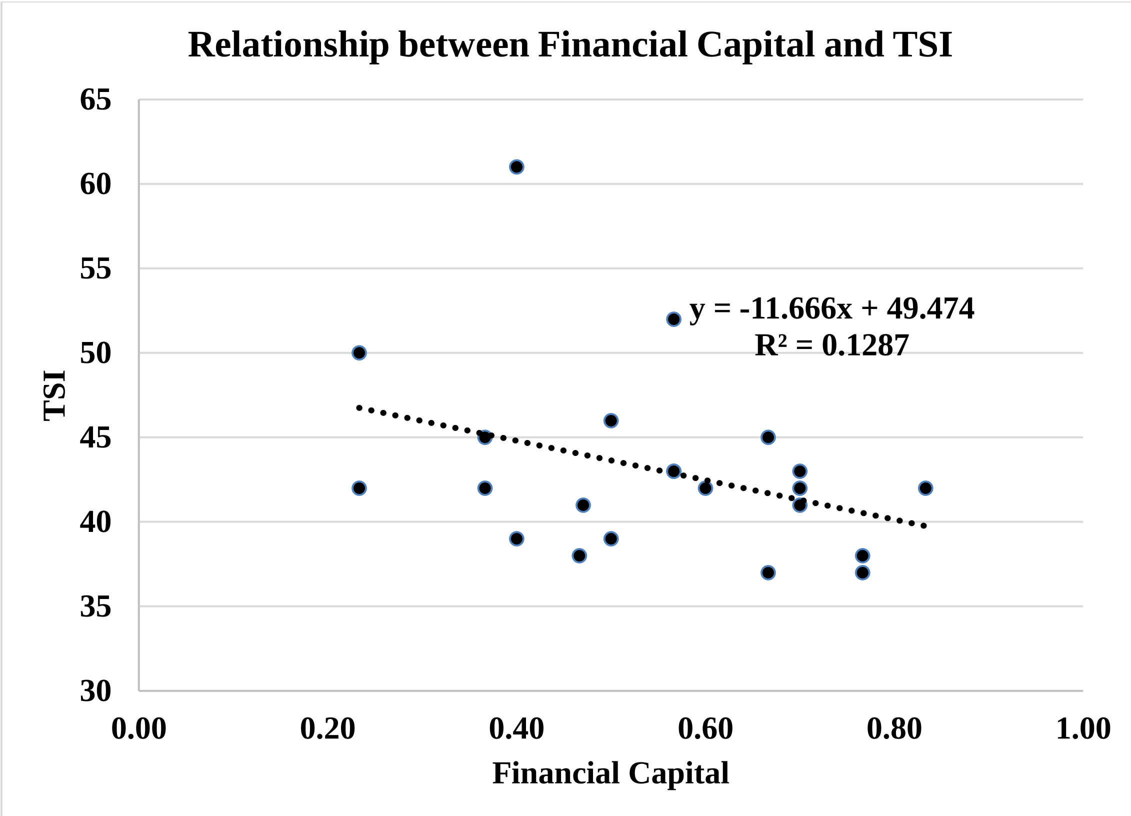

Figure 19. Relationship between financial capital and TSI in riparian communities with a lake management plan.

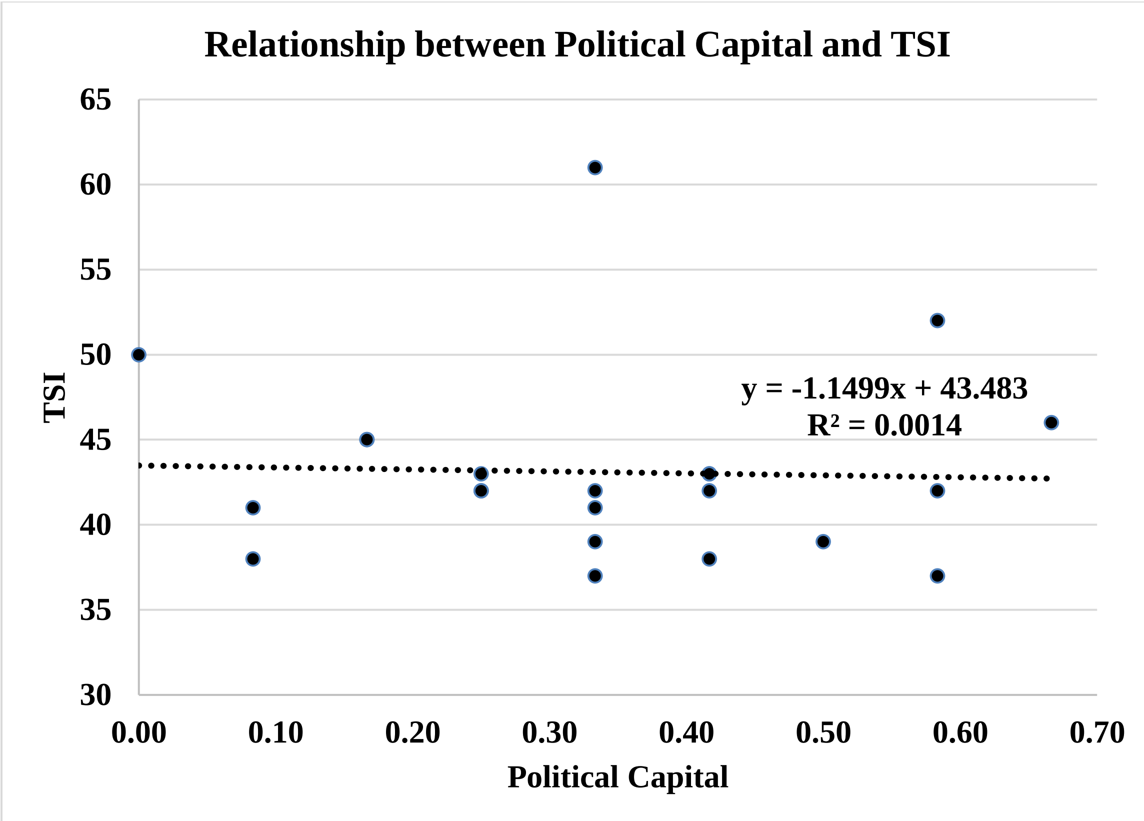

Figure 20. Relationship between political capital and TSI in riparian communities with a lake management plan.

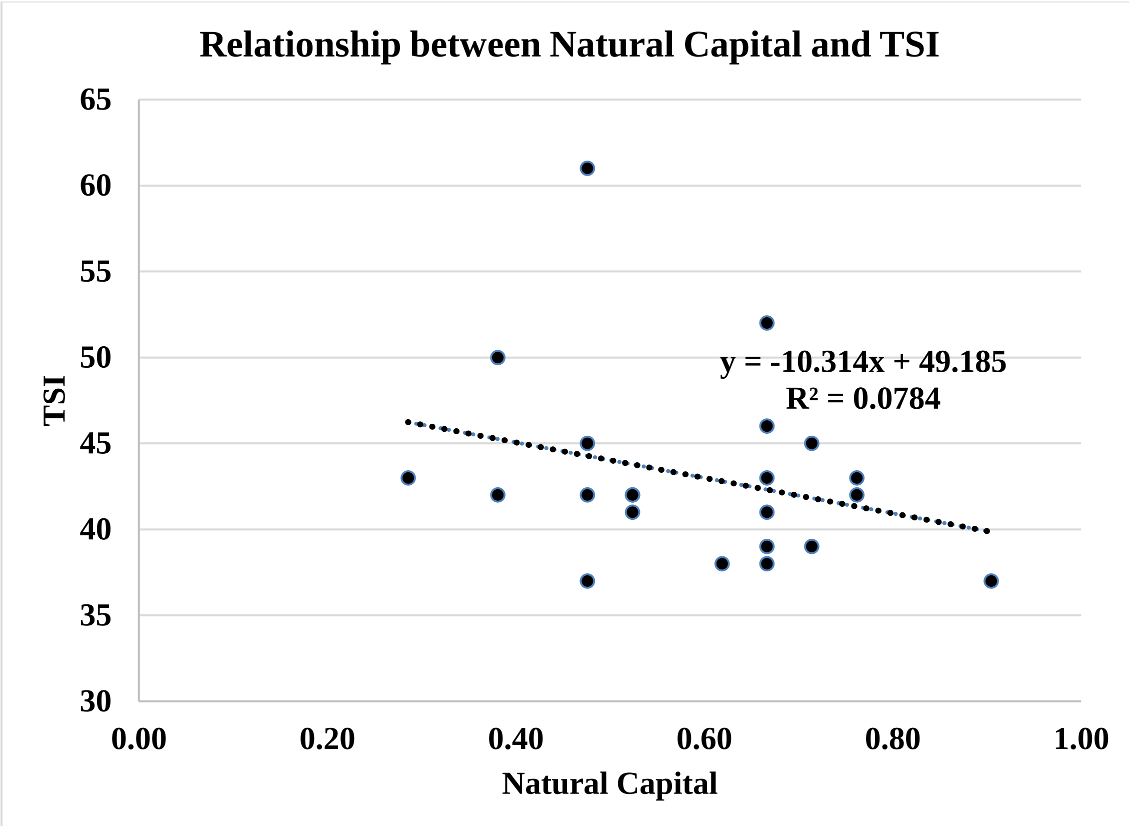

Figure 21. Relationship between natural capital and TSI in riparian communities with a lake management plan.

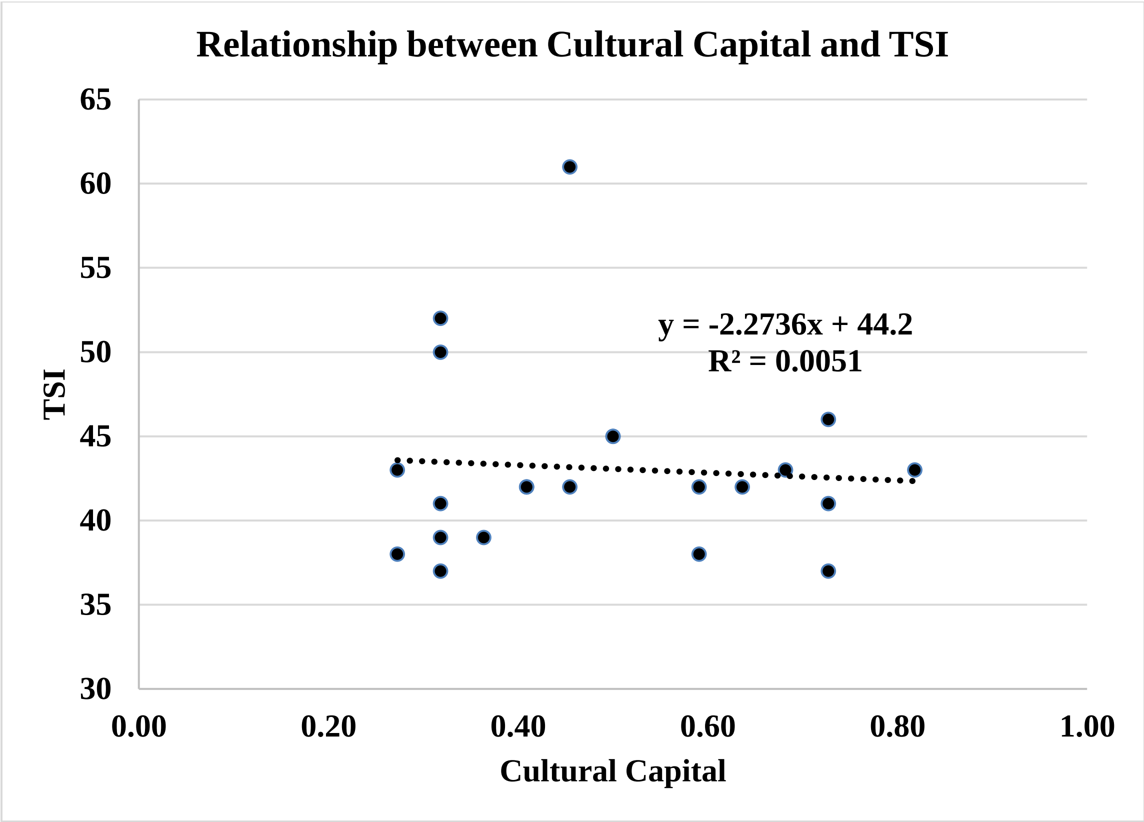

Figure 22. Relationship between cultural capital and TSI in riparian communities with a lake management plan.

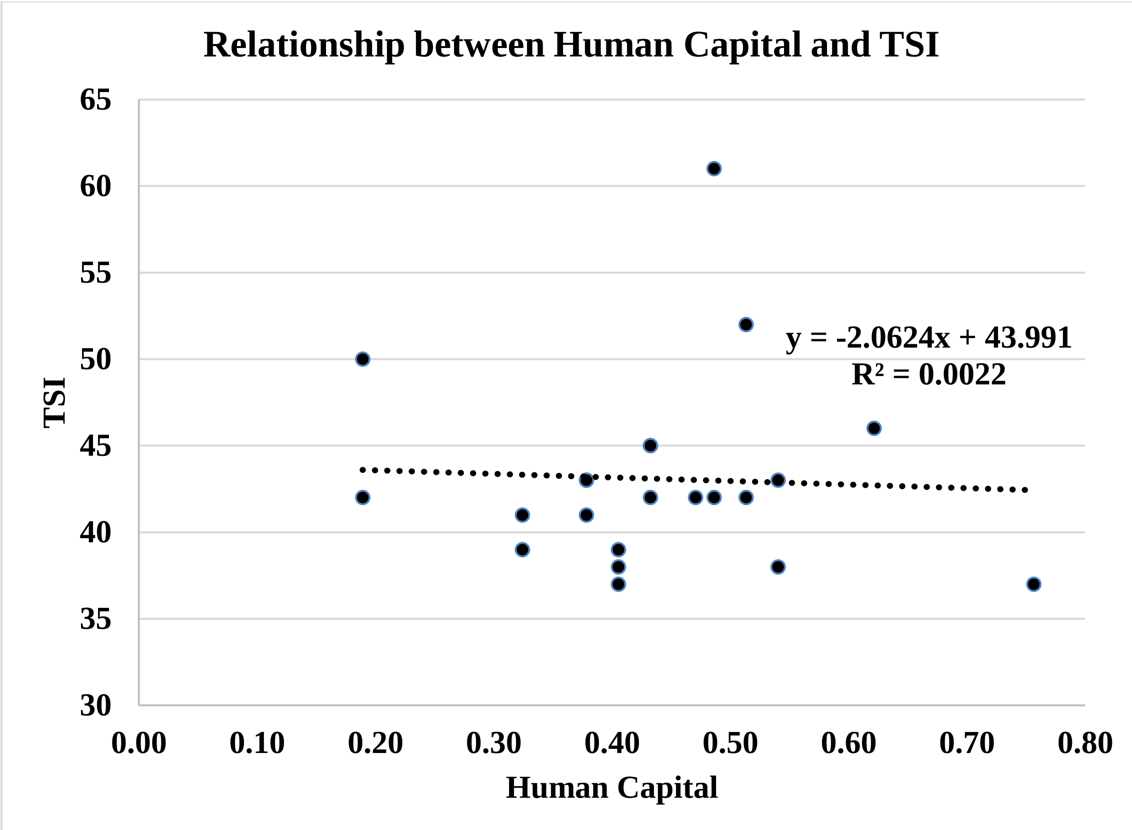

Figure 23. Relationship between human capital and TSI in riparian communities with a lake management plan.

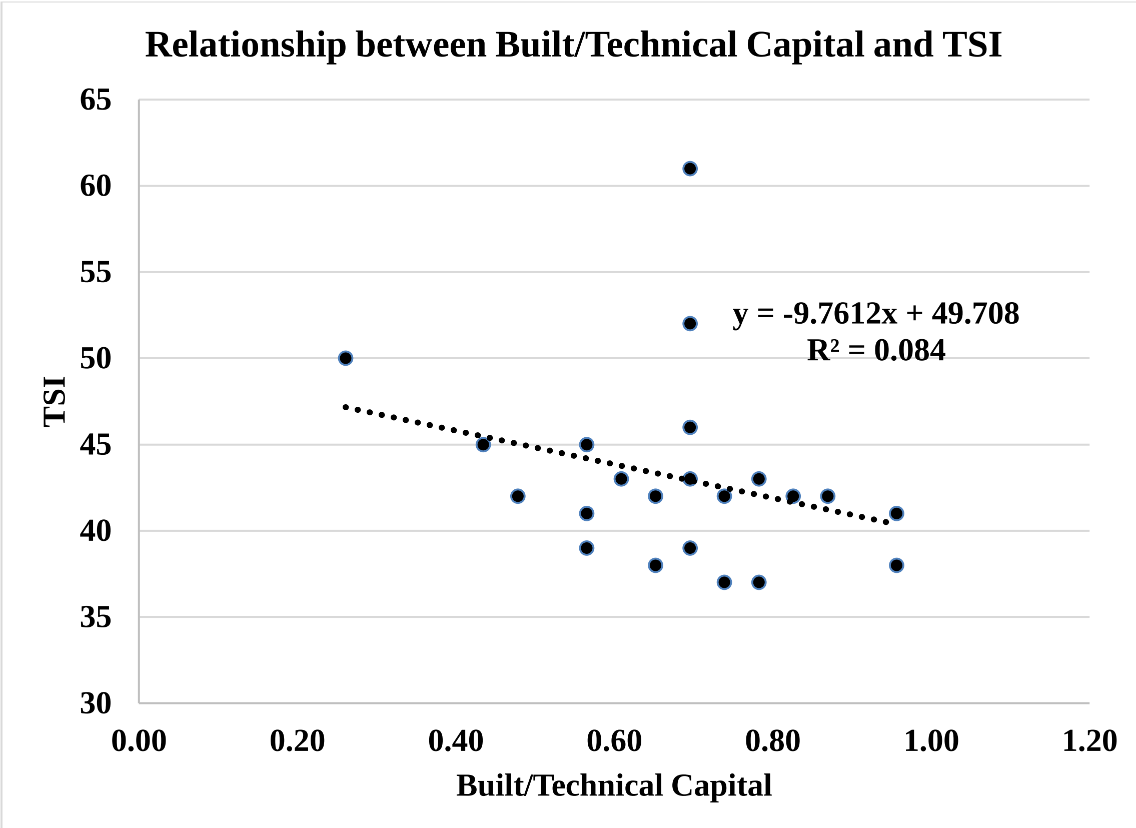

Figure 24. Relationship between built/technical capital and TSI in riparian communities with a lake management plan.

V.13 Statistical analyses on correlations of TSI and community capitals in non-LMP riparian community populations.

To determine if any correlations existed between TSI and the community capitals, a correlation regression was performed for each community capital type for the non-LMP population. A correlation test of significance was then conducted using the Pearson Correlation Coefficient which is a measure of "r" or the linear dependence (correlation) between the dependent (TSI) and independent variables (community capitals). The test was conducted at the 95% confidence level (α=0.05). No statistically significant findings were found for these correlations (Tables B-44-B-50 and Figures 18-24).

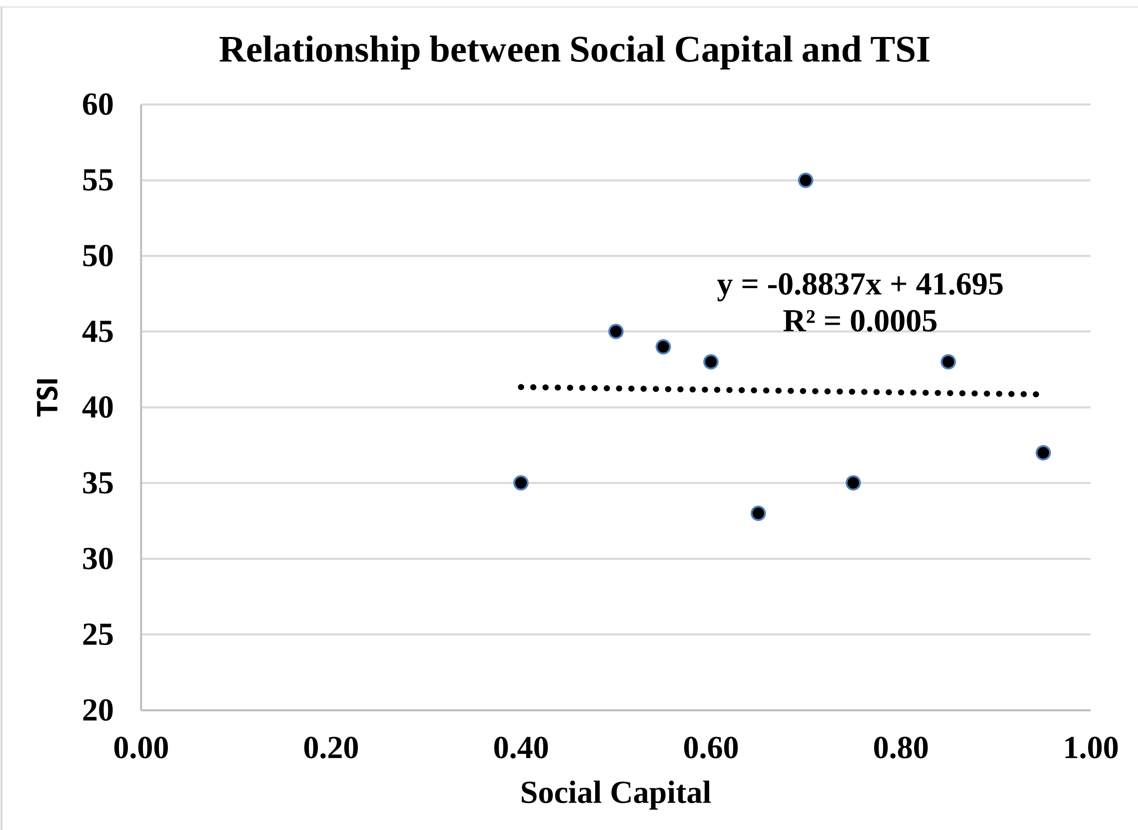

Figure 25. Relationship between social capital and TSI in riparian communities without a lake management plan.

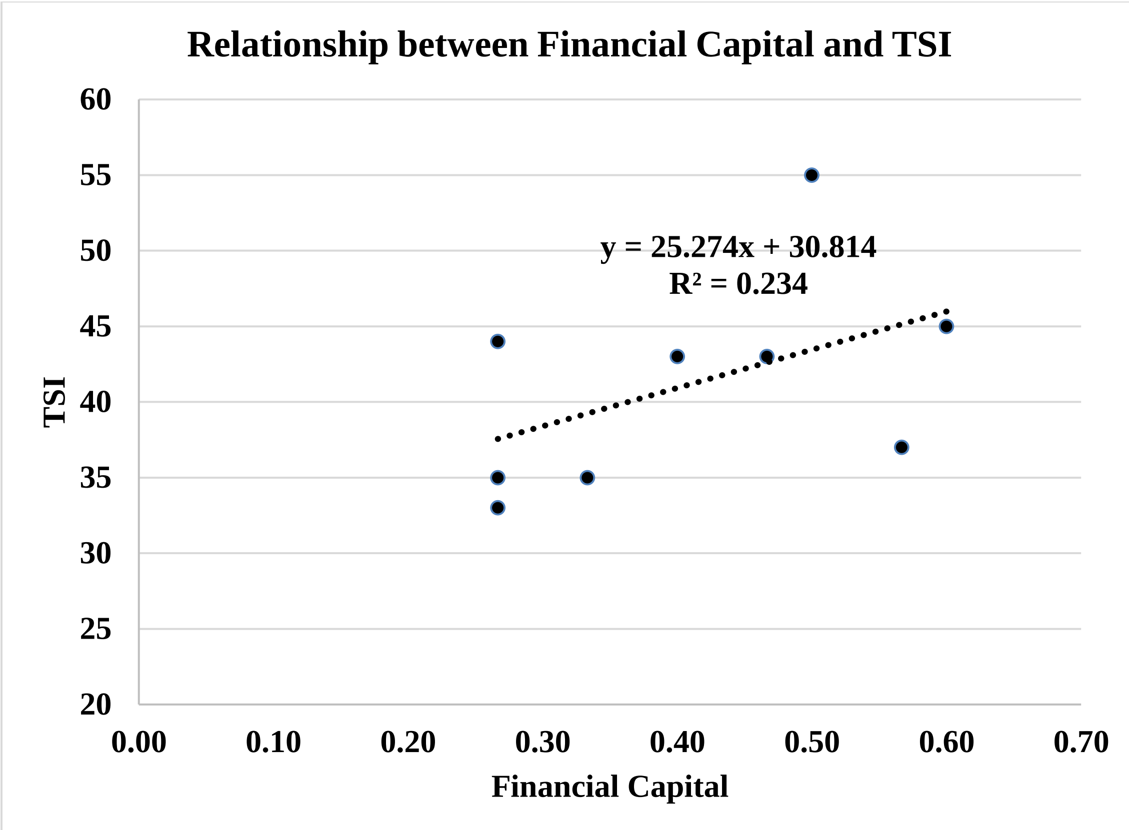

Figure 26. Relationship between financial capital and TSI in riparian communities without a lake management plan.

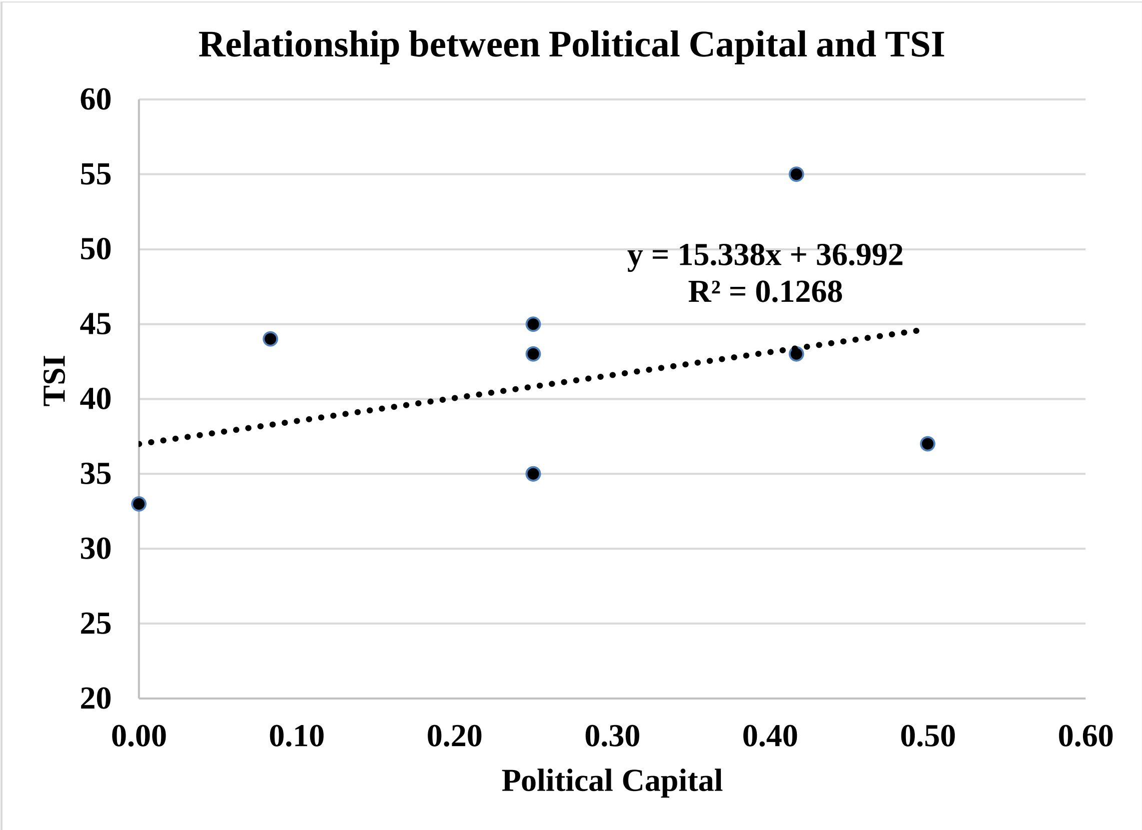

Figure 27. Relationship between political capital and TSI in riparian communities without a lake management plan.

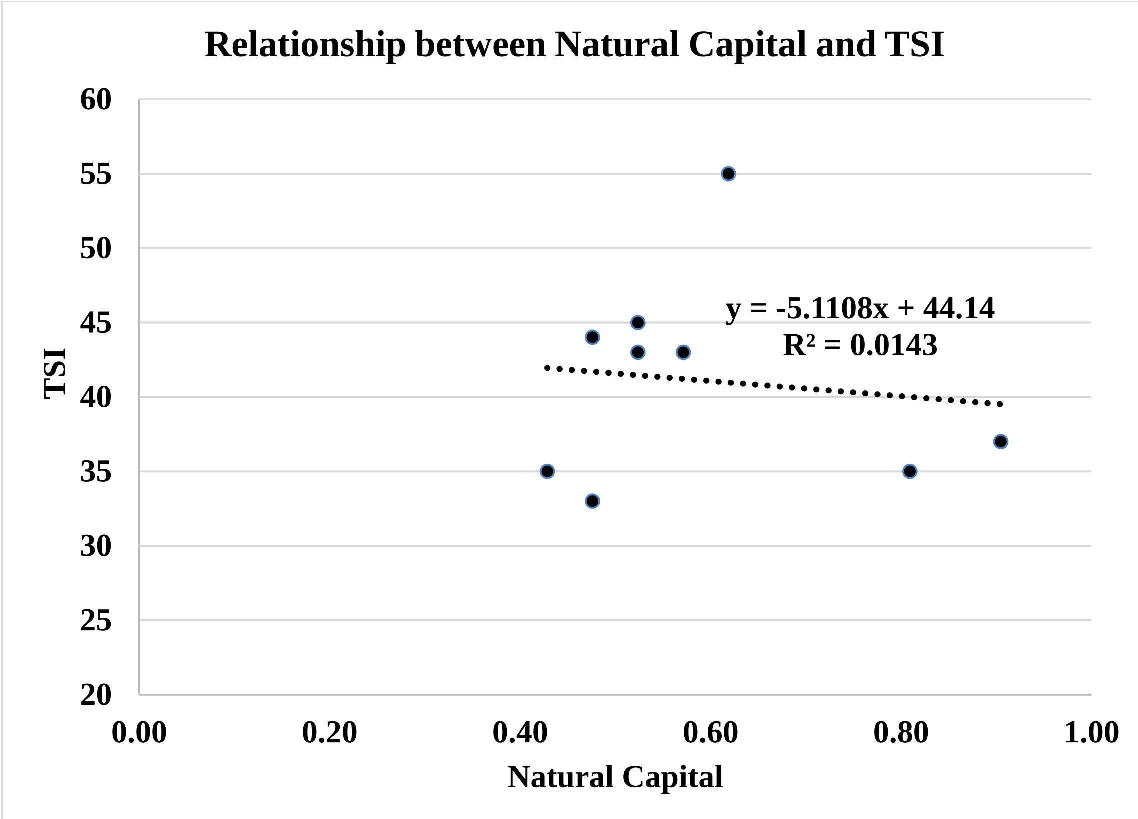

Figure 28. Relationship between natural capital and TSI in riparian communities without a lake management plan.

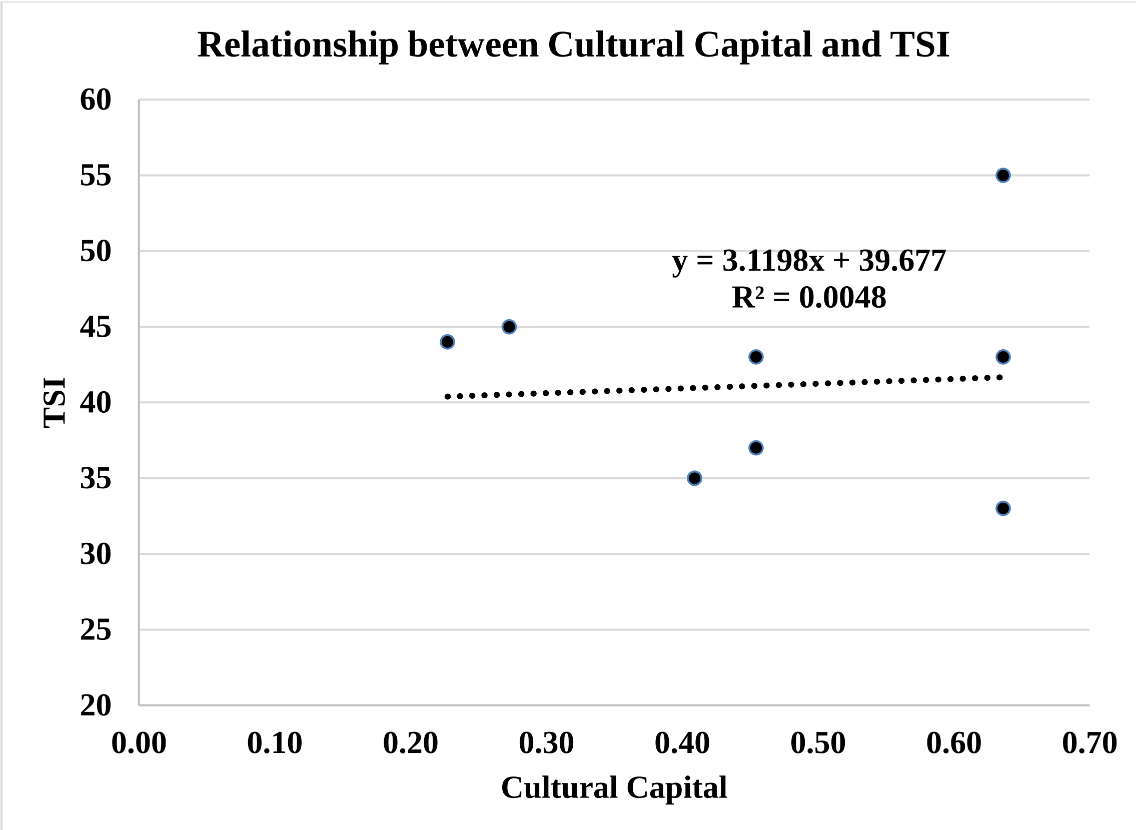

Figure 29. Relationship between cultural capital and TSI in riparian communities without a lake management plan.

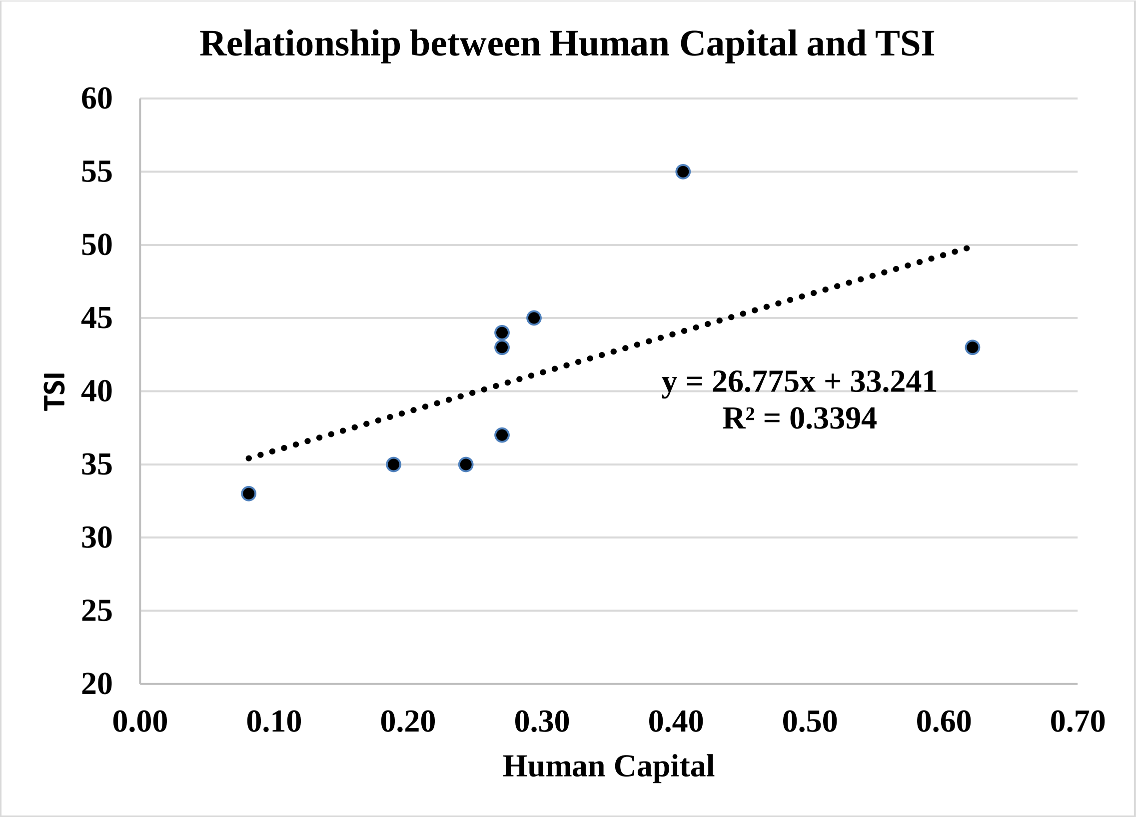

Figure 30. Relationship between human capital and TSI in riparian communities without a lake management plan.

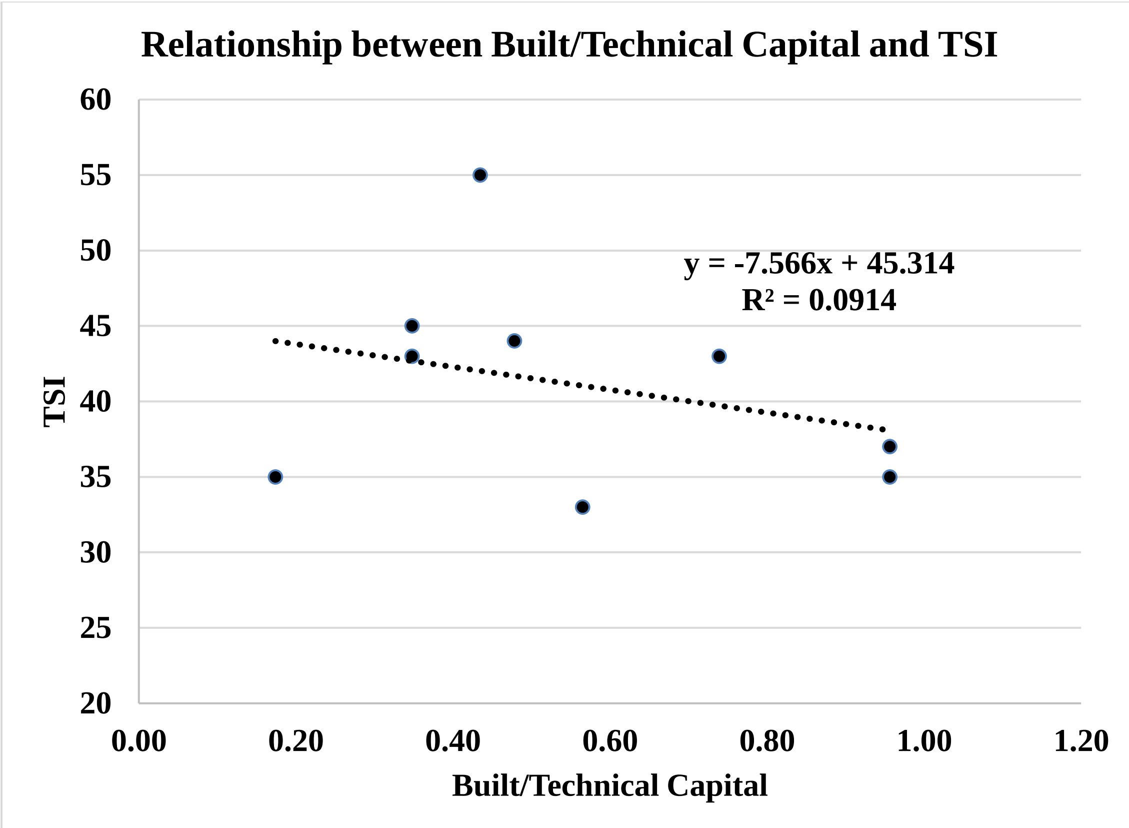

Figure 31. Relationship between built/technical capital and TSI in riparian communities without a lake management plan.

Table 4. Summary statistical table for correlations between community capitals and TSI for Non-LMP and LMP riparian community populations.

Community Capital	Non-LMP Correlation P-value	LMP Correlation P-value
Social	1.0	0.2
Financial	0.2	0.1
Political	0.3	0.9
Natural	0.8	0.2
Cultural	0.9	0.7
Human	0.1	0.8
Built/Technical	0.4	0.2

There were no statistically significant results for this test.
LMP = lake management plan population
Non-LMP = non-lake management plan population

CHAPTER V: DISCUSSION AND IMPLICATIONS FOR FUTURE RESEARCH

In summary, the statistically significant findings of this study include:

1) The correlation between cultural capital and BMPs for the LMP population is statistically significant. This means that in riparian communities with an active LMP, cultural capital is important for increasing implementation of BMPs.
2) There is a significant difference between financial capital for the LMP population and non-LMP population. There is a higher mean financial capital score in the LMP population which means that riparian communities with access to more financial capital are more likely to have LMPs.
3) There is a significant difference between human capital and BMPs for the LMP population and non-LMP population. There is a higher mean human capital score in the LMP population which means that riparian communities with access to more human capital, are more likely to implement BMPs especially if there is an active LMP being followed.

V.1 The Roles of Cultural, Human, and Social Capital in LMP Riparian Communities

Human capital includes the educational attainment of individuals and encompasses the broad subject of knowledge (such as skills, ability to analyze problems, etc.) that people within a community possess. In riparian communities, human capital would be advantageous for the implementation of BMPs since some general understanding of various BMPs and their applications would benefit from such educational background. This form of capital is more than just "power in numbers" relative to the size of a riparian community and also considers the knowledge base. It is also recognized that there is a considerable connection between human capital and social capital since having a sound knowledge base allows for enhanced social communication (Apaliyah et *al*., 2012). Thus, a community that has high bridging and bonding social capital has an advantage in that both forms of this capital can improve human capital. Perhaps some riparian communities with lower human capital can facilitate increasing social capital as a means to improve human capital. This may be especially beneficial to communities that have limited human capital and limited access to educational and informational resources. It may also allow for enhanced civic engagement that can motivate riparian communities on moving forward with management solutions such as BMPs while utilizing a broader lake management plan. Carpenter and Lathrop (1999) mention that restoration of a lake ecosystem from degradation of water quality depends not only upon implementation of suitable restoration strategies but also the inclusion of communities with lake managers in the decision-making process relative to BMP implementation. This would require adequate human and cultural capital to drive this process forward for the betterment of lake systems. The mere presence of natural capital can also increase human capital (Stijns, 2006) since riparians utilize the lake for ecosystem services discussed earlier in this study. This study demonstrated how human capital is important for lake communities to implement BMPs in the presence of a lake management plan. If human capital continues to increase, it may then be attributed to an increase in the availability of natural capital through action-driven decisions such as implementation of BMPs. Human capital is as important for the growth and sustenance of riparian communities much as it is for entrepreneurial operations (Kim et *al*., 2006). There may be some parallels between these two different populations since riparian communities may be innovative which is a key attribute present in entrepreneurs. This innovation would also likely lead to development and/or implementation of BMPs and other lake improvement programs.

Becker (1994) discusses the links between per capita income (financial capital) and human capital since specialized training and education often results in a more skilled labor force which in turn is associated with increased overall economic growth. Based on this research, financial capital itself is not necessarily a guarantee of ability to implement BMPs; however, having a coherent lake management plan or program may be a product of adequate financial capital since such plans are often costly and also usually have on-going implementation costs.

Douglas (2009) offered a sustainability framework that is centered around four attributes which are representative of human, cultural, and social capital. The elements of cultural capital include individual internal beliefs. Human capital elements include the role that knowledge plays in the network process and how the learning process is influenced by individual experience. He emphasizes that in order to have a sustainable program, these key principles need to be thoroughly understood. The path to a sustainable program then would incorporate a thorough understanding of cultural, human, and social capital of a given community. These attributes dictate how adaptable a program can be in the context of sustainability.

Since there is a significant correlative relationship between cultural capital and the ability to implement BMPs in populations with lake management plans, this indicates that the world views, experiences, traditions, and knowledge of the riparian communities likely play a significant role in the development of a lake management plan. Bourdieu and Passeron (1977) suggested the link between cultural capital and behavior. This is important for lake communities since the amount and types of cultural capital could influence the behavior of riparians in response to the lake resource.

Specific objectives that are a part of a lake management plan require some level of background knowledge of the lake baseline conditions and existing issues in order to bring about change. The presence of an expert on lake issues may also contribute significant human and cultural capital but it is important that the riparian community must also understand lake issues and improvement solutions available to them. Community engagement or the direct participation of riparian communities in an improvement program has been shown to be important for successful project completion (Green et *al*., 2013). Lake management plans do not always include community engagement but for optimal resource allocation they should. Cochrane (2006) explains the positive influences that cultural capital has on management objectives and process efficacy. This would support the findings in this study since BMPs can be considered a management objective. The relationship between cultural capital and BMPs although significant, was not strongly positive

(R^2=0.18) and this may have been due to a relatively small sample size. Further research is needed to increase the sample populations for a deeper understanding of these relationships.

V.2 The Roles of Financial Capital in LMP Riparian Communities

Putnam (2000) concluded that social capital is critical in the formation of prosperous communities since high social capital is associated with higher public trust and communication. These actions are more likely to result in higher availability of financial resources within a community. In this study, communities with higher financial capital were most likely to have active LMPs. This may allow for specific communities to implement BMPs that are generally inherent in LMPs. The LMP itself usually has a significant cost associated with it and the long-term implementation of BMPs would incur further costs. It seems logical that communities without access to adequate financial resources may encounter hurdles relative to the implementation of solutions. Financial capital may then be considered a vehicle by which other forms of capital are able to augment and create additional resources. It is clear in this study though, that financial capital itself is not enough to drive environmental change in lake communities. The elements of human and cultural capital are also critical.

V.3 Future Research Needs

This research evaluated the types of resources available to riparian communities that live around an individual lake. To evaluate resources from a systems approach, the same research would have to be conducted for local municipalities such as townships. For this research, only riparian communities were included to represent a relatively confined community for the ease of evaluation at a smaller scale. A complete model could then be created which would include all available resources for a given area.

This study had a few limitations. First, it sampled only riparian communities and not local units of government. It was also limited to lake associations since they are coherent groups of riparians that are not true governing bodies. A similar study evaluating the resources of a community and local unit of government is needed to determine the similarities, differences, or even synergistic relationships that may exist between the two populations. Furthermore, this study utilized proxy indicators that were specifically tailored to riparian communities. Such indicators may need to be modified over time and new indicators may need to be developed for future studies of municipal community capital resources. This study also did not investigate interactions between the various forms of capital although that may be conducted soon while this research is ongoing. Such research would be beneficial and could be conducted on a similar data set that is applied to a stock and flow type of model (Meadows, 2008). Each form of capital could be varied in the analysis and this would allow for the determination of the function of each capital form relative to changes in the others. A study of the interactions of community capitals by Pigg et *al*., (2013) discusses the ability of some forms of capital that are needed to augment other forms of capital. Inland lakes would be categorized as natural capital and this study has shown that human and cultural capital are important in the protection of natural capital.

Of particular interest is the finding of Trophic State Index (TSI) not being correlated with all of the capital forms. This indicates that the state of inland lakes is not necessarily a product of community capital but rather that implementation of BMPs or other behaviors may depend on community capitals. In the long-term, these resources and the ability to implement solutions could have impacts on the lake health. Further studies of heavily degraded lake systems and pristine water bodies along with measurement of community capitals could offer more insight to the importance of community capitals in water quality and ecosystem protection.

Sebatier (1998) discussed an advocacy coalition framework for driving policy change and that such a framework is dependent upon fair representation of values, beliefs, and perspectives. This capital framework may be implemented by riparian communities, local units of government, and outside experts if the cultural and human capital attributes are thoroughly understood by all stakeholders. The survey instrument used in this study offers some indicators that may be used to measure the human and cultural capital capacities within riparian communities but more indicators can be evaluated in the future. In an effort to inform riparian communities of the degree of capital they possess relative to each form of capital, Phillips (2003) recommends visual graphs and charts that can be easily understood by a community and that can allow them to readily visualize what resources are in abundance and what ones are scarce.

Of interest were the findings that political capital did not play a role in riparian communities relative to BMP implementation which suggests that these communities may be likely to implement BMPs without having to utilize outside governing resources. Additionally, it was not surprising that there was a negative correlation between natural capital and BMPs. This may be because some communities that have more pristine lakes may not need to implement BMPs. Although there is some confidence in the significant findings above, further studies are needed to evaluate more riparian communities with a greater sample size. Additionally, since TSI did not appear to be correlated with the various forms of capital but BMPs were with some capitals, this may indicate that community capitals are more likely to have a significant influence on action-oriented parameters such as BMPs.

Increased education (human capital) and return on investment (financial capital) were both considered important for the implementation of BMPs for beef cattle production (Kim et *al*., 2005). Thus, these forms of capital may be applied to many different natural systems.

Getz et *al*., (1999) found that sustainable natural resource conservation must include scientists and citizen-scientists for the ultimate long-term success of a management program. This is another example of how increases in human capital can lead to increases in natural capital. Other forms of capital may be needed to increase natural capital such as social and human capital (Pretty and Ward, 2001). In fact, when natural capital is depleted, the accumulation of other favorable forms of community capital also decline which would be a substantial hurdle for sustainable management (Stratford and Davidson, 2002). For riparian communities, it appears that human capital is more critical to implementing improvements than social capital. This may be because the individual interactions between riparian members are not as critical in driving change as their knowledge base and world views. Similarly, the presence of indigenous knowledge also becomes important for natural resource protection (Gadgil et *al*., 1993). Such knowledge would incorporate both cultural and human capital which were shown to have importance in riparian communities. It may also be beneficial in future studies of community capitals in riparian communities to lay out the context, process, and impacts that each unique form of capital may have on the management capacity of lake systems (Gasteyer and Araj, 2009). This research serves as a beginning for the evaluation of lake community resources which ultimately are needed for a sustainable management of lake ecosystems.

APPENDICES

APPENDIX A

Survey Instrument

Social Capital:

1) How many years has your lake association been in existence?
   a) < 1 year b) 1-5 years c) 5-10 years d) > 10 years e) I do not know

2) How many times per year does your lake association hold meetings?
   a) 0 b) 1-3 times c) 3-5 times d) > 5 times e) I do not know

3) How many social media groups does the association belong to?
   a) 0 b) 1 c) 2 d) > 2 e) I do not know

4) Estimate the degree of trust among lake Association residents:
   a) No trust b) low trust c) moderate trust d) high trust e) I do not know

5) How many times in the past year have you reached out to other lakes (Associations of other groups) for guidance or information on lake issues?
   a) 0 b) 1 c) 2 d) >2 e) I do not know

6) What percentage of your Association has turned over membership in the past 2 years?
   a) 0% b) 1-20% c) 20-40% d) > 40% e) I do not know

Natural Capital:

7) How many lakes lie within five miles of your lake?
   a) 0 b) 1-3 c) 3-6 d) 6-9+ e) I do not know

8) How many years has your lake been managed by your Association or a lake professional?
   a) 0 b) 1-3 c) 3-6 d) 6-9+ e) I do not know

9) Is there a nature center within five miles of the lake?
   a) Yes b) No c) I do not know

10) What is the lake trophic status (i.e. nutrient-rich or poor or moderate)?
   a) Eutrophic (highly nutrient enriched and low in clarity)
   b) moderate in nutrients and clarity (mesotrophic)
   c) oligotrophic (low in nutrients and clarity)
   d) I do not know

11) How many parks are within five miles of lake?
   a) 0 b) 1-3 c) 3-6 d) >6 e) I do not know

12) Percentage of green space/forest/wetlands/ within five miles of lake?
   a) 0% b) 1-10% c) 10-20% d) 20-30% e) > 31% f) I do not know

13) How many miles of walking (non-paved) trails are within five miles of lake?
   a) 0 b) 1-5 c) 5-10 d) 10-15 e) > 15 f) I do not know

14) What is the population density of your riparian community?
   a) < 10 people b) 10-50 people c) 50-90 people d) >90 people e) I do not know

15) Does the lake have public access?
   a) Yes b) No c) I do not know

Cultural Capital:

16) How many unique items have been created as marketing products for your lake or association?
   a) 0 b) 1-3 c) 3-6 d) >6 e) I do not know

17) What is the average annual time investment (in hours) of the Association on lake projects?
   a) 0 hours b) 1-50 hours c) 50-100 hours d) > 100 hours e) I do not know

18) How many lake-specific events are held in your lake Association community annually?
   a) 0 b) 1-2 c) 3-4 d) > 4 e) I do not know

19) How many traditions exist that are specific to your lake Association?
   a) 0 b) 1 c) 2 d) 3 e) >3 f) I do not know

20) Approximately what percent of the population around your lake is seasonal?
   a) 0 b) 1-10% c) 10-20% d) 20-30% e) >30% f) I do not know

21) Approximately what percent of the population around your lake is generational or has relatives that once lived on the lake?
    a) 0% b) 1-10% c) 10-20% d) 20-30% e) > 30% f) I do not know

Human Capital:

22) What is the average age of a riparian in the Association?
    a) Under 20 b) 20-40 c) 40-60 d) > 60 e) I do not know

23) What percentage of your Association has the following educational attainment:
    a) Non high school b) high school c undergrad degree (BS or Associates)
    d) Graduate degree e) I do not know

24) How many riparians in the Association have skills that pertain to natural resources management or protection?
    a) 0 b) 1-5 c) 5-10 d) > 10 e) I do not know

25) How many different civic associations do lake activities around your lake (i.e. Elks, Masons, Rotary, Schools, etc.)?
    a) 0 b) 1 c) 2 d) 3 e) > 3 f) I do not know

26) How many businesses donate time to lake activities each year?
    a) 0 b) 1 c) 2 d) 3 e) > 3 f) I do not know

27) How many businesses donate time to lake protection each year?
    a) 0 b) 1 c) 2 d) 3 e) > 3 f) I do not know

28) How many businesses donate time for lake monitoring each year?
    a) 0 b) 1 c) 2 d) 3 e) > 3 f) I do not know

29) How many small businesses/start-ups exist within your lake community?
    a) 0 b) 1-5 c) 5-10 d) >10 e) I do not know

30) What percentage of the lake population is in your Association?
a) 0% b) 1-10% c) 10-30% d) 30-50% e) > 50% f) I do not know

Political Capital:

31) How many grants have been obtained by the Association in the past five years? (Grants can be municipal, private, non-governmental organization, state, county, national, or township)
a) 0 b) 1 c) 2 d) 3 e) > 3 f) I do not know

32) On average, how many times have riparians worked annually with government or political groups?
a) 0 b) 1-3 c) 3-6 d) > 6 e) I do not know

33) How many riparians on the lake occupy a political office in the area or state?
a) 0 b) 1 c) 2 d) > 2 e) I do not know

34) Is there evidence of the ability of the Association to influence regulations (i.e. ordinances) due to the structure/composition of your lake community?
a) Yes b) No c) I do not know

35) Is there evidence of the ability to implement regulations (such as ordinances) to benefit water quality due to the structure/composition of your lake community?
a) Yes b) No c) I do not know

Built/Technical Capital:

36) How many homes are there around your lake?
a) 20-80 b) 80-140 c) 140-200 d) >200 e) I do not know

37) How many of the homes on your lake are on a sewer system?
a) 0 b) 1-20% c) 20-40% d) 40-60% e) > 60 % f) I do not know

38) How many paved trails exist within five miles of your lake?
a) 0 b) 1 c) 2 d) 3 e) >3 f) I do not know

39) What is the percentage of homes with internet access on your lake?
a) 0 b) 1-20% c) 20-40% d) 40-60% e) > 60% f) I do not know

40) Is there access to a local community center or library within five miles of your lake?
a) Yes b) No c) I do not know

41) Is there a lake expert that manages your lake?
a) Yes b) No c) I do not know

42) Is there access to scientific/technical information on your lake?
a) Yes b) No c) I do not know

43) Is there access to GIS/maps on your lake (regarding your lake)?
a) Yes b) No c) I do not know

44) How many industries or businesses are within five miles of your lake?
a) 0 b) 1-5 c) 5-10 d) > 10 e) I do not know

Financial Capital:

45) What is the average annual per capita income per riparian in the Association?
a) < $20,000 b) $20,000- $40,000 c) $40,000-$60,000 d) > $60,000
e) I do not know

46) What is the annual amount of money received for annual lake Assoc. dues?
a) $0-500 b) $500-$1,000 c) $1,000-$1,500 d) > $1,500 e) I do not know

47) What is the annual amount of grant money received for lake improvement/watershed grants?
a) $0 b) $1-500 c) $500-$1,000 d) > $1,000 e) I do not know

48) How much money is spent annually on lake management?
a) $0 b) $1,000-$30,000 c) $30,000-$60,000 d) > $60,000 e) I do not know

49) How much money is donated annually to the lake for management or preservation?
a) $0 b) $1-$500 c) $500-$2,000 d) > $2,000 e) I do not know

50) What is the approximate percentage of riparians on the lake at poverty level?
a) 0% b) 1-10% c) 10-20% d) 20-30% e) > 30% f) I do not know

51) What is the average cost of housing on your lake?
a) < $100,000 b) $100,000-$200,000 c) $200,000-$300,000 d) > $300,00
e) I do not know

52) What is the percentage of home ownership in your Association?
a) 0% b) 1-30% c) 30-60% d) > 60% e) I do not know

53) Would the Association have the ability to obtain a loan for lake improvements?
a) Yes b) No c) I do not know

APPENDIX B

Statistical Tables

Table B-1. Descriptive statistics for social capital in both LMP and non-LMP riparian community populations.

		N	Mean	Std. Deviation	Std. Error Mean
NONLMP	1.00	10	.6450	.17070	.05398
LMP	2.00	23	.7043	.19593	.04085

Table B-2. Statistical test on the social capital means in both LMP and non-LMP riparian community populations.

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
VAR00001	Equal variances assumed	.000	.993	-.829	31	.413	-.05935	.07157	-.20532	.08663
	Equal variances not assumed			-.877	19.629	.391	-.05935	.06770	-.20073	.08204

Table B-3. Descriptive statistics for financial capital in both LMP and non-LMP riparian community populations.

		N	Mean	Std. Deviation	Std. Error Mean
NONLMP	1.00	10	.4180	.12744	.04030
LMP	2.00	23	.5361	.17601	.03670

Table B-4. Statistical test on the financial capital means in both LMP and non-LMP riparian community populations.

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
VAR00001	Equal variances assumed	1.373	.250	-1.908	31	.066	-.11809	.06189	-.24432	.00815
	Equal variances not assumed			-2.166	23.505	.041	-.11809	.05451	-.23071	-.00547

Table B-5. Descriptive statistics for political capital in both LMP and non-LMP riparian community populations

		N	Mean	Std. Deviation	Std. Error Mean
NONLMP	1.00	10	.2920	.16884	.05339
LMP	2.00	23	.3291	.18231	.03801

Table B-6. Statistical test on the political capital means in both LMP and non-LMP riparian community populations

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
VAR00001	Equal variances assumed	.036	.852	-.549	31	.587	-.03713	.06761	-.17503	.10077
	Equal variances not assumed			-.567	18.493	.578	-.03713	.06554	-.17457	.10030

Table B-7. Descriptive statistics for natural capital in both LMP and non-LMP riparian community populations.

		N	Mean	Std. Deviation	Std. Error Mean
NONLMP	1.00	10	.5900	.15122	.04782
LMP	2.00	23	.5822	.15166	.03162

Table B-8. Statistical test on the natural capital means in both LMP and non-LMP riparian community populations.

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
VAR00001	Equal variances assumed	.349	.559	.136	31	.892	.00783	.05740	-.10924	.12489
	Equal variances not assumed			.137	17.244	.893	.00783	.05733	-.11300	.12865

Table B-9. Descriptive statistics for cultural capital in both LMP and non-LMP riparian community populations.

		N	Mean	Std. Deviation	Std. Error Mean
NONLMP	1.00	10	.4590	.14587	.04613
LMP	2.00	23	.4843	.17061	.03557

Table B-10. Statistical test on the cultural capital means in both LMP and non-LMP riparian community populations.

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
VAR00001	Equal variances assumed	1.234	.275	-.409	31	.686	-.02535	.06205	-.15190	.10120
	Equal variances not assumed			-.435	19.996	.668	-.02535	.05825	-.14686	.09616

Table B-11. Descriptive statistics for human capital in both LMP and non-LMP riparian community populations.

		N	Mean	Std. Deviation	Std. Error Mean
NONLMP	1.00	10	.3050	.14653	.04634
LMP	2.00	23	.4296	.12872	.02684

Table B-12. Statistical test on the human capital means in both LMP and non-LMP riparian community populations.

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
VAR00001	Equal variances assumed	.132	.719	-2.452	31	.020	-.12457	.05081	-.22819	-.02094
	Equal variances not assumed			-2.326	15.345	.034	-.12457	.05355	-.23848	-.01065

Table B-13. Descriptive statistics for built/technical capital in both LMP and non-LMP riparian community populations.

		N	Mean	Std. Deviation	Std. Error Mean
NONLMP	1.00	10	.5490	.26274	.08309
LMP	2.00	23	.6748	.16208	.03380

Table B-14. Statistical test on the built/technical capital means in both LMP and non-LMP riparian community populations.

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
VAR00001	Equal variances assumed	3.670	.065	-1.688	31	.101	-.12578	.07450	-.27773	.02617
	Equal variances not assumed			-1.402	12.089	.186	-.12578	.08970	-.32105	.06949

Table B-15. Descriptive statistics for BMPs in both LMP and non-LMP riparian community populations.

		N	Mean	Std. Deviation	Std. Error Mean
NONLMP	1.00	10	4.7000	3.02030	.95510
LMP	2.00	23	6.6087	2.93473	.61193

Table B-16. Statistical test on the BMP means in both LMP and non-LMP riparian community populations.

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means					95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
VAR00001	Equal variances assumed	.071	.792	-1.702	31	.099	-1.90870	1.12114	-4.19528	.37788
	Equal variances not assumed			-1.683	16.751	.111	-1.90870	1.13432	-4.30462	.48723

Table B-17. Statistical test on the correlation between BMPs and social capital in LMP riparian community populations.

Correlations

		SOCCAP	BMP
SOCCAP	Pearson Correlation	1	.347
	Sig. (2-tailed)		.105
	N	23	23
BMP	Pearson Correlation	.347	1
	Sig. (2-tailed)	.105	
	N	23	23

Table B-18. Statistical test on the correlation between BMPs and financial capital in LMP riparian community populations.

Correlations

		FINCAP	BMP
FINCAP	Pearson Correlation	1	.213
	Sig. (2-tailed)		.328
	N	23	23
BMP	Pearson Correlation	.213	1
	Sig. (2-tailed)	.328	
	N	23	23

Table B-19. Statistical test on the correlation between BMPs and political capital in LMP riparian community populations.

Correlations

		POLCAP	BMP
POLCAP	Pearson Correlation	1	.310
	Sig. (2-tailed)		.150
	N	23	23
BMP	Pearson Correlation	.310	1
	Sig. (2-tailed)	.150	
	N	23	23

Table B-20. Statistical test on the correlation between BMPs and natural capital in LMP riparian community populations

Correlations

		NATCAP	BMP
NATCAP	Pearson Correlation	1	-.095
	Sig. (2-tailed)		.666
	N	23	23
BMP	Pearson Correlation	-.095	1
	Sig. (2-tailed)	.666	
	N	23	23

Table B-21. Statistical test on the correlation between BMPs and cultural capital in LMP riparian community populations.

Correlations

		CULTCAP	BMP
CULTCAP	Pearson Correlation	1	.427*
	Sig. (2-tailed)		.042
	N	23	23
BMP	Pearson Correlation	.427*	1
	Sig. (2-tailed)	.042	
	N	23	23

*. Correlation is significant at the 0.05 level (2-tailed).

Table B-22. Statistical test on the correlation between BMPs and human capital in LMP riparian community populations.

Correlations

		HUMCAP	BMP
HUMCAP	Pearson Correlation	1	.359
	Sig. (2-tailed)		.092
	N	23	23
BMP	Pearson Correlation	.359	1
	Sig. (2-tailed)	.092	
	N	23	23

Table B-23. Statistical test on the correlation between BMPs and built/technical capital in LMP riparian community populations.

Correlations

		BLTCAP	BMP
BLTCAP	Pearson Correlation	1	-.021
	Sig. (2-tailed)		.925
	N	23	23
BMP	Pearson Correlation	-.021	1
	Sig. (2-tailed)	.925	
	N	23	23

Table B-24. Statistical test on the correlation between BMPs and social capital in non-LMP riparian community populations.

Correlations

		SOCCAP	BMP
SOCCAP	Pearson Correlation	1	.018
	Sig. (2-tailed)		.960
	N	10	10
BMP	Pearson Correlation	.018	1
	Sig. (2-tailed)	.960	
	N	10	10

Table B-25. Statistical test on the correlation between BMPs and financial capital in non-LMP riparian community populations.

Correlations

		FINCAP	BMP
FINCAP	Pearson Correlation	1	.475
	Sig. (2-tailed)		.166
	N	10	10
BMP	Pearson Correlation	.475	1
	Sig. (2-tailed)	.166	
	N	10	10

Table B-26. Statistical test on the correlation between BMPs and political capital in non-LMP riparian community populations.

Correlations

		POLCAP	BMP
POLCAP	Pearson Correlation	1	.086
	Sig. (2-tailed)		.813
	N	10	10
BMP	Pearson Correlation	.086	1
	Sig. (2-tailed)	.813	
	N	10	10

Table B-27. Statistical test on the correlation between BMPs and natural capital in non-LMP riparian community populations.

Correlations

		NATCAP	BMP
NATCAP	Pearson Correlation	1	-.197
	Sig. (2-tailed)		.585
	N	10	10
BMP	Pearson Correlation	-.197	1
	Sig. (2-tailed)	.585	
	N	10	10

Table B-28. Statistical test on the correlation between BMPs and cultural capital in non-LMP riparian community populations.

Correlations

		CULTCAP	BMP
CULTCAP	Pearson Correlation	1	.133
	Sig. (2-tailed)		.714
	N	10	10
BMP	Pearson Correlation	.133	1
	Sig. (2-tailed)	.714	
	N	10	10

Table B-29. Statistical test on the correlation between BMPs and human capital in non-LMP riparian community populations.

Correlations

		HUMCAP	BMP
HUMCAP	Pearson Correlation	1	.368
	Sig. (2-tailed)		.296
	N	10	10
BMP	Pearson Correlation	.368	1
	Sig. (2-tailed)	.296	
	N	10	10

Table B-30. Statistical test on the correlation of BMPs and built/technical capital in non-LMP riparian community populations.

Correlations

		BLTCAP	BMP
BLTCAP	Pearson Correlation	1	-.384
	Sig. (2-tailed)		.273
	N	10	10
BMP	Pearson Correlation	-.384	1
	Sig. (2-tailed)	.273	
	N	10	10

Table B-31. Descriptive statistics on TSI chlorophyll-*a* in LMP and non-LMP riparian community populations.

Group Statistics

		N	Mean	Std. Deviation	Std. Error Mean
NONLMP	1.00	9	37.2222	8.21246	2.73749
LMP	2.00	22	41.3636	8.56652	1.82639

Table B-32. Statistical test on the means of TSI chlorophyll-*a* in LMP and non-LMP riparian community populations.

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
VAR00001	Equal variances assumed	.174	.680	-1.236	29	.227	-4.14141	3.35157	-10.99615	2.71332
	Equal variances not assumed			-1.258	15.535	.227	-4.14141	3.29082	-11.13468	2.85185

Table B-33. Descriptive statistics on TSI phosphorus in LMP and non-LMP riparian community populations.

Group Statistics

		N	Mean	Std. Deviation	Std. Error Mean
NONLMP	1.00	9	43.3333	7.71362	2.57121
LMP	2.00	21	44.5238	7.24306	1.58057

Table B-34. Statistical test on TSI phosphorus in LMP and non-LMP riparian community populations.

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
VAR00001	Equal variances assumed	.209	.651	-.405	28	.689	-1.19048	2.94049	-7.21379	4.83284
	Equal variances not assumed			-.394	14.368	.699	-1.19048	3.01816	-7.64828	5.26733

Table B-35. Descriptive statistics on TSI Secchi in LMP and non-LMP riparian community populations.

Group Statistics

		N	Mean	Std. Deviation	Std. Error Mean
NONLMP	1.00	9	42.8889	6.77208	2.25736
LMP	2.00	20	43.7000	4.60092	1.02880

Table B-36. Statistical test on the means of TSI phosphorus in LMP and non-LMP riparian community populations.

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
VAR00001	Equal variances assumed	1.757	.196	-.379	27	.708	-.81111	2.14224	-5.20663	3.58441
	Equal variances not assumed			-.327	11.460	.750	-.81111	2.48075	-6.24456	4.62234

Table B-37. Statistical test on the correlation between TSI and social capital in LMP riparian community populations.

Correlations

		SOCCAP	TSI
SOCCAP	Pearson Correlation	1	-.276
	Sig. (2-tailed)		.214
	N	22	22
TSI	Pearson Correlation	-.276	1
	Sig. (2-tailed)	.214	
	N	22	22

Table B-38. Statistical test on the correlation between TSI and financial capital in LMP riparian community populations.

Correlations

		FINCAP	TSI
FINCAP	Pearson Correlation	1	-.360
	Sig. (2-tailed)		.100
	N	22	22
TSI	Pearson Correlation	-.360	1
	Sig. (2-tailed)	.100	
	N	22	22

Table B-39. Statistical test on the correlation between TSI and political capital in LMP riparian community populations.

Correlations

		POLCAP	TSI
POLCAP	Pearson Correlation	1	-.037
	Sig. (2-tailed)		.870
	N	22	22
TSI	Pearson Correlation	-.037	1
	Sig. (2-tailed)	.870	
	N	22	22

Table B-40. Statistical test on the correlation between TSI and natural capital in LMP riparian community populations.

Correlations

		NATCAP	TSI
NATCAP	Pearson Correlation	1	-.276
	Sig. (2-tailed)		.213
	N	22	22
TSI	Pearson Correlation	-.276	1
	Sig. (2-tailed)	.213	
	N	22	22

Table B-41. Statistical test on the correlation between TSI and cultural capital in LMP riparian community populations.

Correlations

		CULTCAP	TSI
CULTCAP	Pearson Correlation	1	-.074
	Sig. (2-tailed)		.744
	N	22	22
TSI	Pearson Correlation	-.074	1
	Sig. (2-tailed)	.744	
	N	22	22

Table B-42. Statistical test on the correlation between TSI and human capital in LMP riparian community populations.

Correlations

		HUMCAP	TSI
HUMCAP	Pearson Correlation	1	-.050
	Sig. (2-tailed)		.825
	N	22	22
TSI	Pearson Correlation	-.050	1
	Sig. (2-tailed)	.825	
	N	22	22

Table B-43. Statistical test on the correlation between TSI and built/technical capital in LMP riparian community populations.

Correlations

		BLTCAP	TSI
BLTCAP	Pearson Correlation	1	-.285
	Sig. (2-tailed)		.198
	N	22	22
TSI	Pearson Correlation	-.285	1
	Sig. (2-tailed)	.198	
	N	22	22

Table B-44. Statistical test on the correlation between TSI and social capital in non-LMP riparian community populations.

Correlations

		SOCCAP	TSI
SOCCAP	Pearson Correlation	1	-.022
	Sig. (2-tailed)		.955
	N	9	9
TSI	Pearson Correlation	-.022	1
	Sig. (2-tailed)	.955	
	N	9	9

Table B-45. Statistical test on the correlation between TSI and financial capital in non-LMP riparian community populations.

Correlations

		FINCAP	TSI
FINCAP	Pearson Correlation	1	.482
	Sig. (2-tailed)		.189
	N	9	9
TSI	Pearson Correlation	.482	1
	Sig. (2-tailed)	.189	
	N	9	9

Table B-46. Statistical test on correlation between TSI and political capital in non-LMP riparian community populations.

Correlations

		POLCAP	TSI
POLCAP	Pearson Correlation	1	.358
	Sig. (2-tailed)		.344
	N	9	9
TSI	Pearson Correlation	.358	1
	Sig. (2-tailed)	.344	
	N	9	9

Table B-47. Statistical test on the correlation between TSI and natural capital in non-LMP riparian community populations.

Correlations

		NATCAP	TSI
NATCAP	Pearson Correlation	1	-.123
	Sig. (2-tailed)		.752
	N	9	9
TSI	Pearson Correlation	-.123	1
	Sig. (2-tailed)	.752	
	N	9	9

Table B-48. Statistical test on the correlation between TSI and cultural capital in non-LMP riparian community populations.

Correlations

		CULTCAP	TSI
CULTCAP	Pearson Correlation	1	.071
	Sig. (2-tailed)		.855
	N	9	9
TSI	Pearson Correlation	.071	1
	Sig. (2-tailed)	.855	
	N	9	9

Table B-49. Statistical test on the correlation between TSI and human capital in non-LMP riparian community populations.

Correlations

		HUMCAP	TSI
HUMCAP	Pearson Correlation	1	.590
	Sig. (2-tailed)		.095
	N	9	9
TSI	Pearson Correlation	.590	1
	Sig. (2-tailed)	.095	
	N	9	9

Table B-50. Statistical test on the correlation between TSI and built/technical capital in non-LMP riparian community populations.

Correlations

		BLTCAP	TSI
BLTCAP	Pearson Correlation	1	-.307
	Sig. (2-tailed)		.422
	N	9	9
TSI	Pearson Correlation	-.307	1
	Sig. (2-tailed)	.422	
	N	9	9

LITERATURE CITED

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Adams, W.M., D. Brockington, J. Dyson, and B. Vira. 2003. Managing tragedies: Understanding conflict over common pool resources. Science, 302(5652):1915-1916.

Allen, C.R., J.J. Fontaine, K.L. Pope, and A.S. Garmestani. 2011. Adaptive management for a turbulent future. Journal of Environmental Management, 92:1339-1345.

Allen, C.R., and L.H. Gunderson. 2011. Pathology and failure in the design and implementation of adaptive management. Journal of Environmental Management, 92:1379-1384.

Alston, M. 2004. "You Don't Want to be a Check-out Chick all Your Life: The Out-migration of Youth from Australia's Small Rural Towns, "Australian Journal of Social Issues, 39(3):311.

American Planning Association. December 2003. Community Indicators. Planning Advisory Service, Report No. 517. 46 pgs.

Apaliyah, G.T., K.E. Martin, S.P. Gasteyer, K. Keating, and K. Pigg. 2012. Community leadership development education: Promoting civic engagement through human and social capital. Community Development, 43(1):31-48.

Armitage, D. 2005. Adaptive capacity and community-based natural resource management. Environmental Management, 35(6):703-715.

Barles, S. 2010. Society, energy, and materials: The contribution of urban metabolism studies to sustainable urban development issues. Journal of Environmental Planning and Management, 53(4):439-455.

Becker, G.S. 1994. Human Capital: A theoretical and empirical analysis with special reference to education (3rd edition). The University of Chicago Press. ISBN:0-226-04119-0, pgs:15-28.

Berkes, F., and C. Folke. 1992. A systems perspective on the interrelations between natural, human-made, and cultural capital. Ecological Economics, 5:1-8.

Besleme, K., and M. Mullin. 1997. Community indicators and healthy communities. National Civic Review, 86(1):43-52.

Birch, S., and J. McCaskie. 1999. Shallow urban lakes: A challenge for lake management. Hydrobiologia, 395/396:365-377.

Blockstein, D.E. 1992. An aquatic perspective on U.S. biodiversity policy. Fisheries 17(3):26-30.

Bohn, B.A., and J.L. Kershner. 2002. Establishing aquatic restoration priorities using a watershed approach. Journal of Environmental Management, 64:355-363.

Bourdieu, P., and J.C. Passeron. 1977. Reproduction in education, society, and culture. Sage Publications, London.

Burström, F., and J. Kuhonen. 2001. Municipalities and industrial ecology: Reconsidering municipal environmental management. Sustainable Development, 9:36-46.

Carpenter, S.R., and R.C. Lathrop. 1999. Lake restoration: capabilities and needs. Hydrobiologia, 395/396: 19-28.

Carpenter, S.R., N.F. Caraco, D.L. Correll, R.W. Howarth, A.N. Sharpley, and V.H. Smith. 1998. Nonpoint pollution of surface waters with phosphors and nitrogen. Ecological Applications, 8(3): 559-568.

Carlson, R.E. 1977. A trophic state index for lakes. Limnology and Oceanography, 22(2):361-369.

Chave, P. 2001. The EU water framework directive: An introduction. IWA Publishing. 194 p.

Cochrane, P. 2006. Exploring cultural capital and its importance in sustainable development. Ecological Economics, 57:318-330.

Cohen, D., and L. Prusak. 2001. *In good company: How social capital makes organizations work.* Boston: Harvard Business School Press.

Costanza, R., and H.E. Daly. 1992. Natural capital and sustainable development. Conservation Biology, 6(1):37-46.

Costanza, R., R. d'Arge, R. de Groot, S. Farber, M. Grasso, B. Hannon, K. Limburg, S. Haeem, R.V. O'Neil, J. Paruelo, R.G. Raksin, P. Sutton, and M. Van den Belt, 1997. The Value of the World's Ecosystem Services and Natural Capital. Nature, 387:253-260.

Crowl, T., T. Crist., R. Parmenter, et *al.* 2008. The spread of invasive species and infectious disease as drivers of ecosystem change in an increasingly connected world. Frontiers in Ecology and Environment, 6:238-246.

Dale, A., and J. Sparkes. 2007. Protecting ecosystems: network structure and social capital mobilization. Community Development Journal, 43(2): 143-156.

Dietz, T., E. Ostrom, and P.C. Stern. 2003. The struggle to govern the commons. Science, 302:1907-1912.

Dobson, A.P., A.D. Bradshaw, and A.J.M. Baker. 1997. Hopes for the future: Restoration ecology and conservation biology. Science, 277(5325):515-522.

Doss, C.R., and A.J. Taft. 1996. The influence of wetland type and wetland proximity on residential property values. Journal of Agricultural and Resource Economics, 21(1): 120-129.

Dresner, S. 2002. The end of sustainability. Chapter 9 In: Principles of Sustainability. London: Earthscan Publications, pp.139-173.

Everard, M. 1999. Towards sustainable development of still water resources. Hydrobiologia, 395/396:29-38.

Feeny, D., F. Berkes, B.J. McKay, and J.M. Acheson. 1990. The tragedy of the commons: Twenty-two years later. Human Ecology, 18(1):1-19.

Fey, S., C. Bregendahl, and C. Flora. 2006. The measurement of community capitals through research: A study conducted for the Claude Worthington Benedum Foundation by the North Central Regional Center for Rural Development. Online Journal of Research and Policy, 1:1-28.

Flora, C.B. 2004. Social aspects of small water systems. Journal of Contemporary Water Research and Education, 128:6-12.

Flora, C.B., and J. Flora. 2008. Rural Communities: Legacy and change (3rd ed.). Boulder, CO: Westview Press. 402 pp.

Folke, C., M. Hammer, R. Costanza, and A. Jansson. 1994. Chapter 1: Investing in natural capital-why, what, and how? In: Investing in Natural Capital: The Ecological Economics Approach to Sustainability. Island Press. Pgs. 1-20.

Fuller, L.M., and Minnerick, R.J. 2008. State and regional water quality characteristics and trophic conditions of Michigan's inland lakes, 2001-2005. United States Geological Survey, Scientific Investigations Report 2008-5188, 58 p.

Gadgil, M., F. Berkes, and C. Folke, 1993. Indigenous knowledge for biodiversity conservation. Ambio 22(2/3): 151-156.

Gasteyer, S. and T. Araj. 2009. Empowering Palestinian community water management capacity: Understanding the intersection of community cultural, political, social, and natural capitals. Community Development, 40:199-219.

Getz, W.M., L. Fortmann, D. Cumming, J. DuToit, J. Hilty, R. Martin, M. Murphee, N. Owen-Smith, A.M. Starfield, and M.I. Westphal. 1999. Sustaining natural and cultural capital: villagers and scientists. Science, 283(No. 5409): 1855-1856.

Gooch, M., J.A. Butler, L.C. Cullen-Unsworth, D. Rigano, and C. Manning. 2012. Community-derived indicator domains for social resilience to water quality decline in a Great Barrier Reef catchment, Australia. Society and Natural Resources, 25:421-439.

Green, O.O., W.D. Shuster, A.S. Garmestani, and H. Thurston. 2013. Upscaling natural and social capital for decentralized urban stormwater management. U.S. Environmental Protection Agency Papers. Paper 208.

Gutrich, J., D. Donovan, M. Finucane, W. Focht, F. Hitzhusen, S. Manopimoke, D. McCauley, B. Norton, P. Sabatier, J. Salzman, and V. Sasmitawidjaja. Science in the public process of ecosystem management: Lessons learned from Hawaii, Southeast Asia, Africa, and the US Mainland. Journal of Environmental Management, 76:197-209.

Halstead, J.M., J. Michaud, S. Hallas-Burt, and J.P. Gibbs. 2003. Hedonic analysis of effects of a non-native invader (*Myriophyllum heterophyllum*) on New Hampshire (USA) lakefront properties. Environmental Management, 32(3):391-398.

Hanifan, L. J. (1916). "The Rural School Community Center". *Annals of the American Academy of Political and Social Science*, (67): 130–138.

Hardin, G.T. 1998. Extensions of "The Tragedy of the Commons". Science, 280(5364):682-683.

Heinz Center. 2008. *The State of the Nation's Ecosystems 2008: Measuring the Lands, Waters, and Living Resources of the United States*. The H. John Heinz III Center for Science, Economy, and the Environment. Washington: Island Press.

Henry, A.D. 2009. The challenge of learning for sustainability: A prolegomenon to theory. Human Ecology Review 16:131-140.

Herath, G. 2004. Incorporating community objectives in improved wetland management: The use of the analytic hierarchy process. Journal of Environmental Management 70:263-273.

Hernandez, 2003. Internal Colonialism, Social Disorganization, and Persistent Poverty. Master's Thesis. Iowa State University. Ames, Iowa.

Hogg, K., T. Gray., and N. Brown. 2012. Crisis within social capital? The negative impact on natural resources of tension between household and community social capital in a migrant Ladino Enclave on Utila. Society and Natural Resources, 25(5):440-452.

Holling, C.S. 1973. Resilience and stability of ecological systems. Annual Review of Ecology and Systematics, 4:1-23.

Holling, C.S., and G.K. Meffe. 1996. Command and control and the pathology of natural resource management. Conservation Biology, 10(2):328-337.

Huang, G.H., and J. Xia. 2001. Barriers to sustainable water quality management. Journal of Environmental Management, 61:1-23.

Huang, S.L., C.T. Yeh, and L.F. Chang. 2010. The transition to an urbanizing world and the demand for natural resources. Current Opinion in Environmental Sustainability, 2:136-143.

Hughes, R.M., and R.F. Noss. Biological diversity and biological integrity: Current concerns for lakes and streams. Fisheries, 17(3):11-19.

Jansson, A., and B. Jansson. 1994. Ecosystem properties as a basis for sustainability. In: Chapter 5 of : Investing in Natural Capital: The Ecological Economics Approach to Sustainability. Island Press. Pgs. 74-91.

Jorgensen, B.S., and R.C. Stedman. 2006. A comparative analysis of predictors of sense of place dimensions: Attachment to, dependence on, and identification with lakeshore properties. Journal of Environmental Management, 79:316-327.

Joyce, S.B. et *al*., eds (2006). Eutrophication of freshwater and marine ecosystems. Limnology and Oceanography, 51:351-800.

Karr, J.R. 1991. Biological integrity: A long-neglected aspect of water resource management. Ecological Applications, 1:66-84.

Karr, J.R., and I.J. Schlosser. 1978. Water resources and the land-water interface. Science, 201(21):229-234.

Kim, S., J.M. Gillespie, and K.P. Paudel. 2005. The effect of socioeconomic factors on the adoption of best management practices in beef cattle production. Journal of Soil and Water Conservation, 60(3):111-120.

Kim, P.H., H.E. Aldrich, and L.A. Keister. 2006. Access not denied: The impact of financial, human, and cultural capital on entrepreneur entry in the United States. Small Business Economics, 27:5-22.

Knopf, F.L., R.R. Johnson, T. Rich, F.B. Samson, and R.C. Szaro. 1988. Conservation of Riparian Ecosystems in the United States. The Wilson Bulletin, 100(2):272-284.

Krysel, C., E.M. Boyer, C. Parson, and P. Welle. 2003. Lakeshore property values and water quality evidence from property sales in the Mississippi Headwaters region. A report submitted to the Legislative Commission on Minnesota Resources by the Mississippi Headwaters Board and Bemidji State University. 57 pp.

Leggett, C.G., and N.E. Bockstael. 2000. Evidence of the effects of water quality on residential land prices. Journal of Environmental Economics and Management, 39:121-144.

Lemberg, D., R. Fraser, and J. Marsch. 2002. Implications for planning sustainable lakeshores, Part I. In: The Michigan Riparian, publication of the Michigan Lake and Stream Associations. p.8-11.

Lubchenco, J. 1998. Entering the century of the environment: A new social contract for science. Science, 279(5350): 491-497.

Magis, K. 2010. Community resilience: an indicator of social sustainability. Society and Natural Resources, 23:401-416.

Mäler, K.-G. 2000. Development, ecological resources and their management: A study of complex dynamic systems. European Economic Review, 44:645-665.

Martínez de Anguita, P., E. Alonso, and M. Ángeles Martin. 2008. Environmental economic, political and ethical integration in a common decision-making framework. Journal of Environmental Management, 88:154-164.

Mascia, M.B., J.P. Brosius, T.A. Dobson, B.C. Forbes, L. Horowitz, M.A. McKean, and N.J. Turner. 2003. Conservation and the social sciences. Conservation Biology, 17(3):649-650.

Meadows, D.H. 2008. Thinking in Systems-A Primer. Chelsea Green Publishing Company, White River Junction, Vermont. 218 pp.

Meadows, D.H., J. Randers, and D.L. Meadows. 2004. The limits to growth: The 30-year update. Chelsea Green Publishing, 338 p.

Meals, D.W., Dressing, S.A., and T.E. Davenport. 2010. Lag time in water quality response to best management practices: A review. Journal of Environmental Quality, 39(1): 85-97.

Millennium Ecosystem Assessment. 2005. Ecosystems and human well-being: Wetlands and water synthesis. World Resources Institute, Washington, DC.

Miller, E., and L. Buys. 2008. The impact of social capital on residential water-affecting behaviors in a drought-prone Australian community. Society and Natural Resources, 21:244-257.

Minnerick, R.J. 2004. Michigan Lakes: An assessment of water quality. USGS Fact Sheet, FS 2004-3048. 4 p.

Mooney, S., and L.M. Eisgruber. 2001. The influence of riparian protection measure on residential property values: The case of the Oregon Plan for Salmon and Watershed. Journal of Real Estate finance and Economics, 22(2/3): 273-286.

Morton, L.W., and S.S. Brown. 2011. Pathways for Getting to Better Water Quality: The Citizen Effect, DOI 10.1007/978-1-4419-7282-8_1, Springer Science + Business Media, LLC.

Morton, L.W. 2008. The role of civic structure in achieving performance-based watershed management. Society and Natural Resources, 21:751.766.

Naiman, R.J. 1996. Water, society, and landscape ecology. Landscape Ecology, 11(4):193-196.

Naiman, R.J., and M.C. Turner. 2000. A future perspective on North America's freshwater ecosystems. Ecological Applications, 10(4):958-970.

National Research Council. 2004. Adaptive management for water resources planning. The National Academies Press, Washington DC.

Nilsson, J., and S. Bergström. 1995. Indicators for the assessment of ecological and economic consequences of municipal policies for resource use. Ecological Economics, 14:175-184.

Odum, E.P. 1969. The strategy of ecosystem development. Science 164(3877):262-270.

O'Riordan, T.O. 1999. Economic challenges for lake management. Hydrobiologia, 395/396:13-18.

Orr, D.W. 2003. Four challenges of sustainability, School of Natural Resources-The University of Vermont, Spring Seminar Series-Ecological Economics, 5 p.

Ostrom, E. 2009. A general framework for analyzing sustainability of socio-ecological systems. Science, 325:419-422.

Phillips, R. 2003. Community Indicators, American Planning Association, Planning Advisory Service Report Number 517, 46 pgs.

Pigg, K., S.P. Gasteyer, K.E. Martin, K. Keating, and G.P. Apaliyah. 2013. The community capitals framework: an empirical examination of internal relationships. Community Development, 44(4): 492-502.

Postel, S., and S.R. Carpenter. 1997. Freshwater ecosystem services. In G. Daily (ed.), Ecosystem Services. Island Press, Washington, D.C.

Pretty, J., and H. Ward. 2001. Social capital and the environment. World Development, 29(2):209-227.

Pretty, J. 2003. Social capital and the collective management of resources. Science, 302:1912-1914.

Putnam, R.D. 2000. Bowling alone: The collapse and revival of American community. New York: Simon and Schuster.

Rapport, D.J., R. Costanza, and A.J. McMichael. 1998. Assessing ecosystem health. TREE, 13(10):397-402.

Riera, J., P.R. Voss, S.R. Carpenter, T.K. Kratz, T.M. Lilles, and, J.A. Schnaiberg, M.G. Turner, and M.W. Wegener. 2001. Nature, society and history in two contrasting landscapes in Wisconsin, USA Interactions between lakes and humans during the twentieth century. Land Use Policy 18:41-51.

Scheffer, M., S. Carpenter, J.A. Foley, C. Folkes, and B. Walker. 2001. Catastrophic shifts in ecosystems. Nature, 413:591-596.

Serageldin, I. 1996. Sustainability as opportunity and the problem of social capital. Brown Journal of World Affairs, 3(2):187-203.

Smith, E.M., and Y.T. Prairie, 2004. Bacterial metabolism and growth efficiency in lakes: The importance of phosphorus availability. Limnology and Oceanography, 49(1):137-147.

Soranno, P.A., Cheruvelil, K.S., Webster, K.E., Bremigan, M.T., Wagner, T., and Stow, C.A. 2010. Using Landscape limnology to classify freshwater ecosystems for multi-ecosystem management and classification. Bioscience, 60(6): 440-454.

Sseguya, H., R. E. Mazur, and D. Masinde. 2009. Harnessing community capitals for livelihood enhancement: Experiences from a livelihood program in rural Uganda. Community Development, 40:123-138.

Staehr, P.A., and K. Sand-Jensen. 2007. Temporal dynamics and regulation of lake metabolism. Limnology and Oceanography, 52(1):108-120.

Stijns, J.P. 2006. Natural resource abundance and human capital accumulation. World Development, 34(6):1060-1083.

Stratford, E., and J. Davidson. 2002. Capital assets and intercultural borderlands: socio-cultural challenges for natural resource management. Journal of Environmental Management, 66:429-440.

Stynes, D. J. 2002. Michigan statewide tourism spending and economic impact estimates: Accessed at URL http://www.prr.msu.edu/miteim

Thompson, P.B. 2007. Agricultural sustainability: What it is and what it is not. International Journal of Agricultural Sustainability, 5(1): 5-16.

Vesterinen, J., E. Pouta, A. Huhtala, and M. Neuvonen. 2010. Impacts of changes in water quality on recreation behavior and benefits in Finland. Journal of Environmental Management, 91:984-994.

Vitousek, P.M., H.A. Mooney, J. Lubchenco, and J.M. Melillo. 1997. Human domination of Earth's ecosystems. Science, 277(5325):494-499.

Walker, B., and D. Salt. 2006. Resilience Thinking. Sustaining Ecosystems and People in a Changing World. Island Press Publishers. 174 pp.

Walters, C. 1997. Challenges in adaptive management of riparian and coastal ecosystems. Conservation Ecology [online] 1(2):1. Available from the Internet. URL: http://www.consecol.org/vol1/iss2/art1

Wang, Z., J.I. Nassauer, R.W. Marans, and D.G. Brown. 2012. Different types of open spaces and their importance to exurban homeowners, Society and Natural Resources: An International Journal, 25:4, 368-383.

White, M.J., D.E. Storm, P.R. Busteed, S.H. Stoodley, and S.J. Phillips. 2009. Evaluating nonpoint source critical source area contributions at the watershed scale. Journal of Environmental Quality, 38(4):1654-1664.

Williams, B.K. 2011. Adaptive management of natural resources-framework and issues. Journal of Environmental Management 92:1346-1353.

Williamson, C.E., W. Dodds, T.K. Kratz, and M.A. Palmer. 2008. Lakes and streams as sentinels of environmental change in terrestrial and atmospheric processes. Frontiers in Ecology and Environment, 6(5):247-254.

Wilson, H. 1999. Legislative challenges for lake eutrophication control in Europe. Hydrobiologia, 395/396: 389-401.

Wolman, A. 1965. The metabolism of cities. Scientific American, 213:179-188.

Woolcock, M. 2000. Social capital and its meanings. Canberra Bull. Public. Admin. 98:17-19.

Woolley, J.T., and M.V. McGinnis. 1999. The politics of watershed policymaking. Policy Studies Journal, 27(3):578-594.