America's North Coast:

A Benefit-Cost Analysis of a Program to Protect and Restore the Great Lakes

September 2007

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Researched and Written by John C. Austin, Soren Anderson, Paul N. Courant, and Robert E. Litan[1]

Acknowledgments

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CGLI, Great Lakes – St. Lawrence Cities Initiative, and HOW enlisted a highly credible and respected Steering Committee and an Advisory Council for the project. Business and economic leaders who served on the Steering Committee include:

- Paul Dimond, partner in the law firm Miller Canfield, former Special Assistant to President Clinton for Economic Policy and Director of the National Economic Council;

- Edward M. Gramlich, Richard B. Fisher Senior Fellow at the Urban Institute and the Richard A. Musgrave Collegiate Professor at the University of Michigan's Gerald R. Ford School of Public Policy; former Member of the Federal Reserve Board; and Former Director, Congressional Budget Office;

- Steven K. Hamp, Vice President and Chief of Staff, Ford Motor Company, and former President of the Henry Ford Museum;

- Philip Power, Chairman, Michigan Nature Conservancy, and former CEO of the Observer/Eccentric Newspapers; and

- Robert Stempel, Chairman and CEO, Energy Conversion Devices, Inc., and former CEO of General Motors.

These individuals, organizations, and companies were the keystone of our efforts to build an understanding of the economic development associated with environmental improvements.

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Cover photo: EPA

Preface

This comprehensive analysis, America's North Coast: A Benefit-Cost Analysis of a Program to Protect and Restore the Great Lakes, by John C. Austin, Soren Anderson, Paul N. Courant, and Robert E. Litan, was undertaken with significant foundation support with the purpose of better understanding the economic impact of investment in ecosystem restoration. This report must be viewed as a macro economic study of the Great Lakes region and the relationship between environmental quality improvements and economic benefit. Claims regarding the benefits of enhanced environmental quality are made from an overall basin or regional perspective and may or may not apply to any particular locale or result from any particular environmental enhancement. Specific benefits that may or may not occur as a result of specific actions at specific locations must be determined through other, more targeted examinations. This study was based on methods of environmental restoration suggested by the Great Lakes Regional Collaboration in their report, *The Great Lakes Regional Collaboration Strategy*.

Nevertheless, the broad conclusions drawn from this report are impressive. Significant investment in the region's environmental infrastructure could have very significant direct and indirect economic benefits to the Great Lakes Basin and the nation.

This is the product of thorough, independent work on the part of the authors and independent contractors. We are grateful for all the time and effort they have invested in this comprehensive work. We are pleased to present a study that can demonstrate the economic benefits of improvements to the Great Lakes environment.

Andy Buchsbaum
Co-Chair, Healing Out Waters® - Great Lakes Coalition and Regional Executive Director, Great Lakes National Resource Center, National Wildlife Federation

George H. Kuper
President and CEO, Council of Great Lakes Industries

David Ullrich
Director, Great Lakes - St. Lawrence Cities Initiative

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Executive Summary

Protection and restoration of the vast but fragile Great lakes ecosystem has been the focus of growing regional and national attention over the past two years. Efforts include:

- a Presidential Executive Order,
- an EPA-led task force establishing a Great Lakes Regional Collaboration,
- a massive Great Lakes restoration planning process,
- a sobering scientific report on the vulnerability of the Great Lakes,
- the publication of a comprehensive Great Lakes protection and restoration strategy, and
- legislation introduced in Congress to implement and fund that strategy.

These efforts have been focused on the environment – the Great Lakes ecosystem.

But the Great Lakes are much more than places to enjoy sunsets, to swim and to fish. They are the backbone of the economy of the region.

"America's North Coast: A Benefit-Cost Analysis of A Program to Protect and Restore the Great Lakes"

This study answers the question that the EPA task force never asked: what are healthy Great Lakes worth to the regional and national economies? To put a finer point on it: if the nation and region invest in Great Lakes ecosystem restoration as the EPA-led task force recommends, what will be the economic return on that investment?

This study is authored by Robert E. Litan, Senior Fellow in the Economics Studies and Global Studies programs at the Brookings Institution and Vice President for Research and Policy at the Kauffman Foundation; Paul N. Courant, Harold T. Shapiro Collegiate Professor of Public Policy, Professor of Economics and Director of the Center for State, Local and Urban Policy at the University of Michigan; John C. Austin, a non-resident Senior Fellow, Metropolitan Policy Program, The Brookings Institutions and Vice president of the Michigan State board of Education; and Soren Anderson, a doctoral candidate in economics at the University of Michigan.

The study begins with the baseline ecological conditions of the Great Lakes and the physical changes that would occur if the recommendations for Great Lakes protection and restoration are followed. Teams of economists and Great Lakes scientists worked to determine the costs and likely ecological impacts of restoring the Great Lakes. The study then estimates the purely economic benefits of those ecological impacts. The findings conclude that restoration will provide economic benefits to both the region and the nation that substantially exceed the costs.

The baseline conditions are taken from the assessment published in a December, 2005 report, *Great Lakes Regional Collaboration Strategy To Restore and Protect the Great Lakes* ("Great Lakes Restoration Strategy"). The Great Lakes Restoration Strategy was the product of a U.S. EPA-led research project that brought together state, local, tribal, federal, business, conservation, scientific, and policy interests to produce a comprehensive plan to restore the Great Lakes. The Strategy documented that the Great Lakes are one of America's most important natural resources. They account for 95 percent of the available surface fresh water reserves in the United States and 20 percent of reserves in the world. Yet the Great Lakes are increasingly vulnerable to threats like invasive species, sewage overflows, habitat destruction, and contaminated sediments. To address those threats, the Strategy identified the existing and potential future damage to the Great Lakes and the methods of stopping and reversing the damage. The leading problems addressed in the EPA report were contaminated sediments, sewage spills, invasive species, pollution runoff, and habitat destruction, particularly wetlands. The solutions proposed were estimated to cost $20 billion, to be allocated among federal, state, and municipal contributors over a number of years. In addition, operating costs would accrue over time. The present value estimate of all the costs of those recommendations is $26 billion.

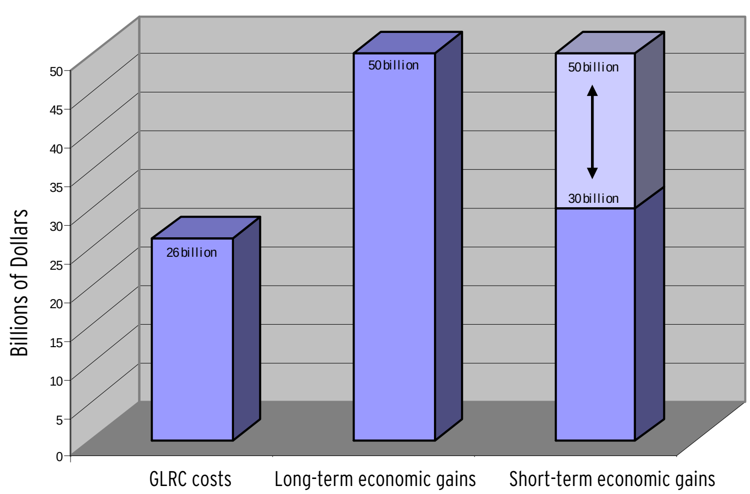
The economic benefits of the $26 billion investment depend on the biological and physical impacts the investments have on the Great Lakes themselves. To determine those impacts, the study convened a panel of credentialed Great Lakes scientists led by Dr. Donald Scavia, Michigan Sea Grant Director and professor of Natural Resources at the University of Michigan, and Dr. Jennifer Read, Assistant Director of Michigan Sea Grant. As that panel determined ecological effects, they were joined by environmental economists to examine the potential impact of those effects on economic values and services.

The Results

Based on a present-value total investment of $26 billion in ecological restoration, the study calculates the following present-value economic benefits:

- Over $50 billion in long-term benefits to the national economy; and
- Between $30 and $50 billion in short term benefits to the regional economy.

GLRC Return On Investment



In addition, the study suggests that further investment in Great Lakes restoration would lead to the development of new technologies and industries that are not captured by the economic benefits calculated above.

The economists took two approaches to calculating the long-term expected national economic benefits of the ecological improvements.

1. Specific improvements: The study identified the specific improvements in the environment that were expected from restoration, valued them, and then added up the individual estimates to arrive at a total. These are summarized in the table below.

Summary of the Economic Benefits of Great Lakes Restoration

Improvement	GLRC effect (relative to baseline)	Affected value	Present value benefit (relative to baseline)	
Increased fish abundance	30-75 percent increase[a]	Improved catch rates for anglers	$1.1-$5.8 billion or higher	
Avoided dislocation of sport-fishery workers and assets	20 percent reduction or higher	Maintenance of sport-fishery wages and profits	$100-$200 million or higher	
Reduced sedimentation	10-25 percent reduction	Lower water treatment costs for municipalities	$50-$125 million	
Reduced bacterial and other contamination leading to fewer beach closings and advisories	20 percent reduction	More swimming activity	$2-$3 billion	
Improved water clarity at beaches	5 percent improvement or higher	More swimming and improved enjoyment of swimming activity	$2.5 billion or higher	
Improved wildlife habitat leading to more birds	10-20 percent improvement[a]	Improved opportunities for birding[b]	$100-$200 million or higher	
Improved wildlife habitat leading to more waterfowl	10-20 percent improvement[a]	Improved opportunities for waterfowl hunting[c]	$7-$100 million	
Removed contaminated sediment in Areas of Concern (AOC)	All toxic sediment contamination remediated	Basin residents benefit directly or indirectly from AOC restoration	$12-$19 billion	
Total quantified specific benefits			**$18-$31 billion or higher**	
Use values (e.g., health-related and recreational) and non-use values (e.g., "existence" and "bequest") for unquantified resources	Unquantified	Multiple	Potentially single digit billions or higher	
Aggregate Long-Run Benefit Estimate				**$29-41 billion or higher**
Short Term Multiplier Effects				**$30-50 billion**

[a] Equals the sum of eventual avoided percent decreases and eventual percent increases in population levels, where percent changes are relative to current levels. We assume that avoided decreases and potential increases would occur gradually over 20 years and 10 years, respectively.
[b] Based on the estimate of one birding trip to the Great Lakes per year per birder.
[c] Based on the estimate that 5 percent of waterfowl hunting trips in Great Lakes states depend on the Great Lakes either directly or indirectly.

As the table indicates, the economic benefits that currently can be quantified are in the $18-$31 billion range or higher. Additional benefits that cannot currently be quantified are likely to add at least several billion dollars. And finally, new technology development and growth of local economies would add additional billions. The grand total of economic benefits using his approach is $50 billion or higher.

2. Aggregated benefits: The second approach estimates the increase in property values in all the areas likely to be affected by the restoration initiative and then sums them to arrive at a total. These are summarized in the table on p. 5. This approach is aggregated because the property value increase reflects how individuals value all of the various disaggregated benefits associated with restoration of any given area. The 2000 census data provide a conservative estimate of the property values for the region, in that those data do not take into account new building and appreciation over the past seven years. A number of studies provide estimates for increases in property values following cleanup activities in Great Lakes cities. To be conservative, the study uses the lower bounds of those estimates for Great Lakes restoration: a 10 percent increase in property values for those living in census tracks adjacent to the Great Lakes, and an average 1-2 percent increase for properties within major metropolitan areas that abut the Great Lakes. Applying these data together, the study estimates a conservative present value increase in property values – the aggregate economic benefits of Great Lakes restoration – to be between $29 and $41 billion. The study's authors conclude that the actual value of Great Lakes restoration when more realistic assumptions are applied would be in excess of $50 billion.

These two approaches estimate roughly the same economic benefit: **for a present value investment of $26 billion in Great Lakes restoration, a long-term economic benefit of at least $50 billion will result.** The fact that the two approaches have roughly the same result enhances the reliability of the estimate.

Aside from these long-term economic benefits, the study estimates additional short-term benefits of between $30 billion and $50 billion, primarily for the Great Lakes region. These so-called "multiplier effects" are well-documented: the spending of $1 by a fiscal authority results in additional spending in the region of between 1.5 and 2.5 times the original spending. Applied to the one-time investment in the Great Lakes of $20 billion, the multiplier would lead to the estimated regional benefits of $30 billion to $50 billion.

The study notes that these short-term multiplier effects do not themselves justify spending on Great Lakes restoration. Spending $20 billion of public funds on other types of initiatives would lead to similar benefits, thereby justifying *any* expenditure in the region. However, because the $26 billion in spending is justified for other reasons – the $50 billion in long-term economic benefits estimated for both the region and the nation – the multiplier effect is real and must be taken into account as one of the significant economic impacts of Great Lakes restoration.

Investing in Great Lakes restoration is economically justified – indeed, preferred – based solely on the quantifiable rate of return on the investment. But according to the study, this investment is more than justifiable; it is essential for the economic health of the region and the nation.

A 2006 economic analysis by Metropolitan Policy Program at the Brookings Institution, *The Vital Center,* also centered on the Great Lakes and determined that the Great Lakes Region faces an uncertain future. The region is losing population and lags other regions in educational attainment of individuals, entrepreneurial activity and venture capital and is overly reliant on low-skilled manufacturing jobs. This study is the first of several close examinations of a single aspect of *The Vital Center*.

The Vital Center study documents the importance of the Great Lakes region to the nation's economy, the challenges facing the region, and the policy measures and outcomes needed to meet those challenges:

- Great Lakes firms and individuals account for almost one-third of the U.S. Gross Domestic Product, the headquarters of 300 of the Fortune 1000 companies in the U.S., and a concentration of the world's leading research universities.
- Yet the region lags behind the rest of the nation in venture capital investments, entrepreneurial activity, and educational attainment, resulting in an exodus of people and talent.

The region needs focused and aggressive measures to revitalize the health of its world-class natural assets: restore the Great Lakes, improve K-12 education and revitalize cities.

The key to recovery for the Great Lakes region is to attract and retain the skilled workers and sustainable industries it needs to thrive in the 21st century. Restoring the Great Lakes is an essential step toward that recovery.

Finally, the study analyzes the relative contribution that various government sectors – federal, state, and local – should play in paying for this essential component of the economic recovery of the Great Lakes region. Of course, cities, states and the region will see direct benefits from such a recovery. But a healthy Great Lakes economy benefits the national economy, grows the national tax base, and provides other benefits, such as easing congestion and slowing population growth in coastal areas that already are overtaxed. The study concludes that all three government sectors should make substantial investments in Great Lakes restoration.

Funding support for this study was provided by The Joyce Foundation, The John D. and Catherine T. MacArthur Foundation, the Healing Our Waters® – Great Lakes Coalition (HOW), Consumer's Energy, and The Dow Chemical Company Foundation. Indirect support was also provided by the sponsors, the Council of Great Lakes Industries, the Great Lakes – St. Lawrence Cities Initiative, the Wege Foundation, and Healing Our Waters.

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- Steven K. Hamp, Vice President and Chief of Staff, Ford Motor Company, and former President of the Henry Ford Museum;
- Philip Power, Chairman, Michigan Nature Conservancy, and former CEO of the Observer/Eccentric Newspapers; and
- Robert Stempel, Chairman and CEO, Energy Conversion Devices, Inc., and former CEO of General Motors.

I. Introduction

We are several years into the 21st century and the race is already on—within the United States and around the world—to attract "talent," or highly trained individuals capable of working in fluid work environments. Economists have only recently begun to document what employers of all sizes have been struggling with for some time: the importance of attracting and retaining highly trained individuals who can cope with the growing challenges of competing in an increasingly sophisticated, interconnected and "always on" global economy.[2]

What is true for employers is also the case for cities, counties, states, regions and countries. One key to vitality and growth is the ability to attract and retain younger college educated individuals. These are the people who give a community its vitality, through the families they raise, the energy they provide in the workplace, the companies they start, and the products and services they purchase.

The Internet has not made location irrelevant, as some may believe. Clusters of firms in the same or similar industries, together with the people who work for and with them, seem to be more important than ever. Young, educated people are attracted to places where others like them live and work. This has led to a growing concentration of talent in both urban and suburban areas, "creating a powerful gravitational pull for other young people and forming a positive feedback loop."[3] America's cities, towns, counties and states thus find themselves in a fierce competitive battle with each other and with private sector employers to attract and retain the best educated and most highly motivated young people.

The modern race for talent differs from the smokestack chasing of the 20th century. Previously, localities, states, and governments competed with one another to attract major employers to their jurisdictions—both to provide stable sources of employment for existing populations, and to attract new residents. People, however, are a lot more mobile than firms, so it is a continuing challenge to draw and retain them.

Further, it can be much more difficult to attract people than firms. Governments can often readily induce firms to locate their buildings and manufacturing plants in given locations through tax breaks, zoning rules, and other relatively "quick fixes." These policy tools won't help, however, when the objective is to change an individual's perceptions about a given geographic location. The quick fix is also difficult, if not impossible, to implement because the winners in the race to draw talent are those places that can offer the most attractive infrastructure—physical, cyber, educational, recreational, and cultural. Regions must grow and cultivate these assets in order to retain, let alone attract, talent, entrepreneurs, and companies. All of this takes time and money. Conversely, those areas that fail to invest in infrastructure risk economic decline, losing people and vitality.

This report focuses on one area of the United States—the counties bordering on America's five Great Lakes—that is all too easily overlooked during an era when most population growth in the country is centered on either of its coasts. Specifically, it focuses on the costs and benefits of enacting a major multi-state, multi-year strategy to preserve and further improve the quality of the Great Lakes themselves as part of a larger strategy to attract and retain highly skilled individuals and related economic activity in and to the region.[4]

The Great Lakes are truly one of America's most important natural resources, yet they are often overlooked. Together, they account for 90 percent of the United States' and 20 percent of the world's surface fresh water. Both are astounding figures, especially given the pressing demands on fresh water from growing populations everywhere.

This report follows an earlier report also published by the Metropolitan Policy Program at the Brookings Institution, *The Vital Center*, which described the history and importance of the Great Lakes region to American society and to the U.S. economy.[5] There were about 84 million people living in the Great Lakes states in 2000, based on data from the U.S. Census. About 24 million, or 28 percent, of these live in the Great Lakes basin.[6]

Among other things, *The Vital Center* highlighted some key facts about the Great Lakes states, of which the basin is an integral part, including:[7]

- The Great Lakes region has been the home of some of America's most famous entrepreneurs—Henry Ford, John D. Rockefeller, Andrew Carnegie, Henry John Heinz, Richard Sears, and Alfred Sloan, among many others—and the companies they founded, which continue to be major employers in the region.
- Firms and individuals located in the Great Lakes region account for almost one-third of the U.S. Gross Domestic Product.
- Over 300 of the Fortune 1000 companies in the United States are headquartered in the region.
- The region has a concentration of many of the world's leading research universities, accounting for roughly 40 percent of all undergraduate degrees awarded by U.S. universities.

Yet with all of these assets, the Great Lakes region faces an uncertain future. As the earlier Brookings report documented, the region has several challenges yet to overcome. These are discussed in greater detail in the next chapter of this report but include:

- The educational attainment of individuals who choose to live in the region lags behind the rest of the country.
- The region is losing people to other parts of the country. Although its universities clearly have been successful in attracting young people to study, large numbers are leaving the region after they earn their degrees.

- Entrepreneurial activity in the Great Lakes states now falls behind that of many other states in the country, and is generally below the national average.
- Venture capital devoted to the region is lower than other areas of the country, especially the coasts.

The challenge for policy makers in the Great Lakes states and local governments is to reverse these trends. In particular, they must make the region attractive to the increasing number of youth who are attending the region's outstanding universities to remain, to establish innovative companies, to help build or revitalize others already in business, and to establish families and roots in the region—in short, to ensure its continuing vitality. At the very least, this will require turning the Great Lakes region into more of a knowledge-based economy, relying less on its labor-intensive manufacturing prowess than it has traditionally. Manufacturing can still be part of the area's future, provided it is high value-added, skills-intensive, and capable of continuous evolution.

Meeting these challenges is of importance and interest not only to those in the region, but to many throughout the country. Continued population growth and concentration on the coasts puts increasing pressure on limited resources such as water and land. It is in everyone's best interest to better distribute human populations and seek better balance with respect to the carrying capacity of the land.

The question this study addresses is whether the benefits of the initiative proposed to restore the vitality of the Great Lakes described in more detail in Chapter 3 outweigh the costs. We attempt to resolve this question primarily through the technique of benefit-cost analysis (BCA). BCA provides a well-established framework for assessing the viability of a wide range of public and private sector investment strategies. Ideally, the framework requires monetary estimates of both benefits and costs. Admittedly, this can be difficult, especially where the project under assessment is designed to generate largely environmental benefits, which are not often capable of being stated in monetary terms. Nonetheless, it is often possible to provide such estimates in ranges; at the very least, benefits may be described in qualitative terms, so the cost-effectiveness of attaining them can be assessed.

We approach our benefit estimation principally from two directions: first, by summing the detailed disaggregated benefits of particular types of impacts (restored wetlands, reduced pathogens, reductions in aquatic invasive species, etc.), and second, by estimating the aggregate impact of the restoration initiative through positive impacts on residential property values along the coastal areas (and several miles inland) of the Great Lakes. Some of the benefits are presented in ranges, reflecting the significant uncertainties involved, and extend considerably further into the future (appropriately discounted) than the five year period of the initial investment. Nonetheless, it is clear that even at the low end of the range, the estimated economic development benefits of the proposed restoration plan substantially exceed the projected costs.

The Great Lakes restoration project also holds the promise of generating additional benefits. As with other types of infrastructure projects, this should generate further construction and other economic activity near the sites of the improvements. It is also likely that in the process of restoration, as well as in its aftermath, new "clean" technologies will be developed that will be useful elsewhere in the U.S. and global economies.

Of course, not all people or communities in the region will benefit from a major Great Lakes restoration project equally. Much will depend on what *other* steps each area takes toward making their locations attractive places to live and work (investments in other infrastructure, improvement in schools, reductions in crime, provision of other amenities).

For those who doubt the promise that a major infrastructure project can hold for a region, it is important to keep in mind that other areas in the United States—cities in particular—have had their ups and downs, and most importantly have bounced back from significant adversity. Harvard Professor Edward Glaeser has documented the various cycles of economic activity in Boston, which originated as a trading center and seaport in the 1600s, then declined relative to manufacturing towns like Lowell in the 1700s and to New York after the Erie Canal opened in the early 1800s. In the mid-1800's, however, Boston reinvented itself as a manufacturing center and revived, tripling its size from 1860 to 1920—a span of just 60 years. Today Boston is a leading financial and high-tech center, having shed much of its labor intensive, low-tech manufacturing employment. Boston's example shows that it is the skills of an area's residents that determine its economic fate.[8]

The key for the communities in the Great Lakes region therefore is to retain and attract workers with skills suited for the 21st century. The area has the institutions of higher learning to provide those skills. What is now needed is a comprehensive strategy to make the area attractive to individuals with those skills so that they not only establish themselves in the region, but remain over the long term. Of course, the availability of jobs is central in this regard. But there is a "chicken-and-the-egg" problem here. Employers won't come to an area or expand into a new location without having a pool of skilled workers to choose from. The fact that the quality of amenities stands out as a major factor in residential location decisions helps to break the circularity of what comes first in the Great Lakes region: jobs or the skilled individuals. The Great Lakes have unique potential to serve as an important enticement to skilled individuals, provided a commitment of resources is made to ensure the health and beauty of the Lakes now and in the future.

We begin our analysis in the next chapter by describing the consensus plan for enhanced restoration of the Great Lakes ecosystem that has been developed in recent years by multiple stakeholders. The five-year cost of this plan is estimated to be approximately $20 billion. In order to achieve the full benefits of the plan, however, some programs would require funding beyond five years. We calculate that accounting for such ongoing program costs where it is possible to do so would increase the cost of the plan by roughly one-third, producing a total cost for the plan of roughly $26 billion in present value.

Is an expenditure of this magnitude worth it? With so much at stake, the restoration plan clearly seems to be a worthwhile, indeed necessary, investment. Chapter 3 provides our detailed analysis aimed at answering this question. We conclude that the present discounted value of the economic benefits of the restoration plan over the long run could conservatively exceed $50 billion. In addition, in the short run, there may be standard economic multiplier spending—the initial spending plus induced spending associated with the cleanup effort—in excess of $30 billion (although we do not rest our benefit-cost conclusions on this estimate, for reasons elaborated in Chapter 4). With so much at stake, the restoration plan clearly seems to be a worthwhile, indeed necessary, investment.

Chapter 4 discusses the key question: who, therefore, should pay for the plan? Clearly, some portion of the cost should be borne by those parties that stand to benefit from it—the residents of the Great Lakes region. However, the restoration initiative should also benefit others throughout the country, and for this reason, a contribution from the federal government is also appropriate.

II. A Great Lakes Infrastructure Program and Its Costs

The Great Lakes serve roughly 35 million people who live in the cities and states that border on them (including those in Canada). The Lakes provide drinking water, recreational opportunities, and a platform for commercial transportation. Many Native American communities also depend on the Lakes for the natural resources necessary for their subsistence, in addition to their economic, cultural, medicinal, and spiritual needs.

However, the Great Lakes basin and surrounding areas face numerous threats to their health. According to *Prescription for Great Lake Protection and Restoration: Avoiding the Tipping Point of Irreversible Change*, a 2005 report published by many of the region's leading scientists and now endorsed by 200 scientists nationally, the Great Lakes have experienced over 400 years of human induced stresses.[9] These scientists have called for the restoration of critical elements of the ecosystems' self-regulating mechanisms. Specifically, they have recommended that managers, to the extent possible, reestablish natural attributes of critical near-shore and tributary communities so they can once again perform their stabilizing function. Where full restoration is not possible, they advise improving desirable aspects through enhancement of important ecological functions.

Further, the scientists call for the reduction or cessation of practices that create sources of stress. This should be accomplished by eliminating physical habitat alterations, pollution loadings, pathways for invasive species, and other stressors or their vectors into the lakes. Finally, the report recommends protecting functioning portions of the ecosystem from impairment by preserving those portions of the ecosystems that are now healthy.

In December 2004, a collaboration of government officials from the federal, state and local levels and private sector stakeholders formed to develop a comprehensive strategy for restoring the vitality of the Great Lakes. This effort, the Great Lakes Regional Collaboration (GLRC), ultimately involved over 1,500 individuals. The GLRC split into eight strategy teams, each focused on a particular subject area. The teams solicited public input, developed recommendations, and worked together to produce a report, *The Great Lakes Regional Collaboration Strategy*, in December 2005.[10]

The GLRC Strategy builds upon a number of prior restoration initiatives by individual states, by federal agencies, and Canada to improve the quality of the Great Lakes. This chapter summarizes the key elements of the proposed Strategy, as well as the projected costs and funding allocations between the state and federal governments that are outlined in detail in that document. Not all of the recommendations advanced in the GLRC Strategy have cost estimates, but for those that do, the cumulative five-year cost of the package of recommendations is approximately $20 billion, calculated in 2005 dollars. The current five-year cost should be modestly higher now, to account for inflation since the Strategy was developed. Moreover, some elements of the Strategy will continue to require funding beyond the first five years. We calculate that accounting for such ongoing costs where it is possible to do so increases total costs by roughly one-third in present value terms.

In brief, the Strategy proposes measures to:

- Prevent the introduction of new aquatic invasive species
- Improve area habitats through conservation of local fish, other species, and wetlands
- Improve the quality of drinking water through reducing discharges from sewers and other sources of contamination
- Dramatically accelerate the cleanup of "Areas of Concern" (AOCs)
- Address non-point sources of pollution
- Reduce, and virtually eliminate, certain toxic pollutants (such as discharges of mercury, PCBs, dioxins, and pesticides)
- Establish a sound information base about the Great Lakes ecosystem
- Assure sustainable development, through application of best practices in land use, agriculture, and forestry and other practices to ensure the sustainability of the Great Lakes

Collectively, if put into action, these objectives will benefit the people and various species that live in the Great Lakes basin, as well as the environment throughout the region.

Addressing Aquatic Invasive Species

Aquatic invasive species (AIS) have posed a continued threat to the Great Lakes ecosystem for at least several decades. AIS are species that are not native, and whose introduction "causes, or is likely to cause, economic or environmental harm or harm to human health."[11] AIS can enter the Lakes through both accidental and deliberate introductions, such as shipping, aquaculture, canals and waterways; through recreational activities; and through the trade and use of live organisms. AIS pose risks to the environment and human health. They also pose risk to as much as 42 percent of all endangered species in the United States.[12]

The GLRC strategy has two main objectives with respect to AIS: to prevent all new introductions and to halt the spread of existing AIS within the basin. If either of those two objectives becomes impossible, then the aim would be to control AIS levels to ensure that Great Lakes ecosystems are healthy and sustainable). The Strategy document outlines the following recommendations to achieve these goals (five-year cost estimates are provided in parentheses):

- Elimination and/or control of AIS spread by ships and barges ($66 million)
- Federal, state, and local government measures ensuring that AIS are not introduced through the basin's canals and waterways, including full federal funding of the Chicago Sanitary Ship Canal Barrier ($225 million)

- Federal and state measures preventing the introduction and spread of AIS through the trade and potential release of live organisms ($85 million)
- Establishment of an AIS management program to implement rapid response and control ($220 million)
- Outreach and education programs aimed at recreational and other users of the Great Lakes ($98 million).

Habitats and Conservation

Development in the Great Lakes states has resulted in the loss of more than half of the region's wetlands, has degraded many habitats and has threatened the existence of various plant and animal species. These habitats play a critical role in maintaining local ecosystems, as well as the social and economic vitality of the region. As discussed in Chapter 4, recreation in and around the Lakes—boating, fishing, hunting and wildlife watching—accounts for more than $50 billion annually in economic activity. [13]

The GLRC Strategy aims to restore and preserve habitats and native species in the Lakes themselves; maintain the full range of ecosystem services in area wetlands; ensure sustainability of basin streams, rivers, and tributaries; and restore coastal shore habitats and the natural processes that sustain them. To accomplish these goals, the GLRC Strategy proposes an increase in habitat conservation and special management funding by $289 million/year, or a five-year total of $1.45 billion. This increase would:

- Provide additional support for efforts to restore and protect native fish communities on the shore and in the open Lakes ($100 million)
- Restore wetlands and establish a regular monitoring program ($943 million)
- Support restoration of Great Lakes rivers ($200 million)
- Create a coastal shore and upland habitat conservation program ($200 million)

Coastal Health

As important as it is to assure the environmental integrity of the Great Lakes, it is also vital to ensure that contacts with near-shore waters do not pose a risk to human health. Near shore waters are sources of drinking water, and are places for recreational activities such as swimming and fishing. This is why it is necessary to reverse several recent disturbing trends, such as waterborne disease outbreaks, beach closings, and advisories related to continued sewer overflows and discharges.

The goal of the GLRC Strategy in this respect is to eliminate by 2020 (or sooner, where possible) discharges of untreated or inadequately treated human and industrial wastes to Great Lakes basin waters from municipal wastewater treatment. Toward this end, the Strategy recommends:

- A five year total of $13.7 billion in spending to improve municipal wastewater treatment facilities along the Great Lakes. The Strategy suggests a 55/45 federal/local cost share, implying $7.535 billion in federal grants, and $6.21 in state and local resources;

- Improving drinking water quality through protection of drinking water sources ($1.61 billion);
- Developing more rapid and more accurate tests for determining when beach water is safe for swimming ($7.2 million).

Areas of Concern (AOCs)

In 1987, a joint U.S.-Canadian commission designated forty-three Areas of Concern (AOCs) for high priority cleanup efforts. AOCs are watersheds in the Great Lakes that suffer from severe environmental degradation due to current and historical pollution. These areas were designated as AOCs on account of their diminished beneficial use and ability to support aquatic life, indicated by the presence of up to fourteen different types of impairment relating to the eating of fish, ability to drink water and swim, and ecological impacts (such as the loss of diversity in aquatic life and destruction of fish and wildlife habitat). [14]

The GLRC Strategy notes that while some progress has been made in addressing the AOCs since 1987, there is a great deal still to be done. In many areas, the largest impediment to restoring beneficial uses is continued impacts from legacy sources. In particular, the Strategy cited a conclusion from the U.S. Policy Committee for the Great Lakes, which identified 75 sites within the AOCs containing contaminated sediments and requiring cleanup at total costs ranging from $1.5 billion to $4.5 billion.

The Strategy proposes as a goal to restore all of the Great Lakes AOCs, ultimately by 2020 (with interim targets in the meantime). Toward this end, the Strategy recommends:

- The appropriation by Congress of $750 million over 5 years, under the Great Lakes Legacy Act, to remediate contaminated sediment sites in the AOCs (along with various amendments to the Act itself).
- Funding of $50 million over 5 years to support state and community-based coordinating councils in the AOCs and $8.5 million over 5 years to the EPA Great Lakes National Program Office for regional coordination and program implementation.
- The Congress should fully fund, at $3 million annually, the research and development program authorized in the Great Lakes Legacy Act (this presumably is not counted as part of the additional cost of the overall restoration initiative).

Non-Point Sources

The Strategy notes that water pollution from non-point sources is "a substantial contributor to the impairment of waters across the Great Lakes basin," and has been particularly severe in wetlands and tributaries.[15] The complexity of the pollutants from these sources makes remediation especially difficult.

Accordingly, the Strategy sets out as an objective to protect and restore existing wetlands in both urban and rural areas so that all water bodies across the Great Lakes region function as healthy ecosystems. In addition, the Strategy proposes that any initiative accomplish significant reductions in the sediment, phosphorous loading and nitrogen loading into the Great Lakes basin—including a 40–70 percent decrease in livestock's contribution to non-point source loading—and improvements in flow regimes to meet sediment reduction objectives.

To achieve these objectives, the Strategy recommends:

- Additional funding to restore up to 550,000 acres of wetlands over 5 years, recognizing that 50–70 percent of the area's historic wetlands already have been lost (between $375 million and $944 million)
- Restoration of 35,000 acres of buffer areas in urban and suburban areas ($335 million)
- Measures to reduce the soil loss in ten selected watersheds by 40 percent ($120 million)
- Support for the development and implementation of comprehensive nutrient and manure management on livestock farms ($106 million)
- Hydrological improvements in ten urban watersheds ($90 million)[16]

Toxic Pollutant Strategy

Although certain toxic substances have been reduced significantly in the Great Lakes area, the Strategy observes that they continue to be present at levels that pose threats to human and wildlife health. Accordingly, the Strategy calls for the virtual elimination of future discharges of any and all "persistent toxic substances" (PTS) to the Great Lakes ecosystem, and also for the significant reduction of exposure to PTS from historically contaminated sources. The goal of these measures is to reduce toxic chemicals in the Great Lakes to the point where all restrictions on the consumption of fish from the Lakes can be eliminated, as well as to protect the health and integrity of wildlife populations and habitat. The Strategy sets forth interim objectives in these areas as well.

To achieve these objectives, the Strategy recommends that measures be taken to:

- Reduce and virtually eliminate principle sources of mercury, PCBs, dioxins, and other toxic substances in the Great Lakes basin ($60 million)
- Prevent new toxic chemicals from entering the Great Lakes basin ($80 million in spending, $250 million in tax incentives)
- Institute a comprehensive research, surveillance, and forecasting capability for identifying, managing, and regulating chemical threats to the Great Lakes basin ($25–50 million, in addition to the $1.5 billion likely to be spent already over the next five years).
- Execute a public education and messaging campaign relating to threats of toxins to fish consumption ($68 million in new spending)
- Support efforts to reduce continental and global sources of PTS to the Great Lakes basin ($30 million in new spending)

Indicators and Information

A successful restoration strategy for the Great Lakes basin will require consistent monitoring and measuring of key indicators of the functioning of the Lakes' ecosystem. Current efforts are under-funded. To provide what is necessary, the Strategy recommends a series of measures aimed at collecting, analyzing, and disseminating key information, including doubling the current Great Lakes research budget and increasing the involvement of universities. The total estimated cost is $350 million over five years.

Assuring Sustainable Development

Finally, the Strategy contains a series of measures aimed at assuring the environmental sustainability of further development in the Great Lakes region. As the document sets forth: "The goal is a Great Lakes Basin where human activities support a strong and vibrant economy, meeting societal and cultural needs in balance with a diverse and resilient ecosystem."[17]

Toward this end, the Strategy offers the following recommendations:

- State and local governments in the region should encourage sustainable development
- State and local regional planning and governance should be coordinated in order to enhance sustainable planning and management of resources ($115 million)
- Marketing and outreach programs should be created to educate consumers and users about sustainable alternatives ($10–20 million)
- Resources should be appropriated to implement this overall Strategy ($30 million)

Summary

The following summarizes the essential building blocks of the restoration strategy, with five year cost estimates. The total is about $20 billion in 2005 dollars.

- AIS control and initiatives ($694 million)
- Protecting habitats and conservation ($1.43 billion)
- Assuring coastal health ($15.3 billion)
- Addressing AOCs ($1 billion)
- Reducing pollution from non-point sources ($500 million)
- Toxic pollutant strategy ($263–288 million in spending, $250 million in tax incentives)
- Indicators and information ($350 million)
- Sustainable development ($750 million)

In addition, there will be ongoing operating costs associated with the recommended infrastructure investments. We estimate that, in present value terms, the total cost of the GLRC, taking into account both the initial capital costs and the continuing operating costs, will be about $26 billion.

III. Benefits of a Great Lakes Infrastructure Program

The proposed GLRC Strategy, in principle, should generate several different types of benefits, including:

- Short-run multiplier effects on economic activity
- Improvements in the environment
- Health improvements
- Attraction and retention of skilled people to the region
- Additional construction and other economic activities over the longer run
- Development of new technologies

The purpose of this chapter is to provide quantitative estimates of the magnitudes of these benefits, where possible.

Short-Run Multiplier Effects

Like any fiscal policy measure, the spending outlined by the Great Lakes Regional Collaboration Strategy will have immediate and indirect "multiplier" economic impacts. Generally, the spending of $1 by a fiscal authority ultimately multiplies to a larger total economic impact, reflecting the fact that the recipients of the first dollar spend some portion of it on labor and materials, and the recipients of those dollars spend them on others, and so on. If resources are not already fully employed, the total level of economic activity rises with every round of expenditure. In the regional context, resources are rarely fully employed because materials and workers are mobile and can be brought in from outside the region. However, new activity in the form of purchases from outside the region has its multiplier effect elsewhere in the economy—wherever the relevant goods and services were produced. The multiplier on a dollar of new spending from external sources (such as the federal government) will depend on the details of the expenditure, and there are a number of regional models that economists have employed to make such measurements. Regional multipliers generally range between 1.5 and 2.5.[18] If applied to Great Lakes Strategy spending this would imply total economic impact throughout the region of $30–50 billion.

Without modeling the specific details of spending down to the level of the likely suppliers of equipment and the availability of labor with the requisite skills, we cannot estimate the impact more precisely. Certain labor-intensive in-region activities will have larger impacts than other, more capital-intensive items. One example is sewer repairs, where one estimate is that the $7.5 billion in such activity contemplated in the GLRC Strategy by itself could generate 350,000 jobs in the short-run (during the period required to complete the repairs) in the construction industry.[19]

Any multiplier benefits, however, should be viewed in their proper context. Multiplier impacts result from a wide range of possible fiscal spending measures, and so the multiplier logic could be used to justify *any* expenditure in the region, not just the Great Lakes Regional Collaboration Strategy. Moreover, although the additional economic activity would benefit residents of the region, the main way in which these benefits would be realized is through migration of economic activity from elsewhere, since the national economy is close to full employment (as it is at this writing and has been for several years). Under these conditions, the spending would have approximately no net national effect.[20] At the same time, *once a decision is made to spend money on a restoration project,* the multiplier effect within that region will be very real.

Long-Run Environmental and Health Benefits

Nonetheless, the central question addressed in this report is whether the proposed project will yield environmental, health, and other *long-run* benefits that exceed the estimated present value spending of $26 billion. To answer that question, it is necessary to conduct a deeper analysis of the specifics of the Great Lakes Regional Collaboration, the subject to which we now turn.[21]

Ideally, when conducting benefit-cost analyses, it is desirable to use market-based measures to quantify both the costs and benefits. As implied by the discussion in the previous chapter, it is always possible to do this for costs, although oftentimes the estimates must be provided in ranges. By definition, investments requiring the application of capital, labor, and material to produce a given outcome will require purchases of these key inputs in the open market.

It is typically far more difficult to find suitable market-based measures for the benefits of investments designed to produce improvements in the environment or human health, since cleaner air or water and better health are not items that are found in the marketplace. Accordingly, analysts have used various other techniques for valuing improvements in these areas including surveys of people to ask how much they would pay for the improvements, or by looking to other markets, such as the property market, which under the right conditions and assuming that other factors can be controlled for, can indirectly reveal what market participants appear willing to pay.[22]

Further, estimates can be made at different levels of aggregation. For example, one approach is to identify specific improvements in the environment that may be expected from restoration, value them, and then add up the individual estimates to arrive at a total. Alternatively, one can take a highly aggregated approach and use the estimated increase in property values in all of the areas likely to be affected by the cleanup initiative, summing to a total. The second approach is aggregated because the property value increase reflects how individuals value all of the various disaggregated benefits associated with the cleanup in any given area.

We adopt both these approaches here, and present the results in the sections that follow. Given the uncertainties surrounding the benefits in general, many of the results are presented in ranges. Table 3-1 and Chart 1 illustrate the alternative benefit calculations.

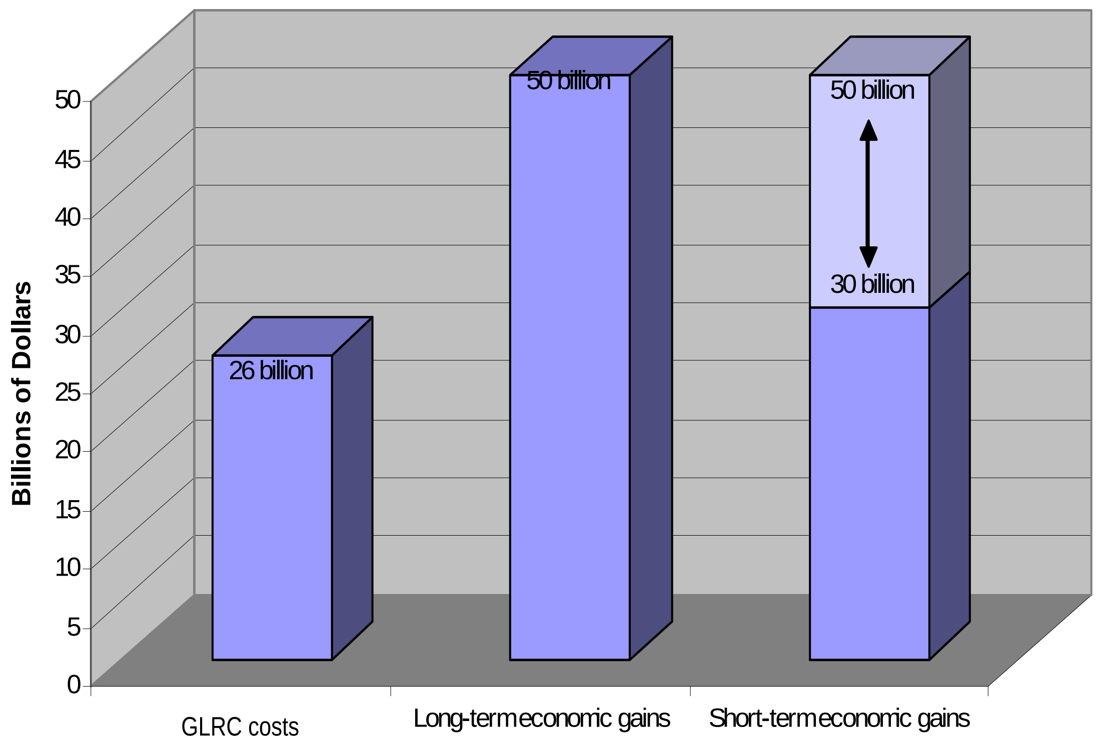
Table 3-1. Summary of the Economic Benefits of Great Lakes Restoration

Improvement	GLRC effect (relative to baseline)	Affected value	Present value benefit (relative to baseline)	
Increased fish abundance	30-75 percent increase[a]	Improved catch rates for anglers	$1.1-$5.8 billion or higher	
Avoided dislocation of sport-fishery workers and assets	20 percent reduction or higher	Maintenance of sport-fishery wages and profits	$100-$200 million or higher	
Reduced sedimentation	10-25 percent reduction	Lower water treatment costs for municipalities	$50-$125 million	
Reduced bacterial and other contamination leading to fewer beach closings and advisories	20 percent reduction	More swimming activity	$2-$3 billion	
Improved water clarity at beaches	5 percent improvement or higher	More swimming and improved enjoyment of swimming activity	$2.5 billion or higher	
Improved wildlife habitat leading to more birds	10-20 percent improvement[a]	Improved opportunities for birding[b]	$100-$200 million or higher	
Improved wildlife habitat leading to more waterfowl	10-20 percent improvement[a]	Improved opportunities for waterfowl hunting[c]	$7-$100 million	
Removed contaminated sediment in Areas of Concern (AOC)	All toxic sediment contamination remediated	Basin residents benefit directly or indirectly from AOC restoration	$12-$19 billion	
Total quantified specific benefits			**$18-$31 billion or higher**	
Use values (e.g., health-related and recreational) and non-use values (e.g., "existence" and "bequest") for unquantified resources	Unquantified	Multiple	Potentially single digit billions or higher	
Aggregate Long-Run Benefit Estimate				**$29-41 billion or higher**
Short Term Multiplier Effects				**$30-50 billion[23]**

[a] Equals the sum of eventual avoided percent decreases and eventual percent increases in population levels, where percent changes are relative to current levels. We assume that avoided decreases and potential increases would occur gradually over 20 years and 10 years, respectively.
[b] Based on the estimate of one birding trip to the Great Lakes per year per birder.
[c] Based on the estimate that 5 percent of waterfowl hunting trips in Great Lakes states depend on the Great Lakes either directly or indirectly.

As noted above, these short term multiplier effects should only be considered after a decision to invest in the Great Lakes is made; they should not be used as an economic justification for spending on Great Lakes restoration per se.

Chart 1. GLRC Return on Investment



The estimated benefits are linked to the ability of the Great Lakes region to retain and attract skilled labor in the future, a prime (if not *the* prime) objective of the restoration initiative. By helping to restore Great Lakes ecosystems and the many environmental benefits that these ecosystems provide, the GLRC plan clearly will improve the general quality of life in the Great Lakes basin. This, in turn, should assist the region in attracting or at least retaining a skilled workforce.

There is substantial economic literature documenting people's willingness to pay to locate in areas with high environmental quality.[24] Of course, other factors, such as an area's crime rate, its educational system, and other amenities, also play an important role in attracting people to an area. Nonetheless, there is evidence that home values differ within metropolitan areas, with residents paying more to live in areas with parks and open spaces, lakes, rivers, wetlands, good air quality, and other environmental amenities.[25]

The evidence also shows up across metropolitan areas, with wages and housing prices adjusting to reflect differences in environmental quality across cities. Areas with high environmental quality tend to attract mobile workers, which leads to property value increases as new people move in. Local businesses also benefit because mobile workers are willing to accept somewhat lower wages to live in areas with high environmental quality. Put differently, workers actually enjoy higher real wages (after adjustment for inflation) in environmentally advantageous areas than are reflected in the nominal wages they take home.

The results of three studies that estimate the effect of environmental quality on wage differentials across U.S. cities are summarized in Appendix B, Table B–1. These estimates should be interpreted as measures of the importance of environmental quality to mobile workers, expressed in terms of their wage-equivalent impact, assuming housing prices are fixed. For example, one recent study finds that living 100 miles closer to a national park is equivalent to a wage increase of 4 percent, holding housing prices fixed.[26] Other studies find similarly large wage-equivalent effects of environmental quality, as measured by local air and water pollution, landfill waste, and the number of Superfund and hazardous waste sites nearby.

While none of these studies estimates the wage-equivalent benefits of improving the environmental quality of the Great Lakes, they do provide evidence that such improvements would increase the attractiveness of Great Lakes region cities to mobile workers. The degree to which they are attracted to the region or induced to remain would depend on the magnitude of the environmental improvement and on other factors that affect quality of life in metropolitan areas, such as education, safety, and cultural amenities. To the extent that mobile workers are attracted to the Great Lakes region, they become a resource for growth across many industries, and thus contribute directly and indirectly to the level of economic activity in the region.

The wage and business effects just described at least partially overlap with the aggregate property value impacts discussed elsewhere in this report in that higher real wages, to some extent, will be captured in higher property values. Those effects are based on the relationship between local property values and proximity to environmental damage that would be remediated by the GLRC. The wage and business impacts depend in part on migration from other regions to the Great Lakes as workers and businesses take advantage of improved amenities. To the extent that such movement is away from regions that are currently over-congested (see the discussion in Chapter 4), the total benefit would be even greater.

Specific Benefits

We begin first by discussing the economic value of a number of improvements in environmental quality that would derive from the GLRC plan. In each case, our estimates come in two parts—the biological and physical effects of the GLRC interventions on the ecosystems in question, as well as the subsequent changes in the levels of economic activity in the Great Lakes region. In order to determine the economic value of these environmental improvements, we outline the methodology we use to develop a list of likely ecosystem impacts resulting from the GLRC plan. We then describe our economic benefit analysis, which is based on our list of likely ecosystem impacts.

Estimating Ecosystem Impacts

To develop estimates of the ecosystem impacts (physical, biological, and chemical) of the actions proposed in the GLRC strategy, we convened a panel of highly credentialed experts under the leadership of Donald Scavia, Michigan Sea Grant Director and Professor of Natural Resources and Environment, University of Michigan, and Dr. Jennifer Read, Michigan Sea Grant Assistant Director.[27] The panel met twice in person but conducted most of its business by e-mail and telephone. In the first meeting, the panel began to identify and estimate known or likely environmental and human health benefits associated with actions recommended in the GLRC document. Additionally, the panel set aside benefits that were unlikely to be quantified in the short duration of this study.

The panel organized its assessment by grouping the GLRC actions into six categories: (1) restoring wetland/habitat; (2) reducing aquatic invasive species (AIS) impacts; (3) reducing toxic impacts; (4) reducing pathogens and nutrient loads via wastewater treatment; (5) reducing nutrient and sediment pollution impacts; and (6) expanding the information base and monitoring. The panel's goal was to identify immediate outcomes, ecological impacts, and long-term objectives for each category, assuming the entire set of actions set forth in the GLRC plan within that category would be implemented.[28]

Recognizing the need to distinguish capital versus operating costs and realizing that many of the proposed GLRC actions will require a policy and/or management response to maximize their effectiveness, the panel adopted the following additional assumptions, which were applied to all subsequent case-studies and estimates:

- *Capital versus annual/operating costs*: Programs that require prolonged annual funding to maintain their ecological impact would continue to receive that level of funding in the future. For example, payments to farmers to implement best management practices for preventing soil erosion would be maintained at levels specified in the plan beyond the five-year horizon. This allowed the panel to assume that any associated reductions in nutrient flow and resulting biological impacts would also continue into the future. One-time capital expenditures with long-lived benefits (e.g., upgrading wastewater treatment facilities) would be assumed to occur just once during the five-year horizon.

- *Human behavior and necessary policy/management*: "Real time" and more efficient policymaking capabilities would provide citizens with high-quality information. For example, fish consumption advisories would provide detailed guidance, such as "one fish per month" when mercury content is high and "four fish per month" when mercury content is low. As another potential example, beaches would open when water contamination disappears, but policymakers would provide additional guidance when necessary, such as cautioning beachgoers against digging around in the sand where they could come in contact with harmful pathogens. Our assumptions here allowed the panel to presume that humans would respond to the cleanup in ways that did not end up making them worse off. For example, if well-informed citizens responded to higher fish populations by catching and eating more fish, the panel may be able to assume that the sporting value and health benefits of fish outweighed the increased mercury consumption.

At the panel's second meeting, the expert team was joined by environmental economists to examine the potential impact of the GLRC actions on economic values and services, with panel members providing an estimate of the level of quantifiable information they could according to their area of expertise. The outcome of that meeting was a more fully articulated understanding of the GLRC strategy's potential environmental impacts and the identification of a series of detailed case-studies (related to specific locales and/or values/services) that might be most useful to the economic analysis that follows.

Valuing Ecosystem Impacts

Several elements of the economic benefits analysis are important to note at the outset. First, the list of quantifiable outcomes identified by the panel is incomplete: there are other non-specific describable and foreseeable consequences of GLRC, such as the value that residents throughout the region place on the amenity value of living and working near one of the world's largest freshwater resources. There are also specific effects that remain unquantified in the analysis. When possible, we have tried to provide a rough indication of how important these benefits might be. Some of the broader, unquantified benefits nevertheless are captured implicitly in the aggregate estimates that are provided later in this chapter. Those benefits that we have been able to quantify appear later in this chapter in Table 3–2, while Table 3–3 lists, by category, those benefits we have not been able to quantify.

Second, because environmental quality generally will deteriorate without further policy interventions, our study compares the improved environmental conditions with the impaired conditions that are projected to otherwise occur. As a concrete example, below we estimate that the productivity of Lake Ontario wetlands as a habitat for waterfowl, migratory birds, and some warm water fish species would decrease at the rate of approximately 5 percent a year in the absence of restoration. The benefits of improving the habitat are calculated relative to this "base case." The same procedure is followed for other ways in which the GLRC strategy should benefit the region.

Third, we are unable to incorporate any estimates of the consequences of global climate change because of uncertainty as to the regional consequences. Nonetheless, the consensus in the scientific literature is that global climate change makes ecosystems generally more fragile, hence increasing the payoff to undertake activities that would make them more resilient.[29] This observation applies to all of the specific estimates that we discuss below. A recent report from the Union of Concerned Scientists recommends that Great Lakes residents take a variety of actions, many of them also recommended in the GLRC, in order to mitigate untoward consequences of global climate change.[30]

For analytical convenience, the sequence in which the following specific benefits are outlined is closely aligned with, but does not necessarily match, the sequence of the objectives of the GLRC, as discussed in Chapter 3. For the purposes of this analysis we assume that the GLRC plan is implemented immediately starting in 2007 and that benefits from the plan begin accruing a year later in 2008. All monetary values are in 2006 dollars unless otherwise noted.

Impacts on Fisheries ($1.1 - 5.8 Billion or Higher)

One of the broad conclusions we drew from the work of our panel of scientific experts is that Great Lakes ecosystems and food webs are incredibly complex, and it is therefore impossible to forecast with precision the impact of the GLRC plan on fish abundance and geographic distribution. Even the qualitative impact of the GLRC plan is sometimes uncertain. For example, restoration of near-shore wetland habitats will tend to increase spawning activity for some game fish species, leading to higher populations. But invasive species, such as zebra mussels, compete for food sources with the species that game fish prey on, and therefore potential population increases could be limited, and some new invader could disrupt the food web even further.

This uncertainty about how food webs operate is further compounded by the fact that the precise effects of the GLRC plan will depend crucially on how the money is spent. For example, implementing best management practices (BMPs) to reduce non-point sources of pollution in Saginaw Bay, Green Bay, or Lake Erie, will tend to increase populations of desirable commercial fish species. By contrast, the same actions in watersheds of the open Great Lakes might lead to lower primary productivity and thus fewer prey fish and lower populations of game fish.

In the absence of any further actions to bolster the Great Lakes sport fishery, which in some locations is in decline, we anticipate game fish abundance to further decline by 25–50 percent relative to current levels over the course of the next two decades and maintain at that reduced state indefinitely. If implemented in its entirety, however, we expect the GLRC plan will lead to an increase in game fish abundance of 5–25 percent relative to current levels over the course of the next decade and maintain at that improved state indefinitely.[31] Much of the projected increase in fish populations can be attributed to wetland habitat restoration. Our panel of scientific experts was unable to quantify reductions in fish contamination levels that might occur if the GLRC plan is implemented in its entirety relative to inaction, but the potential benefits of such a reduction are significant, as we discuss below.

Fish Abundance

A number of studies estimate the benefits of increased fish abundance in the Great Lakes to recreational anglers. Table B–2 in Appendix B provides a partial list of these studies and their estimates of the value of various fishery resource changes. Most of these studies base their estimates on observed angler behavior by relating angler choices of fishing locations and frequency to catch rates at these sites and the cost of accessing these sites in terms of time, fuel, and other fishing-related expenditures. A handful of studies base their estimates on survey methods that elicit information from anglers about what they would be willing to pay for hypothetical fishery resource changes.

Collectively, these studies suggest that Great Lakes anglers value each one percent increase in cold water species (such as trout and salmon) catch rates at roughly $0.02–$0.10 per fishing day with a central value of about $0.05 per fishing day. Lake trout do not appear to factor highly in these estimates based on studies that assess their value separately. Great Lakes anglers value each one percent increase in lake trout catch rates at roughly $0–$0.02 per fishing day with a central value near the upper end of this range, although a couple studies estimate substantially higher values. Great Lakes anglers value each one percent increase in warm water species (e.g., walleye, perch, bass, and pike) catch rates at roughly $0.02–$0.10 per fishing day with a central value of about $0.05 per fishing day.[32] According to one study, Green Bay anglers value each one percent increase in all species at roughly $0.15–$0.30 per fishing day. This is roughly consistent with adding up the estimates for major individual species.

Assuming 23.1 million annual Great Lakes fishing days,[33] and that anglers value each one percent change in fish abundance at $0.15–$0.30 per fishing day, avoiding an immediate 25 percent decline in fish abundance is worth roughly $87–$170 million annually. Avoiding an immediate 50 percent decline is worth roughly $170–$350 million annually. Assuming that fish abundance declines gradually over twenty years and then maintains at the reduced state indefinitely, avoiding an eventual 25 percent decline is worth $0.9–$1.8 billion in present value terms, given a discount rate of 6 percent. Avoiding an eventual 50 percent decline has a present value of $1.8–$3.5 billion.

Making the same assumptions as above, an immediate 5 percent increase in fish abundance is worth roughly $17–$35 million annually, while an immediate 25 percent increase is worth roughly $87–$170 million per year. Assuming that fish abundance increases gradually over ten years and then maintains at the improved state indefinitely, an eventual 5 percent increase in fish abundance is worth $230–$450 million in present value terms, while an eventual increase of 25 percent is worth $1.1–$2.3 billion.

Taken together, these estimated ranges imply that the GLRC plan will likely lead to increases in fish abundance valued at $1.1–$5.8 billion relative to inaction. This range reflects uncertainties regarding the impact of the GLRC plan on fish abundance, as the degree to which anglers value these changes. Uncertainty regarding the number of future Great Lakes anglers could further widen this range.[34]

While the studies summarized in Table B–2 estimate the value of changes in fish abundance, a number of studies estimate the total surplus value of Great Lakes recreational angling. For example, a 1988 study by Daniel Talhelm estimates that the entire Great Lakes recreational

Why the 6 percent discount rate?

It is useful to note at this point the reason for our choice of the 6 percent discount rate used throughout this report. Discounting is used to reflect the fact that benefits in the future are not worth as much as those received today. Although there is some controversy over the appropriateness of discounting environmental benefits, most economists believe that it is appropriate, given the fact that the costs of achieving environmental benefits are routinely discounted and because future generations will have greater resources than current generations (and thus can afford to make greater investments to realize gains, environmental and otherwise). Here we use 6 percent, which is considerably above the current 3 percent risk-free real return available on long-term government debt. Accordingly, in doing so, we are being highly conservative in computing the present discounted value of future benefits—the larger the discount rate, the lower the present discounted value. Nonetheless, a 6 percent rate is closer to the real return on private sector investment, and thus we use it as a benchmark rate here. If we had used a lower discount rate, all the benefits presented in this report would be higher.

fishery is worth about $45 per angler day in 2006 dollars.[35] This is within the range of estimates in Table B–3 in Appendix B, which summarizes studies that report the total surplus value for some or all species in particular regions of the Great Lakes.[36] Also, it is consistent with a more recent study by Aiken and La Rouche (2003),[37] which estimates surplus values of roughly $50 per angler day for walleye, trout, and bass fishing on a nationwide basis. The Talhelm estimate implies that the U.S. Great Lakes fishery has an aggregate value of roughly $1.0 billion annually, or about $17 billion in present discounted value, assuming a 6 percent discount rate, based on the current level of Great Lakes fishing by U.S. anglers. This is the amount that U.S. anglers would be willing to pay to access the Great Lakes fishery for a year. Given that the GLRC plan is unlikely to increase fish populations more than 25 percent above current levels at the outer range but may limit the downside risk to the fishery, this value should be seen as a strict upper bound on the GLRC plan's annual benefit to recreational anglers.

The two approaches to benefit estimation—adding up marginal changes in fish abundance and considering the total surplus—yield estimates that are somewhat different from each other. Based on studies that estimate the value of changes in catch rates, we calculate that each one percent change in catch rates is worth roughly $0.15–$0.30 per angler day. Extrapolating these numbers to a 100 percent decrease in Great Lakes catch rates (or a total collapse of the Great Lakes fishery) implies a total surplus value loss of roughly $15–$30 per angler day. Talhelm (1988), in contrast, estimates the total surplus value of Great Lakes fishing to be about $45 per angler per day. These results suggest that a portion of the total value that Great Lakes anglers derive from fishing is not strongly related to marginal changes in catch rates. However, potentially large declines in catch rates as forecasted in our baseline assumptions might be enough to trigger wholesale abandonment of angling as a recreational activity for some anglers, putting the full surplus value of the fishery at risk. If changes in catch rates act proportionally on the total surplus value of the fishery, then avoiding an immediate 25 percent decline in the fishery is worth $250 million annually, and avoiding a 50 percent decline is worth roughly $500 million annually. These annual benefits are roughly double what we calculated above based on studies that estimate the value of changes in fish abundance.

Besides the direct impacts on recreational anglers, a significant decline in the Great Lakes fishery could also lead to dislocation of fishery-dependent workers and businesses, including marinas, slip rentals, cottages, resorts, and bait and tackle shops. We address the short-term dislocation costs that might result from such an outcome in the next section.

Invasive Species

While it is very difficult to determine how much of the recreational fishery is in jeopardy, the experience with invasive species over the last several decades suggests that the risks could be very large. The sea lamprey essentially destroyed the commercial lake whitefish and lake trout fisheries. Zebra mussels have proved to be very costly in a variety of ways, primarily by disrupting low levels of the food web. Many aquatic invasive species have prospered in the Great Lakes and elsewhere, once introduced. In addition to the zebra mussel, a fish pathogen known as viral hemorrhagic septicemia (VHS) provides another example of the potentially damaging effects of invasive species on the Great Lakes fishery and ecosystem balance. This virus, which is just beginning to emerge in the Great Lakes region, is not harmful to humans but can cause massive internal hemorrhaging of the internal organs of various fish species, and is linked to several recent die-offs of Great Lakes fish.

The panel of experts cited the continuing introduction of invasive species as one of the reasons they believe that the fishery will exhibit a declining trend without intervention. The currently unquantifiable, but potentially disastrous, impact of future invasive species is one reason that we contemplate the loss of 50 percent or more of the recreational fishery as a real possibility to be avoided by implementing the suggested policies in the GLRC.[38]

Fish Contamination

A number of studies estimate the benefits of lower fish contamination levels to Great Lakes and non-Great Lakes anglers alike. Table B–4 in Appendix B summarizes those studies regarding fishermen in the Great Lakes. Separately, Table B–5 in Appendix B reports estimates based on lower fish contamination in other locations.

The results set forth in Table B–4 suggest that

Great Lakes anglers might value every 1 percent decline in fish contamination levels at roughly $0.05–$1.20 per fishing day with a central value of perhaps $0.35. The value of reducing contamination appears to be somewhat lower outside the Great Lakes, as shown in Table B–5. While our panel of scientific experts was unable to quantify the effect of the GLRC plan on fish contamination levels, they did agree that it is likely that those contamination levels will decline, especially if the wetland restoration and protection goals of the Strategy are achieved. Thus it is safe to say that the potential benefits of reduced contamination are large. Assuming the range of values above, an immediate decline in Great Lakes fish contamination levels of just 10 percent would imply aggregate annual benefits of roughly $12–$280 million annually, with a central value of around $81 million annually. Unfortunately, at this time we are unable to quantify the degree to which these potentially large benefits might be realized.

In theory, the value of reducing fish contamination levels might depend on fish abundance and vice-versa. The only study that presents estimates of this interaction is by Kaoru.[39] This study finds that a 25 percent decrease in fish contamination in North Carolina is about 7 percent more valuable when accompanied by a 25 percent increase in fish abundance. These results suggest that calculating the benefits of higher fish abundance and lower contamination levels separately may underestimate the actual benefits to Great Lakes anglers.

Impacts on Fishery-Related Businesses and Employment ($100 - 200 million)

Increased fish abundance and lower contamination levels also would benefit commercial fishing. The Great Lakes commercial fishing industry is quite small, however, generating just 7,500 metric tons of fish in 2004 and only $12 million in revenue. The Talhelm study cited earlier estimates that the Great Lakes commercial fishery in 1985 was less than 2 percent as valuable as the recreational fishery. Although a much expanded commercial fishery could yield significant benefits, it is not clear what is holding the commercial fishery back, or what it would take to revive it. We therefore make no attempt to estimate benefits in the commercial fishery.

In addition to the willingness of anglers to pay for improvements in Great Lakes sport fishery resources themselves, the charter fishing industry may benefit from increased profits arising out of the GLRC initiative. For example, Lichtkoppler and colleagues estimate that the Great Lakes charter fishing industry in 2002 had total revenues (in 2006 dollars) of about $38.7 million, compared to total economic costs of about $40.2 million, indicating a net loss of about $1.5 million.[40] Perhaps a revival of the fishery would lead to positive net income in the charter fishing industry. Again, however, the potential numbers are small relative to the direct consumer surplus from the recreational fishery. We therefore make no attempt to estimate benefits specifically in the charter fishing industry, except to the extent that the initiative probably would help avoid some loss in employment and profits in businesses that depend on the sport fishery, broadly defined. We address this issue immediately below.

The principal value of the sport fishery is in providing benefits directly to anglers, but there are secondary benefits that accrue to others in the Great Lakes economies. In addition to spending their time fishing, anglers purchase equipment, bait, transportation, lodging, and other goods and services in the Great Lakes states. The most recent estimate available of the volume of these expenditures is $1.3 billion in 2001. Taking into account inflation, today this would be equivalent to roughly $1.45 billion. We have no idea how much of this expenditure constitutes economic surplus (profits and value above costs) for the firms and individuals who supply equipment and travel services to anglers. However, there is certainly some surplus, and we would expect it to be roughly proportional to expenditure as a whole, which would in turn be proportional to overall fishing activities.

Further, there are surely employment effects in these industries that would expand or contract in proportion to fishing activity. Earlier we argued that the regional multiplier effects of such employment changes are compensated, from a national perspective, by employment and income changes of opposite but similar magnitudes that occur elsewhere. In any case, these multipliers are generally short-term in nature. At the same time, there is well-developed economics literature on the experience of displaced workers, which indicates that the consequences of job loss in a given industry (in terms of downward shifts in wages) can be long-lived for at least some of the workers who are displaced.[41] We do not have an estimate of employment or wages in the sport fishing industry which are at risk, but with expenditures of $1.45 billion a year for sport fishing, they may be substantial. In the case of a 20 percent reduction in the fishery—a result that would very likely be avoided through enacting the measures envisioned in the GLRC plan—it is plausible that there would be $200 million in lost wages immediately and as much as $20–$40 million annually for a number of years, reflecting the long-standing downward adjustment of many workers' wages. Lost profits could be in this range as well. The two effects together could easily result in present discounted value losses of $100–$200 million. If the regional multiplier is 2, these numbers would be doubled.

Water Treatment Benefits

Management actions included in the GLRC plan are designed to reduce sedimentation by as much as 40 percent in selected watersheds. Our panel estimated a somewhat more conservative range of 10–25 percent overall. The resulting reductions in sediment loading and associated nutrients, pesticides, pathogens, and heavy metal contaminants will reduce water treatment costs for municipalities that rely on the Great Lakes for their water.

Several studies deal with the variability of the cost of drinking water treatment, which depends directly on the turbidity or "cloudiness" of the input water source and indirectly on sediment loading into the water source. Using data from over 400 of the largest U.S. utilities, Holmes estimates that a 1 percent increase in the turbidity of a facility's input water leads to a 0.07 percent increase in operating and maintenance costs.[42]

After estimating how input water turbidity varies with sediment loading levels, he finds that a 1 percent increase in sediment loading leads indirectly to a 0.05 percent increase in water treatment costs.

Other studies use smaller samples to estimate how components of treatment costs vary with input water quality. For example, Dearmont and colleagues find that a 1 percent increase in turbidity raised expenditures on water treatment chemicals by 0.27 percent at twelve Texas facilities,[43] while Moore and McCarl estimate that a 1 percent increase in turbidity raised the costs for alum, lime, and sediment removal by 0.33 percent for a single facility in Oregon.[44] Forster and colleagues estimate that a 1 percent increase in turbidity and watershed erosion raised variable costs (excluding labor and maintenance) by 0.12 percent and 0.41 percent, respectively.[45] All of these responses (or "elasticities") are higher than in the Holmes study, which uses a more comprehensive measure of water treatment costs.

We estimate that operating costs for water supply facilities that draw on water from the Great Lakes total about $600 million in 2006 dollars.[46] Based on the Holmes estimate that a percent decrease in sediment loading will lead to a 0.05 percent reduction in treatment costs, the GLRC plan's goal of achieving a 40 percent reduction in sedimentation might be expected to reduce drinking water treatment costs by $12 million per year. Given our more conservative estimates of a 10–25 percent reduction in sedimentation, the GLRC plan would reduce costs by $3–$7 million annually. In the longer run, there will be reduced capital costs per unit of use required for water treatment in general. We make no estimate here, but the consequences could be large. In any case, the present value of $12 million per year is about $200 million in the long run, while the present value of $3–$7 million per year is about $50–$125 million, given a discount rate of 6 percent. This estimate may well be conservative since it does not account for the benefit to commercial and industrial users of having an enhanced supply of water for their manufacturing processes and products.

Benefits to Beaches and Lakefronts ($2 - 3 Billion, or Higher)

During 2005, Great Lakes beaches were plagued by nearly 3000 days of closings and advisories, an increase of 5 percent from 2004. The major factors driving this trend appear to be a greater number of regularly monitored beaches, as well as an increase in the amount of untreated stormwater and sewage pollution contaminating beach waters with harmful bacteria.[47]

The GLRC plan would eliminate untreated or under-treated waste flows into the Great Lakes from municipal wastewater treatment and on-site disposal systems. It does not necessarily follow, however, that beach closings and advisories will fall to zero. While nearly 600 of the beach closings and advisories in 2005 were due to stormwater, runoff, or sewage pollution, more than 2,000 of the 2,800 closings and advisories did not have an identified source. If implemented in its entirety, we anticipate that the GLRC plan will reduce the number of beach closings and advisories due to storm and wastewater overflows by up to 20 percent and will most likely shorten the duration and severity of the remaining beach closures.

This reduction in beach closings and advisories would be highly valuable. One noted study, for example, collected information from beachgoers at sixteen Lake Erie beaches.[48] The investigators estimated that beachgoers would value a 30 percent reduction in the average number of water quality advisories at about $35 per visitor per year, or about $2.30 per visit. This implies about $23 per visitor per year, or about $1.50 per visit, for a 20 percent reduction in beach closures. What remains is to multiply these valuation numbers by an estimate of annual Great Lakes beach visitors or beach days.

While there are excellent data that measure recreational use of ocean beaches, we were unable to find any reliable comprehensive measurement of the total number of visitors to Great Lakes beaches. Using survey data for recreational use of ocean beaches in states with similar swimming season lengths as in the Great Lakes, we estimate that there are roughly 8 million swimmers and 84 million days of swimming at Great Lakes beaches annually.[49] These estimates imply about ten days of swimming per visitor, which is somewhat lower than in the Lake Erie study, where sampled beachgoers averaged about fifteen visits per year to Ohio state park beaches. Our estimates also appear conservative based on information we were able to find for individual Great Lakes beaches or beaches in individual Great Lakes cities or states. For example, Chicago's beaches receive about 27 million visitors a year according to one source, and we estimate 27 million swimming days for all of Illinois. Indiana's beaches reportedly draw another 2 million visits annually, and we estimate 3 million swimming days in Indiana. Presque Isle, in Lake Erie, Pennsylvania, has 4 million beach visitors a year, and we estimate only 1 million swimming days in Pennsylvania. The limited number of citations that we give here document approximately 50 million beach visitors a year, and so our guess of roughly 80 million total swimming days is likely to be conservative.[50]

Assuming that there are 8 million swimmers and 80 million swimming days annually in the Great Lakes, the economic benefit from a 20 percent reduction in beach closings and advisories would be $130–$190 million per year, which translates into a present value of about $2–$3 billion, given a discount rate of 6 percent. The low end of the range comes from multiplying 80 million swimming days by $1.50 per visit, whereas the high end of the range comes from multiplying 8 million swimmers by $23 per visitor. The difference results from the fact that there are 15 visits per person in the Lake Erie study sample, whereas our estimates imply only 10 swimming days per swimmer.

Improved Water Clarity ($2.5 Billion or Higher)

We also found two studies that estimated the benefits of improved water quality in terms of waterfront property values or the value of residential property near beaches. Table B–6 in Appendix B summarizes the results of these studies. Leggett and Bockstael estimate that a 1 percent reduction in water fecal content increases Chesapeake Bay waterfront property values by about 0.0002 percent,[51] while Ara and colleagues estimate that a 1 percent reduction in fecal content at the nearest Lake Erie public beach increases residential property values by about $6.40 in Ohio counties adjacent to the lake.[52] The Ara study also estimates that a 1 percent increase in water clarity increases residential property values by $60.

If the fecal content measured at Great Lakes beaches decreases by 20 percent—a rate consistent with our projection for reduced beach closures—then we might expect residential property values in counties adjacent to the Great Lakes to increase by about $130 per home, based on the Ara study. Given that there are slightly more than 8 million housing units in U.S. counties adjacent to the Great Lakes,[53] this implies aggregate present value benefits of about $1 billion. This estimate likely reflects the benefits of reduced beach closures and advisories to a large degree, so it can not be added to our estimate above. But it is comforting to know that the estimate is of the same order of magnitude.

The estimates in the previous paragraph do not measure the potential benefits of improved water clarity at Great Lakes beaches, however, at least to the extent that such improvements are not directly correlated with beach closures and advisories. The GLRC plan is designed to reduce sedimentation in selected watersheds by up to 40 percent. Our panel suggests a more conservative reduction in sedimentation of 10–25 percent. Our panel did not project the improvements in water clarity that will result from the GLRC plan, but Holmes estimates that a 1 percent reduction in sedimentation leads to a 0.7 percent reduction in input water turbidity.[54] Assuming, conservatively, that reduced sedimentation improves water clarity at Great Lakes beaches by just 5 percent, then residential property values in adjacent counties would increase by about $300 per unit, based on the Ara study, for an aggregate total of about $2.5 billion in present value terms.

In addition to the benefits of reduced water treatment costs and improved water clarity, keeping sediments and associated nutrients on the land and out of receiving waters will reduce nuisance growths of Cladophora (a species of algae). This will reduce the costs of removing piles of rotting Cladophora from beaches and lakefronts and/or mitigate undesirable sights, sewage-like smells, and nuisance animals associated with the rotting algae. Our team of ecological experts did not quantify the potential reduction in Cladophora that could be expected to result from the GLRC plan, but the reduced management costs and residual impacts could be substantial. Further, decomposition of Cladophora can create the oxygen-deprived conditions suitable to the bacterium that produces the Type E botulism toxin, which can kill fish and other wildlife. The beneficial impact of the GLRC plan on fish is reflected to some extent in the scenarios developed by our expert team for fish populations, discussed above.

We note further that even these estimates do not take into account other amenities that homeowners may value as a result of water restoration. More aggregate studies reviewed and used below imply even higher increases in homeowner values from the kind of major restoration represented by the GLRC. Accordingly, the specific beach-related estimated values here should be viewed as sub-sets of the larger, more aggregated benefits discussed in later sections of this chapter.

Wildlife Watching Benefits ($100 - 200 Million)

Our projections for changes in bird and waterfowl populations are based on scenarios developed by our panel of scientific experts for wetland restoration in Lake Ontario. The panel tells us that efforts aimed at reducing monoculture cattail cover, creating more habitat interspersion, and increasing the cover of meadow marsh as a result of proposed lake level regulation that adds more variability to lake levels,[55] could roughly double desirable meadow marsh habitat relative to current levels. This would lead conservatively to an eventual increase of 5–10 percent in waterfowl hunting and birding opportunities over the next ten years.[56] In the absence of any restoration efforts, meadow marsh habitat would decline 5 percent annually and would eventually disappear entirely over the next two decades. Given that our panel projected a 5–10 percent improvement in hunting and birding opportunities for a doubling of desirable habitat, we assume that a 100 percent loss of such habitat would lead conservatively to a 5–10 percent decline in waterfowl hunting and birding opportunities. We also assume that these ranges reflect what is likely to happen in other areas of the Great Lakes where coastal wetland habitat is restored.

We are not aware, however, of any studies that estimate the total number of recreational visitors to the Great Lakes for purposes other than fishing. It is therefore difficult to determine the extent of bird watching and waterfowl hunting in the Great Lakes. For the purposes of this report, we make educated guesses based on surveys that measure wildlife-related recreational activity by state.

Birding

There are about 17 million bird watchers in the Great Lakes states, including both backyard bird watchers and those that travel to watch birds.[57] This implies 5 million bird watchers in the Great Lakes basin, assuming that residents in and outside Great Lakes coastal areas are equally likely to be bird watchers.[58] Nationally, about 40 percent of bird watchers venture away from home to observe birds,[59] implying that about 2 million traveling birders live in the Great Lakes basin. Assuming conservatively that each of these 2 million traveling birders visits the Great Lakes once per year on average, this would imply about 2 million birding trips to the Great Lakes annually. Nationally, about 69 percent of trips are to sites associated with lakes and streams, and 47 percent of trips are to sites associated with marshes, wetlands, and swamps.[60]

How much economic activity is involved in birding? One estimate suggests that wildlife viewing trips within a viewer's state of residence generate a surplus value of about $40 per trip in 2006 dollars, while trips to locations outside a viewer's state of residence generate a surplus value of about $153 per trip. According to the U.S. Fish and Wildlife Service, about 90 percent of wildlife viewing trips in the Great Lakes states were to locations within a viewer's own state of residence.[61] This implies a weighted average value of about $50 per trip. Given one estimate that about 84 percent of away-from-home wildlife viewers are birders,[62] these values are probably good estimates for the value of birding. One other study estimates that the surplus value of nonresidential wildlife viewing by angling households in Pennsylvania is about $116 per trip.[63]

Assuming that the surplus value of birding in the Great Lakes is $50 per trip on average, and assuming there are 2 million such trips annually, then the total surplus value of birding in the Great Lakes is about $100 million annually. Further, assuming that changes in birding opportunities act proportionally on the surplus value of Great Lakes birding, avoiding an immediate 5–10 percent decrease in watching opportunities is worth about $5–$10 million annually (or, an equivalent amount, if it is possible to increase watching opportunities by 5–10 percent). Finally, on the assumption that reductions in habitat occur gradually over 20 years and that potential improvements resulting from the GLRC plan occur gradually over 10 years, then the total present value of the GLRC plan for Great Lakes birders is $100–$200 million. Because the preceding analysis does not include any estimates of birding in the region by birders who live outside of the region, it is plainly an underestimate of the total value of the GLRC plan to birders nationwide.

Benefits from Increased Hunting ($7 - 100 Million)

The Great Lakes are a major continental flyway for waterfowl, as well as for raptors and song birds. Habitat restoration in and around the Great Lakes will increase the survival rates of migrating birds using the fly-way and, therefore, increase economic values wherever the birds go—be it the Great Lakes themselves or elsewhere on the continent. According to a recent study, there were about 400 thousand waterfowl hunters and up to 4 million days of waterfowl hunting per year in the Great Lakes states in 2004 and 2005.[64] Although we are unable to determine the fraction of waterfowl hunting trips that either occur in the Great Lakes themselves or associated waterfowl breeding habitat, we believe we can safely make the assumption that 5 percent of these hunters and hunting trips depend on the Great Lakes. This assumption implies that 20,000 hunters and 200,000 hunting trips depend on Great Lakes ecosystems.

How valuable are these activities? To answer this question we look to available studies on similar values estimated for other areas. For example, one survey of Louisiana waterfowl hunters suggests that the wildlife hunters in that state are willing to pay about $590 per season for a one-duck increase in the daily bag limit.[65] The lowest bag limit for Great Lakes states is four per day in Minnesota, so this estimate conservatively implies about $590 per waterfowl hunter per season for a 25 percent increase in the daily limit.[66] Assuming that limits increase proportionally with waterfowl populations, avoiding an immediate 5–10 percent decline in waterfowl populations is worth about $2–$5 million annually, assuming 20 thousand hunters. An immediate 5–10 percent in waterfowl populations is worth the same amount. Assuming that reductions in habitat occur gradually over 20 years and that potential improvements resulting from the GLRC plan occur gradually over 10 years, then the total present value of the benefits of the GLRC plan for Great Lakes waterfowl hunters is about $50 – $100 million, assuming a discount rate of 6 percent.

An earlier study has estimated that the total surplus value of waterfowl hunting at California's San Joaquin Valley National Wildlife Refuge wetlands is about $32 per trip.[67] Applying this value to 200,000 Great Lakes waterfowl hunting days implies a surplus value of about $6 million. Assuming that changes in waterfowl hunting opportunities act proportionally on the surplus value of Great Lakes waterfowl hunting, avoiding an immediate 5–10 percent decline in waterfowl hunting opportunity is worth about $300–$600 thousand per year. On the assumption that reductions in habitat occur gradually over twenty years and that potential improvements resulting from the GLRC plan occur gradually over ten years, the total present value of the GLRC plan for Great Lakes waterfowl hunters is $7–$14 million, given a discount rate of 6 percent.

Taking both of these studies into consideration, we estimate that total benefits for Great Lakes waterfowl hunters resulting from the GLRC plan range from $7–$100 million in present value terms. These benefits could be higher or lower, depending on the level of waterfowl hunting in the Great Lakes.

Addressing Areas of Concern ($12-19 Billion)

The GLRC plan would also clean up contaminated sediments in Areas of Concern (AOCs). In addition to benefiting aquatic ecosystems, removing or reducing contaminated sediment in the AOCs may reduce the real or perceived health risk associated with living near these contaminated areas, while allowing nearby residents and visitors to use these areas for recreational purposes without fear of adverse health effects.

In a recent unpublished paper, Braden and colleagues review studies that attempt to estimate the economic benefits of cleaning up AOCs (summarized in Table B–7 in Appendix B).[68] Table B–7 also includes the results of his more recent study with other colleagues.[69] Roughly half the results in the table are based on hedonic property value models, which estimate the impact on home values of being near AOCs. These estimates appear at the top half of the table. Because homeowners will be unwilling to pay as much for homes near undesirable areas, the impact on property values reflects the cost of living near an AOC or, equivalently, the benefits to nearby homeowners of cleaning up an AOC. These studies suggest that homes within five miles of an AOC might suffer a 5 percent decline in property values or greater due to the presence of the AOC.[70]

Based on data from the 2000 U.S. Census, the 2005 Braden study reports that there are about 1.2 million U.S. households living in owner-occupied housing in Census tracts located within two miles of an AOC around the Great Lakes. The weighted median home value for these households, inflated to 2006 dollars, is about $150,000, implying an aggregate value for owner-occupied housing of $180 billion. This number likely underestimates the actual value of owner-occupied housing, because median home values tend to be lower than mean values, and completely ignores rental housing, which presumably is also affected by proximity to an AOC.

Assuming that all Great Lakes AOCs are cleaned up immediately, and that property values increase by an average of 5 percent within two miles of the AOCs, then the total one-time benefit of cleanup to nearby households living in owner-occupied housing is roughly $9 billion. Phasing in these remediation efforts over the course of 10–20 years, as is contemplated in the GLRC plan, would result in present value benefits that are roughly 61–78 percent as high as under immediate remediation, or about $6–$7 billion. Assuming that the cleanups increase property values by 10 percent, the total one-time benefit is doubled to $19 billion. Remediation phased in over 10–20 years would result in present value benefits of $6–$14 billion. Phased-in remediation would achieve a higher percentage of immediate benefits if early remediation efforts were directed where construction is significant and property values are high.

It should be noted that roughly half the estimates in Table B–7 are based on "stated preference" methods, which elicit information directly from Great Lakes basin residents about how much they are willing to pay to clean up sediment contamination in AOCs. These estimates, which appear in the bottom half of the table, measure a full range of remediation benefits for basin residents—not simply the benefits to households living in the immediate vicinity of AOCs. For example, Great Lakes basin residents may benefit from knowing that the AOCs are being cleaned up, even if they do not live nearby or visit frequently. The estimates from studies by Braden and collaborators suggest that households living in close proximity to AOCs might be willing to pay the equivalent of 10–20 percent of their property value for an immediate cleanup of AOCs. These estimates are somewhat higher than those based on observed property values—which might be expected, given that the survey-based estimates measure a more complete range of benefits—but are of the same order of magnitude. The estimates by Stoll and his colleagues can be applied more broadly to all Great Lakes basin residents and assume that full remediation is phased in over 10–20 years.[71] Stoll and colleagues estimate that basin residents are willing to pay about $150 per household annually for such a remediation plan, or about $1100–$1700 in present value terms, assuming a discount rate of 6 percent.

As an alternative to the property-value estimates above, which apply only to residents living near AOCs, we use the study by Stoll and colleagues to estimate the benefits to all basin residents of cleaning up the AOCs. There are over 11 million housing units in the Great Lakes drainage basin.[72] Based on the Stoll study, it assumed that each of these households is willing to pay $150 per year to completely clean up contaminated sediment in Areas of Concern over the next one to two decades. An annual sum of this amount translates into at least $1.7 billion annually for 10–20 years, or $12–$19 billion[73] in present discounted value, assuming a discount rate of 6 percent. This estimate reflects both the benefits to households living near AOCs, that may experience reduced health risks, as well as the benefits to households in more distant areas of the basin, whose residents travel to AOCs and value that improvement. The $12–19 billion in benefits associated with legacy toxic sediments in AOCs is not likely to overlap with the other benefits quantified in this study which are generally associated with species, resources, and/or geographic locations unrelated to AOCs. Thus, we believe we can safely add this range of benefits to our tally of specific GLRC benefits in Table 3–8 without fear of double counting.[74]

Even this range is conservative, in our view, however, because it does not account for the "existence" or non-use value that individuals living outside the Great Lakes basin (including those that live in the region but outside of the basin) would derive from knowing that the Great Lakes are cleaner for future generations. Such values could be substantial and also help explain why the federal government has contributed to the cleanup of contaminated areas throughout the country, as discussed in the next chapter.

Summary of Specific Benefits

Table 3–2 summarizes the estimated magnitudes of the specific environmental benefits, in present discounted values. In all, the table suggests that the total for this partial accounting of benefits is in the $18–31 billion range or higher.

In addition to what is listed in Table 3–2 (page 38), we were able to identify a number of other effects that are likely to result from actions specified in the GLRC plan, but for which we are unable quantify ecological impacts and/or economic values at this time. Table 3–3 (page 39) summarizes these effects and qualitatively describes their economic values. The potential value of these impacts could reach well into the single digit billions of dollars or even higher.

Aggregate Benefits

An alternative method for determining the economic value of the proposed restoration initiative is simply to estimate a broad measure of the increase in property values that may be expected once the GLRC initiative is completed. Property values are proxy variables that capture the multiple factors that individuals take into account when weighing the desirability of cleaner water, for drinking and recreational purposes, within close proximity of their residences. The chief advantage of looking to property values is that they reflect what people are *actually willing to pay*, rather than what they might *say* they are willing to pay for an initiative of this sort.

In principle, the aggregate estimate of the increase in expected property values should equal or at least approximate the sum of the estimated values of each of the specific environmental and health benefits associated with living near bodies of water that are cleaner than they were before the initiative. In practice, the two estimates may differ, however, because the aggregate figures may capture values that some, or many individuals, may place on the existence of the cleaner water that have nothing to do with the specific factors identified here, or by other researchers. In addition, as discussed at the end of this section, the specific estimates do not reflect benefits realized by some renters or owners of commercial properties living or located in the Great Lakes basin.

Table 3-2. Summary of Specific Environmental Benefits

Improvement	GLRC effect (relative to baseline)	Affected value	Present value benefit (relative to baseline)
Increased fish abundance	30-75 percent increase[a]	Improved catch rates for anglers	$1.1-$5.8 billion or higher
Avoided dislocation of sport-fishery workers and assets	20 percent reduction or higher	Maintenance of sport-fishery wages and profits	$100-$200 million or higher
Reduced sedimentation	10-25 percent reduction	Lower water treatment costs for municipalities	$50-$125 million
Reduced bacterial and other contamination leading to fewer beach closings and advisories	20 percent reduction	More swimming activity	$2-$3 billion
Improved water clarity at beaches	5 percent improvement or higher	More swimming and improved enjoyment of swimming activity	$2.5 billion or higher
Improved wildlife habitat leading to more birds	10-20 percent improvement[a]	Improved opportunities for birding[b]	$100-$200 million or higher
Improved wildlife habitat leading to more waterfowl	10-20 percent improvement[a]	Improved opportunities for waterfowl hunting[c]	$7-$100 million
Removed contaminated sediment in Areas of Concern (AOC)	All toxic sediment contamination remediated	Basin residents benefit directly or indirectly from AOC restoration	$12-$19 billion
Total quantified benefits			$18-$31 billion or higher
Use values (e.g., health-related and recreational) and non-use values (e.g., "existence" and "bequest") for unquantified resources	Unquantified	Multiple	Potentially single digit billions or higher

[a] Equals the sum of total avoided percent decreases and eventual percent increases in population levels, where percent changes are relative to current levels. We assume that avoided decreases and potential increases would occur gradually over 20 years and 10 years, respectively.
[b] Based on the estimate of one birding trip to the Great Lakes per year per birder.
[c] Based on the estimate that 5 percent of waterfowl hunting trips in Great Lakes states depend on the Great Lakes either directly or indirectly.

Table 3-3. Unquantified Benefits Associated with Implementation of the Great Lakes Regional Collaboration Strategy

Improvement	Affected Value
Habitat restoration in upland and tributary areas	
Restored wetlands reduce erosion and sedimentation by slowing water, which reduces scouring and allows sediment to be deposited in wetlands rather than wash into streams and rivers.	Reduced costs for sediment dredging, removal, and disposal.
Riverbank greenbelt and wetland restoration improves fish and wildlife habitat, thereby increasing the abundance and diversity of fish and wildlife, including threatened and endangered species.	Value to residents of Great Lakes basin and elsewhere of increased wildlife diversity and survival of endangered species. (See text for benefits of increased sport fish population levels.)
Restored wetlands improve natural flood control.	Reduction in severity of flooding and consequent damage to human health and property.
Restored wetlands improve the land's ability to absorb water, recharging aquifers.	Enhanced groundwater supply.
Restoring habitat in watersheds repairs the links between tributaries and the lakes, which benefit Great Lakes fishes that use tributaries for spawning and nursery habitat.	Improved opportunities for angling in Great Lakes tributaries. Value to residents of Great Lakes basin and elsewhere of increased wildlife diversity and survival of endangered species.
Restoration of forested areas will increase opportunities for sustainable timber harvest.	Timber production.
Habitat restoration in coastal areas	
Restoring soil and sand to beaches creates natural barriers to wave erosion, and restoring natural vegetation also mitigates erosion caused by waves.	Reduced costs of waterfront erosion control. Reduced losses of valuable waterfront property.
Restored coastal wetlands create fish and wildlife habitat, including for threatened and endangered species.	Value to residents of Great Lakes basin and elsewhere of increased wildlife diversity and survival of endangered species. (See text for benefits of increased sport fish population levels.)

Improvement	Affected Value
Aquatic Invasive Species Measures	
Where it is possible to find and implement control measures, restoration of the equilibrium food web (i.e., a mix of native and naturalized species) will result in a food web that is less vulnerable to future invaders and/or other stressors, including climate change.	Reduced risk of future ecosystem damages caused by as-yet unknown invaders and/or climate change. The cost of future invasions is literally unquantifiable but will inevitably cause further disruptions to an already weakened system. A worst-case scenario involves an ecosystem crash, resulting in large losses of ecosystem services and economic value.
A more stable ecosystem is less vulnerable to hyper-abundant native species, such as Canadian geese, deer, and cormorants, which spread disease (e.g., tuberculosis) and require human interventions to control.	Reduced costs of controlling hyper-abundant native species and consequent human and animal health impacts.
Toxic Impacts	
Reduced contamination of fish by toxic substances that accumulate in the food chain will make fish consumption safer for humans and wildlife.	Potential increase in human consumption of Great Lakes fish as a source of protein, offsetting less healthy protein sources. For humans and animals that eat Great Lakes fish, potential reduced impacts of toxic contamination on development and neurological function. (See text for speculative benefits valued at tens to hundreds of millions of dollars annually for sport fishery.)
Removing persistent toxic substances from lake-bottom habitats (e.g., contaminated sediment remediation) will dampen the degree to which these contaminants accumulate and transfer through the food web, improving fish habitat.	Lifting of fish consumption advisories. (See benefits listed above.) Improved recreational opportunities in affected areas once stigma of polluted waters/sediment is removed. (See text for benefits of sediment remediation in Areas of Concern.)
Reduced annual inputs of toxic chemicals into the Great Lakes could lead to improvements in numbers and diversity of native fish populations, especially in upper levels of the food web (e.g., assisting in restoration of native lake trout).	Value to residents of Great Lakes basin and elsewhere of increased wildlife diversity and survival of endangered species. (See text for benefits of increased sport fish population levels.)
Reduced exposure of wildlife to toxic chemicals, leading to improved health (e.g., improved immune, nervous, and reproductive systems) for individual animals and possibly entire populations (overall, and for individual great Lakes, many toxic contaminants have been trending downward).	Value to residents of Great Lakes basin and elsewhere of healthy wildlife. (See text for benefits of increased fish and wildlife population levels.)

Improvement	Affected Value
Waste Water Treatment/Combined Sewer Oveflows (CSOs)	
Reduced exposure to pathogens from recreational use of water and contaminated drinking water, resulting in fewer occurrences of gastrointestinal disease.	Reduction in the costs of sickness, which include health care expenses, lost work, and pain and suffering.
Controlling Non-point Sources of Pollution	
Reduction in die-offs of algae on beaches would improve water clarity. Improved water clarity favors rooted aquatic vegetation that provides important fish habitat.	Improved water clarity would increase the number and enjoyment of visits to Great Lakes beaches. (See text for speculative benefits related to improved water clarity resulting from reduced sedimentation only. See text for benefits of increased sport fish population levels.)
Keep nutrients (i.e., fertilizers) on the land and out of receiving waters. Improved nutrient balance in the Great Lakes, leading to a more stable, productive, and sustainable ecosystem.	Potential improvements in agricultural productivity. Reduced costs for sediment dredging, removal, and disposal. (See text for benefits of increased sport fish population levels.)
Given that harmful algae blooms do well in systems with high inputs of phosphorous (e.g., in Lake Erie and Saginaw Bay), non-point source control efforts likely would reduce beach closures due to water quality issues associated with harmful algae blooms.	Reduced beach closures would increase the quantity of visits to Great Lakes beaches. (See text for benefits of reduced closures that result from bacterial contamination from storm sewer overflows only.)

Note: This table summarizes benefits of the GLRC plan that are not quantified in our report. Our terminology "unquantified" reflects the fact that some benefits of the GLRC plan are literally unquantifiable (e.g., the benefits of preventing an as-yet unknown invasive species), while other benefits were omitted from our analysis due to time constraints. Often, these ecological and economic effects of the GLRC plan are only partially unquantified. For example, we are able to quantify the potential benefits in the sport fishery of some habitat restoration efforts, while the effects of reduced toxic contamination on sport fish populations are unquantified.

Mathematically, the procedure for estimating the increase in property values is straightforward: multiply the total value of property in a position to benefit from the initiative by an estimated percentage increase in value (most likely in the form of a range). This method can be carried out for specific geographic regions, and then summed—reflecting the likelihood that the percentage increase in property values will vary by location—or simply averaged over the entire Great Lakes basin. We adopt the latter approach here, for simplicity, since the objective is more to derive an "order-of-magnitude" estimate rather than one of great (and almost certainly false) precision.

For initial property values, we use values from the 2000 Census for owner-occupied residential property in the metropolitan and other coastal areas of the eight states bordering on the Great Lakes, but adjust them upward for inflation to 2006 dollars using a factor of 1.21. This roughly reflects an average of the cumulative 19.9 percentage point increase in the Consumer Price Index for rental equivalent of urban owner-occupied housing and the 22 percentage point increase in urban areas over that six year period.[75]

We also add an estimate of the value of rental properties, by taking the Census figures for median rent and medium rent-to-income ratios to compute a median income figure for renters in each census tract. We then assume the median and mean incomes to be equal, and multiply the median income by two to arrive at a rough estimate of the mortgage loan amount for which the median renter could qualify (assuming he or she had sufficient funds for the down-payment). We calculate the imputed value of the median (mean) rental property by dividing the loan amount by 0.8, on the assumption that the loan-to-value ratio is 80 percent. The median (mean) rental property value multiplied by the number of rental units is our estimate, per census tract, of the total value of the rental property. We believe the rental values so calculated yield conservative estimates of the true values.

The results are shown in Table 3–4. These results, however, clearly understate the total value of all property in the region as of 2006 since, by definition, the 2000 Census cannot take account of property construction since 2000. Nor does the 2000 Census include the value of commercial property in the areas depicted on the table, which might be equal to or even greater than the cumulative residential figures. For all these reasons, the baseline property values understate the true baseline, and thus lead to an understatement of the economic benefits of the Great Lakes restoration initiative, calculated shortly.

In sum, Table 3–4 illustrates that as of 2000, a total of $173 billion (in 2006 dollars) in residential (owner and renter occupied) housing was located in census tracts directly adjacent to one of the Great Lakes. Another $1.33 trillion in residential property is located in non-coastal census tracts belonging to major metropolitan areas adjacent to one of the Great Lakes. These are the relevant baseline figures from which it is possible to calculate the aggregate improvement in property values that may be attributed to the Great Lakes restoration initiative.

Table 3-4. Value of Residential Property in Selected Areas of States Bordering the Great Lakes (Billions of 2006 Dollars)

Indiana Total		4.6
Gary CT's bordering on the Lakes	2.1	
Rest of Gary MSA	0.0	
Other Indiana CT's bordering on the Lakes	2.5	
Illinois Total		672.3
Chicago CT's bordering on the Lakes	15.4	
Rest of Chicago MSA	593.9	
Other Illinois CT's bordering on the Lakes	63.0	
Michigan Total		425.7
Detroit CT's bordering on the Lakes	4.4	
Rest of Detroit MSA	326.1	
Bay City/Saginaw CT's bordering on the Lakes	1.5	
Rest of Bay City/Saginaw MSA	15.8	
Grand Rapids CT's bordering on the Lakes	6.7	
Rest of Grand Rapids MSA	49.0	
Other Michigan CT's bordering on the Lakes	22.2	
Minnesota Total		9.5
Duluth CT's bordering on the Lakes	1.0	
Rest of Duluth MSA	7.7	
Other Minnesota CT's bordering on the Lakes	0.8	
New York Total		53.9
Buffalo CT's bordering on the Lakes	1.7	
Rest of Buffalo MSA	44.9	
Other New York CT's bordering on the Lakes	7.3	
Ohio Total		200.6
Cleveland CT's bordering on the Lakes	5.8	
Rest of Cleveland MSA	154.5	
Toledo CT's bordering on the Lakes	1.4	
Rest of Toledo MSA	26.9	
Other Ohio CT's bordering on the Lakes	12.0	
Pennsylvania Total		8.1
Erie CT's bordering on the Lakes	3.8	
Rest of Erie MSA	4.3	
Wisconsin Total		133.0
Milwaukee CT's bordering on the Lakes	6.2	
Rest of Milwaukee MSA	85.7	
Green Bay CT's bordering on the Lakes	3.9	
Rest of Green Bay MSA	26.0	
Other Wisconsin CT's bordering on the Lakes	11.2	
Totals		
All CT's bordering on the Lakes		172.9
Metro CT's not bordering on the Lakes		1334.8

CT = Census Tracts
MSA = Metropolitan Statistical Area
Source: Bureau of the Census, 2000 Census; authors' calculations for rental values

As already noted, John Braden and colleagues have conducted extensive analyses of increases in residential real estate values in three Great Lakes cities before or following cleanup activities either on or near the Great Lakes: the Sheboygan River in Wisconsin, Waukegan Harbor in Illinois, and the Buffalo River in New York. In addition, Braden and his team have reviewed the evidence from additional studies of cleanups along the Laurentian Great Lakes, reflected in Table B–7 in Appendix B.[76] Collectively, these studies confirm what one would expect—namely, residential values adjacent to cleanup sites do increase, and that the amount of this increase, in percentage terms, is higher the closer the property is to the cleanup site (or conversely, real estate prices, in the absence of cleanup, are depressed by amounts in the 15–20 percent range). In particular, increases of 15–20 percent in value for properties closest to the sites seem typical.[77] The price increases taper off with distance, usually disappearing within five miles.[78]

For purposes of this study, therefore, we believe it is conservative to apply a 10 percent price increase to property values in census tracts adjacent to the Great Lakes, which would, in 2006 dollars, translate into about $17 billion in additional value. A lower range of average price increase based on the analyses by Braden and his colleagues— conservatively 1–2 percent—would seem appropriate for properties in MSAs that are beyond the coastal census tracts but nonetheless within the zone of possible impacts. Applying this range to the total value of properties in non-coastal MSA properties depicted in Table 3–1 would add an additional $13–27 billion in value.

Combining the two estimates together yields an estimated range of $30 billion to $44 billion in increased property value, and thus economic benefit, from the proposed restoration Great Lakes initiative. This range can be compared to the $18–31 billion range in estimated benefits from summing each of the possible beneficial impacts reviewed in the previous section. As we suggested earlier, it is not surprising that the estimated aggregate increase in property values somewhat exceeds the combined value of the individual benefits, including the estimates attributed to cleanup of the AOCs. This is the case both because the aggregate figure very likely reflects additional benefits that residents assign to the cleanup that are not reflected in the individual benefit categories, and because we are unable to make estimates for all of the benefit categories (benefits such as those depicted in Table 3–8). In addition, the AOC estimates in particular do not take into account individuals living in rental units.

Indeed, we believe the aggregate benefits reported here surely are conservative and understate total benefits for other reasons: because they cannot take account of additional construction since 2006 nor do they take account of all commercial properties in the areas bordering the Great Lakes. When all these supplemental benefits are taken into account, it is conceivable that the total benefits of the plan are likely to exceed $50 billion, or roughly twice the $27 billion present value cost of the GLRC restoration.

Additional Economic Activity

Even this is not the end of the benefits calculations, however. The cleanup and restoration activities embodied in the GLRC are also likely to lead to additional economic activity in the long run well beyond any short-run "multiplier effects" the cleanup itself may generate: commercial and residential construction, retail and other economic operations, among others.[79] These induced economic activity benefits are unlikely to be fully captured in the estimated increases in property values and thus should be viewed, at least in part, as additional to the benefits just described.

In particular, entrepreneurs and established firms will have incentives to undertake additional economic activities once they know that restoration activities are underway or have been completed. With more economic activity, local and state governments will gain additional tax revenue, which can be used to support public services: property taxes on redeveloped and improved property, sales taxes on goods and services sold in new or upgraded commercial establishments, and income taxes on the earnings generated from the construction and ongoing commercial business.[80]

It is difficult to estimate with any precision, however, how much of this follow-on economic activity will take place. However, that it will occur in some magnitude is not in doubt. Evidence from other waterfront cleanups amply demonstrates that cleaner environments definitely do stimulate subsequent economic development.

For example, one of the nation's best-known waterfront restoration projects was in the Baltimore Harbor.[81] The harbor itself was not only cleaned up, but local government support helped create a "festival marketplace"—two indoor shopping malls—together with a convention center, aquarium, and science museum. This initial round of development led to multiple subsequent private efforts. Seven major hotels were constructed between 1981 and 1987, which helped accommodate an explosive growth in the city's tourists, from 2.25 million in 1980 to 7.5 million in 1986. The increased activity in the harbor also led to the construction of additional office buildings and multi-unit residential properties. More recently, two new sports stadiums were added (one for baseball, the other for football). The resurgence of downtown Baltimore is a classic example of how a waterfront project can lead to a snowball of positive follow-on economic activity.

The Boston waterfront restoration project is another prime example of what good can come after a major environmental improvement project. Boston has long been a major port, but its maritime activity declined steadily after World War II. Eventually, federal, state, and local monies were used to purchase abandoned maritime sites, and to improve and revitalize a 7.5-mile stretch of waterfront. Public funds were used for developing mass transit facilities and improving the airport. The public money acted as a magnet for private investment in new housing, hotels, and other commercial establishments. In particular, the Charlestown Navy Yard, closed in 1974, was replaced with mixed-income housing, commercial properties, an aquarium, and a mass transit facility. Harbor Point, a decayed, low-income public housing project was reworked to include improved housing with new roads to downtown. The Rowes Wharf project replaced warehouses with modern office and retail space, a new hotel, and luxury condominiums. In all, $1.5 billion of public investment in the 1970s and 1980s led to $3 billion in private investment.[82] The revitalization of the Boston harbor as part of the "Big Dig" project has been in progress since the early 1990's.

Several major restoration projects already are under way or planned in the Great Lakes region itself. Some, such as the Detroit waterfront restoration will proceed even without further Lakes restoration activities,[83] although the GLRC restoration activities are likely to enhance the prospects that existing efforts will be successful and perhaps extend their reach. As for other projects not yet started, it is notable, as the Director of the Great Lakes Cities Initiative, David Ullrich has indicated, that billions of dollars in waterfront development are ready to flow into the major cities along the Lakes—Rochester, Buffalo, Erie, Cleveland, Toledo, Detroit, Chicago, Gary, Milwaukee, and Duluth—in conjunction with restoration of the Lakes.[84] This additional construction and continuing economic activity generated from the sales and rents of the businesses and residences in these locations represent additional benefits not likely to be reflected in the estimated increase in property values or in the amenities provided by a cleaner Lakes area.

New Technologies

Additional benefits of a different sort and extending well beyond the region itself are also likely to flow from the initiative. Given the greater attention being paid to environmental quality and to sustainable development, there is a growing "environmental market"—that is, a market for technologies used by industry to protect the environment—in both the United States and elsewhere around the world. Especially relevant for this study is the mounting interest around the world in ensuring sufficient clean water to permit economic growth. Cities, states or provinces, and national governments are all keen on finding ways to find, preserve, and restore clean water.

Of particular note here is the rising interest in wastewater treatment, which is a more than $100 billion industry annually worldwide and growing. Thus, a natural question arises: is it possible that in the course of restoring the Great Lakes, new or refined technologies for removing pollutants and bacteria from water will be developed?

We believe that the answer to this question is "yes," though of course no one can be certain of this, or the extent or nature of future technological breakthroughs. For example, technologies developed for the re-use of dredged, treated sediment could be marketed in other parts of the U.S. and around the world, especially to areas adjacent to large bodies of water, which could benefit from technologies used for the Great Lakes restoration.

Separately, in 2005, Michigan's Governor Jennifer Granholm announced that making the state "a worldwide center of research and innovation" was a top state priority and proposed $2 billion in state bonds to achieve this goal. In particular, she cited the fact that whereas once Michigan was strongly identified with the gasoline-powered automobile, in the future the state would be known as one where "wheels run on pollution-free fuel cells or bio-diesel technology; the state where research into alternative energies is done; the state where *clean technology is developed* and where clean cars, products, and businesses are built" (emphasis added).[85]

Other states certainly have expressed interest in using local natural resources to transform their economies. A number of Midwestern states have encouraged or at least hosted companies engaged in the transformation of biomass into means of providing energy. In perhaps a close parallel to the opportunities offered by the unique natural resource of the Great Lakes, one major research institute has fleshed out a proposal to make Arizona a "living laboratory" for broad-based sustainable systems industries. The area's arid land and dry climate are found elsewhere in the world, and thus technologies that might be suited for sustainable development in Arizona could be used in parts of the world with similar climates and environmental conditions.[86]

By the same token, the states bordering the Great Lakes and their leading research universities are ideally positioned to develop and commercialize technologies for conserving water, treating water-based effluents, and for using water in other imaginative ways. These new technologies would not only bring benefits to the people and companies in the region, but to citizens throughout the United States and the world.

IV. The Nation's Stake in Great Lakes Restoration - Who Should Pay and Why?

Normally, the beneficiaries of any major investment program, whether it is private or public, should pay for it. This is both a matter of fairness and efficiency: fairness because to do otherwise would tax individuals or companies who receive no benefits; efficiency because those who stand to benefit and pay for an investment program will have the strongest incentives to ensure that it is undertaken to maximize the benefits at the least cost.

In Chapter 3, we demonstrated that residents, current and future, of the Great Lakes region stand to gain from a major infrastructure program to ensure the vitality of the Lakes and their coastlines—and that the gains, should more than offset the costs. This, however, does not necessarily mean that only those who live in the region should pay for its restoration. Many others throughout the United States—indeed the country as a whole—will reap benefits from such an initiative and thus, should appropriately bear some of its costs.

A More Vibrant National Economy

Economic growth and development is not a zero-sum game, but rather new innovations, new technologies, and productivity improvements ripple through the global economy and create new wealth and whole new industries, raising living standards across the country and the world. As the economy has changed from raw materials based, to industry-based, to knowledge-based—the power of talented, creative people and their clustering in particular places drives and increases overall economic activity. To the degree the Great Lakes region is accelerated as a talent agglomeration center it will contribute to greater economic activity and opportunity for the whole nation.[87]

Regions that today are the most prosperous and are key drivers of the nation's innovation and national economic advantage weren't always thus. Their prosperity and contributions to the nation's economy are hinged in significant part on stewardship and cultivation of unique natural and environmental features comparable to those of the Great Lakes and the "North Coast".

The most prosperous states, with growing real incomes and the greatest share of highly-educated people working in high-education-demanding occupations include almost all of New England, Colorado, and California and Washington State on the West Coast.[88] A generation ago Massachusetts and New Hampshire were called the New Appalachia—as their traditional labor intensive, low-tech manufacturing base evaporated. Vermont became known as much for rural poverty as idyllic Green Mountain beauty.

Armed with similar assets as the Great Lakes (including leading higher education institutions, water, forests, and historical/cultural attributes) these states have purposefully cultivated their natural environs as levers for economic advantage. In the case of Massachusetts, it was cleaning up Boston Harbor, affording public access to its water, and developing the largest state park system for its size. Vermont, which is famous for its zeal in maintaining natural features of the state through aggressive zoning laws and environmental protection, has become a state of choice for educated professionals, is catapulting itself into the front ranks economically. Today Massachusetts and neighboring New Hampshire are among the nation's leading economies—Vermont and Maine (another former economic backwater) have seen 20 years of relative income growth fueled by in-migration of well-educated people craving their special quality of life.

Colorado is an even clearer case. A generation ago the economy of Colorado was meager, based on vestiges of mining and natural resource based industry. By actively preserving and celebrating its incredible Rocky Mountain outdoor environment, Colorado has seen a steady influx of highly-educated citizenry that has today transformed it into one of the most robust economic activity centers in the country.

West Coast communities, including areas like San Francisco Bay, have grown spectacularly, and as the hubs of national innovation (Silicon Valley) in part because of their stunning natural features—an advantage that has been enhanced through the active preservation of open space and water-based recreation (e.g. Point Reyes seashore, Santa Cruz County ocean frontage land preservation) in close proximity to population centers.

Talent in proximity fuels innovation and compounds economic growth. The nation's economy and prosperity is enhanced by the new knowledge and wealth created in burgeoning IT, health, and life sciences, and other fields that have flourished in these communities. Aiding the Great Lakes region's transition to a similarly robust talent center and hothouse should fuel the nation's economic strength as well.

Less Congestion on the Coasts

U.S. population continues to grow, having surpassed 300 million in 2006. But geographically, growth has been very uneven. As depicted in Table 4–1, while population has grown rapidly on both coasts and along the Gulf, it has been essentially stagnant along America's "North Coast," or along the Great Lakes.

Another way to document the unbalanced population growth of coastal states is to rank coastal states in order of population growth, as shown in Table 4–2. Notably, only one Great Lakes state, Michigan, appears in this ranking.

The Coasts have grown rapidly not because birth rates are higher in those states, but because of in-migration, both from U.S. citizens located inland and immigrants who are attracted to the U.S. coastal zone. The reasons for this are varied. Some move because of better job opportunities. Others move to be closer to family members already there. A common denominator in many, if not most, relocations is that the coastal areas offer a huge amenity—nearness to a large body of water, with its recreational and economic attractions.

Table 4 - 1.

Growth of U.S. Population (In Millions)

	East Coast	West Coast	Gulf Coast	Great Lakes	Total U.S.
1970	51.1	22.8	10.0	26.0	203.3
1980	53.7	27.0	13.1	26.0	226.5
1990	59.0	33.2	15.2	25.9	248.7
2000	65.2	37.8	18.0	27.3	281.4

Source: 2000 Census.

Table 4 - 2.

Increase in Coastal State Population Growth from1980-2003

(Millions of People)

State	Number
California	9.9
Florida	7.1
Texas	2.5
Washington (state)	1.7
Virginia	1.6
New York	1.6
New Jersey	1.2
Maryland	1.2
Michigan	0.8
Massachusetts	0.7

Source: Department of Commerce, Bureau of the Census.

Table 4 - 3.

Cities with the Most Traffic Congestion

1. Los Angeles, Long Beach, Santa Ana, California
2. San Francisco, Oakland, California
3. Washington, D.C.
4. Atlanta, Georgia
5. Houston, Texas
6. Dallas, Ft. Worth, Arlington, Texas
7. Chicago, Illinois
8. Detroit, Michigan
9. Riverside, San Bernadino, California
10. Orlando, Florida
11. San Jose, California
12. San Diego, California

Source: David Schrank, *2005 Utility Report* (The Texas Transportation Institute).

The uneven pattern of population growth, however, has consequences both for the regions where growth has been occurring and for the nation as a whole. Within the regions where population is growing most rapidly, so is traffic congestion. Table 4–3 below lists the top twelve cities with the most traffic congestion; most are located in states on or near one of the coasts.

Growing traffic congestion is a serious national problem, not just in the urban and surrounding areas where it already significantly cuts into the quality of life of local residents. The national system of distributing goods and meeting the rigorous demands of just-in-time inventories, one of the major enhancements to U.S. productivity of the last several decades, depends on smoothly and predictably flowing traffic. The Texas Transportation Institute every year calculates the cost of traffic delay to the nation—its most recent estimate, made in 2005, put the total at $65 billion. Traffic congestion leads to more accidents, posing the threat of injury and death, and slows emergency response, which clearly threatens the lives of individuals in need of immediate medical attention.[89]

Traffic is not the only problem generated by rapid population growth. The Western states in particular face a unique problem arising from continued population growth: the shortage of fresh, potable water. In California, where water demand is projected to grow by another 40 percent by the year 2030,[90] measures to assure water supply are already taking an environmental toll. For example, the city of Los Angeles has been forced to reduce water use from Mono Lake after it became clear that water diversions were destroying the Lake's ecosystem and adversely affecting air quality in the area. Proposals to develop water resources in other ways, such as desalinization, are not only costly but create their own environmental difficulties.[91]

Some residents of states with rapid population growth are moving inland, where they create other difficulties. The well known out-migration of some Californians, who have substantial wealth built up from the home equity in their old homes that they then put to use by pushing up real estate prices and real estate taxes in the locations where they move. They can also add to congestion and pressure on limited water supplies as well. Some residents in these locations do not mind and indeed are grateful for the increased value of their homes. Other residents, however, do not appreciate the added congestion or the sacrifices they may have to make to pay the higher real estate taxes that come with higher home prices.

In short, unbalanced population growth can reduce the quality of life for existing residents of locations where such growth is occurring. Measures that make other locations where population levels are stagnant—such as the Great Lakes region—more desirable places to live and work, can rebalance population growth across the country, and in the process, benefit residents in currently high-growth locations. This is one argument for asking much of the country to contribute to efforts to improve the amenities of such areas as the Great Lakes.

Less Exposure to Disaster-Related Costs

As desirable as the East, West, and Gulf Coasts are as places to live, they are also potentially dangerous. The danger arises from the exposure to large natural catastrophes: hurricanes on the East and Gulf coasts, and earthquakes on the West coast. Partly as a result of growing population and construction in these areas, and partly due to natural forces, the ten costliest natural disasters in American history have occurred in the last twenty years, all of them in one or more coastal states, as shown in Table 4–4.

The costs in the table reflect only total insurance claims; in each of these disasters the federal government also provided disaster relief to individuals and families who were uninsured or under-insured and to state and local governments to rebuild damaged infrastructure. Federal disaster relief for victims and the local and state governments adversely affected by Hurricane Katrina alone has already exceeded $100 billion. Taxpayers across the nation have borne and will continue to bear (because disaster relief tends to be funded by federal borrowing, paid for by future generations of taxpayers) the costs of each of the disasters listed in Table 4–3, as well as the cost of natural disasters in the future.

Table 4 - 4.
Costliest Natural Disasters in U.S. History
(Insured Losses, Billions of 2005 Dollars)

Year	Event	Cost
2005	Hurricane Katrina	41.9
1994	Northridge, California earthquake	18.0-27.0
1992	Hurricane Andrew	22.3
1989	San Francisco earthquake	11.4
2005	Hurricane Wilma	10.6
2004	Hurricane Charley	8.0
2004	Hurricane Ivan	7.6
1989	Hurricane Hugo	6.8
2005	Hurricane Rita	5.8
2004	Hurricane Frances	4.9

Source: Insurance Information Institute.

All of this is relevant to the financing of a Great Lakes restoration effort because to the extent the initiative encourages individuals and their families to remain in or move to the region rather than move or live in other parts of the country exposed to natural hazards, it can reduce the extent of damage and disaster relief from future disasters. And because all taxpayers bear a portion of these costs, this provides an additional reason why taxpayers generally should bear at least some of the costs required to improve the livability and attractiveness of the Great Lakes region. In short, the nation as a whole has reason to care about the environmental quality in and near the Great Lakes.

Nonuse Value Of the Great Lakes

Finally, many citizens of the United States will benefit from the knowledge that the Great Lakes will be cleaner as a result of the initiative, even if they do not directly live in or visit the area. It is well established that environmental improvements can lead to significant "nonuse" values.[92] The most important of these have been dubbed "option value" and "existence value." In the context of Great Lakes restoration, option value will accrue to nonresidents to the extent that their future choices for recreation are enhanced by improvements to the natural environment, and that they benefit from the increase in attractive options that they face. Existence value, in contrast, is independent even of the possibility of future use, and derives from a willingness to pay for those improved environments in and of themselves. The distinction can be easily seen with reference to dramatic environmental change. As an example, consider the national response to the Exxon Valdez oil spill that fouled Prince William Sound and other waters and coastlines in Alaska. People far away, with no expectation of ever visiting Alaska, were distressed. Plainly they had a positive willingness to pay to avoid the disaster, and a positive willingness to pay for cleanup. To the extent that they were distressed because of the reduced pleasure that they would derive from a possible trip to the region, their willingness to pay could be classified as option value. To the extent that their distress was simply due to contemplation of oil-covered otters, existence value was in play. What is important is that in both cases there is willingness-to-pay on the part of citizens who are geographically removed from the site.

There has been extended debate among economists about how best to measure nonuse values. Generally, measurement requires experimental or survey techniques, and we know of no studies that bear directly on the overall quality of the Great Lakes. However, many studies find large effects, and a committee chaired by two Nobel prize winners has endorsed the concept of existence value and proposed guidelines for its measurement.[93] It is easy to believe that U.S. residents who live and recreate far from the Great Lakes would be willing to pay for improvement in the quality of the lakes and to avoid further reduction in quality. To the extent that improvement in the environmental quality of the Lakes leads to increases in the populations of endangered, threatened, or highly valued species of birds, fish, and other animals there will also be willingness to pay on the part of citizens who are not part of the Great Lakes population. In each of these cases, relatively small valuations per person would translate into large aggregate willingness to pay.

What Should Be The Federal Contribution?

Clearly, to the extent that residents outside the Great Lakes benefit from any restoration initiative—currently or at some point in the future, for any one or all of the reasons already elaborated—then it is appropriate that they contribute to the cost of the cleanup, along with Great Lakes residents themselves.

But there are precedents of cost-sharing between state and federal governments where the out-of-state benefits are not as clear as in this case. For example, the federal government is currently engaged with the State of Florida in a multi-year $10.5 billion initiative to restore the Everglades. Among its many goals, the project is re-plumbing the Everglades and removing mercury, phosphorous, and other potential hazardous substances that harm wildlife in the area and threaten various endangered species. The main objective of this project is environmental in nature and, to our knowledge, no study has ever been done or even been proposed to document any economic benefits of this initiative, perhaps because economic considerations were never used to justify the project. The preservation of the Everglades simply was deemed to be a project of sufficient national significance—purely on environmental grounds—that federal policymakers believed it was appropriate for the federal government to share equally in the cost of restoring it to its former condition and to sustain its ecosystem into the future. By similar reasoning, the federal government has helped to contribute to the cleanup of the Chesapeake Bay.

Another environmental arena in which the federal government has played an instrumental role is in funding the cleanup of hazardous waste sites under the Superfund program. Although "responsible parties"—those who contributed to the pollution—are typically required to pay much or most of the cost of remediation, the federal government also has typically paid for much of the remainder of the cost leaving the states to pay only a relatively small share.[94] This is the case even though the pollution dangers of individual Superfund sites are localized. The federal government has paid for cleanup because it recognizes there is a *national* interest in having communities reclaim these sites for productive uses in the future.

The Great Lakes' Regional Collaboration Strategy's restoration plan calls for $13.75 billion in federal funding, an amount that falls well within the range of earlier precedents. And more broadly, the GLRC initiative as a whole promises substantially more benefits than costs. A strong case thus exists for having the initiative proceed as promptly as feasible.

Appendix A

Panel of Experts

A panel of experts was convened under the leadership of Donald Scavia and Jennifer Read, Director and Assistant Director of Michigan Sea Grant. The Panel met twice in person and conducted additional analysis and synthesis through email and conference calls. The primary panel members are listed in Table A-1.

Table A-1.
Ecological Team Issue Areas and Team Members

Issue Area	Team Members
Reduce Pathogen and Nutrient Loads from WWT and CSOs	Chuanwu Xi, School of Public Health, University of Michigan
Restore Wetlands and Habitat	Doug Wilcox, U.S. Geological Survey, Great Lakes Science Center
Reduce AIS Impacts	Kristina Donnelly, University of Michigan Erica Jensen, Great Lakes Commission
Reduce Toxic Chemical Pollution Impacts	Gail Krantzberg, McMaster University Olivier Jolliet, School of Public Health, University of Michigan Michael Murray, National Wildlife Federation
Reduce Nutrient and Sediment Pollution Impacts	Stuart Ludsin, NOAA Great Lakes Environmental Research Lab Bo Bunnell, U.S. Geological Survey, Great Lakes Science Center
Improve the Information Base and Track Progress	John Gannon, Great Lakes Regional Office, International Joint Commission
Ecological Economists	Michael Moore, School of Natural Resources and Environment, University of Michigan Frank Lupi, College of Agriculture and Natural Resources, Michigan State University Don Dewees, University of Toronto
At Large Team Members	Mike Donahue, URS Corporation Don Scavia, University of Michigan Jennifer Read, University of Michigan

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Appendix B

Tables Supporting Benefit Estimates in Chapter 3

This Appendix provides the tables that support the various estimates of economic benefits of restoring the Great Lakes.

Table B-1.
Economic Evidence for Amenity-based Worker Mobility

Resource	Affected group	Equivalent price-adjusted wage effect[a]	Source
Proximity to the nearest national park, lakeshore, seashore, or recreation area	U.S full-time urban workers in 1994	4 percent increase per 100 miles closer to amenity	Schmidt and Courant (2006)
Suspended particulate levels within city	U.S urban workers in 1973	0–4 percent decrease per doubling of particulate levels[b]	Roback (1982)
Suspended particulate levels within city	College-educated U.S urban workers in 1973	5–6 percent decrease per doubling of particulate levels[b]	Roback (1988)
Suspended particulate levels within city	U.S. urban workers in 1980	2 percent decrease per doubling of particulate levels[c]	Blomquist et al. (1988)
Water pollution discharge levels within city	U.S. urban workers in 1980	1 percent decrease per doubling of water discharge levels[c]	Blomquist et al. (1988)
Tons of waste deposited in landfills within county	U.S. urban workers in 1980	5 percent decrease per doubling of landfill waste[c]	Blomquist et al. (1988)
Number of Superfund sites within county	U.S. urban workers in 1980	4 percent decrease per doubling of Superfund sites[c]	Blomquist et al. (1988)
Number of hazardous waste treatment, storage, and disposal sites within county	U.S. urban workers in 1980	1 percent decrease per doubling of hazardous sites[c]	Blomquist et al. (1988)

Table B-2.
Benefits of Increasing Fish Catch Rates

Study[a]	Fish species	Lake	Affected angler group	Percent change in catch rate	Benefit per Great Lakes angler day[b]	Benefit per Great Lakes angler day per 1 percent increase in catch rate (cents)
Breffle et al. (1999), SP	All species	Michigan (Green Bay)	Wisconsin anglers near Green Bay in 1998	10 percent	$3.17	32
Breffle et al. (1999), SP	All species	Michigan (Green Bay)	Wisconsin anglers near Green Bay in 1998	100 percent	$15.82	16
Jones and Lupi (2000), RP	Trout and salmon	All Great Lakes	Michigan anglers in 1983-1984	-100 percent	-$2.29	2
Jones and Lupi (2000), RP	Trout and salmon	Michigan	Michigan anglers in 1983-1984	-100 percent	-$1.67	2
Jones and Lupi (2000), RP	Trout and salmon	Michigan	Michigan anglers in 1983-1984	-50 percent	-$1.00	2
Lupi and Hoehn (1997), RP	Trout and salmon	All Great Lakes	Michigan Great Lakes resident anglers in 1994	-33 percent	-$3.06	9
Lyke (1993), RP	Salmon	Michigan	Wisconsin anglers in 1989	-33 percent	-$1.60	5
Jones and Lupi (2000), RP	Trout and salmon	Michigan	Michigan anglers in 1983-1984	-10 percent	-$0.23	2
Jones and Lupi (2000), RP	Trout and salmon	Michigan	Michigan anglers in 1983-1984	10 percent	$0.26	3
Samples and Bishop (1985), RP	Trout and salmon	Michigan	Wisconsin anglers near Lake Michigan in 1979	10 percent	$0.83[c]	8
Breffle et al. (1999), SP	Trout and salmon	Michigan (Green Bay)	Wisconsin anglers near Green Bay in 1998	10 percent	$0.95	10
Provencher and Bishop (1997), RP	Trout and salmon	Michigan (southwest)	Members of two Wisconsin fishing clubs in 1995	20 percent	$1.69[d]	8

Table B-2.
Benefits of Increasing Fish Catch Rates (Cont).

Study[a]	Fish species	Lake	Affected angler group	Percent change in catch rate	Benefit per Great Lakes angler day[b]	Benefit per Great Lakes angler day per 1 percent increase in catch rate (cents)
Chen and Cosslett (1998), RP	Salmon	All Great Lakes	Michigan Great Lakes trout and salmon anglers in 1983-1984	50 percent	$0.88[e]	2
Jones and Lupi (2000), RP	Trout and salmon	Michigan	Michigan anglers in 1983-1984	50 percent	$1.51	3
Jones and Lupi (2000), RP	Trout and salmon	Michigan	Michigan anglers in 1983-1984	100 percent	$3.83	4
Breffle et al. (1999), SP	Trout and salmon	Michigan (Green Bay)	Wisconsin anglers near Green Bay in 1998	100 percent	$4.75	5
Jones and Lupi (2000), RP	Trout and salmon	All Great Lakes	Michigan anglers in 1983-1984	100 percent	$5.20	5
Phaneuf et al. (2000), RP	Lake trout	Michigan	Wisconsin Great Lakes anglers in 1989	-100 percent	-$1.31[f]	1
Lyke (1993), RP	Lake trout	Michigan and Superior	Wisconsin anglers in 1989	-100 percent	-$2.14	2
Lyke (1993), RP	Lake trout	Superior	Wisconsin anglers in 1989	-67 percent	-$0.20	0.30
Lyke (1993), RP	Lake trout	Michigan	Wisconsin anglers in 1989	-50 percent	-$1.00	2
Lyke (1993), SP	Lake trout	Michigan and Superior	Wisconsin Great Lakes trout and salmon anglers in 1989	-50 percent	-$11.38[g]	23
Lupi, Hoehn, and Christie (2003), RP	Lake trout	Huron	Michigan Great Lakes resident anglers in 1994	5 percent	$0.55[h]	11

Table B-2.
Benefits of Increasing Fish Catch Rates (Cont).

Study[a]	Fish species	Lake	Affected angler group	Percent change in catch rate	Benefit per Great Lakes angler day[b]	Benefit per Great Lakes angler day per 1 percent increase in catch rate (cents)
Lupi and Hoehn (1997), RP	Lake trout	Huron	Michigan Great Lakes resident anglers in 1994	100 percent	$0.09	0.09
Lupi and Hoehn (1997), RP	Lake trout	Superior	Michigan Great Lakes resident anglers in 1994	100 percent	$0.17	0.17
Lupi and Hoehn (1997), RP	Lake trout	Michigan	Michigan Great Lakes resident anglers in 1994	100 percent	$0.24	0.24
Lyke (1993), SP	Lake trout	Michigan and Superior	Wisconsin Great Lakes trout and salmon anglers in 1989	Restore naturally producing lake trout	$3.85[i]	
Milliman et al. (1992), SP	Yellow perch	Michigan (Green Bay)	Green Bay anglers in 1983	7 percent	$0.36	5[j]
Breffle et al. (1999), SP	Walleye	Michigan (Green Bay)	Wisconsin anglers near Green Bay in 1998	10 percent	$0.49	5
Breffle et al. (1999), SP	Smallmouth bass	Michigan (Green Bay)	Wisconsin anglers near Green Bay in 1998	10 percent	$0.80	8
Breffle et al. (1999), SP	Yellow perch	Michigan (Green Bay)	Wisconsin anglers near Green Bay in 1998	10 percent	$0.92	9
Milliman et al. (1992), SP	Yellow perch (average size)	Michigan (Green Bay)	Green Bay anglers in 1983	13 percent	$0.55[k]	4
Hushak et al. (1998), RP	Yellow perch	Erie (western basin)	Ohio Lake Erie boat anglers in 1981	50 percent	-$1.20[l]	-2
Hushak et al. (1998), RP	Walleye	Erie (western basin)	Ohio L. Erie boat anglers in 1981	50 percent	$1.91[m]	4

Table B-2.
Benefits of Increasing Fish Catch Rates (Cont).

Study[a]	Fish species	Lake	Affected angler group	Percent change in catch rate	Benefit per Great Lakes angler day[b]	Benefit per Great Lakes angler day per 1 percent increase in catch rate (cents)
Breffle et al. (1999), SP	Walleye	Michigan (Green Bay)	Wisconsin anglers near Green Bay in 1998	100 percent	$2.45	2
Breffle et al. (1999), SP	Smallmouth bass	Michigan (Green Bay)	Wisconsin anglers near Green Bay in 1998	100 percent	$4.01	4
Breffle et al. (1999), SP	Yellow perch	Michigan (Green Bay)	Wisconsin anglers near Green Bay in 1998	100 percent	$4.60	5

References are as follows:

Breffle (1999): William S. Breffle, Edward R. Morey, Robert D. Rowe, Donald M. Waldman, and Sonya M. Wytinck, "Recreational Fishing Damages from Fish Consumption Advisories in the Waters of Green Bay," Report for U.S. Fish and Wildlife Service, U.S. Department of Interior, and U.S. Department of Justice (1999).

Jones and Lupi (2000): Carol A. Jones and Frank Lupi "The Effect of Modeling Substitute Activities on Recreational Benefit Estimates," Marine Resource Economics, 2000, 14: 357–374.

Lupi and Hoehn (1997): Frank Lupi and John P. Hoehn, "A Preliminary Valuation of Lake Trout Using the Existing Michigan Recreational Angling Demand Model," Draft report to the Great Lakes Fishery Commission (1997).

Lyke (1993): Audrey J. Lyke, "Discrete Choice Models to Value Changes in Environmental Quality: A Great Lakes Case Study," Ph.D. Dissertation, University of Wisconsin-Madison (1993).

Samples and Bishop (1985): Samples, Karl C. and Richard C. Bishop, "Estimating the Value of Variations in

Anglers' Success Rates: An Application of the Multiple-Site Travel Cost Method," Marine Resource Economics, 1985, 2 (1): 55–74.

Provencher and Bishop (1997): Provencher, Bill and Richard C. Bishop, "An Estimable Dynamic Model of Recreational Behavior with an Application to Great Lakes Angling," Journal of Environmental Economics and Management, 1997, 33: 107–127.

Chen and Cosslett (1998): Heng Z. Chen and Stephen R. Cosslett, "Environmental Quality Preference and Benefit Estimation in Multinomial Probit Models: A Simulation Approach," American Journal of Agricultural Economics, 1998, 80 (3): 512–520.

Phaneuf, et al (2000): Daniel J. Phaneuf, Catherine L. Kling, and Joseph A. Herriges, "Estimation and Welfare Calculations in a Generalized Corner Solution Model with an Application to Recreational Demand," Review of Economics and Statistics, 2000, 82 (1): 83–92.

Lupi, Hoehn and Christie (2003): Frank Lupi, John P. Hoehn, and Gavin C. Christie, "Using an Economic Model of Recreational Fishing to Evaluate the Benefits of Sea Lamprey (Petromyzon marinus) control on the St. Marys River," Journal of Great Lakes Research, 2003, 29 (Supplement 1): 742–754.

Milliman, et al. (1992): Scott R. Milliman, Barry L. Johnson, Richard C. Bishop, and Kevin J. Boyle, "The Bioeconomics of Resource Rehabilitation: A Commercial-Sport Analysis for a Great Lakes Fishery," Land Economics, 1992, 68 (2): 191–210.

Hushak, et al. (1998): Leroy J. Hushak, Jane M. Winslow, and Nilima Dutta, "Economic Value of Great Lakes Sportfishing: The Case of Private-Boat Fishing in Ohio's Lake Erie," Transactions of the American Fisheries Society, 1998, 117: 363–373.

Lyke (1993), Phaneuf et al. (1998), and Phaneuf et al. (2000) all use the same survey data.

[a] *RP indicates revealed preference study; SP indicates stated preference study.*

[b] *Studies present benefit estimates in various forms. When necessary, we divide annual benefit estimates by 13, the average number of Great Lakes fishing days per Great Lakes angler in 2001 (FWS 2002), we scale statewide averages up by dividing by the fraction of state anglers that were Great Lakes anglers in 2001 (FWS 2002), and we scale fish species averages down by multiplying by the fraction of Great Lakes anglers that targeted that particular species in 2001 (FWS 2002).*

[c] *As reported by Breffle et al. (1999).*

[d] *Midpoint of range based on retired and non-retired anglers that do and do not participate in a large derby.*

[e] *Midpoint of range based on our calculations. Roughly half of Great Lakes anglers are trout and salmon anglers.*

[f] *Based on average of estimates from two separate models.*

[g] *Daily limit falls to one fish from two in Lake Michigan and from three in Lake Superior. Potential strategic bias to overstate valuation.*

[h] *We divided annual aggregate estimate of $10.9 million by total number of Michigan Great Lakes fishing days in 2001 as estimated by FWS (2002).*

[i] *Roughly half of Great Lakes anglers are trout and salmon anglers.*

[j] *Authors' calculations. Effect is only marginally statistically significant.*

[k] *Authors' calculations. Effect is not statistically significant.*

[l] *Authors' calculations. Effect is not statistically significant.*

[m] *Authors' calculations.*

Table B-3.
All-or-Nothing Value of Fishery Resources

Study[a]	Fish species	Lake	Affected angler group	Method[b]	Benefit per Great Lakes angler day[c]
Connelly and Brown (1991), SP	All species	Erie	New York anglers in 1998	Increase cost until demand falls to zero	$4
Lyke (1993), RP	All species	Michigan	Wisconsin anglers in 1989	Eliminate Lake Michigan from choice set	$305
Kealy and Bishop (1986), RP	All species	Michigan	Lake Michigan anglers in 1978	Increase cost until demand falls to zero	$60
Milliman et al. (1992), SP	All species	Michigan (Green Bay)	Green Bay anglers in 1983	Increase cost until demand falls to zero	$47
Connelly and Brown (1991), SP	All species	Niagra River	New York anglers in 1998	Increase cost until demand falls to zero	$1
Connelly and Brown (1991), SP	All species	Ontario	New York anglers in 1998	Increase cost until demand falls to zero	$12
Lyke (1993), RP	All species	Superior	Wisconsin anglers in 1989	Eliminate Lake Superior from choice set	$9
Lupi and Hoehn (1997), RP	Trout and salmon	All Great Lakes	Michigan Great Lakes resident anglers in 1994	Eliminate Great Lakes trout and salmon from choice set	$8
Lupi and Hoehn (1997), RP	Trout and salmon	All Great Lakes and tributaries	Michigan Great Lakes resident anglers in 1994	Eliminate Great Lakes and tributary trout and salmon from choice set	$13
Provencher and Bishop (1997), RP	Trout and salmon	Michigan	Members of two Wisconsin fishing clubs in 1995		$90[d]
Phaneuf et al. (1998), RP	Trout and salmon	Michigan (southern half)	Wisconsin Great Lakes anglers in 1989	Eliminate Lake Michigan (southern half) from choice set	$44[e]

Table B-3.
All-or-Nothing Value of Fishery Resources (Cont).

Study[a]	Fish species	Lake	Affected angler group	Method[b]	Benefit per Great Lakes angler day[c]
Lyke (1993), SP	Trout and salmon	Michigan and Superior	Wisconsin Great Lakes trout and salmon anglers in 1989	Increase cost until demand falls to zero	$24[f]
Phaneuf et al. (2000), RP	Coho salmon	Michigan	Wisconsin Great Lakes anglers in 1989	Catch rates fall to zero	$36[g]
Lupi and Hoehn (1997), RP	Lake trout	Huron	Michigan Great Lakes resident anglers in 1994	Eliminate Lake Huron lake trout from choice set	$0.06
Lupi and Hoehn (1997), RP	Lake trout	Michigan	Michigan Great Lakes resident anglers in 1994	Eliminate Lake Michigan lake trout from choice set	$0.20
Lupi and Hoehn (1997), RP	Lake trout	Superior	Michigan Great Lakes resident anglers in 1994	Eliminate Lake Superior lake trout from choice set	$0.07
Hushak et al. (1988)	Walleye and yellow perch	Erie (central basin)	Ohio Lake Erie boat anglers in 1981	Increase cost until demand falls to zero	$1
Hushak et al. (1988)	Yellow perch	Erie (western basin)	Ohio Lake Erie boat anglers in 1981	Increase cost until demand falls to zero	$9
Hushak et al. (1988)	Walleye	Erie (western basin)	Ohio Lake Erie boat anglers in 1981	Increase cost until demand falls to zero	$12
Menz and Wilton (1983), RP	Bass	Ontario (eastern half)	New York resident bass anglers in 1976	Increase cost until demand falls to zero	$17
Menz and Wilton (1983), RP	Bass	St. Lawrence River	New York resident bass anglers in 1976	Increase cost until demand falls to zero	$26[h]

References not otherwise reported in Table 3–2 are as follows:

Connelly and Brown (1991): Nancy A. Connelly and Tommy L. Brown, "Net Economic Value of the Freshwater Recreational Fisheries of New York," Transactions of the American Fisheries Society, 1991, 120: 770–775.

Kealy and Bishop (1986): Mary Jo Kealy and Richard C. Bishop, "Theoretical and Empirical Specification Issues in Travel Cost Demand Studies, American Journal of Agricultural Economics, 1986, 68 (3): 660–667.

Phaneuf, et al. (1998): Daniel J. Phaneuf, Catherine L. Kling, and Joseph A. Herriges, "Valuing Water Quality Improvements Using Revealed Preference Methods When Corner Solutions Are Present," American Journal of Agricultural Economics, 1998, 80 (5): 1025–1031.

Mentz and Wilton (1983): Fredric C. Menz and Donald P. Wilton, "Alternative Ways to Measure Recreation Values by the Travel Cost Method," American Journal of Agricultural Economics, 1983, 65 (2): 332–336.

Note: Lyke (1993), Phaneuf et al. (1998), and Phaneuf et al. (2000) all use the same survey data.

[a] RP indicates revealed preference study; SP indicates stated preference study.

[b] Refers to how the study modeled the loss of the fishery.

[c] Studies present benefit estimates in various forms. When necessary, we divide annual benefit estimates by 13, the average number of Great Lakes fishing days per Great Lakes angler in 2001 (FWS 2002), we scale statewide averages up by dividing by the fraction of state anglers that were Great Lakes anglers in 2001 (FWS 2002), and we scale fish species averages down by multiplying by the fraction of Great Lakes anglers that targeted that particular species in 2001 (FWS 2002).

[d] Based on average of values of retired and non-retired anglers who do and do not participate in a large derby.

[e] Based on average of estimates from four separate models.

[f] Based on average of estimates from two separate models.

[g] Based on average of estimates from two separate models.

[h] Based on average of estimates for two separate counties.

Table B-4.
Benefits of Decreased Fish Contamination in the Great Lakes

Study	Fish species	Lake	Affected angler group	Contaminant measure	Percent change in contaminant	Benefit per Great Lakes angler day[b]	Benefit per Great Lakes angler day per 1 percent decrease in contaminant (cents)
Phaneuf et al. (1998), RP	Trout and salmon	Michigan and Superior	Wisconsin Great Lakes anglers in 1989	Toxin level in lake trout flesh	-20 percent	$4[c]	22
Phaneuf et al. (2000), RP	Trout and salmon	Michigan and Superior	Wisconsin Great Lakes anglers in 1989	Toxin level in lake trout flesh[d]	-20 percent	$12	62
Kealy and Bishop (1986), RP	All species	Michigan	Lake Michigan anglers in 1978	PCBs	-100 percent	$118[e]	118
Lyke (1993), SP	All species	All Great Lakes	Wisconsin Great Lakes trout and salmon anglers in 1989	Toxins that threaten human health	-100 percent	$58[f]	58
Breffle et al. (1999), SP	All species	Michigan (Green Bay)	Wisconsin anglers near Green Bay in 1998	Various	-100 percent	$5[g]	5
Chen and Cosslett (1998), RP	All species	All Great Lakes	Michigan Great Lakes trout and salmon anglers in 1983-1984	Various	-100 percent	$5	5

References already supplied in earlier tables. This table does not include study by Chen and colleagues, which also estimates value of reduced fish contamination in the Great Lakes. See Heng Z. Chen, Frank Lupi, and J.P. Hoehn, "An Empirical Assessment of Multinomial Probit and Logit Models for Recreational Demand," in J.A. Herriges and C.L. Kling, eds., Valuing Recreation and the Environment (Northampton, MA: Elgar, 1999), pp. 65–120.

[a] *RP indicates revealed preference study; SP indicates stated preference study.*
[b] *Studies present benefit estimates in various forms. When necessary, we divide annual benefit estimates by 13, the average number of Great Lakes fishing days per Great Lakes angler in 2001 (FWS 2002).*
[c] *Based on the average of estimates from four separate models.*
[d] *Toxins equal zero unless respondent was "concerned" about toxins.*
[e] *Based on our calculations using reported coefficient estimates and summary statistics. We assume that concern about PCB contamination is eliminated (i.e., reduced from sample average to sample minimum level).*
[f] *Based on average of estimates from two separate models.*
[g] *Benefit is relative to baseline utility under 1998 contamination levels.*
[h] *Based on average of estimates from three separate models.*

Table B-5.
Benefits of Decreased Fish Contamination Outside the Great Lakes

Study[a]	Fish species	Water resource	Affected angler group	Contaminant measure	Percent change in contaminant	Benefit per angler day[b]	Benefit per angler day per 1 percent decrease in contaminant (cents)
Montgomery and Needelman (1997), RP	All species	New York lakes	New York resident anglers in 1989	Toxic contamination	-100 percent	$2.45	2
Montgomery and Needelman (1997), RP	All species	New York lakes	New York resident anglers in 1989	Acidity-impaired or threatened	-100 percent	$0.52	0.5
Montgomery and Needelman (1997), RP	All species	New York lakes	New York resident anglers in 1989	Toxic contamination and acidity-impaired or threatened	-100 percent	$3.07	3
Lupi and Feather (1998), RP	All species	25 most popular Minnesota inland lakes	Minnesota anglers in 1989	Water clarity	-25 percent	$1.07	4
Kaoru (1995), RP	All species	Albemarle-Pamlico Estuary, North Carolina	Recreational visitors to estuary in 1981-1982	Several water quality indicators	-25 percent	$5.39	22
Kaoru (1995), RP	All species	Albemarle-Pamlico Estuary, North Carolina	Recreational visitors to estuary in 1981-1982	Several water quality indicators	-25 percent	$5.79	23

References not otherwise supplied in earlier tables:

Montgomery and Needelman (1997): Mark Montgomery and Michael Needelman, "The Welfare Effects of Toxic Contamination in Freshwater Fish," Land Economics, 1997, 73 (2): 211–223.

Lupi and Feather (1998): Frank Lupi and Peter M. Feather, "Using Partial Site Aggregation to Reduce Bias in Random Utility Travel Cost Models," Water Resources Research, 1998, 34 (12): 3595–3603.

This table does not include certain other studies that also estimate benefits of reduced fish contamination outside the Great Lakes.

[a] RP indicates revealed preference study; SP indicates stated preference study.

[b] Studies present benefit estimates in various forms. When necessary, we divide annual benefit estimates by 13, the average number of Great Lakes fishing days per Great Lakes angler in 2001 (FWS 2002).

Table B-6.
Estimates of the Value of Cleanup to Local Waterfront Properties

Resource	Affected group	Methodology	Home value effect[a]	Source
Fecal content of water in Chesapeake Bay, Maryland	Anne Arundel County, Maryland waterfront property owners in 1993-1997	Hedonic property values	−0.0002 elasticity −0.0005 elasticity (land value)	Leggett and Bockstael (2000)
Fecal content of water at nearest Lake Erie beach	Property owners in four Ohio counties adjacent to western Lake Erie in 1991-1996	Hedonic property values	-0.004 elasticity[b]	Ara et al. (2006)
Clarity of water at nearest Lake Erie beach	Property owners in four Ohio counties adjacent to western Lake Erie in 1991-1996	Hedonic property values	0.04 elasticity[b]	Ara et al. (2006)

[a] *Effect is for home sales price, including both land and structure, unless otherwise noted.*
[b] *Based on our calculations using reported marginal implicit prices and mean values for variables.*

Table B-7.

Economic Studies of Areas of Concern (AOCs) Cleanup Benefits

AOC	Affected group	Methodology	Home value effect[a]	Other effect[b]	Source
Buffalo River, New York	Homeowners in Erie County, New York within 5 miles of AOC in 2002–2004	Hedonic using market sales prices	5 percent decrease in sales prices due to proximity to AOC		Braden et al. (2006)
Sheboygan River, Wisconsin	Homeowners in Sheboygan County, Wisconsin within 5 miles of AOC	Hedonic using market sales prices	5 percent decrease in sales prices due to proximity to AOC		Braden et al. (2006)
Waukegan harbor, Illinois	Homeowners in Waukegan County, Illinois in 1999–2001	Hedonic using market sales prices	19 percent decrease in sales price due to proximity to AOC[c]		Braden et al (2004)
Grand Calumet River, Indiana	Homeowners near Grand Calumet River in 2003	Hedonic using assessed values	28 percent and 17 percent decrease in value 0-1 blocks and 1-3 blocks from river, respectively[d]		McMillan (2003)[e]
Grand Calumet River, Indiana	Landowners near Grand Calumet river in 2003	Hedonic using assessed values	4 percent decrease in value 0-2 blocks from river[e, f]		McMillan (2003)[g]
Hamilton Harbor, Ontario	Homeowners near Hamilton Harbor in 1983-1996	Hedonic	12 percent decrease in value relative to homes more than 2/3 mile from harbor		Zegarac and Muir (1998)[h]
Buffalo River, New York	Homeowners in Erie County, New York within 5 miles of AOC	Conjoint choice hypothetical payment for home given river cleanup	15 percent increase in payment for home given cleanup		Braden et al. (2006)
Sheboygan River, Wisconsin	Homeowners in Sheboygan County, Wisconsin within 5 miles of AOC	Conjoint choice hypothetical payment for home given river cleanup	10 percent increase in payment for home given cleanup		Braden et al. (2006)

Table B-7.
Economic Studies of Areas of Concern (AOCs) Cleanup Benefits (Cont).

AOC	Affected group	Methodology	Home value effect[a]	Other effect[b]	Source
Waukegan Harbor, Illinois	Homeowners in Waukegan County, Illinois in 2002	Conjoint choice hypothetical payment for home given harbor cleanup	20 percent increase in payment for home given cleanup[i]		Braden et al. (2004)
Fox/Wolf River watershed and lower Green Bay, Wisconsin	Wisconsin households in 1997	Contingent valuation willingness to pay for cleanup of contaminated sediment over 10-20 years	Equivalent of 1 percent of home value[j]	$152 per household annually for full cleanup[k]	Stoll et al. (2002)
Ashtabula Harbor, Ohio	County registered voters in 1997	Vote in hypothetical referendum for tax increase and harbor cleanup	Equivalent of 1 percent of home value[l]	$41 per voter annually	Lichtkoppler and Blaine (1999)

References not otherwise cited elsewhere include:
[a] Property value effects are inclusive of land and structure, unless otherwise noted.
[b] Dollar values have been converted to 2006 dollars using the CPI from the Bureau of Labor Statistics.
[c] Effect is for the city of Waukegan, where homes range from 0.7–4.5 miles from the harbor with a mean distance of 2.5.
[d] Effects are relative to homes 3–4 blocks from river.
[e] Effect is relative to lots 2–4 blocks from river.
[f] That the property value effects in McMillan (2003) are so much larger than the land value effects suggests potential bias in the property value estimates due to some correlated omitted variable, such as quality of construction, which might degrade with proximity to the river.
[g] Assessments are adjusted for "location" but are not tied to market prices.
[h] Results as summarized by Braden et al. (2005).
[i] Based on our calculations using reported mean WTP and home value based on survey of Waukegan and non-Waukegan residents.
[j] Present value in 2000 dollars at 6 percent discount rate for thirty years divided by U.S. median home value from 2000 Census. Study does not report median home value, but reported median income is close to U.S. median.
[k] Based on open-ended valuation questions. Study also estimates WTP for partial cleanup and for Wisconsin households living near water resources using referendum-style questions.
[l] Present value in 2000 dollars at 6 percent discount rate for thirty years divided by median home value in county from 2000 Census. Assumes two voters per household.

Endnotes

[1] Austin is a Non-resident Senior Fellow in the Metropolitan Policy Program at the Brookings Institution and Vice President of the Michigan State Board of Education. Anderson is a Doctoral Candidate in Economics at the University of Michigan. Courant is the Dean of Libraries and Harold T. Shapiro Collegiate Professor of Public Policy at the University of Michigan, as well as Arthur F. Thurnau Professor of Economics and of Information, and former Provost. Litan is a Senior Fellow in the Economic Studies and Global Studies programs at the Brookings Institution and Vice President for Research and Policy at the Kauffman Foundation.

[2] For a thorough guide to the challenges of attracting talented workforces, see "The Battle for Brainpower: A Survey of Talent," *The Economist*, October 7, 2006.

[3] Joseph J. Cortright, *The Young and Restless in a Knowledge Economy* (Chicago, IL: CEOs for Cities, 2005), 5.

[4] These lakes include Lake Erie, Lake Huron, Lake Michigan, Lake Ontario, and Lake Superior.

[5] In this report, "the Great Lakes Basin" refers to the geographic areas in close proximity to the Great Lakes, including portions of the states that border on the Great Lakes—Michigan, Minnesota, Wisconsin, Illinois, Indiana, Ohio, Pennsylvania, and New York. These states, plus the eastern portion of Iowa, West Virginia, Missouri, and Kentucky, were defined as the Great Lakes Region in Brookings' earlier report on the Great Lakes. See The Brookings Institution Metropolitan Policy Program, *The Vital Center: A Federal-State Compact to Renew the Great Lakes Region* (Washington, D.C.: The Brookings Institution, 2006).

[6] Derived from http://www.great-lakes.net/envt/flora-fauna/people.html.

[7] Some of these are more fully elaborated in Chapter 2 of this report.

[8] Edward L. Glaeser, "Reinventing Boston: 1630-2003," *Journal of Economic Geography* 5, no. 2 (April 2005), 119-153.

[9] See http://www.healthylakes.org/news-events/2006/05/07/report-prescription-for-great-lakes-ecosystem-protection-and-restoration

[10] The facts, challenges, and potential solutions and their costs that are discussed in this chapter draw overwhelmingly on *Great Lakes Regional Collaboration Strategy. To Restore and Protect the Great Lakes* (Great Lakes Regional Coalition, December 2005) also available online at http://www.glrc.us/documents/strategy/GLRC_Strategy.pdf. *The Great Lakes Regional Collaboration Strategy* report will be referred to as 'the GLRC Strategy' going forward.

[11] "Executive Order 13112 of February 3, 1999 – Invasive Species," *Federal Register 64*, no. 25 (8 February 1999): 6183-6186. http://www.invasivespecies.gov/laws/eo13112.pdf.

[12] *The Great Lakes Regional Collaboration Strategy*, 17.

[13] *Ibid.*, 23.

[14] For more information, please see Annex 2 of the Great Lakes Water Quality Agreement, available online at http://www.epa.gov/glnpo/glwqa.

[15] See *The Great Lakes Regional Collaboration Strategy*, 41.

[16] The Strategy identifies these cities as likely candidates: Duluth, Milwaukee, Green Bay, Gary, Detroit, Cleveland, Toledo and Buffalo.

[17] The Great Lakes Regional Collaboration Strategy, 59.

[18] See John J. Siegfried, Allen R. Sanderson, and Peter McHenry, "The Economic Impact of Colleges and Universities," working paper, Vanderbilt University, 2005 for a good review of the literature on regional multipliers

[19] Estimate made by Joan Buhrman, spokeswoman for the American Society of Civil Engineers, as quoted in Andy Guy, "Great Lakes Mean Good Jobs," Michigan Land Use Institute, 1 March 2007.

[20] Later in this report, we discuss the possibility that increased Great Lakes activity may serve to reduce population in parts of the country that are overpopulated. Under these conditions, increased economic activity in the Great Lakes may benefit both the Great Lakes and the overpopulated areas of the country. These benefits are conceptually quite different from any multiplier effects discussed here.

[21] Actually, an even tougher question would be to assess whether the $20 billion proposed by the Restoration Strategy represents the *best* use of those funds, or whether alternative uses of that money might yield even greater benefits. The answer to that question would require a detailed benefit analysis of a wide range of possible spending initiatives, a project that is outside the scope of this effort. However, as the analysis in subsequent sections demonstrates, the benefits of this particular initiative are sufficiently substantial in relation to the costs that they establish a strong case for undertaking the activities suggested by the GLRC.

[22] These two methods are discussed in many textbooks that address the topics of environmental economics and benefit-cost analysis. See, e.g. Frank A. Ward, *Environmental and Natural Resource Economics* (New Jersey: Pearson Prentice Hall, 2006).

[23] As noted above, these short term multiplier effects should only be

considered after a decision to invest in the Great Lakes is made; they should not be used as an economic justification for spending on Great Lakes restoration per se.

[24] See, e.g. Jennifer Roback, "Wages, Rents, and Quality of Life," *Journal of Political Economy* 90 (1982): 1257-1278; Jennifer Roback, "Wages, Rents and Amenities: Differences among Workers and Regions," *Economic Inquiry*, 26 (1988): 23–41; and Glenn C. Blomquist, Mark C. Berger, and John P. Hoehn, "New Estimates of Life in Urban Areas," *American Economic Review* 78 (1988): 89–107.

[25] See Soren T. Anderson and Sarah E. West, "Open Space, Residential Property Values, and Spatial Context," *Regional Science and Urban Economics* 36, no. 6 (2006): 773–789 and Kenneth Y. Chay and Michael Greenstone, "Does Air Quality Matter? Evidence from the Housing Market," *Journal of Political Economy* 113 (2005): 376–424.

[26] Paul Courant and Lucille G. Schmidt, "Sometimes Close is Good Enough," *Journal of Regional Science* 46, no. 5 (December 2006): 931–951.

[27] Panel members and participants in the case studies, as well as additional expert consultants, are listed in Appendix A.

[28] Potentially impacted values/services were grouped under three headings: ecosystem services (e.g., erosion control and source water purification costs); quality of life (e.g., eco-tourism activities, hunting, and fishing); and human health (e.g., beaches opening/safety).

[29] See Donald Scavia et al., "Climate Change Impacts on U.S. Coastal and Marine Ecosystems," *Estuaries*, 25, no. 2 (2002): 149–164.

[30] George W. Kling et al, *Confronting Climate Change in the Great Lakes Region* (Cambridge, MA: Union of Concerned Scientists, 2003). See also the revised Executive Summary (George W. Kling et al, *Confronting Climate Change in the Great Lakes Region, Revised Executive Summary* (Cambridge, MA: Union of Concerned Scientists, 2005).) http://www.ucsusa.org/greatlakes/glchallengereport.html.

[31] This range reflects a number of scenarios and assumptions developed by our panel of scientific experts based on their best professional judgment and the limited availability of direct empirical evidence. Also, this estimate by the expert panel relies crucially on the assumption that the benefits of GLRC plan spending will continue indefinitely. Although this is likely a good approximation in the case of one-time expenditures on improved sewer systems and other long-lived infrastructure, it may not be a good approximation for various programs that require ongoing funding beyond five years. We calculate that accounting for such ongoing costs in the GLRC plan where it is possible to do so increases the present discounted value of the plan's appropriations by roughly one-third.

[32] Central values are weighted averages based on individual estimates, where each individual estimate is weighted by the fraction of Great Lakes fishing days attributable to the particular lake and the fraction of Great Lakes fishing days attributable to the particular species on which the individual estimate is based.

[33] Estimated number of Great Lakes fishing days by U.S. anglers is based on survey data from U.S. Fish and Wildlife Service, "National Survey of Fishing, Hunting, and Wildlife-Associated Recreation," (2001), http://federalaid.fws.gov/surveys/surveys.html.

[34] These estimates are based on studies that generally contemplate uniform percentage increases in fish abundance across the Great Lakes. In fact, much of the spending in the GLRC plan would be allocated for storm and wastewater treatment upgrades in population centers in the Great Lakes basin, and so it is possible, though by no means guaranteed, that increases in fish abundance also will be concentrated near populated areas. To the extent that increases in fish abundance are concentrated near urban areas, benefits to anglers could be considerably higher than estimated above, because about 70 percent of Great Lakes anglers reside in urbanized areas. All else equal, increasing the quality of a fishery is more valuable if that fishery is accessible to a greater number of potential anglers. On the other hand, a large portion of GLRC spending would be allocated for habitat restoration and sediment management in watersheds that are not necessarily associated with large population centers.

[35] Daniel R. Talhelm, "Economics of Great Lakes Fisheries: A 1985 Assessment," *Great Lakes Fishery Commission Technical Report No. 54*, November 1988.

[36] Some of the estimates in Table B-2 factor directly into the Talhelm estimate.

[37] Richard Aiken and Genevieve Pullis La Rouche, *Net Economic Values for Wildlife-Related Recreation in 2001: Addendum to the 2001 National Survey of Fishing, Hunting and Wildlife-Associated Recreation,* (Washington, D.C.: U.S. Fish and Wildlife Service Division of Federal Aid, 2003).

[38] See Erika S. Jensen, Kristina Donnelly, and Jennifer Read, "Ecological Consequences of Aquatic Invasive Species: Zebra Mussel Case Study," Unpublished paper on file with Jennifer Read, University of Michigan, 2007.

[39] Yoshiaki Kaoru, "Measuring Marine Recreation Benefits of Water Quality Improvements by the Nested Random Utility Model,"

Resource and Energy Economics 17 (2005): 119–136 and Yoshiaki Kaoru, V. Kerry Smith, and Jin Long Liu, "Using Random Utility Models to Estimate the Recreational Value of Estuarine Resources," *American Journal of Agricultural Economics* 77, no. 1 (1995): 141–151.

[40] Frank R. Lichtkoppler, Chuck Pistis, and Diane Kuehn, "The Great Lakes Charter Fishing Industry in 2002," (Ohio, Great Lakes Sea Grant Network, 2003).

[41] See, eg. Lori G. Kletzer, *Job Loss from Imports: Measuring the Costs* (Washington, D.C.: Institute for International Economics, 2001).

[42] Thomas P. Holmes, "The Offsite Impact of Soil Erosion on the Water Treatment Industry," *Land Economics* 64, no. 4 (1988): 356–366.

[43] David Dearmont, Bruce A. McCarl, and Deborah A. Tolman, "Costs of Water Treatment Due to Diminished Water Quality: A Case Study in Texas," *Water Resources Research*, 34, no. 4 (1987): 849–853.

[44] W.B. Moore and B.A. McCarl, "Off-site Costs of Soil Erosion: A Case Study in the Willamette Valley," *Western Journal of Agricultural Economics* 12 (1987): 42–49.

[45] D.L. Forster and C.P. Bardos, "Soil erosion and water treatment costs," *Journal of Soil and Water Conservation* 42, no. 5 (1987): 349-352. The results from Moore and McCarl (1987) and Forster et al. (1987) as discussed in Dearmont et al. (1998).

[46] According to the U.S. Census, municipalities in Great Lakes states spent $4.5 billion on operation and maintenance of water supply systems in 2002 in 2006 dollars. These costs include acquisition and distribution of water to the general public or to other local governments for domestic or industrial use. About 28 percent of the people in these states live in the Great Lakes drainage basin. (We obtained the total number of state residents in 2000 from U.S. Census (www.census.gov) and the number of basin residents in 2000 from Great Lakes Information Network, "People in the Great Lakes Region," http://www.great-lakes.net/envt/flora-fauna/people.html.) About 47 percent of basin residents depend on the Great Lakes for their drinking water, according to the EPA. (See U.S. Environmental Protection Agency, "The Great Lakes Binational Toxics Strategy," http://www.epa.gov/glnpo/p2/bns.html.) This implies that about 13 percent of Great Lakes states residents depend on the Great Lakes for their drinking water. Assuming that municipal water utility costs per capita are roughly uniform within these states, 13 percent of $4.5 billion implies total water utility operating costs of about $600 million for municipalities that rely on Great Lakes water.

[47] Natural Resources Defense Council, "Testing the Waters: A Guide to Beach Quality at Vacation Beaches, 2005," www.nrdc.org/water/oceans/ttw/sumgreatlakes.pdf.

[48] Chris Murray, Brent Sohngen, and Linwood Pendleton, "Valuing Water Quality Advisories and Beach Amenities in the Great Lakes," *Water Resources Research* 37, no. 10 (2001): 2583–2590.

[49] Estimates are based on Vernon R. Leeworthy and Peter C. Wiley, *National Survey on Recreation and the Environment 2000: Current Participation Patterns in Marine Recreation* (Silver Spring, Maryland: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Ocean Service Special Projects, November 2001), http://marineeconomics.noaa.gov/NSRE/NSRE_2.pdf, and on U.S. Census data for coastal counties from National Oceanic and Atmospheric Administration, "Spatial Trends in Coastal Socioeconomics, Coastal Watershed County Facts," http://marineeconomics.noaa.gov/socioeconomics/czcounties/cz_pop_housing/cz_county_mainpage.html. We calculated the ratio of marine (i.e., ocean) beach swimmers and marine beach swimming days to marine coastal county population for marine coastal states with similar swimming season lengths as in the Great Lakes. These states include Connecticut, Delaware, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Oregon, Rhode Island, Virginia, and Washington. The ratio of swimmers to coastal population was 0.43, and the ratio of swimming days to population was 4.4. We then multiplied these ratios by Great Lakes coastal county population levels to obtain estimates of Great Lakes beach swimmers and swimming days.

[50] We also estimate 21 million swimming days in Michigan, whose whole western shore is one long string of beaches, many of which reportedly draw more than 1 million visits annually. We estimate 12 million swimming days in Ohio, 11 million in New York, 9 million in Wisconsin, and 1 million in Minnesota. We are fairly confident that Minnesota is a gross overestimate. But 1 million swimming days is well within the rounding error of our overall estimate.

- 1.7 million per year to Indiana's beaches from Sea Grant, University of Southern California, "Summaries of Sea Grant Network Efforts on the Urban Coast," http://www.usc.edu/org/seagrant/UrbanCoasts/summaries.html.
- 27 million per year in Chicago from Illinois Government News Network, "Quinn Proposes 'Clean Beach Initiative' Encouraging Illinois Citizens to Help Keep Beaches Open," http://www.illinois.gov/PressReleases/ShowPressRelease.cfm?SubjectID=1&RecNum=3187.

- Over 1 million per year in western Michigan from *Comprehensive Economic Development Strategy Annual Report*, West Michigan Shoreline Regional Development Commission, September 2005, http://www.wmsrdc.org/download/CEDS.pdf.
- 4 million per year to Presque Isle in Pennsylvania from U.S. Environmental Protection Agency, "Beach Sampling in Pennsylvania (Lake Erie)," http://www.epa.gov/reg3esd1/coast/beachpa.htm.
- 1 million visitors per year to Grand Haven State Park in Michigan from Michigan Information, "Michigan State Parks Southwest Lower Peninsula," http://www.usaring.com/travel/dnr/parkswlp.htm.
- 2 million visitors per year to Sleeping Bear Dunes in Michigan and 2 million visitors per year to Indiana Dunes in Indiana from Alliance for the Great Lakes, "An Advocate's Field Guide to Protecting Lake Michigan," http://www.greatlakes.org/field_guide/habitat_sand.asp.
- 2.5 million visitors per year to Illinois Beach State Park in Illinois from Gary Thomas, "Illinois Beach State Park," Northern Star, August 2002, http://www.lib.niu.edu/ipo/2002/oi020808.html.
- 60 million visitors per year to state, provincial, and national parks on the Great Lakes from U.S. Environmental Protection Agency, "Great Lakes Monitoring: Where Would We Be Without the Great Lakes?," http://www.epa.gov/glnpo/monitoring/great_minds_great_lakes/social_studies/without.html.

[51] Christopher G. Leggett and Nancy E. Bockstael, "Evidence of the Effects of Water Quality on Residential Land Prices," *Journal of Environmental Economics and Management* 39 (2000): 121–144.

[52] Shihomi Ara, Elena Irwin, and Timothy Haab, "Measuring the Effects of Lake Erie Water Quality in Spatial Hedonic Models," paper prepared for presentation at the Third World Congress of Environmental and Resource Economists, Kyoto, Japan, 2006.

[53] National Oceanic and Atmospheric Administration. "Spatial Trends in Coastal Socioeconomics, Coastal Watershed County Facts." http://marineeconomics.noaa.gov/socioeconomics/czcounties/cw_pop_housing/cw_mainpage.html.

[54] Holmes, 356-366.

[55] Current regulations aim for relatively constant lake levels through manipulation of flows over dams.

[56] In addition to the effects of wetland habitat restoration, the decline in contaminants in sediments should facilitate the continued rebound of the bald eagle. Moreover, improved water clarity also benefits rooted submerged plants in shallow waters, which provide habitat for birds and other wildlife. Our panel of ecological experts was unable to quantify these specific effects.

[57] Genevieve Pullis La Rouche, *Birding in the United States: A Demographic and Economic Analysis: Addendum to the 2001 National Survey of Fishing, Hunting and Wildlife-Associated Recreation* (Washington, D.C.: U.S. Fish and Wildlife Service Division of Federal Aid, 2003).

[58] This is based on the earlier estimate that approximately 28 percent of people living in Great Lakes states live in the Great Lakes Basin.

[59] La Rouche and Pullis (2003)

[60] *Ibid.*

[61] *Ibid.*

[62] *Ibid.*

[63] Arun Upneja, Elwood L. Shafer, WonSeok Seo, and Jihwan Yoon, "Economic Benefits of Sport Fishing and Angler Wildlife Watching in Pennsylvania," *Journal of Travel Research* 40 (2001): 68-78.

[64] See Paul I. Padding, Kenneth D. Richkus, Mary T. Moore, Elwood M. Martin, Sheri S. Williams, and Howard L. Spriggs, *Migratory Bird Hunting Activity and Harvest During the 2004 and 2005 Hunting Seasons Preliminary Estimates* (Laurel, MD: U.S. Fish and Wildlife Service Division of Migratory Bird Management, Branch of Harvest Surveys, July 2006). There were about 2.3 million and 1.9 million days of duck hunting in the Great Lakes states in 2004 and 2005, respectively, and about 1.8 million and 1.7 million days of goose hunting in those respective years. This implies as much as 4.2 million and 3.6 million days of waterfowl hunting in 2004 and 2005, respectively. While there is substantial overlap in the duck and goose hunting seasons, it is not clear to what degree individual waterfowl hunters target both ducks and geese on the same days. These estimates are consistent with *2001 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation*.U.S. (Washington, D.C.: Department of the Interior, Fish and Wildlife Service and U.S. Department of Commerce, U.S. Census Bureau, 2002), which estimates that there were 7 million migratory bird hunting trips in these states in 2000, of which at least 62 percent were for ducks and 36 percent were for geese.

[65] See Christopher Gan and E. Jane Luzar, "A Conjoint Analysis of Waterfowl Hunting in Louisiana," *Journal of Agricultural and Applied Economics* 25, no. 2 (1993): 36–45.

[66] Daily duck limits are six in Michigan (see Michigan Department of Natural Resources, "Season and Bag Limits," http://www.michigan.gov/dnr/0,1607,7-153-10363_10859_32209-31173--,00.html.), six in Ohio (Ohio Department of Natural Resources, "Hunting Season and Bag Limits," http://www.dnr.state.oh.us/wildlife/regs/seasons&baglimits.htm.), six in Wisconsin (Wisconsin Department of Natural Resources, "2005 waterfowl

seasons set," http://www.dnr.state.wi.us/org/caer/ce/news/rbnews/2005/081705co1.htm.), four in Minnesota (*Waterfowl Hunting Regulations* (St. Paul, MN: Minnesota Department of Natural Resources, Fish and Wildlife Division, 2006), http://files.dnr.state.mn.us/rlp/regulations/hunting/2006/waterfowl_sup.pdf.), six in Illinois (Illinois Department of Natural Resources, "Illinois Waterfowl Hunting Seasons Announced," http://dnr.state.il.us/pubaffairs/2006/july/WaterfowlSeasonDates.htm.), and six in Indiana (Indiana Department of Natural Resources. "Hunting, Waterfowl Season," http://www.in.gov/dnr/fishwild/huntguide1/wtrfowl.htm.).

[67] This is based on an average values generated by alternative statistical models. See Joseph Cooper and John Loomis, "Testing Whether Waterfowl Hunting Benefits Increase with Great Water Deliveries to Wetlands," *Environmental and Resource Economics* 3 (1993): 545–561.

[68] John Braden, DooHwan Won, Laura O. Taylor, Nicole Mays, and Allegra Cangelosi, "Economic Benefits of AOC Remediation: Review of the Evidence," Unpublished manuscript on file with authors, accepted at the *American Journal on Agricultural Economics*, June 2005.

[69] John Braden, Laura O. Taylor, DooHwan Won, Nicole Mays, Allegra Cangelosi, and Arianto A. Patunru, "Economic Benefits of Sediment Remediation (Sheboygan River and Buffalo River)," *Final Report for Project GL-96553601* (Chicago, IL: Great Lakes National Program Office, U.S. Environmental Protection Agency, December 2006).

[70] Most of the hedonic studies of AOCs estimate the contemporaneous relationship between property values and proximity to AOCs. The obvious limitation of such studies is that it is unclear whether differences in property value reflect the negative effects of AOCs or other correlated factors, such as the presence of large industrial facilities. Zegarac and Muir (1998) partially address this issue by comparing the change in property values near an AOC in Hamilton, Ontario that received remediation to the change in property values elsewhere in the city. They find that property values near the AOC increased by 12 percent relative to other areas of the city. However, property value changes in other areas of the city may not be a good control for what is happening near an AOC. The ideal study would compare property value changes near AOCs that receive remediation to property value changes near AOCs that do not receive remediation, where remediation is assigned at random.

[71] John R. Stoll, Richard C. Bishop, and J. Philip Keillor, *Estimating Economic Benefits of Cleaning Up Contaminated Sediments in Great Lakes Areas of Concern* (Madison, WI: University of Wisconsin Sea Grant Institute, 2002).

[72] Total is for housing units in Great Lakes basin counties in Illinois, Indiana, Michigan, Minnesota, Ohio, and Wisconsin, as well as housing units in coastal counties in New York and Pennsylvania. We have not attempted to identify New York and Pennsylvania counties that are in the Great Lakes basin other than those adjacent to the coast. Figures are based on 2000 U.S. Census Data from National Oceanic and Atmospheric Administration. "Spatial Trends in Coastal Socioeconomics, Coastal Watershed County Facts." http://marineeconomics.noaa.gov/socioeconomics/czcounties/cw_pop_housing/cw_mainpage.html.

[73] The range reflects the 10-20 year time period.

[74] We are unable to quantify the benefits of reductions in toxic contamination of fish in the section on fisheries above. The fact that these benefits are at least partially reflected in the survey-based benefit estimates for AOC sediment remediation therefore does not represent a double count.

[75] The CPI figures are taken from Chairman of the Council of Economic Advisors, *Economic Report of the President, 2007* (Washington, DC: U.S. Government Printing Office, February 2007).

[76] Braden (2006); Braden (2005).

[77] One statistical study that relied on surveys of homeowners of what they were willing to pay for a cleanup of the harbor in Waukegan, found values as high as 20 percent of the current market value of the respondents' residences. See Arianto A. Patunru, John R. Braden, and Sudip Chattopadhyav, "Who Cares About Environmental Stigmas and Does It Matter? A Latent Segmentation Analysis of Stated Preferences for Real Estate," unpublished paper on file with the authors.

[78] This finding—that distance from cleanup matters for property values—is also confirmed by Shihomi Ara, Elena Irwin, and Timothy Haab, "The Influence of Water Quality on the Housing Price Around Lake Erie," draft manuscript on file with the authors, January 2006.

[79] As discussed earlier in the text, the short-run multiplier effects of the restoration initiative are analogous to any fiscal stimulus, where the additional dollars of the initial spending lead to subsequent short run spending by those who receive the initial payments. Broadly speaking, economists have measured the fiscal multiplier in the range of 2:1, meaning that for every dollar of government spending, another dollar of private spending, on net, is generated. A

similar effect should happen here, except not all of the initial or subsequent spending would occur in the Great Lakes region itself. Some of restoration monies, for example, "leak" outside to suppliers outside the region (or perhaps even outside the country, where equipment and materials must be imported), which would keep any short-run multiplier within the region below the typical 2:1 ratio. In any event, the subsequent economic activity we describe in this section is not the usual short-run multiplier spending, but rather the longer-run economic activity that would be generated once people and firms know the waterfronts and the water itself is cleaner.

[80] In a less than fully employed national economy, the additional local economic activity will also generate additional federal tax revenue. If, however, the economy is already fully employed—that is, the national unemployment rate is consistent with a stable inflation rate—then any additional activity from restoration activity in the Great Lakes, in principle, should be offset by dampened growth elsewhere in the economy, due to countervailing actions taken by the Federal Reserve to keep the national growth rate stable, so that inflation remains stable.

[81] Christopher Law, "Urban Revitalisation, Public Policy and the Redevelopment of Redundant Port Zones: Lessons from Baltimore and Machester," in *Revitalizing the Waterfront: International Dimensions of Dockland Redevelopment*, Hoyle, B.S., D.A. Pinder, and M.S. Husain, eds. (London: Belhaven Press, 1988), 156.

[82] Tunbridge, John, "Policy Convergence on the Waterfront? A Comparative Assessment of North American Revitalization Strategies," in Hoyle (1988), 70–74.

[83] See "The Lowdown on Motown," *The Economist*, 3 February 2007, 29-30.

[84] *Ibid.* See also Ara, et al. (2006b), who note that economic development in the 1980s and 1990s around Lake Erie was stimulated by cleanup of the Lake in the 1970s and 1980s.

[85] Quoted in Andy Guy, "The Ultimate Water Park," *Water Works: Michigan Land Use Institute Special Report*, May 2005, 2–3.

[86] Battelle Memorial Institute, *Positioning Arizona for the Next Big Technology Wave: Development and Investment Prospectus to Create a Sustainable Systems Industry in Arizona* (Phoenix, AZ: Arizona Department of Commerce, December 2003).

[87] Of course, this is only true to the extent that the gains in the Great Lakes region exceed any losses in opportunities that may not be realized in other locations because of talent migration (or retention) in the Great Lakes.

[88] See Glazer-Grimes Analysis, *A New Agenda for Michigan* (Ann Arbor, MI: Michigan Future, Inc., 2006).

[89] See W. Wierville, et al., *Identification and Evaluation of Driver Error* (McLean, VA: Federal Highway Administration, August 2002) and Robert Davis, "Six Minutes to Live or Die: Many Lives are Lost Across USA Because Emergency Services Fail," *USA Today*, July 28, 2003.

[90] *Does California Have The Water to Support Population Growth?* (San Fransisco, CA: Public Policy Institute of California, 2005) summarizing Hanak, Ellen. *Water for Growth: California's New Frontier*. San Fransisco, CA: Public Policy Institute of California, 2005.

[91] California Coastal Commission, "Seawater Desalinization and California Coastal Act" (2004), http:www.coastal.ca.gov/energy/14a-3-2004-desalination.pdf.

[92] See, A. Myrick Freeman III, *The Measurement of Environmental and Resource Values: Theory and Method,* 2nd Edition (Washington D.C.: Resources for the Future, 2003), Chapter 5, for a summary and exposition of this literature.

[93] Kenneth Arrow, Robert Solow, et.al., *Report of the NOAA Panel on Contingent Valuation* (Washington D.C.: National Oceanic and Atmospheric Administration, 2003).

[94] See The Congressional Budget Office, "The Total Costs of Cleaning Up Non-federal Superfund Sites" (Washington, D.C.: U.S. Government Printing Office, 1994), http://www.cbo.gov/ftpdocs/48xx/doc4845/doc05.pdf.

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