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A socioeconomic analysis of habitat restoration in the Muskegon Lake area of concern

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ABSTRACT

As part of the 2009 American Recovery and Reinvestment Act (ARRA), a $10 million grant was awarded to restore wetlands and stabilize shoreline along the south shore of Muskegon Lake (MI), a Great Lakes Area of Concern. A socioeconomic analysis was conducted as part of this award, which included a travel cost survey for lake recreation and a hedonic housing valuation to estimate return on investment. The value of a trip to Muskegon Lake was estimated to be $39.76; when applied to the anticipated increase in post-restoration recreational trips to Muskegon Lake, and using a conservative 7% discount rate, the Net Present Value over 20 years is $38.1 million. The hedonic analysis examined values for houses between 100 and 800 m from the shoreline, using both the current shoreline distances and the new shoreline distances after restoration; this resulted in a predicted $11.9 million in additional housing value as a result of the improved shoreline features. Summing the hedonic value and travel cost estimates, along with the original $10 million spent, the result is that over 20 years, the total value generated for the local region is nearly six times the initial ARRA spending. In other words, of the $60 million of value created on the Muskegon Lake restoration, $50 million is increased environmental value over the 20 year period.

Introduction

The Great Lakes provide an enormous array of ecosystem services, although currently they have not been inventoried in a comprehensive fashion (Steinman et al., 2017). Allan et al. (2013) mapped cumulative stress throughout the Great Lakes and concluded that heavily populated sites experience the greatest stress, but they also would generate the greatest return on restoration investment in terms of ecosystem services. Ecosystem restoration efforts are currently underway throughout the Great Lakes region to undo some of these past abuses, but there is limited quantitative analysis on the value associated with these efforts. Valuation of ecosystem services can be done through revealed preference methods, such as travel cost analysis, hedonics, and opportunity cost analysis, or through stated preference methods, such as contingent valuation. Generating rigorous valuations for these restoration projects can be a powerful tool in assessing their socioeconomic effectiveness and justifying their implementation, although some argue that valuation demeans nature (cf. McCauley, 2006).

In 1985, Muskegon Lake was designated a Great Lakes Area of Concern (AOC) because of historic abuses, including the loss of critical littoral zone habitat and coastal wetlands, excessive nutrients, and toxic pollutant discharges that contaminated the lake bottom (Steinman et al., 2008; USEPA, 2009). Despite Muskegon Lake's history of environmental problems, it is still an important recreational resource for West Michigan (Alexander, 2006). This ~17 km^2 lake is a drowned river mouth system with the Muskegon River flowing into it from the east and a navigation channel flowing from the lake into Lake Michigan to the west (Steinman et al., 2008) (Fig. 1). Muskegon Lake offers opportunities for boating, kayaking, angling, sailing, and wildlife-watching. A newly created trail along its south shore offers opportunities for walking, jogging, rollerblading, skateboarding, and cycling. While market-based data may exist for some of these activities (e.g., charter boat fishing, boat launch or marina fees, bicycle rentals, and fishing licenses), there are other nonmarket-based values and benefits that to date have not fully been taken into account (Daily et al., 2009; Heal, 2000).

In 2009, with the creation of the American Recovery and Reinvestment Act (ARRA), awards were made throughout the United States to restore damaged wetlands, shellfish beds, coral reefs, and to reopen fish passages that boost the health and resilience of U.S. coastal and Great Lakes communities. For Muskegon Lake – one of only three such projects in the Great Lakes region – $10 million was awarded to restore wetlands and stabilize shoreline along the south shore of the lake (NOAA, 2009). The ecological goals included softening ~3 km of hardened shoreline, restoring ~11 ha of wetland habitat, and removing or improving ~10 ha of unnatural lake fill (~103,250 m^3). A separate project included environmental and socioeconomic monitoring. We focus here on the economic benefits measured via hedonic property values and a travel cost survey for lake-based recreation.

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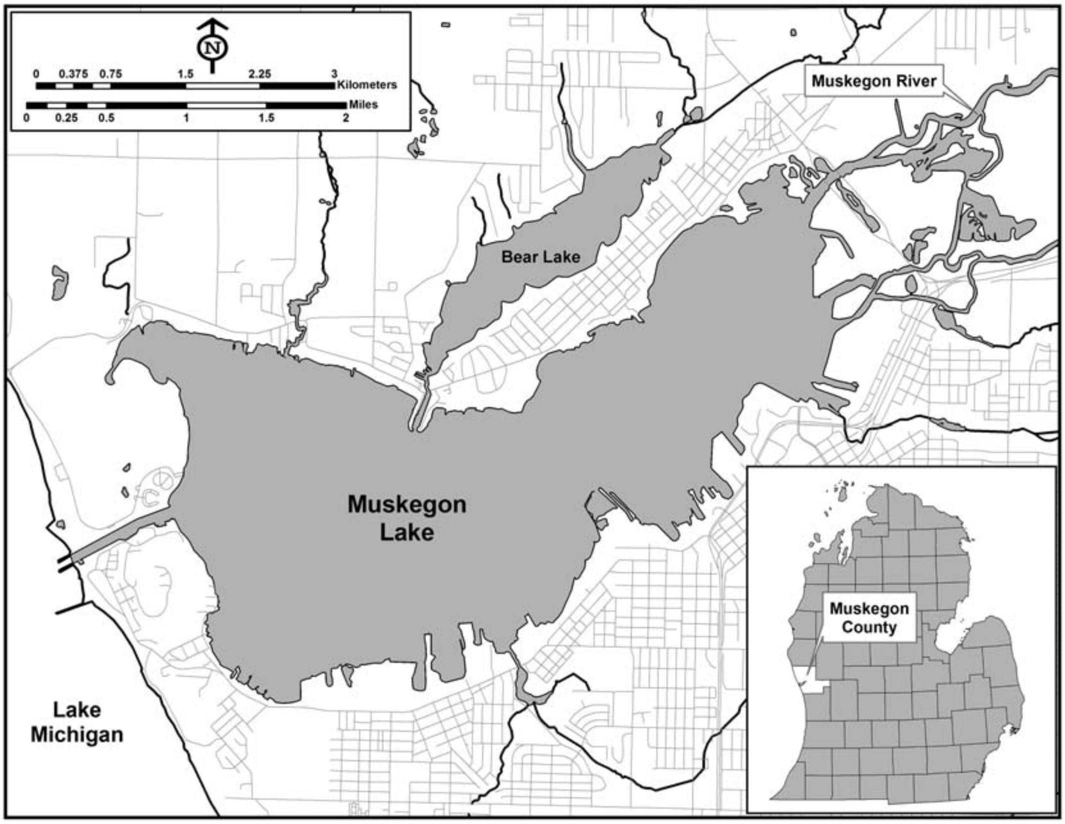

Fig. 1. Hydrography and road map of Muskegon Lake. Inset: Muskegon Lake's location in the western portion of Michigan's lower peninsula.

Conceptual approach

Different economic models have been used to determine the value of recreation-based ecosystem services; the most commonly used method is travel cost. The travel cost method is a revealed preference approach to environmental valuation that uses behavioral data, such as travel distance to recreational sites, frequency of visits, and actual trip expenses, to estimate users' willingness-to-pay for recreational activities and opportunities (Seller et al., 1985; Sutherland, 1982; Whitehead et al., 2009). Knowing the value of recreation on Muskegon Lake and the change in usage allows us to calculate the increased value from the environmental remediation.

In addition to recreation, the softening of the Muskegon Lake shoreline was a highly visible part of the restoration project; therefore, we hypothesized that it would likely affect housing prices. It was anticipated that homeowners would prefer natural shoreline over the aging hardened shoreline on the south side of Muskegon Lake. The effect of proximity to a natural shoreline can be explored using hedonic analysis. Hedonic analysis is a common and well-known method used when examining housing markets, and reveals through actual market transactions the marginally implicit price of individual housing attributes (Rosen, 1974). A house is a composite of many different features, and the price can therefore reveal how much homebuyers are willing to pay for each one. This identifies marginal price for housing attributes, and we are able to determine the values of not only structural features, but also locational and environmental amenities. Hedonic analysis can play a crucial role in environmental valuation assessments, given that there is no actual market for environmental services.

Methods

To determine the socioeconomic impacts of this shoreline habitat restoration project, we monitored the economic value before, during, and after the restoration project was completed. It was anticipated that the restoration of aquatic habitat and coastal wetlands in this Great Lakes AOC would increase the economic value of ecosystem services associated with these restored wetlands (Steinman et al., 2017), which local government and economic development authorities can use to promote local tourism and commerce. This required a survey of lake users, a survey of possible users of the lake, and housing sales information. These data were then used to find the value of recreation, the number of new visitors, and the increase in housing value from the environmental improvement.

Recreation survey

The "Travel Cost Survey of Recreational Users of Muskegon Lake, MI" (Electronic Supplementary Material (ESM) Table S1) was intended to elicit individual information regarding recreational trip length, purpose (primary recreation activity), frequency of visits to different sites on Muskegon Lake, trip expenses, and demographic information. Utilizing a single-site travel cost model for one recreational site (i.e., Muskegon Lake), we orally administered the survey to recreational users accessing the lake primarily for fishing, boating or jet-skiing, bird/wildlife watching, walking, or biking at six access sites along the south shoreline of the lake (Fig. 2). Survey sites were selected from the targeted restoration areas along the south and east shorelines of Muskegon Lake that also had public access to the lakeshore.

Surveys were administered in 4 hour shifts (in three cases, shifts were shortened due to inclement weather) at each site on two randomly selected weekend days and two randomly selected weekdays (ESM Table S2). To randomize the sample of recreational users, we interviewed every third adult-user at each location (Parsons, 2003). The survey takers were instructed to ask for the estimated number of trips if the frequency of visits was "15 or more", which was the maximum number on the survey, thereby avoiding data truncation.

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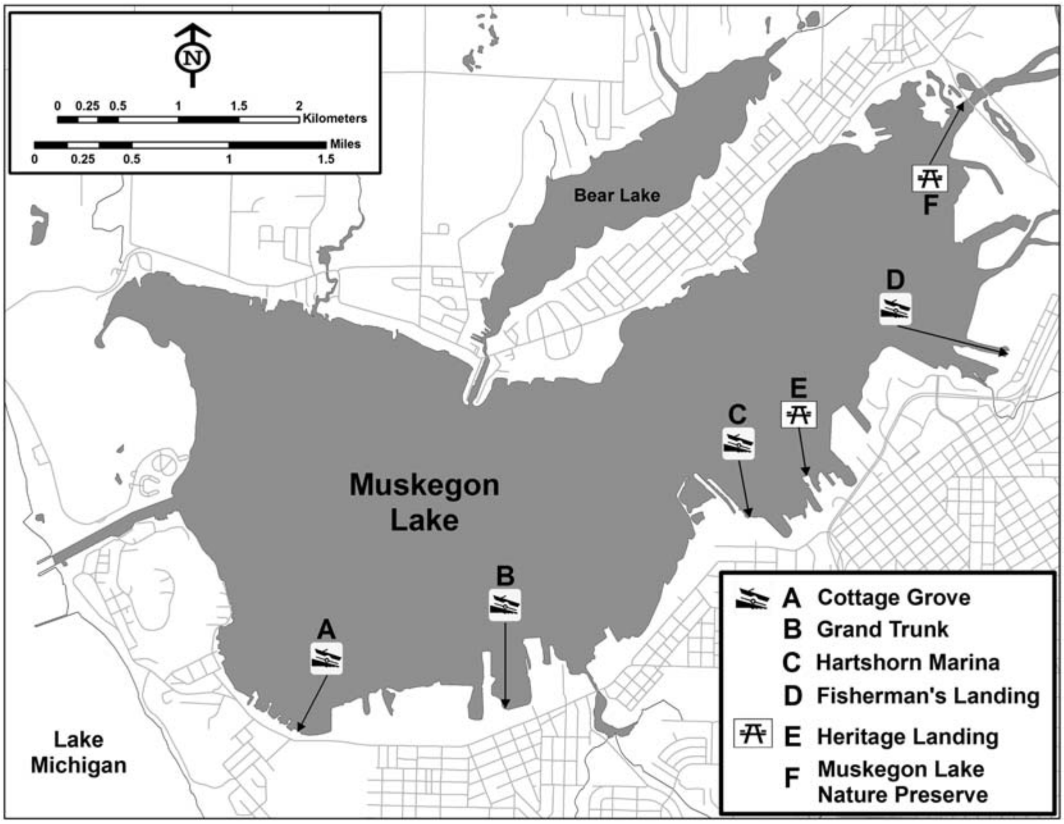

Fig. 2. Travel Cost survey site locations along the south and east shorelines of Muskegon Lake.

Additional clarifications were given when necessary for the questions regarding amount spent on trip and income. For multiple day trips, the amount spent had to match the full length of the trip, and not just on that day's activities. Annual income reported was just for the respondent, and not the entire household.

The data gathered from the travel cost survey were adjusted as follows: 1) only day trips were included in the model, so multi-day trips were eliminated; 2) observations where the respondent reported more than 365 visits a year were eliminated as outliers; and 3) observations where the individual reported costs were excessive or too small (i.e., the top 2% and bottom 2% of reported costs) were eliminated as outliers.

The remaining data were used to calculate travel costs in two different ways. Travel Cost 1 was calculated by taking the respondent's answer regarding how much money was spent and dividing it by the number of people in the traveling party. This value was then added to trip time value. Trip time value was calculated as 1/3 of the survey respondent's income divided by 2080 (the number of hours worked in a year given 40-hour weeks), which was then multiplied by the length of their trip, measured in hours. Travel Cost 2 was calculated by adding the cost of a launch fee ($10) to the mileage costs, calculated by the number of miles to Muskegon Lake roundtrip multiplied by $0.50, and finally dividing by the number of travelers. This value was then added to their trip time value.

Visitors to Muskegon Lake have alternative lakes to visit; hence, we need to control for these potential substitutes. The two substitutes chosen for this study were Spring Lake (18 km to the south) and White Lake (21 km to the north). These are the closest two locations where similar types of recreation, along with access to Lake Michigan, are located. Spring Lake on the southern border of Muskegon County is of particular interest, as it is closer to the large population centers of Holland and Grand Rapids in West Michigan.

A second survey was used to augment the travel cost results. These surveys asked the respondents if they would visit Muskegon Lake more often as a result of the restoration. This information was then used to determine the increase in visits to the lake. In-person surveys were used to collect the data. A calculation of the desired sample size was needed to ensure accuracy of the model. Because the adult population of Muskegon County consists of ~130,000 people (U.S. Census Bureau, 2009a), the sample size did not need adjustments for a finite population. Our computations varied between 90 and 95% confidence and 5–7% error, and resulted in a sample size ranging from 138 to 384. Therefore, we chose a realistic goal of 200 responses. Survey administration was conducted at various locations around the county, including public libraries, a bowling alley, the local community college, a minor league hockey game, a high school football game, and a community stakeholder meeting regarding a different local environmental project. While the survey locations and times were not determined randomly because of time constraints and efforts to reach the desired demographics, random sampling was done at each location by asking every *n*th person depending on the flow of people.

Respondents were read the background information regarding the impairments of the Muskegon Lake ecosystem, the proposed improvements, and the benefits such a project would generate. The interviewer asked questions on lake usage, travel cost, and demographics. A comparison of the survey data against that of Muskegon County using chi-square goodness of fit and one-sample binomial tests revealed no statistically significant differences among income, age, education level, and gender variables. In addition, this survey also showed no statistically significant difference in gender, age, and income with the recreation survey done earlier. The survey results showed that 49.8% of the sample from Muskegon County planned to visit at least once more per year after the restoration. In addition, we repeated the survey in 2011 in adjacent Kent County, where 36 out of the 900 people surveyed (4%) also stated

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they would visit at least once more per year. Applying these percentages, and one additional visit, to the adult populations of Muskegon and Kent Counties resulted in 64,835 additional visits from people in Muskegon County and 17,789 additional visits from people in Kent County.

Hedonic housing valuation

To explore the relationship between the price of a house and the proximity to natural or hardened shoreline, data about the characteristics of the houses were needed as independent variables in a hedonic model used to predict housing prices. Housing characteristics and sales data were provided by the County of Muskegon (Muskegon County Equalization Department, 2009). We also needed spatial data to match the proximity of a house to lakeshore characteristics. We used ArcGIS to estimate spatial variables used in our regression analysis. A shape file of Muskegon Lake and its watershed was obtained from the U.S. Environmental Protection Agency (USEPA, 2009), while transportation framework data were acquired from the Michigan Geographic Data Library (Michigan Center for Geographic Information, 2009). A shape file containing all Michigan counties was provided by the U.S. Census TIGER Shape files (U.S. Census Bureau, 2009b). Finally, property parcel data for those houses within the Muskegon Lake watershed, as well as shoreline inventory data for Muskegon Lake, were provided by the Grand Valley State University's Annis Water Resources Institute.

Muskegon Lake watershed parcels were converted from polygons to points based on the parcels' centroids. The Muskegon Lake shape file also was transformed from polygon to line, and then edited to exclude the watershed and the lake's tributaries in order to create a more accurate representation of the shoreline. The shoreline inventory of Muskegon Lake was used to determine which segments of the shoreline consisted of natural features, such as wetlands vs. those of a hardened nature, such as rock, concrete, timber, riprap, and other similar classifications (cf. Steinman et al., 2008). The shoreline classification, in addition to information concerning the location of remediation sites on Muskegon Lake, was used to create four new shape files displaying natural shoreline, as well as hardened shoreline, before and after remediation. The shoreline shape files after the remediation reflected the conversion of hardened shoreline to natural shoreline, thus allowing some properties to become closer to longer segments of natural shoreline.

Additional variables created using geographic information system (GIS) consisted of location characteristics, such as proximity to industrial and commercial centers, residence in neighborhood, and proximity to Muskegon Lake and Bear Lake, which drains into Muskegon Lake from the north (Fig. 1). Based on a City of Muskegon zoning map (City of Muskegon, 2009b), all houses, selected as the parcels' centroids, within 100 m of an industrial area were determined for use in the regression, as testing showed that housing prices within 100 m of an industrial property were adversely affected. Determining the neighborhood in which a house was located was done in a similar fashion. Upon creating a shape file of Muskegon neighborhoods based on a City of Muskegon map, houses in each of the fifteen neighborhoods in Muskegon were identified (City of Muskegon, 2009a). Lastly, houses within 100 m of Bear Lake were identified, as were properties on the shoreline of Muskegon Lake. All geographic coordinates were determined based on the location of each parcel's centroid for use in the spatial regression.

The raw housing data were cleaned to create consistent data to be used in the estimation. First, residential housing sold only in the last 20 years with a sales price greater than $40,000 were used. In addition, we excluded houses older than 150 years old, below 500 square feet, above 4000 square feet, and less than 2 years old, thereby removing the top and bottom 1% to reduce the effect of outliers. Finally, houses that have a view of Lake Michigan also were excluded as their price was being driven by Lake Michigan and not by Muskegon Lake.

Results

Travel cost

Using the travel cost method, a coefficient for travel cost is generated. This coefficient shows how the number of trips someone will take to a location varies with the cost of the trip. Less expensive trips that have high value happen more often than high value expensive trips or low value less expensive trips. For example, an individual is more inclined to visit a highly valued state park on a regular basis, but may visit Yellowstone National Park only once or twice in a lifetime. Hence, the value of a location can be estimated by understanding the relationship between the expense of visiting a location and how that affects someone's willingness to travel to that location.

Number of trips per year can then be modeled using a basic travel cost model (Parsons, 2003). The expected number of trips by an individual, k, can be hypothesized as an exponential function:

$$E[TRIPS_k|X_k] = \lambda_k = \exp(X_k\beta) \tag{1}$$

where X is the opportunity cost of travel and β is the regression coefficient for the opportunity cost of travel. Where X_k contains:

- $TRIPS_k$ = number of trips per year to Muskegon Lake reported by person k;
- $TRAVEL\ COST_k$ = average of Travel Cost 1 and Travel Cost 2 for individual k;
- $TRAVEL\ COST\ WH_k$ = TRAVEL $COST_k$ plus the additional cost of travel cost needed to go to the substitute location of White Lake (Muskegon County, MI);
- $TRAVEL\ COST\ SL_k$ = TRAVEL $COST_k$ plus the additional cost of travel cost needed to go to the substitute location of Spring Lake (Ottawa County, MI);
- $FISHING_k$ is an indicator variable that is 1 if person k's primary purpose at Muskegon Lake is fishing;
- $BOATING_k$ is an indicator variable that is 1 if person k's primary purpose at Muskegon Lake is boating;
- $MALE_k$ is an indicator variable that is 1 if person k's is on their first visit to Muskegon Lake is fishing;
- *YEAR* is an indicator variable that is 1 if the survey was taken in 2010; and
- $ACCESS\ 1_k$ is an indicator variable that is 1 if person k's is accessing Muskegon Lake from Heritage Landing.

The mean cost of travel based on survey results was $38.41, with slightly higher costs for the substitute sites of White Lake and Spring Lake (Table 1). Fishing and boating were the most common recreational uses (39% and 24%, respectively).

Eq. (1) can be estimated by a Poisson regression since *TRIPS* is a non-negative integer. The primary result of the Poisson regression was a coefficient on TRAVEL COST of −0.025 (Table 2). Following the single trip

Table 1
Travel cost model results based on the Poisson regression.

Variable	No. observations	Mean	Std. Dev.	Min	Max
TRIPS (#)	280	40.71	49.53	1	233
Travel cost ($)	280	38.41	33.39	3.94	182.92
Travel cost WH ($)	280	39.68	32.18	5.16	171.05
Travel cost SL ($)	280	41.16	33.60	4.61	182.8
Fishing (%)	280	39	49	0	1
Boating (%)	280	24	43	0	1
Year	280	2009	50	2009	2010
Access 5 (heritage landing) (%)	280	14	34	0	1
Male (%)	280	69	46	0	1

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Table 2
Coefficients for the Poisson Model for Travel Cost. Z stats (for n = 280) are effectively the number of standard deviations from zero adjusted for heteroscedasticity using Whites Method and are shown in the parentheses below the coefficient. * = significant at the 95% level.

Variable	Poisson model
TRAVEL COST	−0.025*
	(2.57)
TRAVEL COST WH	−0.012
	(0.67)
TRAVEL COST SL	0.032
	(1.63)
FISHING	0.18
	(1.08)
BOATING	−0.04
	(0.18)
MALE	0.15
	(0.93)
YEAR	0.33
	(2.09)*
ACCESS 1	0.54*
	(3.17)
CONSTANT	−654.74*
	(2.25)

cost model (Parsons, 2003), the travel value of a single trip is found using 1/(-βTRAVEL COST). The negative inverse of the TRAVEL COST coefficient resulted in a travel value of $39.76, which is larger than the mean travel cost, which is $38.41 (Table 1). This value provides a basis for determining the effect of improved environmental benefits over the next few years. The value of time was calculated using the best practice of 33% of income; however, if 25% or 50% of income is used in place of 33%, the value has a range of $75.53 to $31.56, respectively. Following best practice, we retained the value of $39.76.

Four specific data issues were addressed: heteroscedasticity, over-dispersion, endogenous stratification, and zero truncation. Tests for heteroscedasticity could not be rejected at the 10% level. In addition there was some evidence of over-dispersion; both problems were addressed by using robust standard errors (White-corrected standard errors). Using robust standard errors with the Poisson regression provided consistent estimators. The recreation user's surveys given only to actual users of Muskegon Lake also resulted in a zero truncation. To correct for zero truncation and the possibility of endogenous stratification, the 1 was subtracted from trips for each user, following Loomis (2003). Alternative processes to correct for these issues were also attempted including running a negative binomial model, a zero-truncated Poisson model, and a negative binomial adjusted for endogenous stratification model (NBREG, ZTP, and NBSTRAT) (Statacorp, 2017). These specifications resulted in coefficients on travel ranging from −0.024 to −0.028; given that our calculated coefficient of −0.025 fell within this range, we opted to use this value going forward.

The recreation value can be applied to the additional recreational trips to Muskegon Lake to find the aggregate increase in recreational value. The result is an additional $3,285,130 per year in recreation value to residents of Muskegon County and Kent County. This is the value for only the additional visits as the total number of visits could not be calculated accurately with the data collected. The choice of discount rate becomes important to compare the future values to the current costs. We selected a 7% discount rate (OMB circular A-94 for environmental goods in federal cost benefit analysis), even though this is far more conservative than the discount rates used for financial instruments. Using this discount rate, the Net Present Value over 20 years, which is a conservative length of time for an infrastructure project, was $38.1 million.

Hedonic valuation

The hedonic model will find regression coefficients (ESM Appendix S1) for environmental amenities. The coefficient can then be used to show the value of a house with and without the amenity. As the Muskegon Lake shoreline was softened, many houses were located closer to the natural shoreline, thereby increasing their value. The coefficients from the hedonic regression can then be used to find the predicted value of every house with and without the new softened shoreline. Aggregating these values results in the total change in value as a result of the restoration activities.

The raw housing data were assessed to ensure data consistency; several criteria were applied to the data for use in the estimation. First, only residential housing sold in the last 20 years, from 1990 to 2009, with a sale price greater than $40,000 were used. In addition, houses that behaved statistically different than the other houses in the pooled data were dropped. These included houses older than 150 years old, houses below 500 square feet, houses above 4000 square feet, houses less than 1 year old, and houses that had a view of Lake Michigan (see Table 3).

The basic model that resulted was:

$$\begin{aligned} \mathrm{LNPRICE} = \alpha + \beta_1(\mathrm{FLOORAREA}) \\ +\beta_2(\mathrm{BASEMENTAREA}) + \beta_3(\mathrm{GARAGETYPE}) \\ +\beta_4(\mathrm{BATHROOMS}) + \beta_5(\mathrm{AGE}) + \beta_6\left(\mathrm{AGE}^2\right) \\ +\beta_7(\mathrm{STONE}) + \beta_8(\mathrm{INDUSTRIAL}) + \beta_9(\mathrm{BEARLAKE}) \\ +\beta_{10}(\mathrm{MLDIST}) \\ +\sum_{t=2}^{20}\partial_t(\mathrm{YEARSOLD}) + \sum_{i=2}^{3}\theta_i(\mathrm{OCCUPANCY}) + \sum_{j=2}^{7}\gamma_j(\mathrm{NEIGHBORHOOD}) \end{aligned} \quad (2)$$

where:

- *LNPRICE*: natural log of sale price
- *FLOOR AREA*: area of house in square feet
- *BASEMENT AREA*: area of basement in square feet
- *GARAGE TYPE*: number of car spaces in garage; equal to 0, 1 or 2
- *BATHROOMS*: number of bathrooms
- *AGE*: age of house at the time of sale; equal to year sold – year built
- *AGE^2*: age-squared of house
- *STONE*: dummy variable for exterior of house; equal to 1 if exterior is brick, brick/siding, or stone; 0 otherwise
- *INDUSTRIAL*: dummy variable for proximity to industrial and commercial areas; equal to 1 if within 100 m; 0 otherwise
- *BEAR LAKE*: dummy variable for proximity to Bear Lake (a connected body of water to the north of Muskegon Lake); equal to 1 if within 100 m; 0 otherwise
- *YEARSOLD*: dummy variable for the year of sale; equal to 1 if sold in a given year; 0 otherwise (1990–2009)
- *OCCUPANCY*: dummy variable for occupancy of house; equal to 1 if house has a given occupancy, 0 otherwise (duplex, single-family, or town home)
- *NEIGHBORHOOD*: dummy variable for Muskegon neighborhoods; equal to 1 if house is within a given neighborhood, 0 otherwise (Beachwood-Bluffton, Jackson Hill, Lakeside, Nelson, or Nims)
- *MLDIST*: distance from Muskegon Lake shoreline in meters

Before running the estimation, proximity was used to evaluate possible statistical differences in the way in which distance from Muskegon Lake affected price. The 51 residential parcels on the lake (11 on the south shore) had a 25% higher value than the same house 100 m away from the lake. In addition, shoreline property owners behave differently regarding their property depending on the condition of their shoreline. Many shoreline property owners on Muskegon Lake harden their shoreline as a means of erosion control. Owners of these parcels would view

Table 3
Summary statistics for housing used in the Hedonic Models. Units for those variables without defined units can be found in the text.

Variable	Mean	Std. Dev.	Min	Max
Price ($)	118,359	81,464	40,000	799,000
Floor area (ft^2)	1493	596	510	3979
Basement area (ft^2)	915	441	0.0	2296
Garage type (stall #)	1.3	0.7	0.0	2.0
Bathrooms (#)	1.5	0.7	1.0	5.5
Age (yr)	54.9	28.7	1.0	144.0
Age^2	3834	3741	1.0	20,736.0
Stone	0.07	0.25	0.0	1.0
Industrial	0.03	0.16	0.0	1.0
Bear Lake	0.06	0.23	0.0	1.0
Year sold				
1990	0.003	0.06	0.0	1.0
1991	0.004	0.07	0.0	1.0
1992	0.006	0.08	0.0	1.0
1993	0.005	0.07	0.0	1.0
1994	0.007	0.09	0.0	1.0
1995	0.014	0.12	0.0	1.0
1996	0.033	0.18	0.0	1.0
1997	0.052	0.22	0.0	1.0
1998	0.057	0.23	0.0	1.0
1999	0.059	0.24	0.0	1.0
2000	0.053	0.22	0.0	1.0
2001	0.071	0.26	0.0	1.0
2002	0.078	0.27	0.0	1.0
2003	0.092	0.29	0.0	1.0
2004	0.102	0.30	0.0	1.0
2005	0.084	0.28	0.0	1.0
2006	0.115	0.32	0.0	1.0
2007	0.082	0.28	0.0	1.0
2008	0.062	0.24	0.0	1.0
2009	0.021	0.144	0.0	1.0
Occupancy				
Duplex	0.003	0.06	0.0	1.0
Single family	0.982	0.13	0.0	1.0
Town home	0.015	0.12	0.0	1.0
Neighborhoods				
Beachwood-Bluffton	0.051	0.22	0.0	1.0
Jackson Hill	0.019	0.14	0.0	1.0
Lakeside	0.232	0.42	0.0	1.0
Nelson	0.013	0.11	0.0	1.0
Nims	0.136	0.34	0.0	1.0
None	0.550	0.50	0.0	1.0
MIdist	425	174	104	799.0
Natratio1	−0.53	1.08	−3.62	2.04
Hardratio1	0.23	1.17	−3.17	3.17
Natratio2	−1.30	1.06	−3.42	1.46
Hardratio2	−0.43	1.30	−4.17	2.27

N = 2001.

hardened shoreline as an amenity likely to increase their property value; however, hardened shoreline has no benefit to non-shoreline property owners. Therefore, houses directly on the lake were not included in the estimation. In addition, houses located more than 800 m from the lake did not continue to drop in value as the distance from the lake increased, so they also were not used in the final estimation. After these adjustments, there were 2001 observations that could be used in the final estimations.

Finally, to test our hypothesis that proximity to natural shoreline was preferred to hardened shoreline, distance to both shoreline classifications needed to be included in the model. However, distance to any type of shoreline was highly collinear with the distance to Muskegon Lake. As a result, a transformation was needed to separate the effects of type of shoreline from distance to shoreline. This was accomplished by taking the lengths of the first and second closest natural shoreline segment and dividing them by the distance from the house to the respective natural shoreline segment. Because of decreasing returns, the natural log of this value was taken. Since it was predicted that the property's value should increase with increased length of the natural area and decrease as the distance from the natural area increased, the predicted sign of this variable was positive. The same procedure was done for hardened shoreline; however, the predicted sign was now negative. The new variables added to the model were:

- *NATRATIO1*: natural log of the length of the closest natural shoreline segment divided by the distance to the nearest natural shoreline segment in meters
- *HARDRATIO1*: natural log of the length of the closest hardened shoreline segment divided by the distance to the nearest hardened shoreline segment in meters
- *NATRATIO2*: natural log of the length of the second closest natural shoreline segment divided by the distance to the second nearest natural shoreline segment in meters
- *HARDRATIO2*: natural log of the length of the second closest hardened shoreline segment divided by the distance to the second nearest hardened shoreline segment in meters

Finally, when specifying hedonic models, spatial aspects need to be addressed. Due to variability within urban areas, identical houses in two different neighborhoods may not sell for the same price. However, houses within the same neighborhood may be priced similarly because of common local amenities. This occurrence causes houses with similar locations to have correlated error terms (Dubin, 1988), and creates the need for spatial adjustments within the model. Without doing so, the standard assumptions of homoscedasticity and uncorrelated standard errors in hedonic analysis would be violated. The systematic error introduced into the model causes estimates for houses in close proximity to have inaccurate significance, biased parameter estimates, and poor estimates of the dependent variable (Can, 1990). As explained by Bell and Bockstael (2000), ignoring the spatial effects that houses have on one another is as serious a matter as ignoring the fact that house prices change over time. Moran's I and Lagrange multiplier tests confirmed that a spatial error correction regression was necessary. Therefore, a spatial error correction regression was used involving a matrix of the inverse distance between all houses within 280 m (the shortest distance where all houses had at least one neighbor) as weights.

The spatial model included homes in the City of Muskegon (Model 1) with altered shorelines and homes in North Muskegon (Model 2) with more natural shorelines. Shoreline restoration and associated potential benefits were restricted to the south side of Muskegon Lake. Nonetheless, houses on the north shore of the lake could be included in the model. Therefore, a Chow test was performed to determine if the houses on the north and those on the south shorelines were similar enough to be pooled into a single model. The results indicated that most variables were statistically different between the two areas (Table 4), and thus they could not be pooled together; therefore, two separate models were used.

Using the results from Models 1 or 2, the estimated values for all houses between 100 and 800 m were found using both the current shoreline distances and the new shoreline distances after the remediation. As distances and lengths of shoreline features changed as a result of the restoration, the predicted values of each house were affected. Aggregate benefits were calculated based on the change in two groups. Group A consists of the houses used in the regression, as well as houses within 100 to 800 m of the lake that have enough data to generate a predicted price for the year 2009, but not enough to be included in the regression. This resulted in a group of 748 houses. Group B consists of the remaining houses that are within 100 to 800 m of Muskegon Lake, but lack the data required to predict a price (1727 houses). The estimated change in value for these houses was calculated by using their shoreline measures before and after the remediation to estimate their change in value (Fig. 3). Distances and lengths of the first and second closest shoreline segments pre- and post-restoration were used to determine each house's value for each of the natural and hardened shoreline ratios, and then multiplied by the respective coefficients from Model 1. The

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Table 4
Spatial regression coefficients for Model 1 (City of Muskegon-south shoreline) and Model 2 (north shoreline). Abbreviations defined in text. Standard errors, adjusted for heteroscedasticity using Whites Method, are in parentheses below the coefficients. * = significant at the 95% level.

Variable	Model 1	Model 2
Floor area	0.00034*	0.00031*
	(0.00003)	(0.00002)
Basement area	0.00010*	0.00012*
	(0.00003)	(0.00002)
Garage type	0.04811*	0.04005*
	(0.01453)	(0.01826)
Bathrooms	0.01869	0.11915*
	(0.02281)	(0.01985)
Age	−0.00450*	−0.00667*
	(0.00104)	(0.00145)
Age^2	0.00001	0.00003*
	(0.00001)	(0.00001)
Stone	0.01373	0.04247
	(0.17818)	(0.03006)
Industrial	−0.06946	0.02577
	(0.04576)	(0.08332)
Bear lake	–	0.51618*
	–	(0.03384)
Year sold	Suppressed	Suppressed
Single family	–	−0.14129
	–	(0.12386)
Town home	0.52117*	−0.07473
	(0.10301)	(0.14108)
Neighborhood	Suppressed	–
Mldist	−0.00039*	−0.00012
	(0.00009)	(0.00007)
Natratio1	0.03658*	0.01850*
	(0.01520)	(0.00908)
Hardratio1	−0.11909*	−0.03304*
	(0.02682)	(0.01006)
Natratio2	0.00007	0.00121
	(0.01299)	(0.00908)
Hardratio2	−0.01743*	−0.03874*
	(0.00783)	(0.00909)
Constant	10.70045*	10.39001*
	(0.10841)	(0.20193)
N	427	522
R^2 or pseudo R^2	0.76	0.82

values for each ratio before restoration were subtracted from the average price of a house depending on the neighborhood, whereas the values for the post-restoration shoreline features were added. This resulted in a predicted price due to the restoration, and the value change was determined by subtracting the value of an average house in their neighborhood (Fig. 4). The total changes were summed to determine aggregate numbers. Therefore, the coefficients from Models 1 and 2 were used to estimate the aggregate increase in property value due to the restoration on the south shore, resulting in an increase of $15.5 and $11.9 million, respectively.

The northern shoreline is significantly more natural than the southern shoreline. According to the shoreline inventory conducted prior to restoration (Steinman et al., 2008), 45% of the northern shoreline is natural, compared to only 24% in the south. It is likely that households north of the lake hold values for natural shoreline that take into account the diminishing returns it provides. Therefore, Model 2 appears to be the most conservative estimate of the values of natural and hardened shoreline features at $11.9 million (Fig. 5). Generally, as the distance from a restoration increases, the value change decreases. However, there is a gap on the south shore where there is little to no change in value sandwiched between areas of high value change. This area is characterized by fragmented natural shoreline; therefore, the closest and second closest natural and hardened shorelines do not change. The result is that no change was predicted in this area, which probably underestimated the change in that region.

Discussion

There is considerable debate regarding the valuation of ecosystem services (cf. Costanza et al., 1997; McCauley, 2006; De Groot et al., 2012), although it is clear these valuations may have considerable influence on policy decisions (Austin et al., 2007; Fisher et al., 2008; Daily et al., 2009). Indeed, even the lack of valuation can have policy implications; in the absence of such an analysis, the default value of ecosystems can be perceived as zero (Isely et al., 2010).

Austin et al. (2007) estimated that a $26 billion investment in restoring the Great Lakes as a whole would generate about a 3:1 return on investment through ~$50 billion in long-term benefits and between $30 to $50 billion in short-term multiplier benefits. These large-scale analyses are rife with uncertainties, but they give a sense of the potential benefit associated with restoration activities. In contrast, valuations conducted at the local scale are likely to be more rigorous, and also may have more impact, as it is at this scale where many critical management decisions are made (cf. Annis et al., 2017). In this regard, AOCs in the Great Lakes may serve as a natural laboratory for the analysis and valuation of ecosystem services (Angradi et al., 2016; Steinman et al., 2017). Prior studies have shown that proximity to an unrestored AOC has clear, negative effects on housing values (Braden et al., 2008a, 2008b). Our study provides a complementary result to those of Braden et al., whereby once an AOC is remediated, proximity to the restored location can generate a net positive value.

Our estimated return of investment of ~6:1 is very likely conservative. It focuses on only two benefits – the value of improved recreation and the improvements to property values. As such, it does not account for the full value of the improvements, but rather examines the portions that most directly affect humans. In addition, our estimate does not include multiplier effects, nor does it attempt to quantify non-use values, such as option values, bequest values, improved health effects or existence values. There are likely to be human health benefits associated with greater activity on the constructed bike/pedestrian trail, and a greater sense of community pride, with a more attractive shoreline. Cultural values are rarely monetized (Daniel et al., 2012; Steinman et al., 2017) given the analytical complexities, as well as the ethical question of whether or not they should remain unmonetized (but still valued).

The ARRA-funded shoreline restoration activities on Muskegon Lake were completed in 2012; plans are in place to repeat this study to confirm and refine the estimates generated. Continued monitoring will reveal if this is indeed a permanent change. Indeed, the economic vitality of the region is dependent, at least in part, on the ecological success of the restoration activities, which require long-term monitoring (Sergeant et al., 2012). There is no guarantee that the restoration action will work according to plan, and therefore investing in a relatively modest, but nimble and adaptive monitoring plan (cf. Lindenmeyer and Likens, 2009; Allan et al., 2012), is critical to ensure that the substantial, upfront costs of restoration generate long-term benefits.

Conclusion

Non-market valuations can be useful when allocating money for restoration activities as they place a numerical value on the benefits, which is often difficult to do. Based on our analyses in Muskegon Lake, approximately 119% of the remediation cost is returned in housing values alone. This estimate is very likely conservative because we evaluated only a portion of the restoration activities, and included coefficients from houses located north of Muskegon Lake, which account for the diminishing returns provided by natural shoreline. In subsequent years, a new study will track actual housing sales to determine if the predicted increase is realized.

According to our estimations, the predicted increase in property value is estimated at $11.9 million due just to environmental restoration on Muskegon Lake. This is based on only the shoreline remediation, so it undervalues the sediment removal also being done on the project. Using

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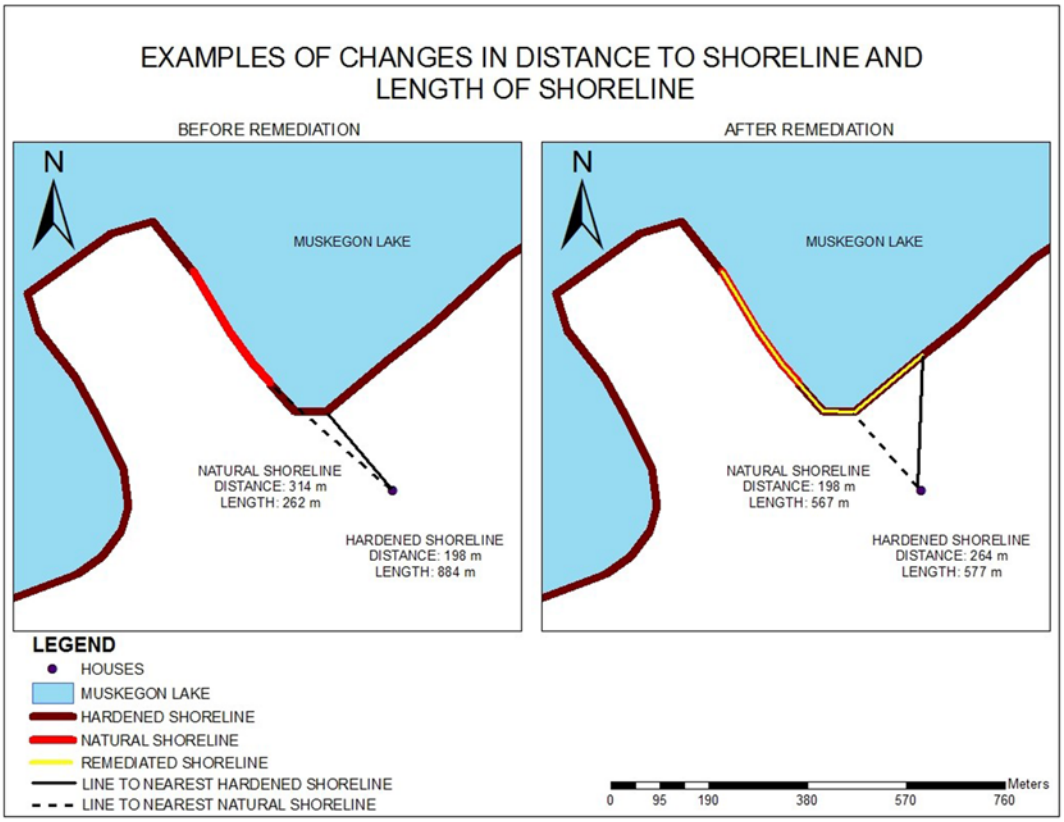

Fig. 3. Map illustrating how shoreline restoration potentially changes the distances and lengths between the shoreline and house location. In this illustration, restoration reduces the length of this hardened shoreline segment from 884 to 577 m, which reduced the house distance to a softened shoreline from 314 m to 198 m.

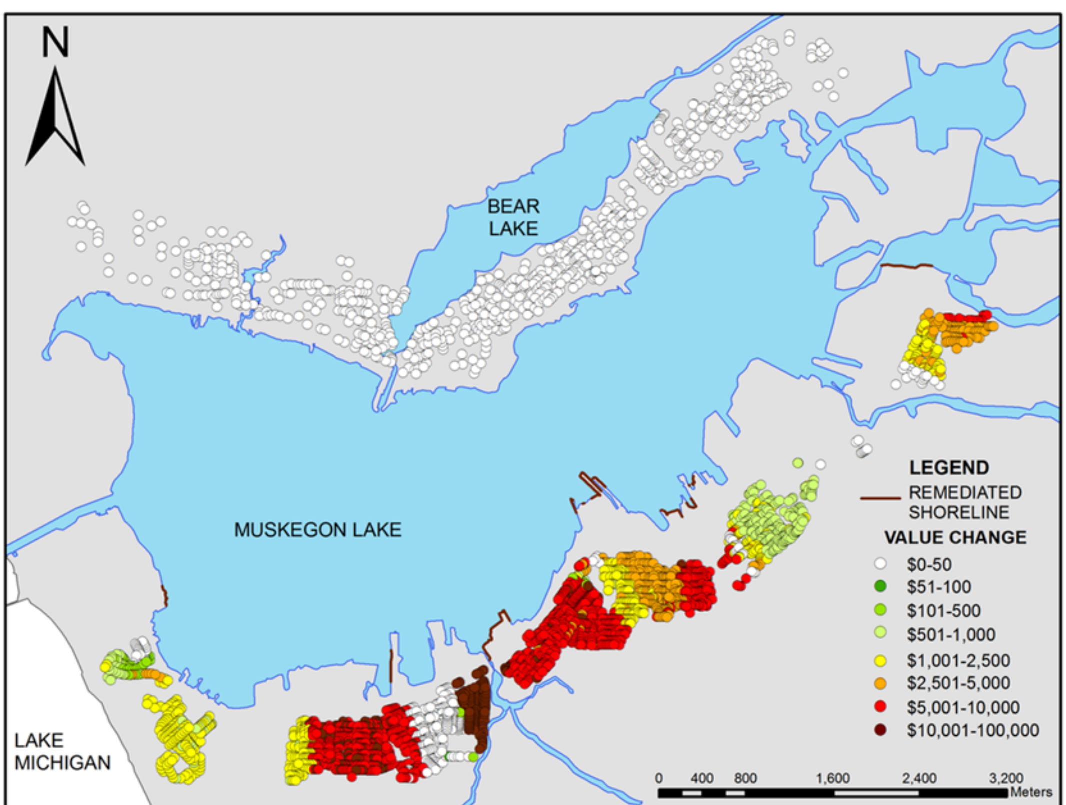

Fig. 4. Predicted change in value following shoreline restoration for houses located between 100 and 800 m of shoreline, for which there are sufficient data to generate predicted prices for the year 2009.

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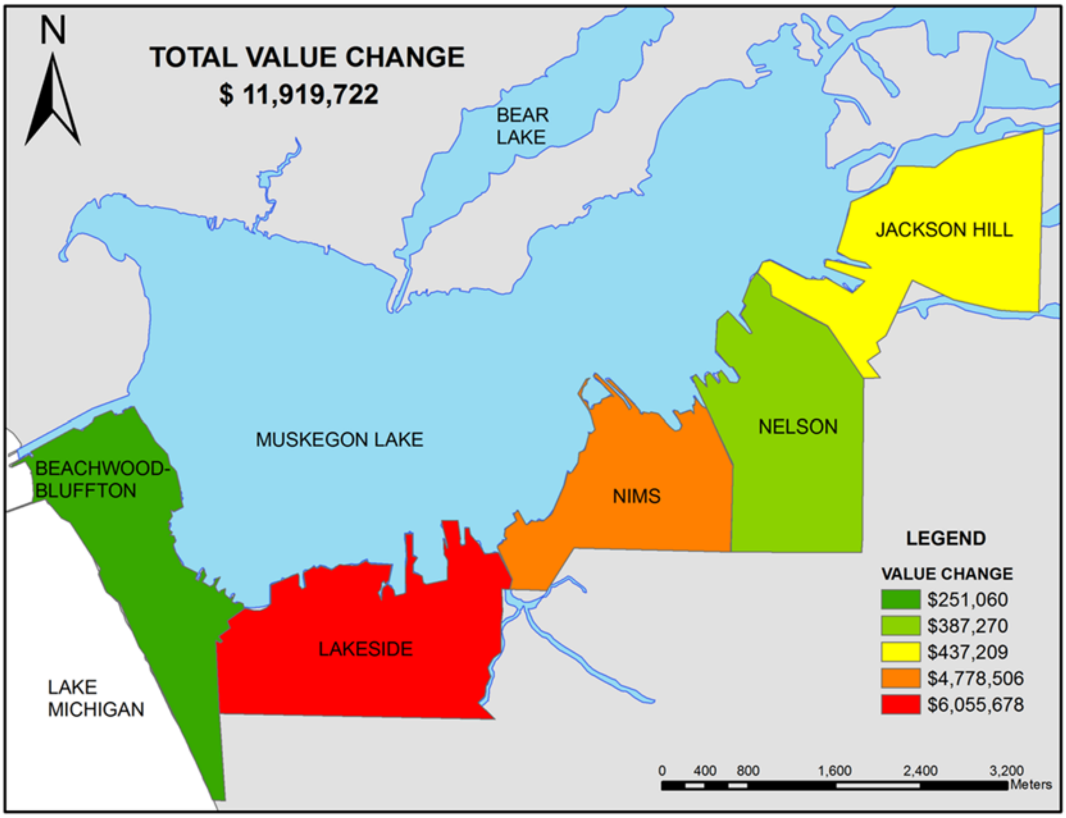

Fig. 5. Cumulative change in housing value segregated by neighborhoods adjacent to Muskegon Lake.

the standard discount rate of 7%, this equates to an annualized value of $337 per house which is 40% higher than estimated in Stoll et al. (2002) and Austin et al. (2007) whose estimate is based on a complete remediation instead of the partial remediation observed here.

As the travel cost estimates were calculated by not including the population within 800 m of the Muskegon Lake, the hedonic value and travel cost estimates can be added together, resulting in $47.5 million in value in addition to the original $10 million spent. The result is that over 15 years the total value generated is nearly six times the initial investment to the local area, with 83% of this value being in ecosystem services value. Although these values do not account for a full cost benefit analysis showing the opportunity cost at a national level, they do support a strong improvement in both the local economy and environmental values when compared to the baseline of doing nothing. This number is estimated prior to the completion of the remediation, as such continuing monitoring will be required to confirm and refine this estimate.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jglr.2017.12.002.

References

Alexander, J., 2006. The Muskegon: The Majesty and Tragedy of Michigan's Rarest River. Michigan State University Press, East Lansing, Michigan.

Allan, J.D., Burton, G.A., Boyer, G., Haffner, G.D., Höök, T., Johnson, L., Karatayev, A., Burlakova, L., Klump, J.V., Lodge, D., Miller, C.J., Pitts, D., Read, J., Scavia, D., Schuchman, R., Steinman, A., Stevenson, R.J., Stepien, C., Taylor, W., Twiss, M., Uzarski, D., 2012. Science Strategy to Improve Great Lakes Restoration. Available at:. http://graham.umich.edu/scavia/wp-content/uploads/2012/11/GL-Science-Strategy_Final.pdf.

Allan, J.D., McIntyre, P.B., Smith, S.D., Halpern, B.S., Boyer, G.L., Buchsbaum, A., Burton, G.A., Campbell, L.M., Chadderton, W.L., Ciborowski, J.J., Doran, P.J., Eder, T., Infante, D.M., Johnson, L.B., Joseph, C.A., Marino, A.L., Prusevich, A., Read, J.G., Rose, J.B., Rutherford, E.S., Sowa, S., Steinman, A.D., 2013. Joint analysis of stressors and ecosystem services to enhance restoration effectiveness. Proc. Natl. Acad. Sci. 110, 372–377.

Angradi, T.R., Launspach, J.J., Bolgrien, D.W., Bellinger, B.J., Starry, M.A., Hoffman, J.C., Trebitz, A.S., Sierszen, M.E., Hollenhorst, T.P., 2016. Mapping ecosystem service indicators in a Great Lakes estuarine Area of Concern. J. Great Lakes Res. 42, 717–727.

Annis, G.M., Pearsall, D.R., Kahl, K.J., Washburn, E.L., May, C.A., Taylor, R.F., Cole, J.B., Ewert, D.N., Game, E.T., Doran, P.J., 2017. Designing coastal conservation to deliver ecosystem and human well-being benefits. PLoS One 12 (p.e0172458).

Austin, J.C., Anderson, S.T., Courant, P.N., Litan, R.E., 2007. Healthy Waters, Strong Economy: The Benefits of Restoring the Great Lakes Ecosystem. Brookings Institution, Washington, DC.

Bell, K.P., Bockstael, N.E., 2000. Applying the generalized-moments estimation approach to spatial problems involving microlevel data. Rev. Econ. Stat. 82, 72–82.

Braden, J.B., Taylor, L.O., Won, D., Mays, N., Cangelosi, A., Patunru, A.A., 2008a. Economic benefits of remediating the Buffalo River, New York area of concern. J. Great Lakes Res. 34, 649–660.

Braden, J.B., Won, D., Taylor, L.O., Mays, N., Cangelosi, A., Patunru, A.A., 2008b. Economic benefits of remediating the Sheboygan River, Wisconsin area of concern. J. Great Lakes Res. 34, 6319–6648.

Can, A., 1990. The measurement of neighborhood dynamics in urban house prices. Econ. Geogr. 66, 254–272.

City of Muskegon, 2009a. City of Muskegon Neighborhoods. Available at:. http://www.muskegon-mi.gov/community/neighborhoods/.

City of Muskegon, 2009b. Zoning and Land Use. Available at:. http://www.muskegon-mi.gov/departments/planning/zoning/.

Costanza, R., dArge, R., de Groot, R., Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., O'Neill, R.V., Paruelo, J., Raskin, R.G., Sutton, P., van den Belt, M., 1997. The value of the world's ecosystem services and natural capital. Nature 387, 253–260.

Daily, G.C., Polasky, S., Goldstein, J., Kareiva, P.M., Mooney, H.A., Pejchar, L., Ricketts, T.H., Salzman, J., Shallenberger, R., 2009. Ecosystem services in decision making: time to deliver. Front. Ecol. Environ. 7, 21–28.

Daniel, T.C., Muhar, A., Arnberger, A., Aznar, O., Boyd, J.W., Chan, K.M., Costanza, R., Elmqvist, T., Flint, C.G., Gobster, P.H., Grêt-Regamey, A., 2012. Contributions of cultural services to the ecosystem services agenda. Proc. Natl. Acad. Sci. 109, 8812–8819.

De Groot, R., Brander, L., Van Der Ploeg, S., Costanza, R., Bernard, F., Braat, L., Christie, M., Crossman, N., Ghermandi, A., Hein, L., Hussain, S., 2012. Global estimates of the value of ecosystems and their services in monetary units. Ecosyst. Serv. 1, 50–61.

Dubin, R.A., 1988. Estimation of regression coefficients in the presence of spatially autocorrelated error terms. Rev. Econ. Stat. 70, 466–474.

Fisher, B., Turner, K., Zylstra, M., Brouwer, R., Groot, R., Farber, S., Ferraro, P., Green, R., Hadley, D., Harlow, J., Jefferiss, P., 2008. Ecosystem services and economic theory: integration for policy-relevant research. Ecol. Appl. 18, 2050–2067.

Heal, G., 2000. Nature and the Marketplace; Capturing the Value of Ecosystem Services. Island press, Washington, DC.

Isely, E.S., Isely, P., Seedang, S., Mulder, K., Thompson, K., Steinman, A.D., 2010. Addressing the information gaps associated with valuing green infrastructure in west Michigan: INtegrated valuation of ecosystem services tool (INVEST). J. Great Lakes Res. 36, 448–457.

Lindenmeyer, D.B., Likens, G.E., 2009. Adaptive monitoring: a new paradigm for long-term research and monitoring. Trees 24, 482–486.

Loomis, J., 2003. Travel cost demand model based river recreation benefit estimates with on-site and household surveys: comparative results and a correction procedure. Water Resour. Res. 39:1105. https://doi.org/10.1029/2002WR001832.

McCauley, D.J., 2006. Selling out on nature. Nature 443, 27–28.

Michigan Center for Geographic Information, 2009. MI Geographic Data Library. Available at:. http://www.mcgi.state.mi.us/mgdl/?rel=cext&action=Muskegon.

Muskegon County Equalization Department, 2009. GeoC Std Export [Data File]. Available from. http://co.muskegon.mi.us/equalization/services.htm.

NOAA, 2009. Commerce Secretary Gary Lock Announces $167 Million in Recovery Act Funding for 50 Coastal Restoration Projects. Press Release, June 30. Available at:. http://www.noaanews.noaa.gov/stories2009/20090630_restoration.html.

Parsons, G.R., 2003. The Travel Cost Model. In: Champ, P.A., Boyle, K.J., Brown, T.C. (Eds.), A Primer in Nonmarket Valuation. Kluwar Academic Publishers, Boston, pp. 269–330 Chapter 9.

Rosen, S., 1974. Hedonic prices and implicit markets: product differentiation in pure competition. J. Polit. Econ. 82, 34–55.

Seller, C., Stoll, J.R., Chavas, J.-P., 1985. Validation of empirical measures of welfare change: a comparison of nonmarket techniques. Land Econ. 61, 156–175.

Sergeant, C.J., Moynahan, B.J., Johnson, W.F., 2012. Practical advice for implementing long-term ecosystem monitoring. J. Appl. Ecol. 49, 969–973.

StataCorp, 2017. Stata Statistical Software: Release 15. StataCorp LLC, College Station, TX.

Steinman, A.D., Ogdahl, M., Rediske, R., Ruetz III, C.R., Biddanda, B.A., Nemeth, L., 2008. Current status and trends in Muskegon Lake, Michigan. J. Great Lakes Res. 34, 169–188.

Steinman, A.D., Cardinale, B.J., Munns, W.R., Ogdahl, M.E., Allan, J.D., Angadi, T., Bartlett, S., Brauman, K., Byappanahalli, M., Doss, M., Dupont, D., Johns, A., Kashian, D., Lupi, F., McIntyre, P., Miller, T., Moore, M., Muenich, R.L., Poudel, R., Price, J., Provencher, B., Rea, A., Read, J., Renzetti, S., Sohngen, B., Washburn, E., 2017. Ecosystem services in the Great Lakes. J. Great Lakes Res. https://doi.org/10.1016/j.jglr.2017.02.004.

Stoll, J.R., Bishop, R.C., Keillor, J.P., 2002. Estimating Economic Benefits of Clean up Contaminated Sediments in Great Lakes Areas of Concern. University of Wisconsin Sea Grant Institute, Madison, WI.

Sutherland, R.J., 1982. The sensitivity of travel cost estimates of recreation demand to the functional form and definition of origin zones. West. J. Agric. Econ. 7, 87–98.

U.S. Census Bureau, 2009a. American Community Survey. Available at:. http://factfinder.census.gov.

U.S. Census Bureau, 2009b. 2009 Tiger/Line Shapefiles for: Muskegon County, Michigan. Retrieved from. http://www2.census.gov/cgi-bin/shapefiles2009/county-files?county=26121.

USEPA, 2009. Great Lakes Area of Concerns: Muskegon Lake Area of Concern. Available at: . http://www.epa.gov/glnpo/aoc/msklake.html.

Whitehead, J.C., Groothuis, P.A., Southwick, R., Foster-Turley, P., 2009. Measuring the economic benefits of Saginaw Bay coastal marsh with revealed and stated preference methods. J. Great Lakes Res. 35, 430–437.

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