DAMS, DAM REMOVAL, AND RIVER RESTORATION: A HEDONIC PROPERTY VALUE ANALYSIS

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This article presents the results of a hedonic property value analysis for multiple hydropower sites along the Kennebec River in Maine, including the former site of the Edwards Dam in Augusta, Maine. The effect of the removal of the Edwards Dam on the Kennebec River in Maine is examined through consumer's marginal willingness to pay to be close to or distant from the dam site. Data from both before and after the dam was removed are used to estimate changes in marginal prices. A similar data set is also used to look at the effects of the remaining upstream dams on property values. This article presents one of the first (to our knowledge) ex post analyses on the economic impact of dam removal on property values. As more privately owned dams in the United States come up for relicensing, evaluating the impacts with and without the dam will become increasingly important. This work can help inform those analyses. (*JEL* Q25, Q51, Q58)

I. INTRODUCTION

The removal of the Edwards Dam on the Kennebec River in 1999 set a national precedent for removing hydropower dams of marginal value. The removal represented the first time a functioning hydropower facility undergoing relicensing under the U.S. Federal Energy Regulatory Commission (FERC, which licenses hydropower facilities) was removed with the goal of restoring aquatic ecosystems. The Edwards Dam was also the first major dam to be removed in Maine. Since its removal, anadromous fish, including Atlantic salmon, have returned to the river above the dam site. Benthic aquatic insect populations—a key indicator of ecosystem health used in Maine to document compliance with water quality standards—appear to be growing dramatically.[1] Recreation on the river in the form of fly-fishing, canoeing, and kayaking has also grown. Upstream dams have faced the need to build fish passage in order to meet the terms of the Kennebec River Restoration agreement. However, little has been done in the way of postproject research or monitoring. The project has been deemed successful by most observers, but without formal evaluation, few objective measures of "success" are possible. This article presents the results of an ex post hedonic property value analysis of the area surrounding the former dam site and an upstream area with two hydropower dams. To the best of our knowledge, this is one of the first studies to undertake an ex post analysis of the economic impacts of a dam removal.[2]

The removal of the Edwards Dam signaled—or partially triggered—a change in thinking about management of Maine rivers. Nearly, half a dozen smaller dams have recently been removed or are currently being evaluated for removal, including the Ft. Halifax Dam, in

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1. The Maine Department of Environmental Protection is responsible for monitoring water quality.

2. This article is submitted as a set with Provencher et al. (this issue). We believe these are the first articles to undertake this type of analysis and make an important policy contribution.

ABBREVIATIONS

CPI: Consumer Price Index
FERC: Federal Energy Regulatory Commission
GIS: Geographic Information System
WSTB: Water, Science and Technology Board

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Waterville. Efforts to establish fish passage at upstream sites have increased as anadromous fish are able to pass downstream dams that have blocked access for most of a century. The Penobscot River Restoration agreement, which has been negotiated but not yet fully funded, would allow for the removal of two major dams north of Bangor and for fish passage to be built at others. On rivers around the country, similar things are happening. Two small hydropower dams on the Sandy River in Oregon are scheduled to be removed this year.[3] All this activity signals a critical need for credible estimates of the socioeconomic benefits of often-expensive restoration efforts (an estimated $25 million in the case of the Penobscot River project).[4]

Additionally, since dam removal is controversial, it is important to fully understand its potential impacts. Impacts on recreation, property values, and community development are all of concern both to local communities and to property owners. Indeed, opposition to dam removal is often especially loud from property owners along impoundments, who may have purchased homes or invested in boats, docks, and other recreational facilities in expectation of the presence of an impoundment. Such losses to waterfront landowners, however, may not appear if potential buyers value homes near free-flowing rivers as much as properties near reservoirs. With river restoration efforts gaining national attention, studies that shed light on direct and indirect costs and benefits associated with dam removal should be valuable to the decision-making process.

The need for better postproject monitoring and socioeconomic evaluation of aquatic restoration projects is widely recognized. The *Draft Maine River Restoration User Guide* (2004)[5] emphasizes the need for a "comprehensive, accurate method for evaluating the beneficial and adverse impacts of a dam removal." This report includes a section highlighting the need for socioeconomic valuation. Johnson and Graber (2002) also emphasize the need for incorporating the social sciences in decision making about dam removal. In 2002, the Department of Interior commissioned the Water, Science and Technology Board (WSTB) to undertake an assessment of water resources research funded by federal dollars. At the Universities Council on Water Resources annual conference, 2005, Henry Vaux, then Chair of the WSTB Committee, presented a keynote talk on the findings. According to Vaux, one of the priority needs is for ex post analysis of projects and for continued monitoring of current projects; social science research is also lacking. These shortcomings will become increasingly apparent as more and more dams outlive their useful lives and come up for relicensing both in Maine and across the nation.

In this study, we use hedonic property value methods to examine the effects of the presence of and the removal of hydropower dams on the Kennebec River in Maine, United States, on property values in adjacent communities. The three dams we examine are (1) the Edwards Dam, which was removed in 1999, located in Augusta; (2) the Ft. Halifax Dam, a dam at the mouth of the Sebasticook River where it meets the Kennebec located in Winslow; and (3) the Lockwood Dam, a dam on the mainstem of the Kennebec between Waterville and Winslow. Figure 1 illustrates our study area watershed, dam sites, and house transactions.

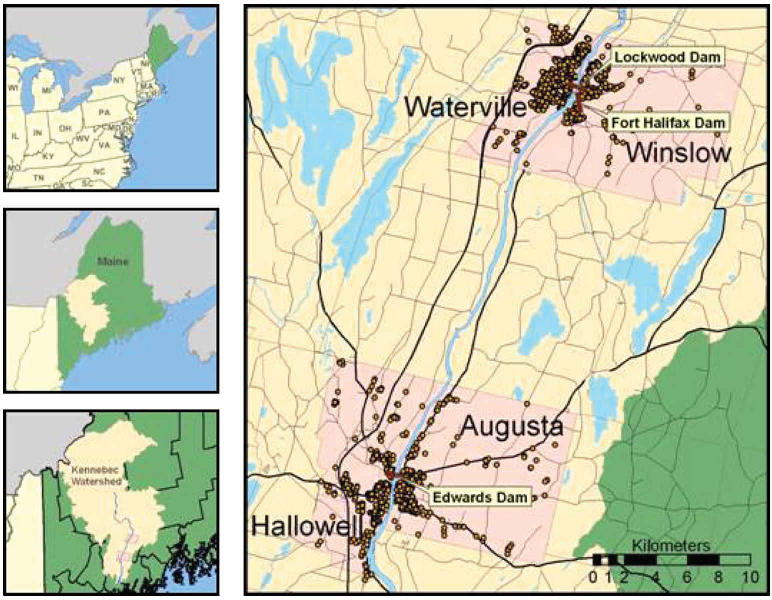
FERC, the agency responsible for regulation and licensing of nonfederal hydropower facilities, will be evaluating licenses for hundreds of dams over the next several decades. As more and more privately owned dams in the United States come up for relicensing, evaluating the impacts with and without the dam will become increasingly important. While this study solely examines the effects on property values and not on recreational values or passive use values, this work can help inform larger analyses. We also believe it is one of the first to address this important aspect of river restoration.

II. KENNEBEC RIVER

The Edwards Dam was the last of a series of dams present at the same location at the head of tide from 1834 to 1999. It was a small (24 ft. high, 917 ft. wide), economically marginal hydropower dam with a generating capacity of 3.5 MW. Originally built to help power a sawmill, it was used only for power production at the time of its removal. At the time of decommissioning, it was owned by Edwards Manufacturing Company. It created a reservoir that extended more than 15 miles up the Kennebec.[6] The

3. *The Oregonian*, May 23, 2007.
4. www.penobscotriver.org.
5. Maine State Planning Office (2004).
6. www.americanrivers.org.

FIGURE 1
The Kennebec Watershed, Maine, United States, and our data sets



dam never provided for effective upstream passage for anadromous fishes.

The Ft. Halifax Dam was built in 1908 at the mouth of the Sebasticook River, the largest tributary of the Kennebec. The costs of providing fish passage facilities at this small hydropower site have made continued operation no longer cost effective and both the dam's current owner, FPL Energy, and the local conservationists are interested in removing the dam. Opposition to removal of the dam, which has a generating capacity of 1.5 MW,[7] has been fierce from some members of the local community. A major concern is that removal of the dam and elimination of its impoundment will destroy important recreational and aesthetic resources.

The 52-ft. high Lockwood Dam is, since removal of the Edwards Dam, the most downstream mainstem dam on the Kennebec. It provides a total generating capacity of nearly 7 MW.[8] A state-of-the-art fish lift was recently constructed at the site at a cost of $2.4 million.[9] The fish lift began operation in 2006. Because another dam blocks the Kennebec about a mile upstream, fish are now trapped at the Lockwood fish lift, sorted, and anadromous species are trucked upstream to bypass both dams. On June 20, 2006, four Atlantic salmon entered the fish lift, marking the first time in 170 yr that Atlantic salmon will have reached the upper Kennebec River.[10] Eventually, fish passage facilities will be built at the upstream sites and trucking of fish to upstream locations will stop. There are no plans to remove the Lockwood Dam at this time.

Opposition to the removal of Edwards Dam was strong. However, since removal, recreation in the form of boating and fishing has improved in that stretch of the river. We are interested in examining the impacts on property values.

III. HEDONIC PROPERTY VALUATION LITERATURE

The hedonic property value method uses market transactions to estimate the marginal prices of the various attributes of housing choice, including environmental quality. The theory of hedonic models is well known[11]

7. Maine Department of Environmental Protection (2006).
8. Ibid.
9. This type of fish passage has an attraction point that leads fish into a lift that carries them up into sorting tanks. From there, species whose spawning grounds are above the dam are trucked upstream.
10. G. Ponte (pers. comm.).
11. The theory was first developed by Griliches (1971) and Rosen (1974). Palmquist (1991) and Freeman (2003) contain thorough overviews of the theory.

and while there are limitations of hedonic models, they are useful because they allow us to determine whether or not environmental variables are reflected in the housing market.

Models that address environmental externalities characterizing locational choice have a strong spatial component. These spatial components may vary within a watershed but also may be attributed to the health or quality of the watershed. Interest in spatial analysis with hedonic property models is increasing as evidenced by the growing number of articles that incorporate spatial issues within hedonic property models. Only quite recently have hedonic models addressed the spatial components of environmental quality and how these may relate to home prices (e.g., Acharya and Bennett, 2001; Bockstael, 1996; Cameron, 2006; Geoghegan, Wainger, and Bockstael, 1997; Lewis and Acharya, 2006; Paterson and Boyle, 2002).

Distance measures are frequently used in hedonic analyses. For example, Michaels and Smith (1990) and Hite et al. (2001) examine the effects of distance from hazardous waste sites and landfills, respectively. Parsons (1992) uses a repeat-sales analysis to study the effect of the distance from critical areas where new development is not permitted on home values. Similarly, Palmquist, Roka, and Vukina (1997) investigated how nonfarm residences were affected by large hog operations. Lewis and Acharya (2006) and Leggett and Bockstael (2000) use inverse distances to capture nonlinearities with environmental disamenities. Cameron (2006) examines using both distance and direction in hedonic property value models. Some recent articles have addressed the question of scale and patterns in land use (Acharya and Bennett, 2001; Bockstael, 1996; Geoghegan, Wainger, and Bockstael, 1997; Lewis and Acharya, 2006).[12]

Leggett and Bockstael (2000) present a hedonic analysis of waterfront property with the a priori expectation that owners of waterfront property care about water quality as they have "essentially self-selected for an interest in water activity." Poor et al. (2001) examine and compare objective measures of water quality with subjective measures based on survey data on individuals' perceptions of quality. Poor, Pessagno, and Paul (2007) estimate the value of ambient water quality for a watershed in Maryland. Proximity to water bodies, such as rivers and lakes, may be an asset to homeowners, but the relative quality of land and water attributes can result in disamenities and reduced home prices (Lewis and Acharya, 2006). Thus, this method is extremely appropriate for evaluating the impacts of dams and dam removal.

One drawback of this method is that environmental or ecological data that help identify the quality of a neighborhood are often not accessible to house buyers or may be highly technical in nature and, therefore, of little import to house buyers. Additionally, many home buyers may not be aware of this information until after purchasing the home or the information must be inferred by the purchaser. For this study, however, the large urban dams and the industrial-scale hydropower facilities associated with them are unlikely to go unnoticed by a homebuyer. Besides, the removal of Edwards Dam was a well-publicized event both in Maine and nationally.

While a few studies have addressed the measurement of recreation and passive use values from dam removal (e.g., Loomis, 1996, 1999), to the best of our knowledge, hedonic property value models have not yet been used in valuation for dam removal, and while studies have used distance to rivers as an independent variable, distance to a dam or dam site has not been examined as potentially affecting property values. This article and Provencher et al. (this issue) may be the first.

A. Data

We obtained real estate sales information from 1997 to 2005 for 18 towns throughout the Kennebec River Valley. There were a total of 7,876 house sales during this time period in our initial data set.[13] The real estate data include information about the list and sales prices as well as structural information about the house and the size of the lot.[14] In order to

12. McConnell and Walls (2005) also contains a thorough summary of the literature on the valuation of open space.

13. Originally, we had hoped to analyze sales from the 5-yr pre-dam removal and 5-yr post-dam removal (Edwards Dam was removed in 1999), but reliable sales information was only available back to 1997. Approximately one-third of our sample is sales data from prior to the dam removal. The remainder has sales dates after the dam was removed.

14. All prices are in 1999 dollars using the CPI. We did not find a reliable price index for these markets, although we did estimate one model using an approximate index for Kennebec County. Given the variability in these markets, we felt the CPI was a better deflator.

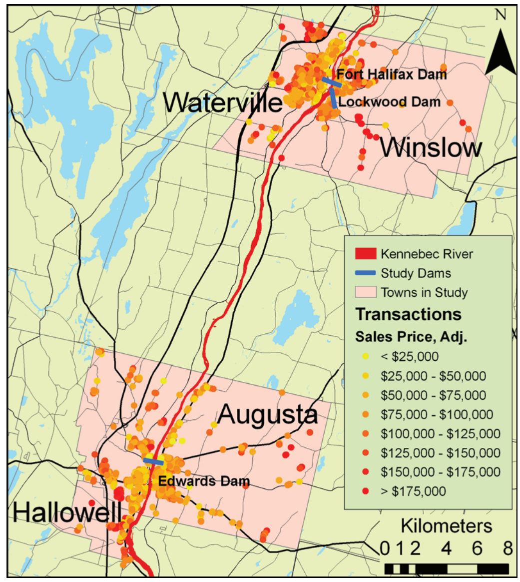
examine the spatial effects, it is very important to be able to associate the location of each house to the components of its surrounding environment. Therefore, each house was geocoded to determine its location using ArcGIS, a geographic information system (GIS) software program. This was possible and relatively simple due to the introduction of the Enhanced 9-1-1 (E-911) service by the Emergency Services and Communications Bureau and the state of Maine.[15] There were seven towns that included all the appropriate additional characteristics and had available E-911 data: Augusta, Chelsea, Hallowell, Randolph, Sidney, Waterville, and Winslow.[16]

Since hedonic analysis requires that real estate transactions being studied be contained within a single real estate market (Freeman, 2003), we reduced the data to focus on the two obvious urban markets—the Augusta, Maine market, and the Waterville, Maine market. The first market contains the former Edwards Dam site and the towns of Augusta and Hallowell. The second contains two dams, the Lockwood Dam and Ft. Halifax Dam, and the towns of Waterville and Winslow. Ft. Halifax Dam is currently undergoing litigation regarding removal. Both these dams have relatively new fish passage installations. A state-of-the-art fish lift came online at the Lockwood Dam in May 2006. The dam above Ft. Halifax Dam is installing a fish lift in preparation for Ft. Halifax's removal. Figure 2 illustrates the geocoded homes scaled by price.

Following Provencher et al. (this issue), we also chose to use only those homes with lot sizes of 1 acre or less.[17] We did this for several reasons. Both the Augusta and the Waterville markets are in relatively urban areas and the distribution of lot sizes is skewed toward the smaller lots. Very few sales were for prop-

FIGURE 2

Home Sales between 1997 and 2005



erties with large lots. Lewis and Acharya (2006) also find that lot size affects the marginal value of the environmental variables and restricting lot size may eliminate that bias. Additionally, we wanted to ensure that we were not inadvertently capturing the value of potential developable sites.[18] Moreover, because large lot sales were rare with lot sizes far from the sample mean, sales of large lots had the potential to have a disproportionate effect on statistical analyses (a high regression leverage). After omitting the smaller towns away from the river and the larger lot sizes, we have approximately 1,200 home sales in each of the two major urban markets.

We then calculated distances from each geocoded house (1) to the Kennebec River, (2) to the former Edwards Dam site, and (3) to the Lockwood and Ft. Halifax dams.[19] We acknowledge that other studies, including one with an author of this article, argue for using inverse distances, we chose straight-line

15. As part of E-911 service, geospatial information based on street addresses is made available to emergency responders to increase speed and efficiency of emergency services. These data were secondarily made available through the Maine Office of GIS Web site (http://apollo.ogis.state.me.us/). The E-911 data provide an efficient way to associate street addresses, as provided by our real estate transaction information, with specific geographic locations.

16. We were unable to geocode certain areas because some towns in Maine had not finished upgrading to the new E-911 service. These towns did not have an available E-911 spatial layer at the time of our analyses.

17. We also carried out analyses using higher lot size cutoffs but do not report them here. Results were generally similar.

18. As in Provencher et al. (this issue), we acknowledge that lot sizes greater than 1 acre are potentially split for development and may not reflect the actual value of having a large lot for use. In growing markets such as Maine's, we wanted to omit this potential bias.

19. Given the condensed geography of our study area, distance to the river and distance to the dam sites tended to be highly correlated. We thus chose to use the distance to the dam sites only.

distances for this study since most observations are relatively close to the river (most are within walking distance).[20] While Provencher et al.'s article includes only those houses within ¼ mile of a water body, we have a wider belt, but all are in the urban area relatively close to the river and dam sites.

In order to capture other potential sources of environmental value, we also incorporated data on land use. We calculated the percentage of open space, open water, and developed land around each house within a 400-m (roughly ¼ mile) and 1,500-m (approximately 1 mile) radii. We use the 400-m radius to capture characteristics of the immediate neighborhood, for example, what can be seen from the house, and use the larger radius to represent land uses within walking distance from the house (as in Acharya and Bennett, 2001; Geoghegan, Wainger, and Bockstael, 1997; Lewis and Acharya, 2006). We did the same for percentages of developed land and percentages of water around each house.

These land use variables were derived from a data layer from the Maine Office of GIS that had 38 different land covers.[21] We narrowed the land covers down to 10—consisting of abandoned fields, agriculture, commercial forests, dense residential, forests, grassland/lawns, highways/runways, sparse residential, water, and wetlands.

We describe the method used to generate maps and derive numerical estimates of the proportion of open space within 400- and 1,500-m radii of each real estate transaction. Methods for open water and developed land are similar. First, we made a simplified map that separated open space from nonopen space. Next, we calculated, on a pixel-by-pixel basis, the proportion of all pixels within a 400- or 1,500-m circular neighborhood that qualifies as open space. We then simply matched up our geocoded real estate transactions with these maps to extract an estimate of the proportion of open space in the immediate neighborhood of each property sale in our data.

We used this approach to calculate six land use variables—three for a 1,500-m radius and three for a 400-m radius, as follows:

- PCTOPN = percent open space within 1,500 or 400 m (includes grassland, agriculture, and forestlands)
- PCTWTR = percent and within 1,500 or 400 m (includes open water and wetland categories)
- PCTDVT = percent developed within 1,500 or 400 m (includes low- and high-density residential, commercial, industrial, and roads).

Since every land use falls into one of the three land use categories (open, water and wetlands, or developed), the three quantities at each radius are mutually exclusive and exhaust all the possible land use types and thus sum to 1. Figure 3, for example, illustrates the percentage of open space in Kennebec County at 1,500 m. Figure 4 illustrates the percentage of area developed around each house at 400 m. We chose to illustrate the dam sites on Figure 3 and the house sites on Figure 4 to reduce clutter on the graphic and for clarity of presentation.

Finally, we used 2000 U.S. census data to characterize socioeconomic characteristics of the neighborhoods of each real estate transaction in our data. The smallest geographic scale at which most economic data are reported by the U.S. census is the Census Block Group. We used the census estimates of median household income and proportion of households living below the poverty level as descriptors of local socioeconomic conditions.[22] Variable descriptions and descriptive statistics of selected variables are displayed in Tables 1 and 2.

IV. ANALYSIS AND RESULTS

The functional form for the hedonic equation is not determined theoretically.[23] We use a semilogarithmic functional form.[24] The

20. We have carried out several analyses looking at alternate functional forms to capture expected nonlinearities with respect to distance from the river and from the dams. Inverse distance models have theoretic appeal, while log-transformed models were suggested by a Box-Cox search for suitable data transformations. We settled on using a linear function of distance for pragmatic reasons: the models were statistically well behaved and readily interpretable in the context of our data and our research questions.

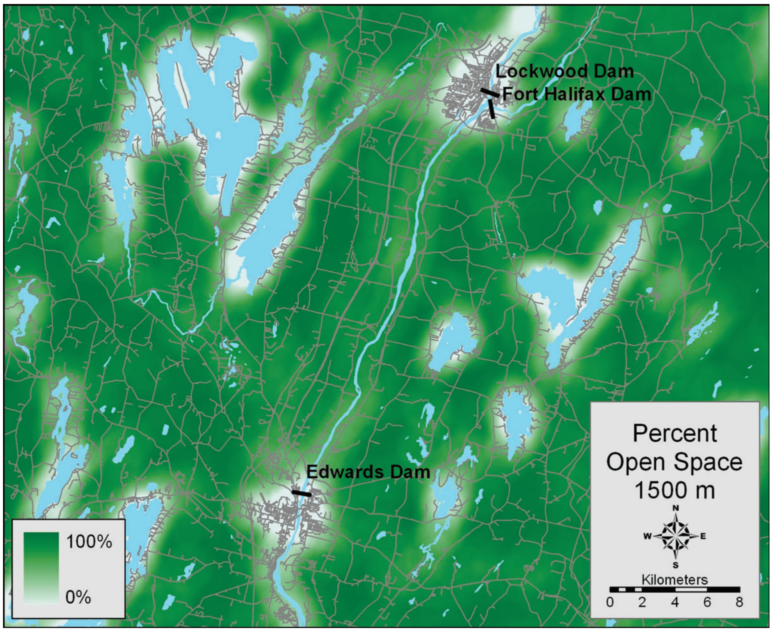
21. Land use data were derived from the gomlc7 data set, developed by the Gulf of Maine Program Office of the U.S. Fish and Wildlife Service, and made available through the Maine Office of GIS. The gomlc7 data set is a raster data set with a 10-m pixel resolution. It represents land cover largely derived from National Wetlands Inventory data and 1992 and 1993 satellite imagery.

22. Each community contains only a small number of Census Block Groups. Thus, these data provide a relatively coarse measure of socioeconomic conditions. These variables also tend to be highly correlated and precluded the use of more than one census variable in our final regression analyses.

23. See discussion in McConnell and Walls (2005).

24. We also attempted a Box-Cox transformation and are unable to reject the semilog form as best fit among all possible Box-Cox transforms.

FIGURE 3
The Percentage of Open Space within 1,500 m



natural log of the sales price as the dependent variable has been used in many recent studies (see, e.g., Butsic and Netusil, 2007; Cameron, 2006; Lewis and Acharya, 2006; Poor et al., 2007; Provencher, Sarakinos, and Meyer, 2007).

For our analysis, then, we examine the following hedonic model:

$$(1)\quad \ln(\text{VALUE}) = \alpha_0 + \alpha_1 S + \alpha_2 N + \alpha_3 Z + \varepsilon.$$

The dependent variable, ln(VALUE), is the natural logarithm of the house value measured by (inflation corrected) sales price. S is a vector of structural characteristics, N is a vector of neighborhood characteristics, and Z is a vector of environmental attributes. We correct for heteroskedasticity using weighted least squares.

We use a quadratic specification for square footage, acreage, and open space in order to capture anticipated nonlinearities in the relationship between those variables and price. We also use an interaction term (POSTDIST) consisting of distance to the nearest dam site and the post-pre removal dummy variable in order to determine whether or not the dam removal has had an effect on values. If dam removal has had an effect on property values, we would expect that the effect of distance from the nearest dam on property values would have changed since dam removal, and thus, this interaction term should prove statistically significant. Following Provencher et al. (this issue), we include an index based on year sold (SALEDATE = 0, 1, 2, 3, . . .) to capture any linear trend in market conditions over time not removed by correcting real estate values for inflation using the consumer price index (CPI). Real estate prices in Maine, as in much of the country, rose significantly faster than consumer prices in the late 1990s and early 2000s and we did not find a reliable local real estate price index. The SALEDATE index thus acts to correct empirically in our model for the difference between changes in real estate prices and inflation as captured by the CPI. Finally, each data set includes a dummy variable where 1 = the larger town of the two towns included in each real estate market. These are labeled AUGUSTA (1 = Augusta, 0 = Hallowell) and WATERVILLE (1 = Waterville, 0 = Winslow). Results for these two models are presented in Tables 3 and 4.

With the semi-log specification, the coefficients are interpretable as a percentage change

TABLE 1
Variable Descriptions

Variable	Description
AGE_HOUS	Age of the house in years
OLD	1 = over 75 yr old, 0 = under 75 yr old
BEDROOMS	Number of bedrooms
BATHROOM	Number of bathrooms
SQUAREFE	Square feet of living space (does not include the basement or garage)
FIREPLAC	1 = working fireplace, 0 = no fireplace
GARAGE	1 = garage, 0 = no garage
ACRES	Lot size in acres
LIST_PRI	Original list price of the house
SOLD_PRI	Sales price of the house
REALSOLD	Sales price in 1999 dollars
DISTTOKE	Distance in meters to the Kennebec River
DIST_LOC	Distance in meters to the Lockwood Dam in Waterville
DIST_HAL	Distance in meters to Ft. Halifax Dam in Winslow
DCLOSEST	Distance to Lockwood or Ft. Halifax (whichever is closer)
DDAMINTO	Distance to Lockwood for Waterville Homes or Distance to Ft. Halifax if in Winslow
DISTTOED	Distance in meters to the former Edwards Dam site
PCTOPN15	Percentage of open space at 1,500-m radius (approximately 1 mile)
PCTWTR15	Percentage of water at 1,500-m radius
PCTDVT15	Percentage of development at 1,500-m radius
PCTOPN40	Percentage of open space at 400 m (approximately ¼ mile)
PCTWTR40	Percentage of water at 400 m
PCTDVT40	Percentage of development at 400 m
MEDHHINC	Median household income (U.S. census)
PROPPOV	Proportion of households living below the poverty line (U.S. census)

in price per unit change in the independent variable. There is a premium on houses in the smaller (less urbanized) town in each market. The house price penalty in Augusta is 25%, while it is only 9% in Waterville. Additionally, homes in both markets appear to lose value with age, and the dummy variable OLD (which takes a value of 1 if the home is greater than 75 yr old) is significant at the 95% level and negative. Our index of year sold also shows prices rising each year by approximately 6% in Augusta and almost 5% in Waterville above the general rate of inflation.

V. AUGUSTA AND THE EDWARDS DAM

Lot size is significant and exhibits diminishing returns for the Augusta data set. These results suggest that urban lots are very valuable. Percentage of open space at a 1,500-m (approximately 1 mile) radius is also positive and exhibits diminishing returns. Percentage of development, as one might anticipate, exhibits the opposite result suggesting that the more developed is the neighborhood, the lower the house value.

The coefficient on DISTTOED (distance to Edwards Dam) is positive and significant. This suggests that the farther away your home is from the dam site, the higher your property value (all else equal). However, recall this dam was removed in 1999. In order to account for changes since the dam was removed, we include the interaction term POSTDIST, which is the dummy variable (= 1 if the sale was after the dam removal and = 0 if the sale was prior to removal) × the distance to Edwards. This coefficient is negative and significant. This suggests that being close to the river at that site confers negative value but is less negative since the removal of the dam. In other words, overall, property value is smaller closer to the dam (which means closer to the river and closer to downtown Augusta). However, the "downtown Augusta penalty" is *smaller* post-dam removal than it was pre-dam removal. This is a very interesting result.

Using the mean residential sales price, these results suggest that the marginal willingness to pay to be farther from the dam is $2.43/m prior to removal but close to 0 ($0.16) after removal. In other words, before the dam was removed, a homeowner, on average, would be willing to pay an additional $2,000 to be ½ mile away from the dam. After removal, the willingness to be shrinks to $134. These results are significant at the 99% level.

The obvious causal interpretation of this statistical result is that removal of the Edwards Dam has resulted in an improvement in conditions near the old dam site that has reduced the downtown Augusta penalty. However, one alternative hypothesis cannot be fully disentangled from this one statistically and that is that this statistical signal reflects a long-term improvement in conditions along the Kennebec River. We will return to this hypothesis in more detail after we examine the results from the Waterville market.

TABLE 2
Descriptive Statistics for Selected Variables

	Augusta/Hallowell (Former Edwards Dam Site, 1,027 Cases)				Waterville/Winslow (Lockwood and Ft. Halifax Dams, 1,134 Cases)			
Variable	**Mean**	**SD**	**Minimum**	**Maximum**	**Mean**	**SD**	**Minimum**	**Maximum**
AGE_HOUS	68.464	39.316	2	234	56.655	31.928	1	216
OLD	0.316	0.465	0	1	0.257	0.437	0	1
BEDROOMS	3.085	0.843	1	10	3.160	0.861	0	6
BATHROOM	1.548	0.640	1	5	1.622	0.696	1	5
SQUAREFE	1,398.648	546.013	460	7,777	1,461.537	566.839	406	4,830
FIREPLAC	0.353	0.478	0	1	0.336	0.473	0	1
GARAGE	0.319	0.466	0	1	0.468	0.499	0	1
ACRES	0.318	0.221	0.030	1	0.280	0.192	0.030	1
LIST_PRI	93,595.296	43,652.990	14,900	350,000	95,320.710	50,956.349	7,900	359,000
SOLD_PRI	89,670.597	41,795.346	11,000	315,000	911,86.109	489,37.303	7,000	340,000
REALSOLD	83,343.492	36,954.437	10,348.072	285,222.745	85,005.781	44,858.063	6,585.136	319,148.936
DISTTOKE	1,222.857	1,366.900	53.13	8,963.380	1,109.523	803.452	60.47	9,096.26
DIST_LOC					1,957.842	1,024.241	154.16	9,346.48
DIST_HAL					2,297.939	1,068.827	237.47	8,988.66
DCLOSEST					1,850.558	1,017.787	154.16	8,988.66
DDAMINTO					1,943.300	1,034.716	237.47	8,988.66
DISTTOED	2,391.824	1,697.046	239.38	10,336.91				
PCTOPN15	0.562	0.168	0.277	0.984	0.469	0.189	0.182	0.968
PCTWTR15	0.087	0.043	0.011	0.379	0.099	0.033	0.007	0.272
PCTDVT15	0.350	0.161	0.002	0.623	0.432	0.176	0	0.695
PCTOPN40	0.413	0.250	0	1	0.347	0.273	0.017	1
PCTWTR40	0.075	0.072	0	0.60491	0.080	0.061	0	0.391
PCTDVT40	0.512	0.253	0	0.98488	0.573	0.266	0	0.981
MEDHHINC	30,837.793	7,346.466	18,494	48,971	34,785.361	9,943.836	11,818	52,440
PROPPOV	0.142	0.076	0.016	0.432	0.125	0.101	0.017	0.405

VI. WATERVILLE AND WINSLOW

The Waterville/Winslow results are quite similar, except that lot size is not a significant determinant of price. We hypothesize several reasons for this, not mutually exclusive. One theory is that in the less urban Waterville market, land is of lower overall value. Alternatively, the smaller average lot size and smaller variation in lot size in the Waterville market as compared to the Augusta market may just make patterns statistically more difficult to discern. Another possibility is a "Colby College Effect." Houses near Colby have a significant premium placed on them regardless of lot size. Since Colby College is a large employer in this relatively small town, there may be a college impact.[25]

Interestingly, open space (OPN1500S) has a quadratic effect only, with the marginal effect rising with percentage of open space. PCTDVT40 (percent developed at approximately ¼ mile) has a similar impact for this data set. The higher the density of development, the lower are property values. This effect increases as density increases. The effects of the structural characteristics of the houses on price are as expected and similar to what was observed in the Augusta market.

Again, there is a penalty for being near the dam sites (we used distance to whichever dam was closer [DCLOSEST]). As in Augusta, properties near the dams (and thus near the river and close to downtown Waterville) have lower value than do properties farther away from the dams (DCLOSEST has a significant positive coefficient). In fact, the penalty for being close to these two dams is approximately three times larger than in Augusta. The penalty is approximately $7.30/m or a marginal willingness to pay of almost $6,000 to be ½ mile from the dam.

Curiously, the magnitude of this "downtown Waterville penalty" has also gotten smaller since the Edwards Dam, nearly 20 miles down-

25. We also examined other types of nonlinearities in lot size such as the ln of the lot size (as in Provencher et al.), but none are significant.

TABLE 3
Regression Results for Former Edwards Dam Site Transactions

Variable	Coefficient	SE
Constant	9.404***	0.187
AUGUSTA	−0.250***	0.048
AGE_HOUS	−0.002***	0.000
OLD	−0.095**	0.041
BEDROOMS	0.028*	0.015
BATHROOM	0.079***	0.020
SQUAREFE	0.001***	5.17E-05
SQFT^2	−6.77E-08***	7.64E-09
FIREPLAC	0.105***	0.022
GARAGE	−0.004	0.021
ACRES	1.023***	0.181
ACRES^2	−0.799***	0.158
SALEDATE	0.058***	0.005
DISTTOED	2.91E-05***	1.05E-05
POSTDIST	−2.71E-05***	8.78E-06
PCTOPN15	3.027***	0.438
OPN1500^2	−2.471***	0.340
PCTDVT40	−0.602***	0.168
DVT40^2	0.584***	0.172
MEDHHINC	2.96E-06*	1.51E-06
n = 1,027		
R^2 = .5886611		

*, **, and *** indicate significance at the 90%, 95%, and 99% levels, respectively.

TABLE 4
Regression Results for Upstream Transactions near Ft. Halifax and Lockwood Dams

Variable	Coefficient	SE
Constant	9.666***	0.145
WATERVIL	−0.080**	0.040
AGE_HOUS	−0.002***	0.001
OLD	−0.167***	0.039
BEDROOMS	0.060***	0.015
BATHROOM	0.088***	0.019
SQUAREFE	0.001***	7.58E-05
SQFT^2	−9.27E-08***	1.75E-08
FIREPLAC	0.176***	0.024
GARAGE	0.100***	0.021
ACRES	0.081	0.155
ACRES^2	−0.118	0.144
SALEDATE	0.048***	0.005
DCLOSEST	8.59E-05***	2.48E-05
POSTDCLO	−6.46E-05***	1.60E-05
PCTOPN15	0.576	0.361
OPN15^2	−0.693**	0.351
PCTDVT40	−0.517**	0.219
DVT40^2	0.407**	0.200
MEDHHINC	9.08E-06***	1.19E-06
n = 1,134		
R^2 = .6442456		

** and *** indicate significance at 95% and 99% levels, respectively.

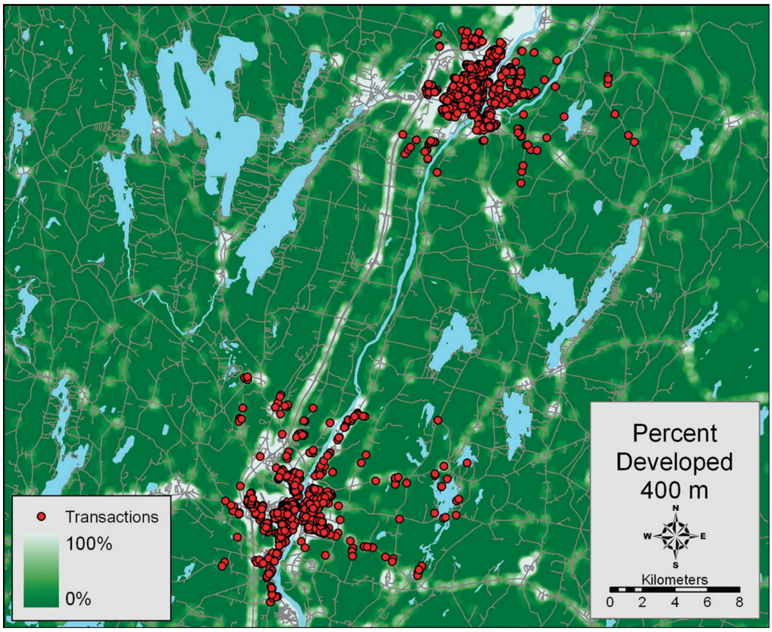
stream, was removed (POST-PRE dummy × distance to the closest dam [POSTDCLO] has significant negative coefficient). This is not entirely surprising since improved fisheries and water quality have received much attention since the removal of Edwards Dam. The recreational fishery above the former Edwards Dam site has recovered to a significant extent, and recreation on the stretch of river between Waterville and Augusta has increased. Populations of anadromous alewives in the Waterville area were sufficient to briefly support a commercial harvest at the Ft. Halifax Dam and along the Sebasticook River, although the practice has since been stopped. Fish passage has been installed around the Lockwood Dam. In fact, in 2006, thousands of fish passed through the brand-new fish lift at Lockwood Dam. Efforts to upgrade fish passage at the Ft. Halifax Dam are in abeyance while a final decision is made whether to remove the dam.

Following the removal of Edwards, the penalty shrinks to $1.80/m or a marginal willingness to pay of almost $1,500 to be ½ mile away. The penalty is smaller, but still much larger than the post-Edwards penalty in Augusta, suggesting that there is still a negative marginal willingness to pay for being close to the current dams.

VII. DISCUSSION

As dams around the country either outlive their useful lives or become safety concerns, the need for socioeconomic analysis on the impacts of dams and dam removal grows. This project documents changes in the relative value of houses close to dams as compared with houses farther away. We document an apparent penalty for being near the river in both the Augusta and the Waterville real estate markets. This is contrary to expectation. Typically, proximity to water is highly valued by homeowners, leading to higher real estate values close to aquatic resources. We also find, however, a substantial reduction in this penalty over time. These changes (1) coincided with removal of the Edwards Dam in time and (2) were of a form consistent with the hypothesis

FIGURE 4
The Percentage of Developed Land within 400 m



that removal of the dam directly or indirectly caused changes in property values. It is tempting, therefore, to attribute observed changes in value directly and quantitatively to dam removal. For almost all landowners, being close to the river means being in what have been, until very recently, relatively undesirable locations.

In ecosystem ecology where experimental replication is often impractical, a common strategy is to apply an experimental treatment at one site (e.g., a watershed or a forest) and observe the effects not only at the experimental site but also at a nearby control site where experimental manipulation was not employed. If a change is observed in the experimental site-while no change is observed at the control site, one is well justified in claiming that the experimental manipulation has caused the change. If not, alternative explanations must be proposed.

Removal of the Edwards Dam provides us with a natural unreplicated "experiment" in Augusta, while conditions in Waterville, near the Lockwood and Ft. Halifax dams (which are still standing), appear to provide us with a "control." Indeed, it was the possibility of using the comparison between the Waterville and the Augusta markets to clarify the importance of dam removal on real estate values that initially motivated us to study both real estate markets.

The treatment-control analogy, however, fails because Waterville was also affected by removal of Edwards. Removal of Edwards has had significant positive effects on fisheries and recreational value of the Kennebec both in Waterville and farther upstream. Fish counts at both Lockwood Dam's fish lift and Ft. Halifax Dam illustrate that migratory fish now reach the Waterville area. Indeed, our own observations of alewives, many river miles up the Sebasticook River, show that anadromous species are now reaching the upper portions of the watershed. This was not the case prior to removal of Edwards Dam.

Indeed, it is possible that the apparent positive effect of the removal of the Edwards Dam on local property values near the dam site (and thus near the river) reflects not only removal of the Edwards Dam but also long-term trends in water quality and the gradual change in the attractiveness of housing close to the river. Since the Edwards Dam site is on the order of 20 miles downstream, it is unlikely that removal of the Edwards Dam has had much direct effect on the Waterville real estate market; however, the long-term effects of the restoration of the Kennebec (of which removal of the Edwards Dam is an important part) may well be important. Fish counts at both Lockwood

Dam's fish lift and Ft. Halifax Dam illustrate that migratory fish are now reaching upper portions of the river. Additionally, at the time of this writing, a new effort called the "Kennebec River Initiative" has been announced to promote conservation and revitalization along the river both in Augusta and in Waterville.[26] These may be separate real estate markets, but the river runs through both, and an improvement in the lower portion of the river seems to have affected the Waterville market as well.

This project addresses a gap in the body of knowledge on valuation of river restoration. Requests are frequently made for information on costs and benefits of restoration that can be used in policymaking. Credible estimates of nonmarket economic values of environmental benefits related to dam removal are especially crucial. This article and the companion piece in this issue present the first (to our knowledge) analyses on the economic impact of dam removal on property values.

Removal of the Edwards Dam is part of a long-term effort of restoration and recovery of Maine's rivers dating back to before the passage of the Federal Water Pollution Control Act in the early 1970s. Hundreds of small dams are scheduled to come up for relicensing over the next few decades. This study should prove useful for decision making about river restoration and especially during the FERC relicensing process.

26. *Kennebec Journal*, November 10, 2006.

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