



The Natural Capital of the Southern Lake Michigan Coastal Zone: First Steps Towards an Economic Valuation

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Abstract

This report provides a review of existing documentation of the physical properties, features, and natural and ecosystem processes relevant to the identification of natural capital of the Southern Lake Michigan Coastal Zone (SLMCZ). This is followed by a description of the concept of natural capital accounting. An overview is provided of the existing environmental economic research that measures the economic value of natural capital and that may support a benefits transfer exercise to value the SLMCZ. We present a supportable monetary estimate of the non-use value of the biodiversity component of the natural capital in the SLMCZ. This is accomplished through a benefits transfer exercise from the mean results of the existing natural capital valuation studies from other regions.

The Southern Lake Michigan Coastal Zone

Lake Michigan, the only Great Lake entirely within the borders of the United States, is the second largest Great Lake by area (22,300 square miles), and has a volume of 1,180 cubic miles, placing it behind Lake Superior. Lake Michigan is considered to be the most geologically diverse of all the Great Lakes because it has many different landform types on the shoreline. These include lake plains, clay bluffs, eroding bluffs, dune fields, rocky cliffs, sand ridges, and clay and pebble shores. Lake Michigan's sand dunes make up the largest concentration of freshwater dunes in the world. 411 coastal wetlands have been identified on the shores, mostly concentrated along the rivers emptying into the lake from the west, in Green Bay, and within embayments in the northern end of the lake (SOLEC, 1996).

The Chicago area and the surrounding smaller cities located on and around the southwestern coast of the Lake constitute the largest urban area in the Great Lakes basin, accounting for about 8 million of the 10 million people living around the whole of Lake Michigan. This area is defined, for the purpose of this report, as the Southern Lake Michigan Coastal Zone (SLMCZ). The zone includes the 45 miles of shoreline in Indiana and the 63 miles of shoreline in Illinois. It also includes the nearshore waters and any wetlands that are close enough to the shoreline to be affected by changes in lake levels and wave patterns. The fish, bird, and plant species that spawn, live, and otherwise rely upon the habitats within the area are too considered to be part of the natural capital of the Southern Lake Michigan Coastal Zone.¹

Lakefront Types

The immediate lakefront areas of the SLMCZ are extremely diverse and include solid, shore-armoring structures, sand beaches, mixed sand and gravel beaches, riprap revetments, vegetated low banks, fringing wetlands, and sand dune systems. Beginning at the Illinois-Wisconsin border, mixed sand and gravel beaches are present as far as Waukegan, where riprap revetments begin and continue as far South as Lake Forest, dotted with areas of beach. Immediately surrounding the Great Lakes Naval Training Center there are some pure sand beaches. From Lake Forest south to Glencoe, the lakefront is mostly sand and gravel beaches with small areas of riprap revetments and exposed artificial structures. From Glencoe south to Wilmette, the lakefront types continue to alternate between mixed sand and gravel beaches, artificial structures, and riprap revetments. North of the Wilmette harbor there is a long stretch of sand beach and south of the harbor the alternating types begin again. The Chicago lakefront is made up of long expanses of solid artificial structures and riprap revetments, with sand beaches appearing just north of Montrose harbor and south of Diversey Harbor. Three lagoons, located just west of the Illinois-Indiana border, have sheltered vegetated low banks. Directly east of the border, the lakefront is mostly riprap revetments with areas of mixed sand and gravel beaches. Around the Indiana Harbor are all solid artificial structures that

¹ The U.S. EPA defines Southern Lake Michigan in its Environmental Sensitivity Index as the shoreline of Illinois and Indiana west as far as Westchester, Illinois. Southern Lake Michigan is also commonly considered to stretch from southeastern Wisconsin to the eastern border of Porter County in Indiana.

expand just east of Gary to the Indiana Dunes National Lakeshore except for a few areas of riprap revetments and one small fringing wetland. The National Lakeshore is a long expanse of sand dunes. East of the National Lakeshore to the Indiana-Michigan border are sand beaches and riprap revetments.

Nearshore Waters

Nearshore waters are defined by the Environmental Protection Agency as: "...beginning at the shoreline or the lakeward edge of the coastal wetlands and extending offshore to the deepest lakebed depth contour, where the thermocline typically intersects with the lakebed in late summer or early fall". The boundary can be from where the depth reaches 9 meters to where it reaches 27 meters {U.S. EPA, 1996}. The volume and length from the shoreline of the nearshore waters can vary depending on meteorological conditions, and general lake levels, and can also vary along a given coast depending on how steep the offshore slope is. For Lake Michigan they typically account for between 7.7% and 26% of the area and between .4% and 4.2% of the volume. The Lake Michigan Federation has an alternative definition for the nearshore: "the area of water just off the shoreline within which construction of breakwaters and other structures can take place." From south to north along the coastline in the SLMCZ, the slope of the nearshore lake bottom becomes steeper and steeper, meaning that there is a larger area of nearshore waters on the Chicago coastline than up at the Illinois/Wisconsin border. These waters contain extremely important physical habitats. It is estimated that 80% of the fish in the Great Lakes use the nearshore waters for at least some part of their life cycle (Lane). From the same study it was shown that of the 139 documented Great Lake fish species, only 5 did not use waters less than 10 meters deep as their nurseries. Most of the human recreation activities related to the lake, such as swimming, boating, and sport fishing, make use of the nearshore waters as well.

Wetlands

Wetlands are defined by the U.S. Army Corps of Engineers as "areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions". Great Lakes coastal wetlands are those that are between the permanent aquatic and permanent upland environments along the shores of the lakes. Coastal wetlands were once considered biologically and economically insignificant and were systematically drained and filled. Today, wetlands make up a very small percentage of the SLMCZ; the only wetland identified on the Environmental Sensitivity Index (ESI) map is on the northeastern edge of the peninsula associated with the Indiana Harbor. These few remaining are critical for a large number of species of birds, fish, insects, and plants. In fact, over 90% of the fish in the Great Lakes directly depend on wetlands for some part of their life cycle (SOLEC, 1996).

Dunes

The coastlines of Illinois and Indiana both contain unique dune and swale sand landscapes. The dunes in Indiana are mountains of sand on the shoreline that rise up to

100 feet above the swales, created by the winds blowing off the lake and the sand continually washing in from the current. The dunes in Illinois have more vegetation and are much smaller because the prevailing winds more generally blow eastward away from the lakeshore. Dune systems evolve over time and this process accounts for the distinct dune zones: beach, foredune, trough, and backdune. Each of these zones supports very different vegetation and wildlife species. Stretching from Southwestern Michigan into Indiana is an expansive stretch of sand dunes, broken only by a few industrialized areas.

Birds, Fish, and Plant Life

Each of the different coastal areas (nearshore waters, wetlands, and dunes), represent distinct habitats for diverse collections of species.² Indiana's Department of Natural Resources published a list of threatened and endangered plant, insect, fish and mammal species existing in the each of the three counties in Northwest region of the state. The list includes well over 150 different species, with vascular plants accounting for two thirds of them (IDNR, 1999).

Twenty different fish species were identified in the ESI maps, but only one of them is listed as endangered, the lake sturgeon. (Personal conversation, Brett Fischer, IDNR). Most of the fish species at risk in the Illinois and Indiana have habitats in smaller lakes, rivers, and streams. There are three federally endangered bird species occurring in the area, the bald eagle, the piping plover, and the common loon. The peregrine falcon, which was recently reclassified from endangered to threatened, also resides in the area. Ten bird species are known to nest in the area and an additional 300 have migration paths or spend at least six months in the SLMCZ (Bird Conservation Network). The ESI maps include an index of the bird and fish species common in specific areas, including endangered and threatened species. For the purpose of the valuation at the end of this report, the most prevalent bird and fish species will be identified in the table in section 4, along with those listed as endangered or threatened.

Illinois Beach State Park

Illinois Beach State Park stretches for six and a half miles along the shore of Lake Michigan in northern Illinois. It includes the only beach ridge shoreline remaining in Illinois and over 650 identified species of plants ranging from wildflowers to grasses to cattails. Recreation activities available at the park include picnicking, camping, swimming, hiking, biking, and boating. Fishing is prohibited in this designated natural area. The site contains many concession stands during the busy season, and a large 96-room hotel and conference center.

² For a complete and more specific index contact the U.S. EPA, Region 5, the Division of Fish and Wildlife in Indiana or Illinois, the Illinois Natural History Survey, or the Illinois Endangered Species Protection Board. All of these agencies have produced detailed species indices for their respective states.

Indiana Dunes National Lakeshore

The National Lakeshore is located about 50 miles southeast of Chicago in parts of Lake, Porter, and LaPorte Counties in Indiana. Indiana Dunes National Lakeshore is a protected area that runs for 25 miles from Michigan City to Gary and contains about 15,000 acres, 2,182 of which make up the Indiana Dunes State Park. The National Lakeshore ranks third among National Parks in plant species diversity, according to The Nature Conservancy, and has 90 of the state's threatened or endangered plant species and is by far the most biologically diverse region of the SLMCZ. It is also an important amenity economically for the region as the site had more than 1.8 million visitors in 1999 who came to view the site, camp, hike, swim, bike, fish, and boat.

The Environmental Degradation of the SLMCZ

Because the SLMCZ continues to face the threats of urban expansion and economic development, the valuation of its natural capital is all the more pressing in order to ensure that existing fragments remain healthy and capable of supporting existing biodiversity. Historical industrialization and infill along the shore has adulterated many natural areas. The Chicago area has gained over 5.5 square miles of additional land from filling in the lake. The sources of the lakefill were sand mined from the Indiana sand dunes and dredged from the Indiana shoals located offshore of East Chicago, Indiana, and debris from construction, demolition, and waste collection (ISGS). Of the 45 miles of shoreline in Indiana, 39% is used as residential, 24% for recreation, 20% for agriculture, 12% for commercial uses, and 5% for industrial uses. The figures are similar for the Illinois coastline.

The SLMCZ has lost all but a tiny percentage of its original coastal wetlands. Since the 1800s, Indiana has lost 87% and Illinois 85% of its wetland due to filling or conversion to other uses. In addition to destroying habitat for numerous species, wetland loss results in a loss of wetland "services." Coastal wetland services include controlling sedimentation, reducing turbidity, improving water quality, and acting as barriers against erosion. Much of the sand dunes have also been destroyed, but not to the extent of the wetlands. The privately owned dunes in Indiana are not subject to strict zoning laws and residential units are rapidly being built, often too close to the shoreline {LMF}. While wetlands can be reconstructed (for a price), sand dunes most likely cannot be replaced.

Habitat loss due to development continues to be a major problem in the SLMCZ, and the area is also severely impacted by pollution from commercial, industrial, agricultural, and residential sources. Pollutants enter the lake not only from direct deposition by factories, but also by run-off from agricultural sources and air pollution. Chemicals known as persistent toxic substances include polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), dioxins, and heavy metals as well as many others. These chemicals and others have been associated with physical and reproductive deformities in fish and wildlife as well as threats to human health. A Michigan Sport Fishery study showed that people who ate 24 pounds or more of Great Lakes fish per year had significantly higher levels of PCBs in their blood compared to a control group (Johnson

et al., 1998). The Michigan Maternal and Infant study found a strong correlation between pregnant women who consumed more than 12kg of contaminated fish and increased neurological deficiencies in their newborns.

Exotic species introduction and persistent over-fishing have threatened the biodiversity and the food web stability of the SLMCZ. The most notable changes in the fish population include the loss of five species of ciscoes and the extreme decline in populations of lake trout and lake whitefish (Fabrizio et al., 1999). Today, lake trout is stocked for recreational angling because their reproduction is no longer successful. Much of this can be attributed to the introduction of the alewife, an exotic planktivore that had no natural predator and reached nuisance levels in the 1960s. Salmon was introduced to control the alewife, but it has been suggested that the pelagic food web of Lake Michigan will not be able to support increased stocking of salmon or trout far into the future (Sprules et al., 1990). The introduction of the zebra mussel into the SLMCZ ecosystems has harmed the position of native species within the food web through their effectiveness at consuming large quantities phytoplankton and zooplankton in the nearshore water column. Additionally, their rapid reproduction has increased the maintenance costs of local water-related businesses and various public agencies by clogging water intake structures. A total of 140 exotic species have entered the Great Lakes since the early 1800s, and recent measures indicate that this rate is increasing, largely from the release of ship's ballast waters (need citation here). The region continues to face introductions of foreign species, which will likely continue to upset the food webs of the Great Lakes.

The Valuation of Natural Capital

The benefits of existing environmental resources and the costs to be incurred from their depletion have become factors of increasing interest to policymakers in recent years. Assignment of standardized monetary values to resources is required for policymakers to make effective, logical decisions. Broadly defined as “natural capital,” these resources include obvious stores of production inputs such as timber stands and farmland, as well as more abstract environmental goods such as air and water quality, biodiversity, and ecosystem services. Natural capital is designated as either renewable or non-renewable. Examples of renewable environmental resources include plants and animals consumed and/or managed in a manner that ensures their future existence, while non-renewable resources include such straightforward examples as crude oil and minerals deposits. In reality, however, the distinction between these two types of environmental resources is not always clear, and it is possible for environmental goods shift back and forth depending on external factors and economic conditions. While individual species may be viewed as renewable, the entire ecosystem supporting that individual species is likely best considered as non-renewable due to the high replacement cost and/or insufficient scientific knowledge as to the structure and function of the ecosystem. The very nature of natural capital, the uncertainty surrounding its full function and design, and the inability to truly know whether an ecosystem is renewable or non-renewable makes its efficient management of existing stocks all the more problematic. As has become evident over the past decades, the market is not necessarily the best means to regulate the

consumption of environmental resources. This is because most natural capital possesses two properties whose existence render the market inefficient.

The first problem is that much of the world's natural capital is considered a public good. A public good is "nonexcludable", meaning it would be too costly or simply impossible to prevent any one party from consuming it. Of goods that are nonexcludable, their consumption can either be indivisible or divisible. The direct consumption of natural capital that is also a public good is almost always divisible. For example, a firm that uses the disposal services that air or a body of water (public goods) provide is simultaneously decreasing the quality of that good. Public goods often have the quality of being undersupplied because, despite the fact that a demand exists for them, it is difficult to exact payment for their creation and use.

The second property of natural capital is that its consumption often carries with it negative externalities. What makes the existence of externalities a serious environmental problem is that ecosystems are often complexly interwoven. It is very difficult to forecast how the consumption of one type of natural capital, say the mining of dune sands, will affect the supply or quality of another, say regional biodiversity. Even when the physical consequences of negative externalities can be predicted, they are often difficult to quantify monetarily.

The basis of our macroeconomy is an efficient pricing system which implies that the party placing the highest value upon any good will consume each available unit of that good. However, in the case of public goods and externalities, the market most often fails to arrive at an efficient "price." The identification of an efficient price for natural capital – most often a public good – will help increase the likelihood of it being efficiently sustained by governmental units responsible for the provision and maintenance of public goods. It follows that in order to incorporate a negative externality into the price of consumption of an environmental good, one must first find the value of the good(s) that will be negatively affected in its supply or quality. Remedying the inefficient overuse of the world's natural resources and increasing the supply of undervalued environmental goods are the end goals of natural capital accounting.

Overview

Natural capital accounting focuses on the determination of the total economic value of a given environmental good. Finding a value for specific goods that are priced in the market is relatively straightforward. For example, the market value of the commercial fishing industry is easily determined from the reported profits from the fishing industry from the sale of fish products in a given year. But as stated above, most environmental goods, like functioning ecosystems, are not priced within the marketplace, and other methods must be incorporated to try and assign to them a value that can support decision-making. This section aims at providing a brief overview of the methods currently in use that aim at reveal the total economic value of an environmental good.

Some of the use values of environmental goods may be priced in the market, but these goods may have other non-use values that are not properly accounted for in the price.

An economist's approach to an environmental good traditionally analyzes the different types of values that individuals and society place upon it. These values can be distinguished as either "use values" or "non-use values". Use values, as the name implies, are those derived from a person's actual use of an environmental resource. An angler fishing in the SLMCZ who keeps his catch to eat it is extracting use value from the Lake. Use value can be further broken down broadly as direct use and indirect use. The local municipalities that withdraw water from Lake Michigan are withdrawing direct use value from the Lake. People enjoying the near shore waters for swimming are enjoying the indirect use value that the Lake provides.

Non-use value is not as straightforward. People can also obtain value from an environmental resource without extracting something from it or using it in any way. Evidence of this kind of value is readily apparent in the contributions that people make to environmental organizations that work to preserve and restore environmental resources that the contributor may never see or use. This kind of value can be further distinguished as either option value, bequest value or existence value. Option value refers to an individual's being able to use the resource at some time in the future. Someone values an environmental good because she may like to use it in the future. Bequest value implies that the individual values a resource due to her desire to pass on the resource intact to a future generation. Existence value is the value an individual places on a resource aside from the other values and is interpreted as a satisfaction in simply knowing the resource exists. The sum of the use value and non-use value of a particular environmental good is its total economic value.

Measuring Non-Use Value: The Contingent Valuation Method

Direct and indirect use values are revealed by measuring the market value of the extracted good or by measuring market activity of individuals indirectly using an environmental resource. However, the non-use values associated with an environmental good must be measured through other means. The most common method that economists employ to determine non-use values is the contingent valuation method (CVM). This method requires that people express their willingness to pay (WTP)³ to either maintain a current resource or to improve upon the resource in the form of a hypothetical choice. CVM has also been used in past studies to elicit an individual's willingness to accept payment in the face of a loss of welfare. However, willingness to accept is much less prevalent in the literature, and none of the studies referred to in this paper use this approach. A contingent valuation study is most commonly administered in the form of a questionnaire administered over the phone, in person, or through the mail⁴. The

³ Willingness to pay is a measure of human welfare and is technically measured by the area under the revealed demand curve for an environmental good, also known as the consumer surplus.

⁴ In response to some of the problems that arise in applications of CVM, the National Oceanic and Atmospheric Administration (NOAA) convened a panel of economists in 1993 to assess the reliability of CVM. One significant recommendation was that CVM studies should rely upon personal interviews over telephone and mail surveys.

questions regarding WTP can be presented as open ended, dichotomous choice (also called take-it-or-leave-it), dichotomous choice with a second round, or as payment cards. Surveys typically provide information pertaining to the environmental good in question, the changes being proposed, who will use and pay for the good, and the payment vehicle. The most commonly proposed methods of payment are increases in taxes or entrance fees or a donation to a foundation or organization. Other socioeconomic and demographic questions are always included in CVM questionnaires, as well as questions regarding each individual's use of or opinions about the good in question. The WTP figure is believed to capture all the values that the market cannot, including the elusive non-use values.

Debate continues to surround the application of CVM method, most of it centered on survey design, the method of administration, and on the fundamental premise that environmental goods can be assigned a meaningful monetary value. Despite the criticism, CVM has been approved for use in benefit-cost analysis by federal agencies (U.S. Water Resources Council, 1983; K. Arrow et al., 1993) and has been held up in court as witnessed in the Exxon Valdez oil spill suit (Carson et. al, 1992). Additionally, variables such as how the WTPs were revealed (i.e. through dichotomous choice, open-ended, or a payment card), the response rate, and the year of the study were all shown to be insignificant variables in explaining the variation in monetary estimates, according to a meta-analysis of CVM studies on endangered and threatened species that spanned 18 different studies over 10 years (Loomis and White, 1996). While this does not dispel the concern over the quality of individual studies, there is sufficient evidence to warrant faith and use of the CVM method for policy making. In this paper, the survey method and design will be noted for each study referenced, but will not be critiqued at any length.

Revealing Use Values: The Travel Cost Method

The second most prevalent method in the literature is the travel cost method (TCM), which is the method most commonly used to determine use values for either a particular recreation site or to determine demand for changes in environmental quality across recreational sites. Similar to CVM, TCM involves administering a questionnaire on site that includes questions pertaining to the distance traveled, costs associated with the trip, frequency of trips, and attitudes towards the site, as well as demographic questions. A total travel cost is calculated by adding fuel costs, food, lodging, and usually a time cost assumed to be from one quarter to one half of each individual's wage. The use and application of the time cost is probably the most debated aspect of the TCM. Another problem noted is that some individuals may self select and move closer to a certain recreation site, something that is not accounted for in all past studies (Gibson, 1978). In any event this would serve to underestimate the full demand for the site. This method is popular due to its relative ease of administration and due to the fact that it uses actual expenditures to extrapolate values for the environmental good, which many prefer to the hypothetical CVM method. However, TCM cannot, by definition, be used to determine non-use values such as option, bequest, or existence values because the respondents must be actual visitors.

Measuring The Value of Changes in Environmental Quality: The Hedonic Pricing Method

The third most common method for assigning a value to an environmental good is the hedonic pricing method (HPM). HPM aims at finding this value through analysis of the value of another good that has a market-revealed price. While it has been argued that HPM can be applied to any market that can be fully estimated (Rosen, 1974), by far the most common use of HPM is in property values that capitalize the value of the environmental goods that surround the property, such as air or water quality. The central idea of HPM is that in a competitive market in equilibrium, all qualities of the market-priced good will be reflected in its price. This implies that, all other things equal, a parcel of real estate on a lake with poor water quality will be priced lower in a competitive market than a parcel of real estate on a lake with high water quality. HPM faces many more restrictive assumptions than CVM regarding the elasticity of the demand, structure of the market, and that consumers must have perfect information. Whether or not people consider current, future, or past states of environmental quality, and the time lags of environment-related diseases and the housing market in general have all been problems for the execution of HPM. However, a few careful HPM study results will be included in this report.

Most of the environmental economics literature that addresses assigning values to natural resources does so only through the individual consumer, be it CVM, TCM, or HPM. But the value of natural resources as necessary production inputs has been touched upon recently, including the value of ecosystem services and resources as far reaching as a particular region's soil and air (Costanza et al, 1997), (MacDonald, 1999). In light of these studies, it could be argued that any study that assigns a value to a resource, such as water quality, a species, or a recreation site, without also including the service values of the ecosystem for which the particular valued resource helps to complete, is fundamentally pricing the resource too low. Therefore, any lower bound reported in a range of values should be considered undoubtedly well below the "actual" value of that natural resource.

Existing Natural Capital Valuation Research

This section presents existing natural capital valuation research. As a whole, this body of work is intended to be a representative sample of the subject matter and methods prevalent within the environmental economics literature; however, a few studies that stray from the norm are also outlined. The section is organized so that the natural capital being valued becomes larger and larger in scale, beginning with water quality, followed by specific endangered species, biodiversity and habitats, recreation, and ecosystem services. The quality of each type of natural capital directly depends on the quality and supply of that of the preceding group. As is common with economic literature, the numerical results of many of these studies are prefaced by technical economic analysis regarding model specification and followed by an analysis of the econometric methods. For the purpose of this report, these aspects of the studies will not be discussed at length, except when necessary for completeness. The research area, subject matter, and methods will be outlined, followed by a statement of the numerical results. It is important to point

out that unfortunately the authors of these studies often choose not to aggregate the values they obtain in order to estimate a total dollar figure for the subject. This is mainly because most of the papers exist often initially as intellectual exercises within the field of economics. Even if a study's results have been aggregated at some point, a researcher is much more likely to encounter the original journal article rather than the secondary publication included in dialogue pertaining to legal battles or policy. This fact does not preclude their findings being considered and used for practical purposes, such as awareness and policy writing. All dollar figures will be reported in terms of the year the paper was published, unless otherwise stated.

Valuing Water Quality – Travel Cost Studies

The economic value of water quality can be estimated in several ways. Most of the literature employs one of the three following methods: (1) travel cost studies that include measures of varying water quality at varying recreation sites, (2) contingent valuation studies that propose reductions or increases in water quality, and (3) hedonic studies on property values. This particular group of studies is intended to represent the three most common natural capital valuation methods; particular studies were chosen because of their relevance to the SLMCZ. The methods will be briefly discussed, followed by a statement of the results.

Caulkins, P.P., Bishop, R.C., Bouwes, N.W., Sr. (1986)

The authors obtained the results from a Wisconsin statewide water quality survey, conducted prior to 1986, and used data such as place of residence, amount and destination of lake trips, and occupation to create a travel cost variable. The travel cost was deflated by the opportunity cost of time, which in this case was designated as one quarter the hourly wage rate. The water quality variable was the Lake Classification Index (LCI), a technical index created by Uttormark and Wall in 1975. Three other lake attributes were included: four categories of shoreline (urban, low intensity development, agricultural, and underdeveloped), lake depth, and lake size. The authors designed two multinomial logit models, the first in order to predict the probability of an individual choosing any one site. The second model was constructed to predict the probability of an individual choosing to participate in lake recreation on any given day.

The multinomial logit model was used to estimate the percentage change in visits to one of the Wisconsin sites, Shadow Lake, from a one unit LCI increase in water quality. The sample was of 60 individuals who made 1,305 visits in one year to Shadow Lake. The model predicted an increase of 12%, which means an additional 154 trips. In 1984 the average annual attendance to Shadow Lake was between 80,000 and 90,000, so the additional 8,000 to 10,000 people would account for a sizeable increased revenue to the state of Wisconsin. The authors did not calculate a total value of the water quality of Shadow Lake, but it conceivably could be determined with adequate recreation expenditure data.

Phaneuf, D.J., Kling, C.L., Herriges, J.A. (1998)

The data used for the second study under discussion was from a 1990 mail survey conducted by the University of Wisconsin-Madison that yielded 240 usable observations.

The 22 reported recreation destinations were separated into four distinct sites, Lake Superior, Southern Lake Michigan, North Lake Michigan, and Green Bay and the authors manipulated the data to create a travel cost variable, with one third of the respondent's wage as the opportunity cost. The site quality was judged by the catch rate for four salmonid species and toxin levels in lake trout flesh. The authors specified three different empirical models, the repeated nested logit model, a system of demands, and the Kuhn-Tucker. The dependent variable⁵ was attractiveness of a recreation site and the independent variables were *travel cost*, *catch rate*, *toxin*, and a dummy variable⁶ for whether the individual owned a boat. Toxin levels and a site's "price" (travel cost) both were significant negative variables, meaning they both decreased the attractiveness of a recreation site at higher levels.

The parameters of the models were used to estimate the changes in welfare – in this case utility of anglers – from changes in water quality. The hypothetical scenarios were: (1) *Scenario A – a 20% reduction in toxins at all sites* and (2) *Scenario B – loss of south Lake Michigan for angling due to an environmental disaster*. The welfare gains from a reduction in toxins averaged \$35.85 over all four models, in dollars per angler per season. The welfare loss from a complete loss of South Lake Michigan ranges from \$98.34 in the repeated nested logit model to \$849.09 in the Kuhn-Tucker model, again reported in dollars per angler per season. The authors point out that the reason the Kuhn-Tucker model has values much higher than the other models is that it incorporates non-use values when the other models reflect only direct-use values. However, the Kuhn-Tucker does not include the existence value of the sites. As in the previously discussed report, the authors declined to aggregate their findings to determine an overall monetary figure for the water quality of Lake Michigan for fishing. But, given sufficient angling data, an estimate could be made. This study serves to display the definite negative effects of pollution, as standardized in dollars, on a region's sporting population.

Sutherland, R.J. (1982)

The final study using the travel cost approach does so in a novel way. It was conducted in 1980 and examined over 179 recreation sites in Washington, Idaho, and Oregon. The author doesn't make use of an actual travel cost survey, but instead estimates one using available census and fish and wildlife service data. He chooses not to include the opportunity cost of time in the estimation of the travel cost variable. He then employs a device called a gravity model to estimate the number of visits to the 179 sites for camping, hunting, fishing, and swimming. The author makes an important assumption that water quality and recreation facilities are perfect substitutes, an assumption that enables him to estimate the benefits of improving water quality through estimating the benefits of increasing facilities on degraded rivers and streams. Regional planners in each state were asked to view maps of degraded rivers and tell if and how many recreation facilities would be constructed in the event of improved water quality.

⁵ The dependent variable in an equation is one whose value is estimated in whole or in part by the other, independent, variables.

⁶ A dummy variable is one that traditionally takes a value of zero or one, to indicate the presence or absence of a condition.

The results were summed up over the entire three-state region and the reported total annual recreation existing benefits were \$377,196,700. The total regional incremental benefits of making all the degraded waters suitable for all recreation were \$18,748,413. The author points out that his method of questioning regional planners may be less scientific, but he stresses the need for a method that can be repeated on alternate sites for a smaller cost than a full blown travel cost study.

Valuing Water Quality – Contingent Valuation Studies

Three studies incorporating the contingent valuation method will be addressed. The descriptions are somewhat less lengthy than those of the travel cost studies because it was not necessary to create models and use econometric techniques to determine the willingness to pay (WTP) in these studies.

Greenley, D.A., Walsh, R.G., Young, R.A. (1981)

The first CVM study comes from a paper published in 1981, centered around a survey conducted in Denver and Fort Collins on a random sample of 202 residents (Greenley, Walsh, Young, 1981). The surveys were given in the respondents' homes where the interviewers displayed pictures of three different rivers and provided information regarding the heavy metal concentration in each. The heavy metal concentration was considered the sole measurement for water quality. The respondents were then asked how much they would be willing to pay to improve the water quality in order to improve recreation along the rivers. Half of the respondents were given the option of water-sewage fee increases in increments of 50 cents per month and the other half were given the option of increased sales taxes in increments of \$.025 on the dollar.

While the value of recreation accounted for approximately 50% of the WTP for cleaner rivers, option value was about 20%, bequest value about 12%, and existence value about 17%. Respondents who currently engaged in recreation activities reported higher option, bequest, and existence values. The authors aggregated the total annual recreation benefits of water quality over the half million households in the River Basin based on the WTP additional sales tax. The total benefits were estimated to be \$61 million, with an option value of \$10.5 million, an existence value of \$14.4 million, and a bequest value of \$9.8. Then the aggregate values were discounted and extended to compute the present value of water quality for the entire River Basin, which was estimated to be nearly \$1 billion.

Jordan, J.L., Elnagheeb, A.H. (1993)

A second use of contingent valuation was demonstrated in a study undertaken in Georgia in 1991 where 567 surveys were mailed to residents and follow up telephone interviews resulted in 192 usable observations. The survey included a small amount of information regarding the current quality of drinking water and was specialized depending on whether the respondent used the public water or wells. The respondents were given a discrete choice of six possible payments from \$0-\$100 that would be used to improve the quality of the drinking water. They also answered questions regarding their education, occupation, and their perceptions of the current water quality. The mean willingness to pay was reportedly \$8.52 for well users and \$7.54 for public water uses, in 1991 dollars per month. The authors aggregated this figure for the entire state of Georgia and

estimated the willingness to pay in Georgia for improved drinking water to be about \$275 million.

Georgiou, S., Langford, I.H., Bateman, I.J., Turner, R.K. (1998)

The final contingent valuation study pertaining to water quality was conducted in England in 1995. Surveys were administered on two different beaches in England, one that had passed the Bathing Water Quality Directive Standard and one that had failed it. The 400 respondents were given information regarding the health risks associated with swimming in water containing high levels of bacteria and then were asked questions about how much they would be willing to pay in an increase in “water rates” to a. *keep the water clean at the passing beach* and b. *clean the water at the failing beach*. The mean WTP to keep the clean beach clean was 14.32 pounds, or \$8.68 annually and at the failing beach it was 12.64 pounds, or \$7.66 annually. The authors presented the results of a regression analysis identifying which variables affect the WTP. Not surprisingly, if an individual was previously aware of the health risks, they were much more likely to bid higher values. The authors did not aggregate the figures in this study to determine the overall value of clean water.

Valuing Water Quality – Hedonic Studies

Michael, H.J., Boyle, K.J., Bouchard, R. (1996)

The first study to be discussed that uses hedonic methods examines the effect of water quality on housing prices in Maine. The authors state that the only major water quality issue in the Maine lakes at the time of the study was eutrophication, which results in decreased water clarity in addition to other biological effects. Water clarity was measured by a device called a secchi disk and had been recorded for all of the sample locations over all the relevant years with a few exceptions. The levels of eutrophication were reportedly different at each lake and varied over time, enabling the hedonic model to function correctly. Twenty-two lakes divided into three distinct property markets made up the sample group. The authors modeled 17 variables describing the structure and location of the properties sampled and then used a telephone survey to ask 52 people (one from each lake) questions about water quality knowledge and perceptions. Lake water clarity was determined to be the second most important lake characteristic after scenic beauty, and 54% of respondents said it had an effect on their decision to purchase the property. Ten variables were modeled to capture people’s water quality perception and whether the respondent considered past, present, or future in forming the opinion. The results of the regression analysis reported that the percentage of a purchase price of a residence in Maine attributed to water clarity ranges from .5% to 2.3%, depending on which market it falls in, which can be translated to between \$5,000-\$10,000.

Legget, C.G., Bockstael, N.E. (1999)

In this paper, the authors point out that there have only been five studies on the effect of water quality on housing prices compared with 25 air quality studies. This study was conducted in Anne Arundel County, Maryland, on the western shore of the Chesapeake Bay. The physical properties of the coastline and industries cause the water quality to differ within one market, a requirement, as stated previously, for hedonic studies. The measure of water quality was the fecal coliform bacteria count. The authors created two

models. The first used the price of the residential property as the dependent variable and 14 independent variables that describe the structure, location, and the water quality. The other used the market price minus the “value” of the structure as the dependent variable. The coefficient for the fecal coliform count was negative and significant in both models and the mean effect on the predicted price of a residence from a 100-count change in fecal coliform ranged from \$5115 to \$9824. The mean market price for a home in the study was \$378,540. The estimated upper bound for the benefits of improving the water quality at all of the 494 residences with high fecal coliform counts was \$12,145,000. The authors point out that this study ignores the potential impact on public beaches and also doesn't capture any non-use values.

Valuing Water Quality – Some Problems

Problems exist in every environmental economics study for the reasons previously discussed. Complete travel cost studies are costly and time consuming and they fail to account for the non-use values because all the respondents have, by definition, used the site. Hedonic studies suffer from the same problem because actual prices are used. Contingent valuation studies do capture all types of values, but are also time consuming and costly, and when administered on site, as in the English study, they may exhibit bias by select respondents that place a higher value on the environmental resource in question. With values of water quality specifically, problems arise in choosing the standard. Ideally, researchers want a standard that reflects people's perceptions of water quality, but it may not always be obtainable and one single standard will surely not capture all the measures of quality. It is important to consider these studies as a group which displays the different dollar values people place on water quality, whether it be for recreation, drinking, or aesthetic purposes.

Valuing Endangered Species, Biodiversity, and Natural Habitats

This section examines natural capital valuation studies that are more diverse and much broader reaching than those valuing only water quality. An area's biodiversity value, the conservation value of a particular coastline, and the values placed on a number of endangered species throughout the nation are addressed in the following group of studies. The majority employs the contingent valuation technique, although there are a few exceptions. It is important to note once again that the econometric sections of these papers will not be discussed. It is common for researchers to perform regression analysis using a logit or tobit⁷ technique on the CVM results in order to correct for the statistical problems that can occur when there is a high number of “0” values in the WTP data. The values reported are considered to be the researchers' best estimates with or without the aid of econometric techniques.

Stoll, J.R., Johnson, L.A. (1984)

One of the earlier studies was conducted in 1983 in Texas and attempted to assign a value to the Whooping Crane, a federally endangered species (Stoll). Surveys were

⁷ Logit and tobit are econometric modeling techniques that are commonly used in the analysis of socioeconomic data.

administered on-site at the Aransas National Wildlife Refuge and mailed to residents of Texas and to individuals in Los Angeles, Chicago, New York, and Atlanta. The respondents were asked questions about their knowledge and previous contact with whooping cranes and various socioeconomic questions. They were then asked to accept or reject a specified WTP amount ranging from \$1 to \$70 for a permit to use the Aransas refuge with and without whooping cranes, and from \$1 to \$130 to join a foundation to help save the whooping cranes.

The authors used the results of the survey to calculate estimates of use value, option price, and existence value. The use value for visitors to the Aransas refuge was estimated at \$213,340 and the existence and option value for the visitors was estimated at \$779,382. Expanding option and existence figures (a WTP of \$7.13) and use values to every resident of Texas, the authors estimated a value of \$38.7 million for the whooping crane. They then expanded those same numbers for the nation, using 1980 census data, resulting in a value of \$1.58 billion. The authors point out that these figures do not include regional revenues from travel costs and extra expenditures on services related to viewing the whooping crane, such as boat rides.

Boyle, K.J., Bishop, R.C. (1987)

In 1987 Boyle and Bishop published a study that attempted to find the total value of two endangered species, the bald eagle and the striped shiner (a minnow whose habitat is the Milwaukee River). The purpose of the study was to find out why Wisconsin taxpayers were not contributing to the state's Endangered Resource Donation (ERD) fund when paying their state income taxes. Five hundred surveys were mailed out to those who did not contribute and 500 to those who did. Half of the individuals were asked to value the bald eagle if it could no longer be viewed (existence only) and the remaining half were asked to value the bald eagle in its current state. The surveys asked about the striped shiner only in its current state because it was assumed to only have existence value. The proposed method of payment was membership in a foundation that would protect these species; respondents were given a dichotomous choice of randomly selected membership fees between \$1 and \$100.

The mean willingness to pay differed significantly between the known species and the unknown species. The mean WTP for viewers of the bald eagle at its current state who were also contributors to the ERD was \$75.31 and for contributing nonviewers it was \$18.02. For noncontributing nonviewers the WTP was \$11.84. If the eagle were to be conserved but not viewable, those figures dropped to \$28.38, \$30.78, and \$10.62 for the contributing viewers, nonviewers, and the noncontributors respectively. The WTP for the shiner was \$5.66 for contributors and \$4.16 for noncontributors. The authors expanded these figures to obtain an aggregate value estimate for all Wisconsin taxpayers of the bald eagle and the striped shiner equal to \$40,179,700.

Kinnel, J.C., Epp, D., Fisher, A., Lazo, J., Shortle, J. (2000)

A survey was mailed to 870 Pennsylvania duck hunters in 1997 providing them with information about the Prairie Pothole region, an area that provides a breeding area for 50% to 80% of the ducks in North America and includes portions of the Northern Midwestern States and the Prairie Provinces in Canada. The hunters were also given

information about the potential damage that may occur there in the future from global climate change, agriculture, or both. The survey asked questions about respondents' hunting habits and preferences, socioeconomic questions, and a question about WTP for measures taken to save the duck population by protecting this area. Eight different versions of the survey were mailed out that specified preventing either a 30% or 75% decrease in the population, from either agricultural causes or global climate change over 100 years, or from a combination of agricultural and climate change over either 100 or 40 years. Some surveys did not contain information leaflets.

The mean WTP reported across the eight different surveys was \$11.33. The greatest WTP was to prevent a proposed 75% decrease in the duck population from global climate change alone over 100 years. The smallest WTP was to prevent a 30% decrease over 30 years from agriculture alone. The surveys that did not contain an information leaflet describing the prairie pothole region and the environmental threats to it did not seem to affect the mean WTP very significantly. It should be noted that the sample contained only duck hunters and was heavily biased towards males. These respondents likely held higher values for ducks than the general population. The complete value of the habitat in the Prairie Pothole Region was not calculated.

Loomis, J.B., White, D.S. (1996)

This 1996 study used a regression analysis to account for the variation in WTP values in a number of contingent valuation studies over species and survey design. The dataset included the estimated values for the bald eagle, the striped shiner (a minnow), and the whooping crane, and listed 15 other values for species ranging from the cutthroat trout to grizzly bears. The authors suggest that with increasing data, meaning more quality contingent valuation studies on particular species, it may be possible to construct an econometric model to estimate the value for any species. This would be particularly helpful to any region wanting to perform a complete economic valuation of its natural capital, by enabling it to estimate values for its rare and endangered animal species without being forced to undertake multiple expensive and time-consuming CVM studies.

Table 1: Reported WTP figures for Species Preservation

Species	Average annual WTP Per Person	Species	Lump WTP Per Person
Northern Spotted Owl	\$70	Bald Eagles	\$216
Pacific salmon/ Steelhead	\$63	Humpback whales	\$173
Grizzly bears	\$46	Monk seal	\$120
Red-cockaded woodpecker	\$13	Gray wolf	\$67
Sea otter	\$29	Arctic grayling/ Cutthroat trout	\$15
Gray Whales	\$26		
Bighorn Sheep	\$21		
Sea turtle	\$13		
Atlantic salmon	\$8		
Squawfish	\$8		

source: Loomis and White, 1996

The main findings of the meta-analysis were that WTP amounts are sensitive to the size of the proposed change in population. This is an important finding because it indicates that the WTP results are not merely symbolic votes for preservation. Additionally, the WTPs for marine mammals and birds are statistically significantly greater than those for fish, land mammals, and reptiles. The lump sum figures are significantly higher than the other because they are presumed to be paid once, while the others are paid annually.

Montgomery et al. (1999)

In a paper entitled *Pricing Biodiversity*, the authors first construct a model of “management prices” for units of habitat contributing to the population size of each species. They stress the importance of management prices because biodiversity is a public good and “land managers” must have prices that measure how their activities will affect its supply and quality. The basic idea is that the management price must equal the aggregate marginal rate of substitution between land for habitat and land for other uses, while incorporating the marginal rate of substitution between biodiversity and other goods. A diversity index is defined as one that depends on the viability of each species and the probability that its population size at a certain time will exceed a certain level.

A case study was undertaken in Monroe County Pennsylvania, an area composed of 20 municipalities where different management prices would be applicable. The study was based on 147 bird species in the area for which a diversity index was created. The authors estimated the sum of all the management prices, the cost to maintain the status quo of biodiversity in the county, to be \$460 million. The opportunity cost, or the decrease in the market value per increment of biodiversity depended directly on the difference between unlimited development of the land and the status quo scenario, was estimated at \$177 million. A value of biodiversity was also estimated, not by contingent valuation methods, but by creating a model for the value of biodiversity and plugging in

the value to society of biodiversity times the level of diversity estimated by the diversity index. The figure obtained was \$1.45 billion, much higher than the sum of the management prices and the opportunity cost.

Goodman, S. L., Seabrooke, W., Jaffry, S. A. (1998)

A survey was conducted through personal interviews of 800 residents of the East Midlands area of England in 1996. Two settings were described to respondents: a group of coastal areas with relatively high conservation value, and a group with low conservation value. The interviewers claimed that each group represented 10% of the British coast and that without intervention 75% of the biodiversity and irreplaceable coastal habitats will be lost and in the next 30 years. Then the interviewees were asked if and how much they would be willing to pay in increased taxes to support conservation in each of these groups and then for the entire coast. Additional questions covered respondents' attitudes and usage of coastal resources.

The annual WTP for a conservation program for the entire coast was 48.36 pounds (\$29.31). The site with high conservation value had a WTP of 24.75 pounds (\$15.00), and the site with low conservation value had a WTP of 17.87 pounds (\$10.83). Those respondents who had visited the coast within the last six months, had a familiarity with coastal nature and conservation, and/or had positive attitudes towards environmental conservation in general were much more likely to have higher WTP figures.

Recreation

Walsh, R.G., Johnson, D.M., McKean, J.R. (1992)

As seen in the section addressing water quality studies, the value of human outdoor recreation is generally viewed as one of the more intuitively valid approaches by which to address natural capital valuation, quality, and supply issues. The level of coastal water quality affects the demand for swimming, the level of coastal biodiversity and the quality of ecosystem function directly affects the demand for sightseeing, hiking, and off-road driving, and the level of habitat conservation affects the supply for hunters. All of these recreation activities can to an extent be priced in the market through travel cost as previously examined, but also through expenditures on gear and lodging, and through the direct market pricing of game that hunters bring in for tagging. Figures placing values on recreation activities are by far the most prevalent in the literature and can be found in economic journals as well as in government and private organizations' publications. In a paper by Walsh, Johnson, and McKean entitled *Benefit Transfer of Outdoor Recreation Demand Studies, 1968-1988*, the authors performed a massive literature search and gathered 120 sources that estimated 287 values over 24 different recreation activities. These studies represent the dollar amounts that participants would be willing to pay above their current expenditures, or consumer surplus, in order to guarantee the recreation resource's availability. The literature review was limited to studies of use values on site, so therefore does not include any estimates for option or existence values.

Walsh, R.G., McKean, J.R. (1999)

Walsh and McKean did go on to address option values and "anticipatory" values through a study of undergraduate students at Colorado State conducted in 1991.

Table 2: Valuation of Recreational Activities

Activity	Number of estimates	Mean	Median
Total	287	\$33.95	\$27.02
Camping	18	19.50	18.92
Picnicking	7	17.33	12.82
Swimming	11	22.97	18.60
Sightseeing and off-road driving	6	20.29	19.72
Boating, motorized	5	31.56	25.67
Hiking	6	29.08	23.62
Winter sports	12	28.50	23.62
Resorts, cabins, and organized camps	2	12.48	
Big game hunting	56	45.47	37.87
Small game hunting	10	30.82	27.48
Migratory waterfowl hunting	17	35.64	25.27
Cold water fishing	39	30.62	28.49
Anadromous fishing	9	54.01	46.24
Warm water fishing	23	23.55	22.50
Salt water fishing	17	72.49	53.35
Nonconsumptive fish and wildlife	14	22.20	20.49
Wilderness	15	24.58	19.26
Other recreation activities	9	18.82	16.06

source: Walsh and McKean, 1999

The survey asked 30 questions aimed at extracting information on participation in recreation activities, expenditures, knowledge of specific sites, socio-economic data, and WTP. The indirect uses associated with anticipating a visit that were listed in the survey were as far reaching as watching TV, reading magazine articles, quiet reflection, and cleaning. The authors hypothesized that the value of the actual visit to one site does not encompass the true value of recreation because sites that are too far away or too expensive to visit display their value through the students' anticipation and indirect activities.

The main result of this study is that the more expensive the individual's travel cost is to a certain site, the higher the WTP is for anticipatory activities relating to that site, when compared to those of other more accessible sites. The value of the indirect uses of anticipation per site is \$12 for the optimal 3.6 hours. The average number of use options (swimming, hiking, etc) is 2.8 per trip taken and results in a value of \$33 per site. The authors estimate that the average total value of a recreation experience would be approximately \$169. This is calculated as the sum of indirect use value of \$18, the on-site use value of \$36, and an option price of \$54.

Economic Impact Studies

An economic impact study focuses on the contribution that natural capital makes to a local or regional economy by estimating the direct and indirect/induced market economic activity – usually in terms of personal income. Two reports published in 1999 undertook the task of tallying up the fiscal benefits of regional recreational beaches. The first, *The Fiscal Impact of Beaches in California* was a report commissioned by the California Department of Boating and Waterways (King 1999). It was determined that the beaches generated \$73 billion dollars of direct, indirect, and induced spending within the State of California and supported a total of 883,000 jobs in 1998. A similar study entitled *The Value of Lake Erie Beaches* obtained an annual figure, but did not include tax revenues and job creation. However, the researchers did estimate “value of satisfaction” using the travel cost method. The total annual value over all Lake Erie beaches in Ohio was \$3,481,578 in 1997. (Sohnngen et al., 2000)

In 1993, The U.S. Army Corps of Engineers, along with the Chicago Park District and the City of Chicago, released an extensive cost-benefit analysis of the City of Chicago’s aging shoreline. The goal of the analysis was to increase federal funding for the repair of the step-stone revetments along certain reaches of the shoreline, thus avoiding extensive erosion while maintaining public access. The study found that the total economic value of Chicago’s shoreline facilities and lakefront property exceeds \$5 billion. These facilities include the museums, public parks, and, most importantly, the Lake Shore Drive federal highway. Of specific interest to this report are the proposed annual recreation benefits that would accrue to Chicago from the proposed step-stone revetment improvement plan, which totaled over \$12 million per year.

Ecosystem Services

American Petroleum Institute (1991)

The API report took a similar form to this report, in that it performed a literature search of economic studies that attempted to value natural capital, in this case specifically wetlands. A table within the report summed up the estimates of functional values of wetlands, not all of which the coastal wetlands in the SLMCZ perform. Table 3 includes only the relevant services.

Table 3: Values Associated with Ecosystem Type

Wetland function	Value (1984\$) in \$/acre/year	\$/acre capitalized value at 5% (1984\$)
Fish and shellfish habitat	\$32 - \$66	\$700 - \$1,320
Waterfowl habitat	\$167	\$3,340
Mammal and reptile habitat	\$12	\$240
Recreation	\$6 - \$70	\$120 - \$1,400

source: American Petroleum Institute (1991)

Unsworth, R.E., Bishop, R.C. (1994)

This study points out that the value of wetland services varies depending on location and the particular physical properties of the wetland. It is often too costly to conduct the research necessary to find a dollar figure applicable to a damage suit. Thus, a model is proposed that helps to determine compensation to the public for the loss of use and the non-use values associated with wetlands when environmental damage occurs. The model assumes that the total value of wetlands, N , cannot be known, so the question becomes: how many acres of newly created wetlands that produce N in services per acre per year in perpetuity would be required to produce the equivalent of the present value of environmental damages. In this model, N appears on both sides of the equation and cancels out, leaving damages equal to wetland acre years. This enables the services of wetlands to be valued in terms of acreage of wetland instead of dollars, which may perhaps be more applicable when increased wetland protection and restoration is the goal.

This model was applied to the Great Swamp National Refuge in New Jersey. Two dumps that contain asbestos are located within the refuge. In 1991 the U.S. Fish and Wildlife Service filed a claim against the firm that operated these sites. A total of 5.58 acres of wetland were lost as a result of the dumps. Because of the large area and dangerous nature of the chemicals involved, it was suggested that the sites be capped. This meant that the wetland services from the 5.58 acres are lost in perpetuity. The equation estimates that 228 acre-years of wetland services (1993 \$) would be lost by 1998, when the new wetlands would be completed. The new wetland acres required to compensate the public for the interim losses between 1968 and 1997 equaled 7.96, for a total of 13.54 necessary new acres.

Costanza et. al (1997)

In a highly controversial paper, 13 researchers attempted to place a value on the entire world's ecosystem services. 17 ecosystem services were defined for the study. They were: gas regulation, climate regulation, disturbance regulation, water regulation, water supply, erosion control and sediment retention, soil formation, nutrient cycling, waste treatment, pollination, biological control, refugia, food production, raw materials, genetic resources, recreation, and cultural. The authors referenced over 100 existing environmental economics studies to assist them in assigning dollar figures to each service. They also made estimates of the global extent of each of the different ecosystems, ranging from open ocean, which provided an estimated \$21 trillion per year, to desert areas, which provided \$0 of ecosystem services annually. The total figure the authors estimated was \$33.2 trillion annually, though the authors acknowledged that there are many sources of error involved with this type of massive analysis, the most prevalent being extensive data gaps in the biological and economic research. The authors emphasized that the point of the exercise was to make this type of analysis more apparent and to point out areas in need of additional research.

An Economic Valuation of the Natural Capital of the Southern Lake Michigan Coastal Zone

Though many of the studies identified above do not go so far as to estimate a total dollar figure for the environmental amenity being considered, some of them do. Unfortunately, none of the cited research focuses on any component of the natural capital of the SLMCZ as the amenity to be valued. An important outstanding question is whether these cited examples provide enough information to attempt a valuation of the SLMCZ. Given that the SLMCZ contains qualitatively similar natural capital stocks and ecosystem functions to which economic values were assigned within the cited research – such as similar endangered species like the bald eagle, active sport fisheries, numerous recreational beaches, and high water quality that supports both humans and non-humans – the benefits transfer exercise attempted here is likely to be defensible.

The concept of ecosystem services as part of natural capital is still a fairly new one and is a focus of the developing field of ecological economics (Costanza, et. al, 1997). A recently published paper (MacDonald, Hanley, Moffatt, 1999) attempts to take the concept of natural capital and apply it across the entire central region of Scotland. This involved analyzing the air, soil, water, and natural flora and fauna and the respective services they provide, as well as the degradation they faced in the past and future. The authors declined to estimate a number for the value of the natural capital, stating: “Identification of natural capital stock and the critical components of that stock requires environmental information on which to base an assessment. If available data do not provide indications of critical levels or insight into whether these are being maintained, this imposes a large data requirement and raises doubts on the practicality of the concept.”

Despite technical and data limitations, any discussion of a given ecosystem as natural capital is incomplete without an attempt at monetary valuation. The notion of “capital” implies that a given stock of assets produces a stream of goods and services for which individuals have economic demand – a willingness-to-pay for these goods and services. Fundamentally this implies that the capital stock – in this case natural capital – producing the flow of goods and services can be valued monetarily, even if it cannot be replaced.

Boundaries and Components of the SLMCZ

As discussed above, an accurate accounting of the natural capital of the Southern Lake Michigan Coastal Zone requires that the relevant ecosystems be completely defined and described. However, similar to the Scottish example cited above, there is a strong general consensus among regional experts that the necessary ecological mapping and description has not yet been completed for the SLMCZ⁸. According to Mr. John Rogner of the U.S. Fish and Wildlife Service, “[species quantification and natural area mapping in] Illinois and Indiana have largely been ignored.” Dr. Jonathon Higgins, senior aquatic ecologist with the Nature Conservancy’s Freshwater Initiative, has described the

⁸ Based on personal conversations with Dr. John Dettmers, Illinois Natural History Survey, John Nelson, Illinois Department of Natural Resources, and Mr. Thomas Brody, U.S. EPA-Region V.

scientific research that would benefit the SLMCZ in a handout to members of the Urban Aquatic Restoration Summit Steering Committee (Higgins, 2000):

“Research on the status (survey and quality analysis framework) of native biodiversity [is needed] in the southern [Lake Michigan] basin. This will help inform the understanding of the types and number of sites that will need to be protected an/or restored, and will help refine the selection of sites. Landscape-scale modeling and analysis of the natural processes and the types and levels of threats to these processes [are required]. In order to conduct adequate protection or restoration of habitats that are a part of, or are connected to the southern basin of Lake Michigan, we have to understand the natural processes and at what scale they operate.”

The State of the Lake Ecosystem Conference: Ecoregional Context (U.S. EPA and Environment Canada) describes the available data and research gaps:

“In the United States a number of classifications have been used to identify ecological regions... The U.S. EPA has also developed an ecoregional classification scheme, generally based on the spatial coincidence of all geographical phenomena that affect or reflect differences in the health/integrity/quality of ecosystems and ecosystem components. To date the only Great Lakes states that detailed ecoregion mapping has been developed for using this approach are Indiana and Ohio...[Ecoregional classification] is an important tool for organizing information across the Great Lakes basin, and for increasing understanding of ecological patterns and connection...because of the close connections between the character of regional landscapes and human activities, ongoing efforts should be made to correlate social and economic characteristics with ecoregional mapping.” (U.S. EPA, 1996).

It bears mention that there have been attempts at ecosystem classification within the SLMCZ. An important example is the U.S. Coast Guard’s shoreline habitat maps that have been produced for most of the SLMCZ (U.S. EPA, 1994). These maps are intended to index how sensitive the SLMCZ habitats would be in the event of an oil spill and outlines the shoreline type and the species of fish, birds, and terrestrial plant life that are either threatened, endangered, or considered important to the ecosystem. It is these USCG maps and the comprehensive plan for the Illinois Nature Preserves System (IHPC, 1973) that have been the primary sources for the detailed description of the lakefront shoreline types and species included in this report. Once again, it is important to note that all of the regional experts contacted expressed an opinion that the current data is incomplete and insufficient with respect to species and/or ecosystems services and the interconnectedness between species and habitats. Despite the research gaps, an attempt will be made here to estimate lower and upper bound figures for the value of some components of the region’s coastal natural capital. It must be emphasized that the

reported figure is very preliminary and will need to be modified and re-estimated as more and better data on the SLMCZ and on willingness-to-pay for ecosystem services becomes available.

The area to be valued is the coastal zone of southern Lake Michigan, running for 108 miles and extending 300 feet inland and 100 feet into the water. This area encompasses 228,096,000 sq. feet or approximately 8.2 sq. miles. A physical description of the lakefront habitats and the species contained within them appeared in a previous section, but was by no means exhaustive. A complete valuation of the SLMCZ should focus on the following components: the region's biodiversity (fish, birds, mammals, invertebrates, and plants), water quality supporting biodiversity, habitat existence and quality, and ecosystem services. The quantitative data available on bird species within the SLMCZ are few and far between. Doug Stotts, an ornithologist at the Field Museum in Chicago, is presently working with Audubon groups within the region to compile and organize their separate site data. Fish populations are more closely monitored, but only species fished commercially or for sport. Invertebrate and plant information is even more difficult to find. While there are listings of species occurrence in certain areas, quantitative species totals are not available with these lists. Natural habitats, such as Illinois Beach and the Indiana dunes, are reasonably well mapped, but information on ecosystem services is much more elusive.

While invertebrates play a pivotal role in the functioning of any ecosystem, there exists no economic study that addresses their value. Therefore, this report will not include a discussion of them in the description of the SLMCZ and will not address their valuation, though their critical role in the food web must be recognized and information regarding this role is a clear gap. Additionally, the value of flora to ecosystems has been largely ignored in the environmental literature. "Conspicuously absent are the benefits of preserving plants, even though over half of the species listed in the U.S. are plants" (Loomis and White 1996). Plants often have a more easily determined economic use value than other species, because they are more often utilized commercially. For example, almost a quarter of all pharmaceuticals in the world are chemical compounds derived from plants. The SLMCZ contains approximately 90 species of endangered, threatened, or rare plants, though their potential commercial application and role in ecosystem function remains highly uncertain.

Economic Value Versus Economic Activity

Economic activity and economic value are two distinct concepts. As previously discussed, the waters and coastal amenities of southern Lake Michigan support direct economic activities such as transportation services, marinas, recreational boating, commercial and recreational angling, tourism, bird-watching, beach-going, and other related activities, and these activities also produce net economic value to the participants and to industries within the region. However, it is important to emphasize measures of economic activity are not equivalent to measures of economic value. Economic activity is a measure of what people actually pay to enjoy coastal resources. Economic value is measured as the willingness-to-pay to enjoy coastal activities such as angling or boating. Technically, this is the total the individuals and/or households are willing to pay as

measured by the area under the demand curves for each activity less what they actually expend in time and money (economic activity), and the techniques used to measure value are very different from techniques to measure economic activity. While the economic activity associated with the SLMCZ may be substantial, it is a measure of economic value that is most relevant for cost-benefit analysis and thus for decision-making. It is the economic value of the biodiversity and ecosystems SLMCZ that we are seeking to estimate here – components of regional natural capital that are generally outside of the market and for which individuals and household exhibit true demand. Economic impacts are important for decision-making. However, when assessing policies or making decisions that might affect coastal resources, it is changes to economic value that are the relevant measure for a cost-benefit assessment. This report seeks to infer the non-use value of the natural capital of the SLMCZ from existing research – what people are willing to pay just to know that the biodiversity and ecosystem function of the SLMCZ is maintained.

Valuation of the Biodiversity of the SLMCZ

Many of the previously discussed ecosystem components are in some way represented in National Income Accounts. A blue ribbon panel of the National Academy of Sciences' National Research Council which reviewed the work of the Bureau of Economic Analysis on including natural capital in the accounts, stated: "Production of market goods and services from these natural assets-e.g., timber, agricultural crops, fish-is already in the core production accounts." They stressed that more attention needs to be given to "identifying, measuring, and valuing the specific types of nonmarket goods and services produced by these assets" (Nordhaus and Kokkenlenberg, 1999). The data and knowledge needed to value ecosystem services and water quality for the SLMCZ is inadequate because we first need an index for the area. In an attempt to touch upon a likely economic non-use value for the natural capital within the SLMCZ, the focus will be on estimating the non-use value associated with important bird and fish species that might approximate the biodiversity of the SLMCZ. The reasons for choosing this avenue are:

1. It has apparently not been attempted in this area.
2. This type of valuing groups of species is fairly new, but has been suggested in the literature (Loomis and White, 1996).
3. Measuring WTP values associated with multiple species or portfolios of species is likely to incorporate values associated with maintaining the ecosystem function required by those species, thus capturing values of other components of natural capital (Loomis and White, 1996).

This analysis will employ the concept of *benefits transfer*, the process of applying the information obtained at one or more studied sites (resource) to a yet unstudied site (resource) in order to make an estimate of value for the unstudied site without having to undertake additional research.

It is not possible to perform a natural capital valuation by using the same methods as an accountant would. We cannot simply count the fish and birds, assign them a price and multiply. There are two reasons for this, the most obvious being that we simply don't have quantitative values for these components. The other is that the willingness to pay figures obtained through the contingent valuation studies referenced in this report cannot be converted to "per fish" or "per bird" values. The WTPs reported in the existing literature most always refers to "the population" without specifying exact numbers, and if population figures were given it was to emphasize that the species was endangered or to give a reference point for the proposed change. The willingness to pay was usually either to prevent 100% species loss, to gain some percentage of the existing population, or to reintroduce the species, and cannot be manipulated in order to find the value for one single organism. The WTP in the contingent valuation studies is statistically significantly sensitive to the magnitude of the proposed change in population size, with larger changes eliciting larger WTPs (Loomis and White 1996). Even so, it is not correct to assume that by extrapolating the average WTP to the entire relevant human population and then dividing it by the number of organisms in the proposed area, we arrive at a per organism figure. Therefore, the values placed on species in the SLMCZ must be obtained through an alternative method.

Almost all of the existing valuation studies attempted to value endangered or threatened species, but it is probably safe to assume that both endangered and plentiful species in the SLMCZ carry some value to humans, no matter how small it may be. The endangered bird, fish, and plant species occurring in the SLMCZ have been identified and outlined in Table 4. The important bird species have been deemed to be those that are endangered or threatened, nest in the SLMCZ, and/or are present at least nine months of the year. The important fish species are those that are fished recreationally and one endangered fish. Certain technicalities arise when directly applying the WTP from available species studies. This report makes the following assumptions to aid the process:

- WTP for species that are endangered is higher than for species that are not endangered.
- WTP for species that nest in the SLMCZ is higher than for those that do not nest and are not endangered.
- WTP for species that exist only in the SLMCZ or the Great Lakes region is higher than for species that are found in multiple regions in the U.S.
- WTP for birds is higher than for fish (Loomis and White, 1996).
- WTP for visible or "popular" species is higher than for unseen and unknown species.

Within our species list, we have designated each species as either endangered, nesting, or common, distinguished high profile species from the unknown, and used the mean WTP from the relevant study/studies to obtain a value. The mean per household WTP figures reported in the studies were extrapolated to the over 8 million households in the Chicago metropolitan area, which includes northwest Indiana. Because all of the species studies we located pertain to endangered or threatened species, we had to devise a way of applying the stated WTP to other categories of species. When referencing a study that

addressed an endangered species found only in that certain region, we thought it reasonable to reduce it by 25% for the endangered species in the SLMCZ because all of them exist in other places.⁹ Otherwise, for nesting species that are not endangered, we cut the related WTP by 50%, and for common species we cut the related WTP by 75%.

Referencing only the studies included in this report, the annual WTP figures for each of the listed species were outlined in Table 4, including and excluding the single high outlying value in both the bird and fish categories. The mean WTP for each case was then adjusted in Table 5 using the previously discussed methodology of discounting the WTP figures according to the prevalence and status of the relevant SLMCZ species to be valued.

In Table 6 the estimated annual WTP figures for the SLMCZ species were aggregated. The aggregation was performed first by assuming that if in any of the original referenced studies the participants were asked to value not one, but 20 species at once, the stated WTP for the group of species would be significantly less than reported for a single species. In order not to overstate the overall value of the species, each SLMCZ species' WTP was discounted by a predetermined percentage of the preceding value. For the group of fish species, which includes only one endangered species, the lake sturgeon was valued first, and then each of the remaining species WTP was reduced by 25% of the preceding WTP. For the endangered bird species, each species WTP was reduced by 15% of the preceding WTP. The nesting species WTPs were in turn reduced by 25%. With each additional species to be valued, the dollar amount added to the aggregated WTP is smaller and smaller. By using this approach, the subsequent addition of more species will result in an aggregate value that will asymptotically approach a number, instead of increasing by equal amounts into perpetuity. The total value reflects the regional willingness to pay to maintain 100% of the existing species within the SLMCZ, and is likely to include the economic value of the ecosystem function required to maintain these species into perpetuity.

After obtaining both a low and a high aggregated annual WTP estimate for both fish and birds, the figures were extrapolated to the number of households in the Chicago metropolitan area, which includes Chicago and Gary, Indiana (Table 7). The most recent available census estimates were used and then divided by the average household size (2.5). It was hypothesized that not all households in the area have the same tastes and preferences towards spending. Again, in order not to overstate the value, conservative estimates were made pertaining to the percentage of households that would pay the stated amount annually, assuming a rapid decline of the WTP as one moves away from the coast to zero outside the statistical metropolitan region of Chicago as defined by the U.S. Census Bureau. Those percentages of the aggregated WTP range from 100% to 0%, and the percentages of households willing to pay those adjusted amounts range from 50% to 4%. Finally, since the WTP figures in the referenced studies were all stated as annual payments, the estimated figures were extrapolated to obtain a net present value, using 10% as the discount rate. The final range for the regional willingness to pay to maintain

⁹ The SLMCZ does host many species unique to the area, but no unique endangered/threatened and or nesting (spawning) bird or fish species.

the existing stocks of the 20 species of fish and birds in the Southern Lake Michigan Coastal Zone – representing the entire biodiversity of the region – is between \$3,188,000 and \$5,374,000 per year in Yr2000 dollars. Assuming a 10% discount rate, the net present value of the regional willingness to pay is between \$3.18 and \$5.37 billion.

It is important to note that the above method of estimating a value for a group of species is only one of a number of options available to an analyst or policy maker. It is always preferable to conduct a new study pertaining specifically to the site and resource being valued, but time and resources do not always allow lengthy, costly research to be performed. In a case such as this, where time and resources are limited, benefit transfer is the next best option. The preceding analysis employed an “average of values” estimation. Other types of benefit transfer include meta-analysis, demand function transfer, and point estimate transfer. A next step in validating this benefit transfer of values for endangered species would be comparing the results with those obtained using other benefit transfer methods.

The preceding analysis has obvious unavoidable errors stemming from the underlying data, in that the stated WTPs are for different species in different regions. It is impossible to accurately predict how the preferences of the people living in the SLMCZ differ from those who were originally surveyed or how individual species will fare. It is for these reasons that the original WTP figures were discounted heavily for this estimate, in order to assure that the values were not overstated. The high dollar figure range that was estimated, in spite of the many restrictions imposed in the analysis, demonstrates that the birds and fish of the SLMCZ have more than enough value to warrant expenditures on further scientific and economic research in the region.

Table 4: Original Study WTP figures

	Lower annual WTP (1999)	Upper annual WTP (1999)	Mean WTP (1999)
<i>Fish</i>			
Pacific Salmon/Steelhead	\$35.76	\$101.52	\$72.67
Atlantic Salmon			\$9.23
Squawfish			\$9.23
Striped Shiner			\$6.92
Mean for fish			\$24.51
Mean excluding high value			\$8.46
<i>Birds</i>			
Northern Spotted Owl	\$50.76	\$109.59	\$80.75
Whooping Cranes			\$40.37
Red-cockaded Woodpecker	\$11.53	\$17.30	\$15.00
Bald Eagles	\$17.30	\$38.07	\$27.68
Ducks			\$11.33
Mean for birds			\$35.03
Mean excluding high value			\$23.60

Table 5: Estimates of WTP for SLMCZ species

SLMCZ species	Status	Familiarity	Lower annual WTP	Upper annual WTP
<i>Sport fish</i>				
Yellow Perch		Well known	50% *\$8.46=\$4.23	50% *\$24.51=\$12.25
Brown Trout		Well known	50% *\$8.46=\$4.23	50% *\$24.51=\$12.25
Rainbow Trout		Well known	50% *\$8.46=\$4.23	50% *\$24.51=\$12.25
Coho Salmon		Well known	50% *\$8.46=\$4.23	50% *\$24.51=\$12.25
Chinook Salmon		Well known	50% *\$8.46=\$4.23	50% *\$24.51=\$12.25
<i>Endangered fish</i>				
Lake Sturgeon	Endangered in States	Popular	75% *\$8.46=\$6.35	75% *\$24.51=\$18.38
<i>Endangered Birds</i>				
Bald Eagle	Federally Endangered	Popular	75% *\$23.60=\$17.70	75% *\$35.00=\$26.25
Peregrine	Federally	Popular	75% *\$23.60=\$17.70	75% *\$35.00=\$26.25

Falcon	Threatened			
Piping Plover	Federally Endangered	Fairly Popular	75%*\$23.60=\$17.70	75%*\$35.00=\$26.25
Common Loon	Federally Endangered	Popular	75%*\$23.60=\$17.70	75%*\$35.00=\$26.25
<i>Nesting Birds</i>				
Spotted Sandpiper		Fairly Popular	50%*\$23.60=\$11.80	50%*\$35.00=\$17.50
Willet		Fairly Popular	50%*\$23.60=\$11.80	50%*\$35.00=\$17.50
Blue-winged Teal		Fairly Popular	50%*\$23.60=\$11.80	50%*\$35.00=\$17.50
Least Bittern		Fairly Popular	50%*\$23.60=\$11.80	50%*\$35.00=\$17.50
American Woodcock		Fairly Popular	50%*\$23.60=\$11.80	50%*\$35.00=\$17.50
Great Blue Heron		Popular	50%*\$23.60=\$11.80	50%*\$35.00=\$17.50
American Coot		Fairly Popular	50%*\$23.60=\$11.80	50%*\$35.00=\$17.50
Black tern		Fairly Popular	50%*\$23.60=\$11.80	50%*\$35.00=\$17.50
Black-crowned Night Heron		Popular	50%*\$23.60=\$11.80	50%*\$35.00=\$17.50

Table 6: SLMCZ biodiversity WTP per household aggregation

Species	Low WTP	Discounted Low WTP	High WTP	Discounted High WTP
<i>Fish</i>				
Lake Sturgeon	\$6.35	\$6.35	\$18.38	\$18.38
Yellow Perch	\$4.23	\$3.17	\$12.25	\$9.19
Lake Trout	\$4.23	\$2.38	\$12.25	\$6.89
Brown Trout	\$4.23	\$1.78	\$12.25	\$5.17
Rainbow Trout	\$4.23	\$1.34	\$12.25	\$3.88
Coho Salmon	\$4.23	\$1.00	\$12.25	\$2.91
Chinook Salmon	\$4.23	\$0.75	\$12.25	\$2.18
Subtotal WTP for fish species		\$16.78		\$48.59
<i>Birds</i>				
Bald Eagle	\$17.70	\$17.70	\$26.25	\$26.25
Piping Plover	\$17.70	\$15.05	\$26.25	\$22.31
Common Loon	\$17.70	\$12.79	\$26.25	\$18.97
Peregrine Falcon	\$17.70	\$10.87	\$26.25	\$16.12

Black-crowned night heron	\$11.80	\$11.80	\$17.50	\$17.50
Spotted Sandpiper	\$11.80	\$8.85	\$17.50	\$13.13
Willet	\$11.80	\$6.64	\$17.50	\$9.84
Blue-winged Teal	\$11.80	\$4.98	\$17.50	\$7.38
Least Bittern	\$11.80	\$3.73	\$17.50	\$5.54
American Woodcock	\$11.80	\$2.80	\$17.50	\$4.15
Great Blue Heron	\$11.80	\$2.10	\$17.50	\$3.11
American Coot	\$11.80	\$1.58	\$17.50	\$2.34
Black Tern	\$11.80	\$1.18	\$17.50	\$1.75
Subtotal WTP for bird species		\$100.06		\$148.39
Total WTP for Fish and Birds		\$116.84		\$196.98

Table 7: Aggregation to Chicago Metropolitan Area

		Percent of households willing to pay % WTP	Number households willing to pay % WTP (thousands)	Low total WTP aggregate (thousands)	High total WTP aggregate (thousands)
Chicago Metropolitan Area Population	8,633,400				
Total households (in thousands)	3,453.36				
% of total WTP					
100% of WTP		50%	1726.68	\$201,746.53	\$340,125.34
75% of WTP		30%	1036.01	\$90,758.94	\$153,056.40
50% of WTP		10%	345.34	\$20,174.65	\$34,012.53
25% of WTP		6%	207.20	\$6,052.40	\$10,203.76
0% of WTP		4%	138.13	0	0
Total WTP				\$318,759.52	\$537,398.04
NPV (10%)				\$3,187,595.19	\$5,373,980.41

Conclusion

As is evident from this simple benefits transfer exercise, the biodiversity of the SLMCZ – a single, though very important, component of the region’s natural capital – is likely to generate significant non-use value to the households of the region. As mentioned above, this value is between \$319 and \$537 million annually, with a total net present value between \$3.1 and \$5.3 billion.¹⁰ This is a significant figure, and it suggests that any publicly funded effort to successfully preserve the existing stocks of biodiversity within the region is likely to pass a benefits-cost test. A definitive answer as to the regional willingness to pay to maintain biodiversity within this region would require a formal contingent valuation exercise. It should be noted that the valuation in this report did not include use values derived from Lake Michigan – i.e. the willingness-to-pay to for direct enjoyment of coastal resources and other water-dependent economic activities (beach-going, boating, commercial and recreational angling, and hunting and bird watching within the coastal zone), which are also likely to be substantial.

It is obvious that the Illinois-Indiana southern Lake Michigan shoreline, coastal landforms and wetlands, and the nearshore and sub-aquatic ecosystems that support a unique stock of biodiversity are natural capital assets of vital importance to the Chicago metropolitan regional economy and to the quality of life for region’s citizens. Cost-effective planning to ensure the sustainability of the natural capital stock of the SLMCZ will require expanded, policy-relevant integrated economic and environmental research as well as strong connections between public and private planning user groups. Specifically, this will require more environmental and ecological research that helps to delineate functional ecosystem boundaries and overlaps, that identifies and quantifies species, and that further documents the interconnectedness of relevant species and their coastal habitats. Additional environmental economic valuation studies must be undertaken, such as a formal contingent valuation study of the biodiversity and ecosystems of the SLMCZ that can help refine the measure of non-use value suggested by this study. This information will be critical in any formal cost-benefit analysis of efforts to preserve or restore the existing stocks of natural capital, such as coastal wetlands, and can help scale these stock’s relationship to the functioning regional economy. Other important economic research that is needed includes a travel cost study that determines dune and beach usage and expenditures specifically in the SLMCZ. This will help determine the use value of the coastal zone. The bottom line is that should actual valuation research be undertaken, evidence presented here suggests that any publicly-funded effort to maintain the existing stocks of biodiversity and ecosystem function within the SLMCZ is highly likely to be justifiable economically and merits further study and quantification.

¹⁰ Calculated at a 10% discount rate.

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