A BENEFIT-COST ANALYSIS FOR THE PROPOSED DEVELOPMENT OF A FORESTED WETLAND IN MACOMB COUNTY, MICHIGAN

by

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A thesis submitted to the Faculty of the University of Delaware in partial fulfillment of the requirements for the degree of Honors Bachelor of Science in Natural Resource Management with Distinction

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ABSTRACT

Over the past few centuries, social perspectives on wetlands have evolved from viewing these areas as valueless cesspools to indispensable ecosystems that provide numerous services necessary for environmental health. As social values have changed, so has the law. However, the law is struggling to keep up with the constantly increasing body of knowledge of wetlands and their impact on surrounding areas, especially nearby bodies of water. This thesis uses one of the wetlands that was at the center of the *Rapanos v. United States Army Corps of Engineers* Supreme Court case as a case study for how economic analysis can complement legal decision making. A benefit-cost analysis is conducted using the benefit-transfer method to determine if the 19.52 acre wetland property has a higher social value in its current state as a forested wetland or as a condominium development. By applying a published meta-analysis with a meta-regression model, the wetland was estimated to have a total 20-year value of $2,445.17. After the 2008 housing market crash, the property under study was foreclosed, indicating that developing the land would not be profitable at this time. The conclusion of this paper is that the most socially efficient use of this property currently is to allow it to remain as a forested wetland.

Chapter 1

INTRODUCTION

1.1 Introduction

In the not-so-distant past, wetlands were viewed as valueless land whose only purposes were to take up otherwise productive space and serve as a breeding ground for mosquitos.[1] Because of this attitude and the need for land for agriculture and development, a significant portion of freshwater wetlands in the pre-colonized United States have been degraded or destroyed since European settlement began.[2] Today, though, we realize the important roles wetlands play both locally and in the larger ecosystem.[3]

As wetland abundance declined, legal protections were established to help preserve those areas that are still left.[4] Not all types of wetlands are protected equally, however.[5] That being noted, not all wetlands provide equal amounts of benefits to the environment and society, but as our knowledge of wetland functions and hydrology grows, we are realizing how wetlands can be connected to as well as benefit other bodies of water in complex ways, regardless of a visible or surface connection.[6] The law is struggling to keep up with this constantly increasing knowledge of wetland hydrology and connectivity because it operates in the legal confines of the Clean Water Act (CWA).[7] With continued wetland loss, it is becoming even more important to protect those remaining wetlands that provide a significant benefit. In all the attempts to clarify what wetland areas are (or should be) protected, though, economic analysis has ultimately rarely been acknowledged in law decisions. This research will

contribute to the current knowledge base by introducing an economic analysis of the valuation of wetlands specifically to provide a complementary perspective for future policy and law decisions. As wetlands increase in scarcity, it is necessary to be able to place a monetary value on the services they provide as well as other nonuse values they possess. Without recognition of these often nonmarket values, it is difficult to quantitatively argue for wetland protection and, therefore, the policy process will be systematically biased against preservation[8].

1.2 Background

June and Keith Carabell own a 19.52-acre parcel in Chesterfield Township of Macomb County, Michigan, just northeast of the Detroit metropolitan area.[9] The property is approximately one mile from Lake St. Clair, which lies between Lake Erie and Lake Huron.[10] The parcel possesses about 15.96 acres of contiguous forested wetland, making it one of the last remaining large forested wetlands in Macomb County.[11]

Less than four acres of the 19.52-acre property are designated as upland, with the remaining 15.96 acres being forested wetland.[12] The parcel is shaped like a right-triangle, with one leg following a north-south line, the second leg following an east-west line, and the hypotenuse running southwest to northeast.[13] Running along the hypotenuse of the property is a drainage ditch.[14] This ditch empties into the nearby Sutherland-Oemig Drain, which in turn empties into the Auvase Creek, which finally empties into Lake St. Clair.[15] A manmade spoil berm separates the wetland portion of the property from this ditch.[16] This berm is a raised mound of soil/earth that was created by excavating the adjacent ditch, and prevents a surface-water connection between the two.[17] The north-south leg of the property runs along Donner Road, and

also has a manmade spoil berm running along it. This berm prevents any runoff from directly flowing onto the property from the road.[18]

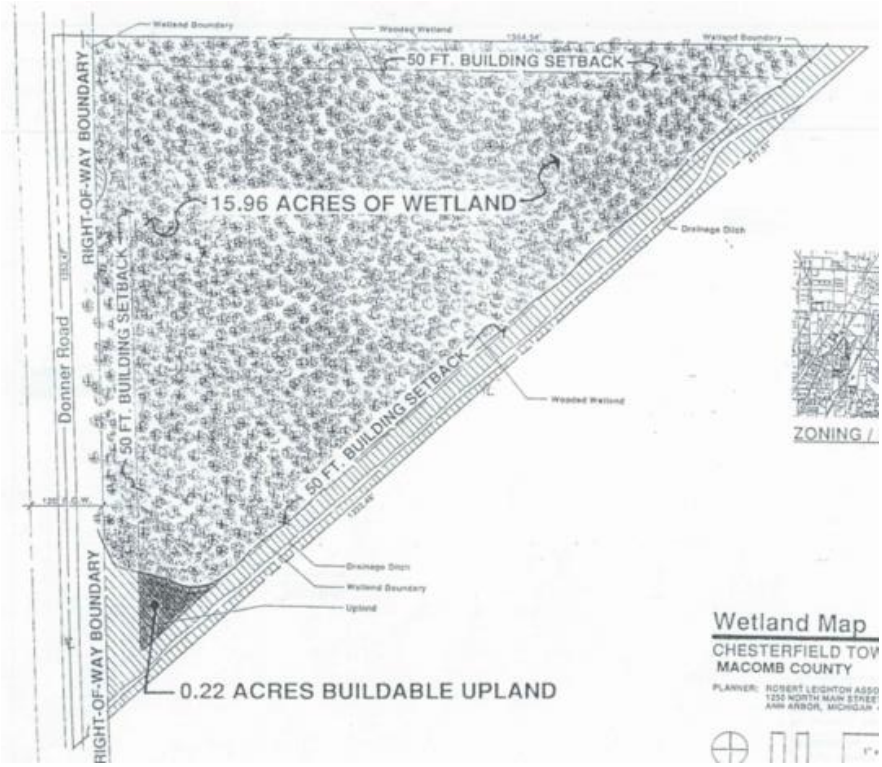

Figure 1: Map of Carabell property[19]

In 1993, the Carabells applied for a permit from the Michigan Department of Environmental Quality (MDEQ) to fill 15.9 acres of wetland to construct 130 condominium units.[20] This initial application was rejected with the reasoning that this scale of development would have "significant adverse impacts" on environmental

quality in the area.[21] The Carabells then applied for a permit for an alternative plan, which involved filling only 12.2 acres of wetlands and constructing only 112 condominium units.[22] The plan also involved the construction of a central storm water retention basin and the conversion of 3.74 acres of forested wetland into open water, shrub/scrub wetland.[23] MDEQ approved this permit application in 1998 after a contested case hearing.[24]

Figure 2: Proposed Development of Carabell Property[25]

The United States Environmental Protection Agency (EPA) stepped in after this hearing and assumed jurisdiction of the property, claiming they had the right to do

so under the CWA.[26] The EPA required the Carabells to submit a permit application to the United States Army Corps of Engineers (Corps), which is the federal agency responsible for reviewing permits and verifying "jurisdictional determinations" under the CWA.[27, 28] The Carabells did so, but the permit was denied in 2000.[29] The Carabells sued the Corps in 2003, arguing that their wetland property was not protected under the CWA, and therefore the EPA and Corps had no jurisdiction over the property.[30] Michigan District Court decided in favor of the EPA; the Carabells appealed, but the United States Sixth Circuit Court of Appeals affirmed the lower court's decision.[31] The Carabells appealed again, and the case was heard by the United States Supreme Court in 2006.[32] In a 4-1-4 decision, the Supreme Court remanded the case back to the lower courts with the instruction to apply a new "significant nexus" rule, created by Justice Kennedy, to assist in determining jurisdiction.[33] Shortly after this decision, the housing market crashed, and the Carabells still had not developed the property as of 2015.[34] In 2015, property foreclosed and has not been sold since.[35]

1.3 Purpose of Research

As a starting point for benefit-cost analysis (BCA), it is useful to recognize that there are two states of the world that exist for this parcel. The first is the low-intensity use: the current, undeveloped state of the parcel. The alternative is the high-intensity use: the proposed development of the parcel. Thus far, the judicial system has decided against the high-intensity use through affirming the EPA and Corps' jurisdiction over the property. They have not necessarily decided in favor of the low-intensity use, though, as litigation is still pending to determine final jurisdiction of the Carabell's land.

The purpose of this research is to conduct a BCA of the proposed development of the Carabell's parcel. This research will attempt to answer the following question: is the property worth more to society as a wetland or as a development? While economic markets make it easy to value the development the Carabells wish to build, it is much harder to determine the opportunity cost of the lost wetland.[36] This study will attempt to find a way to estimate these largely nonmarket values to provide the most comprehensive BCA possible. Because conducting original studies are very costly and time-consuming, benefit-cost analyses using the benefit-transfer method are needed.[37]

1.4 Literature Review

The following section reviews key literature related to this research. It includes the history of the Clean Water Act, an explanation of BCA, the need for the benefit-transfer method, and the meta-analysis paper that will be used for the BCA.

1.4.1 The Clean Water Act

The Clean Water Act (CWA) was established in 1972 to protect the "waters of the United States" from becoming more polluted than they already were.[38] Congress delegated authority to the EPA and Corps to define and regulate this Act.[39] Initially, the CWA only protected "navigable waters", or those bodies of water that could be used for interstate commerce, and their direct tributaries.[40] The Act only allows the federal government to assert jurisdiction over the states due to the Commerce Clause in the Constitution, meaning that all CWA-protected waters must be able to be used in interstate commerce or connected to a water that can be used in interstate commerce.[41] In 1977, the Act was expanded to protect wetlands adjacent to navigable waters or

their tributaries, as it was determined that these areas can significantly impact navigable waters.[42]

In 1985, the case *United States v. Riverside Bayview* was brought to the Supreme Court.[43] A developer of Riverside Bayview Homes, Inc., had placed fill material into a wetland that was (coincidentally) close to the shores of Lake St. Clair.[44] The Army Corps of Engineers sued the developers, arguing that the wetlands were "adjacent to a body of navigable water", which placed them under the protection of the CWA and therefore required a permit from the Corps.[45] Riverside Bayview argued that because this wetland was "not the result of frequent flooding by the nearby navigable waters" (it was fed by groundwater), it was not protected under the Clean Water Act.[46] The Supreme Court released a unanimous decision that wetlands adjacent to traditional navigable waters were under the jurisdiction of the CWA.[47] In a following decision (*SWANCC v. U.S. Army Corps of Engineers*), the Supreme Court used the term "significant nexus" to justify its decision in *United States v. Riverside Bayview*.[48]

From 1986 until 2001, the EPA had regulated nonadjacent wetlands using the "Migratory Bird Rule".[49] This rule allowed the agency to assert jurisdiction over intrastate waters that were isolated from navigable waters.[50] The premise of the rule is that if migratory birds protected by international treaties or migratory birds that participate in interstate travel use these wetlands as stopover areas, then wetland protection becomes a federal matter.[51] In 2001, a case brought forth by Solid Waste Agency of Northern Cook County (SWANCC) against the U.S. Army Corps of Engineers reached the Supreme Court.[52] SWANCC wanted to deposit non-toxic solid waste onto a property that was formerly a mining operation.[53] Some of the gravel

trenches and other depressions created by the operation had formed into isolated marshy wetlands over the course of time and had become a residency and stopover area for migratory birds.[54] SWANCC asked the Corps if these areas fell under the protection of the CWA.[55] The Corps concluded that they did due to the migratory birds residing there, thus they required SWANCC to apply for a permit.[56] Although the company "made several proposals to mitigate the likely displacement of the migratory birds", the Corps would not approve a permit.[57] SWANCC sued, with both the District Court and Court of Appeals ruling in favor of the Corps.[58] In a 5-4 decision, though, the Supreme Court reversed the lower courts' rulings and struck down the Migratory Bird Rule.[59]

The elimination of the Migratory Bird Rule in 2001 required the EPA to rely solely on this idea of significant nexus brought up by *United States v. Riverside Bayview*. Significant nexus is a legal term for a connection between a wetland and a navigable body of water. Therefore, for the Carabell property, the EPA and Corps had to argue that the wetland's adjacency (sans surface connection) to a ditch that emptied into a drain that deposited into a creek which eventually found its way to Lake St. Clair (a navigable water) constituted a hydrological connection between the wetland and Lake St. Clair. Therefore, it could be placed under federal jurisdiction. The Carabells disagreed, and the legal battles discussed above ensued. The Carabell's case was combined with another similar case brought forth by John Rapanos, who had been fined by the Corps for depositing fill material into wetlands on his property without a permit.[60] The wetlands on Rapanos's property connected to drains which eventually deposited into navigable waterways.[61] There were two separate dissenting opinions for this case: the first, led by Justice Scalia, argued that a surface connection must be

present between a wetland and a navigable water for it to be protected under the Clean Water Act.[62] The second opinion, written by Justice Kennedy, does not require a surface connection but rather that a "significant nexus" be proven between a wetland and navigable waters.[63]

Since *Rapanos*, government agencies and the courts have been struggling with how to interpret the new decisions set forth, and there has been some conflict surrounding exactly what significant nexus means and how the significant nexus rule should be interpreted.[64] A few states implemented their own legislative protection of isolated wetlands, but for most states the fate of wetlands remains with the federal government and the unclear judicial interpretation of sufficient hydrological connection to warrant federal regulation.[65] Joshua Bloom explains the significant nexus test in his 2007 article from *Natural Resources and Economics*:

> "The guidance provides that the significant nexus test will assess flow characteristics and functions of the tributary and the functions performed by the adjacent wetlands to determine the effect on the chemical, biological, and physical integrity of the down-stream navigable waters, including consideration of hydrologic and ecologic factors."

Proving a significant nexus must be done on a case-by-case basis.[66] However, Bloom suggests that the Corps and EPA come up with a set of guidelines to assist in determining whether a nexus exists and the extent of the connection.[67] Although the rule is fairly clear in its coverage of those traditionally *non-navigable* waterways whose contamination would lead to the degradation of a traditionally *navigable* waterway, Bloom explains that the rule is more ambiguous when it comes to those bodies of water (like the Carabell's property) that proactively *prevent* degradation of a navigable waterway from occurring.[68]

Because of the restrictions that only allow federal regulation over issues of commerce, if the EPA and Army Corps of Engineers wished to obtain/maintain federal jurisdiction of wetlands like those in *Rapanos*, they would be required to scientifically prove the hydrological and ecological connectivity of seemingly isolated wetlands to "waters of the United States", which is exactly what they did.[69] In 2015, the EPA released a 400-page document detailing the "connectivity of streams and wetlands to downstream waters."[70] It is the product of almost a dozen authors, another dozen consultants, and over twenty reviewers from the EPA's Science Advisory Board Panel.[71] Without these studies, though, the EPA would have a much more difficult time claiming jurisdiction using this new "significant nexus" rule. Even though economics could be more efficient to use for regulation, it is still absent from the law.

1.4.2 Benefit-Cost Analysis

BCA is an economic method used to assist in the decision-making process when choosing from two or more alternatives (although it can be used for non-economic decision making as well).[72] It is a fairly straightforward concept that compares the economic benefits and costs of each alternative being considered. For this study, there are only two alternatives: the property remaining a forested wetland or the property being developed into the proposed condominium complex. Once the benefits and costs of a change between each state of the world are calculated and compared, the alternative that generates the greatest net *social* benefits is recommended--- subject to distributional considerations and an assessment of unquantifiable elements of the analysis. A further explanation of the steps of BCA can be found in Chapter 2.

Although conceptually a simple idea, BCA can become quite complicated, especially when they involve valuing non-market inputs/outputs such as ecosystem services. In addition, the more complex a project, the harder it is to itemize accurately and value all project impacts for every alternative. There is a need for scientific research that takes on these challenges and conducts these valuation studies and analyses for people to have a better, more complete understanding of how decisions impact society as a whole.

1.4.3 The Benefit-Transfer Method

The benefit-transfer method is used when an original nonmarket valuation study is unavailable. Original studies are preferable for conducting benefit-cost analyses as they are site-specific and can (theoretically) provide the most accurate data. However, original studies are not always possible, as is the case with this research. Time, financial, and expertise constraints limit the researcher's ability to conduct an original valuation study. Benefit-transfer is often the next best option. The benefit-transfer method uses valuation data and results from previous research to estimate values for similar studies. Although the benefit-transfer method may not be as precise as an original study, it is often the only adequate and available option for many researchers. If done properly using appropriate data, accurate values can be estimated.

For the Carabell property, the best approach found was to use a meta-analysis that included a meta-regression model for valuing wetlands, which is described directly below as well as in later chapters. This meta-analysis accounted for most of the variables needed to conduct a complete and accurate benefit-transfer, and the meta-regression model allowed for the most site-specificity of any of the studies

reviewed. In other words, because of the meta-regression model, the valuation could be tailored to the specific site/wetland under study.

1.4.4 The Empirics of Wetland Valuation: A Comprehensive Summary and a Meta-Analysis of the Literature[73]

"The Empirics of Wetland Valuation: A Comprehensive Summary and a Meta-Analysis of the Literature" by Brander, Florax, and Vermaat was published in 2006.[74] The article analyzes 80 original wetland nonmarket valuation studies to form a meta-analysis and create a meta-regression model for predicting wetland values in other sites. The researchers analyzed the data from these 80 studies to estimate a more widely-applicable model of wetland values. The studies included in their analysis varied in geographic location, wetland type, size, valuation method, and wetland value(s)/service(s) measured. The model accounts for all of the aforementioned characteristics as well as the socioeconomic variables of GDP/capita and population density. A complete table of the variables and coefficients of the model can be viewed in Chapter 3. The model presented in their paper will be used to execute the benefit-transfer for this study.

Brander, Florax, and Vermaat's (2006) meta-analysis was selected to be used for this benefit-cost analysis because it was the most comprehensive and thus was the most readily adaptable to the Carabell property. To begin, the research included "forested wetland" as a specific wetland sub-category, whereas many other studies did not specify forested wetlands in their evaluation. Secondly, very few valuation studies were found for forested wetlands, especially ones similar to the property under study, and none accounted for as many variables (attributes) as this meta-analysis did. Because the meta-regression created from the meta-analysis allowed for site-specific

values to be inputted, it also made valuation for this specific property straightforward. Finally, this was the only study that included the variables of GDP/capita and population density, both of which should have some influence on the value of a wetland site.

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Chapter 2

METHODS

2.1 Benefit-Cost Analysis

The following discussion of how to conduct a BCA has been adapted from Boardman, Greenberg, Vining, and Weimer's *Cost-Benefit Analysis* (1996). The book describes nine major steps of a Benefit-Cost Analysis, which will be discussed below.

Step 1: "Decide whose benefits and costs count (standing)."[75] In other words, which individuals or groups are impacted by this project enough to be included in the analysis? For the Carabell's parcel, the most appropriate scale to measure the impact of the proposed development seems to be Chesterfield Township at the largest. The majority of the effects of this development will most likely remain local, with those living in sight of the property and those directly downstream from it being the most affected. The property is small, and is surrounded by either developments or agriculture, so the added degradation it contributes to Lake St. Clair will probably be minimal or remain fairly local. Therefore, it will most likely not affect others that live near or use the Lake. The analysis will be conducted under the assumption of a closed system in which there is no immigration or emigration from the township due to the fate of the parcel. As the proposed development is relatively small relative to the County, this is a reasonable, marginal assumption.

Step 2: "Select the portfolio of alternative projects."[76] In the case of this project, there are only two alternatives. The first alternative is the property remains as

forested wetland. The second is the property is converted to the aforementioned proposed development.

Step 3: “Catalogue potential (physical) impacts and select measurement indicators.”[77] This study will be predicting the impacts of converting the property from its current state as a forested wetland to the proposed condominium complex. The measurement indicators are the units each impact is measured in. Project impacts are itemized and described in Chapter 3.

Step 4: “Predict quantitative impacts over the life of the project.”[78] The purpose of this step is to quantify the impacts so as to assign accurately a monetary value to each one in the next step. For example, the amount of carbon 19.61 acres of forest can sequester in a year must be calculated before the cost of losing this service can be monetized.

Step 5: “Monetize (attach dollar values to) all impacts.”[79] Once each impact has been quantified, a dollar value can be calculated. There are several methods that can be used to determine these values. This study will use a meta-analysis with an included meta-regression model and the benefit-transfer method.

Step 6: “Discount for time to find present values.”[80] Because benefits and costs accrued in the future are valued less than benefits and costs in the present, discounting is required to reflect more accurate current values of each alternative.

Step 7: “Sum: add up benefits and costs.”[81] Once all impacts have been monetized, the benefits and costs of the project can be summed (costs are negative values). Because the property in this study only has two possible alternatives and the impacts of changing from one alternative to the other are being measured, if the sum

of the costs and benefits is positive, the property should be developed from society's perspective.

Step 8: "Perform sensitivity analysis."[82] There is a certain level of uncertainty in predicting the future, measuring benefits and costs, or determining the discount rate, so it is wise to calculate several alternatives of one or some of these factors. This provides a study with a range of alternatives that may vary from the outcome determined in the original benefit-cost analysis.

Step 9: "Recommend the alternative with the largest net social benefits."[83] After conducting a sensitivity analysis, a final decision can be made about which alternative will provide the most benefit to society.

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Chapter 3

DATA

3.1 Introduction

This chapter identifies the impacts that will be used in the BCA. In their permit evaluation for the Carabell's property, the Corps identified possible impacts of the proposed development and divided them into three categories: physical impacts, biotic impacts, and social impacts.[84] This chapter reviews both impacts included in the permit evaluation as well as additional impacts not included in the permit evaluation, but considered important enough to be acknowledged. All impacts were mentioned in the permit evaluation unless otherwise specified. The Corps measures each item as having minor or major, short or long term, and positive or negative impacts to society.[85] A major impact will measurably altar the state of a given variable. A minor impact may contribute to the change of a variable, but it alone will not measurably altar it. For example, developing the wetland will have a major impact on biodiversity in the Chesterfield Township because it will destroy one of the last remaining forested wetlands, and therefore a unique ecosystem, in the Township. Short term impacts will last only the duration of the construction of the condominium complex and accompanying infrastructure such as the retention basin and emergent wetlands, while long term impacts will last into perpetuity unless the property is somehow reverted back to its original state. Positive impacts will generate net benefits to society, whereas negative impacts will generate net costs to society. This language will be included in the discussion of all impacts. Although all impacts included by the Corps

will be discussed in this chapter, not all impacts will be included in the final analysis, and a justification as to why will be included in the discussion. The table below summarizes the effect of each impact.

Table 1: Summary of Impacts of a Change from Forested Development to Condominium Development

Impact	Scale	Time	Pos/Neg (Benefit/Cost)
Physical Impacts			
Water Quality	Minor	Long Term	Negative
Erosion	Minor	Long Term	Negative
Flood Hazards	Minor	Short Term and Long Term	Negative
Navigation	None		
Water Supply/Conservation	None		
Carbon Sequestration	Minor	Long Term	Negative
Biotic Impacts			
Aquatic Biota/Terrestrial Biota (Biodiversity)	Major	Long Term	Negative
Wetlands	Major	Short Term and Long Term	Negative
Conservation/Ecology	None		
Social Impacts			
Aesthetic	Minor	Long Term	Negative
Noise	Minor	Short Term and Long Term	Negative
Designated Historic, Cultural, Scenic, and Recreational Values	None		
Land Use Patterns	None		
Economic Effects	Minor	Short Term and Long Term	Negative
Recreation	Minor	Long Term	Negative
Safety (Traffic)	None		
Food and Fiber Production	None		

Table 1 Continued

Mineral Needs	None		
Energy Conservation/ Development	None		
Existence Value	Minor	Long Term	Negative

3.2 Physical Impacts

Physical impacts are those which affect the non-living physical environment. This category includes the variables of water quality, erosion, flood hazards, navigation, water supply, and carbon sequestration. Overall, the proposed development is predicted to have negative impacts to the physical environment of Chesterfield Township and Lake St. Clair.

3.2.1 Water Quality

The Corps divides impacts on water quality into two categories: construction impacts and operational impacts.[86] Construction impacts would occur during construction of the proposed development and would include runoff and erosion of loose soil and fill materials into the Sutherland-Oemig drain. These effects would be minor, short term, and negative. The Corps specifies that damage could be minimized based on the "use of silt curtains around the work area and adequate containment and stabilization measures", and could be a requirement of an issued permit.[87] Because it seems unlikely that a permit would be issued without these conditions, the analysis will be operating under the assumption that all of the aforementioned mitigating technologies are in place during construction. Although this may not completely halt

all pollutant runoff during construction, it should lessen negative impacts to water quality.

Once the development is constructed, water quality will be affected by the regular operation of the condominium complex. Not only will the water/pollutant catchment capabilities of the forested wetland be removed, the development "would replace it with a new source area for runoff pollutants."[88] Once the development is completed, residents and maintenance staff will use pollutants such as fertilizers, pesticides, herbicides, and road salts, and may intentionally or unintentionally improperly dispose of pollutants such as oil. The increase in impermeable surfaces such as roads, sidewalks, and roofs on the property will increase runoff that will pick up and eventually transport these pollutants downstream. The Corps argues that the proposed development will have major, long term, negative impacts on water quality. Although this paper agrees that they will be long term and negative, it disputes the claim that the impacts will be major for Lake St. Clair. The Lake is largely surrounded by either development or agriculture. Although permitting this development will lead to an increase in pollutants, the amount of degradation a property this size would cause to an already polluted body of water may be minor. Impacts to water quality will still be included in the benefit-cost analysis, as they still could have measurable monetary values.

3.2.2 Erosion

The installation of impermeable surfaces (roads, roofs, etc.) on the parcel for the proposed development would lead to increased runoff and therefore erosion downstream. The parcel, which currently retains water after periods of rain, would now be contributing a new source of flow into the Sutherland-Oemig Drain and

beyond. This means that more water will be entering the water channels with more force, leading to increased erosion. The Corps argues that this added runoff will have the greatest erosion impacts on the Sutherland-Oemig Drain and the Auvase Creek, which in turn runs into Lake St. Clair.[89] They believe that the proposed project will have minor, long term, negative impacts on erosion.[90]

3.2.3 Flood Hazards

The proposed development would take a property that aided in storm water retention and replace it in part with a large area of impermeable surfaces. The Carabells propose to install a storm water retention basin in the center of the property. However, the Corps explains that this basin is set to drain into the two manmade emergent wetlands that will be constructed on the property.[91] It is planned that these two wetlands will drain directly into the ditch adjacent to the property.[92] Because the runoff will flow into the retention basin and in turn the emergent wetlands, the Corps explains they "will quickly exceed their storage capacity."[93] Although the emergent wetlands will provide some holding capacity, flooding could increase in frequency. The Corps predicts the proposed development will have minor, short and long term, negative impacts on flooding.

3.2.4 Navigation

Although the Clean Water Act was originally established to protect the navigability of the waters of the United States,[94] the Corps writes that they do not expect the proposed project to have any effect on navigation.[95] The only navigable body of water near the property is Lake St. Clair. Therefore, the amount of erosion/runoff that would occur from a developed property of this size would not be

enough to change the navigability of the Lake. Because of this, navigation will not be included in the BCA.

3.2.5 Water Supply/Conservation

Wetlands are capable of influencing water supply in a couple ways. They can contribute to groundwater recharge as well as act as a pollutant filter for groundwater and aquifers.[96] For this wetland, however, the Corps states that they do not envision any impacts to any water supply. The property itself does not contribute to water supply and is not near any aquifers or other similar systems. Due to this reasoning, water supply/conservation will not be included in the benefit-cost analysis.

3.2.6 Carbon Sequestration

The Corps does not specify carbon sequestration as an impact of the proposed development, but it is worth including in the BCA. The release of carbon dioxide into the atmosphere by humans is one of the leading causes of climate change.[97] Wetlands sequester carbon in two major ways: through the vegetation growing within the wetland as well as through storage in wetland soils.[98] Although removing this forested wetland will not send the earth over the tipping point, the loss of carbon sequestration potential should be recognized. The proposed development project is expected to have minor, short term and long term, negative impacts on carbon sequestration. Deforesting the property will release the carbon stored in organic matter (e.g. trees) and soil into the atmosphere. In addition, the removal of trees and other plants from the property will halt whatever carbon sequestration was occurring from continuing. However, this property is miniscule in the grand scheme of carbon sequestration and emissions, which is why it will only have minor impacts.

3.3 Biotic Impacts

Biotic impacts are those which affect the non-human living organisms and ecology in the area. This category includes biodiversity, wetland ecosystems, and conservation/ecology. Overall, the proposed development is predicted to have negative impacts to the biota and ecology of Chesterfield Township.

3.3.1 Aquatic and Terrestrial Biota (Biodiversity)

Although the Corps specifies aquatic biota and terrestrial biota as two separate categories, they will be combined into one impact for this analysis, and will be referred to generally as "biodiversity". The Corps states that the proposed development will have minor, long term, negative impacts on aquatic biota, and major, long term, negative impacts on terrestrial biota, generating major, long term, negative impacts for overall biodiversity.[99] Biodiversity is a nonuse, nonmarket value, which makes it more difficult to monetize.

3.3.2 Wetlands

This property is one of the last remaining large forested wetlands in all of Macomb County.[100] If the proposed development is approved and completed, this rare ecosystem will become even more scarce. The Corps explains that this value the wetland has is derived from its "uniqueness."[101] The Corps predicts that the proposed development will have major, long-term, and negative impacts on wetlands. Impacts will be major because construction of the development is irreversible. Furthermore, the development will convert a unique ecosystem in the landscape into a land use that is similar to all other properties in the area. Finally, scarcity causes this property as a forested wetland to be more valuable than prior units because it is one of the last remaining large forested wetlands in the County.

3.3.3 Conservation/Ecology

Although the Corps specifies conservation/ecology as its own category, many of the sub-impacts that make up this label are accounted for in other impacts.[102] The Corps mentions a decrease in "species variety",[103] which is included in aquatic and terrestrial biota (aka biodiversity). The Corps also discusses the potential that "the proposed work… could lead to gasoline or oil spills, or releases of various residential pollutants such as solvents soaps, fertilizers, salts, etc.".[104] These sub-impacts, however, are also included in water quality. Next, the Corps mentions that is property has "high natural heritage value",[105] which can be included in either wetlands or perhaps existence value. Finally, the Corps mentions the possibility of an endangered species, the Indiana Bat, being located on the property. After inspection, though, no indicators of the species were found on the premises. Because the above justification, the Corps' category of conservation/ecology will not be included in the benefit-cost analyses. Each component of it, though, will be accounted for in other included impacts.

3.4 Social Impacts

Social impacts are those which affect humans and the institutions they value. This category includes aesthetic, noise, designated historic, cultural, scenic, and recreational values, land use patterns, economic effects, recreation, safety, food and fiber production, mineral needs, energy conservation and development, and existence value. Overall, the proposed development is predicted to have negative impacts to society in Chesterfield Township.

3.4.1 Aesthetic

The proposed development will convert a unique forested natural area into a new condominium development that will look similar to surrounding properties. The Corps argues that this change will have minor, long term impacts on aesthetic, but whether this effect will be positive or negative is "dependent on personal preference."[106] However, numerous studies have found that the aesthetic of open spaces is a benefit to neighbors; it usually increases the value of their homes.[107] These studies indicate that developing the property will therefore most likely have negative impacts on aesthetic values.

3.4.2 Noise

The Corps explains the greatest impact the proposed project will have on noise is the initial construction of the development.[108] After the project is complete, any change in noise levels would be "negligible", or close to no change in noise from the original use of the property.[109] Although the largest effect will be short term, increased noise levels have the potential to generate major negative social costs and will therefore be initially included in the BCA.

3.4.3 Designated Historic, Cultural, Scenic, and Recreational Values

The Carabells' parcel is privately owned, and it does not contain any historically or culturally significant structures.[110] The parcel is also not designated as any sort of protected federal or state land.[111] Because of this, the Corps determined that the proposed development would have no impacts on designated historic, cultural, scenic, or recreational values.[112] This impact category will not be included in the BCA.

3.4.4 Land Use Patterns

The Corps argues that allowing to proposed development to continue will have minor, long term, negative effects on land use.[113] They explain that this could encourage the continued development of natural areas instead of "recycling abandoned, previously developed areas, or agricultural areas to more intensive or better uses."[114] Although their argument has some validity, trying to estimate how much influence this project has (if any) over other projects would most likely prove impossible. Measuring the impacts of each of these projects as influenced by the Carabell's proposed development also seems unnecessarily complicated for the minor (if not insignificant) impact this project will have on land-use patterns. Because of these issues, land use will not be included in the BCA.

3.4.5 Economic Effects

When the project was first proposed, this development was expected to generate a 4.79 percent profit margin as well as create construction, grounds keeping, and maintenance jobs.[115] An increase in "local tax revenues" and "community services",[116] was also mentioned, but because the analysis is operating under the assumption of a closed system, these services would not necessarily increase the social product because there would be countervailing reductions elsewhere. The only city revenue that may increase is from property taxes as residents move into slightly better housing.

The Corps argued that the economic impacts of the proposed development would be minor, short term and long term, and positive, and this could very likely have been true at the time the evaluation was conducted. However, the housing market crash of 2008 stopped the property from being sold or developed, and eventually the

property foreclosed.[117] The inability to sell and/or develop this property and its subsequent foreclosure are indicative that in the current economic climate, the proposed development would not turn a profit and could even generate negative profit. The economic markets have decided that at this time the proposed development would, in fact, have negative impacts on society.

3.4.6 Recreation

The Carabells' property is not open to the public, but still provides some opportunity for recreation. Primarily, neighbors and passersby could use the property for activities such as wildlife watching. On top of this non-consumptive or passive use of the land, the Corps also mentions the parcel's importance in the "maintenance of populations of game".[118] Because of the suburban nature of the area surrounding the property, there was skepticism about the amount of hunting that could occur within a reasonable distance of the property. A hunting map of Macomb County was consulted, and there are in fact two public hunting areas nearby.[119] However, one hunting area is across a multi-lane interstate (I-94),[120] and it seems unlikely that much wildlife would successfully travel between the two parcels on a regular basis. The other hunting area, on the other hand, is on the same side of the interstate as the Carabells' property and within about two miles. It seems fair to retain the property's contributions to hunting as part of its recreational value. The Corps argues that the proposed development will have minor, long term, and negative impacts on recreation.

3.4.7 Safety

The Corps argues that the proposed project would lead to an increase in traffic, and therefore an increase in traffic-related accidents. Because this analysis is operating

on the assumption of a closed system, though, the net traffic in the township will not increase. Because of this, the Corps' Safety impact will not be included in the BCA.

3.4.8 Food and Fiber Production

The property is not used, nor has the potential to be used, for food or fiber production. Neither the Corps nor this thesis expects the proposed project to have any impacts on this category, and therefore it will not be included in the BCA.

3.4.9 Mineral Needs

There is no specification found that mentions any sort of valuable minerals present on the property. Neither the Corps nor this thesis expects the proposed project to have any impacts on this category, and therefore it will not be included in the BCA.

3.4.10 Energy Conservation/Development

Nothing exists on the Carabell's property that contributes in any way to energy conservation or development. Neither the Corps nor this thesis expects the proposed project to have any impacts on this category, and therefore it will not be included in the BCA.

3.4.11 Existence Value

Existence value was not included in the Corps' permit evaluation, but still deserves to be included in the benefit-cost analysis. Existence value is the value placed on something by individuals who will never directly or indirectly use it. In other words, it is the value individuals place on something just because they know it still exists. Although this paper assumes that the proposed development's impact on existence values will be minor, short term, and negative, it is worth accounting for

because of the scarcity of wetlands in the County. Existence value is normally measured in total willingness to pay (TWTP) in a stated preference study.

3.5 Meta-Regression Model

Brander, Florax, and Vermaat's (2006) meta-regression model will be used to calculate the value of the forested wetland incorporating the impacts described above. The researchers formulated the following equation for valuing a wetland:

$$ln(y) = a + X_s b_s + X_p b_p + X_e b_e + u$$

where *y* is the value in "US$ per hectare per year in 1995 prices", *a* is a constant, *X* is a vector of the "study characteristics" or variables, *b* refers to the site-specific values from the wetland being studied (in this case, the Carabell's property), and *u* is a "vector of residuals".[121] The subscripts *s*, *p*, and *e*, describe the type of characteristic *X* as a valuation method, physical/geographical variable, or socioeconomic variable, respectively.[122] The following figure provides the necessary coefficients to apply the model to wetland valuation studies.

Table III. Meta-regression results[a]

Category	Variable[b]	Coefficient	Standard error
	Constant	−6.98	4.67
Socio-economic	GDP per capita (log)	1.16**	0.46
	Population density (log)	0.47***	0.12
Geographic characteristics	Wetland size (log)	−0.11**	0.05
	Latitude (absolute value)	0.03	0.07
	Latitude squared	−0.0007	0.0010
	South America	0.23	1.19
	Europe	0.84	0.92
	Asia	2.01	1.34
	Africa	3.51**	1.52
	Australasia	1.75*	0.94
	Urban	1.11**	0.48
Valuation methods	CVM	1.49**	0.73
	Hedonic pricing	−0.71	1.54
	TCM	0.01	0.65
	Replacement cost	0.63	0.81
	Net factor income	0.19	0.61
	Production function	−1.00	0.75
	Market prices	−0.04	0.53
	Opportunity cost	−0.03	0.72
Type value	Marginal	0.95*	0.48
Wetland type	Mangrove	−0.56	0.82
	Unvegetated sediment	0.22	1.09
	Salt/brackish marsh	−0.31	0.42
	Fresh marsh	−1.46**	0.59
	Woodland	0.86**	0.42
Wetland service	Flood control	0.14	0.55
	Water supply	−0.95	0.71
	Water quality	0.63	0.74
	Habitat and nursery	−0.03	0.35
	Hunting	−1.10**	0.43
	Fishing	0.06	0.36
	Material	−0.83**	0.42
	Fuelwood	−1.24***	0.45
	Amenity	0.06	0.39
	Biodiversity	0.06	0.81
RAMSAR	RAMSAR proportion	−1.32*	0.70
	n	202	

Figure 3: Table 3 of "The Empirics of Wetland Valuation"[123]

Although not as specific as the impacts discussed in Sections 3.2 through 3.4, almost all impacts are accounted for in the variables listed in Figure 3. It should be

noted, though, that carbon sequestration, non-consumptive recreation, noise, and existence value are absent from the model. Economic impacts are not included either, but these values do not directly stem from the wetland itself and would not be expected to be included.

Endnotes

[84] Deroche 2000.

[85] Ibid.

[86] Ibid.

[87] Ibid.

[88] Ibid.

[89] Ibid.

[90] Ibid.

[91] Ibid.

[92] Carabell 1999.

[93] Deroche 2000.

[94] United States Environmental Protection Agency 2016.

[95] Deroche 2000.

[96] Alexander et al. 2015

[97] NASA. "Climate Change Causes: A Blanket around the Earth." *Climate Change: Vital Signs of the Planet*. N.p., n.d. Web. 20 Feb. 2017.

[98] Mitsch, William J et al. "Wetlands, Carbon, and Climate Change." *Landscape Ecol* (2012): n. pag. Print.

[99] Deroche 2000.

[100] Ibid.

[101] Ibid.

[102] Ibid.

[103] Ibid.

[104] Ibid.

[105] Ibid.

[106] Ibid.

[107] Borchers, Allison M., and Joshua M. Duke. "Capitalization and Proximity to Agricultural and Natural Lands: Evidence from Delaware." Journal of Environmental Management 99 (2012): 110–117. ScienceDirect. Web.

[108] Deroche 2000.

[109] Ibid.

[110] Ibid.

[111] Ibid.

[112] Ibid.

[113] Ibid.

[114] Ibid.

[115] Brief for Petitioners, *Carabell v. U.S. Army Corps of Engineers*, 547 U.S. 715 (2006) (No. 04-1384).

[116] Ibid.

[117] Zillow, Inc.

[118] Deroche 2000.

[119] "Lands Open to Public Hunting: Macomb County." Michigan Department of Natural Resources 2016, Web.

[120] Ibid.

[121] Ibid.

[122] Ibid.

[123] Ibid.

Chapter 4

RESULTS

To estimate the monetary value of the Carabell's property as a forested wetland, the appropriate site-specific values for each variable were inserted into Brander, Florax, and Vermaat's meta-regression model. Some variables required specific values, while others were binary variables represented by a 1 or 0 depending on if the variable applied to the property or not. One exception was generating the values for the valuation methods. Values for each valuation method were calculated by dividing the number of observations of each method by the total number of valuation observations in the meta-analysis. Binary variables for wetland services were selected based on the justifications described in Chapter 3. Values can be seen in the table below.

Table 2: Meta-Regression Model Including Values from Carabell Property

Category	**Variable**	**Brander, Florax, and Vermaat's Coefficients[a]**	**Site-Specific Value[b]**	**Calculated Value**
	Constant	-6.98	1	-6.980

[a] The values in this column are taken directly from Brander, Florax, and Vermaat's 2006 meta-analysis.

[b] The corresponding value from the Carabell's property for each variable.

Table 2 Continued

Socio-economic	GDP per capita (log)	1.16	4.436[c]	5.146
	Population density (log)	0.47	2.831[d]	1.331
Geographic Characteristics	Wetland size (log)	-0.11	0.898[e]	-0.099
	Latitude (abs value)	0.03	42.665[f]	1.280
	Latitude squared	-0.0007	1820.328	-1.274
	South America	0.23	0	0.000
	Europe	0.84	0	0.000
	Asia	2.01	0	0.000
	Africa	3.51	0	0.000
	Australia	1.75	0	0.000
	Urban	1.11	1	1.110
Valuation Methods	CVM	1.49	0.163	0.243
	Hedonic Pricing	-0.71	0.021	-0.015
	TCM	0.01	0.0815	0.001
	Replacement Cost	0.63	0.120	0.076
	Net Factor Income	0.19	0.094	0.018
	Production Function	-1	0.082	-0.082
	Market Prices	-0.04	0.391	-0.016
	Opportunity Cost	-0.03	0.047	-0.001
Type Value	Marginal	0.95	0	0.000
Wetland Type	Mangrove	-0.56	0	0.000

[c] This value was derived from taking the log of the state of Michigan's GDP/capita from 1995, which was $27,296 (United States Department of Commerce).

[d] This value was derived from taking the log of Macomb County's population density in people/km^2, which is 678 (United States Census Bureau).

[e] This value was derived from taking the log of the area of the Carabell's property in hectares, which is 7.899 hectares (19.52 acres).

[f] Value obtained from Google Maps.

Table 2 Continued

	Unvegetated Sediment	0.22	0	0.000
	Salt/brackish marsh	-0.31	0	0.000
	Fresh Marsh	-1.46	0	0.000
	Woodland	0.86	1	0.860
Wetland Service	Flood Control	0.14	1	0.140
	Water Supply	-0.95	0	0.000
	Water quality	0.63	1	0.630
	Habitat and nursery	-0.03	1	-0.030
	Hunting	-1.1	0	0.000
	Fishing	0.06	0	0.000
	Material	-0.83	0	0.000
	Fuelwood	-1.24	0	0.000
	Amenity	0.06	1	0.060
	Biodiversity	0.06	1	0.060
RAMSAR	RAMSAR proportion	-1.32	0	0.000
SUM				2.457

When these values are inserted into the meta-regression model, $ln(y) = 2.457$, and $y = 11.67$ US$/ha/year in 1995 U.S. dollars. Adjusted for inflation, $y =$ $18.66/ha/year.[124] The total value of the wetland, using a twenty-year time period and 2.5 percent discount rate (recommended by the Office of Management and Budget[125]), comes to $2,445.17.

As mentioned before, carbon sequestration, non-consumptive recreation, noise, and existence value were not included in the meta-regression model. These variables increase the value of the property as a wetland, as discussed in Chapter 3. Therefore, if these benefits are included, the wetland's total monetary value is more than what was calculated using the model. In addition to these positive impacts that increase the value of the wetland not being included, there are also unmeasured costs of constructing the proposed development that would further decrease its value. These

costs are negative externalities such as increased pollutant runoff, flooding, and erosion. This analysis did not capture these impacts because they would not change the outcome of the BCA. However, they do merit acknowledgement.

There are several limitations to the meta-analysis that should be noted. Primarily, the authors specifically state that their meta-regression model is particularly poor at estimating low-value wetlands, and has a tendency to overestimate their value. However, the model has no way of accounting for the scarcity of this wetland. Because it is one of the last units of forested wetland in the County, its value will be higher than the average unit that this model is predicting. On top of this, the biodiversity provided by this wetland can be found in few other locations in the county. Because of this, the value of biodiversity specifically has probably been undervalued. Biodiversity is also particularly difficult to value in general because it is a nonmarket nonuse value. Even aside from scarcity, it is likely that the model did not accurately predict the value of the wetland's biodiversity and, again, underestimated its value. Finally, this model only allows inputs of 0 or 1 (absent or present) for ecosystem services; it does not account for the scale or quality of these services. Because of these factors, even though the model is poor at valuing low-value wetlands, it could be the case that the wetland is actually worth more than the model predicts. Future research on this topic could benefit from incorporating these dimensions into the analysis.

Although the parcel is not worth a large sum of money in its current low-intensity use, as long as the housing market remains unprofitable in Chesterfield Township the costs of going forward with the proposed development will outweigh the benefits. Because of this, it is recommended that the property remain in its current

state as a forested wetland. It may be prudent, however, to re-conduct the analysis at a later time if developing the land becomes profitable once more.

Endnotes

[124] Bureau of Labor Statistics. “CPI Inflation Calculator.” N.p., n.d. Web. 3 Apr. 2017.

[125] Office of Management and Budget. “Discount Rates for Cost-Effectiveness, Lease Purchase, and Related Analyses.” 2016. Web.

Chapter 5

CONCLUSIONS

As part of the research for this thesis, a BCA of developing a forested wetland property at the center of a high-profile Supreme Court case was conducted to determine economically the most socially efficient use of the wetland. It provided an overview of the history of the CWA to demonstrate the complexities of its evolving law as well as the potential for using economic analysis in the lawmaking process. Impacts of the proposed development were itemized and qualitatively evaluated before using the benefit-transfer method and a meta-regression model to value quantitatively the forested wetland.

Due to the foreclosure of the Carabell property and the negative profitability of the development, the most socially efficient use for this property is to remain a forested wetland, which provides positive benefits to society. Although the meta-regression model contains certain limitations, until the housing market rebounds and construction in Chesterfield Township becomes profitable again, the outcome of the BCA will not change. The property owner may find it simplest to sell the land back to the Township, County, or State to be used as a public recreation area.

Although this particular parcel may not possess a high market value, it suggests that the law should continue to offer a regulatory process to protect some wetlands that provide positive benefits to society. Scientific research and economics used together will give lawmakers the best evidence and strongest argument in favor of preserving these indispensable ecosystems. In a time when environmental

regulations are on the chopping block, it is necessary now more than ever to provide compelling, thorough arguments that give wetlands a fighting chance at surviving and thriving for generations to come.

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