Paying for Costs, Hoping for Quality: Environmental Value and Selection in Conservation Easement Tax Incentives

Kelsey Larson*

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Abstract

A large share of American land conservation happens on privately owned land protected through conservation easements, where a landowner receives tax incentives tied to the land's economic development value in exchange for permanently donating the right to develop their land. In Virginia, measuring environmental value with a state-constructed ranking of conservation priority shows that the quality distribution of easements is wide, despite the state's large tax incentives and strong checks on easement fraud. The quality distribution of easements approximates the distribution of unconserved undeveloped land statewide and is much lower than that of publicly owned conservation land. A difference-in-difference analysis around a 2002 tax reform finds that increasing tax incentives attract donations of lower quality, particularly in regards to agricultural land. I use these results to build a model of conservation easement supply. Compared to a universal increase in conservation subsidies, offering increased tax incentives only to land with medium or high environmental value could substantially increase the amount of high-quality land conserved at a cost of 1.32 acres of low quality land per acre of high quality land, or 1.67 acres of low-to-high quality land per acre of very high quality land. Comparisons to a model with constant marginal quality show that ignoring the changes in marginal quality can lead to overestimates of the environmental benefits of any tax subsidy increase. The no-selection model overestimates the very high quality acres conserved by a nontargeted subsidy increase by 100% and by a targeted subsidy increase by 50%.

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1 Introduction

Much of the United States' conservation happens on private land. Conservation easements, where a landowner retains the right to use and sell their land but permanently gives up the right to develop it, now protect 61 million acres of land, an area more than eight times the size of Massachusetts[1]. The area under private conservation has ballooned in part due to substantial federal income tax incentives that have been in place since 1976 and expanded in 2006 and 2015 (Elkind 2017; Colinvaux 2012). These federal tax deductions now cost the government almost as much as the entire National Park Service (Looney 2017b), and fourteen states offer additional tax breaks (Land Trust Alliance 2019). Policymakers and conservationists around the world are considering further expansions to these tax credits to help meet the 30x30 commitment to conserve 30% of Earth's land and water by 2030, an ambitious goal shared by the 196 signatories of the Kunming-Montreal Global Biodiversity Framework, which would more than double the share of land protected compared to 2020 (Convention on Biological Diversity 2022). While the scale of private land conservation in the US is unique, several other countries are currently expanding similar projects such as the UK's 2021 conservation covenant law (Niker 2022) and France's "real environmental obligations" system created through the 2016 Biodiversity Law (Racinska and Vahtrus 2018).

Advocates support these policies as a way to preserve privately held natural lands more cheaply than purchasing them. However, these programs' designs leave room for land that produces little environmental value to end up permanently protected, possibly at a greater fiscal cost than the environmental benefit is worth. The size of the tax benefits given for a parcel of land depends on the development value of the parcel, defined as the difference in a parcel's market value with and without the restrictions of an easement. The benefits do not vary based on the environmental benefits provided by a parcel as long as the parcel preserves some minimum environmental, historical, or "open space" benefit and the donor can find a government or nonprofit land trust willing to accept the donation (J. Sundberg 2013). Easement policy therefore compensates participants for their private costs incurred rather than the precise social benefits they create. This feature is common to a wide range of government incentive programs, including charitable donation deductions, USDA agricultural practice change contracts, many green technology rebates, health care, and other settings where the costs of an action may be more easily identified than the benefits.

Under current conservation easement policy, private conservation areas range from pollutant-filtering wetlands housing endangered species to isolated stands of trees bordering golf courses. Elkind (2017) and others have documented cases of easements placed on parcels with low environmental quality but high development value. Quality greatly matters because the most valuable ecosystems can provide environmental services orders of magnitude more valuable than those of low-quality areas. For example, Ingraham and Foster (2008) estimates that

[1] Land Trust Alliance 2025, "Conservation Progress", https://landtrustalliance.org/land-trusts/gaining-ground/conservation-progress. Visited 7/11/2025

New England grasslands in the National Wildlife Refuge system deliver approximately \$60 per acre per year in combined carbon storage, water quality and regulation, and habitat provision services while wetlands provide \$2,670. Even when limiting analysis to water-regulation services provided by riverbanks in the Chesapeake Bay watershed, different stretches provide from less than \$1,730 in annual value per acre to more than \$8,400 (Phillips and McGee 2016). As such, low-quality easements may receive large tax deductions but provide offer little benefit(Colinvaux 2012). When poorly located, private conservation may even cause a net loss of environmental value by pushing development away from land with low environmental quality and onto high-quality parcels. In light of this, numerous experts have recommended investigating the environmental value of private conservation lands (Colinvaux 2012; Merenlender et al. 2004; Fishburn et al. 2009), but research on this remains scarce.

In this paper, I explore the environmental value of private conservation land and test the marginal quality of land attracted by increases in tax incentives. I investigate this in the state of Virginia, which has one of the nation's largest conservation easement subsidy programs (J. O. Sundberg 2011) and may serve as a model for states considering expanded private conservation programs. I measure environmental value using the Virginia Natural Landscape Assessment (VCLNA), a detailed set of conservation priority maps made in 2007 by the Virginia state government. These maps rank land according to its value for meeting the State of Virginia's conservation goals for biodiversity, forest conservation, agricultural preservation, recreation, and water quality. Using these measures of environmental quality allows this paper to directly test whether private conservation in Virginia is contributing to the state's established goals for conservation spending. It also provides a clear metric to compare the contributions of public and private conservation.

This paper's first contribution is to establish some basic and previously unexamined empirical facts about the environmental value of private conservation parcels. I find that the conservation priority of private conservation land in Virginia is lower than that of state-owned conservation lands, and, strikingly, almost indistinguishable from the distribution of unconserved undeveloped land in the state. The estimated development pressure facing private conservation lands is also similar to the pressure on other undeveloped land. Only the top 40% of private conservation is similar in quality to public conservation lands. Environmental quality varies widely, so considering a policy change's value requires considering the particular quality levels of land affected. Private conservation lands do comply with the easement's restrictions on development, with pre-2006 easements showing a near-zero change in share of land developed between 2006 and 2016.

This paper also offers a model exploring several reasons why the quality of land selecting into a private conservation program might change as subsidy rates change. Using a simple single-period model of the easement donation decision, I model the donation decision as a product of the land's development value, the tax benefits of an easement, and their personal utility of keeping their land undeveloped. Landowners with higher utility from undeveloped land are more willing to donate when subsidies are lower, while landowners with higher development values on their land may need larger tax benefits to be willing to donate. The impact of a subsidy rate change on marginal quality is theoretically ambiguous. If the utility of nondevelopment correlates with environmental value, such as if landowners enjoy healthy habitats more than ecologically degraded ones, the lands donated when subsidies are large may be less valuable than those donated when subsidies are small. Development value could also drive quality selection. Since land with higher development value is more elastic to the incentive rate, higher subsidies will attract more land with high development value–which will result in higher marginal quality if development and environmental value are positively correlated, and lower marginal quality if the correlation is negative. In Virginia's case, I find that environmental value of parcels is negatively correlated with development value per acre, which would lead us to expect decreasing marginal quality of easements.

This model suggests several lessons about when cost-subsidization policies will be more or less successful in maximizing a policy's social value. First, the key inefficiency comes from a mismatch between the participant's cost of an action and the social benefits created. If social benefits and private costs were perfectly correlated, compensating costs would create a close-to-optimal outcome. Since they are negatively correlated in the Virginia case, there is far more room for inefficiency. Second, increasing subsidy rates decreases the importance of the private preferences or motive for the action in the choice to participate. In the Virginia setting, where the charitable motive may be greater for higher quality land, this leads to diminishing marginal quality. In settings where we are concerned with additionality, where private preferences for a practice lead to lower additionality, increasing subsidy rates may instead lead to higher marginal values.

I further find that in the Virginia setting, the marginal easements attracted by a tax incentive change are lower quality than the always-donated easements, particularly in terms of agricultural value. For each donated easement, I estimate the landowner's post-tax subsidy rate, the share of a landowner's donated development value that is compensated by tax incentives. I then examine the effects of a 2002 reform to the conservation easement program that differentially shifted the subsidy rate by development value and donor income, increasing support for easements on high development value parcels and reducing support for low development value parcels. I run a regression interacting the shift in the subsidy rate pre- and post-2002 and whether the parcel was donated pre- or post-reform. This shows that the environmental value rankings of parcels that became cheaper to donate fell relative to parcels whose subsidies shrank, indicating that the marginal parcels are of lower quality. Approximately 30% of the lower marginal agricultural scores can largely be explained by the inverse correlation between conservation and development value: high development value agricultural parcels, which are more elastic to shifts in the subsidy rate, tend to have lower conservation value. Land trusts do not seem to drive the effect through either variation between them or shifts within them: all large land trusts accept donations with a wide quality range, and controlling for land trust fixed effects in my regression does not change the results.

Past research has found that the total acreage of private conservation donations responds strongly to the post-tax price of donating (Soppelsa 2017), with Parker and Thurman (2018) estimating an acreage elasticity of -2.4 to -6.1. I find a slightly smaller but similar acreage elasticity of -1.5 and a donation count elasticity of -2.4, and I add a new quality elasticity to complement it. By allowing the marginal quality of land to shift as tax incentives change, this paper lowers the estimation of the environmental benefits of a tax incentive increase compared to the pure-acreage estimation. A modeling exercise shows that a constant quality model of Virginia private conservation land would have overestimated the increase in very-high-quality acreage from large donations by 100% compared to a model allowing variation in marginal quality.

This shift adds a new angle to the literature on selection into private conservation programs. Research on such programs often finds adverse selection in terms of additionality, the behavior change induced by a program (Jack and Jayachandran 2019; Alix-Garcia, Shapiro, and K. R. E. Sims 2012), which results in low estimated overall additionality of many voluntary conservation programs (Braza 2017; Honey-Rosés, Baylis, and Ramírez 2011). This additionality problem usually becomes less severe as programs expand and attract more additional land. Conversely, I find that the selection problem in terms of environmental quality may worsen as more landowners join. This effect lowers the optimal subsidy rate for private conservation as policymakers use the subsidy rate to screen out undesirable donations.

My model also expands the easement literature in particular by focusing on the role of landowners rather than land trusts as drivers of selection. Past theoretical work has noted that land trusts are likely to lower their standards as donation incentives increase: Vercammen (2019)'s theoretical work on easements hypothesizes that land trusts that purchase easements may create marginal quality shifts by changing their decision to purchase or donate easements, and Suter, Sahan, and Lynne (2014) finds evidence suggesting land trusts spend less on targeting priority areas when subsidies increase. However, this mechanism may be less relevant in high-subsidy settings like Virginia: when they need only pay the monitoring cost, land trusts need only screen for some contribution to their goals, and landowner choices may become the driving factor. Indeed, this paper suggests that Virginia land trusts are fairly passive recipients of donations, since all large land trusts accept donations with a wide quality range. This means that the quality of land under easement largely depends on which landowners are willing to donate. This paper's analysis of the effects of easement tax incentive shifts shows that changing incentives for donors substantially impacted those landowners' donation choices.

This paper also explores the acreage-quality tradeoff from targeting subsidy increases only at land that meets a higher quality threshold. My model estimates that targeted same-cost policy offering increased subsidies only to medium-to-high quality land could increase conservation of these higher quality acres at a cost of 1.28 low-quality acres per medium-to-high quality acre. A program targeting only high-quality land could have conserved at least ten thousand more acres of high-quality land per year at a cost of 1.80 low- or medium-quality acres per high-quality acre. Given the high variation in per-acre environmental services, land use planners would likely consider this a very worthwhile tradeoff.

I also contribute to the literature on optimal tax deductions for charitable donations. With the goal of inducing donations of private funds towards creating social goods, the US and many other developed countries give substantial tax incentives for charitable donations. In 2020, the charitable donation tax deduction cost the IRS an estimated $44.4 billion (Tax Policy Center 2022). Saez (2004)'s key framework notes that this policy is only treasury efficient if a dollar in reduced tax revenue increases donations by more than a dollar. Many authors have explored the elasticity of donations in response to the post-tax price of donation, finding an elasticity of -1.44 on average (Peloza and Steel 2005), though it varies considerably between types of charities (Duquette 2016). I join a newer strand of this literature that explores how effectively these marginal donations translate into social value. Grant and Langpap (2022) find that despite the high elasticity of water-focused-charity donations, the lower marginal benefits of charitable donations compared to public spending make donation incentives inefficient at creating water quality improvements. Galle (2015) estimates that fundraising spending is elastic to the tax incentive rate, reducing the social good provided by the increase in donations. This paper shows another way in which the marginal donations attracted by tax subsidies may produce less social value, in this case by attracting lower environmental quality land for preservation. In the optimal taxation framework, this effect lowers the optimal size of subsidies for easements.

This paper proceeds with Section 2 describing the setting and data. Section 3 presents a model for the supply of private conservation land. Section 4 provides a comparison of private and public conservation land. Section 5 discusses the empirical methodology for the difference-in-difference analysis of the effect of changing the cost of donation, and Section 6 shows the results. Section 7 estimates the effect of same-cost but targeted easement policies. Section 8 presents robustness checks, and Section 9 concludes.

2 Data and Setting

2.1 Conservation Easement Policy

Conservation easements have been part of the conservation landscape in the United States since they were legalized in the 1970s. Conservation easements add permanent restrictions to a land deed, with a land trust such as a government agency or nonprofit holding the development rights that the landowner relinquishes. Conservation easements let landowners continue current land uses that are compatible with the environmental value to be protected, such as agriculture or maintaining a residence, but prevent further development by any current or future landowner. These laws give land trusts the responsibility for enforcing the terms of easements that they accept. If the easement terms are violated, the land trust can take the landowner to court to correct the violation.

Both federal and state governments subsidize easement donations. In 1976, the federal government made conservation easements deductible as charitable donations (Parker and Thurman 2019). Federal legislation set the amount deductible as the development value forgone by putting the land under easement. Since then, fourteen states have also established tax incentive programs for private conservation, most of which were introduced in the 1990s and 2000s (Land Trust Alliance 2019). During the period of study from 2000 to 2006, federal easement policy was largely stable. However, the 2003 tax cuts indirectly decreased the value of the charitable deductions by lowering the income tax rate for most individuals.

Virginia's conservation easement incentive program is particularly large. The Virginia Land Conservation Incentives Act of 1999[2] allowed taxpayers to claim tax credits worth up to 50% of the fair market value of an easement donation. Taxpayers could use these tax credits to reduce their tax liability one-for-one, claiming up to $75,000 in credits per year, and they could spread use of these credits over the decade after the initial donation.

However, these tax credits could not be used to reduce liability below zero, and any credits not used within ten years would expire. Donors with high development value parcels or small incomes might be able to claim only a fraction of the tax benefits that the development value of the land made them eligible for. Policymakers were concerned that this discouraged large donations and disadvantaged low-income donors, so in July 2002 the Virginia house passed Bill 1322 raising the cap on annual credit usage to $100,000 and specifying that all easements made after January 1, 2002 would be allowed to transfer tax credits to other taxpayers. This sales process requires paying a 2% transfer fee to the Department of Conservation, and a wave of private brokers (at least six searchable online as of 2024) entered the market to help facilitate matching buyers and sellers of credits for a further fee. Sale values range, but donors typically receive 70 to 80 cents per dollar of credit after discounting and fees.[3] At the same time, Bill 1322 reduced the claimable credits for a parcel from 50% to 40% of the development value. This meant that donors with small easements and high incomes, who could use all of their credits even without the sale option, faced a higher price of conservation after the reform.

The Virginia private conservation program also notably includes some provisions to check against fraud. Nationally, fraud is a serious concern in conservation easements. Unscrupulous easement donors hire land assessors to dramatically inflate the expected development value of the land, allowing the donor to claim tax benefits that may be far larger even than the fair purchase price of the parcel. In one such transaction, investors purchased a South Carolina golf course for $5.4 million, and then claimed a disproportionate $40 million in tax deductions from placing an easement on the parcel (Elkind 2017). Fraud is particularly prevalent in states that created state-level incentive programs but

[2] https://law.lis.virginia.gov/vacodefull/title58.1/chapter3/article20.1/

[3] Land Conservation Assistance Network, https://www.landcan.org/article/Buying-and-Selling-Virginia-Tax-Credits/2545

did not improve enforcement, such as Florida, South Carolina, and Georgia, the "'Southeast Triangle' in which federal income tax liabilities mysteriously disappear" (Feld, T. Sims, and Nielson 2022). Virginia's program has built in some meaningful checks against this: all easement donations must send in a full application to the Virginia Tax Bureau for approval of development valuations, and donations claiming development values of over $1 million must also apply to the Department of Conservation and Recreation (DCR) to prove that the easement restrictions will effectively protect at least one environmental value on the land. By proactively monitoring valuations and restrictions, Virginia seems to prevent the abuse seen elsewhere. While Georgia has 1.5% of national easement acreage but claims 36% of federal deductions, Virginia has 7% of national acreage but claims a reasonable 4% of deductions, suggesting low rates of inflated claims (Looney 2017a). This makes Virginia a good setting to analyze the effect of shifts in incentives since the amount of tax incentives landowners are legally allowed to claim and the amount they actually claim should closely align. It also makes the state a potential model for other areas considering expanding easement incentives.

Private conservation has come to dominate Virginia's conservation spending strategy. $1.7 billion of Virginia's $1.8 billion spent on land conservation over the last 20 years has gone to easement tax credits (Vogelsong 2021), protecting 1.07 million acres of land over that time period according to the NCED. Each acre protected therefore cost the state of Virginia approximately $1600 in tax incentives, not including the substantial federal incentives and local property tax incentives. Since public purchases of conservation land have become so rare, Virginia landowners largely choose between easements and no binding conservation.

2.2 Conservation Priority Data

I measure environmental quality of land using the 2007 Virginia Conservation Lands Need Assessment (VCLNA). Commissioned by the Virginia Department of Conservation and Recreation (DCR), VCLNA was a green infrastructure mapping project designed to rank the conservation value of all the lands in Virginia along several dimensions that are key goals for Virginia's land conservation programs. The maps separately rank land from one to five on ecological integrity, watershed value, recreational value, forest value, and agricultural value. Locations that have a rank of 5 for a metric are assigned an "outstanding" value and are highest priority for conservation, a 4 marks "very high" and 3 marks "high" value, while areas with a 2 have moderate value and 1 has only a general value. Since the VCLNA was created for the state to prioritize purchases of land and to measure progress towards conservation goals, it is a useful measure of the extent to which the private conservation tax breaks have achieved Virginia policymakers' own targets. Appendix **??** further details the metrics' construction.

These measures naturally have some limitations. They do not necessarily include all environmental benefits that the land creates. In addition, these measures also do not translate well to a dollar value, or even offer a clear ratio of benefits across different rankings. However, these limitations are common to most attempts at multidimensional environmental value estimations, and VCLNA includes the major environmental values most important to Virginia policymakers. Creating a clear monetary estimate would require detailed value estimates of traits like biodiversity, which is something that economists are only beginning to quantify.

For each category of environmental value, I measure the mean value of a conservation metric over the easement land: for example, a 100-acre easement with 80 acres of land scoring a watershed value of 4 and twenty acres with watershed value of 5 would score a 4.2 for watershed value. I analyze these variables individually and as the maximum and mean category score on a parcel. Maximum or mean value reflect two different extremes of how the 1-5 rankings could relate to one another. If all categories matter equally and the ranking levels are separated by equal steps of value, the mean categorical score will best reflect the total value of the land. If the rankings are separated by orders of magnitude so that if a parcel reaches "Outstanding" in one category we would care little about how it ranks in the others, we would prefer the maximum ranking. The mean rankings take only the means of the scores relevant to the parcel's land use. Accordingly, means of lands in natural use do not include agricultural value, nonforested lands do not include forestal value, and agricultural lands do not include recreational value in the index.

2.3 Easements and Conserved Lands

I locate private conservation lands using the National Conservation Easement Database (NCED). The NCED gathers voluntary data from land trusts on the locations, purposes, and date of establishments of easements. The NCED estimates that their database contains all government-held easements in the state of Virginia and 88% of nonprofit-held easements. Since government organizations hold 82% of all easements in Virginia, this amounts to 98% of total private conservation acres and makes Virginia one of the most complete states in the NCED.

The NCED contains data on 6,816 Virginia land parcels under private conservation. 94% have listed easement establishment dates. Of those, 2,473 easements were established between 1998 and 2006, placing them in my central period for analysis. This period marked a dramatic increase in private conservation following the establishment of the Virginia tax credit program. Before this data, only 1,022 easements had been established in the state, with 20 to 60 easements established a year since the 1970s.

To map the locations of public conservation lands in the state of Virginia, I use the Virginia DCR's Virginia Conservation Lands Database. This database tracks state, federal, and local government preserved lands in the state. These lands include 2.3 million acres of federally owned land, 430 thousand acres of state owned land, and 47 thousand acres of locally owned land. I also make use of the statewide set of tax parcels on the Virginia Department of Transportation's Virginia Parcels map. I use this to create an comparison group of unconserved land, and to test the number and completeness of tax parcel coverage by individual easements.

2.4 Other Data Sources

I also use a set of mapped measures discussed in Appendix B to measure other traits of the land such as its value in current use, development risk, local demographics, land use, weather, and soil quality. I explore land use, development risk, and area demographics as outcome variables, and I use those variables and the others as inputs to my development value estimation model.

3 Model

Conservation easement policy has a central contradiction. While the policy seeks to correct an externality created when landowners develop land with high environmental quality, the incentives given to landowners are tied to development value, the value of preserving the option to develop. I use a simplified two-period model to illustrate this tension. The policymaker wants to attract parcels for private conservation that have high environmental benefits and would have developed in absence of an easement.

From an economist's perspective the potential solutions to this externality might seem obvious: pay or charge landowners according to the amount of environmental value they protect or destroy. However, several factors prevent this option from being implementable. First, pinning down the exact amount of environmental value a parcel provides is extremely difficult. In the past, there were few good estimates of where environmental value was even concentrated. In recent decades, helped by the growth of remote sensing, many researchers have contributed to a rich literature trying to estimate the value of every environmental service from water management to biodiversity to birdwatching. Nonetheless, these exact value estimates remain contentious and incomplete. Therefore, conservation easement policy has gravitated towards using quality thresholds for eligibility instead: policymakers can choose some objective and attainable measurement or ranking to decide whether or not a parcel meets the criteria for a program. The VCLNA project itself shows why policymakers prefer this method. While the scientists who created it do not have an exact benefit ratio between any two tiers of VCLNA priority, they have confidence that the higher tiers hold more environmental value per acre than the lower ones.

While environmental value is hard to measure, our legal system already has a clear structure to measure development value. In most places, assessors already assess land and property values for local taxes. Assessing the development value just requires an additional step of separating the value of the development option from the land's value in its current use. Fraudulent assessments can distort these measures, but active enforcement bodies like the Virginia Department of Tax can detect and correct these overvaluations if they significantly differ from the best practice approach. Using development value as a basis for incentives was a particularly natural policy move because it makes easements legally similar to other charitable donation tax incentives, where a taxpayer receives the same incentive for donating to any nonprofit as long as the nonprofit meets the IRS's criteria for tax exemption.

The policymaker is therefore constrained to an incentive program where the government allows all easement donors who meet an environmental quality level to get a tax subsidy tied to the land's development value. This policy format creates several inefficiencies. Attracting land at high risk of development requires higher subsidy rates to balance the benefits of development for landowners. However, higher incentive rates may also attract landowners with lower intrinsic utility from preserving their land. If that utility of conservation correlates with the environmental quality — if owners of high biodiversity forests or historic farms get more utility from conservation than landowners with fragmented habitat strips alongside golf courses or low-productivity plots — increasing incentives will attract lower environmental quality donations. In addition, higher development value parcels will be more elastic to changes in the development value subsidy, potentially leading to lower marginal quality of easements if development and environmental value are inversely correlated. In setting the subsidy rate, the policymaker therefore needs to balance the costs of inframarginal payments and lower quality easements against the benefits of additional acreage.

To illustrate this challenge, I use a single-period game between a policymaker and landowners. The policymaker moves first. They choose an environmental quality threshold required to be eligible for easement subsidies and a subsidy rate that eligible landowners receive for donating easements. The landowner then chooses whether to donate an easement and then, if not restricted by an easement, whether to develop their land. Society then receives benefits from tax revenues and the environmental quality of undeveloped land, while the landowner receives revenues from their land, subsidies from easements, and a warm glow utility if the land remains undeveloped.

3.1 The Landowner's Decision

In this model, landowners derive utility from two sources: the income the landowner receives from their developed and undeveloped land, and a warm glow utility that landowners may receive from undeveloped land. In absence of a conservation policy, landowner i's utility function is:

$$U = \begin{cases} a(1-\tau)v_i^d & \text{if developed} \\ a(1-\tau)v_i^u + au_i & \text{if undeveloped} \end{cases} \tag{1}$$

where a is their land parcel's acreage, τ is the tax rate on income, u_i is the landowner's private utility from undeveloped land, and v_i^d and v_i^u are the revenue per acre a landowner receives if they develop or do not develop respectively. $V_i \equiv v_i^d - v_i^u$ is the development value of the land. This land also provides an environmental externality e_i per acre if undeveloped and 0 if developed. This value does not directly enter the landowner's utility function.

If the landowner chooses not to develop, they effectively pay a monetary price $a(1-\tau)V_i$ in exchange for au_i in utility of keeping the land undeveloped. This social benefit of conserving will be higher than this monetary price if $e_i > \tau V_i$, so the policymaker may choose to offer some landowners an easement tax incentive. The policymaker chooses a quality floor e^{min} and a subsidy rate s. If a landowner places an easement on a parcel with $e_i \geq e^{min}$, they receive a tax incentive worth saV_i. The easement binds the landowner to nondevelopment, so the landowner's utility function becomes

$$U = \begin{cases} a(1-\tau)v_i^d & \text{if developed} \\ a(1-\tau)v_i^u + saV_i + au_i & \text{if undeveloped} \end{cases} \tag{2}$$

So the landowner, who previously would have left land undeveloped only if $(1-\tau)V_i < u_i$, now keeps land undeveloped (and under easement) so long as $(1-\tau-s)V_i < u_i$. The price of conservation p, defined as the post-tax monetary loss per dollar of development value kept in conservation, lowers from $1-\tau$ to $1-\tau-s$. The landowner donates an easement if:

$$s > s_i(u_i, v_i) \equiv 1 - \tau - \frac{u_i}{V_i} \tag{3}$$

The landowner's minimum subsidy rate required for donation is decreasing in u_i: landowners who get greater personal satisfaction from keeping their land undeveloped need less incentive to protect it. Conversely, increases in the development value V_i mean the landowner will demand a larger subsidy to conserve since they are giving up more development value.

Two potential channels in this model could drive a negative correlation between e_i and s_i, and thus the decreasing marginal quality of easements seen in this paper's results: a relationship between e_i and u_i or a relationship between e_i and V_i. In the first category, we might expect that higher environmental value is correlated with higher conservation utility for the landowner. A healthier, more environmentally valuable ecosystem may offer more psychological benefits from exposure (Wyles et al. 2019), better opportunities for outdoor recreation like hunting or birdwatching, and perhaps a greater "warm glow" for playing a role in protecting it. As such, these landowners need less of a tax incentive to place their land under easement.

In regards to the second channel, the parcels with the greatest environmental value are often located far from the biggest development opportunities. Development value V_i tends to be highest near urban areas, while the greatest environmental value often comes from preserving contiguous and relatively undisturbed habitats more frequently found in rural regions. Table 1 illustrates that in the Virginia context, e_i and V_i are indeed inversely correlated. My empirical results in section 6.5 find that development value distributions seem to have little effect in this setting.

3.2 Costs and Benefits of Subsidies

Next, I scale up the individual landowners' decision into a supply curve. In this model, landowners vary by their values of u_i, V_i, and e_i. The minimum subsidy rate s_i at which a landowner will choose to conserve is a function of u_i/V_i, the ratio of a landowner's private utility of conservation to the value of their development rights. The total acres landowners are collectively willing to donate then becomes

$$A(s) = a \int_{s=0}^{s} f(s)ds \tag{4}$$

where $f(s)$ is the probability density function of s_i. For simplicity in this model section, I set acreage per parcel $a = 1$. $A(s)$ denotes the total number of acres upon which landowners want to place an easement on their land when the subsidy rate is s, but some share of that acreage may have $e < e^{min}$ and therefore not qualify for the easement subsidy. A share of offered acres $P_{e^n}(s)$ has quality $e_i \geq e^n$ for a given environmental value threshold e^n.

To calculate the full environmental benefits of an easement, I also need to consider the marginal development decision. Some landowners may have $u_i/V_i > 1 - \tau$, meaning they would not choose to develop their land even without an easement subsidy. These never-developers are referred to in the environmental literature as "non-additional:" since they behave the same whether or not they participate in the easement program, their participation does not add environmental value. For these non-additional landowners, $s_i \leq 0$: they will always choose to place their land under easement even without a subsidy. Therefore in this model, $A(0)$ acres of prospective donations are nonadditional, and $A(s) - A(0)$ acres are additional.

This entry of low-additionality easements into the program is consistent with the broader literature on selection into voluntary conservation programs (Jack and Jayachandran 2019; Alix-Garcia, Shapiro, and K. R. E. Sims 2012; Vercammen 2019), where the landowners with the least interest in developing their land are the most willing to join a program. My model creates steeper adverse selection than seen in empirical examples because I do not include transaction costs or dynamic uncertainty around development opportunities. When there is uncertainty around development opportunities, landowners who had low development expectations when they placed an easement may later be forced to decline a good development offer, making their easement additional.

I choose not to include these complexities in this model because additionality is difficult to measure and less relevant in my setting. Unlike most kinds of voluntary conservation, easements lock in land use in perpetuity. They create permanent reserves of protected land that should remain undeveloped no matter how future development pressure evolves. Even examining development effects twenty years after an easement's establishment cannot fully tell us the program's impact. In addition, the Virginia setting of this paper only compares across subsidy rates that are always well above zero, so a lack of a selection effect in this range fits with my models predictions. The total amount of environmental value preserved by easements given subsidy rate s would therefore be

$$B(s) = (A(s) - A(0)) * P_{e^{min}}(s) * E[e|0 < s_i \leq s, e_i \geq e^{min}] \tag{5}$$

Two factors enter the benefits equations: the additional acres protected $(A(s) - A(0)) * P_{e^{min}}(s)$, and the average environmental value per additional acre $E[e|0 < s_i \leq s, e_i \geq e^{min}]$.

In regards to costs, the policymaker must pay for both additional and non-additional land, though differently on each. Altogether, the cost is

$$\begin{aligned} C(s) =& A(s) * P_{e^{min}}(s) * sE[V|s_i \leq s, e_i \geq e^{min}] \\ &+ (A(s) - A(0)) * P_{e^{min}}(s) * \tau E[V_i|0 < s_i < s, e_i \geq e^{min}] \end{aligned} \tag{6}$$

Easement subsidy payments cost sV_i for each easement acre regardless of additionality. On land that would have developed, the government also loses the τV_i in tax revenue they would have received from development.

3.3 Costs and Benefits of Subsidy Shifts

This model can illustrate how differences in marginal environmental quality can impact the costs and benefits of changes in easement tax incentives. If the quality of potential donations declines as the subsidy rate increases, a naive estimate ignoring quality effects will overstate the benefits of a subsidy rate increase. It will also overestimate the program's costs and total protected acreage if the program has a higher environmental value floor for eligibility.

As subsidy rates change, the shift in benefits is the derivative of Equation 5:

$$\begin{aligned} \frac{dB}{ds} =& A'(s)P_{e^{min}}(s)E[e|s_i \leq s, e_i \geq e^{min}] \\ &+ (A(s) - A(0))P'_{e^{min}}(s)E[e|s_i \leq s, e_i \geq e^{min}] \\ &+ (A(s) - A(0))P_{e^{min}}(s))\frac{dE[e|s_i \leq s, e_i \geq e^{min}]}{ds} \end{aligned} \tag{7}$$

The change in benefits is composed of three key terms: the change in the number of acres offered, the change in the share of offered acres meeting the environmental requirement, and the change in average environmental value. An estimate with fixed marginal quality considers only the first term, the change in the number of acres offered, since a lack of quality changes sets $P'_{e^{min}}(p) = 0$ and $\frac{dE[e|p,e^{min}]}{dp} = 0$. The latter two terms will be negative if marginal quality is declining, since declining marginal quality means $\frac{dE[e|s,e^{min}]}{ds} < 0$. This lowers the average environmental value preserved per conserved acre as the subsidy for conservation increases, driving down the overall benefits from a subsidy increase.

Second, $P'_{e^{min}}(s) < 0$ reflects that fewer marginal acres meet the policy's required environmental threshold as the conservation subsidy increases, so more potential donations will be rejected and fewer acres will be conserved than the naive estimate expects. This also slows down the growth of costs in response to a subsidy rate change since fewer marginal acres are eligible for incentives. If the floor e^{min} is low few potential easements will be disqualified under any subsidy rate, so this term may be unimportant in current easement policy. However, this will impact evaluation of alternate policies with higher floors for environmental quality because this factor slows the growth in acreage and costs at any specific subsidy rate. If policymakers hope to reach a specific acreage goal despite declining marginal quality, they will need to set a higher subsidy and pay a higher marginal cost than they would in the fixed-quality case.

4 Conservation Land Characteristics

In this section I explore the attributes of conservation land in the state of Virginia, an important step in understanding what value conservation easement programs are producing. I compare parcels under conservation easement to public conserved land and to unconserved undeveloped land statewide, identified with a random sample of 19,000 private unconserved parcels with at least 33% undeveloped land. Publicly owned conservation land clusters around the highest conservation priority scores, as expected. Private conservation land under easement, in contrast, rates poorly. Easement land looks similar in quality to the unconserved undeveloped land. It has lower and more variable quality than public conservation land for every dimension except agricultural value. This variability in quality leaves room for differences in marginal quality to matter while estimating the benefits of a policy change.

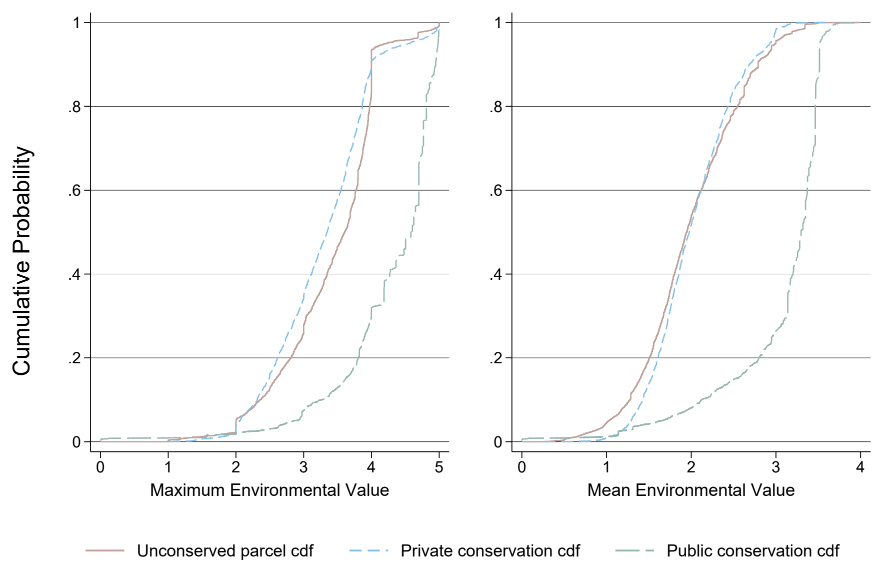
I also test whether parcels under easement comply to the restrictions on development. I find that land use remains fixed after easements are put in place, suggesting a high level of compliance to easement terms. The distribution of development threat level for easements is similar to that of statewide undeveloped land.

4.1 Conservation Land Environmental Value

First, I plot a cumulative distribution function of environmental quality among private and public conservation parcels, as well as unconserved undeveloped parcels statewide. Aside from easements, governments otherwise must buy land to preserve it in parks or reserves. Since governments must either directly pay a market price to own land or at least forgo revenues from selling this land to private landowners, owning land is more expensive for the state than holding easements. However, the government can directly choose which parcels to purchase with more control than the easement process exerts, and land purchases allow stronger control over the land's use.

Figure 1 shows the acreage-weighted CDF of the highest environmental value on conserved and unconserved land parcels. State-owned public conservation land encompasses mostly land in the highest VCLNA rankings: two-thirds of public land scores between a 4 (very high conservation value) and a 5 (outstanding value) in their highest-performing category. Less than 10% of publicly owned

Figure 1: Quality distribution of public and private conservation lands



Note: This graph plots the acreage-weighted cumulative density functions for parcel level VCLNA scores statewide, where 5 is the highest level of conservation priority. It identifies private conservation land in Virginia using the NCED, and public conservation land using state, federal, local government, and mixed ownership parcels in the Virginia Conservation Lands Database. Unconserved parcels are a random sample of 19000 parcels identified using the Virginia DOT's Tax Parcels map with at least 33% NLCD undeveloped land and no private or public conservation overlap.

parcels score below a 3 (high value). The two-way Kolmogorov-Smirnov test to compare the CDFs of public conservation and unconserved land finds that public conservation lands are significantly higher quality at the 1% level for every VCLNA quality measure and index and is statistically signficantly lower quality for none of them except agriculture. This suggests that the VCLNA scores do encapsulate the state's conservation priorities well, since the areas that the government actively chose to purchase are clustered at the high end of this scale. It also implies the state places little conservation value on lands below a 3 on this scale.

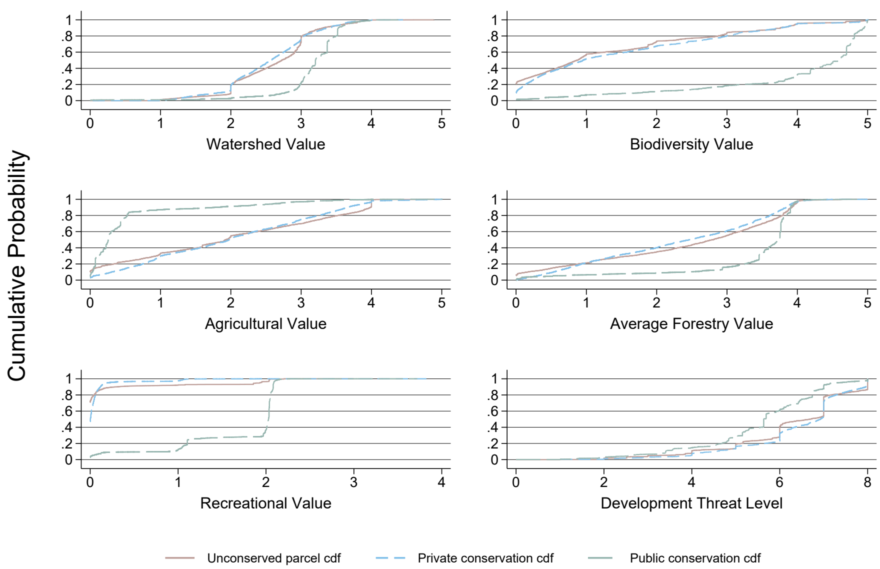
Strikingly, the quality distribution of private conservation lands is lower than the statewide distribution of unconserved undeveloped land. Figure 1 shows that the CDFs for private conservation and unconserved land track closely. The Kolmogorov-Smirnov p-value testing whether unconserved land is lower quality than private conservation is statistically significant at the 1% level. By Virginia's metrics, the environmental quality of land preserved by easements looks as though the state had done slightly worse than throwing darts at a map, excluding only heavily developed parcels. The DCR-measured development risk in Figure 2 is also similar to the state-wide distribution, so easements are not targeting areas with more or less development pressure. Indeed, the private conservation quality distribution is similar to the unconserved distribution for every VCLNA-measured environmental value category, and the Kolmogorov-Smirnov test finds that the CDF of easement conservation land is statistically significantly lower than the unconserved land for every category, and is statistically significantly higher on some stretch of the CDF for only agriculture and the maximum and mean environmental value indices. This suggests that the minimum quality checks on easements are doing little more than confirming that parcels have natural or agricultural land to conserve.

This easement land quality is on average one priority point below public conservation lands and has a high level of variability. Almost a third of easements have a maximum score below a 3, which is rarely seen in public conservation land. This is not inherently non-optimal: easement subsidies are cheaper than public conservation land purchases, so private conservation might optimally cover some lands that would be too expensive to protect under public conservation.

However, there is a good amount of higher-quality unconserved private land in Virginia still available for conservation. As the private unconserved land distribution in Figure 1 shows, there is very little unconserved land with a maximum score that is "very high" or above, but almost 70% of undeveloped unconserved land scores at least a "high" 3. At present, only 60% of conservation easements reach a 3 or above in their best category. Easements are reaching some of the lower-quality land while other high-quality land remains unprotected.

This result is far less optimistic for easements than Villamagna, Scott, and Gillespie (2015), which focused on a smaller sample of easements included in a previous, less complete version of the NCED and found that ecosystem services on private conservation lands in Virginia and North Carolina were largely similar in quality to public conservation lands.

Figure 2: Quality Distribution of Conservation Values



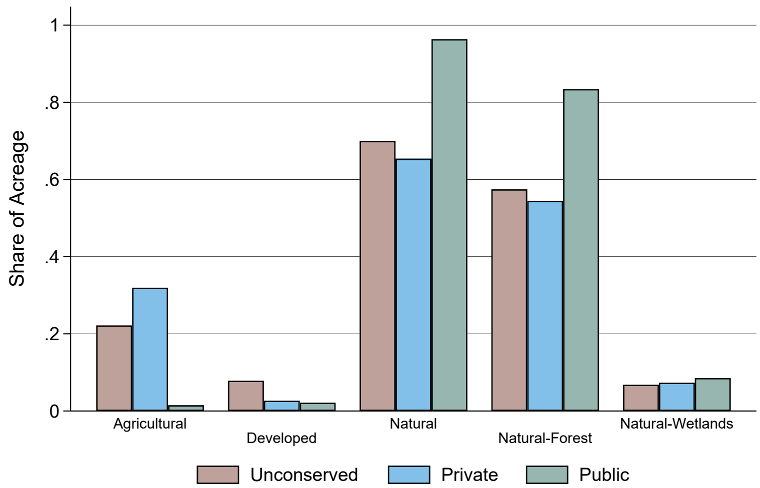
Note: This figure depicts the acreage-weighted cumulative density function for each VCLNA conservation priority category, where 5 is the highest level of conservation priority. A parcel's score is calculated as its mean VCLNA value over the parcel's total area. Conservation status defined as discussed in Figure 1.

Private conservation land also differs from public land in terms of the types of environmental services it provides. As shown in Figure 2, public land has the biggest advantage in recreational and biodiversity value. Easement land does better than public land only in terms of agricultural value. This difference shows up in land use as well as land value. Figure 3 shows that Virginia has almost no agricultural land in public conservation, but one third of private conservation land is used for agriculture.

This higher level of agricultural land in easements makes sense with the relative advantages of easements compared to purchasing land. Public conservation allows the state to fully control human activity on a parcel, which makes it particularly optimal for purposes like protecting fragile habitats or opening recreation opportunities to the public. On the other hand, in cases where protecting environmental value only requires restricting some potential uses, private conservation can do so without requiring the state to pay for the land's full value. This can perform well for agriculture or water quality, where easement-added restrictions preventing large developments and specifying pollution-reducing agricultural practices can protect key environmental services.

The distributions in Figure 2 also draw attention to an important fact shaping private conservation: preserving productive farmland is an explicit major

Figure 3: Land use of public and private conservation lands in Virginia



Note: This figure shows acreage-weighted shares of public, private, and unconserved land classified according to the 2006 NLCD land use database. Agricultural, developed, and natural land are mutually exclusive. Natural-Forest and Natural-Wetlands are subsets of natural land.

goal of current conservation policy. As written in Virginia's Agricultural and Forestal Districts Act, the state looks to preserve farmland both as an environmental resource that provides positive externalities like clean air, watershed protection, and pleasant views, but also because the state wants to "protect and enhance agricultural and forestal land as a viable segment of the Commonwealth's economy."[4] Virginia commits funding to preserve farmland through multiple channels, from conservation easement subsidies to the $4 million in funding given to Virginia's Farmland Preservation Fund annually through the state budget.[5] This preference is common among policymakers, with many policies citing preserving agriculture as important to preserving rural amenities, protecting cultural heritage, and maintaining food stability (Hellerstein and Nickerson 2002).

4.2 The Correlation Between Development and Environmental Value

The central potential inefficiency of easement policy comes from a mismatch between environmental value and development value. If higher environmental quality parcels have lower development value and vice versa, easement incen-

[4] Code of Virginia § 15.2-4301, https://law.lis.virginia.gov/vacode/title15.2/chapter43/section15.2-4301/

[5] Virginia state budget for 2023, https://budget.lis.virginia.gov/amendment/2022/1/SB30/Introduced/CA/98/1s/

Table 1: Correlations Between Development Value and Environmental Value on Unconserved Parcels

VARIABLES	Max Priority	Mean Priority	Biodiversity Priority	Watershed Priority	Agricultural Priority	Forestry Priority	Recreational Priority
Development Threat	0.00	-0.11***	-0.12***	-0.18***	0.15***	-0.09***	-0.07***
	(0.53)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Development Value Per Acre	-0.18***	-0.19***	-0.15***	-0.25***	0.01	-0.15***	-0.05***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.16)	(0.00)	(0.00)
Development Value / Sales Value	-0.03***	0.10***	0.13***	0.02***	0.01	0.16***	-0.03***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.19)	(0.00)	(0.00)
Acreage	0.01	0.07***	0.13***	0.07***	-0.04***	0.07***	0.10***
	(0.24)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Development Value	-0.01	-0.02*	-0.03***	-0.02*	0.01*	-0.01	-0.11***
	(0.19)	(0.02)	(0.00)	(0.02)	(0.04)	(0.22)	(0.00)

p-values in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

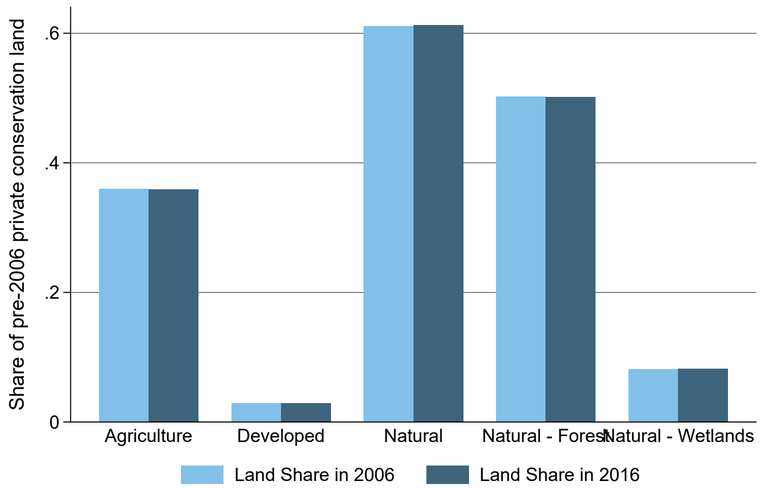
Note: This figure shows the individual variable correlations between environmental values and development values for the sample of 19,000 randomly selected unconserved Virginia Tax Map parcels with less than 33% of the area developed. The priority outcomes are VCLNA conservation priority rankings from 1 to 5. Development Threat is a VCLNA estimated score, and development value is estimated using Equation 9.

tives will offer higher payments for low-quality land and less for high-quality land, leading to inefficient conservation decisions. To test whether this problem exists in Virginia, I compute the correlations between a range of development value measures and conservation priority metrics among the sample of non-developed noneasement parcels. In Table 1, some clear relationships emerge between conservation priority and measures that explore how significant the development opportunity of land is given a parcel's size or total value. Parcels that have a higher per-acre development value and development threat level tend to have lower mean and maximum conservation priorities. Development value as a percentage of total value has a relatively weak negative correlation with conservation priority among easement parcels, and a positive one among nondeveloped parcels. When broken into categories, this negative correlation particularly shows up in biodiversity, watershed, and forestry value. Agricultural priority is the only one that is positively correlated with these development value measures. Together, this suggests that the parcels with lower development cost shares may be quiet rural properties with high environmental value where the land can attain most of its value while left undeveloped. Mismatches in conservation easement donations may therefore be particularly common, where large easement incentives induce donations further from the places where environmental value is concentrated.

4.3 Easement Compliance

Second, I test whether parcels under easement actually remain undeveloped. This understudied question is an important first-order condition for private

Figure 4: Land Use Change on Pre-2006 Easements



Note: This figure shows land use change between 2006 and 2016 on Virginia NCED easements established before 2006. Land use is measured by the 2006 and 2016 NLCD.

conservation to have any impact: it must be able to prevent development if it is to create environmental value. This has been a widespread source of concern since the the responsibility for monitoring and enforcement of easement terms falls on the land trust that accepts the donation of the easement, and land trusts range widely in size, mission, and resources (Merenlender et al. 2004).

To test this, I compare land use in 2006 and 2016 on lands that were put into private conservation before 2006. This analysis shown in Figure 4 shows that lands in private conservation saw almost no change in land use over this decade. Developed land went from 2.87% to 2.90% of private conservation acreage, a statistically insignificant change. This small fluctuation could easily reflect activities allowed by easement terms, since most easements continue to allow some low-intensity use of the land. Only 2.3% of parcels saw any increase in developed land share, and .8% saw development increase by more than 1%. Natural land acreage slightly increased, while agricultural and forest acreage marginally decreased. This is consistent with the requirements on some agricultural easements that farmers create a natural buffer along any waterways or streams within their property. All of these changes reflect less than a percentage point change in total land use.

This lack of land use change suggests that landowners upheld their easement terms, meeting one of the first-order conditions for this policy to have an impact. Two potential reasons could cause this lack of change: either enforcement kept landowners from developing, or landowners had no interest in development in the first place. There is at least some development pressure on easement land, since Figure 2 shows that the development threat levels calculated for easement land match the statewide distribution. However, private conservation land is less likely to be developed for reasons the development threat model cannot consider. Landowners with private information that reduces their interest in development have a good incentive to select into an private conservation program since they can reap the tax benefits while giving up only an option that they considered low-value. In line with this, Braza (2017)'s matching design study on fields under short term agricultural easements estimated that only 14% of the program land would have been cultivated in absence of an easement. Combining this selection effect with the fact that developed land across the the state of Virginia increased by on 2.6% in this decade, and the counterfactual level of development that would have happened without private conservation on this land may have been quite low. Most construction during this period replaced or intensified construction on already-developed land, rather than cutting into forest or farmland. However, since easements are permanent, continued enforcement may have a more substantial effect on preventing development in future decades as undeveloped land grows more scarce.

This measure of easement compliance captures the most substantial potential violations of easement terms, but there are more subtle types of violations that the satellite land use measure cannot detect. For example, agricultural easements designed to protect water quality may require or prohibit implementing certain agricultural practices to reduce erosion and pollution. Since these clauses vary between easements and often cannot be detected without on-the-ground monitoring, this paper cannot test for compliance with them.

5 Methodology

Seeing this variation in environmental quality among conservation lands, I set out to test whether changing easement incentives changes the quality of land donated. I examine this using a difference-in-difference design comparing parcels that saw larger and smaller shifts in projected easement subsidy rates before and after the 2002 Virginia reform. I create a tax calculator, discussed in Section 5.1, to estimate the subsidy rate an easement would receive before and after the 2002 reform. This tax calculator requires estimates of the donor's income and the parcel's development value, which I estimate using a model discussed in Section 5.2. I then use these estimated subsidy shifts for my difference-in-difference regression, which is specified in Section 5.3.

5.1 Understanding Subsidy Shifts

To measure the effects of the 2002 reform, I estimate the subsidy rate for easement donations before and after the reform. Tax benefits for private conservation come from several sources: federal charitable contribution deductions, state tax credit usage, post-2002 tax credit sales, local property tax reductions, capital gains, and estate tax reductions. In this paper, I focus on the first three factors. Most agricultural land in Virginia is covered by a policy that sets local property tax according to the land's current use, so easements rarely change local property taxes in this setting. Property taxes are generally low in the state, with rates between 0.42 and 1.12 dollars per \$100 of valuation. The estate tax and capital gains tax saw no relevant policy change over the 1998 to 2006 window and only 4 of Virginia's 96 counties adjusted their property tax policies during this period (Kulp 2019). The subsidy rate s in year t for a parcel with landowner income y and development value V is estimated as

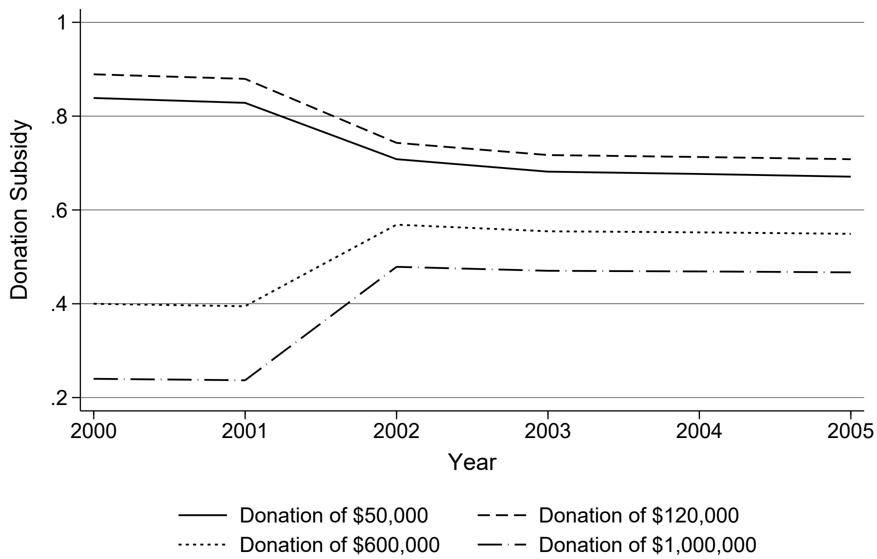
$$s_t(v, y) = \frac{\sum_{x=t}^{t+15}(1-\delta)^{x-t}\sum_{l=f,s}(tax_l^{nc}(V, y) - tax_l^{c}(V, y)) + .8 * sales_s(V, y)}{V} \tag{8}$$

Where tax^{nc} is tax payments without a conservation easement and tax^{c} is payments with an easement, and s is state and f is federal tax payments. δ is an annual discount rate, set at 5% in this calculator. $sales_s$ is revenues from sales of state tax credits. To get the difference in federal taxes, I use federal easement donation law to calculate the size of charitable deduction a donor with development value V could claim in year t, then use the NBER's TaxSim35 tax calculator to estimate the federal taxes a household with income y would owe with and without that charitable deduction. To estimate the state-level tax change, I calculate the household's annual state tax liability with TaxSim35, then reduce each year's tax liability in turn until the time limit is reached or until the donor hits the cap of claimable credits. Post-2002, I assume that the donor uses credits to first reduce their own tax liability, and then sells all remaining credits for 80 cents on the dollar. I calculate these rates using tax policy only in the year of the donation, assuming that landowners plan their donations with the expectation that landowners otherwise expect that state and federal tax and easement policy will remain constant in future years.

Pictured in Figure 5, the results of these calculations show that the 2002 reform dramatically compressed the easement subsidy rate for different parcels. The reform allowed taxpayers to sell tax credits if they exceeded what the landowner could use on their own tax liability. Before 2002, a donor with an income of \$200,000 would get back 88 cents on the dollar of development value if they donated a parcel valued at \$120,000, but only 23 cents on the dollar from a million-dollar parcel. After the 2002 reform, the million-dollar parcel's donation subsidy rose to 47 cents per dollar as the taxpayer sells the credits they cannot use, and the \$120,000 parcel's subsidy falls to 71 cents as the reduction in the credit cap takes effect. The state subsidy rate falls for more than 10% in some cases of particularly small donors as Virginia tax levels for those brackets lowered, causing these donors to spread credit claims into later years. Federal subsidies also decreased in 2003 as an indirect effect of the 2003 federal tax cuts, which reduced the value of easement deductions, leading to a total reduction in easement subsidy rates of up to 23% for the lowest-income donors with low development value parcels.

The change to subsidies is large in absolute terms: the donor of the million-dollar parcel in this example would get almost \$240,000 more in tax benefits from donating after the reform, while the \$120,000 donor would get \$20,000 less.

Figure 5: Virginia easement tax incentives over time



Note: Donor income is fixed at $200,000. The subsidy rate of an easement is the share of development value returned to a Virginia easement donor through state and federal credits and income tax reductions, calculated according to Equation 8. Tax liability with and without a donation is calculated using TaxSim35.

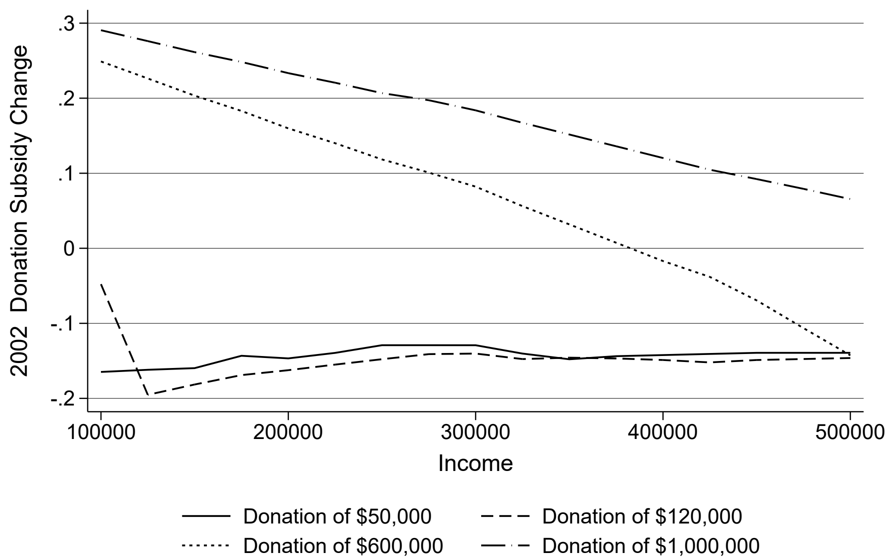
This reform thus both corrected a distributional concern about the incentive program and likely improved its efficiency by smoothing the incentive across groups. The remaining gap in subsidies comes from federal tax policy, which had caps on the share of income that could be reduced with easement credits and a limit similar to Virginia's on years of redemption eligibility until a 2006 reform.

Focusing in on the 2002 reforms, Figure 6 shows how the effect of the reform varied by donor income across different donation sizes. The y axis depicts the difference between 2001 and 2002 subsidy rates for donations of different donor incomes and donor size. The reform's effect was largest for low-income donors, for whom the past limits had been most binding. There are some parcel sizes above which donors of almost all likely incomes would have benefited, and some below which almost all easement donors would have faced a lower subsidy rate.

5.2 Measuring Income and Development Value

To calculate the subsidy rate for each parcel requires estimating landowner income and parcel development value for each easement. The exact income and development value claimed for each donation is confidential tax data. Instead, I estimate both using the following procedures, and I include robustness checks

Figure 6: Variation in 2002 tax incentive shifts



Note: the subsidy rate of an easement is the share of development value returned to a Virginia easement donor through state and federal credits and income tax reductions, calculated according to Equation 8. Tax liability with and without a donation is calculated using TaxSim35.

for a range of different model assumptions.

Nationally, the median easement donor in 2005 had a household income of approximately \$200,000 (Wilson 2005), 4 times the median annual household income. Therefore, I estimate the likely donor income for each parcel as 4 times the median income for the parcel's census tract. The estimated donor incomes for my sample thus range from \$37,500 to \$792,600. I vary this assumption in my robustness checks, testing the results if I assume 2 times the annual income, 6 times the annual income, or a constant annual income of \$200,000.

Next, I estimate the parcel's development value. Virginia easement law defines the development value of land as "the reduction in the fair market value of the land that results from the inability of the owner of the fee to use such property for uses terminated by the easement."[6] I decompose the development value V_i for a plot as

$$V_i = salevalue_i - usevalue_i \tag{9}$$

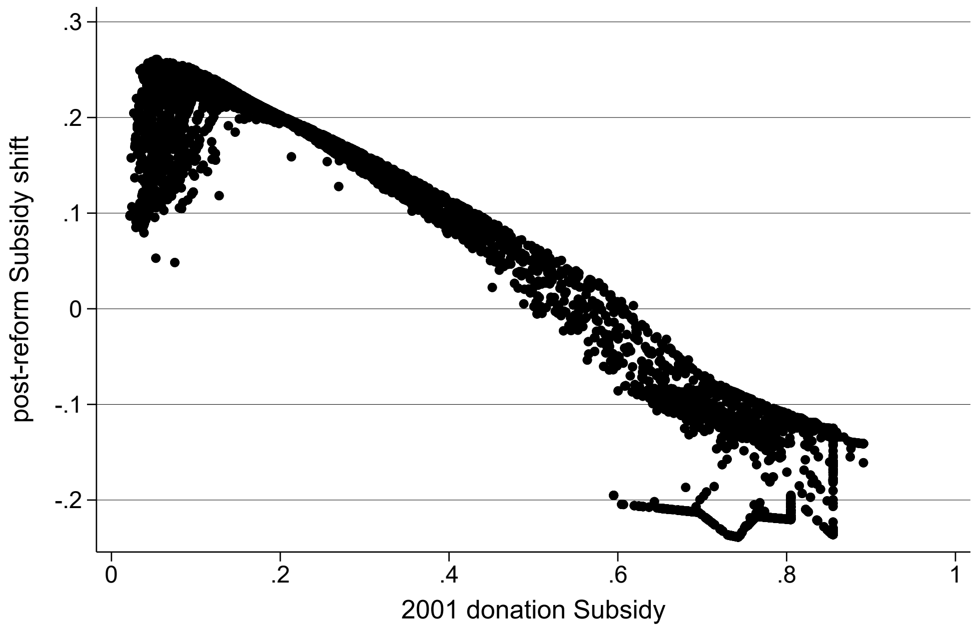
where $salevalue_i$ is the fair market value of a parcel unencumbered by an easement, and $usevalue_i$ is the fair market value of a parcel of land bound to its present use by an easement. V_i is then the market value of the ability to change the land's use. I estimate the sale value of my easement sample using a hedonic regression of sales value on a dataset of land that is not affected by easements. Since there are too few sales of parcels under easement to estimate a similar regression for use value, my land use values instead come from the estimates of land's value per acre in agricultural or forestal use from Virginia's Use-Value Assessment Program, which creates these estimates for use in local property tax assessment. I discuss the details of the estimation methodology in Appendices B and C.

I use a machine learning lasso regression to estimate the sales value per acre, resulting in a model that produces an out-of-sample R^2 of .21. To lower prediction error, the lasso model shrinks the size of coefficients. The combination of this coefficient shrinking and the difficulty in predicting exact parcel value mean that my results are a lower bound on the size of the program's effect. For some cases, the estimated V_i is less than 0. I replace this with a minimum development value of \$10,000, a quarter of the 25th percentile of donated easement value nationally, or \$400 per acre, a quarter of the median easement value per acre looney$_charitable_2$017.

Entering these estimated incomes and development values into my tax calculator, I return an estimated pre-2002 and post-2002 subsidy rate of conservation for each easement parcel in my sample. The difference between pre- and post-reform subsidy rate is the subsidy shift used as a treatment effect in my regressions. Despite the compression of development values and incomes in the estimation procedure, the estimated donation subsidies displayed in Figure 7 still show considerable heterogeneity in the pre-reform subsidy of conservation and the subsidy shift. The 2002 reform compressed subsidy rates towards a 60% subsidy, increasing the easement subsidy for most parcels in the sample. The

[6] Code of Virginia § 10.1-1011 B

Figure 7: The Sample Distribution of Subsidy Shifts



Note: the donation subsidy of an easement is the share of development value returned to a Virginia easement donor through state and federal credits and income tax reductions, calculated according to Equation 8. This figure compares easement subsidies as expected from an easement filed in 2001 under pre-reform Virginia easement incentive rules with subsidies as expected from an easement filed in 2003 post-reform.

greatest possible decrease in the state-level subsidy was 10%, due to the 10 percentage point decrease in the maximum claimable credits with a shift in federal policy, although federal shifts in tax policy further decreased the returns for some of the lowest income donors in low development value areas. On the other end of the spectrum, some of the highest development value parcels saw smaller subsidy increases than other parcels with a similar pre-reform subsidy because the post-reform $100,000 per year cap on credits (either to sell or use personally) was still binding. Overall, development value drives most of the variation in pre-reform subsidies and in the size of the subsidy shift, with income creating the slight variation from the general trend line.

5.3 Difference in difference design

The 2002 reform increased the subsidy for large parcels, especially for those with less wealthy donors, and decreased the subsidy for smaller parcels with higher income donors.

I then run the following difference-in-difference regression, omitting the policy transition years of 2002 and 2003:

$$y_i = \alpha + \beta_1 \Delta s_i * post_i + \beta_2 post_i + \beta_3 \Delta s_i + \epsilon_i \tag{10}$$

where y_i is the environmental outcome of interest for easement parcel i. Δs_i is the "treatment effect" of the 2002 reform, the change the 2002 reform would have induced in parcel i's subsidy per dollar of development value. $post_i$ is a dummy variable that equals one after 2002 and 0 before. The interaction coefficient β_1 is the coefficient of greatest interest. If β_1 is positive, this means that the average environmental quality of parcels with newly increased subsidies rose relative to those with decreasing subsidies. It also shows that as the subsidy for conservation increases, average quality rises. In similar logic to Einav, Finkelstein, and Cullen (2010), this would indicate that the marginal donations influenced by a change in the subsidy rate are lower quality than the inframarginal easement parcels.

Using robust standard errors, I run this regression with a range of outcome variables y_i. For the key environmental value regressions, I use the maximum and mean VCLNA environmental quality scores, as well as each of the separate VCLNA scores. I also test the impact on land use and on census tract demographics as measured in the 2000 census. In my main regressions, I use 2000 to 2001 as the before period and 2004 to 2006 as the after period. Easement tax credit policy was stable during each of those periods at both the state and federal level. I omit 2002 as the year of transition: the Virginia legislature began considering the reform in January 2002 and passed it in July 2002, with the new law applying to donations made in 2002 onward.

The difference-in-difference design requires the parallel trends assumption that aside from the subsidy rates, nothing differentially shifted the quality of small parcels relative to large parcels. In my search through records and discussions with Virginia land trusts, I have found no policy shifts that would challenge this assumption. I check for parallel trends using the 2000 period onward. Using 2002, the year the policy was passed, as the base year, I run the regression

$$y_i = \alpha + \sum_{y=1999}^{2006} \beta_1^y \Delta s_i * (year = y)_i + \sum_{y=1999}^{2006} \beta_2^y (year = y)_i + \beta_3 \Delta s_i + \epsilon_i \tag{11}$$

I test the treatment effects for each year. I find that the pre-treatment years of 2000 2001 are not statistically different from 2002. Years before 2000 are omitted because the Virginia easement tax incentive was first passed in 1999.

To estimate the elasticity of easement supply in response to the price of conservation, I also run a regression on acreage and number of donations in groups of easement value and donor income. I define 16 groups g based on pre-2002 quartiles of pre-2002 price and Δs. For each group and year, I calculate the total acreage and number of donations for each year falling in that bin. I then regress

Table 2: DiD Effect on Easement Donations

VARIABLES	(1) Donation Count (log)	(2) Acres Donated (log)
Price (log)	-1.930***	-1.125**
	(0.394)	(0.547)
Constant	11.19***	13.04***
	(1.705)	(2.386)
Year Fixed Effects	Yes	Yes
Group Fixed Effects	Yes	Yes
Observations	96	96
R-squared	0.530	0.716

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: sample contains 16 observations per year with one for each pre-2002 subsidy rate quartile and 2002 subsidy rate shift quartile. Regressions cover years 2000-2001 and 2004-2006.

$$\ln(y_{gt}) = \alpha_g + \beta_1 \ln(s_{gt}) + \sum_{y=1999}^{2006} \beta_2^y (year = y)_t + \epsilon_{gt} \tag{12}$$

Where s_{gt} is the average expected subsidy rate in group g in year t. The β_1 resulting from this regression is the elasticity of donation numbers or acreage.

6 Results

In this section I measure the impact of the 2002 tax credit reform to test the quality of marginal easement donations. I find that easement donation rates are substantially responsive to the easement subsidy. As subsidies rise, the quality of donations declines, especially in terms of agricultural priority. However, the marginal easements tend to be more oriented towards preserving natural land and less towards agriculture. Marginal easements are more likely to be in lower-income areas, though they remain in areas with low levels of racial diversity. Controlling for land trust fixed effects or for development value has almost no impact on the entry of low-quality lands into easements.

6.1 Elasticity of Conservation Easements

I first use Equation 12 to test the elasticity of easement donation numbers and acreage to changes in the donation price, the amount per dollar of development value that would not be compensated by tax incentives. The donation price equals one minus the subsidy rate. The results in Table 2 show that around the 2002 reform, donation numbers and acreage both responded to the subsidy rate change. Groups with increased subsidies increased donations in comparison to groups with subsidy decreases. The donation count elasticity is -1.93 and the acreage elasticity is -1.13. Since easement counts did not change immediately in response to the change, I find a somewhat higher elasticity of -2.41 for donation count and -1.47 for acreage if I omit 2003 as the year after the policy change. These elasticities largely support the findings elsewhere in the literature, such as Parker and Thurman (2018)'s excellent estimates of the national acreage elasticity ranging from -2.0 to -5.1. This supports that my estimations are able to identify a true differential shift in conservation incentives, enough to meaningfully impact the number of marginal donations.

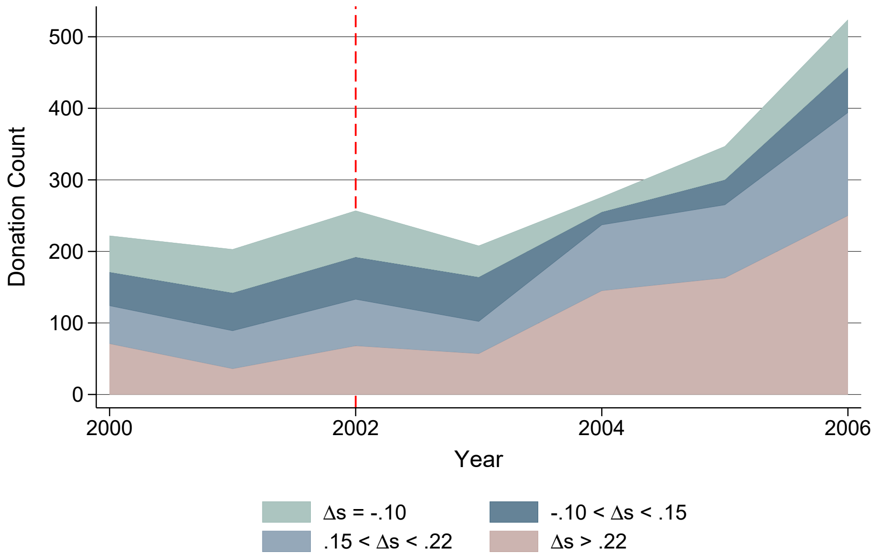
This reform's impact on easement numbers needed several years to take full effect. Figure 8 shows the number of easements in each subsidy shift quantile over time. The shares of easements in each quantile stayed fairly constant between 2002 and 2003 aside from a small decrease in the share of donations from the group for whom the donation subsidy fell by 10 percentage points. The real change in size trends happened in 2004, as the numbers of parcels in the large subsidy increase group almost doubled and the number of parcels in the subsidy decrease quantiles dipped. This response time makes sense given the slow processes involved in an easement donation. According to internal documents from Virginia's largest land trust the Virginia Outdoors Foundation (VOF), putting a parcel under easement with the VOF requires a ten-step process with multiple site visits, legal documents, and board and committee meetings. This process requires at least six months to complete, but it may take far longer if donors are not rushing the process or if complications arise. Delays in informing potential donors about the new program and the time it takes for a donor to decide whether they want to make such a permanently binding commitment with their land mean it is unsurprising that the full treatment effect would take more than a year to manifest. Accordingly, easement numbers in Graph 8 display almost no change in 2003, with easement counts showing adjustments to the new incentives starting in 2004.

Figure 8 also suggests that the 2002 reform led to a long-term increase in the easement supply. Total numbers declined in 2003, since a landowner can cancel a potential donation much more quickly than they can form a new one. However, the median pre-reform donation faced a 10 percentage point lower cost of donations post-reform, so this reform largely encouraged donations on net. By 2006, we see a doubling in annual donation counts over the 2002 numbers.

6.2 Environmental Quality Impacts

Where conservation subsidies increased, the average conservation priority scores declined. Column 1 of the Table 3 results of estimating Equation 10 for the conservation priority measures show that easements with larger subsidy increases had differentially lower mean conservation priority post-reform. The treatment size of -.64 is almost the size of the pre-treatment difference by subsidy shift, -.77, which suggests that the reform's compression of donation subsidies also compressed quality across the development value distribution. The effect on

Figure 8: Conservation Donation Counts by Subsidy Shift Quantile



Note: sample classifies NCED easement donations by estimated 2002 donation subsidy change quartile.

maximum conservation priority is similarly consistent with the story that higher subsidies reduce quality and the 2002 reform smoothed the distribution of quality, though this coefficient is not statistically significant.

As well as decreasing the average quality, increasing the subsidy rate of conservation decreased the share of easements that meet any given quality threshold. Using a logit regression to predict the odds that the maximum priority score of a parcel meets a given threshold, Table 4 shows that the odds of meeting the "very high" quality threshold of 4 falls most starkly as the subsidy rate increases. Considering that 72% of public lands in Virginia have a maximum score of 4 or above, failing to attract quality 4 parcels with subsidy increases feeds the gap between private and public conservation quality in Virginia.

The marginal easements also shifted towards more ecological and natural land uses and away from agriculture. Agricultural priority shows the most dramatic fall of any category in Table 3 in response to a subsidy increase and is the only category that is statistically significant. Forestry and biodiversity priority are both higher for marginal easements than for the average easements. Table 5's land use results display a similar pattern with more agricultural land at lower prices and more forested and natural land when subsidy rates increase. A 15% increase in subsidy rates, the median effect of the 2002 reform, would have increased the likely share of total natural land by 3.6% and of forest land specifically by 5.0%, while decreasing the agricultural land share by 3.8%. Again, for

Table 3: Effect of Conservation Subsidies on Conservation Value

VARIABLES	(1) Mean Priority	(2) Maximum Priority	(3) Biodiversity Priority	(4) Watershed Priority	(5) Agricultural Priority	(6) Forestry Priority	(7) Recreational Priority
Post * Subsidy Shift	-0.644***	-0.494	0.268	0.0159	-1.505***	0.927*	-0.0257
	(0.238)	(0.342)	(0.536)	(0.257)	(0.549)	(0.545)	(0.0658)
Post Reform	0.0481	0.0719	0.353***	0.147***	-0.0980	0.200**	0.00791
	(0.0405)	(0.0569)	(0.0890)	(0.0430)	(0.0905)	(0.0863)	(0.0122)
Subsidy Shift	0.772***	0.371	-1.160***	-0.260	2.166***	-1.304***	-0.145***
	(0.200)	(0.290)	(0.432)	(0.216)	(0.465)	(0.467)	(0.0500)
Constant	1.851***	3.158***	0.832***	2.289***	2.032***	1.893***	0.0681***
	(0.0320)	(0.0459)	(0.0670)	(0.0344)	(0.0720)	(0.0687)	(0.00838)
Observations	1,767	1,780	1,780	1,780	1,780	1,780	1,780
R-squared	0.010	0.002	0.018	0.010	0.016	0.011	0.022

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: sample is Virginia NCED easements donated in 2000,2001, or 2004-2006. "Post" is a dummy variable for easements donated post-reform in 2002, and "Price shift" is the calculated change in a parcel's donation price between 2001 and 2003.The outcome is parcel VCLNA priority, where 5 is highest conservation priority.

Table 4: Effect of Conservation Subsidies on Maximum Priority

VARIABLES	(1) Max Priority ≥ 2	(2) Max Priority ≥ 3	(3) Max Priority ≥ 4
Post Reform * Subsidy Shift	-2.962*	-0.676	-3.990***
	(1.673)	(0.869)	(1.144)
Post Reform	0.540**	0.0210	0.445**
	(0.250)	(0.137)	(0.188)
Subsidy Shift	3.392**	0.291	1.505
	(1.338)	(0.742)	(0.994)
Constant	2.299***	0.498***	-1.929***
	(0.178)	(0.109)	(0.161)
Observations	1,780	1,780	1,780

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: sample is Virginia NCED easements donated in 2000,2001, or 2004-2006. "Post" is a dummy variable for easements donated post-reform in 2002, and "subsidy shift" is the calculated change in a parcel's subsidy rate between 2001 and 2003. The outcome is a dummy that is 1 if the parcel's highest VCLNA score across any of the five categories meets a threshold value.

Table 5: Effect of Easement Subsidy Rates on Land Use

VARIABLES	(1) Development Threat Level	(2) Agricultural Land Share	(3) Developed Land Share	(4) Natural Land Share	(5) Forest Land Share	(6) Wetland Land Share
Post * Subsidy Shift	-1.171***	-0.256**	0.0130	0.243*	0.336**	-0.0866
	(0.431)	(0.127)	(0.0638)	(0.134)	(0.139)	(0.0620)
Post Reform	-0.409***	-0.0647***	-0.000346	0.0651***	0.0132	0.0404***
	(0.0739)	(0.0199)	(0.0118)	(0.0211)	(0.0222)	(0.0106)
Subsidy Shift	1.588***	0.738***	-0.187***	-0.551***	-0.454***	-0.0578
	(0.297)	(0.111)	(0.0534)	(0.116)	(0.118)	(0.0444)
Constant	6.971***	0.360***	0.0720***	0.568***	0.513***	0.0356***
	(0.0501)	(0.0165)	(0.00940)	(0.0173)	(0.0177)	(0.00676)
Observations	1,780	1,780	1,780	1,780	1,780	1,780
R-squared	0.033	0.055	0.044	0.029	0.011	0.016

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: sample is Virginia NCED easements donated in 2000,2001, or 2004-2006. "Post" is a dummy variable for easements donated post-reform in 2002, and "subsidy shift" is the calculated change in a parcel's easement subsidy rate between 2001 and 2003. The outcome is fraction of the parcel under a category of NLCD-defined land use.

most land uses, the post*subsidy shift interaction points the opposite direction as the subsidy shift coefficient. This indicates that making subsidies smoother across development values also made the average value of easements more similar, suggesting that potential easements with different development values and donor incomes have a similar underlying elasticity and quality distribution.

Given these shifts in marginal easement characteristics, whether policymakers consider the marginal changes an improvement or a reduction in quality depends partially on their weighting of different environmental qualities. While mean conservation scores declined, that decline is strongly concentrated in agriculture. A policymaker who prioritizes protecting forests and biodiversity over preserving Virginia's agricultural heritage might prefer the marginal easements for their higher biodiversity and forestry priority.

I next test the effects of the donation subsidy on the share of easements in areas with different income levels and racial composition. Given that the tax benefits from easements are mostly claimed by higher income and whiter households that have greater landholding wealth and therefore greater capacity to donate easements, it is a serious social justice concern if the viewshed and environmental benefits from easements also disproportionately benefit wealthy white households. In regards to income, increasing easement subsidies does shift private conservation towards lower income census tracts. Table 6 shows that increasing subsidy rates substantially decreases the average share of households with incomes over $100,000 and raises the share of households with less than $25,000. However, racial composition does not change. This means that easements tend to stay in whiter areas of Virginia: while the 2000 census estimated that 72% of Virginia is white, easements are in census tracts that are on average 88% white.

Table 6: Effect of Conservation Price on Area Demographics

VARIABLES	(1) Local median income	(2) % of households with income >$100,000	(3) % of households with income< 25,000	(4) % white
Post * Subsidy Shift	-18,831*	-21.88***	18.99***	-0.0244
	(10,747)	(6.278)	(4.143)	(0.0478)
Post Reform	-3,278*	-1.391	2.139***	-0.0198**
	(1,939)	(1.122)	(0.739)	(0.00819)
Subsidy Shift	2,634	11.82**	-20.39***	0.0944***
	(9,499)	(5.453)	(3.291)	(0.0360)
Constant	53,734***	17.08***	23.36***	0.884***
	(1,649)	(0.926)	(0.563)	(0.00594)
Observations	1,780	1,780	1,780	1,780
R-squared	0.022	0.025	0.034	0.010

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: sample is Virginia NCED easements donated in 2000,2001, or 2004-2006. "Post" is a dummy variable for easements donated post-reform in 2002, and "Price shift" is the calculated change in a parcel's donation price between 2001 and 2003.The outcomes are calculated using census tract level demographics.

6.3 Effects over Time

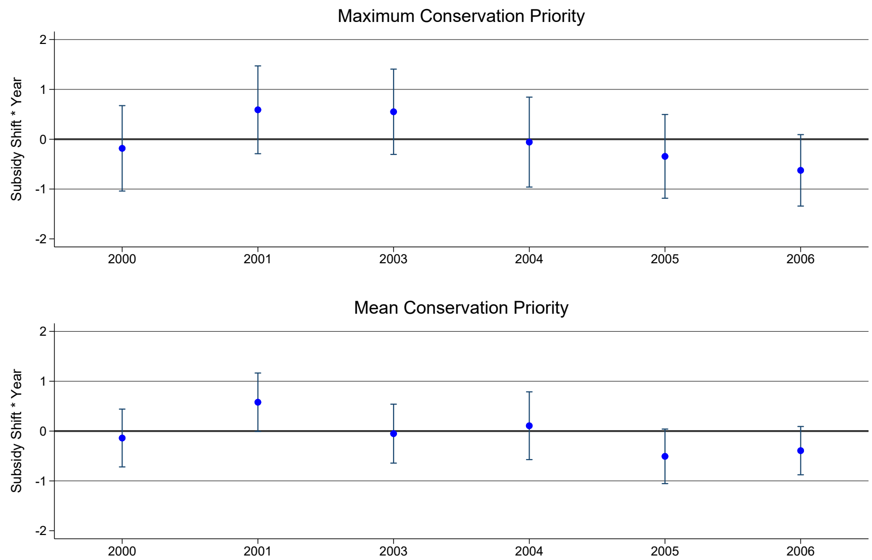
As with the treatment effect on acreage, the treatment effect on average quality also builds over time. Figure 9 and Appendix E show the treatment coefficients produced by estimating Equation 11. The coefficients across years are not statistically different from one another due to the wide confidence intervals, but both maximum and mean quality coefficients trend downwards from 2003 to 2006.

6.4 Intensive Margin Shifts

By lifting the expiration problem with credit usage, the 2002 reform greatly lessened the "penalty" for donating a large, high development value easement. In this section, I explore whether that smoothing of donation prices led donors to change the intensive margin of their donations: did they become more likely to donate larger shares of their land, or less likely to split their land into multiple donations made over longer periods of time?

This is both a question of interest in itself and a potential threat to my identification strategy. The intensive margin matters for policy because large, continuous parcels are more valuable for biodiversity, and because breaking donations into multiple small transactions increases the transaction costs for landowners, nonprofits, and the government. It is important for my identification strategy because I assume that donations each have a fixed development value, with landowners deciding only whether to donate or not. If landowners are changing their donation size, my estimate will be biased by the easements that changed development values and thus subsidy shift groups. In an extreme case, we can imagine that the reform did not alter any donor's choice of whether

Figure 9: Event Study Treatment Effect on Environmental Value



Note: Graph denotes coefficients on year * subsidy shift from Equation 11, with 2002 omitted as the baseline year of the reform.

to donate or not, but it did cause the small parcel donors with the highest quality land to increase their donation size enough to be in a higher subsidy increase category. This would result in an overstated positive treatment effect because the same parcel's change reduces the quality of the increased-subsidy group and increases the quality of the decreased-subsidy group.

First, I check how common repeat donations of easements are to see whether donors seem to be managing the caps on credit usage by spreading their donations over time. The NCED easement database lacks information about donors, so I instead use data from the Virginia Outdoor Foundation (VOF) to explore the frequency of repeat donations. VOF is the largest land trust in Virginia, representing more than half of the NCED easements in Virginia, and they provide a dataset including dates and donor names of their easement projects. This data shows that repeat donors do happen, but donors do not seem to be timing their donations around the ten-year credit expiration threshold. Of the 3,926 easements recorded, 80.7% are from unique donors. Another 6% of easements were from donors making multiple donations in the same year, and 75% of repeat donors completed all of their donations within a five-year span. These donations seem to reflect multiple locations that are all part of the same conservation action rather than an attempt to manage tax credit timing. These split donations would incorrectly show up as multiple lower-value donations rather than a single higher-value one in my dataset, and so may reduce my measured elasticities and treatment effect. VOF sees a small and not statistically significant decrease in repeat donors after the 2002 reform. 87.7% of donors between 1998 and 2001 were unique donors, as were 91.4% of 2002-2006 donors. The relatively low rates of repeat donors over time may reflect the transaction costs involved in making a donation. Given that the VOF's easement donation process involves multiple rounds of paperwork, negotiations, and evaluations, landowners may not find it worth the trouble to break a possible donation into separate transactions.

Landowners also can choose whether to cover their entire property or only a subset of it with an easement. I explore this margin by comparing the maps of private conservation parcels to the map of Virginia tax parcels. Tax parcels are an important unit of landownership used for much official record-keeping. Landowners may own multiple parcels, but each parcel must be owned by a single entity. These parcel maps from Virginia's GIS service correspond reasonably well to conservation parcel areas. With cleaning to remove parcels that marginally overlap due to differences in mapping precision, I am able to match 96% of conservation parcels to at least one tax parcel and 47% of conservation parcels to exactly one tax parcel. Matched tax parcels cover 93% of acreage under easement.

While there are some partial easements, most landowners seem to make conservation decisions as a binary choice over full parcels. To avoid distortions from missingness in the tax parcel dataset, I limit the sample for this analysis to the 92% of conservation parcels for which at least 80% of their acres can be matched to tax parcels. In this group, the median conservation parcel covers 98% of the largest matched tax parcel. After cleaning, 81% of parcels that overlap with easements are fully or almost fully under easement, with at least 90% of the parcel covered by an easement. This suggests that most landowners handle easements as a binary decision at the parcel level: they either place an easement on a parcel or they do not. This does leave the possibility that landowners with multiple adjacent parcels are choosing how many of those parcels to include, since 49% of conservation parcels are spread over at least 2 tax parcels, with 12% spread across 5 or more tax parcels.

To test whether this intensive margin seems to change with the reform, I run my diff-in-diff on the number of tax parcels per easement and the share of the tax parcel that the easement covers. The changes this regression identifies could come from two potential sources. First, donors could change the size of their donations, such as donating 100% of a parcel post-reform where they would have donated 50% pre-reform. Second, this could come from changes in the composition of donors, such as a landowner who only owns one parcel deciding against donating an easement post-reform while a landowner with four parcels is newly attracted into the program.

The results are presented in Table 7, and are more consistent with the change in donor composition story. The number of parcels per easement did increase post-reform, with a significant increase of 1.03 parcels on average. However, overall parcel coverage shares did not change, with a fairly precise null coefficient on Post Reform for both the share of a parcel eased and whether an easement covered a full parcel. The interaction between post-treatment and

Table 7: Changes in Tax Parcel Coverage

VARIABLES	(1) Share of Parcel Eased	(2) Full-Parcel Easement	(3) Parcels Per Easement
Post * Subsidy Shift	-0.105	-0.430**	-2.608
	(0.0850)	(0.167)	(1.896)
Subsidy Shift	0.321***	0.710***	-0.959
	(0.0663)	(0.142)	(0.719)
Post Reform	-0.0105	0.0249	1.043***
	(0.0163)	(0.0298)	(0.369)
Constant	0.907***	0.811***	2.175***
	(0.0123)	(0.0244)	(0.114)
Observations	1,482	1,482	1,482
R-squared	0.031	0.028	0.013

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Note: sample is Virginia NCED easements donated in 2000,2001, or 2004-2006. Outcomes are calculated through intersection of NCED and Virginia Tax Parcel Database. % of Parcel Eased is the fraction of the largest tax parcel in an easement that is covered by said easement. Full-parcel easements is a binary variable for easements where the easement covers at least 90% of the largest eased parcel. Parcels Per Easements is the total number of parcels covered intersecting with an easement. To screen out false positives in overlap due to differences in mapping precision, this measure excludes parcels with less than 10% overlap with the easement.

subsidy shift is negative and significant for whether an easement covers a full parcel, meaning that the coverage share increased for the low-development-value easements that saw subsidies fall and fell for the high-development-value easements that received larger post-reform subsidies. This is the opposite of what the intensive margin theory would expect: the same landowner, when offered higher subsidies, should want to donate a larger share of their land. Combined with the fact that we do not see an overall increase in parcel coverage, this suggests that the changes in Table 7 are due to changes in the kinds of collections of parcels that newly incentivized landowners own, not due to intensive margin changes.

6.5 The Role of Development Value Correlations

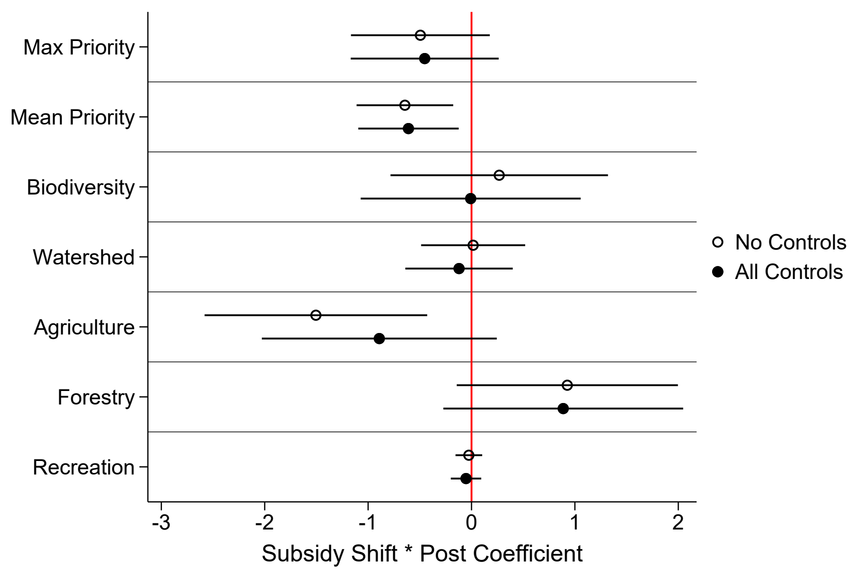
In this section I explore the possibility that the shift in marginal quality are the result of the correlation between development values of land and their environmental quality documented in Table 1.Including these development values as controls in my difference-in-difference regression shows that this correlation can account for some of the treatment effect, particularly in biodiversity and agriculture, but not most of it. Figure 10 plots the subsidy shift * post-reform coefficients with and without including the development controls. The standard errors of the estimates are too large to find a statistically significant difference between coefficients with and without controls, but adding the controls consistently shrinks the coefficients. For biodiversity, the subsidy shift*post coefficent drops to 0 with the controls. For agriculture, the size of the treatment effect declines by a third. This reflects the distribution of agricultural land in Virginia. Agricultural lands closest to cities and particularly in the areas near Washington DC will have the highest development value, but many of the historic and most productive farmlands are in the center of the state and further from these pressures.

6.6 The Role of Land Trusts

I next test whether this quality shift is mediated through land trusts. Land trusts have an ongoing responsibility to monitor and steward conservation lands, but different types of land trusts, such as government or NGO land trusts, may face different funding incentives and hold their donations to different standards as a result. Contrary to this, I find lower quality easements are accepted by a wide range of land trusts and land trust types, suggesting that the easement quality problem cannot be solved simply by regulating a handful of low-quality land trusts.

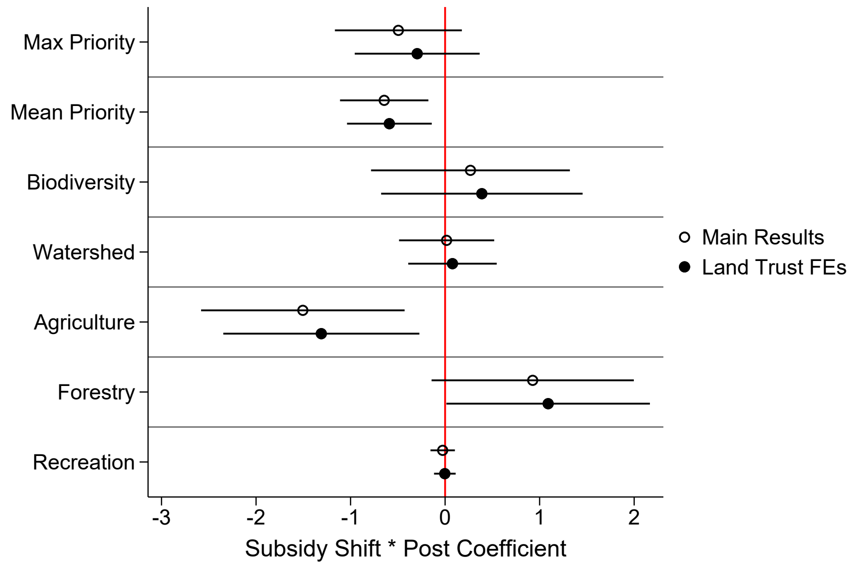
First, I test whether controlling for land trust fixed effects can reduce the treatment effect. If the Post*Subsidy Shift coefficient vanished with the land trust fixed effects, it would indicate that the quality within an individual land trust is fairly constant despite any changes in the donation subsidy. In that case, we could attribute the decline in quality to a relative increase in donations to the land trusts with lower standards. The results in Figure 11 show that this

Figure 10: Treatment Coefficients With Development Value Controls



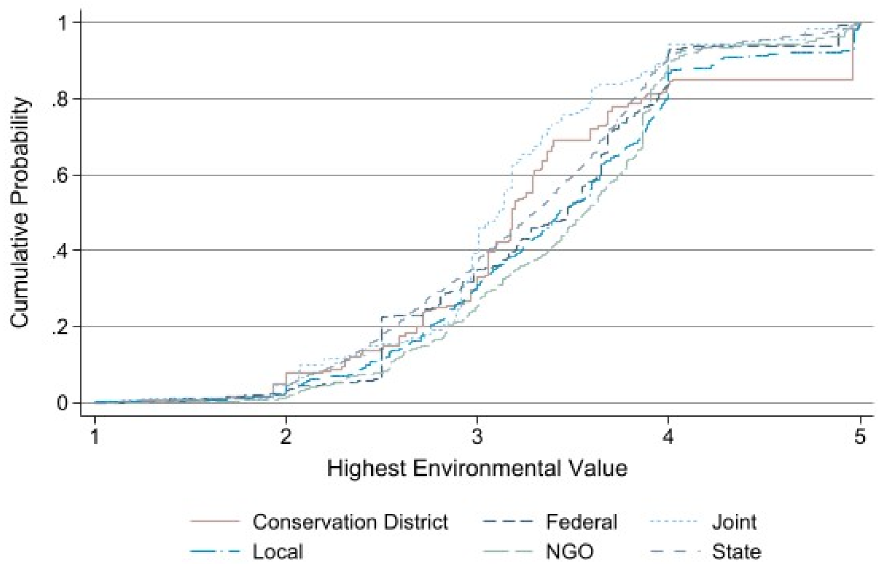
Note: point estimates are the Post*Subsidy Change coefficients estimated according to Equation 10, with or without added controls for development threat, development value (overall, per acre, and as a share of sales value), and acreage. Outcomes are VCLNA conservation priority rankings.

Figure 11: Adding Fixed Effects for Land Trusts



Note: point estimates are the Post*Subsidy Change coefficients estimated according to Equation 10, with or without added fixed effect controls for each land trust accepting donations. Outcomes are VCLNA conservation priority rankings.

Figure 12: Land Quality Distribution by Land Trust Type



Note: This graph plots the acreage-weighted cumulative density functions for parcel level VCLNA scores for NCED easements statewide, where 5 is the highest level of conservation priority. Easements are grouped by the NCED-reported easement holding organization. "Joint" easements are held by multiple organizations of multiple types. Organizations with multiple easement holders of the same type (ie two NGOs) are classified under their shared category.

is not the case. None of the coefficients change significantly with the addition of this full set of fixed controls. Shifts in donation quality within land trusts, rather than between them, must therefore drive the treatment effect.

In addition, no particular kind of land trust performs significantly better than another. Figure 12 traces the cdfs of the six types of land trusts with more than 100 easements in Virginia. Federal, state, local government, conservation district, NGO, and jointly held easements all trace similar distributions. Given how well government-owned conservation lands perform, it is perhaps surprising that the government land trusts, which could internalize the full public cost of the easements they accept, do not perform better. This may reflect a gap between the divisions of government that accept donations, often departments of conservation whose goal is to increase protected land, and the tax system that ultimately bears the revenue cost of the credits. It also reflects that land trust acquisitions are limited by the willingness of potential donors, particularly in a system where most easements are donated instead of purchased.

6.7 Robustness Checks

I check the robustness of these results to two key variations in the assumptions about the incomes of easement donors in Appendix F and classifying easements in a binary high-development-value or low-value bin in Appendix G. Both of these effects find similar results to the main specifications, with the treatment effects somewhat reduced by the decreased precision of the policy shift estimates but still significant in most cases.

I also check robustness to using a different estimate of land's sales value from Nolte (2020), which created a national estimate of 2010 land value per acre using 6 million parcel-level transactions between 2000 and 2019 and incorporated "parcel-level data on ownership, sales, building footprints, terrain, accessibility, land cover, hydrography, flood risk, demographics, and protection" (ibid). I convert the 2010 estimate into 2002 housing values using the All-the All-Transactions House Price Index for Virginia metric from FRED. The Nolte estimates of land value are consistently higher than the estimates derived from my model, which uses Virginia transactions between 1998 and 2006.

The results in Appendix H show that the using the Nolte estimates keeps the finding of negative marginal selection in maximum and mean environmental quality, although the treatment effects for individual environmental scores change significantly, and the land use change coefficients shrink significantly. Using the Nolte estimates also shrinks the estimated elasticity of donations to -.344 for acreage and a positive .139 for acreage donated, which suggests that the Nolte estimates do not provide as accurate an estimate of the incentive change as the results using the main specification: incorrect land valuations would lead to incorrect estimates of the subsidy rates and treatment effects, which would bias the estimated response of donations to subsidy rate change towards zero.

I also check robustness to excluding 2003, considering that the market for easements may move slowly through the process of educating landowners, making decisions about whether to apply, and formally creating an easement. Figure 8 suggests that easement numbers did not respond to the policy change until 2004. Included in Appendix I, omitting 2003 from the analysis increases the estimated effect of the program. This effect is most notable when calculating the elasticity of easement donations: the elasticities rise to -1.47 for acreage and -2.41 for donation counts, bringing them closer in line with the estimates from Parker and Thurman (2018).

7 Model Applications

A key policy question arises from this model and results: if the increase in tax subsidies for easements was targeted more specifically at high conservation priority parcels, how would the cost to taxpayers, conserved acreage, and environmental quality of that acreage have changed? Since the VCLNA rankings do not give us a direct monetary valuation of each rank, I instead look to identify the quality-acreage tradeoffs that same-cost quality-targeted policies could have produced. I particularly focus on the case of high development value parcels in the state of Virginia, which on average saw large increases in tax incentives, to illustrate the potential costs and benefits of quality targeting. To show the potential bias from assuming a constant quality distribution, I also compare estimates with constant and differing elasticities for land with different levels of environmental quality.

Using a simple model of easement supply, I calibrate the marginal quality response to tax incentives with my difference-in-difference results, and I estimate the total acreage of donations using my estimated elasticity. To focus particularly on the effect of a subsidy increase I narrow my analysis to the quartile of easements with the lowest pre-reform subsidy, which largely consists of the highest development value parcels. With this model I then explore the acreage and quality of land conserved under two policy alternatives that have the same taxpayer cost as the actual policy: a subsidy rate increase available only to parcels with a conservation priority of 3 or above, and a subsidy rate increase available only to parcels with a conservation priority of 4 or above.

To build my supply curve of easements, I need to quantify three dimensions that might respond to changes in easement incentives: acreage donated, environmental quality, and cost per acre. I use a constant elasticity supply curve for total acreage, $1 - s = \alpha q^{1/\epsilon}$. I set the elasticity of total donations as $\epsilon = -1.125$ from Table 1. I calibrate the constant α using the acreage q and average estimated conservation subsidy s for the targeted quartile of 2000-2001 easements, and I assume a constant acreage per donation and development value of easement using that same data.

For environmental quality, I use the Table 4 logit estimates of $P(e_i > k|s)$, the probability that given a specific subsidy rate an offered easement's maximum conservation priority e_i is greater than some floor k. This lets me estimate the share of donated land that will fall in each quality bin, as well as the share of offered land that will not be allowed to donate under the policy floor scenarios. I use the coefficient on Post * Subsidy Shift as an instrument for the post-reform shift in s and use that to calculate the change in environmental quality under alternative post-reform s.

7.1 The Effects of Targeting

Compared to a uniform increase in subsidy rates, how would a same-cost policy offering a higher increase only to easements that meet a certain quality threshold perform? Such a policy could be implemented through channels already used by government funds, similar to a competitive grant-offering system. To focus particularly on the effect of a subsidy increase, I narrow my analysis to the quartile of easements with the lowest pre-reform subsidy, which largely consists of the highest development value parcels. This pool is also of particular interest because it both saw the largest effect of the reform and represents the largest acreage and government expenditures. This group faced an average pre-reform conservation subsidy of 13.8 cents per dollar of development value and received an average of 37.7 donations per year. They conserved an average of 6,710 acres

Table 8: Actual and Alternative Policy Scenarios

	Policy Scenario		
	Actual	High Floor	Very High Floor
Donation Subsidy if Priority Below High	.354	.138	.138
Donation Subsidy if High Priority	.354	.430	.138
Donation Subsidy if Very High Priority	.354	.430	.962
Estimated Annual Cost	$26.8 million	$26.8 million	$26.8 million

Note: this table shows estimated simulated donation costs and subsidies for three scenarios. These scenarios compare the actual pre-reform behavior to estimated post-reform situation of the quartile of pre-reform easements with the smallest pre-reform subsidies. The estimated annual cost is the total (state and federal) reduction in tax revenue post-reform. The "actual" scenario uses the average pre- and post-reform donation prices for this quartile. The donation prices in the Floor scenarios keeps the pre-reform .856 average price for the lower priority brackets, and set the higher donation price to the highest possible subsidy that keeps the total cost equal to the "Actual" estimated cost.

at a total cost of $7.5 million. The 2006 reform increased this group's subsidy rate to 35.4 cents per dollar on average. The calibrated model predicts that this would have increased donations per year to 52.2 acres per year, conserving 9,390 acres per year at a cost of $26.8 million.

Using the estimated supply curve of easements, I calculate the quality floor policies that would match the $26.8 million annual cost while providing an increased subsidy only to easements with a maximum conservation priority score above the "high quality" score of three (High Floor) or above the "very high quality" score of four (Very High Floor). The resulting donation prices are listed in Table 8. The High Floor case keeps a subsidy rate of .138 for easements with quality below 3, rising to a .430 subsidy rate for easements that meet the High Quality mark. This High Floor scenario includes subsidy rates within the range we see in the actual Virginia range, so the validity of the estimated elasticities should hold within this range. Setting the floor at Very High (4) allows for even greater subsidies to the most valuable land: the donation subsidy rate for high-quality land soars to .962, approaching the level of fully purchasing easements.

Figure 19 shows the acreage implications of these alternatives. In the actual policy with no floor, more than a third of private conservation acreage has a maximum conservation quality below high, a quality level equivalent to the lowest 6% of public conservation lands. Putting in place a floor at high quality shifts the mass of easements from the [2, 3) Moderate bin to the [3, 4) High bin. The cost in total acreage conserved is low. The state gives up some cheap acres, but high-quality acreage responds substantially to the 16 percentage point increase in incentives over the Actual scenario. Since there is relatively little Very High quality land and it is positively selected, the Very High Floor scenario must increase the subsidy rate dramatically for the target group, creating a larger drop in total acreage than in the transition from the Uniform to High

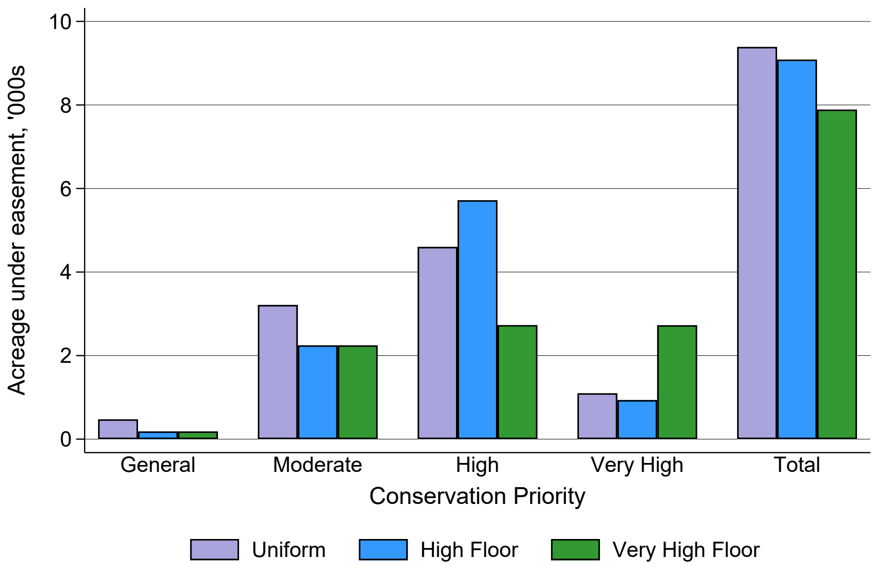
Floor scenario. As this scenario extrapolates easement subsidies well beyond the range seen in sample, this Very High Floor model may even estimate the acreage it can achieve, as it is pushed into the inelastic range of the supply curve.

This illustrates the key tradeoff of introducing quality floors as subsidy rates increase. The supply of moderate-quality donations is quite elastic, and moderate- and general-quality donations become even more common as subsidy rates rise. Setting a quality floor reduces payments on these lower-quality lands, but high environmental value acres are more expensive to acquire. The policymaker would prefer the High Floor policy over the Uniform policy if a high-quality acre is worth at least 1.32 acres of moderate quality. In addition, the policymaker would prefer setting a floor at four instead of three if an acre of very high quality land is worth at least 1.67 acres of high or moderate quality land. The literature on environmental valuation suggests the acreage tradeoff for these higher floors is likely to be worthwhile: Phillips and McGee (2016) finds that high-value stretches of riverbank in the Chesapeake Bay watershed provide almost five times the environmental services per acre of low-value areas, and Ingraham and Foster (2008)'s estimates of environmental services from National Wildlife Refuge system lands in New England ranged from \$60 per acre per year from well-conserved grasslands to \$2,670 from wetlands. Gaining one high-quality acre per 1.3 or 1.7 moderate-quality acres lost would create a substantial gain even if the true value difference between VCLNA levels is much smaller than the range found in those papers.

The decline in marginal quality heavily shapes the expected benefits from any of these policies. Figure 14 shows the acreage conserved by these policies assuming the marginal quality of land $P(e_i \geq k|s)$ is constant, still allowing for time trends in quality distribution. With constant marginal quality, increasing the subsidy rate looks like a very effective policy for attracting high-quality land. The constant marginal quality model in Figure 14 expects that the uniform policy would conserve twice as much very high-quality land as the model expects when marginal quality is allowed to vary. The constant marginal quality model is also overoptimistic about the benefits of offering targeted subsidy increases: it overestimates the very high-quality land conserved in the Very High Floor case by 52%. The acreage trade-offs involved in increasing quality floors are smaller as well, since the constant marginal quality model ignores the relative inelasticity of the higher-quality land supply. Without marginal quality shifts, the policymaker can attract significant high-quality acreage with only modest increases in the subsidy rate. Together, this suggests that ignoring the marginal quality effect can make policymakers overoptimistic about the benefits of raising conservation easement subsidies.

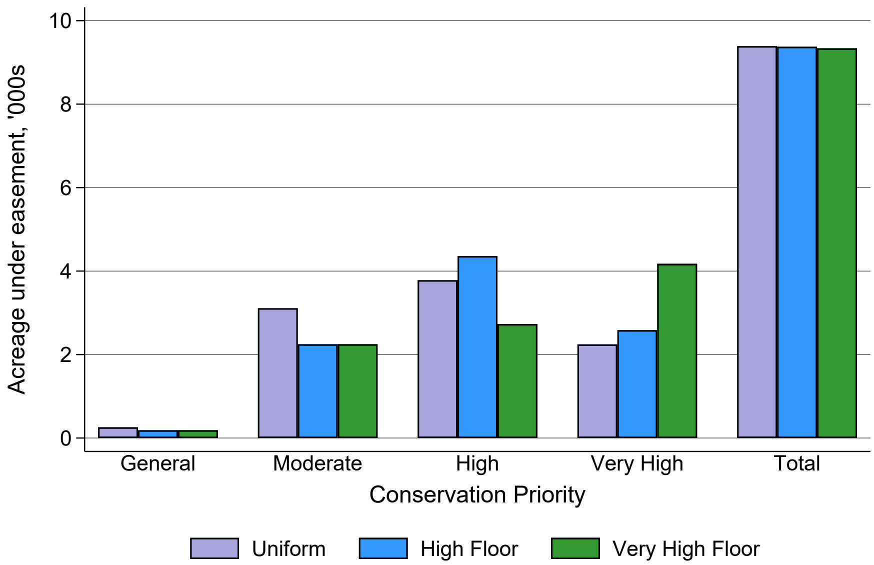
These results largely hold with alternate elasticities. I also test the model using the nationally estimated donation price acreage elasticity of -4.52 from Parker and Thurman (2018). With a higher elasticity of donations, donations of all quality levels respond much more strongly to changes in the incentive level. This model predicts that this group would donate 24,930 acres per year post-reform, closer to the 37,582 acres a year seen in the real-world data than the

Figure 13: Private Conservation Acreage Under Alternative Policies



Note: this table shows the model estimated post-reform annual easement donations for land in the quartile of parcels with the greatest subsidy increase from the 2002 reform. Conservation priority categories are set according to the maximum VCLNA conservation priority score a parcel receives. Post-incentive rates for easements are set according to Table 8. Prices for the hypothetical High Floor and Very High Floor scenarios offer lower conservation prices to land with a VCLNA conservation priority of 3 or higher and 4 or higher respectively while keeping the incentive for lower-quality land constant at the pre-reform level.

Figure 14: Private Conservation Acreage Under Alternative Policies, Price-independent Quality Distribution



Note: this table shows the model estimated post-reform annual easement donations for land in the quartile of parcels with the greatest donation price decrease from the 2002 reform. Calculated similarly to Figure 19, this alternative set of scenarios assumes the same elasticity of donation acreage, but now assumes that the quality distribution of potential easement donations is constant from the pre-reform period. The uniform scenario prices are the same as in Figure 19, but the lower prices in the High Floor and Very High Floor scenarios now differ to keep price the same as this scenario's Uniform case.

other estimate. The same-cost High Floor policy would raise the subsidy rate to .401 and the Very High Floor policy would raise the subsidy rate to .628, both lower levels than the policies chosen using the elasticity in this paper. The total acreage levels acquired would nonetheless be higher than in the main case, as shown in Appendix J. The acreage tradeoffs for the policies remain similar to the main case. With this elasticity, the High Floor case would trade 1.24 moderate-quality acres per high-quality acre, and Floor 4 would trade 1.58 moderate-to-high quality acres per very high-quality acre.

8 Conclusion

While the 30x30 goal measures conservation achievement in acreage, both the area and the quality of the land preserved will decide whether society meets the ultimate goals of the Kunming-Montreal agreement and, indeed, of conservation more broadly: to preserve species and ecosystems, to provide clean air and water, to supply natural resources like wood and food, and to protect cultural systems like recreation and agriculture that are tied to the health of the land. Oliva and García Frapolli (2024) describe the tendency to set goals in terms of area protected as a "surface bias" which risks blinding us to the actual value of conservation. Higher surface areas conserved have often translated poorly to reductions in deforestation (**reynaert˙environmental˙2023**) . This paper demonstrates that environmental quality is also not guaranteed to follow quantity.

The conservation easement tax incentive program in Virginia has successfully attracted large volumes of land for conservation, with the state's protected acreage increasing by 24% between 2002 and 2011 (O'Bannon 2012). This program's $1600 per acre average price tag in state tax incentives seems reasonable. However, that land varies widely in environmental value, and increasing subsidies for easements does not fix this. It is very concerning that the land under private conservation more closely resembles the state's full distribution of undeveloped parcels than it does the areas deliberately chosen for public conservation. In the worst case, the lower-quality conserved parcels may push development onto higher-quality lands, reducing rather than increasing the amount of environmental services on undeveloped land. Simply leaving the quality screening role to land trusts is not enough to prevent this. Most land trusts accept parcels with a wide range of quality, which is legal and a reasonable response when the trust only needs to bear the cost of monitoring an easement and not of the full state, federal, and local tax incentives.

This problem offers lessons both for easement policy and also for policymaking in other settings where identifying the exact social value induced by a private action is difficult and where we often fall back on subsidizing eligible individuals for their private costs instead. Many of these programs, including agricultural incentive programs, green rebate programs, and even health insurance payments to providers, therefore subsidize the implementation costs for any transaction that achieves a certain quality threshold. In these cases, stepping subsidy rates up across multiple quality thresholds may improve program impact compared to a single-rate option. Using VCLNA's mapping assessment to offer different subsidy rates to high-quality and lower-quality land could help increase high-quality acreage at a very reasonable cost in terms of total acreage. In other states, raising the quality threshold for large incentives could involve competitive application processes where state grants would go only to parcels offering the highest environmental value. At the federal level it is worth exploring whether the parcels that claim tax incentives based only on their "open space value" as opposed to historical, environmental, or agricultural value truly provide enough public value to justify the current level of incentives they receive.

The size of the easement quality problem likely differs across regions. Albers, Ando, and Chen (2008) offer some evidence that the environmental quality of private conservation varies considerably across states: private conservation acreage in Illinois is concentrated in high environmental value counties, while Massachusetts conservation acreage correlates more strongly with income. The decline in marginal quality estimated in this paper suggests that Virginia's very high subsidy rate, now approximately 60% from state and federal subsidies, may have attracted low-quality easements that would not have happened without these subsidies. In addition, the correlation between high development value and low environmental value contributes to this problem. Further work should explore how widespread this problem is nationally.

Easement policies may also vary in distributional effects, both in terms of who receives tax benefits for easements and who benefits from the environmental values of conserved land. The easement tax credit is extremely regressive, with more than 95% of federal deductions for land and easement donations in 2005 going to households with incomes over $100,000 and 22% going to households making over $10 million (Wilson 2005). Further, as tax policy changes where conservation happens, it will also shift who benefits from the conserved lands. Virginia's private conservation spending is heavily concentrated in the wealthiest and whitest counties in the state, although higher easement subsidies at least shift some of that concentration to lower-income areas. Conservationists far beyond Virginia are concerned about similar patterns. Future research on attracting conservation land to disadvantaged areas could help ensure that more of the population can share in the benefits of private land conservation.

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Appendices

Appendices

A Description of VCLNA Conservation Rankings

The ecological integrity metric is designed to prioritize land that makes the greatest contribution to preserving biodiversity in Virginia. Recognizing that species benefit most from large and connected patches of preserved habitat (Haddad et al. 2015), VCLNA uses satellite-derived land cover data to identify cores of intact habitat and corridors that connect them. The ranking system then uses results from DCR ecologist's past mapping exercises to prioritize cores and corridors that are large and compact, that overlap with the ranges of endangered species, that have diverse terrain likely to host a range of species, and that have wetlands and interior streams.

The DCR's watershed integrity metric highlights locations that make a valuable contribution to water quality in Virginia. Driven by ecologists' models of runoff, the ranking system awards priority points based on proximity to drinking water sources, proximity to rivers and streams, slope steepness and therefore erosion risk, health and biological diversity of nearby waters, and health of terrestrial habitat.

The forest value map denotes land that the state of Virginia believes create the most value as forests, taking into account both tax revenues from wood production and the aesthetic and cultural value of preserving continuous and healthy forested cover. For lands with current forest cover, the forest layer prioritizes areas with high soil productivity and that are part of areas that produce high value timber. It also gives higher rank to areas that incorporate wetland and riparian features and that are part of natural heritage resource areas or continuous forests.

The agricultural value metric looks to protect historic farmland and high productivity agricultural land on the basis that the presence of agricultural land supplies air quality, scenery, agricultural products, and cultural resources. For areas currently used as agricultural land, the agricultural value index was based 80% on the likelihood of prime farmland as calculated from soil type, land cover, and elevation maps and 20% on the presence of culturally significant agricultural resources (usually historic farms) as designated by the Virginia Department of Historical Resources.

The recreational score encourages protecting lands that are useful for hiking, boating, birding, hunting, or other recreational sources, and gives greater weight to areas that are accessible from major population centers. Using maps of recreational locations from the Virginia Department of Game and Inland Fisheries, the index gives 1 point for each recreational use possible in the location.

B Land Characteristic Data

Use Value: Estimates of agricultural land use value come from Virginia's Use-Value Assessment Program. The government-sponsored program housed at Virginia Tech provides estimates of the per-acre present daily value of agricultural land, using data from USDA farm surveys to estimate per-acre costs and profits. I use the annual estimates of the average use value by county. This serves as a proxy for the value of land with an easement, since agricultural land with an easement typically cannot be developed and thus is only valuable as an agricultural input.

Development Risk: As part of the VCLNA exercise, the state also mapped created a model of development risk statewide. This model is designed to highlight locations with the greatest development pressure. Using satellite and census measures, they calculate housing growth and imperviousness growth from 1990 to 2000 to find development "hot spot" census tracts that have seen the most growth. They then calculate development risk as a function of road commuting times to the nearest such hot spot. They reduce their estimated development risk in areas that would be difficult to develop, such as parcels with steep slopes. The model outputs a 1-8 scale of development pressure, where 8 is at greatest risk of development.

Local Income: Local median incomes and racial demographic information is from the 2000 census, and is calculated at the census tract level.

Land Use: Land use data comes from the National Land Cover Database (NLCD). A satellite-based measure of land use, the NLCD's 30-meter resolution level allows detection of even small changes in development or land cover. NLCD sorts land into more than 30 kinds of habitat and human land use. For this analysis, I simplify these categories into developed land (buildings and impervious surfaces), agricultural land (agricultural fields and pasture), and natural land (all natural habitats). I also examine forests and wetlands as subsets of natural land.

Weather: For weather data I use Wolfram Schlenker's Daily Weather Data for Contiguous United States, calculating heating and cooling degree days from 65 degrees and days over and below each 10 degree bin. Estimates of daily high and low temperatures and daily precipitation for each day from 1970 to 2000 are made at a 2.5 mile resolution, interpolating data from the nearest PRISM weather stations. [7]

Soil quality: I use soil quality data from the USDA's Digital General Soil Map of the United States, or STATSGO2, which maps soil classification units across the United States. I use the soil survey's land capability classification system for soils, which offers a 0-100 scale of the land's suitability for agriculture. The state of Virginia has 67 soil classification units.

[7] Data is available at http://www.columbia.edu/ ws2162/links.html

C Estimating Sales Value

Since the sales value of a parcel is its fair market price, I use the ZTRANS and ZASMT real estate datasets from Zillow to estimate the sales value of land in Virginia. The ZTRANS dataset compiles data on land transactions from county records nationwide, including a parcel's location, size, and transfer type. The ZASMT dataset of real estate assessments provides details on what kind of improvements or buildings exist on each land parcel. It also offers some information on zoning restrictions. To build a dataset of land similar to what might be placed under an easement, I identify 25,099 transactions between 1998 and 2006 of undeveloped Virginia land outside of commercial and high-density housing zoning areas. I omit parcels with buildings to ensure my model values undeveloped land, and I omit areas zoned for high-density housing or commercial usage since easements are extremely rare in those areas. This leaves me with a sample of 24,237 land sales, of which I set a quarter aside as a validation set.

I then use a ridge regression on the remaining 17,866 parcels to estimate the price per acre of a parcel. The linear elastic net immproves the predictive accuracy of the model by reducing overfitting bias by imposing penalty terms for larger coefficients. The λ coefficient is chosen by cross-validating across the grid and choosing the coefficients that minimize prediction error. I then calculate the price per acre of a parcel as $\hat{p}_i = \hat{\beta}X_i$, where

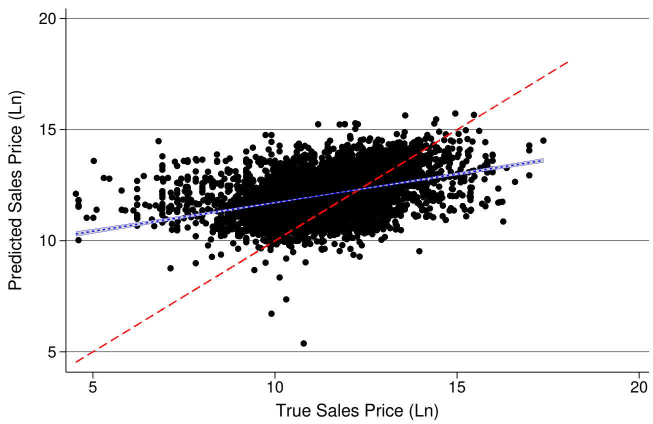
$$\hat{\beta} = argmin_{\beta}||p - \beta X||^2 + \alpha||\beta||^2$$

The variables in this regression cover a range of physical, economic, and environmental variables. They were derived from the ZTRAX data and from using the spatial coordinates given in the ZTRAX dataset to other data sources. These countrols are lot size, county, year, land use, flood risk, DCR-estimated development pressure, current land use, agricultural soil productivity, and weather. The weather variables are annual precipitation, heating degree days, and cooling degree days. The resulting model's performance on the ZTRAX test set is shown in figure 15.

D Estimating Use Value

To estimate the use value of parcels, I draw on the use value estimates for agricultural and forested land created by Virginia's Use-Value Assessment Program. Many of Virginia's counties tax undeveloped land based on its use value, essentially treating land as though the land was under easement. The Use-Value Assessment Program, implemented by Virginia Tech economists with funding and oversight from the state government, creates annual estimates of the per-acre use value of forestal and agricultural land by county. These estimates are then used as guidelines by local property tax assesssors. As such, they make a reasonable estimate for the way an assessor might determine the post-easement value of agricultural or forested land.

Figure 15: Sales Value Prediction Accuracy



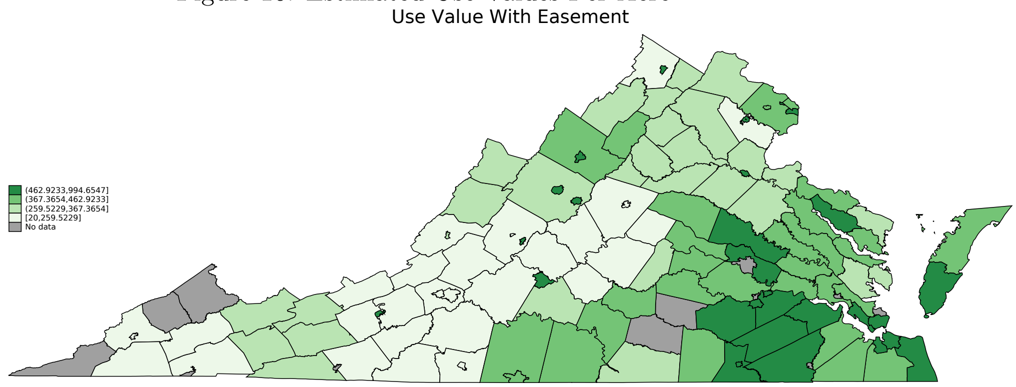
The program creates these estimates by estimating the capitalized present day value of the future revenue stream that could be expected from a land use. For the agricultural estimates, they use farm-level agricultural production data from the USDA's Census of Agriculture and state-wide data on the prices of agricultural inputs and outputs to estimate the per-acre profits of agricultural land in each county, and they use similar data on timber production to estimate forest profits. They accommodate differences in climate and transportation costs across the state by producing separate estimates for each county, and they produce estimates for fair, good, and high quality land. These estimates are redone annually to reflect changes in prices of agricultural products and inputs. 76 of 95 Virginia's 95 counties have use value taxation and thus have estimates through the Use-Value Assessment Program.

To apply these estimates to the sample of private conservation parcels, I calculate the total use value for parcel i donated in county c at time t as

$$usevalue_{ict} = acres_i * (\sum_{q=1}^{3} agvalue_{ct}^{q} * agshare_i^q + \sum_{q=1}^{3} forestvalue_{ct}^{q} * forestshare_i^q$$

where $acres$ is a parcel's total acreage, $agvalue_{ct}^{q}$ is the agricultural use value of land quality q in county c in time t, and $agshare_i^q$ is the share of parcel i's land that is agricultural and of q quality. $forestvalue_{ct}^{q}$ and $forestshare_i^q$ similarly refer to the use value and land share of forested land. I fill in the missing county's estimates with the mean of the use-value assessments for the surrounding counties. Figure 16 shows the average per-acre value of these parcels. In line with expectations, calculated use values for land are higher in the more agriculturally productive and more densely populated eastern areas.

Figure 16: Estimated Use Values Per Acre



E Event Study Figures

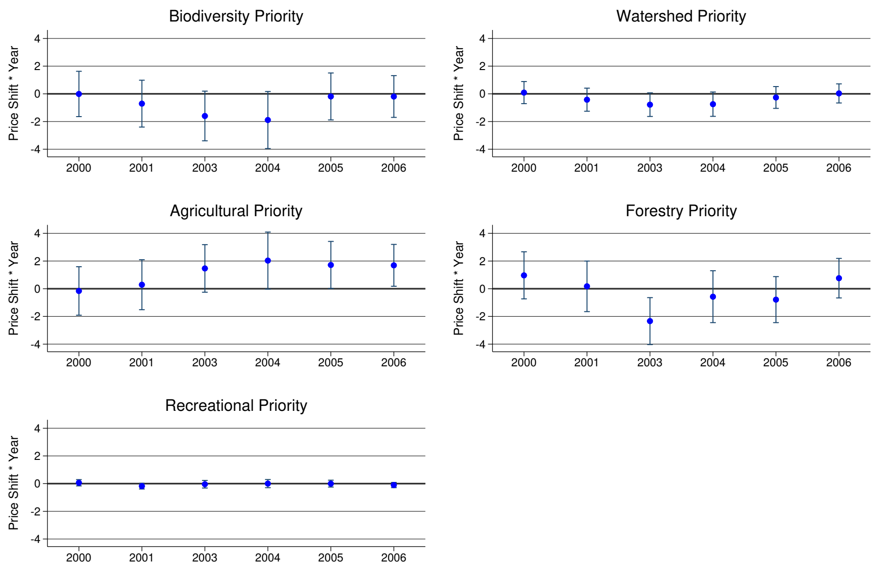
F Robustness checks: Income Assumptions

In the main results, I calculate the post-tax easement donation subsidies using estimated donor incomes of four times the census tract median income. Since there is not publicly available data on the exact incomes of Virginia easement donors, this assumption matches the national trend in easement donors, who in 2005 had on average 4 times the median household income nationally. Here, I test the robustness of my results to varying the income estimation procedure: assuming two times the median income, six times the median income, or constant income of four times the statewide median.

The results in Table 9 show that varying the income assumption slightly shifts point estimates and in some cases changes significance levels for the quality results, but the core outcomes hold. Mean conservation priority has a significant and negative treatment coefficient for all income levels, and maximum priority also reaches significance at the 10% level for the 2x median income scenario and significance at the 1% level for the constant statewide income scenario. The effect on agricultural priority is consistently large and significant as well. The effects on biodiversity and watershed priority remain ambiguous.

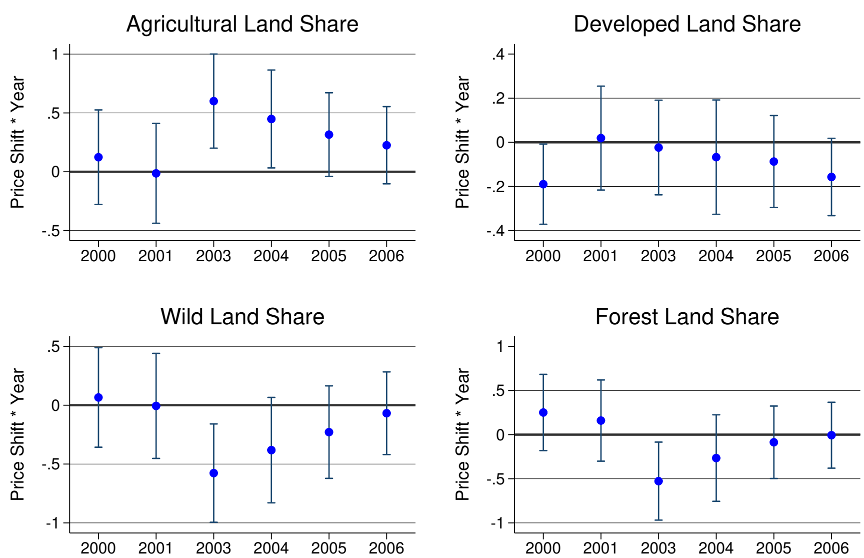
The land use results in Table 10 also remain similar. Development threat level's relationship with the subsidy shift post-2002 is still negative and significant in the 6x and 2x median income scenarios, as is the agricultural land share. They do lose their significance in the constant income scenario, though the coefficient remains positive. Since development pressure is higher in areas with higher incomes, assuming constant income statewide reduces the regression's ability to pick up that variation. Forest land share has a positive relationship with subsidy shift * post in all scenarios, and the effect on natural land share remains positive although varies in significance.

Figure 17: Event Study Treatment Effect on Conservation Categories



Graph denotes coefficients on year * large, with 2001 omitted as the baseline year of the reform.

Figure 18: Event Study Treatment Effect on Land Use



Graph denotes coefficients on year * large, with 2001 omitted as the baseline year of the reform.

Table 9: DiD Effect on Environmental Value with Varying Income Assumptions

VARIABLES	(1) Mean Priority	(2) Maximum Priority	(3) Biodiversity Priority	(4) Watershed Priority	(5) Agricultural Priority	(6) Forestry Priority	(7) Recreational Priority
Panel A: Income 6x Median							
Post * Subsidy Shift	-0.689***	-0.537	0.253	-0.284	-1.302**	0.721	-0.0231
	(0.256)	(0.377)	(0.578)	(0.279)	(0.609)	(0.611)	(0.0668)
Post Reform	0.0194	0.0585	0.349***	0.155***	-0.167**	0.244***	0.00804
	(0.0359)	(0.0512)	(0.0777)	(0.0384)	(0.0834)	(0.0794)	(0.0101)
Subsidy Shift	0.860***	0.354	-0.903*	0.0403	2.008***	-1.124**	-0.154***
	(0.220)	(0.329)	(0.479)	(0.240)	(0.530)	(0.536)	(0.0525)
Constant	1.880***	3.173***	0.781***	2.273***	2.120***	1.838***	0.0626***
	(0.0289)	(0.0420)	(0.0589)	(0.0312)	(0.0679)	(0.0643)	(0.00701)
Panel B: Income 2x Median							
Post * Subsidy Shift	-0.591**	-0.568*	0.107	0.308	-1.675***	0.930*	-0.0378
	(0.230)	(0.325)	(0.507)	(0.243)	(0.506)	(0.498)	(0.0614)
Post Reform	0.0857*	0.105	0.360***	0.105**	0.0276	0.138	0.00594
	(0.0483)	(0.0668)	(0.108)	(0.0507)	(0.103)	(0.0997)	(0.0143)
Subsidy Shift	0.664***	0.495*	-1.271***	-0.502**	2.231***	-1.280***	-0.0902**
	(0.189)	(0.268)	(0.393)	(0.200)	(0.414)	(0.414)	(0.0454)
Constant	1.818***	3.121***	0.914***	2.333***	1.895***	1.968***	0.0703***
	(0.0381)	(0.0531)	(0.0813)	(0.0405)	(0.0803)	(0.0794)	(0.0101)
Panel C: Constant Income							
Post * Price Shift	-4,020	-13.51**	7.605*	0.0332			
	(10,136)	(5.894)	(3.902)	(0.0464)			
Post Reform	-6,069***	-3.051***	3.845***	-0.0262***			
	(1,873)	(1.069)	(0.714)	(0.00847)			
Subsidy Shift	15,862*	21.20***	-26.35***	0.0958***			
	(9,042)	(5.144)	(3.071)	(0.0339)			
Constant	52,891***	16.44***	23.82***	0.883***			
	(1,653)	(0.919)	(0.556)	(0.00608)			
Observations	1,767	1,780	1,780	1,780	1,780	1,780	1,780

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: regressions conducted according to Equation 10, varying the assumed donor income used to calculate shifts in easement donation incentives. Panel A assumes the donor's income is 6 times the median income for the easement's census tract, Panel B assumes it is 2 times the census tract median, and Panel C sets the income for all donors statewide at 4 times the median Virginia income.

Table 10: DiD Effect on Land Use with Varying Income Assumptions

VARIABLES	(1) Development Threat Level	(2) Agricultural Land Share	(3) Developed Land Share	(4) Natural Land Share	(5) Forest Land Share	(6) Wetland Land Share
Panel A: Income 6x Median						
Post * Subsidy Shift	-1.486***	-0.221	0.0212	0.200	0.265*	-0.0625
	(0.457)	(0.145)	(0.0622)	(0.150)	(0.154)	(0.0616)
Post Reform	-0.433***	-0.0774***	0.00107	0.0764***	0.0299	0.0358***
	(0.0644)	(0.0189)	(0.00936)	(0.0197)	(0.0203)	(0.00916)
Subsidy Shift	1.678***	0.702***	-0.200***	-0.503***	-0.405***	-0.0641
	(0.327)	(0.129)	(0.0530)	(0.133)	(0.134)	(0.0444)
Constant	7.032***	0.390***	0.0649***	0.545***	0.494***	0.0334***
	(0.0445)	(0.0158)	(0.00740)	(0.0163)	(0.0165)	(0.00616)
Panel B: Income 2x Median						
Post * Subsidy Shift	-0.845**	-0.288**	0.0362	0.252**	0.345***	-0.0833
	(0.427)	(0.113)	(0.0687)	(0.121)	(0.128)	(0.0621)
Post Reform	-0.394***	-0.0370*	-0.00775	0.0447*	-0.0115	0.0438***
	(0.0898)	(0.0221)	(0.0158)	(0.0240)	(0.0260)	(0.0131)
Subsidy Shift	1.625***	0.738***	-0.186***	-0.551***	-0.432***	-0.0716
	(0.288)	(0.0968)	(0.0577)	(0.103)	(0.106)	(0.0448)
Constant	6.872***	0.316***	0.0832***	0.601***	0.538***	0.0406***
	(0.0594)	(0.0183)	(0.0130)	(0.0197)	(0.0207)	(0.00863)
Panel C: Constant Income						
Post * Price Shift	-0.303	-0.154	0.00921	0.145	0.263*	-0.101*
	(0.415)	(0.124)	(0.0614)	(0.130)	(0.135)	(0.0606)
Post Reform	-0.523***	-0.0691***	-0.00225	0.0714***	0.0170	0.0421***
	(0.0747)	(0.0196)	(0.0117)	(0.0209)	(0.0221)	(0.0107)
Price Shift	1.821***	0.706***	-0.181***	-0.525***	-0.412***	-0.0749*
	(0.288)	(0.108)	(0.0510)	(0.112)	(0.114)	(0.0417)
Constant	6.950***	0.359***	0.0725***	0.568***	0.512***	0.0369***
	(0.0521)	(0.0165)	(0.00948)	(0.0173)	(0.0178)	(0.00699)
Observations	1,780	1,780	1,780	1,780	1,780	1,780

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: regressions conducted according to Equation 10, varying the assumed donor income used to calculate shifts in easement donation incentives. Panel A assumes the donor's income is 6 times the median income for the easement's census tract, Panel B assumes it is 2 times the census tract median, and Panel C sets the income for all donors statewide at 4 times the median Virginia income.

Table 11: DiD Effect on Environmental Value, Binary Treatment

VARIABLES	(1) Mean Priority	(2) Maximum Priority	(3) Biodiversity Priority	(4) Watershed Priority	(5) Agricultural Priority	(6) Forestry Priority	(7) Recreational Priority
Post * High Value	-0.246***	-0.265**	-0.279	-0.0810	-0.371*	0.115	-0.0175
	(0.0808)	(0.117)	(0.186)	(0.0890)	(0.189)	(0.188)	(0.0240)
Post Reform	0.125*	0.154	0.565***	0.107	0.00142	0.146	0.0176
	(0.0695)	(0.0988)	(0.161)	(0.0745)	(0.154)	(0.150)	(0.0226)
High Development Value	0.250***	0.260***	-0.349**	-0.130*	0.842***	-0.297*	-0.0300*
	(0.0637)	(0.0931)	(0.142)	(0.0704)	(0.155)	(0.157)	(0.0169)
Constant	1.803***	3.058***	1.040***	2.439***	1.692***	2.031***	0.0686***
	(0.0513)	(0.0746)	(0.115)	(0.0550)	(0.119)	(0.117)	(0.0152)
Observations	1,286	1,298	1,298	1,298	1,298	1,298	1,298
R-squared	0.012	0.006	0.040	0.018	0.040	0.008	0.017

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: this regression replaces the standard Price Shift treatment values in Equation 10 with a binary High Value treatment variable that equals 0 for development values below $120,000, which would have faced higher post-reform donation prices over 95% of the national range of land donor incomes, and 1 for development values above $600,000 that would likely have paid lower donation prices post-reform over 95% of land donor incomes. Easements with middle levels of development value are omitted.

G Robustness Checks: Binary Treatment Effects

Given the uncertainties around precise donor incomes and development values, I also test whether my result is robust to comparing only the highest development value easements that almost certainly received a higher subsidy rate post-2002 to the low-donation value parcels that almost certainly faced a lower post-reform donation subsidy. I define low development value parcels as those with development values below $120,000 and high development value parcels as those with development values above $600,000. The low parcels would have received smaller subsidies post-reform and the high parcels would have received larger subsidies over at least 95% of the national range of land donor incomes. I omit mid-valued easements from the regression.

The environmental quality results in Tables 11 are similar in direction and significance to my main results, since high value corresponds to a positive post-reform price shift. The high-value group has lower mean and maximum priority post-reform, particularly in agriculture. The land use results in Table 12 do change slightly: without the greater nuance in the main results, the shift away from agricultural land use is no longer detectable.

Table 12: DiD Effect on Easement Land Use, Binary Treatment

VARIABLES	(1) Development Threat Level	(2) Agricultural Land Share	(3) Developed Land Share	(4) Natural Land Share	(5) Forest Land Share	(6) Wetland Land Share
Post * High Value	-0.0434	-0.00439	0.0104	-0.00598	0.0509	-0.0606***
	(0.149)	(0.0429)	(0.0248)	(0.0456)	(0.0480)	(0.0222)
Post Reform	-0.483***	-0.0653**	-0.0124	0.0776**	-0.00595	0.0793***
	(0.135)	(0.0328)	(0.0246)	(0.0359)	(0.0388)	(0.0193)
High Development Value	0.624***	0.188***	-0.0624***	-0.125***	-0.0983**	-0.00955
	(0.0999)	(0.0373)	(0.0204)	(0.0392)	(0.0399)	(0.0135)
Constant	6.671***	0.288***	0.0972***	0.615***	0.549***	0.0359***
	(0.0894)	(0.0273)	(0.0202)	(0.0294)	(0.0303)	(0.00934)
Observations	1,298	1,298	1,298	1,298	1,298	1,298
R-squared	0.057	0.061	0.049	0.031	0.008	0.030

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: this regression replaces the standard Price Shift treatment values in Equation 10 with a binary High Value treatment variable that equals 0 for development values below $120,000, which would have faced higher post-reform donation prices over 95% of the national range of land donor incomes, and 1 for development values above $600,000 that would likely have paid lower donation prices post-reform over 95% of land donor incomes. Easements with middle levels of development value are omitted.

Table 13: DiD Effect on Environmental Value with Nolte (2020) Land Value Estimates

VARIABLES	(1) Mean Priority	(2) Maximum Priority	(3) Biodiversity Priority	(4) Watershed Priority	(5) Agricultural Priority	(6) Forestry Priority	(7) Recreational Priority
Post * Subsidy Shift	-0.858***	-0.981***	-1.210**	-0.876***	-0.119	-1.000*	0.0384
	(0.250)	(0.363)	(0.540)	(0.274)	(0.591)	(0.564)	(0.0778)
Post Reform	0.104**	0.135**	0.427***	0.221***	-0.136	0.335***	-0.00874
	(0.0433)	(0.0618)	(0.0896)	(0.0472)	(0.101)	(0.0943)	(0.0137)
Subsidy Shift	1.031***	0.455	0.569	0.340	1.477***	-0.231	-0.204***
	(0.215)	(0.322)	(0.444)	(0.239)	(0.507)	(0.486)	(0.0631)
Constant	1.794***	3.135***	0.708***	2.240***	2.013***	1.839***	0.0797***
	(0.0373)	(0.0545)	(0.0728)	(0.0410)	(0.0872)	(0.0805)	(0.0112)
Observations	1,767	1,780	1,780	1,780	1,780	1,780	1,780
R-squared	0.016	0.007	0.013	0.018	0.020	0.016	0.026

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: regressions conducted according to Equation 10, using Nolte (2020) land values to estimate land sales value.

Table 14: DiD Effect on Land Use with Nolte (2020) Land Value Estimates

VARIABLES	(1) Development Threat Level	(2) Agricultural Land Share	(3) Developed Land Share	(4) Natural Land Share	(5) Forest Land Share	(6) Wetland Land Share
Post * Subsidy Shift	0.228	-0.0570	0.131*	-0.0740	-0.0345	-0.0539
	(0.451)	(0.133)	(0.0774)	(0.140)	(0.148)	(0.0654)
Post Reform	-0.475***	-0.0427*	-0.0244*	0.0671***	0.0296	0.0307***
	(0.0752)	(0.0223)	(0.0140)	(0.0237)	(0.0249)	(0.0112)
Subsidy Shift	0.463	0.613***	-0.266***	-0.347***	-0.233*	-0.0324
	(0.342)	(0.117)	(0.0717)	(0.123)	(0.127)	(0.0476)
Constant	7.018***	0.343***	0.0874***	0.570***	0.510***	0.0354***
	(0.0589)	(0.0195)	(0.0130)	(0.0207)	(0.0212)	(0.00846)
Observations	1,780	1,780	1,780	1,780	1,780	1,780
R-squared	0.028	0.057	0.045	0.031	0.011	0.009

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: regressions conducted according to Equation 10, using Nolte (2020) land values to estimate land sales value.

Table 15: Donation Elasticity with Nolte (2020) Land Value Estimates

VARIABLES	(1) Donation Count (log)	(2) Acres Donated (log)
lnprice	-0.344	0.139
	(0.270)	(0.375)
Constant	4.035***	7.716***
	(1.173)	(1.675)
Year Fixed Effects	Yes	Yes
Group Fixed Effects	Yes	Yes
Observations	96	96
R-squared	0.653	0.922

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: regressions conducted according to Equation 12, using Nolte (2020) land values to estimate land sales value.

Table 16: DiD Effect on Environmental Value Omitting 2003

VARIABLES	(1) Mean Priority	(2) Maximum Priority	(3) Biodiversity Priority	(4) Watershed Priority	(5) Agricultural Priority	(6) Forestry Priority	(7) Recreational Priority
Post Reform * Subsidy Shift	-0.724***	-0.722**	0.0767	-0.0321	-1.543***	0.529	-0.0222
	(0.248)	(0.357)	(0.568)	(0.267)	(0.576)	(0.565)	(0.0673)
Post Reform	0.0615	0.107*	0.376***	0.142***	-0.0987	0.247***	0.00667
	(0.0429)	(0.0603)	(0.0967)	(0.0456)	(0.0973)	(0.0914)	(0.0126)
Subsidy Shift	0.772***	0.371	-1.160***	-0.260	2.166***	-1.304***	-0.145***
	(0.200)	(0.290)	(0.432)	(0.216)	(0.465)	(0.467)	(0.0500)
Constant	1.851***	3.158***	0.832***	2.289***	2.032***	1.893***	0.0681***
	(0.0320)	(0.0459)	(0.0670)	(0.0344)	(0.0721)	(0.0687)	(0.00838)
Observations	1,561	1,572	1,572	1,572	1,572	1,572	1,572
R-squared	0.011	0.003	0.021	0.010	0.017	0.013	0.024

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: regressions conducted according to Equation 10, excluding 2003 as a second adjustment year

Table 17: DiD Effect on Land Use Omitting 2003

VARIABLES	(1) Development Threat Level	(2) Agricultural Land Share	(3) Developed Land Share	(4) Natural Land Share	(5) Forest Land Share	(6) Wetland Land Share
Post Reform * Subsidy Shift	-1.663***	-0.221*	0.0282	0.193	0.259*	-0.0409
	(0.449)	(0.131)	(0.0663)	(0.138)	(0.144)	(0.0642)
Post Reform	-0.350***	-0.0644***	-0.00215	0.0665***	0.0223	0.0286**
	(0.0773)	(0.0208)	(0.0124)	(0.0224)	(0.0236)	(0.0111)
Subsidy Shift	1.588***	0.738***	-0.187***	-0.551***	-0.454***	-0.0578
	(0.297)	(0.111)	(0.0534)	(0.116)	(0.118)	(0.0444)
Constant	6.971***	0.360***	0.0720***	0.568***	0.513***	0.0356***
	(0.0501)	(0.0165)	(0.00940)	(0.0173)	(0.0177)	(0.00677)
Observations	1,572	1,572	1,572	1,572	1,572	1,572
R-squared	0.036	0.056	0.042	0.031	0.014	0.009

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

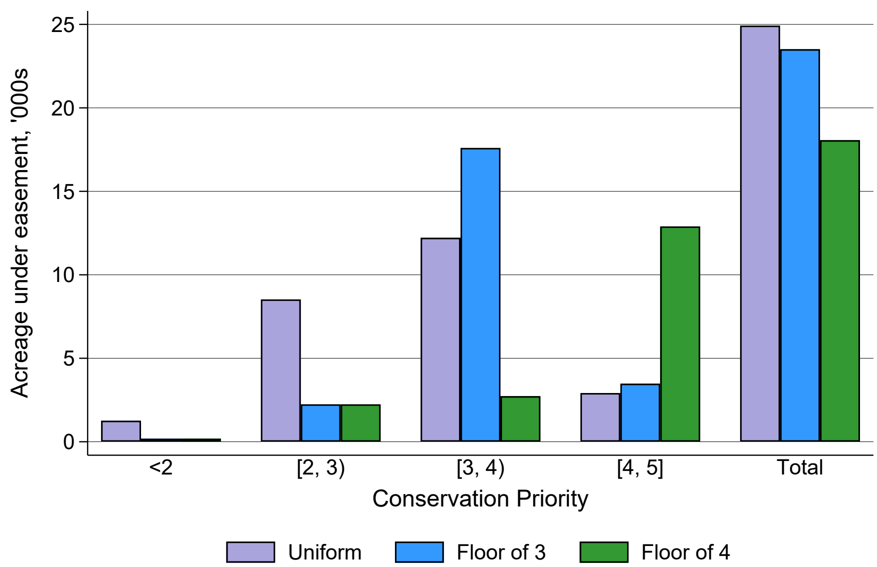
Note: regressions conducted according to Equation 12, excluding 2003 as a second adjustment year

H Robustness Checks: Alternate Land Value Estimates

I Robustness Checks: Omitting 2003

J Model with Alternate Elasticity

Figure 19: Modeled Private Conservation Acreage with Alternate Elasticity



Note: this table shows the model estimated post-reform annual easement donations for land in the quartile of parcels with the greatest subsidy increase from the 2002 reform. Elasticity of acreage is set at -4.52 from Parker and Thurman (2018). priority categories are set according to the maximum VCLNA conservation priority score a parcel receives. Post-incentive rates for easements are set according to Table 8. Prices for the hypothetical Floor 3 and Floor 4 scenarios offer lower conservation prices to land with a VCLNA conservation priority of 3 or higher and 4 or higher respectively while keeping the incentive for lower-quality land constant at the pre-reform level.

Table 18: Donation Elasticity Omitting 2003

	(1)	(2)
VARIABLES	Donation Count (log)	Acres Donated (log)
lnprice	-2.411***	-1.472**
	(0.402)	(0.605)
Constant	13.38***	14.64***
	(1.722)	(2.645)
Year Fixed Effects	Yes	Yes
Group Fixed Effects	Yes	Yes
Observations	80	80
R-squared	0.620	0.718

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Note: regressions conducted according to Equation 10, excluding 2003 as a second adjustment year