Socioeconomic Impacts of the Great Lakes Restoration Initiative

University of Michigan Research Seminar in Quantitative Economics

September 30, 2018

Contents

Executive Summary

This report analyzes the economic impacts of the funding provided by the Great Lakes Restoration Initiative (GLRI) from 2010 through 2016 on the Great Lakes region using a combination of econometric analysis (looking back in time) and regional economic modelling (looking back in time and projecting into the future); the study was conducted by a team of economists at the University of Michigan's Research Seminar in Quantitative Economics.

We estimated that there was a total of $1.4 billion in federal spending on GLRI projects in the Great Lakes states between 2010 and 2016. Matching funds, primarily from state and local governments, contributed an estimated additional $360 million in funding, bringing total spending on GLRI projects in the Great Lakes states to $1.7 billion. [1]

Some key results from the study were:

- Every dollar of federal spending on projects funded under the GLRI from 2010–2016 will produce a total of $3.35 of additional economic output in the Great Lakes region through 2036.
- Every dollar of GLRI spending from 2010–2016 increased local house prices by $1.08, suggesting that GLRI projects provided amenities that were valuable to local residents.
- Additional tourism activity generated by the GLRI in the Great Lakes region will increase regional economic output by $1.62 from 2010–2036 for every $1.00 in federal government spending, nearly half of the total increase we estimated.
- The GLRI created or supported an average of 5,180 jobs per year and increased personal income by an average of $250 million per year in the Great Lakes region from 2010–2016.

We employed a conservative approach to modelling the regional economic impacts of the GLRI, and we believe that our estimates are likely to understate the program's true impacts. Although the GLRI was designed and implemented as an environmental restoration program, rather than an economic development program, it nonetheless produced economic benefits for the Great Lakes region that were on par with more traditional economic stimulus measures.

[1] Throughout this report, all spending and economic output quantities are reported in inflation-adjusted 2009 dollars unless otherwise noted. Also unless otherwise noted, economic impacts through 2036 are reported as present discounted values from the perspective of 2016 using a 3.5 percent annual real discount rate. The Great Lakes region comprises the eight Great Lakes states: Illinois, Indiana, Michigan, Minnesota, New York, Ohio, Pennsylvania, and Wisconsin.

Background for this Report

This report summarizes the results of an analysis of the Great Lakes Restoration Initiative's (GLRI's) economic impacts on the Great Lakes region conducted by a team of economists at the University of Michigan's Research Seminar in Quantitative Economics. We examined the impacts of GLRI projects that started during the years 2010–2016. To capture the long-term costs and benefits of the program, we chose an evaluation period that extended twenty years after the start of the final projects that we considered, so that our study period encompasses the years 2010–2036 but does not include funding new projects beyond 2016.

The study's research design benefitted greatly from the input of an Expert Panel of reviewers composed of five economists who are recognized authorities with diverse and relevant expertise. Appendix A: Expert Panel Process describes the Expert Panel process in detail.

The study's research design and some modelling choices were also informed by the work of two teams that conducted case studies in local Great Lakes communities. One of the teams conducted primarily qualitative case studies, while the other team conducted quantitative case studies.

Appendix B: Project Teams and Appendix C: Semi-structured Interview Questions describe the work of the case study teams in more detail.

The project team that coordinated the work of the case study teams and the economic impact analysis in this report was headed by staff at the Great Lakes Commission and the Council of Great Lakes Industries. Additionally, staff from the U.S. Environmental Protection Agency's Great Lakes National Program Office provided help with data and guidance on analytical assumptions. Additional data regarding detailed project spending was provided by the Great Lakes Commission and Michigan Department of Natural Resources, Office of the Great Lakes.

The participation and input of personnel from those organizations does not imply any responsibility for the conclusions in this report, which are the sole responsibility of the University of Michigan's Research Seminar in Quantitative Economics.

Economic Background for the Great Lakes Region

The Great Lakes region's economic background provides context for the impact of the GLRI.[2] In the four decades prior to the start of the GLRI in 2010, the Great Lakes region experienced substantial economic and demographic strains, substantially lagging the United States in terms of employment and population growth.

Table 1 documents the long-run economic and demographic trends in the Great Lakes region relative to the United States. From 1970 to 1980, the Bureau of Economic Analysis (BEA) estimates that employment in the United States grew by 24.9 percent. Employment in the Great Lakes states grew less than half as quickly, both in the watershed counties and elsewhere in the states. The region fared a bit better in the 1980s and 1990s, but still lagged the nation very substantially in employment growth. A

[2] This report uses two different definitions of the Great Lakes region. The first is the set of U.S. counties that contain some part of the Great Lakes watershed, hereafter the "watershed counties." The second is the set of eight states that contain part of the watershed: Illinois, Indiana, Michigan, Minnesota, New York, Ohio, Pennsylvania, and Wisconsin, hereafter the "Great Lakes states."

sharp employment slowdown in the 2000s saw growth for the whole United States fall to just 4.6 percent, but led to an outright decline of 0.5 percent in the Great Lakes states. The watershed counties fared even worse, losing a full 6 percent of their employment in that time. For comparison, from the business cycle peak in 2007 to the cyclical trough in 2010, the BEA estimates that national employment declined by 3.8 percent. It therefore seems reasonable to describe the employment situation in the Great Lakes region from 2000 to 2010 as a full-blown, if slow-moving, crisis.

The pattern of population growth in the Great Lakes region from 1970 to 2010 was potentially even more troubling. During the 1970s, as population in the United States grew 11.5 percent, population in the Great Lakes states grew by only 1.3 percent, and by only 0.8 percent in the watershed counties. The Great Lakes states grew slightly faster in the 1980s, 1.6 percent, but population growth slowed in the watershed counties to just 0.2 percent for the decade. Regional population growth rebounded in the 1990s, as the population of the Great Lakes states overall grew 6.6 percent, and the watershed counties grew 5.2 percent. Still, those numbers substantially lagged the national growth rate of 13 percent. The relatively strong performance of the 1990s was followed by a particularly difficult decade from 2000 to 2010. Although the national population grew 9.6 percent during the decade, the Great Lakes states grew only 2.4 percent. The population of the watershed counties suffered an outright decline in that time, contracting by 0.2 percent.

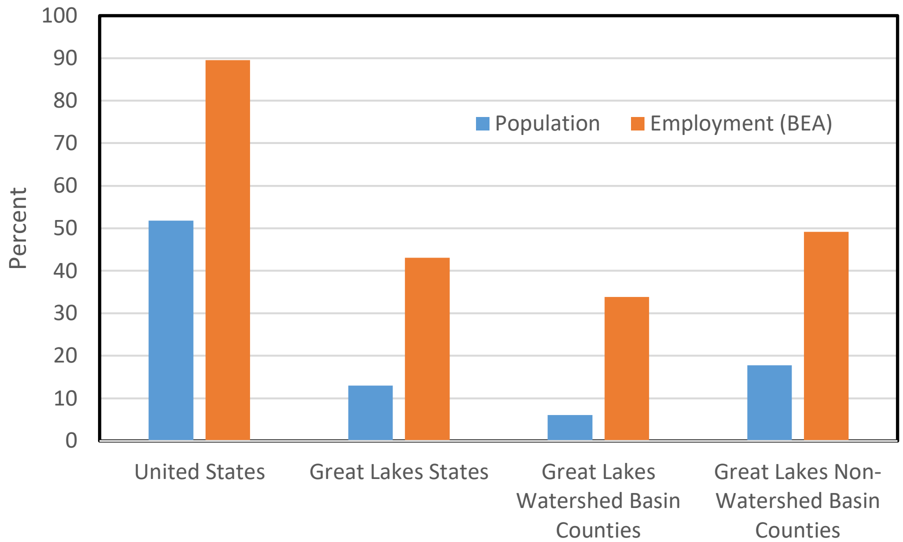
Table 1: Long-Run Economic and Demographic Trends in the Great Lakes Region

	Percent Change from:			
	1970-1980	1980-1990	1990-2000	2000-2010
Employment				
United States	24.9	21.4	19.5	4.6
Great Lakes States	10.4	14.2	14.1	-0.5
Great Lakes Watershed Counties	10.7	13.5	13.3	-6.0
Great Lakes States, Non-Watershed Counties	10.2	14.7	14.5	3.0
Population				
United States	11.5	9.9	13.0	9.6
Great Lakes States	1.3	1.6	6.6	3.0
Great Lakes Watershed Counties	0.8	0.2	5.2	-0.2
Great Lakes States, Non-Watershed Counties	1.7	2.5	7.5	5.0

Note: Counties that contain any part of the Great Lakes Watershed are included as Watershed counties. Employment is measured using the Bureau of Economic Analysis definition.

Figure 1 displays the population and employment growth rates for those regions over the entire period 1970–2010. The figure shows graphically that the Great Lakes region lagged the United States as a whole economically and demographically during that period. These trends highlight the importance of policies that stabilize Great Lakes communities by supporting jobs and retaining and attracting residents.

Figure 1: Regional Population and Employment Growth, 1970–2010



Background of the Great Lakes Restoration Initiative

The Great Lakes Restoration Initiative was created under President Obama in 2010 as an outgrowth of Executive Order 13340, issued by President George W. Bush in 2004. The Executive Order created the Great Lakes Interagency Task Force, which was charged with promoting "regional collaboration to address nationally significant environmental and natural resource issues involving the Great Lakes".[3] The Great Lakes Interagency Task Force, which is chaired by the Administrator of the U.S. Environmental Protection Agency (U.S. EPA), continues to oversee the activities of the GLRI. The GLRI is charged with restoring the environmental health of the Great Lakes watershed. Its five focus areas are "the remediation of toxic substances, the prevention and control of invasive species and the impacts of invasive species, the protection and restoration of nearshore health and the prevention and mitigation of nonpoint source pollution, habitat and wildlife protection and restoration, and accountability, monitoring, evaluation, communication, and partnership activities."[4]

While the GLRI was not conceived with the primary goal of promoting the economic development of the Great Lakes region, and indeed none of its reporting requirements include any measures of social or economic activity, GLRI projects do have the additional benefit of promoting and sustaining the Great Lakes economies. In this report, we have attempted to fill in this missing information by documenting the economic benefits of GLRI programs to the Great Lakes region both historically and well into the future.[5]

Semi-structured Interviews in Case Study Counties

In the early phases of the project, a separate team of researchers from Central Michigan University, Marcello Graziano, Ph.D., Leila Irajifar, Ph.D., and Matthew Liesch, Ph.D., conducted 22 semi-structured

[3] https://georgewbush-whitehouse.archives.gov/news/releases/2004/05/20040518-3.html
[4] https://www.congress.gov/congressional-report/114th-congress/house-report/465/1
[5] The U.S. Environmental Protection Agency and other government agencies provided us with information and data assistance, but did not provide any other support. The findings of this report are solely the responsibility of the authors.

interviews in four localities in the Great Lakes region.[6] The localities were Buffalo (NY), Duluth/Superior (MN/WI), Muskegon (MI), and Sheboygan (WI). The team conducted interviews with different, yet complementary backgrounds, representing the local and regional business communities, regional economic agencies, local governments, including county-level agencies, developers, community organizations, and scientists.

The objectives of the interviews were:

- To provide additional information to support the modelling assumptions for the quantitative economic impact analysis and additional information about leveraged direct and indirect investments in selected locations;
- To provide a narrative of the effects that GLRI-sponsored projects have had (or are having) on regional economies and ecosystems as well as their linkages with other regional initiatives dependent of or co-located with GLRI; and
- To investigate the intangible and no-monetary benefits related to GLRI-sponsored projects to residents in the selected locales.

Several of the themes that emerged from the semi-structured qualitative case studies supported the research approach and assumptions used in the economic impact analysis:

- Interviewees believed the GLRI was a major initiator of remediation efforts in their communities—no comparable policy existed prior to the GLRI.
- Interviewees felt that GLRI projects had improved the quality of local social and ecological amenities.
- Interviewees repeatedly mentioned the tourism sector as a focal point of the changes the GLRI had brought about in their communities, indicating that the GLRI had initiated major changes in local perception, well-being, demography, and investment patterns.
- Interviewees felt that the impacts of GLRI projects would be persist beyond the periods of project activity, and that the projects' eventual long-term impacts were not yet fully visible in their communities.

Economic Impact Analysis

Our economic impact analysis had three major components:

- First, we constructed a dataset of GLRI spending by estimating the time pattern and types of spending associated with individual GLRI projects.
- Second, we conducted historical econometric analysis to estimate the projects' benefits in terms of local quality of life and tourism.
- Third, we modeled the economic impacts of those projects over the period 2010 to 2036 using the Regional Economic Model Inc. (REMI) PI+ model, one of the most widely-used models for economic impact analysis.

[6] The sections "Appendix B: Project Teams" and "Appendix C: Semi-structured Interview Questions" describe the semi-structured case studies and project team in more detail.

Constructing the Dataset for Analysis

The EAGL Database

The starting point for our analysis is the Environmental Protection Agency's Environmental Accomplishments in the Great Lakes (EAGL) dataset, which was provided to us by EPA staff.[7] The version of the dataset we received contains detailed information on 3,652 projects that received more than $1.8 billion nominal (i.e., not inflation-adjusted) of federal funding in total during the period 2010–2016. For each project, the dataset records the funding agency (e.g., U.S. EPA, the U.S. Fish and Wildlife Service, the National Oceanic and Atmospheric Administration, etc.), project title and description, focus area, and project start and end dates.[8]

There are four main questions that must be answered in order to study and model the economic impacts of an individual GLRI project:

1. Location: where did project work and spending occur?
2. Timing: when was project money spent?
3. Amount: how much project money was spent, including matching or leveraged funds?
4. Industry: in what industries was project money spent?

We describe how we answered each of those questions below.

Location

The EAGL database includes latitude and longitude coordinates for more than 99% of the project listings. Per the recommendation of staff at the U.S. EPA's Great Lakes National Program Office (GLNPO), the research team assigned most spending associated with each project to the point defined by the listed coordinates, except when the coordinates contained clear errors.[9] The project team was able to resolve most of those problems with guidance from the GLNPO.

Some spending associated with each project was spent by the federal agency that administered the project. We attributed that spending to the county containing the agency's nearest program office, which was located for individual agencies. For instance, all administrative spending for projects administered by the EPA was attributed to Cook County, IL, the location of EPA's GLNPO. Federal agency spending on travel was attributed to the location where the project occurred.

Figure 2 maps the distribution of GLRI projects using the reported coordinates. The majority of GLRI projects are distributed across the coasts of the Great Lakes states. The figure also displays the 227 economic regions in the version of the REMI model that we used to conduct the economic impact modelling. The Great Lakes Basin includes areas of 8 Midwest States. The 227 regions in the REMI model comprise: 216 individual U.S. counties from the 8 Great Lakes states that lie partially or completely within the Great Lakes Basin; 3 additional counties in the Chicago Metro area; 7 state-specific regions for each of the 8 Great Lakes states that represent the combination of all counties that do not intersect the Great Lakes Basin; and the rest of the United States grouped into a single region.

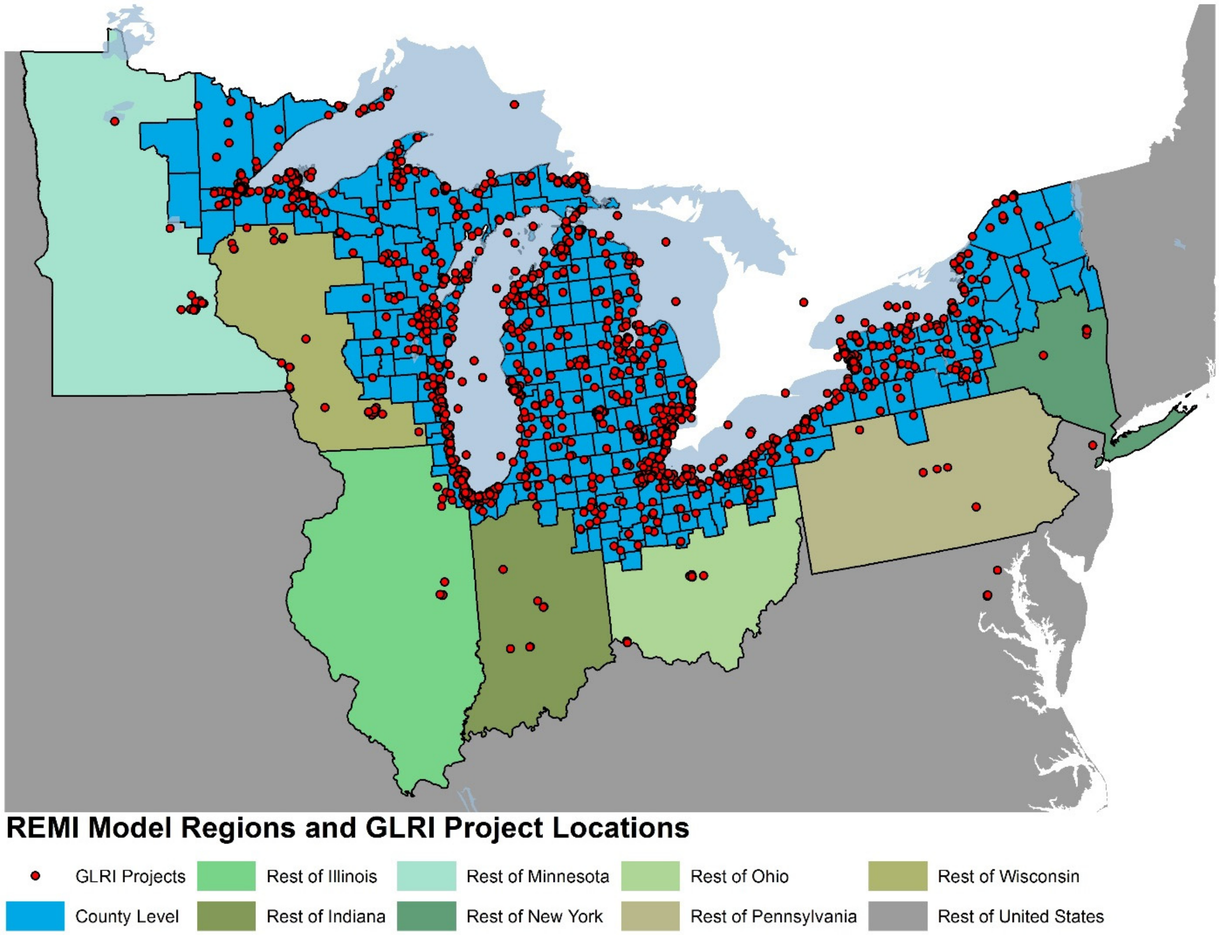
---

[7] Versions of the dataset are publically available at the official GLRI website: https://www.glri.us//

[8] Projects are grouped into 6 different focus areas: Toxic Substances and Areas of Concern; Invasive Species; Nonpoint Source Pollution Impacts on Nearshore Health; Habitats and Species; Foundations for Future Restoration Actions; and Multiple Focus Areas.

[9] Examples include switched latitudes and longitudes or missing negative signs for longitudes.

Figure 2: Geographic Distribution of GLRI Projects



Timing

We allocated real project spending in 2009 dollars evenly across the months of the project using the project start and end dates listed in the EAGL database. We assumed that real spending on GLRI projects was evenly divided by month over the duration of a project.

We did not consider any projects with a project start date after 2016. We did, however, include all projected spending within projects that began by 2016 in our economic modeling, even if that spending extended after 2016. Some projects in the EAGL database that began by 2016 extend beyond 2020, but about five-sixths of the real spending we analyzed occurred during the years 2010–2016, and 99.7 percent of the spending is projected to have occurred during the years 2010–2020.

Amount

The EAGL dataset provides direct federal government spending totals for the GLRI projects, but non-federal matching funds are an important additional source of funding. The EPA GLNPO provided us with a listing of required matching funds for projects administered by seven different agencies: the EPA, the U.S. Fish and Wildlife Service, the U.S. Geological Survey, the Army Corps of Engineers, the National Oceanic and Atmospheric Administration, the Natural Resources Conservation Service, and the U.S. Forest Service.

Table 2 shows the required matching rates for these agencies. Together, the grants administered by these agencies account for approximately 93% of all real GLRI spending from 2010–2016.[10] Weighted by nominal project spending for all GLRI spending, the required match rate on projects for those agencies is 34.5 percent. We applied that blended match rate to the remaining GLRI projects for the purposes of estimating matching funds. We believe our strategy for estimating matching funds is conservative because we do not impute any additional funds beyond the minimum required match rates.

Table 2: GLRI Matching Rates by Administering Agency

Administering Agency	Direct GLRI Spending, 2010-16 (Real 2009 Dollars)	Match Rate (%)
Environmental Protection Agency	571,000,000	32.8
Army Corps of Engineers	165,000,000	16.0
Fish and Wildlife Service	147,000,000	69.8
National Oceanic and Atmospheric Administration	125,000,000	23.6
National Resources Conservation Service	108,000,000	22.8
U.S. Geological Survey	70,300,000	5.0
U.S. Forest Service	40,200,000	40.0
All Other Agencies	93,567,102	34.5

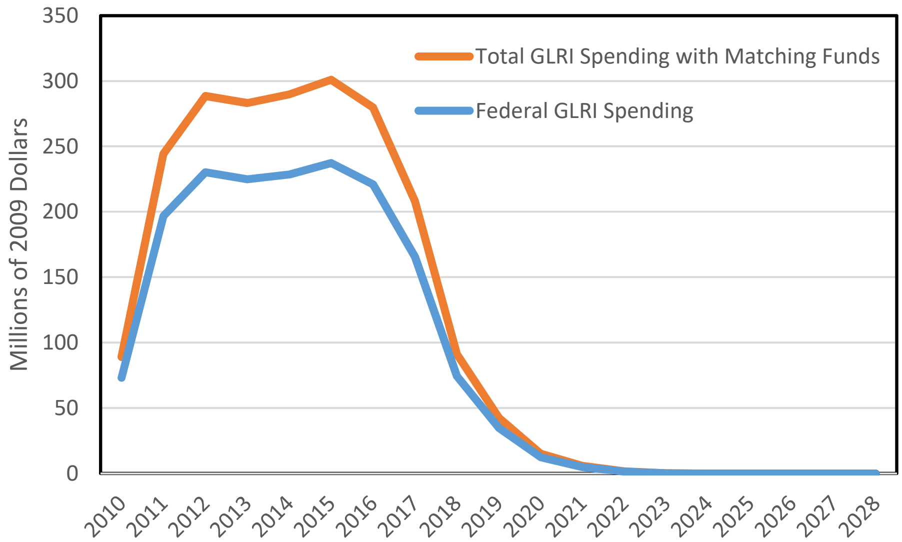
Note: the match rate of 34.5% for all other agencies is a weighted average of the listed agencies' match rates weighted by nominal dollar spending.

Figure 3 displays the total spending amounts for these projects on an annual basis, including non-federal matching funds.[11] The total direct spending from 2010 to 2016 is 1.4 billion 2009 dollars, or an average of $202 million per year. Matching funds accounted for an additional $364 million of spending from 2010 to 2016, an average of $52 million per year. Therefore, accounting for matching funds makes a quantitatively important difference to total GLRI spending even using our conservative assumptions.

[10] Some GLRI project funds are spent directly by federal agencies, while other funds are given as grants to projects in the region.

[11] The projects were restricted to projects with valid funding and timing information that we were able to geocode to a United States county.

Figure 3: Annual GLRI Spending



Another key question related to matching funds is the source of the matching funds. The qualitative case study interviews indicated that the vast majority of the matching funds in the case study communities came from state and local government rather than from nonprofit organizations or private industry. We therefore assumed that matching funds came evenly from state and local governments, and were financed by reductions in other spending. An exception concerns projects connected to the Great Lakes Legacy Act, which required matching funds from private industry.[12]

Table 3 displays total spending on GLRI projects annually from 2010 to 2016. The spending is split between federally funded spending and matching funds, and the table breaks out project spending for each of the eight Great Lakes states and the rest of the United States.

[12] The project team did a keyword search of the project titles and descriptions in the EAGL database for the terms "glla" and "legacy," and whittled the resulting list down to projects with a connection to the Great Lakes Legacy Act, as determined by a project-level examination of the project descriptions.

Table 3: Great Lakes Restoration Initiative Spending, 2010 to 2016, Thousands of 2009 dollars

	2010	2011	2012	2013	2014	2015	2016	Total
Federally Funded Spending								
All Great Lakes States	70,547	191,307	224,338	217,952	220,611	231,433	215,168	1,371,357
Illinois	12,642	33,894	41,104	41,546	40,416	39,513	33,238	242,353
Indiana	3,242	11,319	9,597	18,156	20,501	20,800	10,183	93,799
Michigan	23,136	60,489	73,533	66,087	63,274	67,158	79,130	432,807
Minnesota	3,431	9,475	12,597	13,792	16,113	15,745	17,331	88,485
New York	7,318	17,729	14,609	14,283	19,531	19,139	21,900	114,509
Ohio	9,184	20,756	23,664	25,387	22,424	24,160	22,049	147,624
Pennsylvania	532	1,305	1,272	801	876	677	524	5,988
Wisconsin	11,063	36,339	47,961	37,900	37,477	44,241	30,813	245,792
Rest of United States	2,451	5,481	5,918	6,963	7,883	5,893	5,699	40,288
Matching Funds								
All Great Lakes States	15,819	47,208	58,235	58,253	61,314	63,520	58,694	363,042
Illinois	1,535	4,362	6,806	7,691	7,349	6,532	6,831	41,105
Indiana	939	3,498	2,967	5,749	6,520	7,078	3,373	30,126
Michigan	5,488	16,126	20,127	18,874	19,225	19,597	21,518	120,955
Minnesota	814	2,332	2,732	2,831	3,167	2,947	3,270	18,094
New York	1,495	4,336	4,281	4,390	6,420	5,922	7,220	34,063
Ohio	2,117	5,199	6,128	6,963	6,377	6,677	6,112	39,574
Pennsylvania	150	424	503	360	415	331	309	2,493
Wisconsin	3,281	10,930	14,690	11,394	11,841	14,435	10,060	76,632
Rest of United States	163	438	92	70	42	81	102	988
Total Spending								
All Great Lakes States	86,367	238,515	282,573	276,205	281,925	294,953	273,862	1,734,399
Illinois	14,176	38,256	47,910	49,237	47,765	46,045	40,069	283,459
Indiana	4,182	14,817	12,565	23,906	27,021	27,879	13,556	123,925
Michigan	28,624	76,615	93,660	84,961	82,499	86,755	100,648	553,762
Minnesota	4,245	11,807	15,329	16,623	19,280	18,692	20,601	106,579
New York	8,812	22,065	18,890	18,672	25,950	25,061	29,121	148,572
Ohio	11,301	25,956	29,793	32,350	28,801	30,837	28,161	187,198
Pennsylvania	682	1,730	1,776	1,161	1,291	1,008	833	8,481
Wisconsin	14,344	47,268	62,651	49,295	49,317	58,676	40,873	322,424
Rest of United States	2,614	5,919	6,011	7,033	7,925	5,973	5,801	41,275

Industry

The version of the REMI PI+ model that we used in this project divides economic activity into 23 sectors across 227 distinct geographic regions. Table 4 lists those sectors, which comprise 19 industrial sectors, 3 government sectors, and farming.

Table 4: Industrial Sectors in the REMI PI+ Model

Forestry, Fishing, and Related Activities	Management of Companies and Enterprises
Mining	Administrative and Waste Management Services
Utilities	Educational Services; private
Construction	Health Care and Social Assistance
Manufacturing	Arts, Entertainment, and Recreation
Wholesale Trade	Accommodation and Food Services
Retail Trade	Other Services, except Public Administration
Transportation and Warehousing	State and Local Government
Information	Federal Civilian
Finance and Insurance	Federal Military
Real Estate and Rental and Leasing	Farm
Professional, Scientific, and Technical Services	

Allocating project spending across industries turned out to be a complicated process because the federal agencies that administer the GLRI do not track spending by industry in a systematic way. We began with an entry in the EAGL dataset that specifies a project's "Primary Measure of Progress." Table 5 presents the full list of primary measures. Following guidance from the EPA's GLNPO, we used these measures to group similar projects. We used those groups as a starting point in estimating the spending pattern associated with each project.

Table 5: Primary Measures of Progress in the Environmental Accomplishments in the Great Lakes Dataset

0.0.0 - no applicable action plan ii measure
1.1.1 - areas of concern where all management actions necessary for delisting have been implemented (cumulative)
1.1.2 - area of concern beneficial use impairments removed (cumulative)
1.2.1 - number of people provided information on the risks and benefits of great lakes fish consumption by GLRI-funded projects
1.2.2 - number of GLRI-funded projects that identify and/or assess impacts of emerging contaminants on great lakes fish and wildlife
2.1.1 - number of GLRI-funded great lakes rapid responses or exercises conducted
2.1.2 - number of GLRI-funded projects that block pathways through which aquatic invasive species can be introduced to the great lakes ecosystem
2.1.3 - number of GLRI-funded early detection monitoring activities conducted
2.2.1 - number of aquatic/terrestrial acres controlled by GLRI-funded projects
2.2.2 - number of tributary miles protected by GLRI-funded projects
2.3.1 - number of technologies and methods field tested by GLRI-funded projects
2.3.2 - number of collaboratives developed/enhanced with GLRI funding
3.1.1 - projected phosphorus reductions from GLRI-funded projects in targeted watersheds (measured in pounds)
3.1.2 - number of GLRI-funded nutrient and sediment reduction projects in targeted watersheds (measured in acres)
3.1.3 - measured nutrient and sediment reductions from monitored GLRI-funded projects in targeted watersheds (measured in pounds)
3.2.1 - projected volume of untreated urban runoff captured or treated by GLRI-funded projects (measured in millions of gallons)
3.2.2 - number of GLRI-funded projects implemented to reduce the impacts of untreated urban runoff on the great lakes
3.2.3 - measured volume of untreated urban runoff captured or treated by monitored GLRI-funded projects
4.1.1 - number of miles of great lakes tributaries reopened by GLRI-funded projects
4.1.2 - number of miles of great lakes shoreline and riparian corridors proteced, restored and enhanced by GLRI-funded projects
4.1.3 - number of acres of great lakes coastal wetlands protected, restored and enhanced by GLRI-funded projects
4.1.4 - number of acres of other habitats in the great lakes basin protected, restored and enhanced by GLRI-funded projects
4.2.1 - number of GLRI-funded projects that promote recovery of federally-listed endangered, threatened, and candidate species
4.2.2 - number of GLRI-funded projects that promote populations of native non-threatened and non-endangered species self-sustaining in the wild
5.2.1 - number of educators trained through GLRI-funded projects
5.2.2 - number of people educated on the great lakes ecosystem through GLRI-funded place-based experiential learning activities
5.3.1 - project evaluations completed and used to prioritize GLRI funding decisions each year
5.3.2 - annual great lakes monitoring conducted and used to prioritize GLRI funding decisions each year
5.3.3 - GLRI-targeted watersheds, habitats and species identified and used to prioritize GLRI funding decisions

We selected one project for each of the 36 primary measures of success in the EAGL database randomly, subject to minor restrictions.[13] The GLNPO provided spending breakdowns for those projects, but the spending categories tracked by the EPA were not sufficient to allocate project spending across industries in the REMI model. In particular, much of the project spending in the GLNPO data was allocated to a "contractual" category indicating the funding allocated to the contractor, which did not contain further detail.

Fortunately, the Great Lakes Commission (GLC) and Michigan Department of Natural Resources, Office of the Great Lakes (MDNR) were able to provide us with supplementary spending data for 24 total projects administered by those agencies. The project team used that data to allocate spending in the GLNPO data in the "Equipment," "Supplies," "Contractual," and "Other" categories, to industries in the REMI model.

Project spending was allocated across industries as follows:

First, we used all available spending data to calculate the average proportion of administrative and travel spending attributable to the federal agency administering the grant. The travel spending was attributed to the Accommodation and Food Services industry as "Exogenous Final Demand" in the REMI model.[14] The administrative spending was attributed to Federal Civilian output, except for projects administered by the U.S. Army Corps of Engineers, which was attributed to Federal Military output.

Second, the data provided by the GLNPO was used to estimate, for each primary measure of success, the proportion of spending on personnel wages and salary, fringe benefits, and indirect costs. Grant recipient spending was split into contractual, non-contractual, and travel shares using averages calculated from the detailed spending data provided by the GLC and MDNR. The non-contractual spending was attributed to the industrial sector associated with each grant recipient, as determined by economic impact research team staff in a project-level recipient review. The non-contractual spending was attributed to the appropriate industry as "Industry Sales" for non-governmental recipients, and to Federal Civilian, Federal Military, or State and Local government output for governmental recipients. Recipient spending on travel was again attributed to the Accommodation and Food Services Industry as exogenous final demand.

Third, spending identified as "Contractual" was allocated to industries in the REMI model according to averages in the detailed spending data provided by the GLC and MDNR. Keyword searches of the project descriptions were used to identify projects that contained elements related to the Construction; Professional and Business Services; Forestry, Fishing, and Related Activities; and Farm sectors. We entered all contractual spending into the REMI model as "Exogenous Final Demand" with the exception of farm sector spending, which we entered as "Farm Output."

Table 13 in "Appendix D: Project Description Keyword Search Terms" displays the keywords that were used as search terms to identify each project as having an industry element. The list of keywords was developed with input from GLNPO staff.

[13] For instance, when possible we required projects to be at least halfway complete.

[14] Section "Regional Economic Impact Analysis" describes how we entered the estimated GLRI impacts into the REMI model in detail.

A project was categorized as having an element associated with a given industry if its description contained a single match to the list of keywords for that category. The categories are not mutually exclusive, and many projects contained matches with multiple categories. 78 percent contain keywords related to Professional and Business Services, 69 percent of projects contain keywords related to the construction industry, 10 percent contain keywords related to Farming, and 9 percent contain keywords associated with Forestry, Fishing, and Related Activities. 3 percent of projects do not contain keywords that match with any of the industries. Table 6 provides a list of all combinations of keyword-matched industries in the data, along with a breakdown of how spending was allocated across industries for each case. The breakdowns were constructed to follow the averages of projects in the detailed spending data provided by the GLC and MDNR.

Table 6: Allocation of Contractual Spending to REMI Industries by Keyword Associations

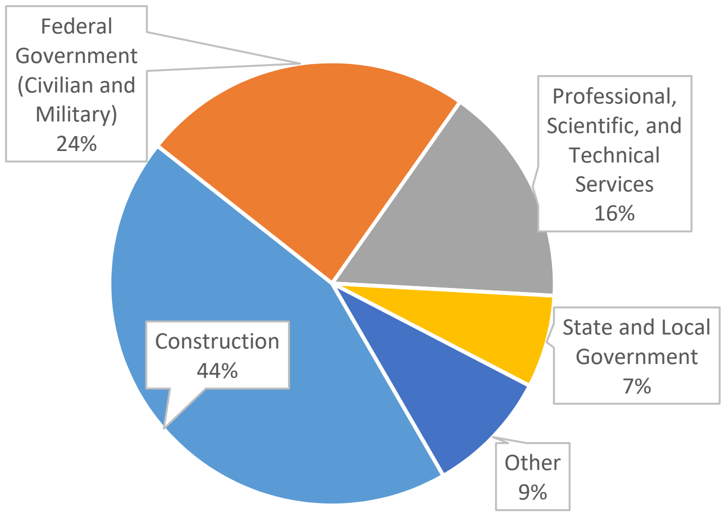
Keyword Associations							
Construction	Forestry & Fishing	Farm	Prof. Services	No Match	Project Count	Project Percent	Industry Spending Allocation
X			X		1,419	39%	91.5% Construction, 8.5% Professional Services
			X		883	24%	100% Professional Services
X					555	15%	100% to Construction
X		X	X		267	7%	45.75% Construction, 45.75% Farm, 8.5% Professional Services
X	X		X		142	4%	45.75% Construction, 45.75% Forestry & Fishing, 8.5% Professional Services
				X	104	3%	50% Construction, 50% Professional Services
X	X				87	2%	50% Contruction, 50% Forestry & Fishing
	X		X		86	2%	91.5% Forestry & Fishing, 8.5% Professional Services
X		X			51	1%	50% Contruction, 50% Farm
		X	X		36	1%	91.5% Farm, 8.5% Professional Services
	X				13	0%	100% Forestry & Fishing
		X			5	0%	100% Farm
X	X	X			3	0%	33% Construction, 33% Forestry & Fishing, 33% Farm
	X	X	X		2	0%	45.75% Forestry & Fishing, 45.75% Farm, 8.5% Professional Services
X	X	X	X		2	0%	30.5% Construction, 30.5% Forestry & Fishing, 30.5% Farm, 8.5% Professional Services

Note: Table 13 contains a list of keyword search terms for each industry. Industry spending allocations were chosen to match averages from spending data provided by the Great Lakes Commission and the Michigan Department of Environmental Quality where possible.

Figure 4 displays our ultimate allocation of total GLRI spending across industry groups in the REMI model.[15] We estimate that the construction industry was the largest single recipient of GLRI spending, accounting for 44 percent of the total, consistent with the GLRI's nature as a public works program. Federal Government output was the next largest recipient, accounting for 24 percent of the total between the civilian and military sectors. The Professional, Scientific, and Technical Services industry accounted for 16 percent of GLRI spending, and State and Local Government accounted for another 7 percent. All other industries accounted for a total of 9 percent of GLRI spending.

[15] The proportion of spending is calculated in present discounted value terms from the perspective of 2016 using a 3.5 percent annual real discount rate.

Figure 4: Proportion of GLRI Spending Allocated to Various Industries



Analysis of Historical Quality of Life and Tourism Impacts

A major part of our study was devoted to analyzing the GLRI's impacts on local quality of life and tourism. For those portions of the analysis, we focused on the GLRI's historical effects through the year 2016. We then used the results of those analyses in our regional economic modeling through 2036. We consider the results of the quality of life and tourism analyses to be important metrics of the GLRI's impacts in their own right as well.

GLRI's Impacts on Local Amenities and Quality of Life

A recurring theme in the semi-structured qualitative case studies was that the GLRI had served as a catalyst for improvements in local communities' amenities or quality of life. Therefore, a key goal of the economic impact modelling was to capture the GLRI's effects on local amenities and quality of life, independently from the economic multiplier effects of additional federal spending in the region.

Our analysis implies that local residents significantly valued the improvements in local amenities and quality of life provided by GLRI projects. In the hedonic house price analysis that we describe below, we estimated that every dollar of GLRI spending produced quality of life benefits worth $1.08 to local residents.

Hedonic Regression: Measuring Quality of Life Impacts through House Prices

We estimated the quality of life benefits of GLRI projects by examining how GLRI spending affected local house prices, a technique known in the literature as hedonic regression. In a standard economic model of spatial equilibrium (Rosen 1974; Roback 1982), an improvement in a local area's quality of life should increase demand to live in the area, which in turn should increase the price of local housing and lower local wage rates. In theory, local house prices and wages should adjust until additional potential migrants are indifferent between relocating to the region versus staying in their original locations. Standard parameterizations of models of inter-city spatial equilibrium suggest that the lion's share of this adjustment process should occur via house prices rather than wages. For instance, Albouy and Farahani (2017) suggest that roughly four-fifths of the value of an increase in local quality of life produced by an improvement in public goods should be capitalized into house prices in their typical specifications.

Rising house prices in and of themselves need not always be a good thing. Rising house prices increase local homeowners' net worth (Cooper 2013; Aladangady 2017), but they may also reduce a local area's affordability for non-homeowners. Harvard University's Joint Center for Housing Studies recently estimated that as of 2016, 38.1 million U.S. households were "cost burdened" by housing, meaning that they spent more than 30 percent of their incomes on housing. For those households, rising costs of housing may reduce their welfare. To the extent that housing prices in the Great Lakes region have historically been depressed by the pollution and other environmental problems that the Great Lakes Restoration Initiative was designed to correct, however, increases in local house prices spurred by the GLRI may have benefits even for cost burdened households.

We have chosen to measure the GLRI's quality of life effects in local communities because it provides a quantitative, evidence-based way to put a dollar value on how much households value benefits such as a cleaner environment and better access to water resources and recreational opportunities. Those advantages are why hedonic house price regressions are in such common use in the field. When assessing this evidence, though, it is worth keeping in mind that what we ultimately would like to measure is how much local residents value the improvements in amenities and quality of life produced by GLRI projects, not whether house prices rose *per se*.[16]

Finally, it is important to note that the quality of life benefits we estimated through this approach are likely to underestimate the full extent to which local residents value the improved amenities that the GLRI provides. As noted above, some of the value to local residents will be capitalized in other ways, such as through lower market wages.

Hedonic Regression Results

Our preferred estimation strategy for the hedonic house price regressions was to compare zip code-level house price appreciation from the Federal Housing Finance Agency (FHFA; see Bogin et al. 2016) in zip codes that received GLRI funding to appreciation in neighboring zip codes and regressing the differential appreciation rates on measures of GLRI spending.[17] The basic intuition behind this approach is that neighboring zip codes are sufficiently geographically compact and proximate that their house prices should have exhibited the same trends in the absence of GLRI spending. Therefore, comparing differences in house price appreciation across neighboring zip codes to differences in GLRI spending should yield the spending's causal effect on house prices.

We also performed a spatial regression analysis, in which we examined the geographical pattern of GLRI spending's effects on house prices and quality of life. We found suggestive results that GLRI spending improved local quality of life at distances of up to 10 miles from the project site. Those estimates implied substantially larger impacts of GLRI spending on local house prices and quality of life than in our

[16] Improving a community's quality of life should increase its population, either by reducing net out-migration or increasing net in-migration. Most of the Great Lakes Basin counties that we studied have historically experienced net out migration, so we would expect higher retention of current residents (reduced out migration) to be the more important effect in this context.

[17] It is frequently the case that neighboring zip codes both receive GLRI spending. In those cases, we focus on the difference in spending as the driver of interest.

baseline specifications. Ultimately, however, the precision of those alternative estimates was not high enough for us to choose them as our preferred specification.

We focused our analysis primarily on counties that are on the coasts of the Great Lakes because many of the projects located in non-coastal counties appeared to be project types that would be unlikely to improve local amenities. For instance, the map in Figure 2 shows that many projects are located in state capitals or University towns such as Columbus, OH or Ann Arbor, MI. We believe projects in those locations are typically research projects or administrative efforts that are not primarily focused on improving local public amenities or quality of life, whatever their other benefits. We show evidence that supports this idea in the regression analyses below.

Pre-Trends Analysis

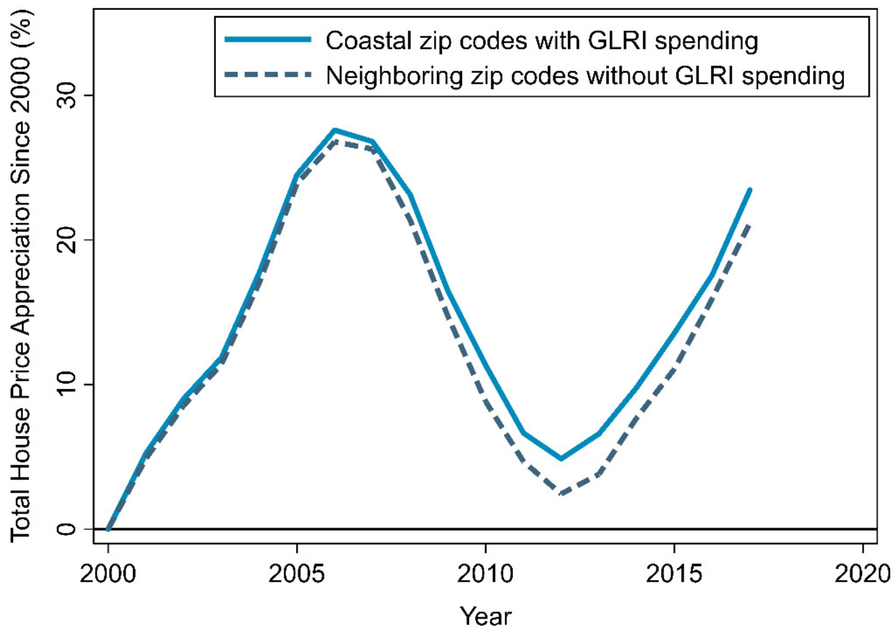
Our analysis comparing house price appreciation and GLRI spending between zip code neighbors relies on the assumption that neighbors are good controls for each other and would have experienced similar house price trends in the absence of GLRI spending. That motivating assumption is known as the "parallel trends" assumption in the econometrics literature. The parallel trends assumption is formally untestable, because testing it would require observing what house prices in zip codes that received GLRI spending would have done in a counterfactual universe in which they received no funding. Economists will typically examine whether the trends of interest are parallel prior to the beginning of the policy they are studying, however. The thinking is that the parallel trends assumption is more reasonable if the so-called "pre-trends" are parallel.

Our analysis is a bit atypical in these studies because the "treatment" we studied, GLRI spending, is not binary: different zip codes saw very different amounts of spending, even conditional on being the site of a project. Additionally, many zip codes that received funding were themselves neighbors to another zip code with funding. These issues do not pose a problem for our regression estimates, which are identified based on differentials of neighbor spending and house price appreciation, but they do make it difficult to separate the sample into "treated" and "non-treated" zip codes for the pre-trends analysis.

To avoid these problems, we separated zip codes into two groups: (1) zip codes in coastal counties that received GLRI funding at some point between 2010 and 2016, and (2) zip codes that neighbor at least one zip code in the first group, but do not, themselves, receive any funding. This procedure produced a total of just over 1,000 zip codes, with 40% belonging to the group with funding and 60% in the group without funding.

Figure 5 displays average cumulative house price appreciation since the year 2000 in the two groups of zip codes through 2017. The trends for the two groups are very similar through 2009, prior to the beginning of the GLRI in 2010, at which point a gap between the two begins to open. We interpret that pattern as suggesting that the pre-trends between the two groups of zip codes are very nearly parallel, which may provide reassurance that the assumption of parallel trends in the treatment period is credible. We caution that although it is tempting to look for a graphically observable "treatment" effect in the figure, much of the identification in our regressions comes from variation between zip codes that received funding, so that it is simpler to look at the regression results we discuss in the next section.

Figure 5: Trends in Cumulative House Price Appreciation, 2000–2017



Preferred Specification: Comparing Neighboring Zip Codes

Our preferred specification to analyse GLRI projects' impacts on local house prices and quality of life was to run regressions of the form:

$$\Delta HPI_{it} - \overline{\Delta HPI_{jt}} = \alpha + \beta\left(\frac{GLRI09_{it}}{Housing\ Units_i} - \overline{\frac{GLRI09_{jt}}{Housing\ Units_j}}\right) + \varepsilon_{it}.$$

In this regression ΔHPI_{it} represents the change in house prices in zip code i from year $t-1$ to year t in percentage points, and $\overline{\Delta HPI_{jt}}$ represents the average change in house prices in all neighboring zip codes (the simple average across all neighboring zip codes).[18] $GLRI09_{it}$ represents GLRI spending in 2009 dollars we have geocoded as occurring in zip code i (technically the zip code tabulation area) in year t. We have normalized spending by the number of housing units in the zip code from the 2010 Census, $Housing\ Units_i$, to capture real GLRI spending per housing unit in the zip code each year. $\overline{\frac{GLRI09_{jt}}{Housing\ Units_j}}$ represents the simple average of real GLRI spending per housing unit across neighboring zip codes in year t.

Table 7 displays the results from a series of regressions that share this basic form. Column 1 displays our baseline results, which result from the exact regression specification above using zip codes only in coastal counties. The estimated regression coefficient of 0.0025 is statistically significant at the 5-percent level using standard errors clustered at the zip code level. The economic interpretation of the estimated coefficient is not intuitive; we discuss the interpretation in detail below.

[18] We did not include zip codes that adjoin only at a point as neighbors.

Columns 2 through 4 of Table 7 display the results of variations of our preferred specification. Column 2 shows the results of a regression that adds year by county fixed effects. Consistent with the notion that comparing neighboring zip codes are similar enough to provide valid controls, the estimated coefficient in column 2 hardly changes from column 1. Unsurprisingly, the estimated standard error rises slightly when including so many fixed effects (the p-value on the estimated coefficient rises to 6 percent). Column 3 includes only GLRI spending that we coded as related to construction-type activity. The estimated coefficient rises slightly relative to column 1, although the difference is not statistically significant. We decided to focus on all types of spending both because our coding procedure is subject to error and because theoretically other types of spending may also increase an area's amenities and house prices. Finally, column 4 includes all zip codes with GLRI spending in the Great Lakes basin, not only the zip codes in coastal counties. When the sample is expanded this way, the estimated effect falls essentially to zero. This result is consistent with the notion that spending in non-coastal counties is unlikely to be the type of spending that improves an area's amenities.

Table 7: GLRI Project Spending and House Price Appreciation 2010-2016

	(1)	(2)	(3)	(4)
Annual Real GLRI Spending	0.0025	0.0024	0.0032	0.0001
Standard Error	(0.0010)	(0.0013)	(0.0014)	(0.0001)
Number of Observations	2769	2769	2769	3633
R-squared	0.002773	0.1927	0.002448	0.0001124
Spending Included	All	All	Construction	All
Area Included	Coastal Counties	Coastal Counties	Coastal Counties	Great Lakes Basin
Additional Controls	None	County x Year Fixed Effects	None	None

Note: Unit of observation is the zip code. Real GLRI spending includes matching funds. Please see the text for a full description of the regressions.

We believe that this estimation strategy is likely to be a conservative estimate of GLRI spending's true effects on house price appreciation for two reasons:

- First, there is noise in the geolocation of projects. We used the project location reported by the entity performing the work, which is sometimes the organization's main business address rather than the location of the project itself. Furthermore, project locations are provided as single points even if the work is performed over a geographically large area. Misclassification of project locations will lead mechanically to attenuation bias in the estimated impact of GLRI project spending on house prices.
- Second, GLRI projects are likely to have spillover benefits on house prices in neighboring zip codes. To the extent that these spillovers are significant, comparisons with neighboring zip codes will overstate the appropriate counterfactual rate of house price appreciation, leading to a downward bias in the estimated effect size. We provide suggestive evidence in support of this notion in the spatial regression analyses below.

We therefore conclude that our preferred specification provides a conservative lower bound on GLRI project spending's effects on local house prices.

Interpreting the Neighboring Zip Codes Regression Estimates

To provide an economically meaningful interpretation of our regression estimates, we calculated the cumulative total dollar increase in housing values for each zip code from 2009, the year prior to the start of GLRI, through 2016 predicted by GLRI spending. We then compared that price appreciation to total GLRI spending to estimate the impact that one dollar of GLRI spending had on local house prices.

Calculating the total dollar value of house price appreciation by zip code was complicated by the fact that the house price index provided by FHFA is expressed in index points rather than in dollar values (e.g., the index might increase from 140 to 145 from 2009 to 2016, where the index is normalized to have value 100 in a base year). To convert those index values into dollars, we first merged the FHFA house price index with the Zillow Home Value Index (ZHVI), which is expressed in dollar terms. A second complication was that the ZHVI provides the median value of all housing units in a zip code rather than the mean. We converted median zip code level house prices to mean prices using state-level factors calculated from FHFA data for the year 2009, the last year for which FHFA provides such data.[19]

We then calculated zip code level house price appreciation using those adjusted year 2009 ZHVI house values as the base. We included all zip code tabulation areas that intersect with a coastal county in the analysis.[20] Finally, we multiplied the average dollar increase in value per house by the number of housing units in each zip code to arrive at aggregate house price appreciation.

Aggregating in this manner, we calculated that GLRI spending increased the total value of housing in coastal counties by $920 million from 2010 to 2016. On a percentage basis, the predicted average cumulative appreciation in zip codes that experienced GLRI spending came to 0.28 percentage points. We also calculated that there was $850 million of GLRI spending in those zip codes including matching funds.[21] We therefore conclude that every dollar of total GLRI spending increased house prices by $1.08 over our study period**.** We estimate that there was a total of $640 million of federal GLRI spending in those zip codes (i.e., not including matching funds), implying that every dollar of federal GLRI spending increased house prices by $1.44 over our study period. As noted above, we interpret these results as implying that local residents valued the improvements in local amenities and quality of life provided by GLRI projects.

Sensitivity Analysis: Spatial Hedonic Analysis

Our baseline approach to estimating the quality of life benefits provided by GLRI projects is likely to be conservative in part because it does not allow the benefits to extend to a wide geographical area. In reality, however, there are reasons to expect that the benefits of GLRI projects might extend over a

---

[19] The data are provided in Leventis 2009, "An Approach for Calculating Reliable State and National House Price Statistics." The national ratio of mean to median house prices in 2009 was 1.19.

[20] Note that because we subtract GLRI spending in neighboring zip codes on the right-hand side of the regression, predicted appreciation was negative for some zip codes. That effect washed out over the large area of our study, but it does make drawing inferences from this regression approach less reliable for small geographical areas.

[21] Due to the nature of the procedure, we only included zip codes that were also present in the Zillow house price data in this analysis.

considerable distance. Motivated by this possibility, we conducted a spatial hedonic regression analysis to examine the geographical pattern of GLRI projects' quality of life benefits.

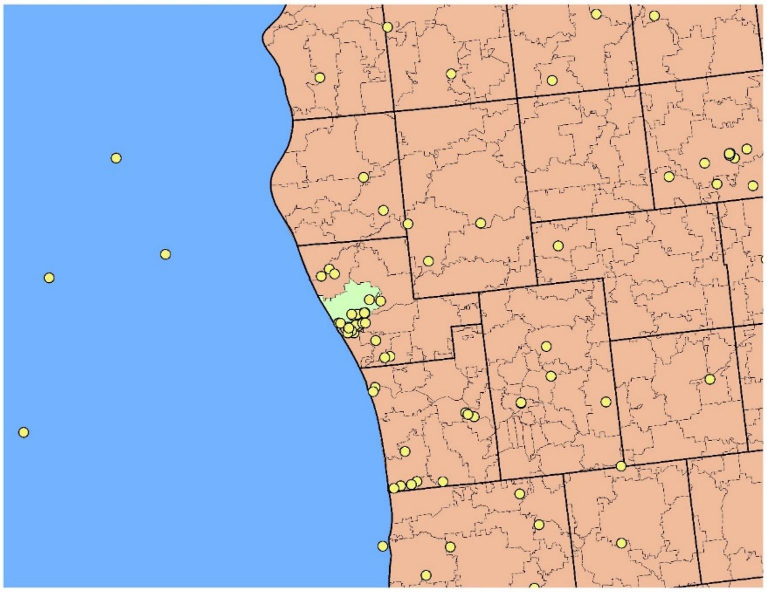
There are many different methods of spatial analysis, requiring analysts to use their judgment on the best method for the question at hand. We chose a fairly nonparametric approach, in which we regressed annual appreciation at the zip-code level on spending within the zip code as well as a series of binned spending-by-distance variables that identify the effect of GLRI spending at a range of distances outside of each zip code. Formally, the specification that we used is:

$$\Delta HPI_{it} = \alpha + \beta \left(\frac{GLRI09_{it}}{Housing\ Units_i}\right) + \sum_{d \in D} \gamma_d \left(\frac{GLRI09_{dt}}{Housing\ Units_i}\right) + \mu_i + \varepsilon_{it}.$$

The first several terms in this equation are the same as in the preferred neighbor-based approach above. μ_i is a fixed effect for zip code *i*.[22] The new summation term $\sum_{d \in D} \gamma_d \left(\frac{GLRI09_{d,10-16}}{Housing\ Units_i}\right)$ represents the series of binned spending-by-distance variables, normalized by the number of housing units from the 2010 Census in the central zip code associated with the dependent variable. This specification allows the effect of spending on house price appreciation to vary by distance without imposing a functional form assumption on the resulting effects (for instance, linear or quadratic in distance).

Figure 6 displays a map of zip code 49445 in Muskegon, MI, and its surrounding areas that will help illustrate our approach. The dark black lines in the figure delineate counties, while the light black lines delineate zip codes. Zip code 49445 is highlighted in light green. The yellow dots show the locations of all of the GLRI projects we have geocoded in the area.

Figure 6: Zip Code 49445, Muskegon Michigan



We created a series of 5-mile wide rings around each zip code out to a distance of 25 miles. As in our preferred specification, we restricted the analysis to zip codes in coastal counties. In the spatial analysis,

[22] We estimate a fixed effects regression using the traditional within-estimator.

however, we did allow spending from outside those counties to be captured by the distance-based spending variables.

Figure 7 illustrates the 5-mile wide rings we constructed for zip code 49445. In our spatial regression approach, we calculated total GLRI spending within each ring in each year from 2010 to 2016 and used those values as regressors in equation above.[23]

Figure 7: 5-mile wide rings around zip code 49445 in Muskegon, MI

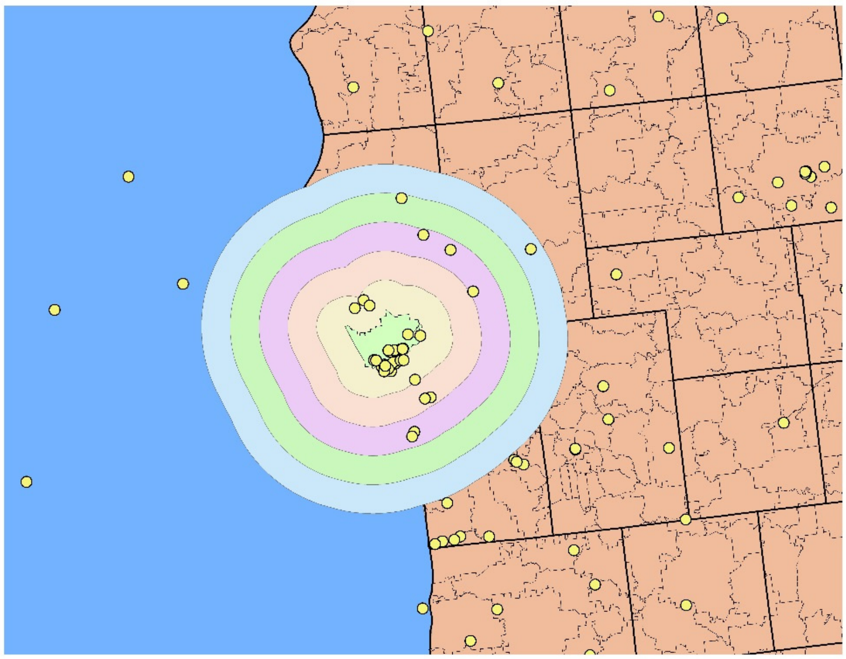


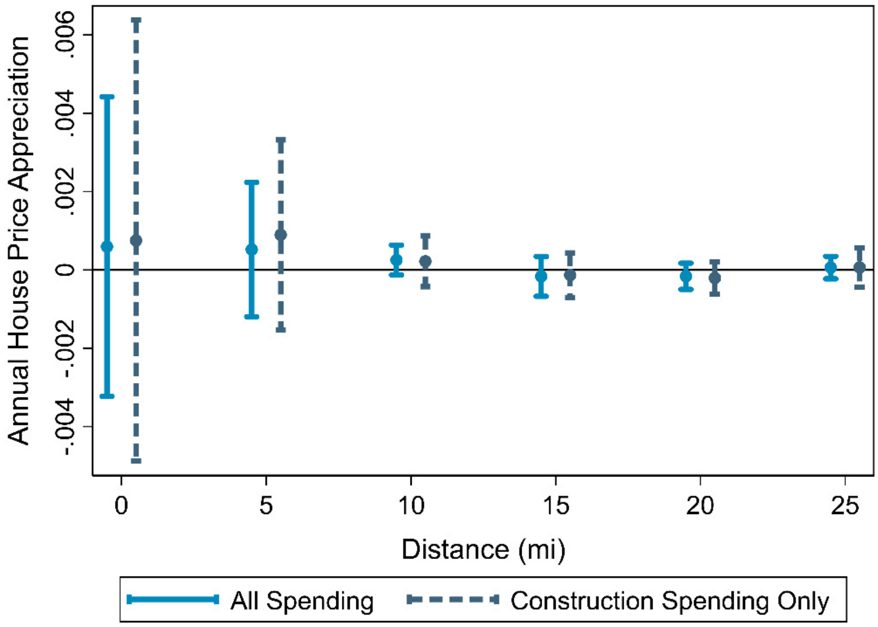
Figure 8 illustrates the estimates from our regressions graphically. Each dot represents the coefficient estimate on spending associated with the distance on the x-axis; the "whisker" lines around each dot represent 95% confidence intervals. Results for two separate regressions are illustrated: the first estimates the effect of total GLRI spending on house price appreciation, while the second uses only construction spending.

Economic theory suggests that amenities induced by GLRI spending should be more pronounced for residents in closer proximity to the spending or actual improvements. For this reason, we expected to see a diminishing effect of spending on house price appreciation as distance increases.

The results in Figure 8 suggest that GLRI spending had positive effects on house price appreciation in nearby zip codes, with the magnitude of the effect declining out to a distance of 10 miles, after which there was essentially zero effect. That pattern is consistent with what we had expected to find prior to conducting the analysis, although it was not as pronounced as we had expected.

[23] We normalized the spending values by the number of housing units in zip code *i* in 2010.

Figure 8: The effect of distance on house price appreciation



When we aggregated the appreciation in housing values implied by the spatial regressions, the estimated effects were substantially larger than in our baseline specification using neighboring zip codes. The spatial regression using all GLRI spending implies that one dollar of GLRI spending including matching funds led to an aggregate increase in housing values of slightly over $3. Those results are consistent with the notion that GLRI projects provided valuable amenities and quality of life benefits over a relatively large geographical area, which our baseline specification is unable to capture.

Ultimately, we decided to use the neighboring zip codes specification as our baseline because the results of the spatial house price regressions are not very precise—none of the estimated coefficients for any of the individual distances is statistically significant. The neighboring zip codes approach provides more precise estimates and is also more conservative. The spatial house price analysis suggests that our baseline specification is likely to provide a lower bound on the true extent to which local residents valued the quality of life benefits of GLRI projects.

GLRI's Impacts on Local Tourism Activity

Another theme that arose out of the semi-structured interviews in the qualitative case studies was that the GLRI had provided major benefits to local tourism industries in the Great Lakes region by cleaning up waterfronts and making the Great Lakes themselves more pleasant for recreation. In order to measure those benefits, we analyzed the association between GLRI spending and local economic activity in two tourism-related industries over the period 2010 to 2016. We estimated that every million dollars of total GLRI spending in the region was associated with 1.6 additional jobs in the Arts, Entertainment, and Recreation industry and 1.2 jobs in the Accommodation and Food Services industry.

Tourism Employment Regressions

We measured local tourism activity by county-level employment in the two most closely related industries in our version of the REMI model. Those industries were Arts, Entertainment and Recreation

(AER) and Accommodations and Food Services (AFS). According to the Bureau of Economic Analysis, these two major industry groups accounted for 65 percent of all direct tourism jobs in the country (3,493,000 out of 5,346,000 direct tourism jobs).[24] Another 646,000 direct tourism jobs are in transportation services, especially air transportation services, but this aggregate industry is much more likely to be influenced by trucking and warehousing activity than by tourism activity. Therefore, we chose not to estimate the effects of GLRI spending on local activity in the transportation services industry.

Unfortunately, an approach of the sort we undertook as part of our analysis of GLRI's impacts on local quality of life was not feasible for our analysis of GLRI's impacts on local tourism activity because we lack high-quality administrative data at the necessary level of geographical precision. We instead used a multiple regression approach in which we examined the county-level association of GLRI spending with employment in the two tourism-related industries, controlling for a series of potentially relevant confounders. To increase the power of the results and provide a control group, we included all 653 counties in the Great Lakes region, not only the coastal counties.

Specifically, we ran cross-sectional county-level regressions of the form:

$$\frac{\Delta arts_{i,16-10}}{pop_{i,10}} = \alpha + \beta \frac{GLRI09_{i,10-16}}{pop_{i,10}} + X_i'\delta + \epsilon_i$$

$$\frac{\Delta acc_{i,16-10}}{pop_{i,10}} = \alpha + \beta \frac{GLRI09_{i,10-16}}{pop_{i,10}} + X_i'\delta + \epsilon_i$$

The outcomes of interest are the dependent variables in these regressions, $\frac{\Delta arts_{i,16-10}}{pop_{i,10}}$ and $\frac{\Delta acc_{i,16-10}}{pop_{i,10}}$, which represent the changes in employment in county i of state s in the two tourism industries between 2010 and 2016, divided by the county's population in 2010. $X_i'\delta$ is a set of county-level control variables that varied across the different specifications that we considered.

The right-hand side variable of primary interest in the regressions is $\frac{GLRI09_{i,10-16}}{pop_{i,10}}$, the cumulative total of all real GLRI spending in county i between 2010 and 2016 (in thousands of 2009 dollars) divided by county population in 2010. The estimated coefficient of interest, $\hat{\beta}$, indicates how many jobs in the relevant tourism industry were generated by $1,000 in real GLRI spending. We considered both total GLRI spending and total construction spending in the regressions.

We included six additional control variables across the various regression specifications we considered:

- The first control variable was the state-level per capita growth in the tourism-related industry in question over the study period 2010–2016, *excluding* county i. It was meant to account for state-wide trend growth in the tourism industry in question, or "secular industry" effects.
- The second control variable was overall per capita growth in employment in county i between 2010 and 2016, *excluding* growth in the two tourism industries. It was meant to account for the multiplier effects of GLRI spending as well as the general health of the local economy.

[24] See https://www.bea.gov/scb/pdf/2017/06%20June/0617_travel_and_tourism_satellite_accounts.pdf table D.

- The third control variable was county i's personal income per capita in 2010, which was meant to control for the possibility that counties with higher average incomes in 2010 would have experienced differential employment growth in tourism industries regardless of GLRI spending.
- The fourth control variable was the share of county i's population that was 65 years old or older as of 2010. It was meant to control for the lower employment rates and incomes of the senior population.
- The fifth control variable was county i's per capita growth in the tourism industry in question prior to the study period, in the years 2004–2010. It was meant to account for the possibility that the dependent variable may have had differential pre-existing trajectories across different counties.
- The sixth control variable was county i's employment per capita in the tourism industry in question as of 2010. Similarly to the previous variable, this variable was meant to account for the possibility that county employment in the tourism-related industries may have had differential pre-trends related to those industries' employment levels as of 2010.

Table 8 shows the results of the regressions for the Arts, Entertainment, and Recreation (AER) industry, and Table 9 shows the results for Accommodations and Food Services (AFS) industry.

Column 1 of Table 8 shows the results from a regression in which we included only the first three of the control variables described above and used only spending we coded as being related to construction in the GLRI spending variable. The estimated coefficient of 0.00081 implies that every million dollars of GLRI construction spending created or supported 0.81 jobs in the AER industry. In column 2, we used total GLRI spending instead of restricting our attention to projects with a construction element only. The estimated coefficient fell roughly in half, to 0.00044. The pattern that the estimated coefficient on GLRI spending was approximately half as large when we included all spending instead of restricting our attention to construction spending was persistent throughout the analysis.

From the perspective of total employment impacts, the choice of which spending measure to use is not very important, because we estimate that approximately half of all GLRI spending is related to construction activities. Multiplying twice as much spending by a coefficient that is half as large yields approximately the same estimated employment impact when we switch focus from construction spending to all spending.

In columns 3 and 4 of Table 8, we added the fourth, fifth, and sixth control variables described above. The estimate in column 3 implies that every million dollars of GLRI construction spending creates 1.7 jobs in the AER industry, while the estimate in column 4 implies that every million dollars of total GLRI spending creates 1.0 jobs in the industry. Therefore, controlling for the AER industry's employment share at the start of the GLRI and the industry's growth beforehand increased the GLRI's estimated association with future employment growth in the industry. The statistical significance of the estimated associations also increased.

Finally, in columns 5 and 6 of Table 8 we added fixed effects for counties we identified as outliers using Cook's D statistic.[25] Controlling for outliers increased the estimated associations further. The estimate in

[25] The Cook's D statistic (Cook 1977) attempts to identify data points that have substantial influence on the regression results and can be used to identify outliers. We used a threshold of 0.5 to identify outliers in our data.

column 5 implies that every million dollars of GLRI construction spending creates 3.1 jobs in the AER industry, while the estimate in column 6 implies that every million dollars of total GLRI spending creates 1.6 jobs in the industry. Those estimates were statistically significant at standard significance levels.

Table 8: GLRI Project Spending and Tourism Activity 2010-2016: Arts, Entertainment, and Recreation

	Dependent variable: County employment growth per capita in Arts, Entertainment, and Recreation, 2010-2016					
	(1)	(2)	(3)	(4)	(5)	(6)
Cumulative county GLRI spending 2010-2016 per capita (thousands of 2009 $)	0.00081	0.00044	0.00166	0.00103	0.00311	0.00159
	(0.00092)	(0.00052)	(0.00091)	(0.00051)	(0.00129)	(0.00065)
State per capita employment change in AER, 2010-2016	0.45712	0.45768	0.41399	0.41727	0.38147	0.38285
	(0.1189)	(0.11906)	(0.11532)	(0.11533)	(0.10603)	(0.10607)
Total per capita county employment growth, 2010-2016	0.01011	0.01013	0.01031	0.01029	0.00912	0.00907
	(0.0026)	(0.00256)	(0.00271)	(0.00271)	(0.00249)	(0.00249)
County personal income per capita, 2010	6.55E-08	6.55E-08	1.12E-07	1.13E-07	9.24E-08	9.26E-08
	(1.32E-08)	(1.32E-08)	(1.45E-08)	(1.45E-08)	(1.39E-08)	(1.39E-08)
County share of population 65+, 2010			-0.00207	-0.0023	-0.00393	-0.00418
			(0.00268)	(0.00269)	(0.00246)	(0.00247)
County per capita employment change in AER, 2004-2010			0.01517	0.01408	-0.21167	-0.21563
			(0.03699)	(0.03696)	(0.04314)	(0.04314)
County employment per capita in AER, 2010			-0.10156	-0.10246	-0.02940	-0.02966
			(0.01556)	(0.01559)	(0.01708)	(0.01710)
GLRI Spending Included	Construction	Total	Construction	Total	Construction	Total
Outlier Fixed Effects Used	No	No	No	No	Yes	Yes
Number of Observations	653	653	653	653	653	653
Adj. R-squared	0.110	0.104	0.164	0.165	0.300	0.300

Notes: The unit of observation is the county. Real GLRI spending includes matching funds. Please see the text for a full description of the regression equations. We identified 4 outlier counties using the Cook's D statistic. All per capita variables are expressed in terms of population as of 2010. All real variable are expressed in 2009 dollars.

Table 9 follows a parallel structure to Table 8, but it uses employment in the AFS industry as the outcome variable of interest. The specification in column 1, using the first three control variables and focusing on construction spending only, gave an estimated coefficient of 0.0064, which would imply that one million dollars of GLRI construction spending in a county from 2010 to 2016 was associated with 6.4 additional jobs in the AFS industry. The estimate in column 2, which used total GLRI spending, implies that one million dollars of total GLRI spending created or supported 3.4 additional jobs in the industry.

Adding the additional control variables, as in columns 3 and 4, reduced the estimated impacts of GLRI spending in the AFS industry by more than half, to 2.9 jobs per million dollars of construction spending (column 3) and 1.4 jobs per million dollars of total spending (column 4). That pattern stood in contrast to the pattern for the AER industry, in which the estimated employment impacts of the GLRI became larger when we included the additional control variables. Finally, columns 5 and 6 display the estimated results when we control for outlier counties. The estimated impacts shrank a bit further from the results in columns 3 and 4, to 2.5 jobs per million dollars of construction spending (column 5) and 1.2 jobs per million dollars of all spending (column 6). Unlike the estimates for the AER industry, the estimates of GLRI spending's impact on employment in the AFS industry were not statistically significant at conventional levels in columns 3 through 6.

Table 9: GLRI Project Spending and Tourism Activity 2010-2016: Accommodations and Food Services

	Dependent variable: County employment growth per capita in Accommodations and Food Services, 2010-2016					
	(1)	(2)	(3)	(4)	(5)	(6)
Cumulative county GLRI spending 2010-2016 per capita (thousands of 2009 $)	0.00642	0.00339	0.00290	0.00140	0.00254	0.00124
	(0.0019)	(0.00106)	(0.00198)	(0.00112)	(0.00192)	(0.00108)
State per capita employment change in AFS, 2010-2016	0.44669	0.44920	0.45018	0.45114	0.44679	0.44764
	(0.1343)	(0.13453)	(0.13134)	(0.13139)	(0.12683)	(0.12687)
Total per capita county employment growth, 2010-2016	0.03700	0.03707	0.02254	0.02249	0.02329	0.02326
	(0.0052)	(0.00521)	(0.00552)	(0.00552)	(0.00533)	(0.00533)
County personal income per capita, 2010	1.80E-07	1.80E-07	1.30E-07	1.30E-07	8.81E-08	8.79E-08
	(2.64E-08)	(2.64E-08)	(2.65E-08)	(2.66E-08)	(2.85E-08)	(2.85E-08)
County share of population 65+, 2010			-0.02935	-0.02946	-0.03412	-0.03423
			(0.00568)	(0.00570)	(0.00554)	(0.00555)
County per capita employment change in AFS, 2004-2010			-0.05703	-0.05847	-0.1699	-0.17152
			(0.03419)	(0.03423)	(0.03949)	(0.03951)
County employment per capita in AFS, 2010			0.07884	0.07939	0.06338	0.06380
			(0.01184)	(0.01192)	(0.01168)	(0.01176)
GLRI Spending Included	Construction	Total	Construction	Total	Construction	Total
Outlier Fixed Effects Used	No	No	No	No	Yes	Yes
Number of Observations	653	653	653	653	653	653
Adj. R-squared	0.186	0.179	0.253	0.252	0.304	0.303

Notes: The unit of observation is the county. Real GLRI spending includes matching funds. Please see the text for a full description of the regression equations. We identified 2 outlier counties using the Cook's D statistic. All per capita variables are expressed in terms of population as of 2010. All real variable are expressed in 2009 dollars.

We chose the specifications in column 6 of both Table 8 and Table 9 as our baseline specifications for both industries. As noted, the choice between focusing on construction spending only, as in column 5, or total spending, as in column 6, does not make a substantial difference in terms of the estimated employment impacts.[26] We chose to focus on total spending to be parallel with the approach in our quality of life analysis. Our choice of baseline specifications was conservative in the sense that the specifications that included the full list of control variables implied smaller total employment impacts than the specifications that included only a subset of the control variables. Finally, controlling for outlier counties increased the explanatory power of the regressions substantially, as seen in the adjusted R-squared statistics. It was not surprising that there were outliers in the results given that some of the counties we analyzed are quite small in terms of population and economic activity. Although our preferred coefficient for the AFS sector is not statistically significant at conventional confidence levels, we still consider it to be our best point estimate of the true impact.

Our estimation approach for the GLRI's impacts on tourism activity has a less clear causal interpretation than our approach for the GLRI's quality of life benefits. Additionally, as noted above, the estimate of the GLRI's impact on employment in the AFS industry was not statistically significant in our preferred specification.

After consulting with the expert panel, we decided to include our estimates for the GLRI's impacts on local tourism activity in our economic impact modelling for a number of reasons. First, the GLRI's beneficial effects on local tourism industries was one of the most consistent themes that came out of the qualitative and quantitative case studies.[27] Second, the results for the AFS industry in columns 1 and 2 were highly significant at conventional significance levels. Third, the results for the AER industry were statistically significant at conventional levels, and those results accounted for the majority of the GLRI's estimated impact on the local tourism industry. Fourth, we took a very conservative approach to entering the GLRI's direct tourism impacts into the REMI model, which we discuss in the section "Modelling Direct Tourism Impacts" below. For completeness, we include a discussion of the regional economic modeling results omitting the GLRI's direct impact on employment in the AFS industry in the section "The Present Discounted Value Regional Economic Multiplier" below.

Regional Economic Impact Analysis

We modelled the GLRI's historical and future impacts on the economy of the Great Lakes region using the REMI PI+ model, or simply "the REMI model," one of the most widely used models for regional economic impact analysis. We analyzed both the GLRI's historical economic impacts on the region over the period 2010 to 2016, and its expected future impacts through the year 2036.

We chose to extend our analysis through 2036 to capture a period of twenty years after the beginning of all of the projects we analyzed, the last of which began in 2016. The twenty year period was consistent with the time period analyzed in "Healthy Waters, Strong Economy: The Benefits of Restoring the Great

[26] Using total spending rather than construction spending reduces the estimated employment impacts slightly, but the difference is not material.

[27] For instance, one story from the qualitative case study in Muskegon, Michigan, involved a hotel that had been constructed by Lake Michigan. The hotel had been constructed so that its windows faced away from the lake, because, according to an interviewee, "When that hotel was built, the lake was a pit. It was a sewer. Could you imagine building a hotel today and not only facing the Lake but charging a premium" (sic; Liesch et al. 2017).

Lakes Ecosystem" (Austin et al. 2017), which attempted to quantify the economic benefits of a hypothetical program along the lines of the GLRI.

We focused on estimating what we call the regional economic multiplier of GLRI spending as our primary metric of the GLRI's impact. The regional economic multiplier answers the question, "By how much would one additional dollar of federal GLRI spending from 2010 to 2016 have increased economic output in the Great Lakes states on a present discounted value basis over the period 2010 to 2036?" We will clarify how we defined the regional economic multiplier further below.

Background on the REMI Model

The REMI PI+ model augments an input-output model similar to the Bureau of Economic Analysis Regional Input-Output Modeling System (RIMS II; see Bess and Ambargis 2011 for a description) with methods from regional science and economics, including a computable nearly general equilibrium model of regional economies. A particularly attractive feature of the REMI model for the purposes of our study is that it has incorporates an explicit time dimension, as opposed to similar models such as RIMS II or IMPLAN, which do not.[28] The lack of a time dimension in those models effectively imply that the supply of local factors of production is perfectly elastic at prevailing market prices, and in particular, that local labor supply labor is unlimited at current market wages. The inclusion of a time dimension in the REMI model allows us to distinguish between the historical and future economic impacts of the GLRI. An additional advantage in the context of this project is that the REMI model explicitly models regional population changes over time, allowing us to study immigration into the Great Lakes region induced by the GLRI.

Entering GLRI Impacts into the REMI Model

The REMI model includes a variety of so-called "policy variables" by which an analyst can model the effects of an economic policy change. We will discuss the specific policy variables that we used to enter the relevant effects of the GLRI sequentially.

Modelling Federal GLRI Spending

We first had to allocate all project spending (federal and matching funds) across the 23 industries in the REMI model listed in Table 4. We allocated the federal spending associated with each GLRI project in the EAGL database according to the classification scheme described in subsections *Amount* on page 8 and *Industry* on page 11 above.

As discussed, we entered the contractual spending in each industry into the REMI model as an increase in the "exogenous final demand" policy variables. An alternative would have been to enter the spending as an increase in the "local industrial output" policy variables. The difference is that using the exogenous final demand policy variables allows the REMI model to allocate the increase in output between local and non-local firms according to its industry-specific input-output matrix for each county. If the spending had been entered as an increase in local industrial output, all of the work would have implicitly been treated as being done by local firms. Our decision to use the exogenous final demand policy variables was informed by the qualitative case study results, which indicated that a mix of local and outside firms performed the project work. Using the final exogenous demand policy variables was also a more conservative modelling choice than using the local industrial output policy variables, because it

[28] Rickman and Schwer (1995) present a detailed comparison of the IMPLAN and REMI models. Neill (2013) presents a briefer, but more current, comparison of the RIMS II, IMPLAN, and REMI models.

allowed the REMI model to account for “leakages” of the new demand from the federal spending outside of the individual counties consistent with empirical patterns.

We assumed that all of the federal spending on the GLRI was deficit financed. Funding for the GLRI is appropriated by Congress directly to the EPA. It has not been formally tied to fiscal stimulus legislation such as the American Recovery and Reinvestment Act of 2009.

We nevertheless felt it was clear that federal GLRI funding was best thought of as deficit financed for two reasons. First, the spending for the program is a separate appropriation from Congress, so it did not offset other spending. Second, the federal government was actively attempting to stimulate the economy through fiscal policy over most of the period 2010–2016. The federal budget deficit averaged 5.1 percent of gross domestic product on a National Income and Product Accounts basis from 2010 to 2016, relative to its long-run average from 1952 to 2016 of 1.5 percent.

Modelling Matching Funds Spending

The matching funds were allocated across industries in the REMI model in the same way as the federal spending, as described in subsections *Amount* and *Industry* above. Specifically, for each project, after removing agency specific spending for administrative and travel purposes, the remaining federal funds were summed with the estimated matching funds and that total was then allocated across industries in the REMI model.

The main difference in the treatment of the matching funds concerned our assumptions about the source of the financing. Based on the results of the qualitative case study interviews, we assumed that the substantial majority of the matching funds came from state and local governments, which are generally unable to run substantial deficits. We therefore assumed that the matching funds were paid for by reductions in other spending by those units of government.[29] For projects connected to the Great Lakes Legacy Act, under which private industry was required to contribute matching funds, we did not apply any offsets to the matching funds. Our reasoning was that the companies providing those matching funds were likely to have had much of their business outside of the county or state in which the relevant projects occurred, so any proper offset would occur at a national or international scale, not at the local level.

Modelling Quality of Life Impacts

The REMI model offers multiple ways to enter the local quality of life impacts that we measured through our house price analysis. One option is to use the model policy variable called “non-pecuniary amenity aspects.” In principle, this variable corresponds to the local amenities we measured in our hedonic house price analysis, but using this policy variable is operationally difficult. The units in which the variable is measured are difficult to interpret, and are fundamentally unobservable. We would need to convert our house price estimates into those units in order to enter them into the REMI model using the non-pecuniary amenity aspects policy variable, which would require making additional assumptions about the relationship between house prices and amenities. Additionally, the relationship between the stock and the flow values of that policy variable is very complicated.

[29] The state offsets are aggregated to the state level, and then divided between the REMI regions based on each region’s state population share for the year. The offset numbers are entered separately into the REMI model from the other state and local spending amounts.

In light of those considerations, we decided to enter the GLRI's quality of life benefits estimated in our hedonic house price regressions through the REMI model's "residential real estate price" policy variable. In particular, we entered the *negative* of the predicted price impacts of GLRI spending from our regression analysis into the REMI model. The basic notion is that the quality of life improvements from GLRI spending allow local residents to obtain the same level of utility or satisfaction from living in a particular location for less money than they would otherwise be able to do. Some advantages of that approach were that it allowed us to translate the effects from our regression analysis into the REMI model in a straightforward manner, and that it avoided some of the potentially unwanted downstream effects of using the non-pecuniary amenity aspects variable. We discussed our approach with the Expert Panel, who agreed with our assessment that this approach was a preferable way to model the GLRI's quality of life benefits.

We entered the GLRI's predicted quality of life benefits in each county on an annual basis as GLRI project spending occurred. We then had to make an assumption about how long-lasting those effects were likely to be. We decided to depreciate the benefits over time using the REMI model's depreciation rate for non-residential capital of approximately 3 percent per year. Our reasoning was that the projects that produce the quality of life benefits are likely to be public works projects such as cleaning and improving waterfronts. Therefore, although the benefit shows up in residential housing prices, the projects themselves take the form of non-residential capital.

Modelling Direct Tourism Impacts

We calculated the change in employment predicted by GLRI construction spending in the two tourism industries at the county level from 2010 to 2016 using the estimated regression coefficients from column 6 of Table 8 and Table 9. We then entered the estimated increases in tourism employment into the REMI model using the "firm employment" policy variables. The REMI model accounts for competition between new and existing businesses when new employment is entered into a regional industry using the firm policy variables. The result is that the entry of new employers in the industry leads to some substitution of employment away from the existing employers, and the net increase in industry-wide employment is lower than the direct increase. That effect was not trivial in our application, reducing the estimated increase in employment in the two tourism industries in the Great Lakes watershed by more than half from the directly inputted amount in 2016.

An alternative approach would have been to use the REMI model's "exogenous employment" policy variables, which do not allow for substitution between the new and existing employers within an industry. To some extent, our regression analyses in Table 8 and Table 9 accounted for the substitution or competition effect by including the state-level change in per capita employment in the two tourism industries as a control variable. We nonetheless chose to enter the GLRI's impacts on the local tourism industries using the firm policy variables in order to be conservative in our analysis.

As we did for the quality of life impacts, we depreciated the estimated direct tourism employment impacts using the REMI model's depreciation rate for non-residential capital of approximately 3 percent per year to reflect the depreciation of improvements in the physical environment that drive the increase in tourism activity.

Choosing a Model Closure Option

The REMI model requires users to choose a "closure option," which specifies how the macroeconomy, in particular, the U.S. Federal Reserve, responds to the policy change being modelled. We chose the closure option "Historically Observed," specifying "Restore employment to baseline levels in 9.5 years." This closure option assumes that the Federal Reserve did not act to offset any federal fiscal stimulus from 2010 through 2018, offsets roughly half of any stimulus during 2019, and fully offsets any federal fiscal stimulus thereafter.

We believe that the assumption of no monetary offset through mid-2019 is appropriate given that the federal funds rate was near its lower bound from late 2008 through December 2015, and stayed below half a percent through 2016. Monetary policy tightening has continued to proceed very deliberately since then. The Congressional Budget Office estimates that following the Great Recession, the economy did not get back to its level of potential until the second quarter of 2018. As the economy reaches its potential level of output, sometimes known as "full employment," we expect the Federal Reserve to use monetary policy to steer the economy more actively, regardless of any additional fiscal stimulus.

Estimated Regional Economic Impacts of the Great Lakes Restoration Initiative

The REMI model allows us to estimate the economic impacts of the GLRI on the Great Lakes region on an annual basis from 2010 to 2036. We first report those results, and then discuss how we put both the economic impacts and the costs of the GLRI on a present-value basis as of 2016. That calculation allows us to express the ratio of the increase in regional economic activity generated by the GLRI to the federal spending on the program as a single number, which we call the regional economic multiplier. After we present our estimate of the regional economic multiplier for the whole region, we conclude by presenting some local economic impact results for the communities analyzed by the quantitative case study team.

Time Path of Regional Economic Impacts

Figure 9 displays our estimate of the GLRI's economic impact on the Great Lakes states each year from 2010 to 2036. The blue line shows our estimate of federal spending on GLRI projects in the Great Lakes states, which is unchanged from Figure 3.

The dashed gray line with square markers shows the GLRI's estimated impact on regional economic output accounting only for GLRI project spending, without including the quality of life (QoL) or direct tourism impacts that we measured.[30] We labeled that measure "Direct spending impacts only" in Figure 9. It grew from $109 million in 2010 to $366 million in 2012 as GLRI spending ramped up, and then held roughly steady until 2015, at which point it declined along with GLRI spending, to about $224 million in 2017.[31] It declines to approximately zero by 2021. As a multiple of federal GLRI spending, the direct spending impacts multiplier ranges from 1.4–1.7 during the high spending period from 2010 to 2017.

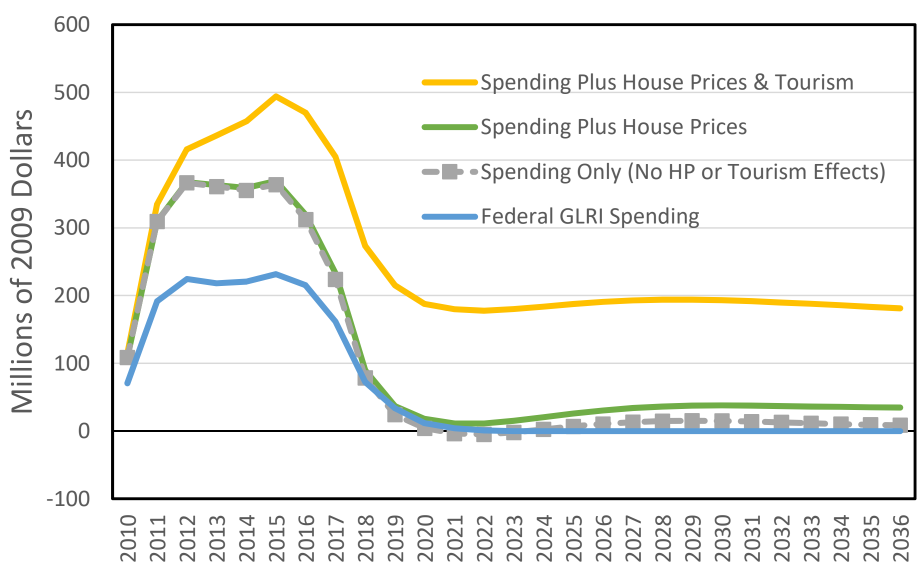
The solid green line displays the path of the GLRI's regional economic impact after adding in the local quality of life impacts that we estimated from our hedonic house price regressions. The green line is nearly on top of the dashed gray line at the beginning of the analysis period, reflecting the mechanism by which the quality of life benefits increase regional economic output, which is through increased net migration. As the GLRI makes the region a more attractive place to live, out migration slows and in

[30] We used regional value added as our measure of economic output for this report. Value added is one way of measuring gross domestic product, also known as the "income" approach. The alternative "output" approach can be very sensitive for small geographies in the REMI model because of how the model treats the value of shipments. See BEA (2015) for a brief description of different methods of calculating gross domestic product.
[31] All of the dollar values in this section are expressed in real (inflation-adjusted) 2009 dollars.

migrations rises, leading to a slow increase in population relative to the baseline without the GLRI. That pattern can be seen in the gradually widening gap between the green and gray lines in Figure 9. We estimate that in the period 2024–2036, after which time all of the federal spending we have analyzed will have stopped, the Great Lakes region will produce between $18–27 million per year of additional economic output due to the local quality of life benefits generated by the GLRI. (It is not possible to express that figure as a multiple because we did not consider GLRI spending during that period.)

Finally, the yellow line at the top of Figure 9 displays the path of the regional economic impact adding in the GLRI's estimated direct impacts on the local tourism industry. The direct impacts on the tourism industry rise sharply over the first few years of the analysis period as GLRI spending leads to job gains in the tourism industries. The additional output from the direct tourism impacts peaks at $183 million in 2018, when it accounts for two-thirds of the total regional economic impact that we estimated. It actually accounts for an even larger share of GLRI's estimated economic impact in later years, as the impact from the direct project spending fades. The increase in regional economic output from the direct tourism impacts fades slowly over the project period with the projected depreciation of the physical improvements brought on by the GLRI, but remains significant, contributing an additional $150 million in economic output at the end of the study period.

Figure 9: GLRI's Annual Impact on Economic Output in Great Lakes States, 2010 to 2036



Expressing GLRI Costs and Benefits as Present Discounted Values

As Figure 9 illustrates, the costs and benefits of GLRI spending follow complex dynamic patterns. In order to summarize the relative costs and benefits in a single summary metric, we would like to express all annual costs and benefits as present values from the perspective of the year 2016. Doing so requires choosing an appropriate discount rate.

There is not a broad consensus within the economics profession on how exactly to choose a discount rate for environmental projects; see Chapter 6 of the U.S. Environmental Protection Agency's *Guidelines for Preparing Economic Analyses* (2010) for a discussion of the issues. Therefore, we reviewed a substantial literature to inform our choice of the discount rate for the GLRI's future costs and benefits.

There were two aspects of our analysis that simplified the choice of a discount rate. First, we considered a time horizon of twenty years in the future, so we did not need to consider what is termed *intergenerational discounting*, as would have been necessary for longer-term issues such as climate change. Second, we focused primarily on the *economic* impacts of the GLRI, rather than its environmental impacts.[32] Arguably, that focus made standard approaches to selecting a discount rate more applicable to our analysis.

A full summary of the literature we reviewed would be beyond the scope of this report, so our discussion here focuses on relatively recent contributions to the literature. It also omits studies primarily related to intergenerational discounting, although some of these, such as the Stern Review (2006) are very well-known. Instead, the summary here focuses on practical contributions related to intra-generational discounting of environmental projects.

Table 10 below summarizes the recommended discount rates for environmental projects in the studies we reviewed. The table splits the studies into two groups: academic studies and government guidelines. The academic studies we reviewed generally recommended real discount rates around 3.5 percent; the highest recommended rate was the 4 to 5 percent recommended in Spackman (2004).

The guidelines used by U.S. Government agencies varied considerably, and the academic literature notes that the application varies widely by agency. We started with the EPA's *Guidelines for Preparing Economic Impact Analyses* (2010). EPA advises to conduct a bounding exercise by using discount rates of 3 percent and 7 percent. Those recommendations are in turn based on guidance from the Office of Management and Budget's *Circular A-4* (2003), which in turn references *Circular A-94* (1992). In contrast to that guidance, OMB now offers annual updates to the discount rates in Circular A-94; the currently published real discount rate in the circular is negative 0.1 percent for a 10-year real Treasury bond and positive 0.7 percent for a 30-year real Treasury bond, consistent with the substantial decline in real interest rates over the past 30 years. We were not certain why the EPA's guidelines and OMB's guidance in Circular A-4 have not been updated to reflect the decline in real rates as well.[33] Outside of the Executive Branch, Bazelon and Smetters (1999) report that the Congressional Budget Office uses a base real discount rate of 2 percent for social welfare analysis, with sensitivity analyses of plus and minus 2 percent around that rate (i.e., 0 percent and 4 percent).

Our study is not a government economic impact analysis, so we chose to use a real discount rate of 3.5 percent as our base rate, in line with the academic literature we reviewed. In order to promote comparability to government economic impact analyses, however, we also conducted sensitivity analyses using alternative discount rates of 3 percent and 7 percent.[34]

[32] To the extent that the environmental impacts of the program are reflected in our tourism and hedonic house price analyses, our study touches on those impacts as well.

[33] The distinction between the applicability of the guidance in Circulars A-4 and A-94 is that A-4 is intended for "cost-benefit analysis" but A-94 is intended for "cost-effectiveness analysis." The difference between the two types of analysis pertains to the extent to which the relevant benefits of a proposed government action can be expressed in monetary terms.

[34] We must note that we had misgivings about presenting results using a real discount rate of 7 percent, which struck us as badly outdated given the large decline in real interest rates seen since 1992.

Table 10: Literature Review on Discounting for Environmental Projects

Authors/Agency	Year	Study Name	Recommended Real Discount Rate	Notes
Academic Studies:				
Gollier	2010	Ecological Discounting	3.2%	Consumption discount rate
Moore et al.	2004	"Just Give Me a Number!" Practical Values for the Social Discount Rate	3.5%	Assumes no crowding out; used for benefits up to 50 years
Spackman	2004	Time Discounting and of the Cost of Capital in Government	4% to 5%	
Boardman et al.	2006	Cost-Benefit Analysis: Concepts and Practice	3.5%	
Government Guidelines:				
EPA	2010	Guidelines for Preparing Economic Analyses	3% and 7%	Refers to OMB Cicrular A-4
OMB	2003	Circular A-4	3% and 7%	Refers to OMB Cicrular A-94
OMB	1992	Circular A-94	3% and 7%	
OMB	2018	Memorandum, 2018 Discount Rates for OMB Circular No. A-94	-0.8% to 0.6%	For cost-effectiveness but not cost-benefit analysis
CBO	1999	Discounting Inside the Washington D.C. Beltway	2% +/- 2%	Consumption discount rate; as described in Bazelon and Smetters (1999)

The Present Discounted Value Regional Economic Multiplier

Applying those discount rates to the time paths of costs and benefits associated with GLRI spending allows us to express the regional economic multiplier on a present discounted value basis from the perspective of the year 2016. Table 11 presents the resulting regional value-added multiplier calculated a few different ways.

When we included only the direct spending impacts of the GLRI in the analysis, we estimated a regional economic multiplier on federal GLRI spending of 1.57. That number means that one dollar of federal spending on the GLRI will lead to an increase in economic output in the Great Lakes region of $1.57 over the period 2010–2036. Including the local quality of life impacts increased the estimated regional economic multiplier to 1.73.[35] Additionally including the effects of the GLRI's direct impacts on regional tourism increased the estimated regional economic multiplier further to 3.35, which was our preferred estimate of the regional economic multiplier on federal GLRI spending.

Table 11 also presents the estimated regional economic multiplier using the alternative annual discount rates of 3% and 7% the EPA recommends using as a bounding exercise. Reducing the annual discount

[35] Of course, the primary benefit of those quality of life impacts is non-monetary, so it does not show up directly as economic output. Measuring and quantifying those benefits was the purpose of our hedonic house price analysis. Those non-monetary benefits are in addition to the increase in regional economic output discussed here.

rate to 3% increased the estimated regional economic multiplier slightly, to 3.44, while increasing the annual discount rate to 7% reduced the regional economic multiplier to 2.90.

Table 11: Present Discounted Value Regional Economic Multiplier of the GLRI

Inputs	Multiplier
Direct spending impacts only	1.57
Direct spending plus Quality of Life impacts	1.73
Direct spending plus Quality of Life and Tourism impacts	3.35
With 3% discount rate	3.44
With 7% discount rate	2.90

Notes: Great Lakes region comprises the 8 Great Lakes States. Economic output is meaured using a regional value added concept. Spending and fiscal impacts are expressed in present value terms as of 2016 using a base discount rate of 3.5%. Only federal GLRI spending, not matching funds, is used to calculate the multiplier.

Comparing the estimated regional economic multiplier with and without including the GLRI's direct impacts on the tourism industry allows us to estimate by how much one dollar of GLRI spending increases regional tourism activity. The difference in the two multipliers was 1.62, implying that one dollar of federal GLRI spending will generate $1.62 of output in the Great Lakes tourism sector from 2010 through 2036.

As discussed in the section "Tourism Employment Regressions," our estimates of the GLRI's impacts on local employment in the Accommodation and Food Services industry were not statistically significant at standard confidence levels. Of course, the relative imprecision of the estimates for that industry could mean that the GLRI's true impact was larger or smaller than we estimated. Nonetheless, for curious readers, we also performed that economic impact analysis omitting the direct impacts on employment in the AFS industry. The estimated present-value multiplier was 3.02 in that case.

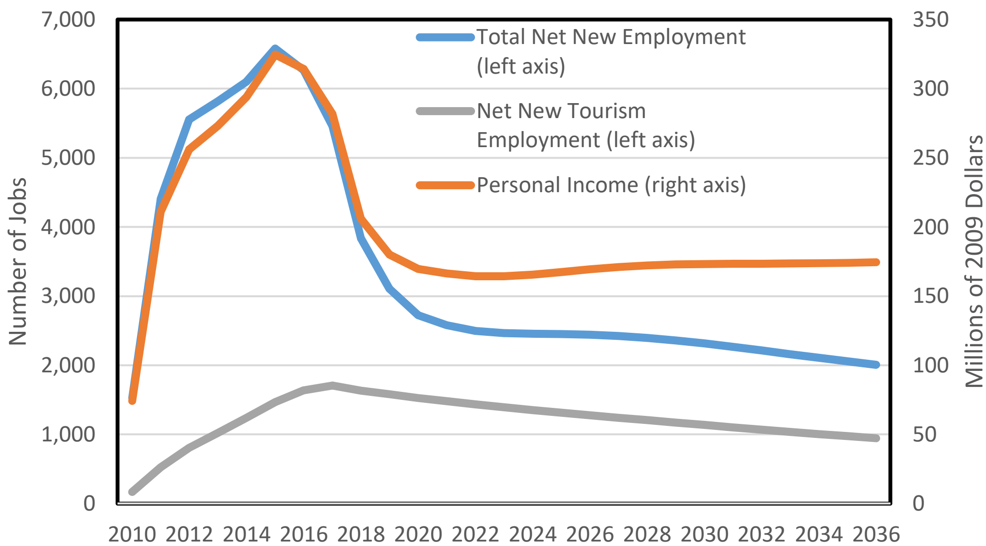
Employment and Personal Income Impact Estimates

For ease of interpretation, we have focused primarily on the regional economic multiplier of GLRI spending. Other metrics of the GLRI's impact on the Great Lakes region are also of interest, however. Figure 10 displays our estimates of the GLRI's net impact on total regional employment and personal income over the years 2010–2036. The estimated impact on net new employment has the same basic shape as the estimated effect on economic output, peaking in 2015 and declining thereafter. GLRI spending created or supported an average 5,180 net new jobs in the Great Lakes States from 2010–2016. That number falls to a bit over 2,700 in 2020 as the direct spending impacts fade. After that, the GLRI's employment impacts decline gradually, to just over 2,000 jobs created or supported in 2036.

Figure 10 also displays the time path of the GLRI's estimated impacts on employment in the tourism industries that we studied. The estimated impact grows steadily during the higher spending period from 2010 to 2017. It reaches a peak of 1,700 net new tourism jobs in 2017, about 30 percent of the total employment impact. It then begins to decline, but more slowly than the GLRI's total employment impact. We estimate that the GLRI will create or support 945 net new tourism jobs in the region in 2036, about 47 percent of the GLRI's total employment impact in that year.

The time pattern of the GLRI's effects on personal income in the Great Lakes region mirrors the pattern of the employment impacts through 2016. The average increase in personal income from 2010–2016 is $250 million (2009 dollars) per year, for a total increase of a bit over $1.7 billion. The GLRI's estimated effect on personal income is more persistent than the estimated effect on regional employment. It settles at between $160–175 million per year from 2020–2036. The personal income effects do not decline in the later years of the analysis period because of the growth of non-labor income, much of which is attributable to additional retirees living in the region.

Figure 10: Estimated Employment and Personal Income Impacts of the GLRI



A natural question concerns how to assess the size of these estimated impacts: are these employment effects big, or are they small? A convenient metric with which to assess the economic stimulus effect associated with federal spending is the cost per job created and supported. Chodorow-Reich (forthcoming) summarizes a set of studies that estimated fiscal multipliers based on components of the American Recovery and Reinvestment Act (ARRA) of 2009. He reports, using nominal dollars, "The cost-per-job across these studies ranges from roughly $25K to $125K, with around $50K emerging as a preferred number." Bartik (2010) estimates that conventional fiscal stimulus costs about $100,000 per job created in nominal dollars.

The implied cost-per-job-year supported or created over the period 2010–2016 in our estimates is $38,000 of federal spending, expressed in 2009 dollars. Including matching funds, that cost rises to $48,000 per job year. Those estimates are well in line with the estimates surveyed by Chodorow-Reich and substantially lower than the costs described by Bartik. Therefore, our estimates suggest that the GLRI delivered approximately the same job creation benefits as more conventional federal stimulus programs, although its primary aim was not to serve as an economic stimulus program.

Local Economic Impact Estimates

In order to provide additional detail regarding the GLRI's economic impacts in the Great Lakes region, we estimated impacts for the eight communities that were the subjects of the quantitative case studies. The version of the REMI model that we used in the analysis was a county-level model, so we could not examine results for any smaller geographies. We did aggregate the county-level results to the Metropolitan Statistical Area (MSA) level for the Buffalo, Detroit, and Duluth areas; we present the results for those areas in addition to the results for their principal counties.

Table 12 presents our estimates of the local economic impacts for the quantitative case study communities. We have included some additional metrics in addition to those we presented for the entire Great Lakes region. In particular, we have included net new residents, net new jobs in the two tourism industries we considered, and net new jobs across all industries as of 2016. We also present the aggregate quality of life benefits calculated from our hedonic house price regressions expressed both per person and per housing unit in order to convey their magnitudes more intuitively.

We estimate that Ashtabula County, Ohio, located on the shores of Lake Erie in Northeastern Ohio, will receive nearly $22 million in federal GLRI funding for projects that started by 2016.[36] We estimate that that spending raised local residential property values by nearly the same amount by 2016. The total increase in residential property values translates to $213 per person or $470 per housing unit. We also estimate that the GLRI created or supported 80 net new jobs to Ashtabula County as of 2016. That number may sound small, but total employment in Ashtabula County increased by only 852 jobs from 2010 to 2016. Therefore, our estimates suggest that the GLRI was responsible for nearly 10 percent (9.4 percent) of all net job growth in Ashtabula County in that time period.

Federal GLRI spending was over four times as large in the Detroit metropolitan region as in Ashtabula, at a bit under $90 million. We estimate that that spending resulted in over five times as many net new jobs being created in the Detroit MSA by 2016 (423 compared to 80). Between 2010 and 2016, though, employment in the Detroit MSA grew by 298,508 jobs. Therefore, we estimate that the GLRI is responsible for only 0.14 percent of all net new jobs created in the Detroit MSA between 2010 and 2016. Those results show that while the dollar value of GLRI spending may be larger in some of the bigger areas that we studied, such as the Detroit area, the impact of GLRI spending tends to be disproportionately larger relative to the size of the local economy in some of the smaller geographical areas such as Ashtabula. Other local areas where we estimate that GLRI spending accounted for a substantial proportion of observed job growth from 2010–2016 included the Duluth metropolitan area (4.2 percent of net job growth) and Sheboygan County, Wisconsin (3.2 percent of net job growth).

[36] That quantity is expressed in present discounted value terms in inflation-adjusted 2009 dollars, as are the other dollar amounts reported in this section unless otherwise noted.

Table 12: Estimated Local Economic Impacts of the GLRI

Region	Quality of Life Benefits as of 2016 (measured from house prices; 2009$)	Quality of Life Benefits per Person (2009$)	Quality of Life Benefits per Housing Unit (2009$)	Net New Residents, 2016	Net New Jobs in Tourism Industries, 2016	Net New Jobs in All Industries, 2016	Present Value of Total Increase in Regional Economic Output, 2010-2036 (2009$)	Present Value of Federal Spending, 2010-2036 (2009$)	Regional Economic Output Multiplier
Ashtabula County, OH	21,652,343	213	470	112	45	80	59,576,261	21,684,539	2.75
Erie County, NY	17,706,041	19	42	204	80	271	270,970,708	65,789,356	4.12
Buffalo MSA	*20,763,716*	*18*	*40*	*231*	*84*	*292*	*290,699,234*	*71,094,762*	*4.09*
Wayne County, MI	12,531,698	7	15	115	17	149	155,142,439	47,396,232	3.27
Detroit MSA	*53,307,391*	*13*	*29*	*320*	*32*	*423*	*379,727,184*	*88,495,468*	*4.29*
Douglas County, WI	14,149,935	320	620	77	28	55	38,157,786	11,452,889	3.33
St. Louis County, MN	43,031,529	215	418	168	80	179	115,834,136	44,787,779	2.59
Duluth MSA	*59,041,837*	*211*	*417*	*274*	*116*	*260*	*168,414,606*	*60,068,897*	*2.80*
Erie County, PA	3,741,949	13	31	15	4	15	18,455,450	5,374,403	3.43
Muskegon County, MI	29,770,219	173	405	149	60	137	103,967,897	34,303,541	3.03
Sheboygan County, WI	46,383,977	402	914	212	87	141	109,468,212	41,570,370	2.63
Waukegan, IL (Lake County)	20,207,584	29	78	117	31	100	153,186,410	35,348,848	4.33

Notes: We used MSA definitions from the Office of Management and Budget. The Buffalo MSA contains Erie and Niagara Counties, New York; the Detroit MSA contains Wayne, Lapeer, Macomb, Oakland, St. Clair, and Livingston Counties, MI; the Duluth MSA contains Carlton and St. Louis Counties, MN and Douglas County, WI. Spending and fiscal impacts expressed in present value terms as of 2016 using a base discount rate of 3.5%. Regional economic output and the regional economic output multiplier are measured using a value-added concept.

Conclusion

The Great Lakes Restoration Initiative (GLRI) is a major U.S. environmental restoration program designed to improve the environment of the Great Lakes and its surrounding watershed. Since its inception in 2010, the program has involved the expenditure of more than $2 billion on thousands of individual projects in eight Great Lakes states. In this study, we evaluated the economic impacts of GLRI projects that started during the years 2010–2016 on the Great Lakes states. In order to capture the long-run nature of those projects' costs and benefits, we considered a period of twenty years after the final projects we examined began, resulting in a study period of 2010–2036.

The GLRI produces three main types of economic benefits to the Great Lakes states. First are the standard macro-economic benefits generated by the federal government spending a substantial amount of money in the region each year. Those benefits are similar to the benefits that would be generated by other types of federal government spending, such as defense or health care spending. Second are the benefits that accrue because the GLRI improved the local quality of life in Great Lakes communities. Those benefits are reflected primarily by an increase in local housing prices. Third is the improvement in the local tourism industry in areas where GLRI projects have improved the physical environment.

We estimated that the GLRI's annual economic benefits to the eight Great Lakes States accelerated between 2010 and 2016 as project spending ramped up and the longer-term benefits from improved quality of life and attractiveness as a tourism location took effect. By 2015, annual economic output in the region had increased by an estimated $500 million due to the program. Although the annual regional economic impact will decline as project spending slows, the annual regional economic impacts of the GLRI projects we considered will exceed $180 million even by 2036.[37]

To summarize the benefits and costs of the GLRI in a single measure, we compared the present value of the federal expenditures on the program to its regional economic impacts from the perspective of the year 2016. We estimated that every $1.00 of federal spending on the GLRI will boost regional economic output in the Great Lakes states by a total of $3.35 over the period 2010–2036. Additionally, we estimated that as measured by house prices, every $1.00 of GLRI spending produced quality of life benefits that local residents valued at $1.08 in 2016. Given our attempt to employ a consistently conservative estimation strategy throughout the analysis, we believe the program's actual benefits to the region were likely higher than our estimates.

The economic prosperity of the Great Lakes states, and especially their watersheds, has been hampered by the historical environmental pollution of the Great Lakes and the rivers, bays, and lakes connected to them. We have provided evidence that the Great Lakes Restoration Initiative has provided substantial benefits to the economy of the Great Lakes region even as it has begun the work of restoring the physical environment of the Great Lakes.

[37] Both that amount and the estimate for 2016 were measured on a value-added basis in inflation-adjusted 2009 dollars.

Literature Cited

Aladangady, Aditya. 2017. Housing Wealth and Consumption: Evidence from Geographically Linked Microdata. *American Economic Review*, 107(11): 3415–3446.

Albouy, David and Farahani, A. 2017. Valuing Public Goods More Generally: The Case of Infrastructure. Uphjohn Institute working paper 17-212.

Austin, John C., Anderson, S., Courant, P.N., Litan, R.E. (2007) America's North Coast: A Benefit-Cost Analysis of a Program to Protect and Restore the Great Lakes.

Austin, John C., Anderson, S., Courant, P.N., Litan, R.E. (2007) Healthy Waters, Strong Economy: The Benefits of Restoring the Great Lakes Ecosystem. *The Brookings Institution*

Bartik, T. 2010. Estimating the Costs per Job Created of Employer Subsidy Programs. Presented at Upjohn Institute conference on "Labor Markets in Recession and Recovery," October 22-23, Kalamazoo, MI. http://research.upjohn.org/confpapers/19/

Bazelon, Coleman, Smetters, K. (1999) Discounting Inside the Washington D.C. Beltway. *Journal of Economic Perspectives* 13(4) pp. 213-228

Board of Governors of the Federal Reserve System (US). 2018. 10-Year Treasury Constant Maturity Rate [WGS10YR], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/WGS10YR, August 29, 2018.

Boardman, David, Greenberg, D., Vining, A. (2006) Cost-Benefit Analysis: Concepts and Practice, 3rd Edition. Ch. 10. Upper Saddle River, New Jersey

Bogin, Alexander, Doerner, W.M., Larson, W.D. (2016) Local House Price Dynamics: New Indices and Stylized Facts. FHFA Staff Working Paper 16-01. URL: https://www.fhfa.gov/PolicyProgramsResearch/Research/Pages/wp1601.aspx

Bureau of Economic Analysis. (2015) Measuring the Economy: A Primer on GDP and the National Income and Product Accounts. URL: https://www.bea.gov/sites/default/files/methodologies/nipa_primer.pdf

Chodorow-Reich, G. Forthcoming. Geographic Cross-Sectional Fiscal Multipliers: What Have We Learned? *American Economic Journal: Economic Policy*.

Congressional Budget Office. (2018) An Update to the Economic Outlook: 2018 to 2028. URL: https://www.cbo.gov/publication/54318

Cook, R. Dennis. (1977) Detection of Influential Observation in Linear Regression. *Technometrics*, 19(1), pp. 15–18.

Cooper, Daniel. 2013. House Price Fluctuations: The Role of Housing Wealth as Borrowing Collateral. *Review of Economics and Statistics*, 95(4): 1183–1197.

Dynan, Karen and Sheiner, L. (2018) GDP as a Measure of Economic Well-being. Hutchins Center Working Paper number 43. URL: https://www.brookings.edu/wp-content/uploads/2018/08/WP43-8.23.18.pdf.

Environmental Protection Agency. (2010) Guidelines for Preparing Economic Analyses. National Center for Environmental Economics

Gollier, Christian. (2010) Ecological Discounting. *Journal of Economic Theory,* 145(2), 812-829

Joint Center for Housing Studies of Harvard University. (2018) The State of the Nation's Housing 2018. *Harvard University* URL: http://www.jchs.harvard.edu/sites/default/files/Harvard_JCHS_State_of_the_Nations_Housing_2018.pdf

Liesch, Matthew, Graziano, M., Irajifar, L. (2017) Great Lakes Economy and the Environment Program: Report on Project 1. *Unpublished manuscript*.

Leventis, Andrew, Weiher J. (2009) An Approach for Calculating Reliable State and National House Price Statistics. *Federal Housing Finance Agency.*

Moore, Mark A., Boardman, A.E., Vining, A.R., Weimer, D.L., Greenberg, D.H. (2004) Just Give Me a Number Practical Values for the Social Discount Rate. *Journal of Policy Analysis and Management* 23(4) 789-812

Office of Management and Budget. (2003) Circular A-4, Subject: Regulatory Analysis.

Office of Management and Budget. (2018) Discount Rates for Cost-Effectiveness Analysis of Federal Programs. *Federal Register* 83(27)

Rebecca Bess & Zoë O. Ambargis. (2011) Input-Output Models for Impact Analysis: Suggestions for Practitioners Using RIMS II Multipliers. BEA Working Papers 0081, Bureau of Economic Analysis. URL: https://ideas.repec.org/p/bea/wpaper/0081.html

Rickman and Schwer (1995) present a detailed comparison of the IMPLAN and REMI models. Neill (2013) presents a briefer, but more current, comparison of the RIMS II, IMPLAN, and REMI models.

Roback, J. (1982) Wages, Rents, and the Quality of Life. *Journal of Political Economy*, 90(6): 1257-1278.

Rosen, S. (1974) Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition. *Journal of Political Economy*, 82(1): 34-55.

Spackman, Michael. (2004) Time Discounting and of the Cost of Capital in Government. *Fiscal Studies* 25(4): 467-518

Stern, Nicholas. (2006) Stern Review: The Economics of Climate Change. *Government of the United Kingdom*

Appendix A: Expert Panel Process

The project team developed an Expert Panel review process to provide input to the economics teams and ensure methodological rigor. Because of the ambitious timeline for this study, the usual process for ensuring rigor in approach and methods – academic peer review – was not possible. The Expert Panel provided an intensive review process in both Phase I and Phase II, as the team refined their methods and generated initial results, with the ultimate goal of assuring regional and national audiences of the validity of the study's findings.[38]

Composition of the Panel

In each phase, the Expert Panel was composed of five economists that are recognized authorities with diverse and relevant expertise, who will be seen as non-partisan and regionally neutral. The panel included:

- Experts in regional economic analysis and the use of REMI. These individuals understood both the strengths and challenges of REMI analyses and provided specific feedback on the input data, model assumptions and interpretation of results.
- Experts in hedonic analysis that provided input on the hedonic price analysis and reviewed housing regressions used to help set up to the REMI model.
- Senior individuals with experience leading multiple-approach economic analyses and tackling policy relevant questions.

A short biography of each panelist is provided below.

The Review Process

The project team convened the expert panel for three meetings during the first phase of the project. The timeframe and objectives for each meeting are outlined in the table below. Panelist participated remotely in panel meetings using video conferencing and slides. Each meeting lasted 2 – 3 hours and involved short presentations from the economics teams followed by extended Q&A and discussion. Jennifer Read, Director of the University of Michigan Water Center, facilitated each meeting, drawing upon her experience facilitating proposal review panels and advisory board meetings for a variety of programs and projects.

Panelists received written materials from the economics teams in advance of the call and were given five or so days to submit written comments after the panel meeting. Comments were collected through a google doc feedback form and panelists were encouraged to read, reference and build-on each other's comments.

Panelists collectively provided about 6 pages of comments after each meeting, which were shared in full with the project team. The economics teams annotated the feedback form with their own response, outlining if and how they planned to integrate the ideas, which were later shared with the Expert Panel.

[38] Phase I represents research conducted in 2017, which focused primarily on the direct impacts of GLRI spending. We expanded the analysis in Phase II, which was conducted in 2018, to improve the analysis of local quality of life, tourism, and the resulting economic impacts.

At two points, the team shared spreadsheets with input data and modeling parameters to allow panelists to review their work in more detail.

During Phase II, four of the five original panelists were able to continue with the project. The project team recruited a fifth panelist with credentials and expertise similar to the individual unable to continue into Phase II. Once again, the expert panel was convened three times over the course of the project period and timeframe and objectives for each meeting are outlined below.

Panelist participated remotely in panel meetings using video conferencing and slides. Each meeting lasted 2 – 3 hours and involved short presentations from the economics teams followed by extended Q&A and discussion. Jennifer Read, Director of the University of Michigan Water Center, also facilitated each of these meetings.

The structure of the review process worked so well in Phase I that it was retained for Phase II. Panelists received written materials, typically a report with specific questions the economics or case study team had for the panel four to five days prior to the panel meeting. Comments were collected via google document enabling panelists to both hear and consider each other's comments during the panel meeting as well as to reflect on them as they provided written comments in the google document.

A short summary of the Expert Panel process and the type of feedback received will be made publicly available as an appendix to the full report at the end of Phase II to help build confidence in results while acknowledging limitations.

Expert Panel Timeline during Phase I:

First Expert Panel Meeting *Focus: Regional economic modeling and case study methods*	
Meeting Time	noon – 2:00 pm (eastern), Wednesday, July 19
Work Discussed	Regional Economic Modeling: • Description of the data • How processed and being used in REMI model • Anticipated model output metrics Case Studies: • Locations and how/why selected • Profile list of interviewees • Semi-structured interview questions Hedonics: • Outline of approach

Second Expert Panel Meeting *Focus: Hedonics Methods Feedback, Input to REMI, Case Study Process*

Meeting Time	1:00 – 4:00 pm (eastern), Monday, August 28
Work Discussed	Hedonics: • Data. How many repeat sales of properties before and after delisting of the four AOCs? • Methods. How to identify the effect of AOC delisting on residential housing prices? Regional Economic Modeling: • Initial results from baseline Case Studies: • Post-interviews analytical methods • Initial feedback from interviews

Third Expert Panel Meeting *Focus: Integrating and communicating initial study results, additional tweaks*	
Meeting Time	2:00 -5:00 pm (eastern), Monday, September 25
Work Discussed	Initial project results, including: • Regional economic modeling; • Hedonics price analysis; and • Case studies. Strategies for integrating project elements. Key messages for communicating results

Expert Panel Timeline: Phase II

Fourth Expert Panel Meeting *Focus: Hedonics house price analysis (revised)m tourism analysis, long-run economic analysis*	
Meeting Time	1:30-4:30 pm (eastern), Friday, June 29, 2018
Work Discussed	Project methods and initial results for three regional economic modeling elements: • Hedonics house price analysis, as proxy for quality of life; • Tourism analysis; and • Long-run economic impact analysis

Fifth Expert Panel Meeting *Focus: Phase II case studies, hedonics house price analysis, tourism analysis, long-run economic analysis*	
Meeting Time	1:30-4:30 pm (eastern), Wednesday, August 22

Work Discussed	Overview and discussion of Phase II case-study analysis Refined project results for: • Hedonics house price analysis, as proxy for quality of life; • Tourism analysis; and • Long-run economic impact analysis Initial thoughts on integrating case-study and economic results

Sixth Expert Panel Meeting *Focus: Integrating and communicating study results, additional tweaks*	
Meeting Time	1:30-4:30 pm (eastern), Wednesday, September 12
Work Discussed	Final project results Strategies for integrating project elements. Key messages for communicating results

Expert Panel Members

Expert Panelists	Brief Biography
Patrick Barkey Director, Bureau of Business and Economic Research, University of Montana	Patrick Barkey has served as Director of the Bureau of Business and Economic Research since 2008. The Bureau is a research department within the School of Business Administration at the University of Montana, Missoula. They produce a variety of economic and industry data including annual economic forecasts for the United States as well as Montana, its industries, and counties. Patrick has been involved with economic forecasting and policy research for more than 30 years, in both the private and public sectors. Before coming to Montana he served as Director of the Bureau of Business Research at Ball State University in Indiana for fourteen years. His recent research has been on the economic impact of energy development, the property tax treatment of the telecommunications industry and the economic impact of trade with Canada. He holds a B.A. and a Ph.D. in economics from the University of Michigan.

Colby Lancelin Principal Planning Coordinator, Atlanta Regional Commission, Research Analysis Division	Colby Lancelin is a long-range socioeconomic planning forecaster and econometric modeler with the Atlanta Regional Commission. Mr. Lancelin is the program manager of the agency's Economic Analysis Program providing custom impact studies and economic assessments on developments of regional impact within the Atlanta Region. He is responsible for developing the region's employment and population forecast controls. His work focuses planning resources around key regional issues assisting communities and civic leaders with measuring socioeconomic impact and assessing the cumulative effect of implementing various policies, development spending, and alternative transportation investments and revenue-generating resources in the region. Prior to this role, Colby was a Comprehensive Planner with the City of Mobile. He received a Bachelor's degree in Geography from the University of South Alabama specializing in research methods in urban and economic geography.
Robert Litan Visiting Senior Policy Scholar, McDonough School of Business, Georgetown University	Robert Litan is an Adjunct Senior Fellow at the Council on Foreign Relations, a visiting senior policy scholar at Georgetown's Center for Business and Public Policy, and a partner at the law firm of Korein Tillery, based in St. Louis and Chicago. He formerly was vice president and director of economic studies and a senior fellow at the Brookings Institution, a Vice President and director of research at the Kauffman Foundation, and director of research for Bloomberg Government. As an economist and attorney, Robert has had nearly four decades of experience in the worlds of the law, economic research, and policy, and as an executive in both the private, public, and government sectors. During his research career, Litan has published numerous books and articles. Robert's latest books include The Trillion Dollar Economists, The Need for Speed and Better Capitalism. Robert earned his B.S. in economics at the University of Pennsylvania; his J.D. at Yale Law School; and his Ph.D. in Economics at Yale University.
Expert Panelists	**Brief Biography**
Craig Bond Senior Economist, Rand Corporation (Phase I)	Craig Bond is an applied microeconomist who specializes in natural resource and environmental economics, including stochastic dynamic modeling, resource valuation, consumer and producer choice, and applied welfare economics. Methodologically, he has extensive experience with non-market valuation of ecosystem services, as well as panel data and discrete choice econometric methods. His structural modelling work is focused on stochastic dynamic programming approaches to adaptive management planning and assessment and sustainability, as well as agent-based modelling, and other structural dynamic models of economies. Craig has worked on resilience issues, valuation of ecosystem services, environmental and economic impacts of long-term changes along the Louisiana and Florida coasts, the relationship between economic growth and environmental quality in Australia.
Bryce Ward Associate Director at the Bureau of Business and	Bryce Ward is the Associate Director at the Bureau of Business and Economic Research and the Co-Founder of ABMJ Consulting. He has a PhD in economics from Harvard University and BAs in economics and history

Economic Research, University of Montana	from the University of Oregon. He has expertise in urban and regional economics, labor economics, health economics, public finance, social economics, real estate economics, environmental and natural resource economics, and statistics/econometrics. He taught classes at Harvard University, Lewis and Clark College, the University of Oregon, and Portland State University. He has published dozens of scholarly articles and economic reports, and he has provided expert testimony in dozens of court cases and legislative proceedings. His research has been featured in places like the New York Times, Scientific American and MSN Money.
Nicholas Burger Senior Economist, Rand Corporation (Phase II)	Nicholas Burger is a senior economist at the RAND Corporation and director of RAND's Washington office. He is also associate director of RAND Labor and Population, the director of the Center for Research and Policy in International Development (RAPID), and a professor at the Pardee RAND Graduate School. His work focuses on environmental economics and international development, including energy and climate change. He was a lead author on the Fourth Assessment Report produced by the Intergovernmental Panel on Climate Change. He has a Ph.D. in economics from the University of California, Santa Barbara and a B.A. in economics and philosophy from the University of Southern California.

Appendix B: Project Teams

The research in this report was conducted by a team of economists at the University of Michigan's Research Seminar in Quantitative Economics (RSQE).

The research and study design were informed by a qualitative case study research team from Central Michigan University (CMU) and a quantitative research team from Issue Media Group.

The qualitative case study research team conducted case study interviews in four communities in the Great Lakes region: Erie County, NY; Muskegon County, MI; Sheboygan County, WI, and Duluth, MN. The case study research team comprised Marcello Graziano, Ph.D., Leila Irajifar, Ph.D., and Matthew Liesch, Ph.D. A list of the semi-structured interview questions used in the qualitative case studies is available in Appendix C: Semi-structured Interview Questions below.

The quantitative case study team conducted case studies of the economic impacts of GLRI investments in 8 Great Lakes communities: Ashtabula County, OH; Buffalo, NY; Detroit, MI; Duluth, MN; Erie County, PA; Muskegon County, MI; Sheboygan County, WI; and Waukegan, IL (Lake County). The research included stakeholder interviews, collection and analysis of existing data.

Focus areas for the research included growth in existing industries, the emergence of new industries, economic development, job growth, the attraction of the locale to millennials and families, increases in tourism and recreation, changes in public health and outdoor activities, optimism, changing community perceptions, and others. The team synthesized new and existing quantitative and qualitative research together with economic modeling results to produce readable, narrative descriptions of the economic impacts of GLRI in each community using personal stories, anecdotes and examples.

The quantitative case study team comprised Nina Ignaczak and Patrick Dunn.

Economic Impact Research Team

Gabriel Ehrlich is Director of the University of Michigan's Research Seminar in Quantitative Economics. His research focuses on macroeconomics and regional economics. Prior to joining RSQE, Gabe worked in the Financial Analysis Division at the Congressional Budget Office. He testifies twice per year to the Michigan Legislature on the state's fiscal and economic prospects, and is the coauthor recently of *The U.S. Economic Outlook for 2017–2018*; *The Michigan Economic Outlook for 2017–2018*; *Economic Effects of Medicaid Expansion in Michigan*, published in the *New England Journal of Medicine*; and *Metropolitan Land Values*, forthcoming in the *Review of Economics and Statistics*. He received his Ph.D. in Economics from the University of Michigan.

Donald Grimes is a Research Area Specialist Lead at the University of Michigan's Research Seminar in Quantitative Economics. His primary research interests are in labor economics and economic forecasting. For more than 30 years, he has been engaged in economic forecasting for state and local governments and is frequently called upon for policy advice. He has been involved in research projects sponsored by the U.S. Department of Commerce, the U.S. Department of Labor, the Federal Reserve Bank of Chicago, and the Robert Wood Johnson Foundation. His recent publications include *The Michigan Economic Outlook for 2017–2018*; *Exploring Wage Determination by Education Level: A U.S. Metropolitan Statistical Area Analysis from 2005 to 2012*, published in *Economic Development Quarterly*; and *Economic Effects of Medicaid Expansion in Michigan*, published in the *New England Journal of Medicine*. He received his M.A. in Economics from the University of Michigan.

Michael McWilliams is Research Area Specialist Lead at the University of Michigan's Research Seminar in Quantitative Economics. His research focuses on a range of topics in environmental and natural resource economics, including land use change and its causes and environmental consequences, regulation of light-duty vehicles, and the impact of the Renewable Fuel Standard. His work has been published in the *Proceedings of the National Academy of Sciences* and *Energy Policy*. Mike is a coauthor recently of *The Michigan Economic Outlook for 2017–2018*. He received his Ph.D. in Economics from the University of Michigan.

Qualitative Case Study Team

Marcello Graziano is Assistant Professor in the Department of Geography at Central Michigan University. Marcello is an economic geographer, with a specialization in regional economics and energy geography. Prior to his current position, Marcello was Postdoctoral Research Associate at SAMS – University of the Highlands and the Islands. In addition, he is currently a Research Fellow for the Connecticut Center for Economic Analysis (CCEA) at the University of Connecticut, and an Associates of the SAM Learned Society. He holds a B.Sc. in Foreign Trade, and a M.Sc. in International Economics (both from the University of Turin), and a PhD in Geography from the University of Connecticut.

Leila Irajifar is Postdoctoral Research Fellow in the Department of Geography at Central Michigan University. Leila is a trained architect and an urban planner, specializing in deliberation and decision-making processes for hazard responses and natural resource management. Her past research includes working in the U.N. HABITAT program for the Pacific region, and developing a decision-making tool for emergency responses in Australian cities. Leila holds a Ph.D. from Griffith University (Australia), and has been recently appointed Lecturer in Architecture by the Royal Melbourne Institute of Technology.

Matthew Liesch is Associate Professor of Geography and Environmental Studies at Central Michigan University. Liesch publishes research on the communities of the Great Lakes Basin, particularly around Lake Superior. His research involves techniques such as interviews, ethnography, archival methods, and geospatial software to investigate the relationships between people, place, and land use in the Great Lakes Basin. Liesch holds a PhD in Geography from the University of Wisconsin, with additional training in environmental history, anthropology, and landscape planning.

Quantitative Case Study Team

Nina Ignaczak, IMG's lead editor on this project, holds an M.S. in Natural Resources from the University of Michigan-Ann Arbor and has more than 18 years of experience working with Great Lakes communities on issues at the local, state and regional level. From 1999-2014, Nina worked as an environmental planner for Oakland County, Michigan with a focus on water resource planning. During this time, she served on the Public Action Advisory Council (PAC) for the Clinton River Watershed and multiple state and local watershed coalitions. In 2014, Nina secured funding for and launched the WaterTowns project for the Clinton River Watershed Council, which works to integrate water-based placemaking and blue economy planning into the plans, programs and ordinances of communities along the Clinton River waterway.

Nina translated her experience in water resources planning to media work with IMG starting in 2015, when she led the Greater Lakes co-branding project on for The Great Lakes Commission. For this project, Nina led the production of two videos and four feature stories on stormwater management in the Great Lakes. In 2016, IMG published a 20-part series on the economic and ecological benefits of GLRI investment in Michigan's Great Lakes Areas of Concern for the Michigan Office of the Great Lakes, with Nina as project lead. Nina also co-produced a two-video series on the economic benefits of the GLRI in Sault Ste. Marie and Muskegon for an IMG project in partnership with The Great Lakes Commission and NOAA. Also in 2016, Nina led production of an online series for The Nature Conservancy and the Erb Foundation to highlight stormwater management leadership in the City of Detroit.

Patrick Dunn is IMG's lead writer on this project. He is also the managing editor of the Ann Arbor-based online magazine Concentrate. He has written for national publications including The A.V. Club and Paste, as well as Michigan-based publications including the Detroit News, the Ann Arbor Observer, Hour Detroit, Pulp, MLive, and Real Detroit Weekly.

Other Contributors

The results of this research have not undergone a formal peer-review process. However, the analytical strategy was discussed in detail at three meetings with a review panel composed of experts in the field of regional economic modelling, and in written correspondence with the panel. Appendix A: Expert Panel Process provides additional detail on the panel, which was organized by the University of Michigan Water Center. Additionally, staff from the U.S. Environmental Protection Agency's Great Lakes National Program Office provided help with data and guidance on analytical assumptions. Additional data regarding detailed project spending was provided by the Great Lakes Commission and Michigan Department of Natural Resources, Office of the Great Lakes.

The participation of the expert panel and input of the U.S. Environmental Protection Agency staff, the Great Lakes Commission, and the Michigan Department of Natural Resources does not suggest responsibility for or the endorsement of the results contained in this report, which are the sole responsibility of the research teams.

Appendix C: Semi-structured Interview Questions

Questions for all GLRI Interviews, regardless of interviewee background:

1. Introduce ourselves in 1 min apiece. Then: Tell me more about your work and role in the community.
2. What are your experiences with the GLRI restoration project (describe the specific project(s), including the dates undertaken).
3. How has GLRI-funded work changed the community?
4. What areas have changed the least?
5. Has GLRI work changed the area in ways you didn't expect, or anticipate, at the outset of the work?
6. How did this work affect public perception of the site amongst people using the site?
7. Are there more people spending time at the [insert AOC name here] site today?
8. Who are they, residents, tourists? Millennials? Retirees? [and similar vernacular groupings of demographics] How many more site visits have you seen because of the project?
9. Do you think the GLRI project has increased residential property values in the area? Do you have any idea how much (in percentage terms)?
10. Has there been any commercial or industrial development spurred by the project? If so, do you have a sense of how much investment that involved?
11. What segments of the community have benefited most from the GLRI work?
12. Are there any other noneconomic changes that you think are worth noting? If so, what?
13. At end: Is there anything else you think is relevant but has not yet been discussed? About how much do you think the project has been worth to the local community?

Pool of questions that may be asked depending upon the directions that stakeholders go into:

The prime benefit of interviewing different stakeholders is that they serve different roles and experiences within each case study community. Accordingly, there are different kinds of questions that can be best used for a given person's experience. If the respondent has touched upon some aspects of the below questions, the words "how else" or "can you tell me more about" may be used to elicit more conversation on the topic.

1. Are there aspects of the GLRI that initiated/supported new businesses/economic activities? Can you give me some examples? Approximately how many new jobs do those activities support? In what industries?

2. Have private organizations contributed to the project to supplement the government funding? If so, what types of organizations (e.g., nonprofits, individuals, private corporations)? Approximately how much private funding was contributed?
3. How would this area be different if the GLRI work had never been conducted?
4. (How else) Do you feel that the [insert AOC name here] has changed economically?
5. (How else) Do you think the GLRI has enabled any new activity in [AOC name here]?
6. (How else) Has the GLRI work impacted city planning (or city governance)?
7. Have you recorded any impact on existing business in the area?
8. Has the GLRI initiated functioned as a catalyst for investments in the area? Would you have any examples?
9. (How else) Has the GLRI work impacted the ecosystem/environment/local ecology?
10. (How else) Has the GLRI work impacted your organization?
11. (How else) Has the GLRI work impacted your investments?
12. (How else) Has the GLRI work impacted your neighborhood/this neighborhood?
13. (How else) Has the GLRI work impacted the kinds of recreation people do?
14. How do you think demand for the area has changed?
15. What businesses have benefited most from the GLRI work? Which kinds of businesses have not seen benefits?
16. What share/percentage of GLRI spending do you think has impacted the amenities of your community? (Note: this question has been adapted depending on the interview, and was added after the first meeting of the research teams with the Expert Review Panel in July 2017).

Note: Some questions must be spur-of-the moment.

In some situations, questions are useful intended to clarify or steer conversation. Not knowing what topic a given respondent pivots to, there is no possible way to develop a list of such questions beforehand. Probable questions include:

Can you provide me with an [or another] example?

Can you clarify?

Could you or your office provide us with data on [insert prior specific topic here].

Thank you, I have a good overview of your insights on this; could you now tell me about [insert some other aspect of AOC change here]?

There are also follow-up questions specific to property parcels about given developments, features, zoning issues, and financing incentives. The nature of each interview (background, experience, degree of incisive commentary) inherently conditions the breadth and depth of these follow-up questions.

Appendix D: Project Description Keyword Search Terms

Table 13: Project Description Keyword Search Terms

REMI Industry	Prof. & Bus. Services	Construction	Forestry & Fishery	Farm
Search Terms	analy	acre	hatchery	agricultur
	assess	barrier	forest	best management
	build capacity (variations)	construct	sturgeon	bmp
	characteriz	control		farm
	communicat	dredg		
	compliance	erod		
	control	erosion		
	coordinat	excavat		
	design	improv		
	determin	infiltrat		
	develop	install		
	educat	maintenance		
	evaluat	reconnect		
	forecast	remediat		
	identif	remov		
	inform	reopen		
	investigat	replace		
	knowledge	restor		
	manag	sewage		
	map			
	measure			
	model			
	monitor			
	outreach			
	plans			
	quantify			
	research			
	sampl			
	scientist			
	studies			
	study			
	survey			
	technical			
	test			
	train			

Note: In order to capture multiple verb conjugations and variations of words with the same base, many search terms are shortned to be word stems rather than full words.