1-2023

A Hedonic Study of New England Dam Removals

Todd Guilfoos

Jason Walsh

A Hedonic Study of New England Dam Removals

Todd Guilfoos* and Jason Walsh†

February 7, 2023

Abstract

There are over fourteen thousand dams in the New England region. Recent efforts to remove dams to return rivers back to their natural orientations in the United States have increased, though a host of potential externalities exist to nearby communities. We compile 75 removed dams in the New England region to estimate the aggregate treatment effect of dam removal on nearby properties. We employ a repeat sales sample with property fixed effects and a difference-in-differences strategy to estimate proximity effects of dam removal. We cannot reject the null hypothesis that dam removals having no effect on proximity properties.

*Department of Environmental and Natural Resource Economics, University of Rhode Island, 219 Coastal Institute, 1 Greenhouse Road, Kingston, RI 02881. Email: guilfoos@uri.edu

†Department of Environmental and Natural Resource Economics, University of Rhode Island, 219 Coastal Institute, 1 Greenhouse Road, Kingston, RI 02881. This work is supported by the National Science Foundation EPSCoR award #IIA-1539071. We thank Leah Palm-Forster for helpful comments.

1 Introduction

Dams play an important role in water storage, flood protection, and hydropower (Jeuland, 2020; Duflo and Pande, 2007; Kotchen et al., 2006). There are over 90,000 dams in the United States, and many are old, block fish passage, and no longer serve their original purpose. For instance, there are many old mill dams in New England that no longer provide power to mill sites. Due to their age, many of these dams have fallen into disrepair causing potential hazards. Dam removal can also provide significant benefits for the ecosystem by improving habitat for fish and animals. While existing dams may block fish passage or pose a hazard to the public, they can also play a part of the historical identity or provide value for recreation to residents. The existing academic literature on dam removals lacks strong evidence on how proximate properties to a dam removal are affected by a dam removal and what drives these values.

Dam removals are complex in that their removals can impact many different facets of a community. They can change recreation opportunities, community identity, the natural landscape, and flood risks. When a dam removal is proposed the community may have an opportunity to voice their opinion on the project in a public forum (Magilligan, 2017). Despite community input, dam removals are rarely blocked by the community if the dam owner is in favor of the removal and there is funding for the project. Communities that are exploring a dam removal have expressed concern that their home values could be impacted by the removal of the dam especially when there is an impoundment (Born and White, 1998). Sensitivity to flood zones have been found to have a significant effect on housing prices (Pope, 2008; Bin and Polasky, 2004; Gibson and Mullins, 2020). Further, the change in hydrology can cause homes to lose access to groundwater from a dam removal. We expect that only some of these values would be capitalized into home prices (e.g. risk of flooding, groundwater loss, value of impoundment, construction externalities, viewscape, risk of dam failure). Our study helps clarify the extent of aggregate external impacts of dam removals on housing.

We estimate the impact of dam removals on housing prices in New England using a repeat sales sample with property level fixed effects and a difference in difference econometric identification strategy. We cannot reject the null of dam removals having no effect on proximity properties. We do not find statistically significant heterogeneous effects of our average treatment effect by the length of dam, height of dam, or upstream or downstream location of the property. Dams that are designated as high hazard dams or have impoundments may have impacts, though we cannot reject the null hypothesis that these dam removals change the average treatment effect of removal. Our results do inform dam removal management that most properties likely do not have a significant change in housing prices due to a removed dam.

There is a small literature on the valuation of dam removals (Provencher et al., 2008a; Lewis et al., 2008; Bohlen and Lewis, 2009a; Loomis, 1996). Provencher et al. (2008a) find no benefit of living upstream from a dam on a basin compared to living downstream from the dam on a meandering stream. They find that living proximate to, but not on, a meandering stream increases property value compared to similar properties living proximate to an impoundment. Lewis et al. (2008) finds a positive impact of removing dams on property values. The authors argue that their study area, the Kennebec River in Maine, was a highly polluted waterway until recently and the negative correlation between proximity to water and housing values is reflective of changes in pollution levels. Bohlen and Lewis (2009a) find a small premium of living next to a hydroelectric dam and observe a similar disamenity to living on the Penobscot river, which is also a polluted waterway in Maine. Loomis (1996) finds that residents are willing to pay between \$58 and \$73 to remove two dams on the Olympic Peninsula in Washington State to restore fisheries and ecosystem services in that area. We build on this literature by looking at a greater number of dam removals across the New England region.

Free flowing rivers also hold value to the public. Dam removal can return a stream back into a free flowing state and allow fish passage as well as opportunities for recreational fishing at that site and above stream. Bergstrom and Loomis (2017) conduct a meta analysis of the valuation of river restoration. They find, mostly through stated preference methods, that willingness to pay is positively related to the number of miles restored. Jarrad et al. (2018) find restoration projects that include permanent protection of land increase property values, while projects that maintain restoration temporarily or use heavy machinery decrease property values. In the case of the Edwards Dam on the Kennebec River in Maine, anglers are willing to spend more time to get to the river and are willing to pay more for opportunities to fish the flowing river (Robbins and Lewis, 2008). Fishing and hiking can generate significant value along free flowing rivers. (Getzner, 2015) study the River Mur in Styria, Austria, and find visitors are willing to pay a premium to walk and hike free flowing sections compared to the sections that are dammed. Null et al. (2014) and Null and Lund (2006) look at the water scarce region of California's central valley. They find dams used for storage are not very beneficial and gains from habitat may be larger (Null et al., 2014). Bin et al. (2009) find a significant housing price premium for riparian properties.

2 Dam Removal Process

The differences in timing and process are highly variable by dam, based on the conditions and issues faced by the particular dam. The dam removal process is variable across states but has common elements. The process of dam removal generally includes inspection and planning, permitting, fundraising, and deconstruction of the dam regardless of state. Permits must be approved from the state's environmental management department, often by a state's council in charge of coastal resources, and finally by the U.S. Army Corp of Engineers[1]. To help communities with the dam removal process American Rivers, The Executive Office of Energy and Environmental Affairs (EOEEA), the Riverways Program in the Department of Fish and Game, and others provide several guidebooks. Here we briefly review the common elements of dam removal in New England.

All dams must go through the federal, state, and in some cases municipal permitting process. Timing and costs associated with each permit vary between dams[2]. Dam removals must abide by the Clean Water Act (CWA) and pass a series of consultations and certifications. Dam hazard status is determined through inspections; municipality or state regulations determine the frequency of inspections. High hazard dams have more frequent inspections as they pose a greater risk of failure without remediation. The state agency will often recommend actions to address deficiencies at the dam and forward that to the owner.

Planning and inspection involve assessment of ownership, functionality, and the state of repair the dam is in. Dams are designated by functionality: power generation, flood control, recreation, water supply or irrigation, transportation, or historical benefits. If the dam does not provide any of the services or if the

[1] New Hampshire has streamlined to be housed by one department, the New Hampshire Department of Environmental Services Wetlands Bureau.

[2] The federal permitting process consists of multiple permits, three consultations and two certifications. To abide by the Clean Water Act (CWA), a CWA section 404 permit must be sent to the U.S. Army Corps of Engineers (Corps). In the case that the dam produces hydropower the dam owner would need to apply for surrender of the Federal Energy Regulatory Commission (FERC) license. Historic preservation officers are consulted if the dam is on the National Register of Historic Places.

dam owner would like to remove the dam, the state may designate the proposed dam as a potential candidate for removal. Certain dams are extremely unlikely to be removed, such as if they currently provide flood protection. The most important and possibly prohibitive attribute to removing a dam is ownership. If the dam owner can be identified and is not willing to participate in the removal, the process will not be pursued unless the dam is under a repair or a remove order. Ownership of dams can be the state, the local municipality, a company, or a homeowner in close to equal parts. A review of high hazard dams in Rhode Island suggests that the state, local municipalities, and private land owners make up ownership of high risk dams. If the targeted dams have support by the owner to be removed then permits for removal and impact assessments are needed.

Dams targeted for removal will be assessed for the impact to the habitat for endangered species or impact to infrastructure. If the dam is found to be in or around such habitats, it must be closely monitored by state and federal biologists as a part of the planning. As a part of the planning phase a feasibility study is designed to summarize all environmental and engineering information needed approve or deny the proposal for removal. The cost of feasibility studies vary by dam but are generally between \$50,000 and \$250,000 American Rivers (2015). Finally, the funding needs to be secured before removal is finalized. Funding is often supplemented by state or federal grants as the cost of removal can be significant.

The dam removal process may require public hearings based on the dam being removed, which is highly dam specific. Dams on historic properties are required to have public hearings by National Historic Preservation Act. Further, if the dam is in a wetland there must be a public hearings based on the Wetlands Protection Act. For large impoundments there may be requirements to notify the municipality before a draw down occurs. After all permitting and assessments are made and approved, construction can start on the project. Construction can vary in cost but is often between $50,000 and $500,000 American Rivers (2015). Removal costs are not limited to this cost but often fall within this range. The timing of construction for small dams is usually within a year.

The entire process can take three to five years to complete, and the construction phase of dam removal can be a small fraction of that time. The process also lacks a formal avenue to assess external costs of removal, which means that nearby property owners may not be provided an opportunity to oppose or support a dam removal, excepting for large impoundments. Further, factors that relate to the process of dam removal may impact the capitalization of removal in property prices, though we are unable to identify them in our study which is a limitation of this study. These factors include the time to removal from when the dam was first considered, changes in viewscapes, or historical importance of the dam.

3 Data

There are 1,403 removed dams in the national American Rivers database as of 2017 (American Rivers, 2017). We use removed dams in our analysis that traverse our period of study, 1998 to 2016, have information on the existence of an impoundment, exact coordinates, and year of removal. In addition some dams have hazard designations, with high hazard being a designation that the dam is in danger of failing. We compile 75 dams removed in New Hampshire, Massachusetts, Rhode Island, and Connecticut. The removed dams are illustrated in Figure 1. Appendix A lists the years and frequency of dam removals. In almost all cases we do not have a starting date of removal and exclude housing transactions during the year of the dam removal. Summer in New England is the most realistic time for removals because Spring receives too much rain and snow thaw, Fall is more susceptible to nor'easter and hurricane storms, and Winter is too cold and the ground is frozen. The exclusion of the year of removal may exclude identifying any effect of short term disruption of construction at the dam site.

Many removed dams' attributes are not well documented. We lack precise dates on the process of removal, if soil remediation was required, what type of recreation is available at the dam site, and the construction material of the dam. Any of these variables could play a role in the capitalization of dam removals in property prices. There is only partial information on the height and length of the dam before removal, though we do not exclude dams in the analysis based on missing height or length information. We explore heterogeneity of results to the size of the dam in the appendix.

We use deed and assessment data from Connecticut, Massachusetts, New Hampshire, and Rhode Island to construct our property data[3]. Each state's data is in a different format with slightly different housing attribute variables which limits the availability of common attributes. We retain date sold, sale price, number of bedrooms, building area in square feet, number of full bathrooms, age, and lot size in acres. We also calculate the distance of a property to the closest dam, the distance to the closest stream, the distance to the nearest major road, and if the property is upstream of the removed dam by calculating the watershed upstream of the removed dam.

We initially limit our housing sales to be within five kilometers of dams to look at the localized impact of dam removals. To normalize prices into 2010 dollars we use the Bureau of Labor Statistics CPI. We choose to deflate prices by the CPI as a measure of purchasing power by households. We excluded those homes with a sale price less than $1,000 to eliminate homes not at arms length.

[3]This data was purchased from First American Data Tree and the Warren Group.

Once those sales were omitted we further excluded the top and bottom 5% of sales. We eliminate transactions with a living area greater than 6,000sq feet, and sold prior to ten years before the removal of the closest dam. Transactions that occur further than 10 years from a dam removal are also excluded. We retain 59,315 transactions after these procedures.

In the repeat sales sample we retain properties that sell more than once across the entire study period. A property could be only included in the period prior to dam removal if sold more than once during the pre dam removal years. The mean number of times a property sells in our sample is 2.61. 81.4% of the properties are both in the pre and post period of dam removal. The median number of times a property was sold in this sample is 2.

The benefits of a repeat sales sample with property fixed effects are that it controls for property specific unobservables that are constant over time. This method is especially useful when there is a scarcity of data on the attributes of the properties. The weaknesses of the repeat sales sample are that it reduces the sample of observations for analysis and may include systematic differences from the entire housing market sample.

To check for this systemic difference, we calculate the difference of means of variables across the repeat sales sample and the full sample shown in Table 5. Of the variables we have data for, we observe a statistical difference in lot size of approximately 0.12 acres between the two samples. We do not observe statistical difference in any other house variable means. Though we do not observe difference in our observable variables, our observed house characteristics is small and there could be differences across the samples that we do not observe.

3.1 Repeat Sales Comparison

In this section we compare the repeat sample of properties sold to the full sample of properties sold in Table 2. Differences between the samples may indicate that repeat sales differ significantly from single sales and may indicate that results could be sensitive to sub-sample choices of the researcher. We investigate the statistical differences in the sample by running a regression on the variable of interest (each housing attribute) with a binary control for the "repeat" sample and use year and census tract fixed effects. We find that lot size in the repeat sample is smaller than in the full sample, but that all other variables are not statistically difference between samples.

4 Methods

4.1 Model and Identification

We rely on a repeat sales sample with property level fixed effects and a Difference-in-Differences (DiD) hedonic model to identify average treatment effects of dam removals on housing prices in New England. The hedonic model decomposes property prices to value attributes that are otherwise unobservable as they don't have independent markets (Rosen, 1974).

The difference-in-differences specification is given in equation 1.

$$P_{it} = \beta_0 + \beta_1 * Post_{it} + \beta_2 * Treat_i * Post_{it} + X'_{it}\delta + \alpha + \epsilon_{it} \tag{1}$$

The subscript i indicates property and t indicates time. A home within the treatment buffer is assigned a binary indicator of treatment, $Treat_{tk} = 1$. Similarly, there will be a binary variable dedicated to identify if a home was sold after a dam removal, indicated by $Post_{itk}$. β_2 is the average treatment effect of removal of a dam on a treated property. $X_i t$ is a vector of temporal controls. α are fixed effects by property. The property level fixed effects control for time invariant aspects of the property (ex. distances to city, bedrooms, basement).

DiD relies on the common trends assumption for identification and compares pre-removal to post-removal prices to identify the effect of treatment. The common trends assumption requires that treated and control home prices would follow the same trajectory in the pre-treatment period for valid inference.

We have multiple hypotheses from this identification. First, we expect that the average treatment effect of removal of a dam on treated properties could be either positive or negative and represent the aggregate impact of dam removals on nearby properties. The negative effects may be driven by the loss of the sense of place from the dam, the changing of recreation, or the loss of an impoundment. Yet, positive effects may be accrued by different increased recreational opportunities (like canoing or kayaking) or reduced risk of failure in some dams. Some of these effects we can identify and others we are not able to. We know which dams have impoundments so can specifically identify the effect of the loss of impound compared to dams without an impoundment. To the extent that the sense of place and recreation does not differ between dams with and without an impoundment, we hypothesize the loss of an impoundment would generate a negative effect on treated properties. We also know the risk designation of dams (hazard designation), and can identify if high hazard dams generate a positive price change on houses due to the removal of risk. We hypothesize that the removal of high risk dams would generate a positive effect on treated properties due to the lower risk of dam failure to nearby properties.

4.2 Defining Treatment

To find the definition of treatment in our data we use a non-parametric model of distance (”bins”) and the repeat sales sample to identify if and when effects dissipate with distance to a removed dam. Figure 2 shows the results a regression with distance bins at every 200 meters interacted with the binary variable ’Post’ to illustrate the effect of treatment across distance from the dam. The regression used to produce this figure includes property fixed effects, year by state fixed effects, and controls for age of the property at the time of sale.

We find some evidence that treatment should be defined at 200 meters distance with a significant attenuation further than 200 meters. We define properties as treated that are closer than 200 meters in the remaining analysis.

We have selected a control group of properties between 200 meters and 500 meters, which reduces our preferred sample in our analysis to 1,430 property sales. There are 645 individual properties in the repeat sales sample and 128 properties are within 200 meters of a removed dam. This sample selection was decided based on two measures, how well the common trends assumption held and the balance of observable attributes between treatment and control properties. The summary statistics of the repeat sales sample by treatment status is provided in Table 1 to assess the appropriateness of our control group as a counterfactual. Table 1 Column 1 reports the sample of properties within 500 meters of the dam site. Column 2 reports the control properties during the pretreatment period. Column 3 reports the treated properties during the pretreatment period. Column 4 reports the mean differences between control and treatment through a regression of each characteristic on treatment definition with controls for year fixed effects and census tract fixed effects. We find some differences in bedrooms and lot size between control and treatment. The differences suggest that houses closer to dams are slightly smaller and have a lower base level of price. As would be expected, when we expand the distance from the dam for the control group we introduce bigger differences in the observable attributes. Next, we look at the pre-treatment trends in Figure 3, which presents the residuals of the regression that only includes property by dam fixed effects and controls for housing characteristics. On visual inspection the trends of the error term in a model seem to be parallel across time in the pre-treatment time period and assumptions of parallel trends seems to hold.

5 DiD Results

Table 3 reports the primary coefficient of interest and interactions with treatment and pond, high hazard dams, and upstream designation. Column 1 reports a model with year fixed effects. Column 2 adds an additional temporal control, year trend for each dam. Column 3 uses a state by year fixed effect control. Column 4 expands the sample to include properties sold once in addition to the repeat sales sample and includes controls for housing attributes. Column 5 uses a dam by year fixed effect. Column 6 includes an interaction with a binary if the removed dam was designated as high hazard, had an impoundment, or if the property was upstream of a dam, using a triple DiD framework. There is a consistent negative average treatment effect of removal of a dam between 4 to 9%. None of the estimates are statistically significant, therefore we cannot reject the null hypothesis that there is no effect of dam removal on nearby properties. We find this to be an imprecise null finding and recognize the statistical insignificance is statistically weak with a p-value of 0.187, and is lower than is typically accepted as statistically significant.

The interaction of treatment with a binary indicator for pond post removal shows an insignificant effect larger than the average treatment effect. The direction of the coefficient is expected as the loss of an impoundment is thought to be a loss of an amenity to home owners. A difficulty in identification of the loss of impoundments is that many of the impoundments are also high hazard dams, making the separation of the effect of high hazard status and impoundments difficult. Seven removed dams have impoundments and six have high hazard designations. Three of the dams are both high hazard and and have impoundments. Properties around these three dams make up approximately 80% of the properties around all impoundments. We find a negative though statistically insignificant effect of the dam removal on upstream properties, compared to downstream properties. Hazard status has a potentially mitigating effect on the negative effect of dam removal, though the estimated coefficient is statistically insignificant. As expected the coefficient is positive which suggests there may be a benefit of removing high hazard dams through improved safety, though it is statistically insignificant.

We also assess the effects of size of the dam in Appendix B. We find little statistical evidence that the size of the dam changes the average treatment effect significantly. One concern about identification of heterogeneity based on the size of the dam is that our sample of dams is smaller leading to less statistical power. While we attempt to control for the size of the dams, we lack information that may be relevant to recreation and other complexities of how dams relate to the value we recover. So, we are hesitant to claim the exact mechanisms for the change in value due to dam removal.

Our findings differ from other studies in the direction of effects. Other hedonic studies find weak positive effects of removal with distance to a dam removal (Bohlen and Lewis, 2009b; Lewis et al., 2008; Provencher et al., 2008b), where we find a null result with a negative sign of effects of dam removal. One concern in our result, and in the other studies, is that there is a small number of individual homes that are very close to the removed dam. Small sample sizes reduce the power in any study and investigation of proximity effects closer than 200 meters may have large effects, but those effects cannot be differentiated from other idiosyncratic shocks to housing price changes without more observations. We emphasize again that we cannot reject the null of there being no effect.

5.1 Discussion

When considering dam removal the cost benefit analysis should incorporate external effects to nearby properties. The net value of a dam removal often assumes that local communities are either not affected or only the direct property owner needs to be indemnified. We cannot statistically reject that there is no effect on properties of a dam removal. A surprising finding is that the removal of impoundments did not generate a more statistically significant negative effect on communities. Perhaps the impoundments were so small it didn't really have an impact on surrounding homes.

This study is the most expansive hedonic valuation of dam removals to date, though it has some weaknesses. The extremely proximate effects reduce the power of statistical inference, even with 75 removed dams. The lack of information about each dam removal obfuscates the exact mechanisms for any potential changes in valuation due to dam removals. Better data on dam characteristics are needed to address these weaknesses in a hedonic study. It is worth noting that in most cases dams do not have a house within 100 meters sold over our study period in our data. In this case with a small dam there is not much evidence that externalities exist for nearby homeowners in a hedonic study. The lack of response to housing prices could indicate that changes in environmental factors in the waterway are not capitalized in housing prices. More research is required in the hedonic and dam removal literature to identify dam removal impacts to communities. Other methods, such as choice experiments, may bring to light the specific concerns to property owners when a dam removal is proposed and may be needed to supplement hedonic work in this area.

These findings are important for policy because of the potential externalities imposed on property owners near removed dams but lack ownership over the dam. It suggests that dam removal does not produce large externalities on nearby homes in aggregate. Even a null effect is important for policy as it alleviates the concern that homeowners not immediately next to a dam will be affected and should be compensated. It is also unclear if a bargaining solution is likely to succeed in a dam removal case, putting a burden on dam removal management to incorporate external costs of removal. Another important aspect about hedonic studies which is policy relevant is that larger scale ecological benefits are also not captured in the studies. This would include any improvements in the regional health of the ecosystem that wouldn't be capitalized into housing prices.

We cannot say that there is no effect for homes closer than 100 meters, as there are so few homes in this proximity to dams, and that in our data we cannot reject the null that there is no aggregate effect. In planning dam removals a broadened community involvement of the closest homes should be conducted to gauge concerns that might lead to property value loss. This study could be referenced in those conversations to help alleviate concerns expressed by property owners. However, we do not think our results are transferable to large high profile dams that offer additional amenities. Each dam removal should be inspected independently. Our study should be used as a reference and not as a rule when evaluating impacts of discrete dam removals. In the case of high hazard dams where there is significant public risk unless some sort of remediation is accomplished, removal or updating the dam, we don't find evidence that loss of property prices is significant enough to weigh against the concern of public safety.

6 Conclusion

Many dams in New England are aging and need to either be removed or repaired. Our study helps to inform homeowners and policy makers how removals impact the local communities. We find a null result and cannot statistically reject that dam removal does not have an impact on housing prices. As dam removal has become more prevalent across the United States, this suggests that in most cases home price loss can assumed to be minimal for all but extremely proximate properties to the removed dam.

We are limited in our ability to discuss all potential effects that dams have based on this hedonic analysis. The benefit in this study is to systematically look across many dams to understand average aggregate treatment effects over New England dams where previous studies have focused on a smaller set of dams or case studies. A further benefit is to alleviate concerns that homeowners face large negative externalities from dam removals in close proximity of their homes. As more rivers are shifting into free flowing rivers and dams are removed the value of fish passage and recreational fishing may be enhanced without significant effects on home owners. Larger or more urban dams may also have differing proximity effects than the ones found here; as this study relies on smaller dams in rural dam locations.

References

American Rivers (2015). Removing small dams: A basic guide for project managers. https://www.americanrivers.org/wp-content/uploads/2015/06/NatlDamProjectManagerGuide$_0$6112015*.pdf*.[*Accessed on* 5 − 5 − 2020].

American Rivers (2017). American rivers dam removal database. figshare. https://doi.org/10.6084/m9.figshare.5234068.v2. [Accessed on 2-1-2018].

Bergstrom, J. C. and J. B. Loomis (2017). Economic valuation of river restoration: An analysis of the valuation literature and its uses in decision-making. *Water Resources and Economics 17*, 9–19.

Bin, O., C. E. Landry, and G. F. Meyer (2009). Riparian buffers and hedonic prices: a quasi-experimental analysis of residential property values in the neuse river basin. *American Journal of Agricultural Economics 91*(4), 1067–1079.

Bin, O. and S. Polasky (2004). Effects of flood hazards on property values: evidence before and after hurricane floyd. *Land Economics 80*(4), 490–500.

Bohlen, C. and L. Y. Lewis (2009a). Examining the economic impacts of hydropower dams on property values using gis. *Journal of Environmental Management 90*, S258–S269.

Bohlen, C. and L. Y. Lewis (2009b, jul). Examining the economic impacts of hydropower dams on property values using GIS. *Journal of Environmental Management 90*(SUPPL. 3), S258–S269.

Born, S. M., G. K. D. F. T. L. H.-M. N. K. M. L. and K. A. White (1998). Socioeconomic and institutional dimensions of dam removals: The wisconsin experience. *Environmental management 22*(3), 359–370.

Duflo, E. and R. Pande (2007). Dams. *The Quarterly Journal of Economics 122*(2), 601–646.

Getzner, M. (2015, feb). Importance of Free-Flowing Rivers for Recreation: Case Study of the River Mur in Styria, Austria. *Journal of Water Resources Planning and Management 141*(2), 04014050.

Gibson, M. and J. T. Mullins (2020). Climate risk and beliefs in new york floodplains. *Journal of the Association of Environmental and Resource Economists 7*(6), 1069–1111.

Jarrad, M., N. R. Netusil, K. Moeltner, A. T. Morzillo, and J. A. Yeakley (2018, jun). Urban stream restoration projects: Do project phase, distance, and type affect nearby property sale prices? *Land Economics 94*(3), 368–385.

Jeuland, M. (2020). The economics of dams. *Oxford Review of Economic Policy 36*(1), 45–68.

Kotchen, M. J., M. R. Moore, F. Lupi, and E. S. Rutherford (2006). Environmental constraints on hydropower: an ex post benefit-cost analysis of dam relicensing in michigan. *Land Economics 82*(3), 384–403.

Lewis, L. Y., C. Bohlen, and S. Wilson (2008). Dams, dam removal, and river restoration: A hedonic property value analysis. *Contemporary Economic Policy 26*(2), 175–186.

Loomis, J. B. (1996). Measuring the economic benefits of removing dams and restoring the elwha river: results of a contingent valuation survey. *Water Resources Research 32*(2), 441–447.

Magilligan, FJ, S. C. F. C. (2017). The social, historical, and institutional contingencies of dam remova. *Environmental management 59*(6), 982–994.

Null, S. E. and J. R. Lund (2006). Reassembling hetch hetchy: Water supply without o'shaughnessy dam 1. *JAWRA Journal of the American Water Resources Association 42*(2), 395–408.

Null, S. E., J. Medellín-Azuara, A. Escriva-Bou, M. Lent, and J. R. Lund (2014). Optimizing the dammed: Water supply losses and fish habitat gains from dam removal in california. *Journal of Environmental Management 136*, 121–131.

Pope, J. C. (2008). Do seller disclosures affect property values? buyer information and the hedonic model. *Land Economics 84*(4), 551–572.

Provencher, B., H. Sarakinos, and T. Meyer (2008a). Does small dam removal affect local property values? an empirical analysis. *Contemporary Economic Policy 26*(2), 187–197.

Provencher, B., H. Sarakinos, and T. Meyer (2008b). Does small dam removal affect local property values? an empirical analysis. *Contemporary Economic Policy 26*(2), 187–197.

Robbins, J. L. and L. Y. Lewis (2008, dec). Demolish it and They Will Come: Estimating the Economic Impacts of Restoring a Recreational Fishery ¡sup¿1¡/sup¿. *JAWRA Journal of the American Water Resources Association 44*(6), 1488–1499.

Rosen, S. (1974). Hedonic prices and implicit markets: product differentiation in pure competition. *Journal of political economy 82*(1), 34–55.

7 Tables

		Pre-treatment		
	Full sample means	200m-500m	0-200m	Differences in means
	(std. dev.)	(std. dev.)		(std. errors)
Log sales price (CPI adj)	12.080	12.159	11.961	-0.124*
	(0.508)	(0.503)	(0.495)	(0.059)
Distance to road (feet)	7,679.378	7,252.389	10,284.740	597.700
	(11,518.200)	(10,678.190)	(15,286.460)	(575.400)
Distance to city (feet)	14,183.76	13,375.010	19,184.870	1,056.00
	(11,039.000)	(10,444.070)	(11,463.420)	(630.600)
Distance to river (feet)	730.397	683.607	1,006.347	-13.650
	(1,422.437)	(1,399.349)	(1,707.867)	(112.300)
# of bedrooms	2.801	2.883	2.408	-0.333**
	(0.908)	(0.856)	(1.117)	(0.121)
# of bathrooms	1.395	1.392	1.223	-0.138
	(0.577)	(0.578)	(0.532)	(0.087)
Lotsize (acres)	0.390	0.399	0.205	-0.158*
	(0.614)	(0.556)	(0.416)	(0.073)
Age	65.989	65.651	60.783	-0.896
	(42.977)	(39.815)	(44.864)	(8.293)
N	1,430	691	184	

Table 1: Housing variables by treatment. Log sales prices are adjusted to 2013 levels using CPI. The differences in means in column 5 are generated by regressing each housing attribute on treatment and year and census fixed effects using pretreatment data. Standard errors are clustered at the census tract level. *, **, and *** indicate significance at 5%, 1%, and 0.1%, respectively.

	Full sample means (std. dev.)	Repeat Sample means (std. dev.)	Differences in means (std. errors)
Log sales price (CPI adj)	12.159	12.095	-0.041
	(0.013)	(0.023)	(0.032)
Distance to road (feet)	8,173.213	8,286.285	-313.600
	(287.393)	(528.034)	(254.800)
Distance to city (feet)	13,220.940	13,304.890	-84.060
	(265.790)	(474.235)	(269.700)
Distance to river (feet)	730.405	802.123	-1.553
	(36.002)	(69.322)	(43.470)
# of bedrooms	2.941	2.859	-0.084
	(0.024)	(0.041)	(0.057)
# of bathrooms	1.461	1.400	-0.046
	(0.015)	(0.025)	(0.036)
Lotsize (acres)	0.524	0.415	-0.121**
	(0.021)	(0.030)	(0.044)
Age (years)	65.353	66.304	2.579
	(1.075)	(1.900)	(2.683)
N	2,879	1,430	

Table 2: Housing Variables by Sample Selection. Log sales prices are adjusted to 2013 levels using CPI. Standard errors are clustered at the census tract level. *, **, and *** indicate significance at 5%, 1%, and 0.1%, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
PostxTreated	-0.082	-0.080	-0.098	-0.091	-0.069	-0.048
	(0.075)	(0.089)	(0.073)	(0.148)	(0.060)	(0.239)
TreatedxPostxUpstream						-0.024
						(0.219)
TreatedxPostxHazard						0.154
						(0.190)
TreatedxPostxPond						-0.134
						(0.231)
Housing Attributes	N	N	N	N	Y	N
Year FE	Y	Y	Y	Y	Y	Y
Dam FE x Year FE	N	N	N	Y	Y	Y
Dam FE x Year Trend	N	Y	N	N	N	N
State FE x Year FE	N	N	Y	N	N	N
Census FE	N	N	N	N	Y	N
R^2	0.855	0.863	0.869	0.922	0.740	0.929
N	1,430	1,430	1,430	2,879	1,430	1,430

Table 3: Repeat Sales Results. *, **, and *** indicate significance at 5%, 1%, and 0.1%, respectively. Clustered standard errors by dam are in parentheses. All columns exclude the year of removal.

	(1)	(2)	(3)	(4)
PostxTreated	-0.098	-0.083	-0.075	-0.090
	(0.073)	(0.067)	(0.080)	(0.094)
State FE x Year FE	Y	Y	Y	Y
R^2	0.869	0.883	0.887	0.918
N	1,430	1,178	1,338	1,099

Table 4: Robustness Results. *, **, and *** indicate significance at 5%, 1%, and 0.1%, respectively. Robust standard errors are in parentheses. All columns exclude the year of removal and the year prior to removal. Columns 1 is our baseline result. Column 2 restricts repeat sales to less than four per property. Column 3 restricts repeat sales in the same year. Column 4 restricts repeat sales to be at least three years apart.

8 Figures

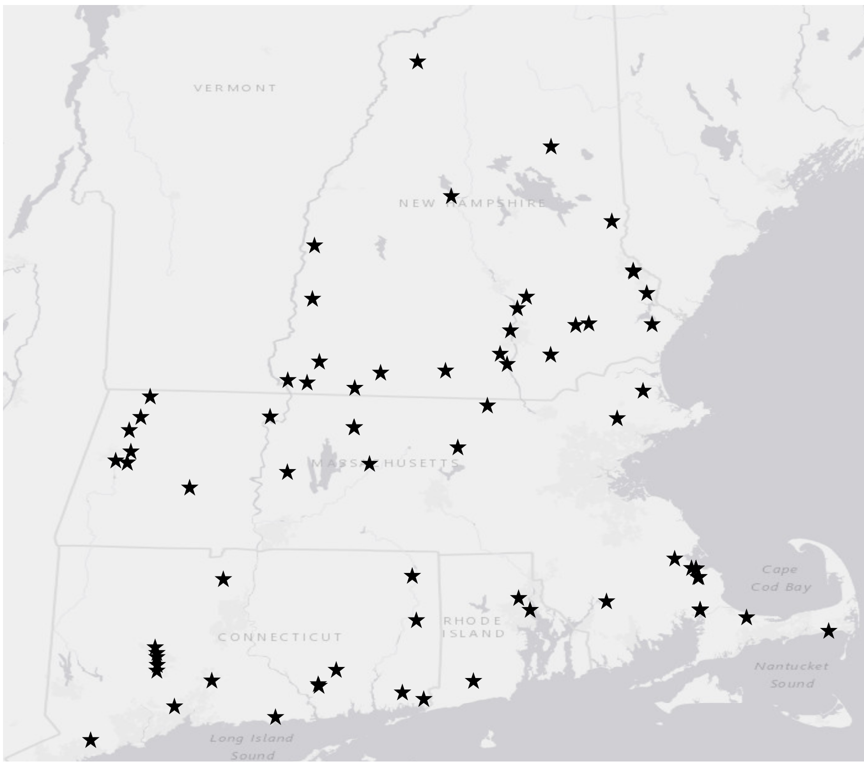

Figure 1: New England dams used in the analysis. Stars indicate the location of removed dams.

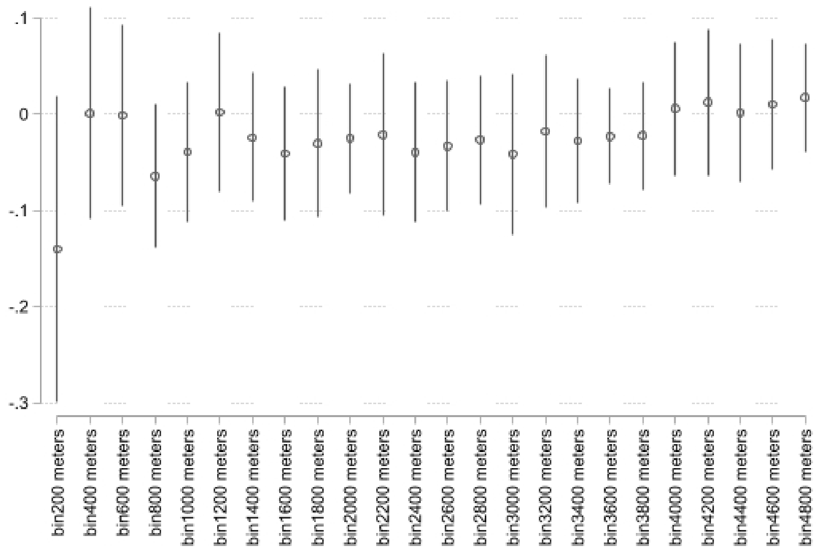

Figure 2: Non-parametric Distance to Removed Dam. This specification includes the repeat sales model with year FE and year trend by dam FE. 95% confidence intervals reported.

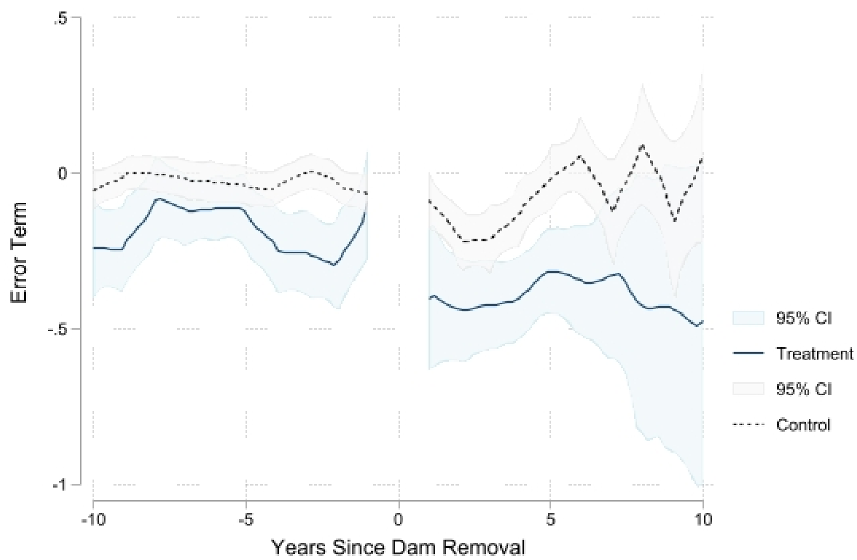

Figure 3: The error term for homes within 200m and homes within 200m and 500m of a removed dam over time. The error term is calculated from a model with only Year by Dam fixed effects.

A Dam Removal Years

Year Removed	# of Dams
1994	1
1995	1
1999	4
2000	1
2001	1
2002	2
2003	2
2004	2
2005	3
2006	3
2007	1
2008	4
2009	8
2010	10
2011	6
2012	13
2013	1
2014	7
2015	5

Table 5: Years the Dams Were Removed.

B Heterogeneity of Result

To assess any heterogeneity of our main result by the characteristics of the dams. Table 6 reports the baseline result of average treatment effect in Column 1. Column 2 interacts treatment with dam length. Column 3 interacts treatment with dam height, Column 4 interacts treatment with both height and length, and Column 5 uses the full sample of housing and not just the repeat sales sample. The results suggest there are not statistically significant effects of heterogeneity on the average treatment effects. The results become more imprecise as we lose power as we must drop dams without information on dam length and dam height. The direction of the coefficients suggest that larger dams have larger effects on property prices, which is consistent with our intuition, but the coefficients are statistically insignificant.

	(1)	(2)	(3)	(4)	(5)
PostxTreated	-0.098	0.077	0.083	0.022	-0.125
	(0.073)	(0.299)	(0.257)	(0.235)	(0.087)
DamHPostTreat		-0.020			
		(0.020)			
DamLPostTreat			-0.001		
			(0.001)		
DamSizePostTreat				-0.000	0.000
				(0.000)	(0.000)
Property FE	Y	Y	Y	Y	N
State FE x Year FE	Y	Y	Y	Y	Y
Cenus FE	N	N	N	N	Y
Housing Controls	N	N	N	N	Y
R^2	0.869	0.890	0.901	0.901	0.659
N	1,430	816	741	735	1578

Table 6: Heterogeneity Results. *, **, and *** indicate significance at 5%, 1%, and 0.1%, respectively. Robust standard errors are in parentheses. All columns exclude the year of removal. Columns 1 is our baseline result. Column 2 includes an interaction with dam height and treatment. Column 3 includes an interaction with dam length and treatment. Column 4 includes an interaction with dam height, dam length, and treatment. Column 5 uses the full sample with controls for housing attributes.