Does land conservation raise property taxes? Evidence from New England cities and towns

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Abstract

Protected lands provide high ecological and social value, yet a perception that land protection erodes local property tax bases and shifts tax burdens to other owners creates barriers for new protection. We investigate the impact of land protection on local property tax rates using panel data from more than 1400 towns and cities in New England between 1990 and 2015, including both ownership and easement-based protection. We find that on average, new protection results in a small increase in annual tax rates, with an expected change of $0.0231 per $1000 of value for a 1 percentage point increase in the percent of municipal area protected. This corresponds to an increase in a homeowner's annual property tax bill of $1.16 per $100,000 of value for 100 acres of new land protection. We do not find that taxes continue to increase over time or reduce municipal expenditures. However, for towns that are growing slowly, have lower household incomes, or use municipal land protection, we estimate greater tax bill increases of up to $10 for each $100,000 of value. These results provide evidence that land protection does not have a substantial impact on property taxes, but also highlight the importance of maintaining and expanding public compensation mechanisms, such as payments in lieu of taxes, where expected burdens from new protection may be greater.

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1. Introduction

Protected land provides multiple ecological and social benefits including carbon sequestration, habitat for a diverse set of plant and animal species, watershed functioning, preservation of prime agricultural soils, and space for recreation and cultural preservation (Dinerstein et al. 2019; Watson et al. 2014; Brauman et al. 2007). In the U.S., land protection has expanded rapidly in recent decades, motivated by the continued loss of open space to development (Nelson et al. 2007; Kotchen and Powers 2006). This increase has been facilitated by state and federal funding (The Trust for Public Lands 2021; Stubbs 2020), shifts in land ownership (Meyer et al. 2014), tax incentives (Parker and Thurman 2018), and funding for open space protection through local referenda (Lang 2018). Substantial federal funding is currently available for new land protection through the reauthorized Land and Water Conservation Fund (National Park Service 2020) and the Farm Bill (Stubbs 2020) as well as the recently passed Inflation Reduction Act (Congressional Research Service 2022) and infrastructure bills (Rigley 2021).

The surge in funding has renewed debate about the fiscal implications of land protection. Land that is protected through conservation restrictions or under ownership by public and non-profit organizations is frequently tax-exempt or taxed at lower rates than developed or unprotected land. Critics of new land protection worry that it will erode local property tax bases and result in higher property tax rates for other landowners (Brandon 2021; Ricketts 2021; Rule 2019; Neuman 2018; LePage 2018; McWhirter 2014). These concerns have fueled opposition to both local land protection efforts (LePage 2018) and national conservation initiatives including President Biden’s 30-by-30 conservation target (Brandon 2021). Proponents of land protection counter by arguing that open space pays for itself because it requires less in municipal expenditures than it contributes to revenues, or because it creates recreation-based economic opportunities and amenity values that increase the property tax base (e.g., Davis et al. 2018; The Trust for Public Land 2007).

Despite the crucial role that local property taxes play in funding public goods, few studies have quantified the possible causal impacts of land protection on property tax rates to inform this debate (Vandegrift and Lahr 2011; King and Anderson 2004). Indeed, estimating these relationships is difficult due to the potentially endogenous nature of land protection. For example, communities that engage in more land protection may tend to have greater wealth, past histories of land protection, or more to gain from recreation-based economies. Alternatively, communities with more land protection may be more rural and have fewer development opportunities.

To overcome these potential selection bias concerns, we exploit plausibly exogenous changes in land protection over time within municipalities. Specifically, we estimate the effects of new land protection on changes in local property tax rates using municipal-level panel data from 1990 to 2015 across five New England states. Our data combines information on property tax rates, property tax levies, and taxable property value for more than 1400 municipalities in the region (also referred to as New England’s “towns and cities”). We match these with detailed spatial data on new land protection over time assembled by the Harvard Forest and the Highstead Foundation, which follow the Protected Areas Database of the United States (PAD-US) in defining protected lands as areas “dedicated to the preservation of biological diversity and to other natural, recreational and cultural uses, managed for these purposes through legal or other effective means” (U.S. Geological Survey 2022).

Our regression model estimates changes in property tax rates as a function of lagged changes in land protection, with controls for state-by-time-period fixed effects, core-based statistical area trends, and lagged changes in the labor force, unemployment, and property tax base growth. This approach differences out unobserved time-invariant characteristics of municipalities and reduces serial correlation. The key identifying assumption inherent to this empirical strategy is that the timing of new protection within municipalities, conditional on these controls, is exogenous to potential outcomes. This is plausible because protection in the region is the result of decentralized and uncoordinated actions by more than 350 separate land trusts, hundreds of local governments, and multiple state and federal agencies. Land trusts overlap in their spatial jurisdictions and missions (Wildlands and Woodlands 2021; Foster et al. 2017; Labich 2015), and many local protections have been driven by the efforts of just a few committed individuals. In addition, opportunities for protection often occur when there is a generational shift within families due to retirements, health shocks, or deaths (Markowski-Lindsay et al. 2017; Bigelow et al. 2016). The nature of these protection processes within New England creates considerable randomness in the extent and timing of new land protection.

We estimate average effects and test for differential impacts across land protection types and by several key characteristics of the communities where land protection is occurring. We also examine fiscal outcomes (municipal revenues, expenditures) for the states with available data in order to study broader fiscal responses to land protection and we estimate a model with lagged protection to investigate longer-term impacts on tax rates.

We find that on average, new land protection has had small impacts on property tax rates. We estimate an expected increase in annual property tax rates of $0.0231 per $1000 of value that is attributable to a one percentage point increase in new municipal area protected annually. For an annual increase in new land protection of 100 acres, this property tax rate change translates to an annual property tax bill increase of just $1.16 per $100,000 of value, or $3.00 for an owner of a typical New England home.[1] We do not find evidence that municipalities collect less revenue or reduce expenditures on public goods as a result of land protection, or that there are additional longer-term impacts on the tax rate.

While average impacts are small, we do observe important heterogeneity in property tax bill impacts by land protection type and local characteristics, with annual increases of up to $10 per $100,000 of home valuation. The types of towns that are associated with greater estimated impacts are those that are growing slowly, have lower median incomes, have less land enrolled in current use programs that allow reduced taxes for agriculture and forestry, or have fewer second homes. We also find suggestive evidence for larger tax increases associated with land protection conducted by municipalities, particularly in towns and cities with smaller property tax bases or slower growth.

Overall, our findings indicate that the property tax rate changes due to land protection are generally not substantial, particularly in comparison to the magnitude of changes that residents may experience for capital projects such as new buildings or increases in municipal staff. Yet the heterogeneity in impacts highlights the reality that some communities may be at higher risk for greater tax burdens. These differences emphasize a need for public compensation mechanisms, such as state and federal payments in lieu of taxes, that can assist communities engaging in land protection, and provide a rationale for targeting these programs to the types of communities that may be most impacted by new land protection.

2. Conceptual Framework and Contributions to the Literature

2.1 Conceptual Framework

Economic theory suggests that the impacts of land protection on local property tax rates could be either positive or negative in net (Wu et al. 2016; Wu 2014; King and Anderson 2004;

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[1] Valued at $259,045 in 2015 dollars, according to Zillow Home Value Index for 1996-2015 that reflects the mean value of single-family homes in the 35th to 65th percentile range of home values (Zillow Research 2019).

Geoghegan et al. 2003). This can be illustrated in a simple way by considering the relationship between the property tax rate, municipal property tax base, expenditures and revenues (assuming a balanced budget and a single tax rate):

$$Property\ Tax\ Rate = \frac{Total\ Expenditures - Other\ Revenue}{Property\ Tax\ Base} = \frac{Property\ Tax\ Levy}{Property\ Tax\ Base} \quad \text{(Eq 1)}$$

The property tax rate is determined by the funds needed to cover expected expenditures, less other available sources of revenue, divided by the value of the taxable property in a municipality. This amount of property tax revenue is raised via the property tax levy (revenue raised from the property tax).

A common concern is that newly protected land will have lower taxable value or will be removed from the tax rolls altogether if the owner is tax exempt, which would reduce the total municipal property tax base. If expected expenditures and other revenues are constant, such a reduction in the property tax base would require an increase in the property tax rate to raise the same total property tax revenues.

On the other hand, land protection can create amenity value which may boost nearby property values or the desirability of a municipality as a place to live and property values in the municipality as a whole (Lang 2018; Vandegrift and Lahr 2011; Anderson and West 2006; Irwin 2002). Amenity-driven property value growth can increase the local property tax base and reduce the need to raise property tax rates or even lead to lower tax rates. Land protection may also attract new amenity-based development in nearby areas if developable land is available, potentially growing the tax base (Davis and Hansen 2011; Wade and Theobald 2010; Radeloff et al. 2010). In addition, land protection may create opportunities for recreation-based economic activity (e.g., Walls, Lee and Ashenfarb 2020; Sims et al. 2019; Chen, Lewis and Weber 2016; Rasker, Gude and Delorey 2013), increasing other revenue sources for a municipality. Finally, the cost of services may be lower for undeveloped than developed land. Preventing land from being developed may reduce current or future revenues but may also keep expected expenditures low by limiting service needs, reducing pressures on property tax rate growth over time (Murray and Catanzaro 2019; Kotchen and Schulte 2009).

Our study seeks to understand the overall impact of land protection on property tax rates, which is an empirical question that depends on the magnitudes of these individual channels through which protection can affect property tax rates.

2.2 Contributions to the Literature

Prior research corroborates each of these possible channels, although only a limited set of previous studies directly explores the impacts of land protection on property tax rates. Much of the related prior literature in economics establishes the importance of amenity values. Research on how the value of open space is capitalized into property values includes studies at the parcel (e.g., Chamblee et al. 2011; Anderson and West 2006; Geoghegan et al. 2003; Irwin 2002; Thorsnes 2002), zip code (Lang 2018), and municipal (Vandegrift and Lahr 2011) levels.

Hedonic studies of open space impacts on property values consistently find positive localized impacts. Studies of residential property values report impacts ranging from 0.05% to 1.87% (Anderson and West 2006; Geoghegan et al. 2003; Irwin 2002), while studies of vacant land sales show that land values can increase by as much as 19-46% due to adjacency to protected land (Thorsnes 2002, Chamblee et al 2011). At the zip code and municipal levels, Lang

(2018) and Vandegrift and Lahr (2011) also observe positive impacts of open space expenditures on home values.

Previous literature also finds important heterogeneity in amenity values. Studies have demonstrated a positive relationship between willingness to pay for open space and income (Earnhart 2006; Breffle et al. 1998), and have found increasing demand for open space as a function of income in the context of open space referenda (Nelson et al. 2007; Kline 2006; Kotchen and Powers 2006), environmental ballot measures (Kahn and Matsusaka 1997), and municipal open space acquisitions (Bates and Santerre 2001). There is also evidence that the amenity value of nearby open space increases with neighborhood income (Anderson and West 2006). Accordingly, land protection may disproportionally boost property values in high income municipalities. Additionally, higher income municipalities may have more resources to obtain grants or private donations that mitigate the loss of taxable property value. For example, Sims et al. (2022) find that median household income is strongly correlated with the amount of land protected in New England towns and cities since 1990.

The potential for fiscal impacts of land protection has also been considered within the context of preferential taxation of working lands. All U.S. states provide some form of tax relief to land used for forestry and agriculture, usually with the goals of promoting rural livelihoods and providing incentives to reduce the conversion of working lands to developed uses (Anderson 2012). The most common mechanism for tax relief is through current use provisions (also referred to as use-value assessment). Under current-use programs, eligible property is assessed for its income-producing capacity in agriculture and forestry, instead of its potential housing or commercial market value, which usually results in substantially lower tax obligations (Anderson and England 2015). Some early studies calculate the potential shift in property tax burden from agricultural to non-agricultural property under the assumption that lost property tax revenue is fully compensated for by increased tax rates on non-agricultural land, finding expected increases of 1-20% for non-agricultural land (Chicoine et al. 1985; Dunford et al. 1981; Ching and Frick 1970). Several county-level studies also estimate the foregone property tax revenue from current-use taxation by comparing property taxes paid under current-use and fair-market value, finding that current-use taxation may reduce property tax revenue by 35-75% (Coogan et al. 2014; Anderson and Griffing 2000). However, a recent national study by Bigelow and Kuethe (2022) using observational data on municipal finances found that while adoption of current-use taxation led to an 11% reduction in property tax revenue at the county level, the revenue loss was offset by increased transfers from state governments, leading to no overall impact on local revenues.

Cost of community services studies have also played an important role in public debates about land protection and tax rates (Clapp et al. 2018; Kotchen and Schulte 2009). These studies seek to compare the revenues gained from land in different uses to the costs of serving those land use types. These studies are accounting based and apportion municipal revenues and expenditures to specific land classes (e.g., residential development vs. commercial vs. open space) with the goal of comparing the ratio of expenditures to revenues for different land uses (Kotchen and Schulte 2009). The findings from this literature show that open space/farmland and commercial/industrial land uses often have expenditures to revenues ratios of less than one, meaning they “pay for themselves.” This is consistent with situations where most municipal expenditures are driven by needs such as schools, sanitation services and emergency services. Open space lands tend to “consume” few of these resources. However, the conclusions that can be drawn from this literature are limited because the findings often depend on the underlying assumptions of how to apportion budgetary costs to different land classes.

Our work is most closely related to the small number of empirical studies that examine the impact of permanent land protection on property tax rates or the property tax base. We are aware of only two: King and Anderson (2004) investigated the effect of new land protection with conservation easements in 29 Vermont towns, during a 10-year time period. They find that property tax rates increase for up to four years after land is protected but that the impact of easement protection becomes insignificant or negative in the longer term. Vandergrift and Lahr (2011) examined the impact of contemporary and historical open space expenditures on property tax base growth in 566 New Jersey municipalities across a five-year period. They find a small negative impact of contemporary land protection on tax base growth and no long-term impacts associated with historical expenditures on open space.

Our paper advances this literature by estimating the effects of land protection on tax rates using plausibly exogenous changes in land protection across a wide set of municipality types. By using panel data on more than 1400 towns and cities over a 20-plus year time span, we are able to isolate impacts using variation within municipalities over time and control for potentially confounding trends at the regional level and within time periods.

Studying New England also allows us to assess the impacts of both public and private land protection types. Private land protection, mainly through conservation easements, is playing an increasingly important role in preserving ecosystems and biodiversity across the country (Cortés Capano et al. 2019; Parker and Thurman 2019; Land Trust Alliance 2015), yet is understudied relative to public land protection. In addition, we are able to assess heterogeneity in property tax impacts of land protection across towns and cities with an array of local economic characteristics. An understanding of impact heterogeneity is particularly important given growing concerns about equity in the benefits and costs of environmental policies (e.g., Currie, Voorheis and Walker 2021; Shapiro and Walker 2021; Carley and Konisky 2020; Colmer et al. 2020; Banzhaf, Ma and Timmins 2019). Significant disparities in access to protected land have been documented by factors including income and race (e.g. Sims et al. 2022; The Trust for Public Land 2020; Jennings, Johnson Gaither and Gragg 2012). While greater equity in access to the benefits of open space may be achieved partly through additional protection in disadvantaged communities, it is also important to understand the potential fiscal risks of new land protection across different community types.

3. Study Area and Data

To examine the impact of land protection on property tax rates, we assemble an annual panel at the municipal level. We combine data on municipal fiscal outcomes, land protection, land with current use tax breaks, and socio-economic characteristics from 1990-2015 for 1436 municipalities (also "towns and cities") in the New England region (Figure 1, Table 1).[2] We give a brief overview below, with further details of the region and data collection described in Appendix B.

3.1 Regional Structure and Property Tax Process

We examine municipal data from the five states of Massachusetts, Connecticut, New Hampshire, Vermont, and Maine (which comprise five of the six New England states and the

[2] Specifically, we use data on land protection from 1991-2012, tax rates and other fiscal outcomes from 1991-2015 and baseline population and economic variables from the 1990 Census (Table 1).

large majority of land area). Municipalities in our study area are generally charged with providing local public goods and services such as schools and fire-departments, collecting taxes to pay for them, and allowing building permits for new development. New England has weak county government structures and land is generally incorporated into municipalities (exceptions discussed in Appendix B). The population included in our study region was 13.6 million in 2015, and includes a continuum of urban areas like Boston, Hartford, and Worcester, dense to sparse suburban areas, and rural areas (U.S. Census Bureau 2016).[3]

Municipalities throughout New England have a similar process for setting municipal budgets. Generally, a budget or finance committee works in collaboration with municipal departments to prepare a budget for the upcoming fiscal year (Byrnes 2017; Massachusetts Municipal Association 2014; Neal 2012; Vermont League of Cities and Towns 2002; Hill 1992). The budget balances proposed expenditures against expected revenues and is then adopted or rejected directly by town residents at a town meeting or by a city council or another representative body in larger municipalities (Byrnes 2017; Massachusetts Municipal Association 2014; Neal 2012; Vermont League of Cities and Towns 2002; Hill 1992). Once a budget is approved, a property tax rate is set to raise the revenue required to cover the approved municipal appropriations in excess of other local revenues and transfers from the state (Reid 2012). The tax rate is set based on the value of taxable property in the municipality, according to the most recent valuation from the municipal assessor.

Municipalities in New England are quite dependent on property tax revenue, making it a good study area to detect impacts of land protection on property tax rates. The share of local government revenue from property taxes in 2015 was 55% in Connecticut, 54% in Maine, and 60% in New Hampshire, which is more than twice the national average of 27% (Urban Institute 2020). In Massachusetts, the property tax revenue share was 44%, also considerably above average (Urban Institute 2020). Other local revenue sources are relatively small: across the five states, in 2015, non-property tax revenues (own source) accounted for 14-27% of local revenues, relative to an average of 40% for local governments in the rest of the U.S. (Urban Institute, 2020). Sales taxes in our study region are primarily set at the state level. In Maine, New Hampshire, Massachusetts and Connecticut, municipalities cannot impose additional local sales taxes (Fritts 2021). In Vermont, local sales taxes are limited to 1% and only apply to a minority of towns (Department of Taxes 2022; Fritts 2021). None of the New England states allow local personal income taxes (Walczak 2019). Changes in fees for water or other services must be justified according to the expense of providing the service and so are unlikely to be affected by other needs for revenue (Division of Local Services 2016; Sanderson 2010). Given these constraints, options for municipalities to raise taxes or fees to make up for lost revenue from property taxes beyond raising the property tax rate are limited.

[3] Our study area excludes Rhode Island due to limited availability of fiscal data. We exclude the unincorporated areas of Maine, New Hampshire and Vermont since they do not set municipal tax rates, and we exclude towns with population of less than 100 in 1990. The excluded population is a very small share of the total state population in our region, representing 0.11% of the 2015 population.

3.2 Municipal Fiscal Data and Tax Rate Measures

Municipal fiscal data were obtained from each state's department of revenue.[4] Our main outcome of interest is the equalized property tax rate (also known as the effective property tax rate). The equalized property tax rate is calculated as the property tax levy (revenues needed from property taxes) divided by the full, fair market value of properties (the equalized property tax base; further explanation in Appendix B). This measure allows a more equitable comparison of effective tax burdens across jurisdictions because it is less affected by reappraisal cycles and state or local idiosyncrasies in assessment practices (Lincoln Institute of Land Policy and Minnesota Center for Fiscal Excellence 2015; Bell and Kirschner 2009; Clapp et al. 2008). As a robustness check, we also consider the nominal tax rate, which is the rate that is published and depends on the assessed values of property (see Appendix B). Figure 2 illustrates the spatial variation in property tax rates (A) and tax bases (B) within our study region. Differences in property tax systems across states create some challenges in constructing comparable measures across the region. To address these differences, we focus on property tax rates that are residential (if there are multiple rates) and are clearly controlled by the municipalities themselves (see Appendix B for further details). Finally, we also assemble data on the municipal tax levy, assessed and equalized taxable property values, as well as budget revenues and expenditures for the two states where these data are available (CT and MA). Fiscal variables for our study municipalities are summarized in Table 1 with more detailed definitions included in Appendix Table A1.

3.3 Land Protection Data and Types

Land protection data are from the protected open space (POS) database (Harvard Forest 2020), which includes parcel-level spatial data on land ownership type, method of land protection (fee/easement), and the timing of the protection events. These data aggregate multiple data sources to provide a comprehensive layer of spatial land protection with a consistent schema of attributes (see Appendix B for further details). We measure land protection as a percentage of town land area to account for differences in town size.

Our analysis considers the change in four types of land protection: ownership by NGOs, ownership by municipalities, private conservation easements, and ownership by state or federal agencies. Conservation easements are voluntary, legal agreements between a landowner and a qualified NGO or public agency that extinguishes the right to develop the land. We restrict this category to easements on private land to create mutually exclusive categories for analysis. In the few cases where there is an easement on land in municipal, state/federal or NGO ownership, we characterize protection according to the ownership type.

The region has experienced large increases in land protection since 1990, as summarized in Figure 3 and Figure A1. In 1990, 12.8% of our study area was protected. Since then, all categories of land protection have increased, with the greatest increase from new easements on private land (Meyer et al. 2014), particularly in New Hampshire and Vermont (Figure 3). Among land protected in our study area between 1990 and 2015, 52.3% of the new acreage was under private ownership with easement protection, 22.9% was under state/federal ownership, 14.8% was acquired in fee by NGOs, and 8.9% was protected through municipal acquisition. This

[4] These data specifically capture outcomes at the municipal level, omitting property taxes levied separately by sub-municipal special districts like village, water-, fire-, and lighting-districts (See Appendix B).

reflects in part the substantial private land ownership in New England. Private landowners, including hundreds of thousands of family forest owners with small to mid-sized parcels, own more than 75% of the land across the region as a whole (Butler et al. 2016).

By 2015, 20.2% of our study area was protected, with 9.6% of the study land area protected by state/federal government ownership, 2.2% through NGO ownership, 2.9% through municipal ownership, 5.1% through acquisition of easements on private land and 0.4% uncategorized. Figure 1 maps the percent of total land protected and by each protection type at the municipal level in 2015. Table 2 summarizes the four protection types and the potential parcel-level change in property tax obligations expected for each type. For fee simple acquisition of land by NGOs, the full taxable value of protected land would typically be removed from the property tax base, due to their tax-exempt status. Referring to Equation 1, this implies a likely reduction in the property tax base (the denominator). However, some NGOs do make voluntary payments to the towns, or provide infrastructure and services that might otherwise be paid for by municipalities (e.g., Davis et al. 2018); which may also reduce the needed property tax levy (numerator).

Land acquired in fee by municipalities is removed fully from the tax rolls. Additionally, in some cases, municipalities must raise the funds to purchase the land, which could require a tax increase or additional local fees. In terms of Equation 1, this means a reduction in the tax base as well as a potential increase in expenditures to fund the land acquisition. An increase in expenditures is not a given, however, as the land may be donated to the municipality or acquisition funds may come from state or federal grants or out of existing planned expenditures.

Conservation easements on private land usually result in a reduction in taxable value but not a full removal from the tax rolls. Taxable value is generally reduced because easement terms restrict future development and uses. At the same time, if this land was already enrolled in current use, if development was already restricted (e.g. by wetlands laws), or the land does not have high market value, then the impacts on the tax base may be limited.

Finally, we consider land acquired in fee by state and federal agencies, which also becomes tax-exempt. The federal government and all states in our sample except for Maine do make payments in lieu of taxes (PILOTs) to municipalities as compensation for the lost property tax revenue. Compensation varies and can be based on average tax rates in the state (DeNucci 2001), a fixed proportion of lost property tax revenue (Pinho and Dilworth 2020), value of land under current use (Knapp et al. 2014) or a combination of factors like population and revenues received from public lands as in the case of the federal government (Hoover 2017). Additionally, at least in Massachusetts, the state-level PILOT program has been habitually underfunded (Bump 2020; DeNucci 2001; DeNucci 1994), meaning that promises to offset lost tax revenue are often not met. The inadequate and inconsistent funding of PILOT programs has been reported as a source of fiscal stress for rural towns with substantial public land (e.g., Davis, 2017; Schoenberg, 2019). For the fiscal relationships in Equation 1, these changes imply a decrease in the tax base and an offsetting increase in revenues, which may or may not offset the full amount of lost property tax revenue.

3.4 Current Use Value Assessments

As highlighted in the section above and Table 2, the expected change in the property tax base due to permanent land protection may also be related to current-use-value assessment programs. If land is already given tax breaks under current-use provisions at the time of protection, we expect the additional impact of permanent land protection on taxes to be smaller (Table 2). Substantial amounts of land were enrolled in current use provisions during our study period. State land shares in current use as of 2010 are: 30% in CT[5], 35% in ME (Maine Revenue Services, 2010), 38% in VT (Division of Property Valuation and Review 2011) and 52% in NH (Department of Revenue Administration, 2010). In Massachusetts, at least 9% of land is under a form of current use assessment that requires a forestry management plan.[6] There is variation in the type of data available across states to quantify land enrollment in current use taxation, with reports based on taxable value in Massachusetts and on acres enrolled in other states. To create a single measure of land in current use assessment, we construct a state-specific percentile ranking for each municipality (see Appendix B and Figure A2).

3.5 Municipal Characteristics

We expect that the characteristics of a municipality are potential mediators of property tax impacts when new land protection occurs. To test these relationships, we collect data on the size and growth of each municipality's property tax base, community type by residential density, the existing share of land protected, the share of vacation homes, and the median household income. Summary statistics are given in Table 1 and characteristics are mapped in Figure A2. Details of the construction of each of these variables are described in Appendix B.

4. **Empirical Strategy**

4.1 Main Estimation Approach

We estimate the effect of land protection on property tax rates and other fiscal outcomes using a panel data approach where we model changes in tax rates as a function of lagged changes in land protection within each town and relevant controls. Specifically, we calculate differences in the tax rate and in the percent of land protected from each year to the next and average these over three-year time periods. We thus use seven three-year time periods for the tax rate outcomes: 1994-1997, 1997-2000, 2000-2003, 2003-2006, 2006-2009, 2009-2012, 2012-2015.[7] Lagged land protection is correspondingly calculated for three-year time periods from 1991-2012.

We use differences in tax rates and differences in land protection (rather than levels) to subtract out the time-invariant determinants of tax rates within each town. We average these differences across three years to reduce the influence of outliers in individual annual periods and to account for the fact that land protection dates may be measured with some lag because of event timing.[8] Since the choice of a three-year time step is a somewhat arbitrary modeling decision, we include robustness checks with two-year and four-year average differences (Section

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[5] Data on current use acreage for 2010 from the Forestry Division of the Connecticut Department of Energy and Environmental Protection.

[6] Current use acreage for Massachusetts was obtained via communication with staff, Massachusetts Department of Conservation and Recreation

[7] The first period for the tax rate outcomes is the average of differences from 1994-5, 1995-6, and 1996-7. The next period is average of differences from 1997-8, 1998-9, 1999-2000, and so on.

[8] For example, a land trust may acquire land temporarily that is then transferred to a municipality and permanently protected.

5.7). We model the change in tax rates as a function of the lagged change in land protection to reduce the possibility of reverse causality and to allow time for municipalities to adjust their tax rate following changes in assessments.[9]

Our main regression model is therefore:

$$IhsΔTaxRate_{ic,t} = \beta_1 IhsΔ\%ProtLand_{ic,t-1} + IhsΔX_{ic,t-1} + \gamma_{st} + \Omega'(t \times \lambda_c) + \epsilon_{ic,t} \text{ (Eq 2)}$$

where i denotes each municipality, c is the metro-region of that municipality (see Appendix B) and t indexes each three-year time period. The dependent variable, $IhsΔTaxRate_{ic,t}$, is the Ihs transformed average difference in the equalized property tax rate. The policy variable of interest, $IhsΔ\%ProtLand_{ic,t-1}$, is the Ihs transformed average difference in the percent of land protected. $IhsΔX_{ic,t-1}$ is a vector of controls for local economic conditions including: the Ihs transformed lagged average changes in the labor force, Ihs transformed lagged average changes in the unemployment rate, and the lagged average percentage change in the property tax base (tax base growth). While our use of changes-on-changes controls for time-constant municipal characteristics, we include this set of lagged time-varying controls to mitigate possible concerns that new land protection may be correlated with local economic conditions or appreciation of the tax base.[10] In addition, we include γ_{st} , a state-by-time-period fixed effect, and $(t \times \lambda_c)$ which controls for linear time trends for each metro-region. These account for possible differential trends in tax rates within sub-regions of New England. Our identifying assumption is that conditional on these controls, the remaining variation in new land protection is plausibly exogenous because it is driven by the uncoordinated activities of thousands of landowners and hundreds of land trusts, local governments, state, and federal agencies, as well as randomness in the timing of property transitions. We include the count of town observations by time-period and state used in the estimation in Appendix Table A2.

Our rationale for using the Ihs transformed differences—rather than the more standard approach of a difference in logged values—is based on its better performance in reducing the influence of outliers in our dataset as well as preserving the rank order of the within-municipality changes in the key variables (visualized in Appendix Figure A3). Despite averaging across three years, our data does include some large changes in property tax rates and land protection. To ensure that potential outliers are not driving the results, we transform the average differences using the inverse hyperbolic sine (Ihs—see Burbidge et al. (1988)) and winsorize the furthest 1% of the data.[11] In addition, we include robustness checks using the differences of log transformed variables and other possible specifications (Appendix Figure A3, Section 5.7).

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[9] For discussion of the use of lagged explanatory variables, see Bellemare et al. (2017).

[10] We include lagged tax base growth as a control since previous research has shown that growth/development is a predictor of open space bond passage (Nelson et al. 2007; Kotchen and Powers 2006). Since land protection could be driven by greater development threat, we include this control to mitigate possible omitted variables bias. However, we acknowledge that including lagged tax base growth may raise concerns about over-controlling. We check robustness to omitting this control in Table 3.

[11] We winsorize the top and bottom 1 % of the distribution for all non-percentile variables used in estimation except for the change in land protection variables, for which we winsorize only the top 1%. Variables are winsorized after averaging to three-year time periods. We check robustness of our results to using non-winsorized data (Section 5.7).

4.2 Heterogeneity in Impacts, and Impacts Across Time

To understand possible heterogeneity in the impacts of new land protection, we test for differential impacts by protection type and by municipal characteristics, including measures of land in current use, property tax base size and growth, municipality type based on housing density (rural, exurban, urban), percent of land protected in a municipality at the beginning of a time-period, share of vacation homes in municipal housing stock, median household income, and the lagged tax rate.

We first estimate a series of single interaction models with each characteristic included alone. However, as there may be important co-variation between these municipal characteristics, we also estimate two multiple interaction models. For these models we leave out housing density and land enrolled in current use due to data limitations and potential multicollinearity.[12] We estimate the fully interacted model for aggregated changes in land protection and then for each protection type separately.

In addition, we test for the possibility that towns may adjust to land protection through a reduction in property tax revenue and expenditures on public goods. We have expenditures and revenue data from two states to test this directly. We also assess potential impacts on the total property tax levy and property tax base using data from all states. For these outcomes, there is an extremely wide range of values for the differences (from hundreds of dollars to hundreds of million dollars) which may make results sensitive to the choice of a scaling factor for the Ihs transformation.[13] Therefore, for these dependent variables, we use the standard specification of difference in logs, keeping the right-hand side of our specification identical to Equation 2:

$$\Delta Ln(Y)_{ic,t} = \beta_1 Ihs\Delta\%ProtLand_{ic,t-1} + Ihs\Delta X_{ic,t-1} + \gamma_{st} + \Omega'(t \times \lambda_c) + \epsilon_{ic,t} \quad \text{(Eq 3)}$$

Where $\Delta Ln(Y)_{ic,t} = Ln(Y)_{ic,t} - Ln(Y)_{ic,t-1}$ and Y represents our fiscal outcomes, including municipal expenditures, revenues, the property tax levy, and property tax base values. This specification models the relative (i.e. approximate percentage) changes in these fiscal variables as a function of the same transformed differences in land protection.

Finally, to assess the potential impacts of land protection on taxes over the longer term, we modify Equation 2 by introducing up to three time-period lags for the change in total land protection:

$$Ihs\Delta Tax\ Rate_{ic,t} = \sum_{j=1}^{3}(\beta_j\, Ihs\Delta\%ProtLand_{ic,t-j}) + Ihs\Delta X_{i,t-1} + \gamma_{st} + \Omega'(t \times \lambda_c) + \epsilon_{ic,t} \quad \text{(Eq 4)}$$

where the subscript j represents the temporal lag. Each lag represents a three-year time period, so this tests for impacts of land protection initiated up to nine years prior. We estimate this model to

[12] Based on a review of correlations between variables (shown in Appendix Table A3), we exclude housing density from the fully interacted model due to the high degree of correlation between it and municipal property tax base size (>0.7). Town percentile rank by land enrollment in current use assessment is also excluded due to the relatively high correlation with property tax base percentile (>0.6) and because data for this variable is available for only one year (2010).

[13] As illustrated in Bellemare and Wichman (2020) as well as Aihounton and Henningsen (2021), model results can be sensitive to the choice of a scaling factor for Ihs when there is a great range in the values. As a robustness check, we also estimate Equation 3 for these fiscal outcomes with both sides specified as differences of logs (Section 5.7).

test the idea that tax rates might initially increase and then go back down again or that they may increase initially but not change further in the longer term.

5. Results

5.1 Average Impacts of Land Protection

Table 3 presents the results from our main specification, building up to this by including control variables in a stepwise fashion. This and subsequent figures and tables, unless noted otherwise, report estimated slopes evaluated at the mean values of the change in the tax rate and the lagged change in land protection. These slope estimates are derived by back transforming from the model coefficients and can be interpreted as the predicted change in the average annual equalized tax rate change ($ per $1000 value) resulting from a one percentage point increase in the average annual municipal area share newly protected in the prior three-year time-period. For reference, for the average municipality in our study area, one percent of town area is equal to 199.3 acres (Table 1). We explain the back transformation steps and provide an example in Appendix B.

We find that without controls, the relationship between the change in the tax rate and the change in prior period land protection is negative, with an estimated decrease in the average annual equalized tax rate change of $0.0149 per $1000 (Table 3, not statistically significant). With the addition of CBSA trends and state-by-time period fixed effects, the estimated impact of new land protection becomes positive and significant with a magnitude of $0.0241 per $1000. The addition of further controls for labor market conditions and lagged property tax base growth does not substantially change the estimated impact, resulting in only a small reduction in the estimated magnitude of the tax rate change. Column 7 shows our preferred specification with the full set of controls as described in Equation 2. The estimated slope is $0.0231 per $1000 of value ($p$=0.036), again corresponding specifically to a one percentage point increase in the average annual municipal share of area newly protected in the prior time period (evaluated at average values of the change in tax rates and the change in land protection).

For comparison, we also represent this change in terms of an annual change in the property tax bill associated with a reference level of 100 acres of new land protection and for a typical home value (see Table 4). We estimate that 100 acres of new land protection results in an annual tax bill increase of $1.16 per $100,000 of value. Or, for an owner of a typical single-family home in New England, valued at $259,045,[14] this translates to a tax bill increase of $3.00, which is a small change compared to the overall property tax bill (based on the average equalized tax rate across the region) of $2,893 on that same home (Table 4).

100 acres is somewhat larger than the actual average change in protection among towns that did protect land: the average non-zero annual change is 84.9 acres and the average annual change overall is 45.8 acres. However, some towns saw several periods with larger increases. Therefore, for additional comparison, we calculate that the expected tax bill increase for the 90th percentile of annual non-zero increase in land protection (217.1 acres) would be $2.52 per $100,000 of value, or $6.53 for an owner of a typical New England home.

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[14] $259,045 (2015 dollars) is the typical home value in our study area according to the Zillow Home Value Index (ZHVI) for 1996-2015. ZHVI reflects the mean value of single-family homes in the 35th to 65th percentile range of home values (Zillow Research 2019).

Small overall impacts on the property tax rate for the region could mask heterogeneity across individual states. We re-estimate the model separately for each state with results shown in Table 4. We find statistically significant impacts of land protection on tax rate change for some states, but all estimated slopes remain small (Table 4). An additional one percentage point increase in the average annual municipal area share protected results in a statistically significant increase in the property taxes in New Hampshire (estimate = $0.0546 per $1000 of value, p=0.005) and a marginally significant increase in Vermont (estimate= $0.0292 per $1000 of value, p=0.066). We do not find statistically significant impacts in Massachusetts, Connecticut, or Maine, with the estimated slopes indicating increases in Massachusetts and Connecticut that are similar to the overall estimated increase, and a possible small reduction in tax rates in Maine. Table 4 shows the estimated tax bill changes for each state, assuming a 100 acre per year increase in new protection. In comparison to the average tax bills expected based on typical home values and the municipal tax rates, each of these represents a small proportion of the average tax bill.[15]

While the average effect of new land protection on property tax rate change is small, including across states, this may still obscure important impact heterogeneity that is based on the type of land protection or municipal characteristics, rather than state. We next examine how the impact of land protection varies by type of protection and municipal characteristics using individual interactions and then fully interacted models that use aggregate change in protection and individual protection types (Figures 4, 5 and 6, Tables A4-A8).

5.2 Impact Heterogeneity by Land Protection Types

Figure 4 graphs estimated slopes and standard errors for protection types and municipal characteristics, plotting variation in the marginal impact of new land protection across different values of the interacted variables (corresponding numerical estimates are in Table A4). Considering the different types of land protection, we find that conservation easements have a positive and statistically significant impact on tax rates, increasing the average annual tax rate change by $0.0356 (p=0.039), which is somewhat larger than the average impact on tax rate change for all land protection reported in Table 4. Municipal protection is associated with the highest estimated increase in tax rate change of $0.0722, (Figure 4A) but this estimate has only marginal statistical significance (p=0.083). The increase in tax rate change associated with state and federal protection is $0.0305, which is also larger than the average for all land protection (Table 4), but not statistically significantly different from zero. Finally, the estimated impact for NGO protection is negative, implying a possible reduction in tax rates resulting from this type of land protection (Column 1, Table A4, estimate= $-0.0525; Figure 4A), but this estimate is not statistically different from zero.

While there is considerable randomness in the overall process and timing of land protection, changes in protection may still reflect some differential selection, particularly among individual protection types (Figure A1). From our visualization of the changes, we note that municipal protection is more common in the faster growing and more populous southern New England, while easements and state/federal land protection are more prevalent in more rural areas in western and northern New England. Some NGO protection in turn is occurring in amenity rich areas with more vacation homes (Figure A1). Land protection types may therefore

[15] Note that the average tax rates for NH and VT include only the municipal portion of those rates, not property taxes paid to the state to cover education; further explanation in Appendix B.

interact with other municipal characteristics. For this reason, we estimate models allowing for interaction between protection types and municipal characteristics. All estimated coefficients are evaluated at the mean values of the change in tax rates and the change in land protection and for mean values of other variables in the multiple interaction models.

Our results from the multiple interaction models indicate a similar pattern for the overall impacts of different land protection types, with slightly larger estimated tax rate changes (Figure 6A and Table A8). The largest increase in tax rate change is associated with municipal protection (estimate = \$0.103, p=0.045, evaluated at the means of all variables), followed by conservation easements (estimate = \$0.0480, p=0.042), state/federal protection (estimate=\$0.0317, p=0.26), and NGO protection (estimate= -\$0.0318, p=0.41).

In terms of tax bill changes, assuming an increase in new protection of 100 acres, these results by type translate to annual tax bill increases of \$5.17 (municipal protection), \$2.41 (private easements), and \$1.59 (state/federal protection) per \$100,000 of value, while NGO protection is associated with a tax bill decrease of -\$1.60 per \$100,000 of property value. Our conservation easement results fall near the range of property tax impacts estimated by King and Anderson (2004), the most relevant previous study.[16]

These findings may be partly explained by how different protection types are expected to affect property taxes, as discussed in Section 3.2. In particular, municipal land acquisition may require raising funds to purchase land, so the expected impact could be greater than for other types. Easement protection may result in smaller changes in tax rates, compared to municipal land acquisition, because only a portion of taxable property value is lost when an easement is established and many lands were in current use assessment prior to being protected. The fiscal impacts of state and federal protection may be partially offset by PILOT payments. The possible reduction in tax rates due to NGO protection is somewhat surprising. Although this result is not precisely estimated, if the true impact on tax rates is indeed negative, this could be explained by amenity effects or increased recreation spending associated with these properties that contributes to other municipal tax revenues. Anecdotally, NGOs in the region have invested considerably in infrastructure for recreation or historical visitation and worked in partnership with towns, possibly contributing to a positive impact on local property values.

5.3 Heterogeneity by Municipal Characteristics: Current Use, Tax Base Size, Tax Base Growth, Density, Tax Rates

A possible explanation for the overall small impacts of land protection on taxes is that many lands were already paying relatively low taxes due to current use value assessment programs prior to acquisition or easements. Although data on current use enrollment is limited, we test this by interacting the percentile rank of land in current use with new land protection. We find that the tax rate impacts do decline with increasing amount of land in current use (Figure 4B and Table A4, Column 2) and may even be negative for towns with large amounts of enrolled land.

The size and growth of the local property tax base as well as the existing tax rate may also play an important role in how tax rates respond to new protection. Smaller tax base towns

[16] They estimate that protecting 100 acres using conservation easements can result in tax bill increase ranging from \$8.40 to \$15.80 per \$100,000 of value in the three years following the change in land protection. Our lower estimates are consistent with our use of only the municipal portions of the property tax rate for Vermont and New Hampshire (King and Anderson use the aggregate property tax rate).

may experience proportionally greater losses of taxable property value for the same dollar value change. At the same time, many towns with small tax bases are rural and face less development pressure, so parcel values may be less, meaning that dollar value changes are less for the same size and land use type.

In the single interaction model, we find that on average, the tax impacts of new land protection do not vary substantially by property tax base size (Figure 4C and Table A4, Column 3). This result is somewhat surprising, since we might expect towns with large tax bases to be better positioned to absorb a loss of property tax revenue when land is protected. Instead, we find that the rate of tax base growth generally matters more than the level of the tax base (Figure 4D, and Table A4, Column 4). The slope of the interaction term between new land protection and tax base growth is negative and statistically significant. This indicates (as also shown in Figure 4D) that new land protection does result in significant increases to tax rates when it coincides with low rates of tax base growth.

The implication of this result is that the towns that may need to worry most about seeing larger tax increases from land protection are those that are experiencing slow growth in their tax base over time. However, as Figure 4E (and Table A4, Column 5) shows, this cannot be easily predicted simply on the basis of whether areas are more urban vs. more rural. We find that the magnitude of the increase in property tax rate change is significantly different from zero only for exurban towns (estimate: \$0.0309 per \$1000, p=0.049). Although this is imprecisely estimated, towns and cities classified as urban had the largest estimated increase in tax rate change (Figure 4E). Rural areas, which often draw the most attention in debates about land protection and might be expected to be growing more slowly, did not see large or statistically significant impacts on taxes on average as a result of land protection. We see similar results in Figure A4, which gives a comparison of results based on using a continuous measure of housing density (See Appendix B for more details). Finally, we also find that the local tax rate level influences the impact of land protection. The interaction between the change in land protection and the prior period tax rate in the single interaction model is negative and statistically significant (p=0.007), suggesting that municipalities with higher lagged tax rates see smaller tax rate increases from land protection (Column 9, Table A4). It is possible that municipalities with already high rates are reticent to increase them further.

Interestingly, our results indicate that while additional tax base growth may reduce the tax rate impacts of land protection, tax base growth by itself is consistently associated with an increase in property tax rates (as shown across all columns in Table A4, last row of the table). While speculative, this is consistent with the findings from the costs of community services literature suggesting that growth actually raises taxes because the high costs of new municipal services outweigh the additional revenue brought by new development (Murray and Catanzaro 2019; Clapp et al. 2018; Kotchen and Schulte 2009).

In the fully interacted model, we find generally similar results (Figure 5, Figure 6). However, for tax base size (Figure 5B, Table A6) we find suggestive evidence of higher tax impacts for smaller tax base towns. For towns at the 10th percentile of tax base size, the estimated increase in tax rate change is \$0.0349 (p=0.055). For 100 acres of new protection, this translates to a tax bill increase of \$1.75 per \$100,000 of value. Estimates from the multiple interaction model by protection type suggest that this result may be driven by municipal land protection (Figure 6B, Table A8). Note that the estimated increase in tax rate change from new municipal protection for towns at the 10th percentile of tax base size is about 8 times larger than the overall average (estimate = \$0.190, p=0.056). For 100 acres of new protection, this translates to an annual tax bill increase of $9.53 per $100,000 of value, which is among the highest impacts that we find.

In the fully interacted model, tax base growth again appears to be a more consistent predictor of the impacts of land protection on tax rates (Figures 5C and 6C). We find that the increase in tax rate change associated with new land protection decreases with the rate of tax base growth. This finding is consistent across both of our multiple interaction models, for total change in land protection and all land protection types. We observe some of the highest increases in tax rate change in our analysis for the slowest growing towns (See 10th percentile results in Tables A6 and A8), with increases in tax rate change as high as $0.0580 per $1000 (p=0.002) for total change in land protection (Table A6) and increases of $0.148 per $1000 (p=0.033) for municipal protection and $0.0952 per $1000 (p=0.002) for easements (Table A8). For a 100 acre increase in new annual land protection, these increases in tax rate change represent annual tax bill increases of $2.91, $7.43 and $4.78 per $100,000 of value for total change in land protection and municipal and easement protection, respectively, holding all other variables at their means. This highlights the potential role of growth as an important factor for mitigating tax rate increases that can result from land protection, even though growth by itself does not necessarily reduce tax rates.

5.4 Municipal Characteristics: Existing Land Protection, Second Homes, Median Income

In addition to growth rates, debates about land protection and tax rates often focus on possible constraints to development (or at least development of single-family homes with large lot sizes) that are posed when a high share of town land is set aside as protected. For this reason, we test whether the impact of additional protection is different for municipalities with a high cumulative share of area already protected at the beginning of the prior three-year time period. Figure 4F (and Table A4, Column 6) shows that on average, there is no significant variation in the impact of land protection by land share protected (land share is measured at the start of the prior period). In fact, if anything, there are smaller expected increases in taxes in the towns with a high share of land already protected. These results may indicate either that most towns in the region had not yet hit “build-out” constraints, or that such concerns can be overcome by re-development and increased density of housing. Alternately, a high share of land protection may substantially raise the value of the existing housing stock. Regardless, this result is important to note as it runs against a conventional wisdom that taxes will generally increase the most where there is already a lot of protected land.

This result generally holds in the multiple interaction models, with some exceptions. Estimates from the multiple interaction model with total change in protection show no significant differences in tax impacts with share of land protected (Figure 5C, Table A8). Results from the multiple interaction model with individual protection types actually indicate a pattern of lower expected tax impacts for towns that already have a high share protected for NGO, municipal and private easement protection (Figure 6D, Table A8). For these protection types, the towns and cities most affected by tax increases appear to be those with little existing land protection. In particular, among municipalities in the 10th percentile of already protected land, we find increases in tax rate change of $0.2065 per $1000 (p=0.031) for municipal protection and $0.0784 (p=0.013) for easement protection. These increases in tax rate change are associated with tax bill increases of $10.36 and $3.93 per $100,000 of value for municipal and easement protection, assuming 100 acres of additional annual protection. However, for state and federal protection, we estimate higher increases in tax rate change with more land protected at baseline rather than less. The estimated increase in tax rate change is $0.0897 per $1000 (p=0.024) for towns in the 90th percentile of pre-existing land protection (>34% land area protected). Among the towns in the 90th percentile of pre-existing land protection, state and federally owned land on average accounts for 73% of total protected land. The larger tax rate impacts associated with new state and federal protection in these towns may potentially reflect the cumulative impact of state and federal land ownership and associated PILOT payments that don't fully offset the lost property tax revenue (Bump 2020; Pinho and Dilworth 2020; DeNucci 2001; DeNucci 1994). This suggests that special attention is warranted to assess potential tax impacts in towns where new state and federal protection is proposed and large amounts of land are already in reserves.

Communities may also be better positioned to benefit from land protection if they have a larger number of second homes or greater average incomes. The benefits of land protection may capitalize into local property values faster and to a greater extent in scenic, high amenity areas as well as in higher income towns with greater ability to pay for amenities. Second homes also tend to use fewer local services and may be associated with areas particularly rich in natural amenities, such as near coastlines or lakes (Polyakov et al. 2013; Irwin et al. 2010). Consistent with these expectations, we find that where there is a larger share of vacation homes in the municipal housing stock, there are smaller impacts on property tax rates due to new land protection (Figure 4G and Table A4, Column 7). These results also hold based on estimates from the multiple interaction model for total protection (Figure 5D) and individual protection types (Figure 6E).

In addition, we find that the impact of land protection on tax rates increases as municipal-level median household income decreases (Column 8, Table A4 and Figure 4H). For low-income towns (10th percentile rank), we estimate an increase in the tax rate change of $0.0357 per $1000 (p=0.049) compared to high income towns (90th percentile rank) where the estimated increase in the tax rate change is $0.0079 (p=0.638). In the fully interacted models (Figure 5E, Figure 6F), we also find that income is a consistent predictor of tax rate change for total protection and all protection types, with the largest increase in tax rates resulting from new municipal land protection in low-income municipalities. Specifically, for towns at the 10th percentile of median household income, we find increases in tax rate change of $0.0525 per $1000 (p=0.010) based on total change in protection (Appendix Table A6), and $0.1525 (p= 0.068) for municipal protection, $0.0797 (p=0.021) for easements and $0.0854 (p=0.079) for state/federal protection (Appendix Table A8). For a 100 acre increase in new annual land protection, these increases in tax rate change represent annual tax bill increases of $2.63, $7.65, $4.00 and $4.29 per $100,000 of value for total, municipal, easement and state/federal protection. These results indicate that greater attention to the potential tax impacts of land protection is warranted for lower-income municipalities.

5.5 Impact of Land Protection on Levies and Expenditures

A fundamental concern about land protection is that it could affect spending on other public goods that municipalities provide. If land protection results in a loss of property tax revenue that is not made up for by increases in taxes, towns may be forced to reduce expenditures. However, using the data from Massachusetts and Connecticut where expenditure data is available, we do not find evidence consistent with these concerns.[17] As shown in Table 5, we find that the estimated impacts of new land protection on expenditures and revenues are actually positive, although only marginally significant for expenditures (p=0.062) and not substantial in magnitude compared to the overall average expenditures ($43,610 for a 100 acre change, compared to an average of $26.70 million).[18]

In addition, using data from both MA and CT as well as all five states, we test for impacts on the property tax levy and total property values (assessed and equalized). We find a small, marginally significant estimated increase in the property tax levy for MA and CT (Table 5, Column 3, p=0.090). The increase is also positive for all five states although not statistically significant, and again the estimated dollar values of both are small ($19,206 and $3,801).

Finally, we find decreases in total assessed and equalized property values, although they are not statistically significant for either MA and CT or our region as a whole (Table 5, columns 4 and 5). Here we would expect to see a negative first order impact as land protection takes land off the tax rolls, but this may be offset by a secondary effect of potential increases in amenity values. Given the negative coefficients on assessed/equalized values and the positive coefficients on levies as well as the tax rate, our results are consistent with a scenario where towns may slightly overshoot in adjusting tax rates. In other words, they may set tax rates based on expectations of lost revenue from land protection without counting on potential gains from amenity effects. Municipalities then end up raising slightly more in levies than expected due to amenity effects raising the value of surrounding properties.

Crucially, these results suggest that municipalities were not fiscally constrained by land protection. However, while the options to raise revenue from other sources are limited, non-property tax channels could potentially have been used to offset lost property tax revenue. Further exploration of these non-property tax channels of fiscal adjustment using different datasets is outside the scope of our study but would be a fruitful avenue for future research.

5.6 Impacts Over Time; Amenity Effects

To understand the temporal trajectory of the tax rate change, and to test for the possibility that tax rates may decrease in the long run due to tax base growth from the amenity effects associated with land protection (Chamblee et al. 2011; Anderson and West 2006; Geoghegan et al. 2003; Irwin 2002; Thorsnes 2002), we include additional lagged values of land protection and estimate Equation 3. Table 6 builds up the lagged model results, adding one lagged time period at a time up to three lags, which together span a nine-year time period. If tax rates were to go up and then back down again as a result of land protection, we should expect that the prior period coefficient (3-year lag) is positive, while the preceding lags (6 and 9-year lags) are negative, or become increasingly negative. If tax rates were to go up once but not increase further, then we should expect that the prior period coefficient is positive while the preceding ones are zero. Our

[17] We note here that the levy increase estimated for the Massachusetts and Connecticut sample may be affected by Proposition 2.5 in Massachusetts, which limits the year-to-year tax levy increase to 2.5% (Division of Local Services 2007). However, municipalities can also choose to override this limit by a majority vote of the electorate and city council; 38% of such requests in MA were successful between 1990 and 2007 (Roscoe 2014).

[18] We use logged values of the municipal expenditures, revenues, levy, and assessed as well as equalized values in our analysis. To obtain means in dollars, we exponentiate the average logged values presented in Table 1. For expenditure, exponentiating 17.10, yields $26,695,351.

lagged model estimates are not statistically significant but show a pattern of estimated positive impacts on tax rate change in the first lagged period, negative in the second and close to zero in the third.[19] Together with our main estimates, we interpret these results as being consistent with a small tax rate increase due to recent land protection, that does not continue to increase and possibly may come back down in the intermediate term, without additional long term impacts.

The possibility that increased amenity values due to land protection may be capitalized into property values also raises the issue that our estimated tax bill change due to a municipal tax rate increase may be a lower bound. In a national study, Lang (2018) found that housing prices at the zip code level increased by 0.68-1.12% for every $1000 of open space spending per household authorized through open space referenda. Similarly, in a case study of two Massachusetts towns, Heintzelman (2010) showed that the passage of the Community Preservation Act to fund open space and historical preservation was associated with local property value growth of 1.5-4.5% (although these benefits accrued only to homes above the 65th percentile of value).

Applying Lang's estimates to our region, we roughly estimate that an increase in protection of 100 acres may result in property value growth ranging from 0.14%-0.43% at the regional level, leading to an increase in tax bills of $1.40-$7.47 per $100,000 of value. At the state level, property value growth may range from 0.048% to 1.02%, with associated tax bill increases of $0.66 - $12.83 per $100,000 of value (see Appendix B for details of the calculations and Appendix Table A9 for estimates by state and region). These estimates indicate that the potential increase in the tax bill due to capitalization of amenity value is comparable in magnitude, and could possibly be even larger, than the increase due to tax rate change.

In addition, while our results indicate important heterogeneity by municipal characteristics, they cannot measure important possible heterogeneity at the parcel level, driven by very localized amenity effects. Future research at the parcel level would help to understand the specific incidence of costs and benefits associated with land protection at the household level.

5.7 Robustness Checks

Our estimates for the overall impact of land protection are generally robust to alternative decisions about the length of time steps, treatment of outliers and model specification. Appendix Table A10 compares estimated slopes for the average effect, and by protection type, across alternative averaging time steps. Results from two- and three-year averaging periods look very similar, while impacts on tax rate change overall are estimated as close to zero for the four-year averaging period. This is consistent with potentially smaller long-term impacts over time or could possibly reflect a greater amenity effect over time associated with NGO owned land. Appendix Table A11 presents estimated slopes with and without winsorization and where outliers are dropped instead of winsorized. The overall results are robust to the treatment of outliers (Table A11).[20]

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[19] Robustness checks using annual data and successive annual lags confirmed these general patterns.

[20] We prefer winsorization to dropping outliers to ensure that individual observations do not drive the results because we do not have a clear justification to drop them and we do not want to further unbalance the panel unless necessary.

Table A12 (Columns 2-5) presents estimates based on alternative functional forms of the main specification. We include percentage differences, log differences, untransformed differences of the tax rates and land protection and an alternative model using municipal fixed effects rather than a differences approach. The magnitude of the estimated tax bill change for 100 acres of new protection varies across these models from \$0.35 to \$0.90 per \$100,000 of value and indicates that our overall conclusion that new land protection has only small impacts on tax rates is not being driven by our choice of model specification. In Table A13, we provide a robustness check of results using the published tax rate, also called the nominal tax rate following conventions in the literature (Song and Zenou 2006; Dye et al. 2001; Mikesell 1980). Since this is the rate seen by local property owners, it may be most salient. However as noted in the main text, nominal tax rates do not account well for differences in assessment practices or timing across localities. We find similar average annual tax rate increases associated with a one percentage point annual increase in municipal area protected: \$0.025/\$1000 of value with nominal tax rate (vs \$0.0231/\$1000 of value with equalized tax rate).

Finally, as a robustness check of Table 5, we estimate the impact of land protection on revenues, expenditures, levy and property tax base where we specify both the change in the fiscal variables and land protection as log differences (Appendix Table A14). The signs of the estimates are consistent, with somewhat larger estimated magnitudes and a marginally significant decrease in assessed values for all states (p=0.091) and a marginally significant increase in the property tax levy for all states (p=0.085).

6. Conclusion

Public desire for additional protected open space and also for low property taxes is a perennial source of tension and debate. The aim of this study was to estimate the impacts of new land protection on property tax rates, and to test for heterogeneity in impacts across protection types, municipal characteristics and conditions that may amplify or moderate these effects. Using data from more than 1400 towns and cities in New England, we analyzed the impacts of new land protection, using a panel data estimation approach comparing changes in tax rates following changes in land protection within municipalities.

Our results indicate that on average, the tax impacts of new public and private land protection are small, adding just a few dollars to the annual tax bill for most homeowners in the short run. These results suggest that for the majority of towns and cities, new land protection can be achieved without substantial impacts on other taxpayers or on the provision of public goods. The local benefits of this protection, including recreational opportunities, preservation of cultural heritage, wildlife habitat, and ecosystem services such as improved water quality, decreased flood risk and increased climate resilience may be considerably larger in value to residents than the modest increase in property tax bills.

While the impacts are typically small, they are heterogeneous, with some towns and cities likely to experience relatively larger tax rate increases than others. This includes municipalities with slowly growing tax bases, fewer vacation homes, lower average household incomes and less land enrolled in current use taxation. We also found greater tax impacts for towns that engaged in substantial municipal protection when they had low growth rates or small tax bases, and for towns that received state and federal protection when they already had a very high share of land protected.

These results highlight disparities in impacts and suggest that the towns least able to afford increases in property tax rates may also be those most likely to experience the greatest impacts. In addition, while potential tax costs are borne by the municipalities where the protection occurs, the benefits of land protection often extend to communities throughout the region through visitation, improved air and water quality, climate mitigation and other ecosystem services. In recognition of these broader public benefits, state and federal agencies can support local fiscal health by ensuring that payments in lieu of taxes programs are fully funded and are large enough to provide real compensation for the value that these protected lands provide, particularly in communities with fewer fiscal resources. Public and private organizations can also play a role in ensuring access to additional funds for land protection. For example, current requirements for municipalities to provide matching funds or prepare open space plans in order to receive state or federal grants for municipal land protection may create barriers to accessing outside funds that can be overcome with additional public or private assistance. Agencies and NGOs engaged in land protection should be aware of how the likely fiscal impacts of land protection may depend on where this protection occurs and can be proactive in sharing strategies or resources that support healthy municipal budgets and empower local communities to make sustainable decisions about new land protection.

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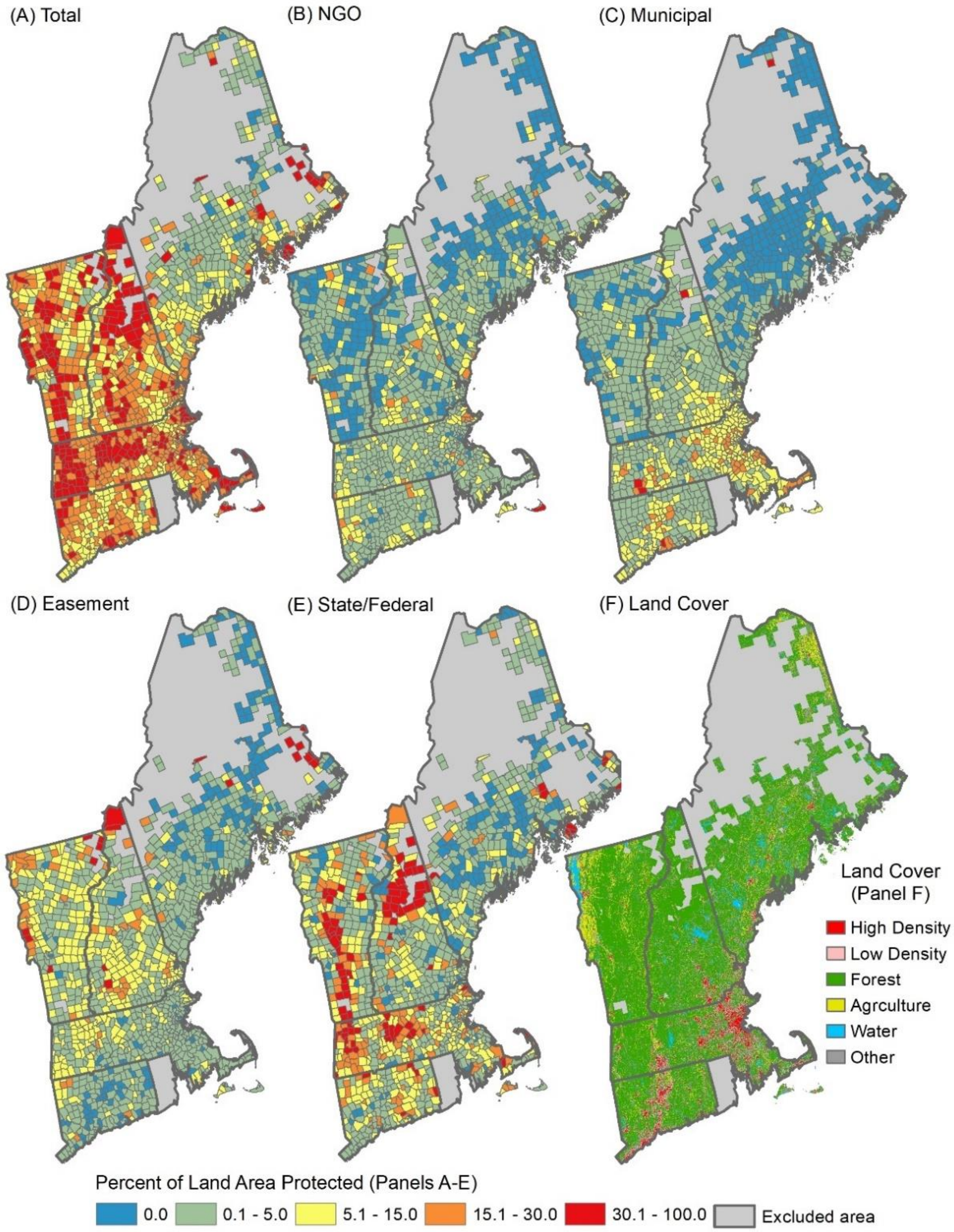
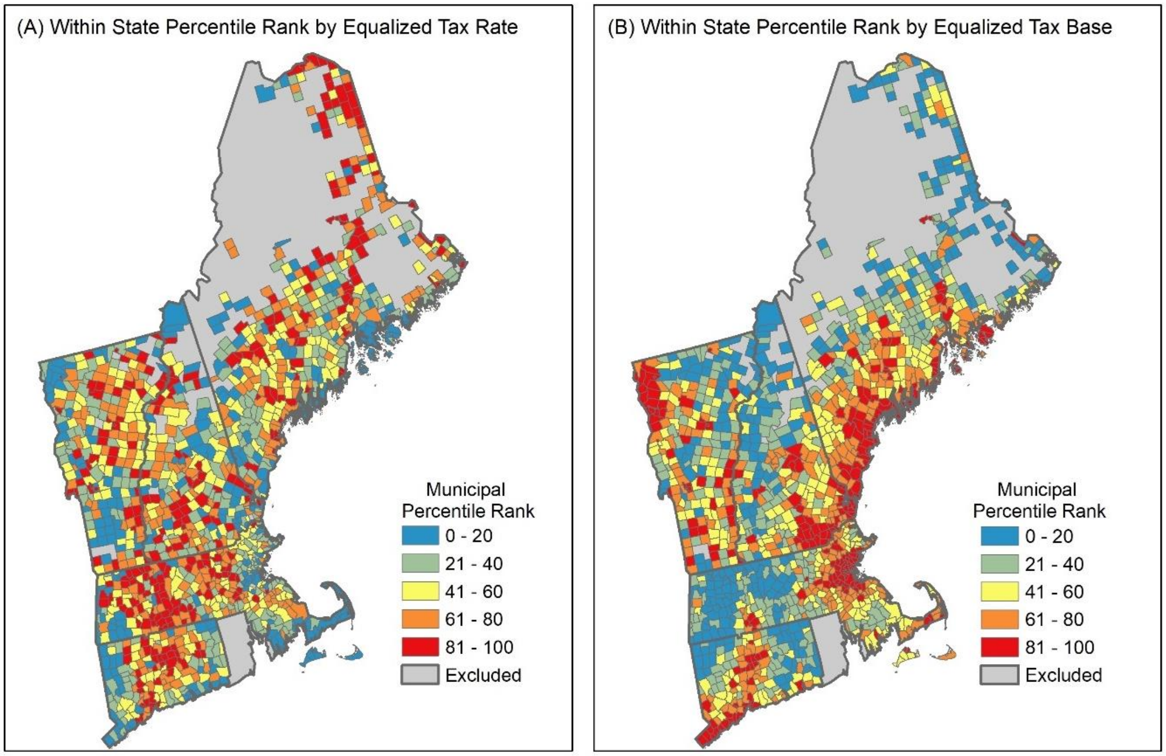
Figure 1: Study Area – Land Protection and Land Cover by 2015



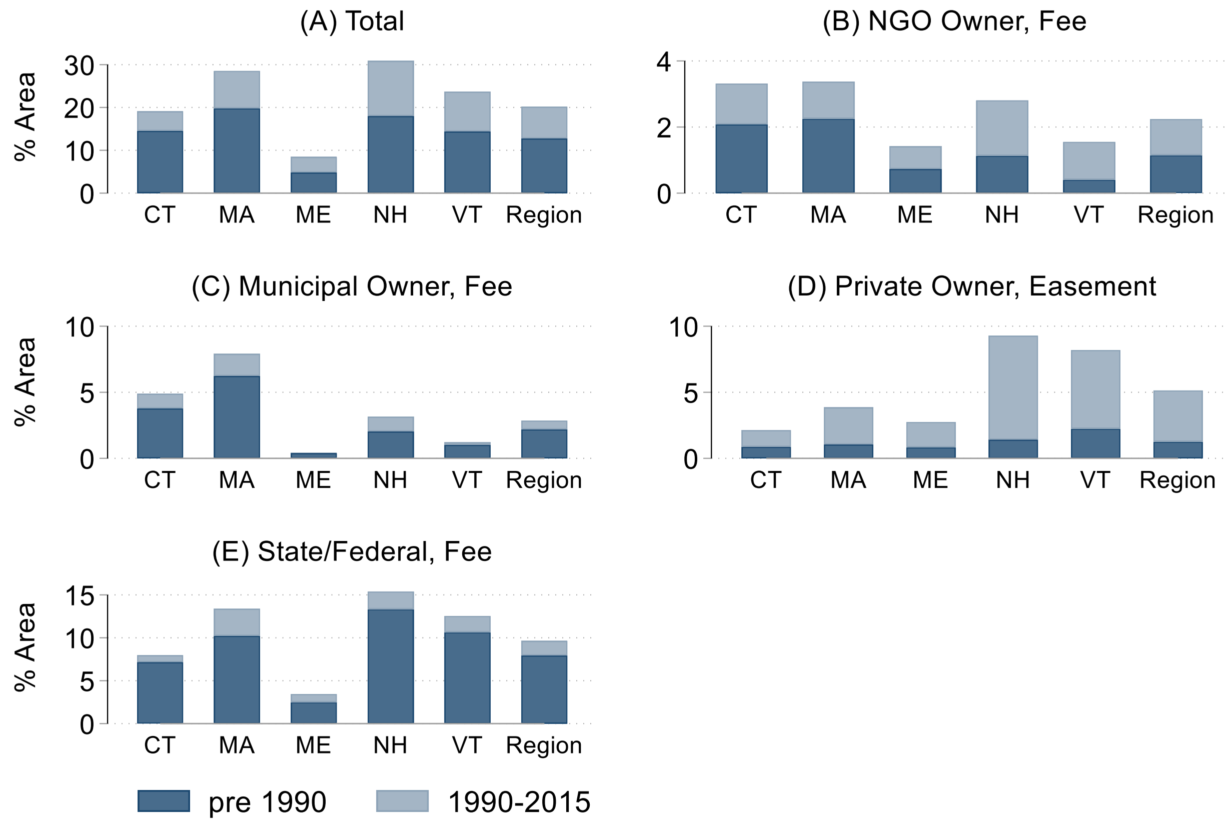
Notes: (A)-(E): Protected land by 2015 as a percentage of area within a municipality from the Harvard Forest/Highstead database with: (A) total land protected (B) land owned in fee by NGOs (C) land owned in fee by municipalities (D) easements on private land (E) land owned in fee by state/federal government. (F): Land cover in 2016 from the National Land Cover Database (Dewitz 2019). High and Low density indicate developed land classes (with the "High" category here including both High and Intermediate density from the NLCD). Excluded areas are described in Appendix B.

Figure 2: Municipal Property Tax Rate and Property Tax Base



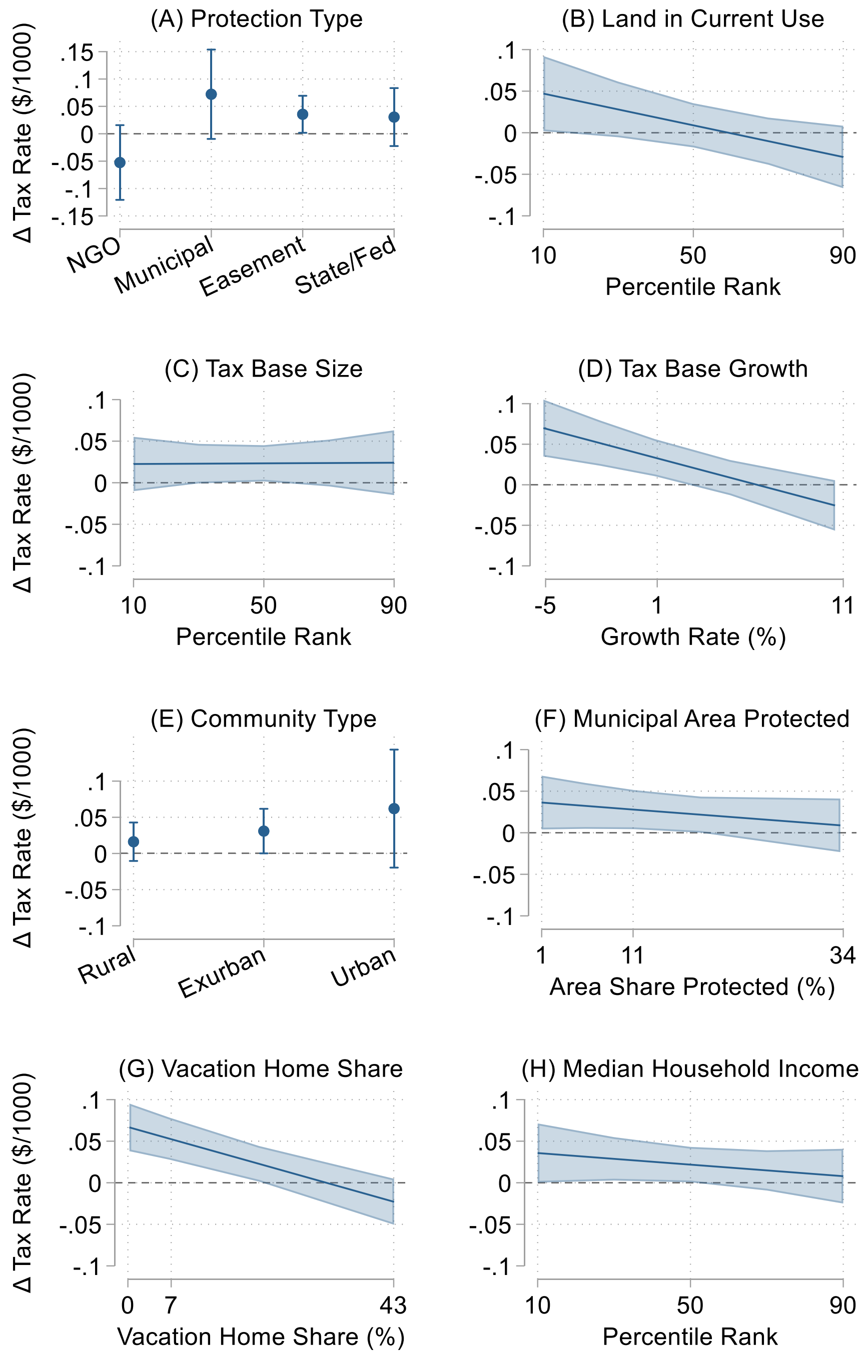
Notes: (A) Within state municipal percentile rank based on average equalized property tax rate from 1994-2015. The average is taken using the three-year analysis time periods used in estimation. Higher rank municipalities have higher property tax rates on average relative to other municipalities in the same state. (B) Within state municipal percentile rank of average equalized value per acre at baseline. The baseline years are 1992-1994 for municipalities outside of Vermont and 1996-1997 for Vermont municipalities.

Figure 3: State and Regional Area Protected Over Time, by Land Protection Type.



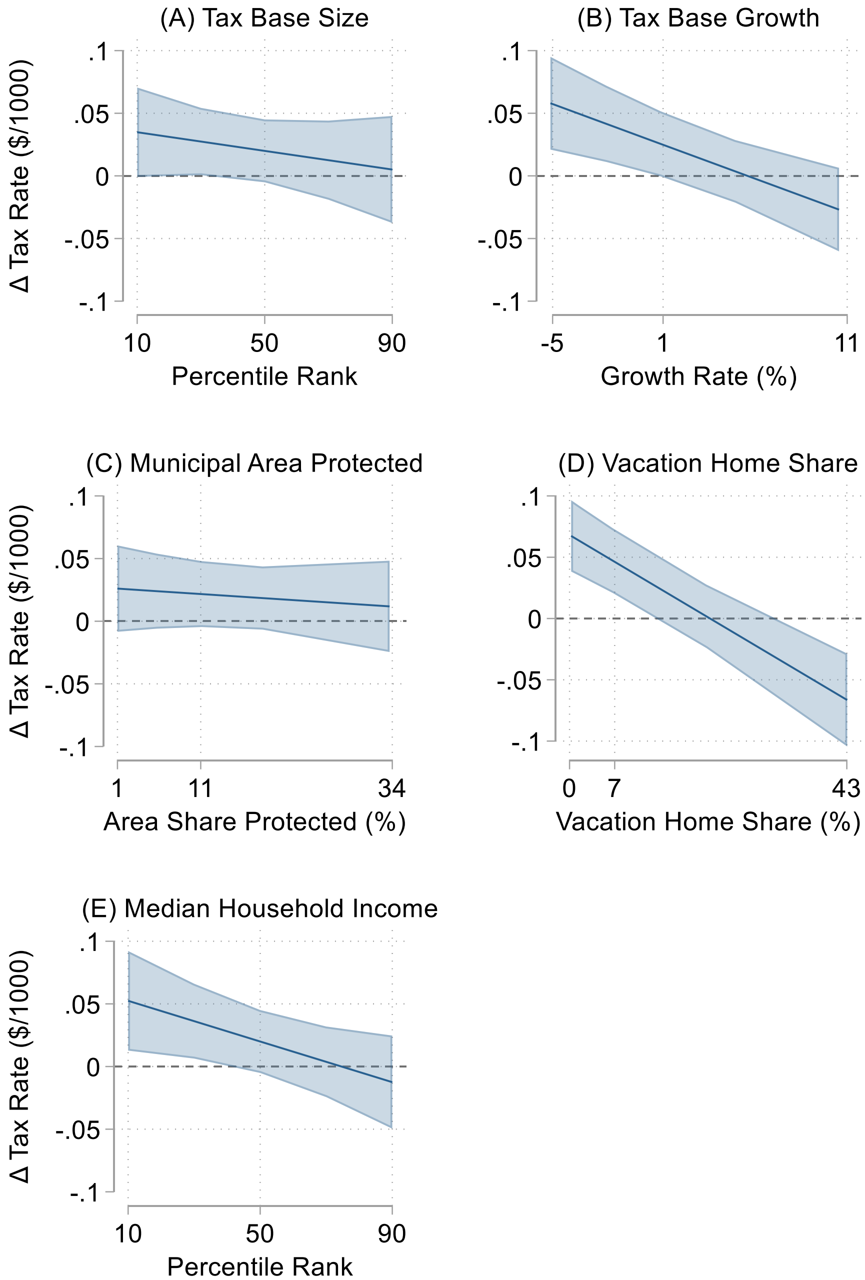
Notes: Figure 3 shows the percent of state and regional area protected in 1990 within our study area, and the change in percent area protected between 1990 and 2015, by land protection type and in total.

Figure 4: Heterogeneity in Impacts of New Land Protection on Tax Rates, Single Interaction Models



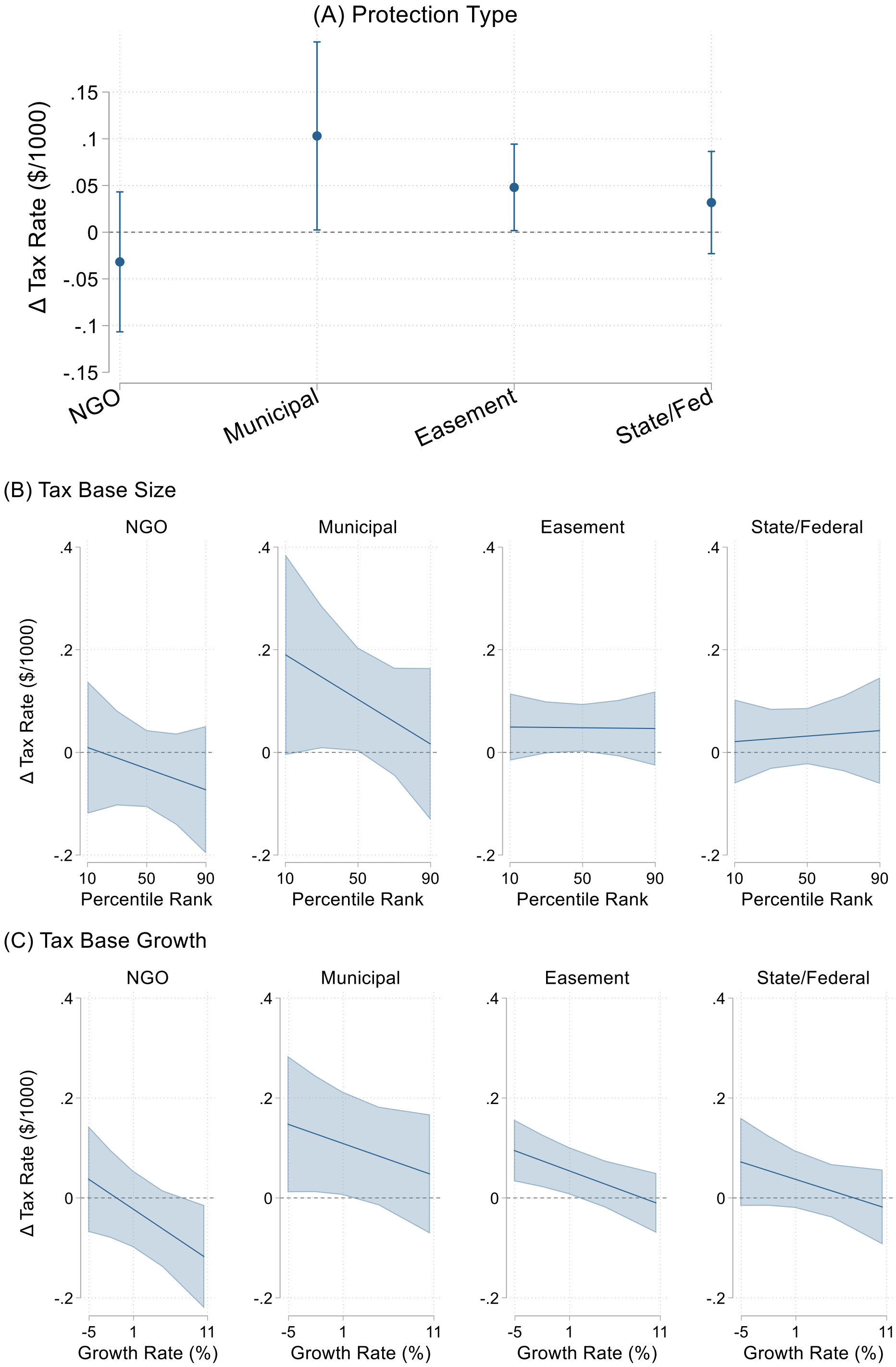
Notes: Plots A-H show heterogeneity in the estimated impacts of new land protection on equalized tax rates, by protection type and municipal characteristics. The plots present the expected change in the average annual equalized tax rate change for a 1 percentage point increase in the annual municipal area share protected in the prior time-period. The expected changes are back transformed estimates based on Equation 2 with the addition of interaction terms; see also Appendix Table A4 for numerical results and Appendix B for explanation of back transformation. Tax rate change estimates are evaluated at 10^{th}-90^{th} percentile values of the variables used in the interaction, in the case of continuous variables, while holding other variables at their means. The 10^{th}, 50^{th} and 90^{th} percentile values of the individual terms being evaluated are labeled on the X axes.

Figure 5: Heterogeneity in Impacts of New Land Protection on Tax Rates, Multiple Interaction Model

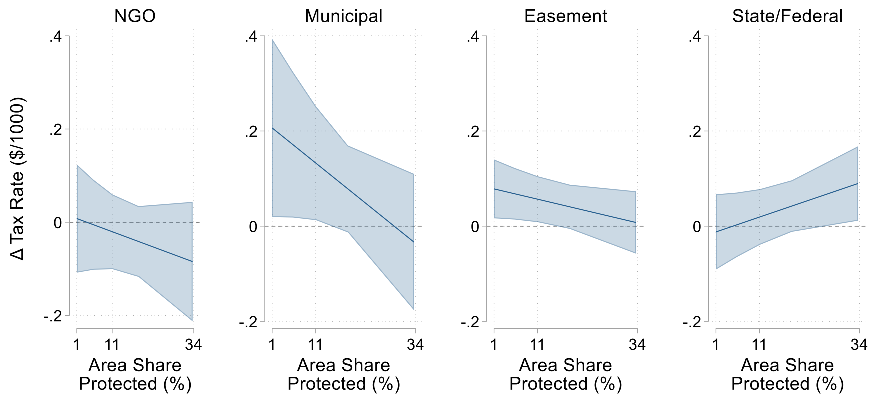


Notes: Plots A-E show heterogeneity in the estimated impacts of new land protection on equalized tax rates with respect to the municipal characteristics included in the multiple term interaction model. These plots present expected change in the average annual equalized tax rate change for a 1 percentage point increase in the annual municipal area share protected in the prior time-period. See Appendix B for explanation of back transformation. Tax rate change estimates are evaluated at 10th-90th percentile values of the variables used in the interaction while holding other variables at their means. The 10th, 50th and 90th percentile values of the individual term being evaluated is labeled on the X axes. See Appendix Table A5 for the interaction model coefficients used to compute these changes and Table A6 for the numerical results plotted here.

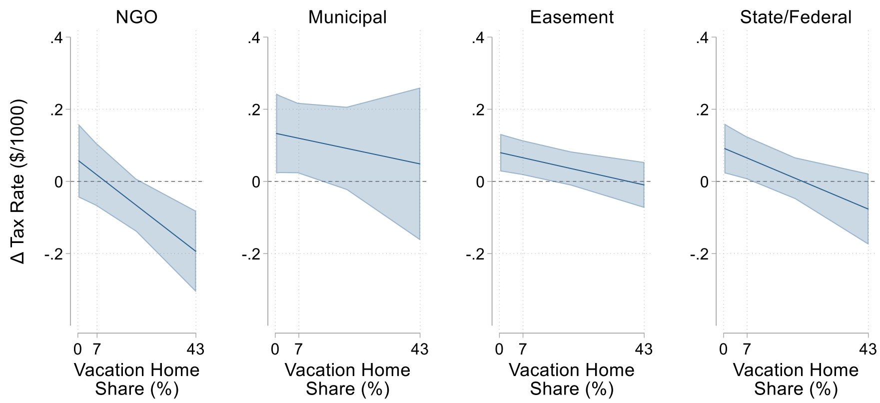
Figure 6: Heterogeneity in Impact of New Land Protection on Tax Rates by Land Protection Types, Multiple Interaction Model



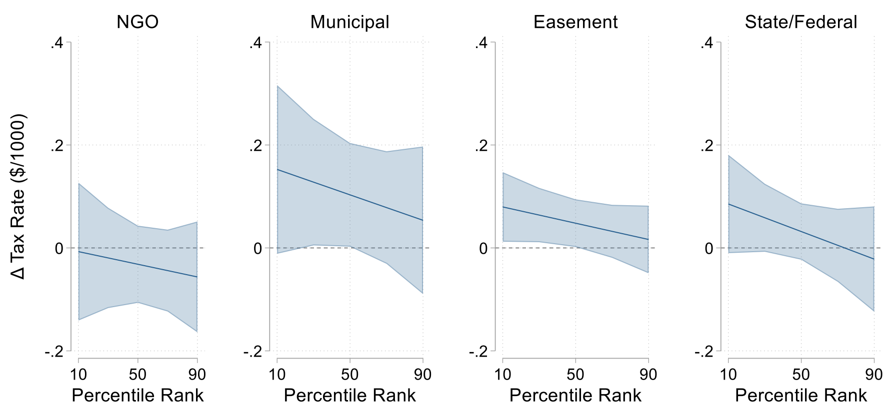
(D) Municipal Area Protected



(E) Vacation Home Share in 1990



(F) Median Household Income in 1990



Notes: Figures A-F show how the tax impacts of land protection vary by protection type and with respect to individual terms included in the multiple term interaction model. These figures present expected change in the average annual equalized tax rate change for a 1 percentage point increase in the annual municipal area share protected by a given type of land protection, in the prior time-period. See Appendix B for explanation of back transformation. Tax rate change estimates are evaluated at 10th-90th percentile values of the variables used in the interaction while holding other variables at their means. The 10th, 50th and 90th percentile values of the individual term being evaluated is labeled on the X axes. See Appendix Table A7 for the interaction model coefficients used to compute these changes and Table A8 for the numerical results plotted here.

Table 1: Summary Statistics for Differenced and Level Variables

	Obs.	Towns	Time Period	Units	*Level Variables* Mean	SD	Units	*Differenced Variables* Mean	SD
Fiscal Variables (Regional Sample)									
Tax rate, equalized	9581	1436	1994-2015	$/$1000 value	11.17	5.61	$/$1000 value	0.0690	0.6318
Tax rate, nominal	9581	1436	1994-2015	$/$1000 value	13.04	7.55	$/$1000 value	0.0705	0.8177
Ln equalized value	9581	1436	1994-2015	Ln(dollars)	19.74	1.59	ΔLn (dollars)	0.0196	0.0551
Ln assessed value	9581	1436	1994-2015	Ln(dollars)	19.61	1.58	ΔLn (dollars)	0.0204	0.0642
Ln property tax levy	9581	1436	1994-2015	Ln(dollars)	15.09	1.79	ΔLn (dollars)	0.0251	0.0467
Ln municipal revenues (CT,MA)	9581	519	1994-2015	Ln(dollars)	17.21	1.34	ΔLn (dollars)	0.0205	0.0242
Ln municipal expenditures (CT,MA)	9581	519	1994-2015	Ln(dollars)	17.10	1.34	ΔLn (dollars)	0.0200	0.0275
Land Protection									
Total land protected as of prior time period	9581	1436	1991-2012	% town area	15.68	15.12	% town area	0.2325	0.5033
Ngo protection as of prior time period	9581	1436	1991-2012	% town area	1.80	3.48	% town area	0.0347	0.1234
Municipal protection as of prior time period	9581	1436	1991-2012	% town area	3.27	5.09	% town area	0.0230	0.0854
Easement protection as of prior time period	9581	1436	1991-2012	% town area	2.80	5.35	% town area	0.0987	0.2813
State/federal protection as of prior time period	9581	1436	1991-2012	% town area	7.55	13.17	% town area	0.0445	0.1841
Current Use Value									
Land share in current use in 2010 (No MA)	7140	1086	2010	% town area	35.90	22.15	–	–	–
Value share of land in current use in 2010 (MA)	2447	350	2010	% taxable value	0.17	0.24	–	–	–
Socioeconomic Variables									
Unemployment rate, prior time period	9581	1436	1991-2012	percent	5.34	2.94	percent	-0.0177	0.8099
Labor force, prior time period	9581	1436	1991-2012	labor force/acre	0.43	1.15	labor force/acre	0.0010	0.0091
Municipal Characteristics									
Municipal area	1436	1436	2010	acres	19927.72	10647.26	–	–	–
Median household income	1436	1436	1990	USD, thousands	62.50	21.20	–	–	–
Vacation home share	1436	1436	1990	percent	15.42	18.37	–	–	–
Urban municipality	1436	1436	1990	0/1	0.13	0.34	–	–	–
Exurban municipality	1436	1436	1990	0/1	0.35	0.48	–	–	–
Rural municipality	1436	1436	1990	0/1	0.52	0.50	–	–	–

Notes: Summary statistics showing average values and standard deviation for level and differenced variables at the three-year analysis time period. Level variables represent average values within three-year time periods used in the analysis, while differenced variables represent annual differences averaged over three years.

Table 2: Expected Changes in Tax Obligations by Protection Type

Protection Type	**Pre-Protection Taxation Regime**	**Property Value Removed from Tax Base**	**Payments that Offset Lost Property Tax Revenues**
1) NGO Fee Acquisition	Market Value Assessment	Total Taxable Value	Sometimes[1]
2) Municipal Fee Acquisition	Market Value Assessment	Total Taxable Value	No
3) Easement on Private Land	Market Value Assessment	Partial Taxable Value	No
4) State/Federal Fee Acquisition	Market Value Assessment	Total Taxable Value	Yes[2]
1) NGO Fee Acquisition	Current Use Assessment	Current Use Value	Sometimes[1]
2) Municipal Fee Acquisition	Current Use Assessment	Current Use Value	No
3) Easement on Private Land	Current Use Assessment	Little to No Additional Impact	Sometimes[3]
4) State/Federal Fee Acquisition	Current Use Assessment	Current Use Value	Yes[2]

Notes: This table describes the expected first order fiscal impacts associated with each land protection type and pre-protection taxation regime of the land.
[1]Sometimes land trusts choose to make voluntary payments in lieu of taxes to municipalities to offset the property tax revenue loss resulting from their land acquisition. They are not required to do so however and there is not a systematic way of knowing who is making such contributions.
[2]The federal government and all states except for Maine make compensating payments in lieu of taxes to municipalities for state/federal owned land.
[3]Vermont compensates municipalities for lost property tax revenue due to current use valuation. Towns are compensated for the municipal portion of property tax revenue lost due to the difference in market and current use valuation (Vermont Department of Forests, Parks and Recreation 2010). If an easement decreases the market value of property in current use, that will reduce state payments to the town. Maine compensates municipalities 90% of lost property tax revenue due to current use, but only for losses related to the forestry focused Tree Growth program (Maine Revenue Services 2020), which accounts for about 90% land in current use in Maine(Maine Revenue Services 2010). Easements don't affect compensation to towns for land in Tree Growth current use because payments are based on the difference between current use value and value of undeveloped land in the region, not the specific parcel that an easement is placed on (Maine Revenue Services 2020). In Massachusetts, Connecticut, and New Hampshire, municipalities carry the cost of lost property tax revenue due to current use without compensation from the state.

Table 3: Estimated Changes in Municipal Equalized Tax Rates as a Function of Lagged Changes in Land Protected

Estimates	ΔTaxRate$_t$ (1)	ΔTaxRate$_t$ (2)	ΔTaxRate$_t$ (3)	ΔTaxRate$_t$ (4)	ΔTaxRate$_t$ (5)	ΔTaxRate$_t$ (6)	ΔTaxRate$_t$ (7)
Δ % Protected $_{t-1}$	-0.0149	-0.0046	0.0318***	0.0241**	0.0241**	0.0239**	0.0231**
	(0.0139)	(0.0142)	(0.0122)	(0.0110)	(0.0110)	(0.0110)	(0.0110)
Δ Unemp. Rate $_{t-1}$					0.0036	0.0028	-0.0018
					(0.0120)	(0.0120)	(0.0119)
Δ Labor Force/Acre $_{t-1}$						-2.9391***	-3.3438***
						(0.4653)	(0.4616)
% Tax Base Growth $_{t-1}$							0.0126***
							(0.0013)
N	9581	9581	9581	9581	9581	9581	9581
R^2_{adj}	-0.0000	0.0979	0.3495	0.4368	0.4367	0.4388	0.4453
Municipalities	1436	1436	1436	1436	1436	1436	1436
CBSATrends	No	Yes	Yes	Yes	Yes	Yes	Yes
Time Period FE	No	No	Yes	No	No	No	No
State-By-Time-Period FE	No	No	No	Yes	Yes	Yes	Yes

Notes: Stepwise addition of controls. Column 1 indicates marginal effects from a regression of the Ihs transformed change in tax rate on the Ihs transformed lagged change in land protection without any controls. Column 2 adds CBSA time trends. Column 3 includes time-period fixed effects. In column 4, time-period fixed effects are replaced by state-by-time-period fixed effects. In columns 5 and 6, Ihs transformed lagged average changes in labor force per acre and unemployment rate are added as controls. In column 7, we add lagged average tax base growth (%) as an additional control. Column 7 corresponds to the preferred main specification (Equation 2). Table values are the estimated change in average annual equalized tax rate change ($/$1000 value) due to a one percentage point increase in prior period average annual municipal area share protected. Back transformation as described in Appendix B is used to calculate these values and the estimated standard errors. Standard errors in parentheses, clustered by municipality *p<0.1; **p<0.05; ***p<0.01

Table 4: Average Impacts of Land Protection on Municipal Tax Rates

	New England	CT	MA	NH	VT	ME
	(1)	(2)	(3)	(4)	(5)	(6)
Estimates	$\Delta TaxRate_t$	$\Delta TaxRate_t$	$\Delta TaxRate_t$	$\Delta TaxRate_{t\,t}$	$\Delta TaxRate_t$	$\Delta TaxRate_t$
Δ % Protected $_{t-1}$	0.0231**	0.0301	0.0266	0.0546***	0.0292*	-0.0513
	(0.0110)	(0.0674)	(0.0200)	(0.0196)	(0.0159)	(0.0318)
N	9581	1010	2447	1577	1425	3122
R^2_{adj}	0.4453	0.5223	0.5919	0.2837	0.2118	0.3831
Municipalities	1436	169	350	230	241	446
LaborMarketControls	Yes	Yes	Yes	Yes	Yes	Yes
State-By-Time-Period FE	Yes	No	No	No	No	No
Time-Period FE	No	Yes	Yes	Yes	Yes	Yes
CBSATrends	Yes	Yes	Yes	Yes	Yes	Yes
TaxBaseGrowth	Yes	Yes	Yes	Yes	Yes	Yes
Estimated Change in Tax Bill						
Tax-Bill Change for 100 Acres, per $100,000 of Value	$1.16	$1.64	$1.87	$2.39	$1.25	$-2.35
Relevant Values						
1% of Avg Municipal Area	199.28	183.31	142.42	227.81	234.33	218.60
Annual Non-Zero Change in Acres Protected	84.88	44.51	54.15	118.48	175.63	76.53
Equalized Tax Rate, Dollars per $1000 of Value	$11.17	$17.74	$12.59	$5.17	$5.03	$13.76
Typical Home Value, Dollars	$259,045	$280,227	$356,320	$246,091	$231,829	$194,915
Municipal Typical Tax Bill, Dollars	$2892.97	$4971.91	$4485.41	$1272.86	$1166.33	$2681.48

Notes: Top section of table shows the estimated changes in average annual equalized tax rate change ($/$1000 value) due to a one percentage point increase in the prior period average annual municipal area share protected, for our New England study region and by state. These estimated slopes and standard errors are obtained by estimating Equation 2 and back transforming as described in Appendix B. Control variables include the prior period Ihs transformed average changes in labor force per acre and unemployment rate, average prior period tax base growth (%), time-period or state-by-time-period fixed effects, and linear CBSA specific time trends. Standard errors in parentheses, clustered by municipality. *p<0.1; **p<0.05; ***p<0.01.

Bottom section of table presents the corresponding estimated annual property tax bill change associated with 100 acres of new land protection per year. The tax bill change is calculated by (1) adjusting estimated slopes to obtain the tax rate change per thousand dollars of taxable value for 100 acres of new protection and (2) multiplying the tax rate change (which is per $1000) by 100 to get tax bill change per $100,000 of value. Using column 1 as an example, where a 1 percentage point change in area is 199.28 acres, the adjustment factor is 100/199.28 = 0.5018. Tax Bill Change = 0.5018 * 0.0231 * 100 = $1.16 per $100,000 of taxable value. Typical home values by state (Zillow ZHVI index, mean of 35^{th}-65^{th} percentile home values) help to understand the magnitude of the tax bill change for the typical homeowner.

Table 5: Impact of Land Protection on Fiscal Outcomes.

	ΔLn Expenditure$_t$ (1)	ΔLn Revenues$_t$ (2)	ΔLn Levy$_t$ (3)	ΔLn AssdVal$_t$ (4)	ΔLn EqlVal$_t$ (5)
MA & CT Only					
Δ % Protected$_{t-1}$	0.0024*	0.0018	0.0016*	-0.0009	-0.0012
	(0.0013)	(0.0012)	(0.0009)	(0.0017)	(0.0017)
Change for 100 acre annual increase in protection	$43,610	$35,647	$19,298	$-636,934	$-1,091503
Observations	3457	3457	3457	3457	3457
R^2_{adj}	0.2442	0.2746	0.2656	0.6627	0.7122
All States					
Δ % Protected$_{t-1}$	–	–	0.0021	-0.0023	-0.0011
			(0.0014)	(0.0016)	(0.0009)
Change for 100 acre annual increase in protection	–	–	$3,812	$-389,716	$-213,133
Observations	–	–	9581	9581	9581
R^2_{adj}			0.1273	0.3997	0.6741
LaborMarketControls	Yes	Yes	Yes	Yes	Yes
State-By-Time-Period FE	Yes	Yes	Yes	Yes	Yes
CBSATrends	Yes	Yes	Yes	Yes	Yes
Tax Base Growth	Yes	Yes	Yes	Yes	Yes

Note: This table shows the estimated predicted change in the average annual log difference for a one percentage point increase in prior period average annual municipal area share protected. These estimated marginal effects, standard errors and the corresponding dollar changes are obtained by estimating Equation 3 and back transforming coefficients as described in Appendix B. Marginal effects in $ are evaluated at the mean values of fiscal outcomes and lagged land protection for a 100 acre increase in annual land protection.

The same control variables are used in all Table 5 regressions: Ihs transformations of the prior period average changes in labor force per acre and unemployment rate, average prior period tax base growth (%), state-by-time-period fixed effects, and linear CBSA specific time trends. Change in revenues and expenditures are outcomes from municipal budgets and are available only for MA & CT, while changes in the municipal levy, assessed values and equalized values are available for all states. Standard errors are in parentheses, clustered by municipality. *p<0.1; **p<0.05; ***p<0.01

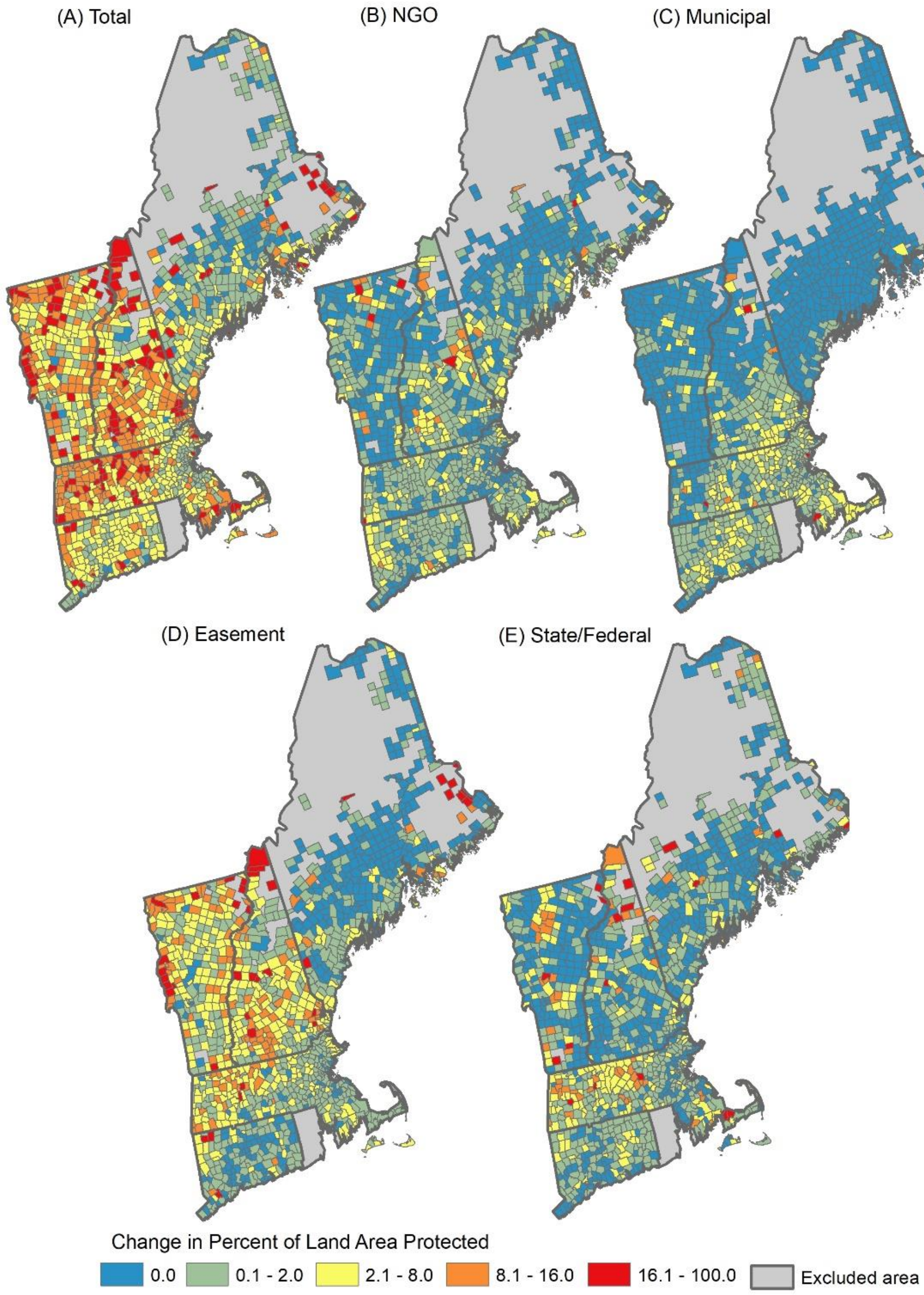
Table 6: Impact of Land Protection Over Time

	$\Delta TaxRate_t$ (1)	$\Delta TaxRate_t$ (2)	$\Delta TaxRate_t$ (3)
3 Yr Lag: Δ % Protected$_{t-1}$	0.0231**	0.0145	0.0151
	(0.0110)	(0.0124)	(0.0137)
6 Yr Lag: Δ % Protected$_{t-2}$		-0.0129	-0.0089
		(0.0118)	(0.0138)
9 Yr Lag: Δ % Protected$_{t-3}$			0.0006
			(0.0124)
N	9581	7989	6398
R^2_{adj}	0.4453	0.4645	0.4911
LaborMarketControls	Yes	Yes	Yes
State-By-Time-Period FE	Yes	Yes	Yes
CBSATrends	Yes	Yes	Yes
TaxBaseGrowthControl	Yes	Yes	Yes

Notes: Estimated slopes show the change in average annual equalized tax rate change ($/$1000 value) due to a one percentage point increase in prior period average annual municipal area share protected as well as in additional lagged periods. The 3-year lag is the standard lag used in our analysis and represents the average change in the prior time period. The 6- and 9-year lags represent average change in protection two and three time periods prior. These slopes and standard errors are obtained by estimating Equation 4 and then back transforming as described in Appendix B. Control variables include the Ihs transformations of the prior period average changes in labor force per acre and unemployment rate, average prior period tax base growth (%), state-by-time-period fixed effects and linear CBSA specific time trends. Standard errors in parentheses, clustered by municipality. *p<0.1; **p<0.05; ***p<0.01

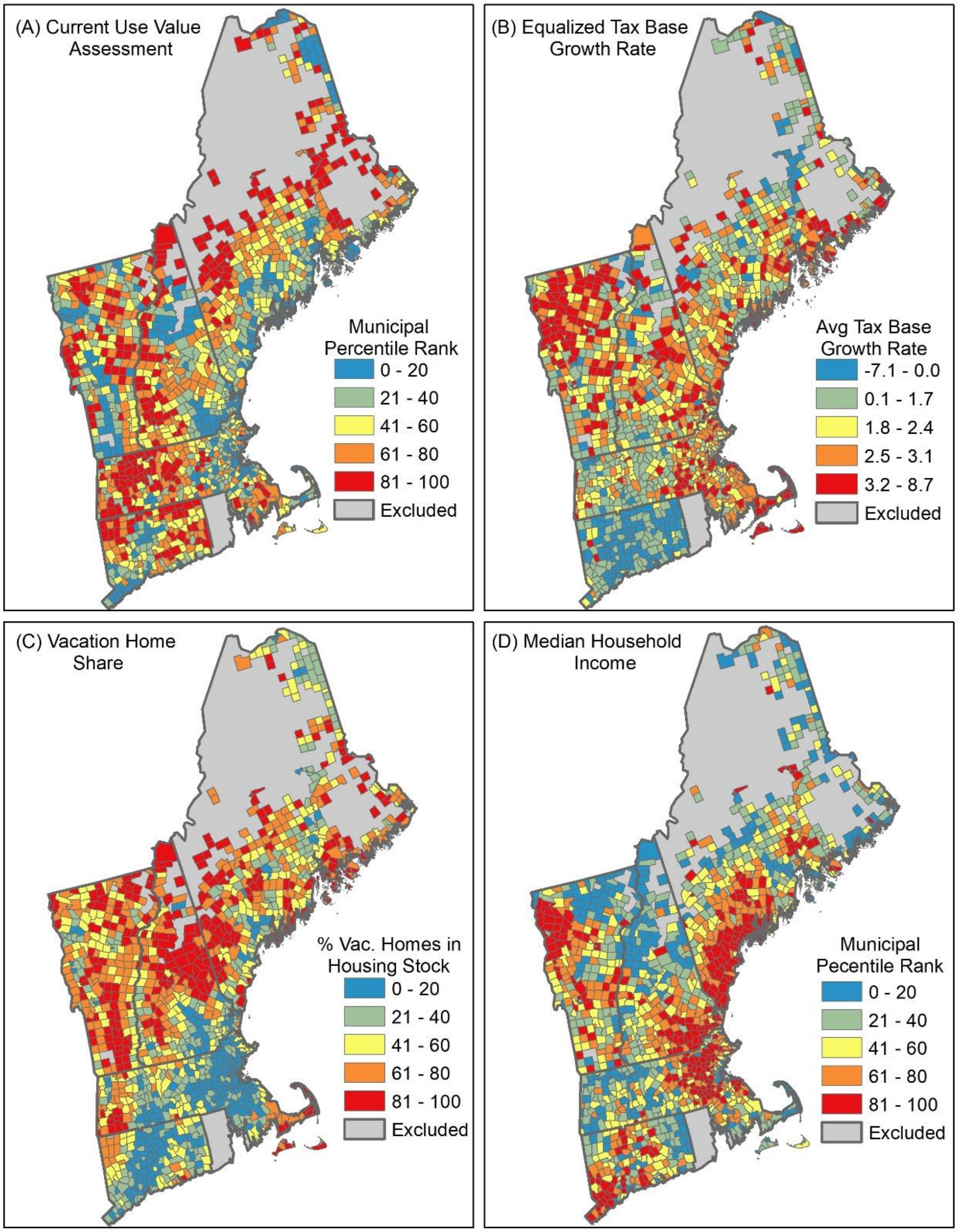
Appendix A: Supplemental Figures and Tables

Figure A1: Change in Land Protection and Land Cover by Type, 1990-2015



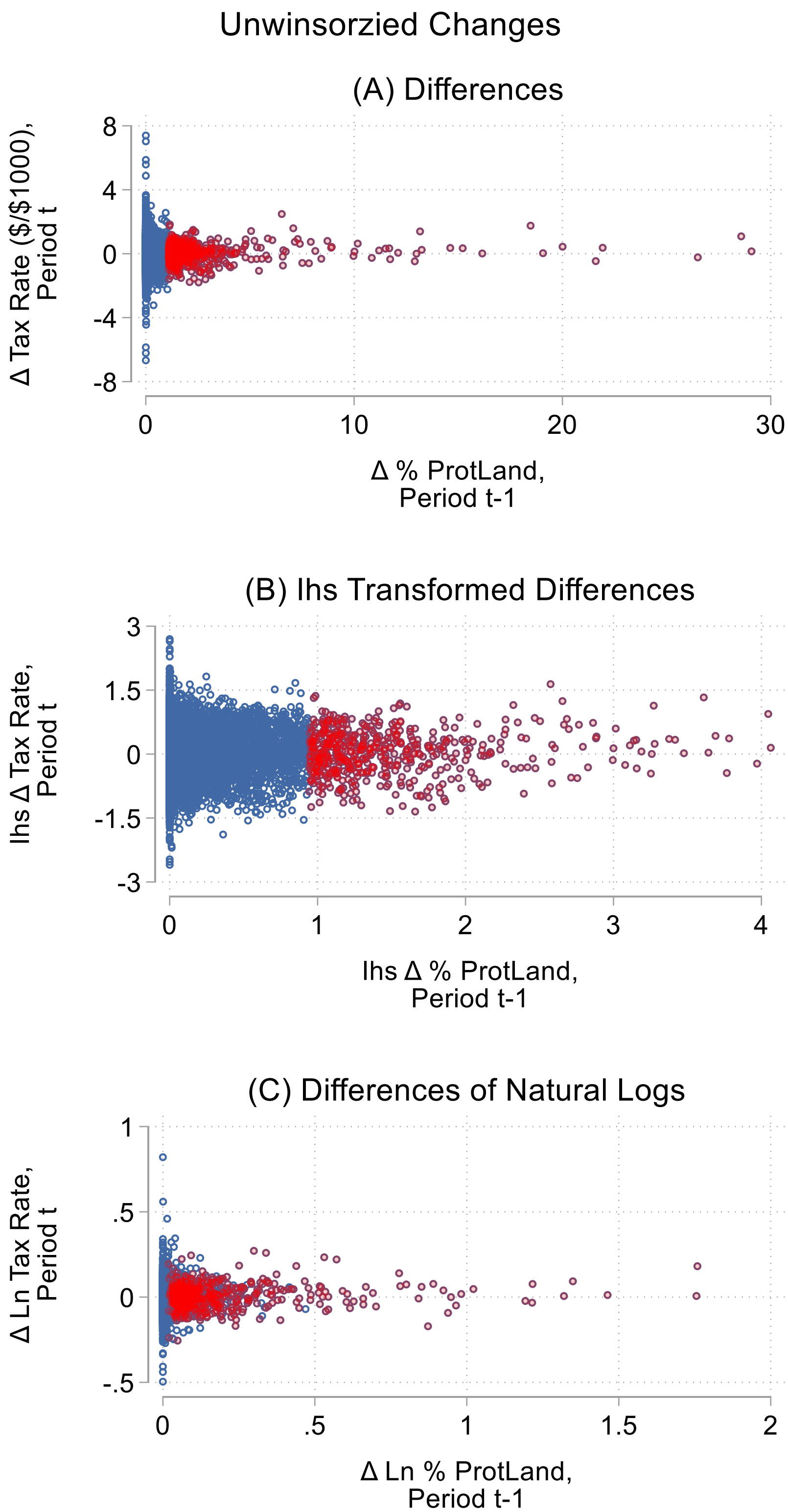
Notes: Change in protected land between 1990 and 2015 is shown as percentage of area in a municipality, disaggregated by type. Subfigure (A) shows total change in protected land, while Subfigures B-D show changes for mutually exclusive categories of protection: (B) land owned in fee by NGOs (C) land owned in fee by municipalities (D) easements on private land (E) land owned in fee by state/federal govt. See Appendix B for description of municipalities excluded from the study area.

Figure A2: Municipal Characteristics

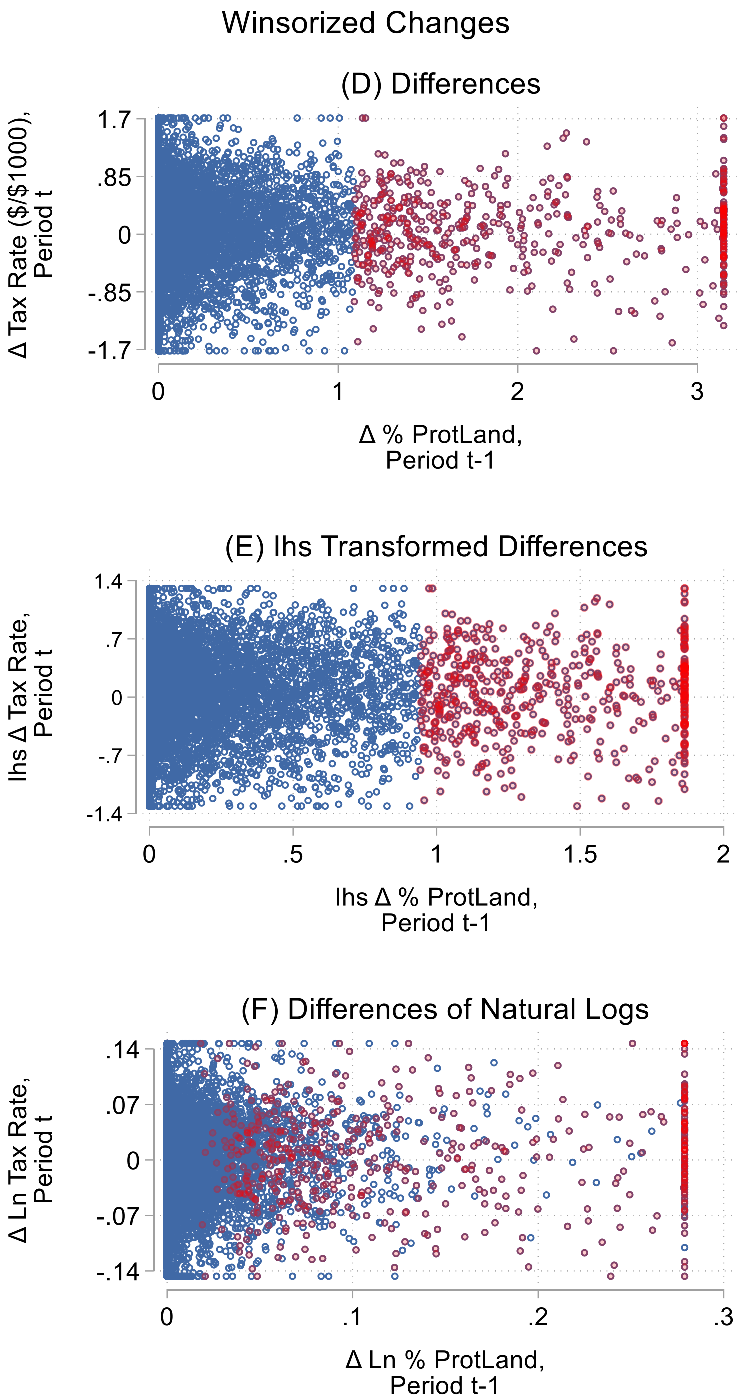


Notes: Municipal characteristic include (A) within state percentile rank for municipalities based on amount of land under current use assessment in 2010 (B) average annual tax base growth from 1992-2012 based on average annual changes from three-year analysis time periods used in estimation (C) percent of housing stock made up by vacation homes in 1990 and (D) within state percentile rank for municipalities based on median household income in 1990. See Appendix B for description of these variables.

Figure A3: Changes in the Tax Rate vs Changes in Land Protection



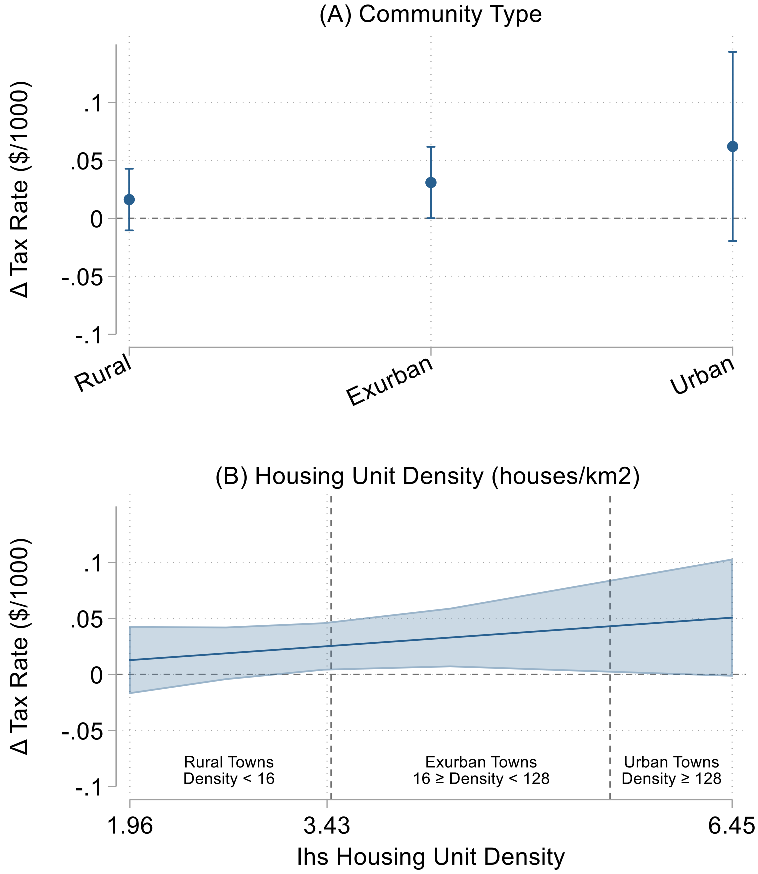
Note:(1) Red points represent top 10% of non-zero, untransformed 3 year average changes in land protection. (2) Changes are unwinsorized



Note: (1) Red points represent top 10% of 3 year average untransformed changes in land protection. (2) The changes are winsorized at the 1st and 99th percentiles for the tax rate and 99th percentile for land protection

Notes: Figure A3 plots three-year averages of annual changes in equalized tax rates against average annual changes in lagged municipal area share protected to show the impact of winsorizing variables and to compare distributions of the untransformed changes with two transformations: (i) taking the Ihs transformation of the average change and (ii) taking the average of natural log differences. The Ihs transformation compresses outliers while maintaining rank order of individual changes; natural log differences compress outliers but do not maintain rank order.

Figure A4: Comparison of Housing Density Continuous and Categorical Variables



Notes: Figure A4 plots the estimated slopes from single interaction models with housing density, comparing results between discrete density categories (Rural, Exurban, Urban) based on density thresholds and a continuous density variable (see Table A16 for slopes and standard errors). The continuous density variable is Ihs transformed and the x axis in plot B shows the Ihs transformed values of housing density (10^{th}, 50^{th} and 95^{th} percentiles). Vertical lines indicate the density thresholds (houses/km^2) for classifying towns into categories that describe rural, exurban and urban community types.

Table A1: Fiscal Variable Definitions

State	Definition
Nominal Property Tax Rate	***Rate of taxation levied on property ($/$1000 of value)***
CT, ME	Single property tax rate
MA	Residential property class tax rate
NH, VT	Municipal portion of the property tax rate
Property Tax Levy	***Property taxes collected by a municipality***
ME, CT, MA	Total property tax levy collected.
VT, NH	Tax levy collected for municipal purposes only (excludes school funding).
Assessed Values	***Value of all taxable municipal property in a municipality, as valued by town assessor***
CT, ME, NH, VT, MA	Sum of all taxable property value. Note, in CT, property is assessed at 70% of market value.
Equalized Value	***Fair market value (FMV) of all taxable property in a municipality.***
ME, NH, CT, VT, MA	FMV of all taxable property
Equalized Property Tax Rate	***Tax levy divided by the fair market value of taxable property in a municipality***
CT, ME	Total property tax levy as share of FMV
MA	Residential property tax levy as share of FMV
NH,VT	Municipal levy as share of FMV. Equalized municipal tax rate in NH is constructed by multiplying the nominal municipal share tax rate by assessed property value to obtain the municipal levy share, and then dividing that by the equalized value. Vermont equalized tax rates are published in annual reports by Department of Taxes.
Municipal Revenues & Expenditures	***Municipal budget revenues and expenditures***
CT, MA	Municipal annual revenues & expenditures

Table A2: Number of Municipalities in Estimation Sample by State and 3-Year time Period, for Tax Outcomes

	CT	MA	ME	NH	VT	Total
1994-1997	167	348	446	226	-	1,187
1997-2000	169	349	446	222	237	1,423
2000-2003	169	350	446	224	237	1,426
2003-2006	-	350	446	225	238	1,259
2006-2009	168	350	446	225	237	1,426
2009-2012	168	350	446	227	239	1,430
2012-2015	169	350	446	228	237	1,430
Total	1,010	2,447	3,122	1,577	1,425	9,581

Notes: A summary of municipal observations used in our main estimates that utilize three-year averages of first differenced variables. The count of municipalities is shown by state and time period. Our panel is unbalanced due to some observations dropped in dataset cleaning and construction, as described in Appendix B. While there are 1436 municipalities in our analysis – individual time periods have fewer municipalities due to towns dropping out from some time periods. Note that 1991-1994 data are used to construct the lagged explanatory variables for the 1994-1997 period and are not shown separately, because they don’t contribute to the observation count.

Table A3: Correlations Between Model Variables

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
(1) Ln Housing Density, 1990	1.000												
(2) Curr Use Pcile, 2010	-0.507	1.000											
(3) Tax Base Pcile, First Period	0.731	-0.629	1.000										
(4) Area % Protected $_{t-1}$	0.013	-0.090	-0.160	1.000									
(5) Tax Base Growth $_{t-1}$	-0.036	-0.010	0.001	0.008	1.000								
(6) Household Income Pcile, 1990	0.135	-0.165	0.338	-0.024	0.042	1.000							
(7) Vacation Home Share %, 1990	-0.439	0.124	-0.197	0.145	0.075	-0.197	1.000						
(8) Ihs Eq. Tax Rate $_{t-1}$	0.264	0.026	-0.004	-0.205	-0.156	-0.070	-0.394	1.000					
(9) Ihs Δ Protected $_{t-1}$	-0.045	0.123	-0.099	0.110	0.049	-0.007	0.043	-0.160	1.000				
(10) Ihs Δ NGO Protected $_{t-1}$	-0.004	0.044	-0.009	0.054	0.050	0.017	0.058	-0.043	0.427	1.000			
(11) Ihs Δ Municipal Protected $_{t-1}$	0.185	-0.038	0.063	0.057	0.074	0.084	-0.111	0.023	0.300	0.045	1.000		
(12) Ihs Δ Easement Protected $_{t-1}$	-0.106	0.141	-0.079	0.067	0.016	-0.003	0.059	-0.234	0.696	0.067	0.005	1.000	
(13) Ihs Δ State/Fed Protected $_{t-1}$	-0.022	0.059	-0.118	0.087	0.011	-0.051	0.002	0.030	0.531	0.037	0.013	0.067	1.000

Notes: This table presents correlations between variables used to estimate single interaction models. Correlations are based on three-year time periods. These correlations are used as a guide for selecting variables for the multiple interaction models.

Table A4: Heterogeneity in Tax Rate Impacts by Municipal Characteristics

	Prot Type	Current Use	Tax Base	Tax Base Growth	Comm. Type	Share Protected	Vac. Homes	Median Income	Lagged Tax Rate
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Δ%NGO Prot. $_{t-1}$	-0.0525								
	(0.0348)								
Δ%Municipal Prot.$_{t-1}$	0.0722*								
	(0.0416)								
Δ%Easement Prot.$_{t-1}$	0.0356**								
	(0.0172)								
Δ%State/Fed Prot.$_{t-1}$	0.0305								
	(0.0270)								
Δ%Prot.$_{t-1}$		0.0566**	0.0224	0.0388***		0.0372**	0.0671***	0.0392*	0.1463***
		(0.0265)	(0.0196)	(0.0123)		(0.0171)	(0.0147)	(0.0210)	(0.0437)
Δ%Prot.$_{t-1}$# Current Use Pcile		-0.0010**							
		(0.0004)							
Δ%Prot.$_{t-1}$# Tax Base Pcile			0.0000						
			(0.0004)						
Δ%Prot.$_{t-1}$# Tax Base Growth $_{t-1}$				-0.0061***					
				(0.0016)					
Δ%Prot.$_{t-1}$# Rural					0.0162				
					(0.0136)				
Δ%Prot.$_{t-}$ # Exurban					0.0309**				
					(0.0157)				
Δ%Prot.$_{t-1}$# Urban					0.0620				
					(0.0416)				
Δ%Prot.$_{t-1}$# Area % Protected $_{t-1}$						-0.0008			
						(0.0007)			
Δ%Prot.$_{t-1}$# Vacation Home Share %							-0.0021***		
							(0.0004)		
Δ%Prot.$_{t-1}$# Median Income Pcile								-0.0003	
								(0.0003)	
Δ%Prot.$_{t-1}$# Ihs Tax Rate $_{t-1}$									-0.0458***
									(0.0170)
Tax Base Growth $_{t-1}$	0.0058***	0.0062***	0.0058***	0.0064***	0.0058***	0.0058***	0.0059***	0.0059***	0.0058***
	(0.0006)	(0.0008)	(0.0006)	(0.0006)	(0.0006)	(0.0006)	(0.0006)	(0.0006)	(0.0006)
N	9581	5545	9581	9581	9581	9581	9581	9581	9581
R2_adj	0.4454	0.5147	0.4453	0.4459	0.4453	0.4453	0.4461	0.4453	0.4457
LaborMarketControls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State-By-Time-Period FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CBSATrends	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
TaxBaseGrowth	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: This table shows heterogeneity in tax impacts by protection type and across local economic conditions. The slope estimates are interpreted as the change in average annual equalized tax rate change ($/$1000 value) due to a one percentage point increase in prior period average annual municipal area share protected. These slopes and standard errors are obtained by estimating variations of Equation 2 and back transforming coefficients as described in Appendix B. Control variables include the Ihs transformations of the prior period average changes in labor force per acre and unemployment rate, average prior period tax base growth (%), state-by-time-period fixed effects and linear CBSA specific time trends. The "#" symbol indicates an interaction term. Standard errors in parentheses, clustered by municipality. *p<0.1; **p<0.05; ***p<0.01.

Table A5: Multiple Interaction Model with Total Land Protection Change

	Ihs∆TaxRate
Tax Base Growth $_{t-1}$	0.0244***
	(0.0059)
Tax Base Growth $_{t-1}$ # Area % Protected $_{t-1}$	0.0000
	(0.0001)
Tax Base Growth $_{t-1}$ # Tax Base Pcile	0.0001***
	(0.0000)
Tax Base Growth $_{t-1}$ # Vacation Home Share %	0.0000
	(0.0000)
Tax Base Growth $_{t-1}$ # Income Pcile	0.0001***
	(0.0000)
Tax Base Growth $_{t-1}$ # Ihs Tax Rate $_{t-1}$	-0.0068***
	(0.0017)
Tax Base Growth $_{t-1}$ # Area % Protected $_{t-1}$ # Tax Base Pcile # Vacation Home Share % # Income Pcile # Ihs Eq. Tax Rate $_{t-1}$	-0.0000**
	(0.0000)
Ihs ∆ % Protected $_{t-1}$	0.3832***
	(0.0658)
Ihs ∆ % Protected $_{t-1}$ # Tax Base Pcile	-0.0004
	(0.0004)
Ihs ∆ % Protected $_{t-1}$ # Tax Base Growth $_{t-1}$	-0.0058***
	(0.0018)
Ihs ∆ % Protected $_{t-1}$ # Vacation Home Share %	-0.0032***
	(0.0005)
Ihs ∆ % Protected $_{t-1}$ # Area % Protected $_{t-1}$	-0.0005
	(0.0008)
Ihs ∆ % Protected $_{t-1}$ # Income Pcile	-0.0008**
	(0.0004)
Ihs ∆ % Protected $_{t-1}$ # Ihs Tax Rate $_{t-1}$	-0.0796***
	(0.0193)
Ihs ∆ % Protected $_{t-1}$ # Tax Base Pcile # Tax Base Growth $_{t-1}$ # Area % Protected # Vacation Home Share % # Income Pcile # Ihs Tax Rate $_{t-1}$	0.0000
	(0.0000)
Observations	9581
R^2_{adj}	0.4505
LaborMarketControls	Yes

State-By-Time-Period FE	Yes
CBSATrends	Yes

Notes: This table presents estimates from the multiple interaction model between total change in land protection and measures of local economic conditions described in Section 4.2. The outcome variable is the Ihs transformed average annual change in the equalized property tax rate. The explanatory variables of interest are the interactions of the Ihs transformed average annual change in municipal area share protected in the prior time period with variables that capture local economic conditions. The coefficients on change in land protection and its interactions are not back transformed. The "#" indicates an interaction term. Variation in impact of land protection by type with respect to the interaction variables is estimated and plotted in Figure 5 and summarized in Table A6. Control variables include the Ihs transformations of the prior period average changes in labor force per acre and unemployment rate. Additional controls include average prior period tax base growth (%), the Ihs of prior period equalized tax rate that is included as an interaction term, state-by-time-period fixed effects and linear CBSA specific time trend. Standard errors are shown in parentheses, clustered by municipality. *p<0.1; **p<0.05; ***p<0.01

Table A6: Impact of Change in Total Land Protected from Multiple Interaction Model

	Interaction Term Value	Aggregate Protection
Average Effect	N/A	0.0199 (0.0128)
Tax Base		
10th Pcile	10	0.0349* (0.0182)
30th Pcile	30	0.0274** (0.0137)
50th Pcile	50	0.0200 (0.0128)
70th Pcile	70	0.0125 (0.0161)
90th Pcile	90	0.0051 (0.0218)
Tax Base Growth $_{t-1}$		
10th Pcile	-5.12	0.0580*** (0.0189)
30th Pcile	-2.06	0.0414*** (0.0155)
50th Pcile	0.87	0.0255* (0.0133)
70th Pcile	4.92	0.0036 (0.0127)
90th Pcile	10.56	-0.0269 (0.0170)

Table A6 continued

	Interaction Term Value	Aggregate Protection
Town Area % Protected $_{t-1}$		
10th Pcile	0.99	0.0260
		(0.0176)
30th Pcile	5.77	0.0240
		(0.0152)
50th Pcile	11.11	0.0217
		(0.0134)
70th Pcile	18.44	0.0185
		(0.0128)
90th Pcile	33.68	0.0119
		(0.0186)
Vacation Home Share %		
10th Pcile	0.25	0.0674***
		(0.0148)
30th Pcile	1.44	0.0637***
		(0.0145)
50th Pcile	6.71	0.0472***
		(0.0135)
70th Pcile	21.23	0.0018
		(0.0132)
90th Pcile	43.06	-0.0665***
		(0.0193)

Table A6 continued

	Interaction Term Value	Aggregate Protection
Median Household Income		
10th Pcile	10	0.0525***
		(0.0203)
30th Pcile	30	0.0362**
		(0.0152)
50th Pcile	50	0.0200
		(0.0128)
70th Pcile	70	0.0038
		(0.0144)
90th Pcile	90	-0.0125
		(0.0189)

Notes: This table presents the estimated slopes and standard errors plotted in Figure 5. The slopes show the variation in the impacts of new land protection with respect to individual terms included in the multiple term interaction model for total change in protected land described in Section 4.2, while holding other variables at their means. The estimated slopes are interpreted as the change in average annual equalized tax rate change ($/$1000 value) due to a one percentage point increase in prior period average annual municipal area share protected. These slopes are obtained by estimating the multiple interaction version of Equation 2 (Table A5) and then back transforming those coefficients as described in Appendix B. Standard errors in parentheses, clustered by municipality. *p<0.1; **p<0.05; *** p<0.01

Table A7: Multiple Interaction Model With Individual Land Protection Types

	Ihs∆TaxRate
Tax Base Growth $_{t-1}$	0.0247***
	(0.0059)
Tax Base Growth $_{t-1}$ # Area % Protected $_{t-1}$	0.0000
	(0.0001)
Tax Base Growth $_{t-1}$ # Tax Base Pcile	0.0001***
	(0.0000)
Tax Base Growth $_{t-1}$ # Vacation Home Share %	0.0000
	(0.0000)
Tax Base Growth $_{t-1}$ # Income Pcile	0.0001***
	(0.0000)
Tax Base Growth $_{t-1}$ # Ihs Tax Rate $_{t-1}$	-0.0068***
	(0.0017)
Ihs ∆ % NGO Protected $_{t-1}$	0.9806***
	(0.2275)
Ihs ∆ % NGO Protected $_{t-1}$ # Tax Base Pcile	-0.0011
	(0.0013)
Ihs ∆ % NGO Protected $_{t-1}$ # Tax Base Growth $_{t-1}$	-0.0128**
	(0.0056)
Ihs ∆ % NGO Protected $_{t-1}$ # Vacation Home Share %	-0.0062***
	(0.0019)
Ihs ∆ % NGO Protected $_{t-1}$ # Area % Protected $_{t-1}$	-0.0032
	(0.0030)
Ihs ∆ % NGO Protected $_{t-1}$ # Income Pcile	-0.0007
	(0.0012)
Ihs ∆ % NGO Protected $_{t-1}$ # Ihs Tax Rate $_{t-1}$	-0.2577***
	(0.0682)
Ihs ∆ % NGO Protected $_{t-1}$ # Tax Base Pcile # Tax Base Growth $_{t-1}$ # Area % Protected # Vacation Home Share % # Income Pcile # Ihs Tax Rate $_{t-1}$	0.0000
	(0.0000)
Ihs ∆ % Municipal Protected $_{t-1}$	0.9539***
	(0.2998)
Ihs ∆ % Municipal Protected $_{t-1}$ # Tax Base Pcile	-0.0022
	(0.0018)

Ihs Δ % Municipal Protected $_{t-1}$ # Tax Base Growth $_{t-1}$	-0.0070 (0.0065)
Ihs Δ % Municipal Protected # Vacation Home Share %	-0.0021 (0.0030)
Ihs Δ % Municipal Protected # Area % Protected $_{t-1}$	-0.0074* (0.0043)
Ihs Δ % Municipal Protected # Income Pcile	-0.0013 (0.0015)
Ihs Δ % Municipal Protected # Ihs Tax Rate $_{t-1}$	-0.1781** (0.0706)
Ihs Δ % Municipal Protected # Tax Base Pcile # Tax Base Growth # Area % Protected # Vacation Home Share % # Income Pcile # Ihs Tax Rate $_{t-1}$	0.0000 (0.0000)
Ihs Δ % Easement Protected $_{t-1}$	0.2177** (0.1005)
Ihs Δ % Easement Protected $_{t-1}$ # Tax Base Pcile	-0.0000 (0.0007)
Ihs Δ % Easement Protected # Tax Base Growth $_{t-1}$	-0.0069** (0.0027)
Ihs Δ % Easement Protected # Area % Protected	-0.0022 (0.0014)
Ihs Δ % Easement Protected # Vacation Home Share %	-0.0022*** (0.0008)
Ihs Δ % Easement Protected # Income Pcile	-0.0008 (0.0006)
Ihs Δ % Easement Protected # Ihs Tax Rate $_{t-1}$	-0.0167 (0.0305)
Ihs Δ %Easement Protected $_{t-1}$ # Tax Base Pcile # Tax Base Growth $_{t-1}$ # Area % Protected # Vacation Home Share % # Income Pcile # Ihs Tax Rate $_{t-1}$	0.0000 (0.0000)
Ihs Δ % State/Fed Protected $_{t-1}$	0.3954** (0.1942)
Ihs Δ % State/Fed Protected $_{t-1}$ # Tax Base Pcile	0.0003 (0.0010)
Ihs Δ % State/Fed Protected $_{t-1}$ # Tax Base Growth	-0.0051

	(0.0044)
Ihs Δ % State/Fed Protected $_{t-1}$ # % Area Prot	0.0032*
	(0.0018)
Ihs Δ % State/Fed Protected $_{t-1}$ # Vacation Home Share %	-0.0038**
	(0.0016)
Ihs Δ % State/Fed Protected $_{t-1}$ # Income Pcile	-0.0013
	(0.0011)
Ihs Δ % State/Fed Protected $_{t-1}$ #Ihs Tax Rate $_{t-1}$	-0.0990**
	(0.0502)
Ihs Δ % State/Fed Protected $_{t-1}$ # Tax Base Pcile # Tax Base Growth $_{t-1}$ # Area % Protected # Vacation Home Share % # Income Pcile # Ihs Tax Rate $_{t-1}$	-0.0000
	(0.0000)
Observations	9581
R^2_{adj}	0.4503
LaborMarketControls	Yes
State-By-Time-Period FE	Yes
CBSATrends	Yes

Notes: This table presents estimates from the multiple interaction model with individual land protection types and measures of local economic conditions described in Section 4.2 and Equation 2. The outcome variable is the Ihs of the average annual change in the equalized tax rate. The explanatory variables of interest are the interactions of the Ihs transformed average annual change in municipal area share protected in the prior time period, by protection type, with variables that capture local economic conditions. The coefficients on the change in land protection and its interactions are not back transformed. The "#" symbol indicates an interaction term. Variation in impact of land protection by type with respect to the interaction variables is estimated and plotted in Figure 6 and summarized in Table A8. Control variables include the Ihs transformations of the prior period average changes in labor force per acre and unemployment rate. Additional controls include average prior period tax base growth (%), the Ihs of prior period equalized tax rate that is included as an interaction term, state-by-time-period fixed effects and linear CBSA specific time trend. Standard errors are shown in parentheses, clustered by municipality. *p<0.1; **p<0.05; ***p<0.01

Table A8: Impact of Change in Land Protected by Type from Multiple Interaction Model

	Interaction Term Value	NGO	Municipal	Ease	State/Federal
Average Effect					
	N/A	-0.0318	0.1030**	0.0480**	0.0317
		(0.0382)	(0.0513)	(0.0236)	(0.0279)
Tax Base					
10th Pcile	10	0.0096	0.1904*	0.0494	0.0210
		(0.0657)	(0.0997)	(0.0333)	(0.0417)
30th Pcile	30	-0.0110	0.1468**	0.0487*	0.0264
		(0.0470)	(0.0706)	(0.0258)	(0.0298)
50th Pcile	50	-0.0317	0.1033**	0.0480**	0.0317
		(0.0382)	(0.0514)	(0.0236)	(0.0279)
70th Pcile	70	-0.0523	0.0597	0.0473*	0.0371
		(0.0453)	(0.0536)	(0.0281)	(0.0376)
90th Pcile	90	-0.0729	0.0161	0.0465	0.0424
		(0.0633)	(0.0755)	(0.0368)	(0.0528)
Tax Base Growth $_{t-1}$					
10th Pcile	-5.12	0.0381	0.1479**	0.0952***	0.0725
		(0.0540)	(0.0695)	(0.0315)	(0.0451)
30th Pcile	-2.06	0.0077	0.1284**	0.0747***	0.0547
		(0.0447)	(0.0595)	(0.0268)	(0.0359)
50th Pcile	0.87	-0.0215	0.1096**	0.0549**	0.0377
		(0.0391)	(0.0528)	(0.0241)	(0.0293)
70th Pcile	4.92	-0.0617	0.0838*	0.0277	0.0143
		(0.0391)	(0.0503)	(0.0239)	(0.0271)
90th Pcile	10.56	-0.1177**	0.0478	-0.0101	-0.0184
		(0.0527)	(0.0608)	(0.0305)	(0.0382)

Table A8 Continued

	Interaction Term Value	NGO	Municipal	Ease	State/Federal
Town Area % Protected$_{t-1}$					
10th Pcile	0.99	0.0080	0.2065**	0.0784**	-0.0121
		(0.0593)	(0.0956)	(0.0315)	(0.0403)
30th Pcile	5.77	-0.0055	0.1713**	0.0681**	0.0028
		(0.0491)	(0.0781)	(0.0276)	(0.0346)
50th Pcile	11.11	-0.0206	0.1321**	0.0565**	0.0194
		(0.0409)	(0.0609)	(0.0246)	(0.0298)
70th Pcile	18.44	-0.0413	0.0782*	0.0407*	0.0423
		(0.0387)	(0.0466)	(0.0237)	(0.0276)
90th Pcile	33.68	-0.0845	-0.0339	0.0077	0.0897**
		(0.0654)	(0.0732)	(0.0334)	(0.0399)
% Vacation Homes					
10th Pcile	0.25	0.0575	0.1330**	0.0798***	0.0914***
		(0.0520)	(0.0564)	(0.0265)	(0.0352)
30th Pcile	1.44	0.0505	0.1307**	0.0773***	0.0867**
		(0.0505)	(0.0548)	(0.0261)	(0.0341)
50th Pcile	6.71	0.0195	0.1203**	0.0662***	0.0660**
		(0.0445)	(0.0497)	(0.0246)	(0.0303)
70th Pcile	21.23	-0.0659*	0.0916	0.0358	0.0089
		(0.0375)	(0.0588)	(0.0241)	(0.0295)
90th Pcile	43.06	-0.1944**	0.0484	-0.0099	-0.0769
		(0.0575)	(0.1080)	(0.0324)	(0.0503)

Table A8 Continued

	Interaction Term Value	NGO	Municipal	Ease	State/Federal
Median Household Income					
10th Pcile	10	-0.0071	0.1525*	0.0797**	0.0854*
		(0.0683)	(0.0836)	(0.0344)	(0.0487)
30th Pcile	30	-0.0194	0.1278**	0.0639**	0.0586*
		(0.0497)	(0.0627)	(0.0269)	(0.0337)
50th Pcile	50	-0.0317	0.1031**	0.0480**	0.0318
		(0.0382)	(0.0513)	(0.0236)	(0.0279)
70th Pcile	70	-0.0440	0.0784	0.0322	0.0050
		(0.0405)	(0.0557)	(0.0263)	(0.0362)
90th Pcile	90	-0.0564	0.0537	0.0164	-0.0218
		(0.0549)	(0.0731)	(0.0335)	(0.0522)

Notes: Table A8 presents the estimated slopes and standard errors plotted in Figure 6, which show the variation in the estimated impacts of land protection change by type with respect to individual terms included in the multiple term interaction model described in Section 4.2, while holding other variables at their means. The slopes are interpreted as the change in average annual equalized tax rate change ($/$1000 value) due to a one percentage point increase in prior period average annual municipal area share protected. These slopes are obtained by estimating the multiple interaction version of Equation 2 (see estimates in Table A7) and then back transforming those estimates as described in Appendix B. Standard errors in parentheses, clustered by municipality. *p<0.1; **p<0.05; *** p<0.01

Table A9: Property Tax Bill Increase Due to Property Value Growth

State	Avg Housing Units per town in 2015	Avg Equalized Tax Rate ($/$1000)	Farmland ($ per Acre)	25th Pcile Vacant Land ($/AC)	50th Pcile Vacant Land ($/AC)	75th Pcile Vacant Land ($/AC)
CT	8827	17.74	11,300	12,618	23,441	42,265
ME	1578	13.76	2,090	829	1,954	4,645
MA	8079	12.59	10,400	10,130	37,219	90,454
NH	2706	5.17	4,280	3,289	5,353	12,827
VT	1357	5.03	3,300	1,796	2,186	3,118
Property Value Growth (%) for 100 Acres of New Protection						
CT			0.116	0.130	0.241	0.434
ME			0.120	0.048	0.112	0.267
MA			0.117	0.114	0.418	1.016
NH			0.143	0.110	0.179	0.430
VT			0.221	0.120	0.146	0.208
Area Weighted Average			0.143	0.094	0.197	0.430
Tax Bill Increase per $100,000 of Value						
CT			2.07	2.31	4.29	7.73
ME			1.66	0.66	1.55	3.69
MA			1.47	1.44	5.28	12.83
NH			0.74	0.57	0.93	2.23
VT			1.11	0.61	0.74	1.05
Area Weighted Average			1.40	0.95	2.21	4.90

Notes: This table presents results from the back of the envelope analysis to approximate impacts of land protection on property values and resulting tax bill increases, together with variables used in the calculations. We use the steps described in Appendix B to calculate the percent increase in property values and property tax bills based on the range of property values that may represent the purchase value per acre of protected land in our study region. Data on housing units were obtained from the 2011-2015 American Community Survey (U.S. Census Bureau 2016), farmland prices come from the 2015 U.S. Department of Agriculture Land Value Summary (National Agricultural Statistics Service 2015) and vacant land prices were obtained from Nolte (2020). The regional average was constructed using state shares of study region land area.

Table A10: Impact of Averaging Time Step on Estimates

	Three Year Estimates: Main specification (1) $\Delta TaxRate_t$	Two Year Estimates (2) $\Delta TaxRate_t$	Four Year Estimates (3) $\Delta TaxRate_t$
Δ % Total Protected$_{t-1}$	0.0231**	0.0205**	-0.0061
	(0.0110)	(0.0102)	(0.0119)
N	9581	14564	6750
R^2_{adj}	0.4453	0.3586	0.5217
Δ % NGO Protected $_{t-1}$	-0.0525	-0.0248	-0.0752**
	(0.0348)	(0.0320)	(0.0362)
Δ % Municipal Protected $_{t-1}$	0.0722*	0.0618	0.0713*
	(0.0416)	(0.0416)	(0.0430)
Δ % Easement Protected $_{t-1}$	0.0356**	0.0357**	0.0231
	(0.0172)	(0.0178)	(0.0187)
Δ % State/Federal Protected $_{t-1}$	0.0305	0.0220	-0.0338
	(0.0270)	(0.0293)	(0.0281)
N	9581	14564	6750
R^2_{adj}	0.4454	0.3586	0.5219
LaborMarketControls	Yes	Yes	Yes
State-By-Time-Period FE	Yes	Yes	Yes
CBSATrends	Yes	Yes	Yes
TaxBaseGrowth	Yes	Yes	Yes

Notes: Table A10 shows the impact of the time step window used for averaging differences on our winsorized regional estimates for all land protection and protection by type. The slopes are interpreted as the change in average annual equalized tax rate change ($/$1000 value) due to a one percentage point increase in prior period average annual municipal area share protected. These estimated slopes and standard errors are obtained by estimating Equation 2 using total change in land protection and individual protection types, and then back transforming those estimates as described in Appendix B. Control variables include the prior period Ihs transformation of the average change in labor force per acre and unemployment rate, average prior period tax base growth (%), state-by-time-period fixed effects, and linear CBSA specific time trends. Standard errors in parentheses, clustered by municipality. * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

Table A11: Alternative Outlier Treatment

	Winsorized	Not Winsorized	Drop Outliers
	(1)	(2)	(3)
	$\Delta TaxRate_t$	$\Delta TaxRate_t$	$\Delta TaxRate_t$
Δ % Total Protected	0.0231**	0.0239**	0.0191
	(0.0110)	(0.0101)	(0.0127)
N	9581	9581	9300
R^2_{adj}	0.4453	0.4325	0.4498
Δ % NGO Protected $_{t-1}$	-0.0525	-0.0268	-0.0594
	(0.0348)	(0.0223)	(0.0448)
Δ % Municipal Protected $_{t-1}$	0.0722*	0.0361	0.0667
	(0.0416)	(0.0304)	(0.0538)
Δ % Easement Protected $_{t-1}$	0.0356**	0.0340**	0.0427**
	(0.172)	(0.0154)	(0.0199)
Δ % State/Federal Protected $_{t-1}$	0.0305	0.0243	0.0522
	(0.0270)	(0.0192)	(0.0407)
N	9581	9581	9030
R^2_{adj}	0.4454	0.4325	0.4480
LaborMarketControls	Yes	Yes	Yes
State-By-Time-Period FE	Yes	Yes	Yes
CBSATrends	Yes	Yes	Yes
TaxBaseGrowth	Yes	Yes	Yes

Table A11 shows the impact of alternative outlier treatment. The slopes are interpreted as the change in average annual equalized tax rate change ($/$1000 value) due to a one percentage point increase in prior period average annual municipal area share protected. Column 1 shows estimated slopes based on winsorzied variables (our main results from Tables 4 and A4). Top 1 % of changes are winsorized for land protection and top & bottom 1% for the tax rate as well as the labor market & tax base growth control variables. In column 2, average changes are unaltered. In column 3, we drop the changes that are winsorized in column 1, but only for the tax rate & the land protection variables. These estimated slopes and standard errors are obtained by estimating Equation 2 using total change in land protection and individual protection types, and then back transforming those estimates as described in Appendix B. Control variables include the prior period Ihs transformation of the average change in labor force per acre and unemployment rate, average prior period tax base growth (%), state-by-time-period fixed effects, and linear CBSA specific time trends. Standard errors in parentheses * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

Table A12: Alternative Specifications for the Average Effect of Land Protection on the Equalized Tax Rate

	Ihs of Difference	Untransformed Difference	Difference as % Change	Difference of Natural Logs	Fixed Effects (Ihs)
	(1)	(2)	(3)	(4)	(5)
	Ihs Δ Tax Rate$_t$	Δ Tax Rate$_t$	% Δ Tax Rate$_t$	Δ Ln Tax Rate$_t$	Ihs Tax Rate$_t$
Ihs Δ % Protected$_{t-1}$	0.0237^{**}				
	(0.0113)				
Δ % Protected$_{t-1}$		0.0180^{*}			
		(0.0093)			
% Δ Protected$_{t-1}$			0.0246^{***}		
			(0.0084)		
Δ Ln % Protected$_{t-1}$				0.0325^{**}	
				(0.0130)	
Ihs % Protected$_{t-1}$					0.0098
					(0.0087)
Tax bill change per $100,000 of value for a 100 acre increase in area protected annually	$1.16	$0.90	$0.37	$0.48	$0.35
Observations	9581	9581	9299	9581	9581
R^2_{adj}	0.4453	0.4301	0.3418	0.3814	-
R^2_{within}	-	-	-	-	0.5242
LaborMarketControls	Yes	Yes	Yes	Yes	Yes
MunicipalFE	No	No	No	No	Yes
State-By-Time-Period FE	Yes	Yes	Yes	Yes	Yes
CBSATrends	Yes	Yes	Yes	Yes	Yes
TaxBaseGrowthControl	Yes	Yes	Yes	Yes	Yes

Note: Table A12 shows alternative variable transformations and model choice for estimating the impact of land protection on equalized tax rates. Variables are transformed as labeled in the table and coefficients are not back transformed when the Ihs transformation is used. Column 1 presents our average estimated regional impact of land protection based on Ihs transformed and winsorized average changes. In column 2, variables are untransformed, winsorized average differences. Column 3 shows all changes specified as winsorized average percent differences, while column 4 presents winsorized average difference of logs. Column 5 shows the fixed effects estimates with Ihs transformed level variables. Control variables are the same as in Equation 2 but follow the indicated transformations. One exception is that in the fixed effects model, prior period average tax base growth remains a percent change. There are fewer observations for column 2 because the town with zero land protection in a given time period drop out, since one cannot divide by zero to compute % change. Standard errors in parentheses, clustered by municipality. *p<0.1; **p<0.05; ***p<0.01

Table A13: Average Impacts of Land Protection on Nominal Municipal Tax Rates

	New England	CT	MA	NH	VT	ME
	(1)	(2)	(3)	(4)	(5)	(6)
	$\Delta TaxRate_t$	$\Delta TaxRate_t$	$\Delta TaxRate_t$	$\Delta TaxRate_t$	$\Delta TaxRate_t$	$\Delta TaxRate_t$
Δ % $Protected_{t-1}$	0.0250*	-0.0156	0.0380**	0.0461**	0.0217	-0.0108
	(0.0146)	(0.1262)	(0.0193)	(0.0220)	(0.0205)	(0.0514)
N	9581	1010	2447	1577	1425	3122
R^2_{adj}	0.2947	0.3454	0.6151	0.1573	0.0845	0.1493
Municipalities	1436	169	350	230	241	446
LaborMarketControls	Yes	Yes	Yes	Yes	Yes	Yes
State-By-Time-Period FE	Yes	No	No	No	No	No
Time-Period FE	No	Yes	Yes	Yes	Yes	Yes
CBSATrends	Yes	Yes	Yes	Yes	Yes	Yes
TaxBaseGrowth	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Estimated slopes show the change in average annual nominal tax rate change ($/$1000 value) due to a one percentage point increase in prior period average annual municipal area share protected, for our New England study region and by state. These estimated slopes and standard errors are obtained by back transforming coefficients estimated using Equation 2 as described in Appendix B. Control variables include the prior period Ihs transformed average change in labor force per acre and unemployment rate, average prior period tax base growth (%), time-period or state-by-time-period fixed effects, and linear CBSA specific time trends. Standard errors in parentheses, clustered by municipality. *p<0.1; **p<0.05; ***p<0.01.

Table A14 Impact of Land Protection on Levy, Taxable Property Value, and Municipal Revenue and Expenditure.

	ΔLn Expenditure$_t$ (1)	ΔLn Revenues$_t$ (2)	ΔLn Levy$_t$ (3)	ΔLn AssdVal$_t$ (4)	ΔLn EqlVal$_t$ (5)
MA & CT Only					
ΔLn %Protected $_{t-1}$	0.0292*	0.0210	0.0252*	-0.0222	-0.0353
	(0.0176)	(0.0162)	(0.0139)	(0.0249)	(0.0228)
Change for 100 acre annual increase in protection	$66,727	$57,192	$47,857	$-2,301,657	-3,718,540
Observations	3457	3457	3457	3457	3457
R^2_{adj}	0.2453	0.2761	0.2705	0.6627	0.7146
All States					
ΔLn % Protected $_{t-1}$	–	–	0.0238*	-0.0224*	-0.0101
			(0.0138)	(0.0133)	(0.0085)
Change for 100 acre annual increase in protection	–	–	$15,801	$-880,423	$-411,469
Observations	–	–	9581	9581	9581
R^2_{adj}			0.1285	0.4149	0.6758
LaborMarketControls	Yes	Yes	Yes	Yes	Yes
State-By-Time-Period FE	Yes	Yes	Yes	Yes	Yes
CBSATrends	Yes	Yes	Yes	Yes	Yes
Tax Base Growth	Yes	Yes	Yes	Yes	Yes

Note: This table shows the impact of land protection on municipal fiscal outcomes other than the equalized tax rate. The outcome variables are average annual differences of natural logs. The explanatory variable is the lagged average annual difference of the natural log of municipal area share protected. The coefficients are interpreted as elasticities. The same control variables are used in all Table A14 regressions: average annual differences of natural logs for the prior period labor force per acre, unemployment rate, and tax base, along with state-by-time-period fixed effects, and linear CBSA specific time trends. Changes in revenues and expenditures are outcomes from municipal budgets and are available only for MA & CT, while changes in the municipal levy, assessed values and equalized values are available for all states. Standard errors in parentheses, clustered by municipality. *p<0.1; **p<0.05; ***p<0.01

The change in the fiscal outcomes for a 100 acre increase in new protection is calculated using the estimated elasticities. We illustrate the calculation using the levy result for MA/CT. An elasticity is interpreted as a percent change in the average annual levy change for a one percent increase in new protection. The unconditional average change in new annual land protection in MA & CT is 39.32 acres. A 1% increase is 0.3932 acres. 100 acres represents a 254.32 % increase (100/0.3932 = 254.32). We get the change in the expenditures by multiplying the percent increase in land protection by the estimated elasticity to get percent change in expenditure growth, and then multiplying the percent change by average annual change in expenditures: [(0.0292 * 254.32)(1/100)] * $ 898542.12= $66727.03

Table A15: Correlation Over Time for Slow Moving Variables

	Household Income 2010	Vacation Home Share % 2010	Tax Base 2010
Household Income 1990	0.926		
Vacation Home Share % 1990		0.957	
Tax Base, First Time Period			0.961

Notes: Correlations constructed using three-year averaged annual differences.

Table A16: Comparison of Housing Density Continuous and Categorical Variables

	Housing Density Categories	Housing Density Interaction
	(1)	(2)
	$\Delta TaxRate_t$	$\Delta TaxRate_t$
Δ % Protected # Rural $_{t-1}$	0.0162	
	(0.0136)	
Δ % Protected # Exurban $_{t-1}$	0.0309**	
	(0.0157)	
Δ % Protected # Urban $_{t-1}$	0.0620	
	(0.0416)	
Δ % Protected $_{t-1}$		-0.0037
		(0.0285)
Δ % Protected $_{t-1}$ # Ihs Housing Density		0.0084
		(0.0079)
N	9581	9581
R^2_{adj}	0.4453	0.4453
LaborMarketControls	Yes	Yes
State-By-Time-Period FE	Yes	Yes
CBSATrends	Yes	Yes
TaxBaseGrowth	Yes	Yes

Notes: These estimated slopes show variation in tax impacts by housing density, with discrete (column 1) and continuous (column 2) density interaction terms. The slopes are interpreted as the change in average annual equalized tax rate change ($/$1000 value) due to a one percentage point increase in prior period average annual municipal area share protected. These estimated slopes and standard errors are obtained by back transforming coefficients estimated using Equation 2 with density interaction terms, as described in Section 4.2 and Appendix B. Control variables include the prior period Ihs transformed average change in labor force per acre and unemployment rate, average prior period tax base growth (%), state-by-time-period fixed effects, and linear CBSA specific time trends. Standard errors in parentheses, clustered by municipality. *p<0.1; **p<0.05; ***p<0.01.

Table A17: Impact of Land Protection on Tax Rates, Untransformed Estimates

	Total Protected	Protection by Type
	(1)	(2)
	IhsΔTaxRate$_t$	IhsΔTaxRate$_t$
Ihs Δ % Protected$_{t-1}$	0.0237**	
	(0.0113)	
Ihs Δ % NGO Protected$_{t-1}$		-0.0524
		(0.0347)
Ihs Δ % Municipal Protected$_{t-1}$		0.0720*
		(0.0415)
Ihs Δ % Easement Protected$_{t-1}$		0.0357**
		(0.0173)
Ihs Δ % State/Fed Protected$_{t-1}$		0.0305
		(0.0269)
Observations	9581	9581
R^2_{adj}	0.4453	0.4454
LaborMarketControls	Yes	Yes
State-By-Time-Period FE	Yes	Yes
CBSATrends	Yes	Yes
TaxBaseGrowth	Yes	Yes

Notes: These estimates show the untransformed regression coefficients from estimating Equation 2 using the total change in land protection and also change by protection type. The coefficients illustrate that back transforming estimates results in a very small adjustment (compare to estimates in Tables 4 and A4). See Appendix B for additional details about back transforming. The estimates are interpreted as the change in the Ihs of the average annual equalized tax rate change due to a one unit change in Ihs of prior period average annual municipal area share protected. Control variables include the prior period Ihs transformed average change in labor force per acre and unemployment rate, average prior period tax base growth (%), state-by-time-period fixed effects, and linear CBSA specific time trends. Standard errors in parentheses, clustered by municipality. *p<0.1; **p<0.05; ***p<0.01.

Appendix B: Additional Data Construction and Estimation Details

1. Municipality Units: Sources and Construction

Our municipalities are derived from the U.S. Census County Subdivision data for New England (U.S. Census Bureau 2010), which generally correspond to towns and cities in the region. Towns typically have smaller populations than cities and many retain the traditional town meeting form of governance in which residents gather and vote directly on fiscal matters. Cities are typically larger and governed by representatives. However, there is no strict definition or population cutoff and we do not distinguish between these types in our analysis except by their characteristics themselves (e.g. housing density, property tax base).[21]

The initial county subdivision file for our states has 1567 units and includes towns and cities as well as some unincorporated areas (primarily in Maine). These areas have low populations, do not have local government, and do not set/collect their own property taxes. To create a comparable dataset for analysis, we exclude 79 county subdivisions that are unincorporated or don't set local tax rates, 46 municipalities with fewer than 100 people in 1990, two municipalities with extensive missing data, and 4 municipalities that were incorporated or disincorporated during the study period. Additionally, we exclude some individual town-year observations due to extreme values and suspicious year to year changes indicating possible typographical errors in the data. In total, our analysis uses 1436 municipalities, which includes 97 cities and 1339 towns. The final number of municipalities used in each state and time-period is summarized in Table A2.

We assign municipalities to core-based statistical areas (CBSAs) for metro regions to control for regional trends, using 2015 CBSA boundaries from the US Census. CBSAs are county-based areas defined by the U.S. Census that include an urban area with population of at least 10,000 and adjacent counties integrated with the urban area through commuting ties (U.S. Census Bureau 2021). For each state, we create similar groupings for rural towns outside CBSAs by combining them in to their own CBSA equivalent.

2. Municipal Tax Rates and Fiscal Data: Sources and Construction

2.1 *Fiscal Variable Definitions*

We provide additional details in this section about assembly and definitions of our fiscal variables. Appendix Table A1 shows that there are some differences in how fiscal variables are defined within the region and in our analysis. Specifically, while municipalities in Maine and Connecticut set a single property tax rate, municipalities in Massachusetts set separate tax rates for commercial, industrial, open space and residential uses. Municipalities in Vermont and New Hampshire have separate tax rates for education, municipal, and county needs (NH only), with education taxes affected by state education funding reforms over time. Massachusetts and Connecticut are the only states in our sample with revenues and expenditures data available for the duration of our study period.

[21] Some municipalities with larger populations continue calling themselves towns (e.g., Brookline, MA with population of about 60,000 has 255 elected town meeting representatives) and some cities have relatively small population (e.g., Northampton, MA has a population of only about 30,000 people but has a mayor and city council).

We construct measures of both nominal and equalized tax rates. The equalized tax rate represents the rate of taxation if all taxable property is assessed at fair market value. It is computed by dividing the municipal tax levy by the equalized property value, which represents the fair market value of taxable property in a jurisdiction. Equalized property value is estimated at the state level by conducting studies of property sales in each town and estimating the ratio of assessed to market value for sold properties. This ratio is used to convert the town's assessed value to equalized value. States in our study area compute equalized property values for each municipality annually or bi-annually, by comparing sale and assessed values for all properties sold in the prior one or two years and adjusting assessed values by that municipality-specific ratio.

For an example of the equalized tax rate calculation, consider the numbers from the town of Granby in Connecticut, from the fiscal year that spans 2009-2010. In this year, the assessed property value is $1,042,797,363 while equalized property value is 1,482,340,792. The tax levy is $30,507,400. The equalized tax rate (per thousand dollars of value) equals = $30,507,400/ ($1,482,340,792/1000) = $20.58 per $1000 of value. The nominal tax rate equals $30,507,400/$1,042,797,363 = $29.25. The difference between these tax rates reflects that property is assessed at 70% of market value in Connecticut. In contrast, other New England states assess property at fair market value. Equalized tax rates therefore enable a more fair comparison of tax burdens across states. At the state level, equalized values and tax rates are also often used for assessing municipal property tax burdens and allocating state aid.[22]

2.2 *State-level Data Sources*

Connecticut fiscal data were obtained from Municipal Fiscal Indicator reports, which are available through the Office of Policy and Management. Connecticut has a uniform property tax rate. The nominal tax rate is reported in the Fiscal Indicators data, while the equalized tax rate was constructed by dividing the property tax levy by the equalized value. Assessed and equalized values represent the total taxable municipal property value, while the property tax levy captures the amount of property tax collected. Expenditure and revenue data represent total general fund revenues and expenditures.

Massachusetts data were obtained from the municipal databank, a state resource that maintains economic data about municipalities. Municipalities in Massachusetts tax different classes of property (residential, industrial, commercial, open space and personal property) at varying tax rates and the municipal databank reports taxable property value, nominal tax rates and property tax levies for each property class. For consistency with other states, we evaluate the impact of land protection on the residential property tax rate. However, we use aggregate measures of the property tax levy as well as assessed and equalized values that represent all property types.

[22] Consider an example from Maine for state general revenue sharing with municipalities and education aid. To determine the percentage of revenues going to a particular town from the state's Local Government Fund, a given town's equalized tax rate is first multiplied by its population to get a "municipal number," a value that accounts for local tax burden and population. This number is then divided by the sum of all municipal numbers to determine a given town's percentage of shared revenue (Office of Fiscal and Program Review 2013). For education aid, the state applies a uniform tax rate to a town's equalized taxable property value. The funds raised this way are subtracted from the established cost of education, with the state making up the remainder (20-A M.R.S. § 15671-A, 2022, Maine State Legislature). The result is a funding system where towns with smaller tax bases receive more education aid.

Massachusetts computes equalized values every two years, publishing the ratios of assessed to equalized (full market) values by property type on even years. To obtain an annual series of equalized values for each property class, we take the town specific ratio of assessed to equalized values for the years when both outcomes are available and hold this ratio constant for two consecutive years to interpolate the equalized values in the odd years. To construct the equalized property tax rate, we divide the property tax levy collected from residential property by the equalized residential property value. While other data for the state is available back to 1990, the ratios of assessed to equalized values, and consequently our equalized tax rate measure, are available starting in 1993.[23] In Massachusetts, expenditure data represent actual general fund expenditures, while revenues are projected revenues that municipalities report to the state to justify their property tax rates.

Maine data was digitized from Municipal Valuation Return Statistical Summary (MVRSS) reports for the years 1990-1999 and downloaded from Maine Revenue Services for the rest of our study period. Maine has a uniform property tax rate. The nominal tax rate was reported in the data while the equalized tax rate was constructed by dividing the property tax levy by the equalized value. Assessed and equalized values represent the total taxable municipal property value while the tax levy captures all property taxes collected. While the MVRSS data reported the property tax levy variable, it was not available in the data downloaded for the 2000-2015 years, which included the nominal tax rate, assessed, and equalized values. For these years, the levy was calculated using tax rate = property tax levy/assessed value.

Fiscal data for Vermont were obtained from the Department of Taxes. Vermont has separate municipal and education tax rates. We use only the municipal portion of the tax rate and levy due to substantial policy changes in the education tax rates over time. Specifically, Vermont passed a major education reform bill in 1997 (Act 60), seeking to mitigate education funding inequality between towns resulting from unequal local property wealth (Stadler et al. 2017). A new statewide property tax was created to fund local expenditures on education. The new funding approach aimed to equalize local property tax burdens for funding education based on per pupil expenditures, such that education tax rates would be the same in towns with equal per pupil spending, regardless of local property wealth (Stadler et al. 2017). As a result, changes in the property tax base no longer affect the education tax rate and these rates are not controlled locally. However, the way municipalities fund other services through the municipal tax rate was not affected by these education reforms (Stadler et al. 2017)and is the tax rate we analyze. In addition, in 1996, the appraisal of land enrolled in current use underwent a major change in Vermont that decreased municipal tax bases in proportion to the amount of land enrolled in current use (Division of Property Valuation and Review 2000; Basch 1997). Due to these major policy shifts, we exclude VT data prior to 1996. Vermont reports both nominal and equalized tax rates in annual reports, so we use the published equalized tax rate in our analysis. The assessed and equalized values for Vermont represent the total taxable municipal property value.[24]

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[23] This affects two of our control variables slightly: when the lagged average percent change in equalized value is used as a control in our regression analysis for the 1994-1997 period, it consists of only one change in Massachusetts, as compared to the average of three changes in other cases. Similarly, the lagged equalized tax rate, is an average of two years instead of three for this period.

[24] Our data is affected by minor inconsistencies in variables published in annual tax reports by the Vermont Department of Taxes. The published equalized tax rates for the 24 towns in Windsor County are missing from the Vermont Department of Taxes publication for 2004 and could not be recovered. In years 2002-2006 and 2015, the municipal, assessed, and equalized values are not reported. Assessed values are also omitted in 2000 and 2001. We

New Hampshire data were obtained from the Department of Revenue Administration (DRA). New Hampshire has separate municipal, education and county tax rates. We use only the municipal tax rate and levy because municipalities don't set the county tax rate and education reforms have affected the extent of local control over the education tax rate. Specifically, in 1997, the New Hampshire Supreme Court ruled that the existing funding formula for education was unconstitutional due to the inequitable tax burden it produced. In response, the state moved to increase its share of education funding from <10% of total K-12 funding to around 50% (Kenyon 2007; Olabisi 2006). Half of this funding came from the newly created statewide education property tax, set by the state legislature. Property tax revenues in excess of local education funding requirements were reallocated to less affluent communities in order to reduce inequities in education funding (Kenyon 2007; Olabisi 2006). As a result of these reforms, the education property tax rate that was previously set locally was split into two tax rates in 1999: one set by the state and the other is set locally to supplement the state funding.

Given these changes, we use the municipal portion of the tax rate because it has been consistently defined over time. For New Hampshire, the nominal municipal share of the tax rate is reported in the annual DRA tax report while the equalized tax rate was constructed by multiplying the municipal tax rate by assessed value to get the municipal portion of the tax levy and dividing that by equalized values. The assessed and equalized values for New Hampshire represent the total taxable municipal property value.

Finally, we note that in some cases there are additional property taxes raised by sub-municipal special districts like village, water-, fire-, and lighting-districts for the purposes of providing specific services or maintaining local infrastructure (see e.g., U.S. Census Bureau (2002). We do not separately incorporate such districts into our analysis, because data on boundaries and fiscal outcomes of these special districts are not consistently available in our study region. This is a limitation of our analysis, as these tax rates could potentially also be affected by land protection, in addition to the tax rates that we are able to consistently measure.

3. Land Protection Data Sources

The percentages of land protected in each municipality were constructed by spatial overlay between county sub-division boundaries and protected lands data. The Protected Open Space (POS) data draw from multiple local and regional sources, including the five state governments' conservation GIS layers, the National Conservation Easement Database (NCED), Protected Areas Database of the US (PAD-US), The Nature Conservancy, and data from individual land trusts in the region that do not necessarily contribute to these other information systems. The Highstead Foundation and Harvard Forest aggregate these data to obtain consistent estimates of area, timing, and type of protection. We use version 1.0 of the POS data. The changes in land protection overall and by type for the time-period between 1990 and 2015 are shown in Appendix Figure A1 for reference.

Protected land percentages were calculated as a share of town land area, net of water bodies, with land area coming from the U.S. Census County Subdivision shapefile (U.S. Census Bureau 2010).

A very small share of protected land is owned by entities with incomplete or missing data (fee simple landowner type: Other, Missing or PXX – private land of unknown type). Protected

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recover this variable using the algebraic relationship between the taxable value, tax rate and levy: municipal tax rate = municipal levy/assessed value.

land in this category accounted for approximately 1% of the change in area protected within our study region between 1990 and 2015. In 2015, this land represented 0.4 percentage points of the 20.2 percent of study area protected. Our results are robust to either including or excluding these lands from the analysis; they are included in the results presented. Finally, we note that a specific error in the Connecticut protected lands data means that some long-existing protected lands may be incorrectly coded as being protected in 2003. For this reason, we exclude lands protected in 2003 in CT from our analysis.

4. Current Use Value Program Sources

We use two different types of data characterizing land enrolled in current use assessment programs due to differences in data collection systems across states. For Connecticut, Maine, Vermont, and New Hampshire, we know the acres of land enrolled in current use, by town, for a limited set of years. Connecticut data were requested from the Forestry Division of Connecticut Department of Energy and Environmental Protection, while data from other states were available in published reports (Division of Property Valuation and Review 2011; Department of Revenue Administration 2010; Maine Revenue Services 2010). In Massachusetts, we know the taxable property value of the parcels enrolled, as well as the total taxable property value by town, but not acreage (Data Analytics and Resources Bureau 2011). To create a comparable measure, we compute the municipal land share under current use assessment for CT, ME, VT, and NH. We compute the municipal property tax base share represented by parcels in current use for MA. We then convert these into a continuous, state-specific percentile ranking for towns for the year 2010, a year that is available for all states and towns. This allows us to create a single measure of land in current use assessment for all states (see map in Appendix Figure A2, panel A). When current use data are included in the estimation, we limit the analysis time-period to 2004-2015 to match reasonably close time-periods from which the current use data are drawn.

5. Municipal Characteristics: Sources and Data Construction

As summarized in Table 1, we include several municipal-level variables as controls and as interaction terms in the analysis of heterogeneity. Data sources and additional notes about variable construction are given below.

5.1 Property Tax Base: Size and Growth

We specify the property tax base size as a time-invariant and state-specific percentile rank variable (see Figure 2B). Municipalities within each state are ranked based on the size of their tax base, relative to other municipalities in the same state, in terms of equalized value per acre in the first analysis time-period. We use this relative percentile ranking to avoid the influence of extreme values and regional clustering of high and low tax base towns and because of the slow rate of change for this variable over time. Appendix Table A15 shows that the correlation between tax base from the first analysis time-period and 2010 is 0.96, supporting the assertion of a slow rate of change.

We represent property tax base growth as a percentage change in equalized value relative to the previous year. We use the change in equalized value because it represents fair market value of land and as a result should more accurately capture growth resulting from demand side changes rather than assessment rules. We map average annual growth rates in Appendix Figure A2, panel B.

5.2 Residential Density

We construct housing density using total housing unit counts from 1990 and municipal area in km. Housing units data come from the U.S. Census and were obtained from the National Historical Geographic Information System (2017). We use housing density thresholds to classify municipalities into rural, exurban, and urban categories, following Radeloff et al. (2005). Municipalities with housing density < 16 homes/km^2 are considered rural. Exurban towns have housing density between 16 and 128 homes/km^2 and urban towns have a housing density >128 homes/km^2. We use density categories to allow for non-linear impacts of density. As a robustness check, we estimate a single interaction version of Equation 2 using continuous housing density. The estimates are shown in Table A16 and are plotted in Figure A4. Using continuous density results in similar estimates as using density categories.

5.3 Share of Vacation Homes

To construct a measure of the prevalence of second homes, we use U.S. Census data on the share of municipal housing units consisting of vacation homes in 1990. These data were obtained from the National Historical Geographic Information System (2017). As with the property tax base, this is a slow-moving variable. Appendix Table A15 shows that the correlation between vacation home share in 1990 and 2010 is 0.96. We map the percentage of municipal housing stock comprised by vacation homes in Appendix Figure A2C.

5.4 Median Income

We use census data on median household income in 1990 to examine variation in tax impacts of land protection with income. These data were obtained from the National Historical Geographic Information System (2017). We construct our income measure as a time invariant and state specific percentile rank variable, like the property tax base (Appendix Figure A2D). Our measure of income is again time invariant because it is not available for municipalities at an annual time step and is a slow-moving variable. Appendix Table A15 shows that the correlation between household income in 1990 and 2010 is 0.93, supporting the assertion of a slow rate of change.

5.5 Labor Force and Unemployment Rate

Annual data on the unemployment rate and labor force were obtained from the Bureau of Labor Statistics (U.S. Bureau of Labor Statistics 2017). Labor force was normalized by town land area (acres) to account for differences in town size.

6. Back Transformation of Regression Coefficients

We estimate Equations 2, 3, and their variations using Ihs transformed variables. For these models, the regression coefficients themselves do not have an exact intuitive interpretation due to the inverse hyperbolic sine transformation. We use derivations from Bellemare and Wichman (2020) to obtain expressions for the change in the equalized tax rate and other fiscal variables due to a one percentage point change in lagged land protection.

6.1 Equation 2, Ihs-Ihs Model

For large values of x and y, the Ihs-Ihs model coefficients can be roughly interpreted as elasticities. However, our values are small and the approximation does not hold well. We therefore find an expression for $\frac{\Delta y}{\Delta x}$ in terms of the Ihs-Ihs model coefficients and the values of x and y at which the slope is evaluated in order to calculate the slope estimates reported throughout the paper.

Specifically, using equation 16 from Bellemare and Wichman (2020), the predicted elasticity from an Ihs-Ihs model in general is:[25]

$$\frac{\widehat{\%\Delta y}}{\%\Delta x} = \hat{\beta}\,\frac{\sqrt{y^2+1}}{y}\cdot\frac{x}{\sqrt{x^2+1}}$$

where the β is the coefficient from the regression of Ihs transformed variables. (Note that in our case, y and x are variables measuring the change in the tax rate and the change in land protection respectively).

Rearranging this expression implies:

$$\frac{\widehat{\Delta y}}{\Delta x} = \hat{\beta}\,\frac{\sqrt{y^2+1}}{\sqrt{x^2+1}}$$

We use this expression to evaluate predicted slopes, or the predicted change in the tax rate corresponding to a one percentage point change in the lagged land protection, based on the estimated model coefficients. We evaluate these at the mean values of our variables and use the nlcom command in Stata to compute the standard errors of the predicted slopes using the Delta method. In our case, the X and Y variables are themselves changes, so the above expression becomes:

$$\frac{\Delta(\Delta \widehat{TaxRate_t})}{\Delta(\Delta\% LandProt_{t-1})} = \hat{\beta}\,\frac{\sqrt{\Delta TaxRate_t^2+1}}{\sqrt{\Delta\% LandProt_{t-1}^2+1}}$$

In practice, our x and y variables have small mean values, so the transformation often results in a slope estimate that is quite similar to the coefficients. (For comparison, Table A17 presents the untransformed coefficients estimated from equation 2). As an example, consider the following calculations to back transform the average impact of new land protection overall, as

[25] Note this expression also illustrates why the elasticity approximation holds for large values of x and y.

well as by protection type, for the Ihs-Ihs model. To transform the coefficient for the average effect (0.0237), we use the average change in the equalized tax rate of \$0.069 per \$1000 of value and the average change in land protection of 0.233 percentage points of town area. Plugging those numbers into the expression above we get the estimated increase in the equalized tax rate (\$/\$1000 value) for a one percentage point (pp) increase in new protection:

$$\frac{\Delta(\Delta \widehat{TaxRate}_t)}{\Delta(\Delta\% LandProt_{t-1})} = 0.0237\,\frac{\sqrt{0.0690^2+1}}{\sqrt{0.233^2+1}}$$

$$= \$0.0231 \text{ per } \$1000 \text{ of value and } 1 \text{ pp increase}$$

We similarly back transform the coefficients for the individual land protection types from Table A17, noting that the average change in land protection (in percentage points of town area protected) is 0.0347 for ngo protection, 0.0230 for municipal protection, 0.0987 for easement protection and 0.0445 for state/federal protection.

$$\frac{\Delta(\Delta \widehat{TaxRate}_t)}{\Delta(\Delta\% NGOLandProt_{t-1})} = -0.0524\,\frac{\sqrt{0.0690^2+1}}{\sqrt{0.0347^2+1}} = \$-0.0525/1\text{pp increase}$$

$$\frac{\Delta(\Delta \widehat{TaxRate}_t)}{\Delta(\Delta\% MunicipalLandProt_{t-1})} = 0.0720\,\frac{\sqrt{0.0690^2+1}}{\sqrt{0.0230^2+1}} = \$0.0722/1\text{pp increase}$$

$$\frac{\Delta(\Delta \widehat{TaxRate}_t)}{\Delta(\Delta\% EasementLandProt_{t-1})} = 0.0357\,\frac{\sqrt{0.0690^2+1}}{\sqrt{0.0987^2+1}} = \$0.0356/1\text{pp increase}$$

$$\frac{\Delta(\Delta \widehat{TaxRate}_t)}{\Delta(\Delta\% State/Fed.LandProt_{t-1})} = 0.0305\,\frac{\sqrt{0.0690^2+1}}{\sqrt{0.0445^2+1}} = \$0.0305/1\text{pp increase}$$

6.2 Equation 3, Difference in Logs-Ihs Model

Similarly, we calculate estimated slopes for equation 3. For a model with the Ihs only on the RHS, Bellemare and Wichman (2020) show that for the estimation equation:

$$y = \alpha + \beta Ihs(x) + \varepsilon$$

The predicted slope will be:

$$\frac{\widehat{\Delta y}}{\Delta x} = \hat{\beta}\,\frac{1}{\sqrt{x^2+1}}$$

where β is the coefficient from the regression and x represents the average value of the explanatory variable. In our case, our dependent variable is the difference in logs, so this expression becomes:

$$\frac{\Delta[\widehat{Ln(Y_{ic,t}) - Ln}(Y_{ic,t-1})]}{\Delta(\Delta\%LandProt_{t-1})} = \hat{\beta}_1 \frac{1}{\sqrt{\Delta\%ProtLand^2 + 1}}$$

To obtain estimated slopes, we evaluate this at the average change in percent area protected for either Massachusetts and Connecticut (0.2547) for variables specific to those states or for the whole region (0.2325). In practice, the adjustment from coefficients estimated using Equation 3 to estimated slopes is again small. For example, the coefficient on the change in log difference of expenditure for MA/CT in column 1 of Table 5 is 0.0025. Applying the above back transformation yields:

$$\Delta\left[Ln\left(Y_{ic,t}\right) - Ln\left(Y_{ic,t-1}\right)\right] = 0.0025 \frac{1}{\sqrt{0.2547^2+1}} = 0.0024 \text{ for a 1 pp change in land protection}$$

We report these estimated changes in the log difference outcomes (with corresponding standard errors calculated using the delta method) in Table 5 (noting that they are approximately interpretable as percent changes, or growth rates). To convert this predicted change in the difference in logs to dollar values for a 100 acre increase in protection, we evaluate it at the average logged values of fiscal variables and for the corresponding change equivalent to 100 acres. The steps are as follows. First, we note that the change in the fiscal outcomes due to land protection is calculated by taking the difference between logged outcome values with and without growth due to land protection.

<u>Without land protection</u>, a fiscal variable, Y, is changing from its average value in period *t-1* by the amount of the average log difference, ΔLnY_t. In other words:

$$Ln\left(Y_{ic,t}\right) - Ln\left(Y_{ic,t-1}\right) = \Delta LnY_t$$

Moving the lagged log value to the right and exponentiating, we have a predicted counterfactual value for the fiscal variable, Y:

$$Y_{ic,t-no\ prot} = Exp\left[Ln\left(Y_{ic,t-1}\right) + \Delta LnY_t\right]$$

<u>With land protection</u>, the fiscal variable, Y , is changing from the average log difference plus the expected change in the average log difference due to land protection, $\Delta(\Delta LnY_t)$. So:

$$Ln\left(Y_{ic,t}\right) - Ln\left(Y_{ic,t-1}\right) = \Delta LnY_t + \Delta(\Delta LnY_t)$$

Again, moving the lagged log value to the right and exponentiating, we have a predicted value for the fiscal variable, Y under the land protection change of:

$$Y^*_{ic,t-prot} = Exp\left[Ln\left(Y_{ic,t-1}\right) + \Delta LnY_t + \Delta(\Delta LnY_t)\right]$$

To obtain the change in outcome Y due to land protection, we take the difference:

$$Y^*_{ic,t} - Y_{ic,t} = Exp\left[Ln\left(Y_{ic,t-1}\right) + \Delta LnY_t + \Delta(\Delta LnY_t)\right] - Exp\left[Ln\left(Y_{ic,t-1}\right) + \Delta LnY_t\right]$$

For example, we illustrate the calculation using the expenditure result for MA and CT (column 1 of Table 5). In this case, we calculate an estimated $43,610 increase in expenditures for a 100 acre (or .6478 percentage point change). Specifically:

$Y^*_{ic,t} - Y_{ic,t}$ = Exp(17.10 + 0.02 +0.0016) - Exp(17.10 + 0.02) = $43610.29

where expenditure with land protection is the sum of average logged expenditures (17.10), the average change in logged expenditures (0.02) plus the difference in the average change in logged expenditures due to 100 acres of land protection (0.0016). Note that a 1 percentage point increase in land protection in MA and CT is 154.36 acres, so .0016 is $\Delta(\Delta LnY_t)$ for 100 acres, or (100/154.36)*.0024 = (0.6478)*.0024 = 0.0016. Additionally, we use the average logged values of fiscal variables from the contemporary time period in these calculations, as summarized in Table 1. Contemporary and lagged average values of logged fiscal variables are nearly the same, with a correlation coefficient of greater than 0.99.

7. Notes on Data Transformation

As described in Section 4.1, our main specification uses the Ihs transformed values of the average differences in tax rates and lagged land protection. We choose this approach over using a difference of logged values, because the Ihs of the difference performs better in reducing the influence of outliers and maintains the rank order of the within-municipality change in tax rate and land protection.

This is illustrated by Figure A3. Part A shows a simple scatterplot of the average three-year changes in tax rates from time-period, *t*, against average changes in land protection (in percent of town area) from the prior time-period, *t-1*. This figure illustrates why we have a potential outlier problem if we do not employ any transformations. The top 10% of the changes in land protection are shown in red. Part B plots the Ihs(differences) vs. Ihs(differences) and Part C the differences in logs vs. differences in logs. The same observations are shown in red in order to show how the ranking of the largest changes varies across transformations. This illustrates that the Ihs transformation reduces the spread of the data while also preserving the rank ordering of the relationship between the changes. In contrast, the difference in logs changes the rank ordering and more outliers remain that are not close to the distribution of the rest of the data.[26]

[26] The rank order changes as expected because of the interpretation of the difference in logs as (approximately equal to) a percentage change. E.g., consider a situation where the tax rate at time t-1 is $10 and at time t is $11. The Ihs of the difference specification first takes the difference in tax rates from time t-1 to time t (a $1 change), and then uses the Ihs of that difference (Ihs($1) = .88) as the dependent variable. The difference in logs on the other hand is approximately equal to a percentage change, so the dependent variable is 0.095 (Ln(11)-Ln(10)=0.095) or an approximately 10% change in the tax rate. For many situations, these two transformations would be quite similar, but consider how they are different for large or small values of the tax rate. A tax rate change from $20 to $22 is a $2 absolute change and a 10% increase, whereas a tax rate change from $5 to $7 is also a $2 absolute change but a 40% increase.

The practical effect of this is that some towns where the baseline level of land protection is very low now to appear with very high percentage changes in land protection (because the relative changes are indeed large). This gives substantially more influence in the model to some of these changes which, in reality, are very small actual changes in land protection. Conversely, some of the larger acreage changes in land protection appear small when they are modeled as a percentage change. Similar issues apply to the tax rate variable. These comparisons indicate that in this case the Ihs of the difference is a measure that preserves the meaningful rank ordering of absolute changes in tax rates versus changes in land protection while also minimizing the potential influence of outliers.

In addition, Parts D-F of Figure A3 show the impact of winsorizing the top 1% of changes in land protection, together with the top and bottom 1% of changes in the tax rate. Table A11 illustrates the impact of winsorizing variables, compared to dropping outliers or not doing anything, on the estimated tax impact of land protection. We prefer winsorization as the main specification as outliers do somewhat influence estimates, in particular for municipal protection, justifying the winsorization. Winsorizing variables results in estimates similar to those produced by dropping outliers.

8. Impact of Land Protection on Property Values

We do a back-of-envelope analysis to estimate the impact of land protection on property values which allows us to characterize more fully the potential change in the property tax bill due to land protection. We base this exercise on zip code level estimated property value impacts of open space referenda from Lang (2018) and property value estimates from Nolte (2020) and from the U.S. Department of Agriculture (National Agricultural Statistics Service 2015).

Lang (2018) presents estimated impacts on home prices for the ten years after passage of an open space referendum, comparing communities where an open space bond had just passed to those where it had just failed, using a regression discontinuity approach. He estimates increases in housing prices ranging from about 0.68–1.12% for every $1000 per household of open space spending authorized. For our analysis, we use the average of the individual year estimates for the ten years after referendum passage, which equals 0.907%.

We estimate the impact of protecting 100 acres on home values by converting the value of 100 acres of protected land into dollars per housing unit (from 2011-2015 ACS) and scaling the average home price increase from Lang (2018) to match this value. We then use the resulting estimated property value increase to obtain the increase in property value per $100,000 of taxable value. Finally, we multiply this increase by the equalized tax rate to determine the increase in the tax bill associated with property value growth due to land protection. We obtain a range of tax bill increases using USDA farmland values as well as the 25th, 50th and 75th percentiles of vacant land values from national estimates in Nolte (2020).

We illustrate this analysis with an example calculation using the town level average of 50th percentile vacant land values for Massachusetts of $37,219 per acre and the average town level number of households (8079 households):

i. We first estimate the cost per housing unit to conserve 100 acres: (100*37,219)/8079: = $461/housing unit
ii. We then scale the average home price increase from Lang by 0.461 (461/1000 =

.461) to get the estimated percent increase in house values associated with this amount of open space spending: 0.907*0.461 = 0.418%

iii. We next calculate additional taxable value that results from this increase per $100,000: 100000*(0.418/100) = $418

iv. Finally, we apply the average Massachusetts residential property tax rate ($12.59/$1000) to this value increase to obtain the tax bill increase: 12.59*(418/1000) = $5.26

We present the results of this exercise for each state and the region as a whole, using a range of vacant and agricultural property values in Table A9. These results suggest that that the increase in the tax bill due to growth in property values may be as big or bigger than the increase resulting from the municipal tax rate increase. We note however that these calculations assume that the 100 acres are purchased in fee simple. In reality, much of new land protection occurs through acquisition of conservation easements, which cost less than outright purchase, and should result in smaller open space expenditures per household and resulting property value increases. As a result, our estimated property value and tax bill increases likely represent an upper bound.