A Welfare Analysis of Conservation Easement Tax Credits

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Abstract

The use of conservation easements to protect vulnerable land is growing rapidly but there is growing public concern that in many cases generous easement tax credits far exceed the environmental value of the protected land. Landowners who agree to an easement sell or donate their development rights to a conservation agency and receive a tax credit on the "gifted" amount. The tax credit subsidy is designed to reduce under-investment in land preservation by conservation agencies that operate with tight budgets. This papers shows that the tax credit program is least effective for land with the highest environment value because the value of the easement gift is lowest in these situations. Moreover, monopsony pricing by the conservation agency lowers tax credit pass through to landowners, possibly to the extent that a marginal increase in the tax credit rate decreases rather than increases the probability of an easement outcome. A final important result is that the combination of adverse selection and a failure of the conservation agency to internalize the land's development value can result in the agency agreeing to accept a welfare-worsening donated easement.

Keywords: Conservation Easement, Tax Credit, Environmental Externality, Crowding Out, Real Option.

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1 Introduction

Conservation easements are a popular market based instrument for preserving U.S. farmland, forest land and land that is rich in biodiversity. A conservation easement allows a public or private conservation agency to purchase or accept a donation of a landowner's development rights rather than purchasing and managing the actual land in order to permanently prevent development activities. Landowners who agree to an easement are provided sizeable tax credits that extend over multiple years and in some cases are transferable. Uptake by landowners has been rapid in recent years and as a result federal, state and local governments are currently foregoing hundreds of millions of dollars of tax revenue each year. Updike and Mick [2016] indicate (see their note 3) that approximately \$11 billion of conservation easement tax deductions and credits were granted to U.S. landowners between 2003 and 2009. Colorado alone granted \$965 million in conservation easement tax credits over a recent 15 year period [Migoya, 2016].

The purpose of this paper is to examine the welfare implications of a stylized conservation easement tax credit program. Despite growing public concern over both the magnitude of transfers and perceptions of tax evasion [Swift, 2010], easement tax credits have yet to be formally examined in a rigorous economic framework. This paper models the dynamic strategic interaction of the various market participants, the specific market externalities and important institutional details such as budget constraints for conservation agencies and irreversible decision making with uncertainty for landowners. This paper also frames the problem in terms familiar to economists including real options, asymmetric information, pricing with market power, crowding out of agency payments and corner solutions. The main result of this paper is that although a conservation easement can work well as a policy tool under the right conditions, there are number of complexities and unintended consequences that not only limit the easement's usefulness but can also result in an inefficiently high level of land protection. Excessive protection is particularly costly for society when foregone tax revenues are large, and the land in question has comparatively low preservation value and comparatively high development value.

If a conservation agency is not budget constrained and prices its easement offer competitively then there is no need for an easement tax credit. Under these conditions the agency will bid for the land's development rights up to the external environmental value of the land, and the price will ensure a socially efficient decision by the landowner regarding when to develop the land. The reality, however, is that sizeable budget constraints normally cause conservation agencies to under-invest in conservation easements, and this is particularly problematic when the land in question has both high environmental value and high development value. A tax credit program allows the landowner to claim as a charitable donation the difference between the market value of the land without and with the easement in place minus the amount received as payment for the development rights. The tax credit is equivalent to a public Pigouvian subsidy that shifts the easement market outcome toward the efficient level.

The paper shows that the main weakness of an easement tax credit is that the program's effectiveness as an instrumnent for reducing market failure depends on the size of the easement gift. The easement gift is lower the higher the price that is offered by the conservation agency. The agency will offer a higher price for land with a higher environmental value and so the easement gift and the effectiveness of the tax credit program are the smallest for land that has the highest environmental value. A second important result is that the potential exists for socially undesirable land to be drawn into the easement market via a donated easement. Of particular concern is land with comparatively low environmental value and high non-market private valuation by the land's owner. This combination is the most likely to give rise to an easement donation that is not in society's best interest. In this case, rather than the landowner failing to internalize the land's development value and prematurely developing the land, it is the conservation agency that fails to internalize the development value of the land and thus agrees to hold the donated easement, even though doing so reduces social welfare.

A number of important secondary results also emerge from the analysis. For example, the agency prices the easement to maximize environmental surplus and this singular focus results in easement under-pricing, similar to standard monopsony pricing. Pricing with market power implies that the extent the agency reduces its price offer in response to a more generous tax credit varies with the size of the easement gift. The analysis shows that as the gift becomes sufficient small, which is consistent with land that has high environmental value, a marginal increase in the easement tax credit will result in greater than 100 percent crowding out of the agency payment. In this case the increase in the tax credit is inefficient because it lowers rather than raises the probability that the landowner will accept the agency's easement offer.

Another important secondary result concerns the dynamics of the landowner's decision making. The conservation agency provides the landowner with a one time easement offer. If the landowner rejects the offer because the agency has overestimated her private valuation of the land's non-market amenities, then the landowner must choose when to accept a stochastically evolving offer from a developer. This sub-problem is a standard real option problem and as such the landowner's opportunity cost when considering the agency's easement offer must reflect the value of the landowner's real option from the sub-problem. A higher level of volatility in the developer's offer price has two opposing impacts on tax credit effectiveness. The obvious effect is that the conservation agency must offer a higher easement price when the developer's offer price is more volatile, and this higher offer price reduces both the size of the easement gift and the effectiveness of the easement tax credit program. The less obvious effect is that the higher level of development price volatility induces the landowner to delay her development decision by a longer amount of time in the event the easement offer is rejected. This longer delay implies the agency enjoys a temporary flow of environmental benefits for a longer period of time. The delay also makes the landowner's demand for the easement more elastic, and this higher elasticity increases the rate at which an increase in the easement tax credit passes through to the landowner. Both of these features imply a higher overall effectiveness of the tax credit program.

The next section provides a brief overview of conservation easements and their associated tax credits. The formal model is introduced in Section 3. In sections 4 formal results concerning tax credit effectiveness are presented for the case of a purchased easement and no development value uncertainty. These two restrictions are relaxed in Section 5 by considering the specific role of development value uncertainty and the implications of a donated easement. Concluding remarks are presented in Section 6.

2 Background

Public concern over land development continues to grow due to a shrinking supply of land for food production, wildlife habitat, biodiversity and green space. The U.S. Department of Agriculture (USDA) [2009] estimated that between 1982 and 2007 approximately 14 million acres of mostly prime U.S. farmland was developed. In response to this loss, private land trusts have formed to conserve land through a combination of outright purchases and conservation easements. A conservation easement is a perpetual legal contract that allows land to remain in private hands, but which requires current and future owners of the land to preserve specific land attributes and to forego certain types of activities [Anderson and King, 2004]. Easements vary from simple restrictions on land modification such as water drainage to major restrictions that prohibit any type of non-natural activity. The amount of land that is protected by conservation easements and the number of private land trusts who administer these easements has grown rapidly over the past two decades. Using data from the national conservation easement database, Updike and Mick [2016] note that as of September, 2015 there were 23,349,840 acres of land in the U.S. spread over 114,216 easements. Moreover, as of 2010 there were over 1700 local, state and national land trusts operating in the U.S. [Chang, 2010]. The use of conservation easements has grown rapidly in Canada as well, although in this country most of the acres are held by a small number of land trusts.

A conservation easement facilitates both cash sales and donations of the land's development rights to a non-profit local, state or national conservation agency. When the easement is purchased, both within and outside of the federally cost-shared "purchase of development rights (PDF)" program, the transaction price is expected to closely reflect the environmental value of the land.[1] However, landowners commonly donate easements and it is for this particular case where it is most unclear whether the preserved environmental attributes justify the foregone tax receipts. A lack of minimum environmental attributes for easement land was made explicit by

[1]Through out the paper "purchase the development rights" and "purchase the easement" are used interchangeably because they are equivalent descriptions of the transaction. The concept of "purchase" may be misleading because an easement agreement does not give the agency the option to resell the development rights back to the landowner or to a third party. Once an easement is sold, the restriction on land use is permanent.

an auditor in Colorado who questioned whether nearly $1 billion in tax breaks for landowners were justified since in each case there was no or very little determination of environmental gain [Migoya, 2016].

Strong lobbying by conservation groups has resulted in an increasing number of tax concessions for landowners who choose to utilize a conservation easement. The concessions vary by jurisdiction but at a minimum all landowners qualify for a federal income tax deduction. Landowners in Colorado receive particularly large tax concessions. Suppose a Colorado landowner donates a conservation easement on a parcel of land that was valued at $2 million prior to the easement. With the easement in place suppose the assessment authority values the land in agricultural use at $1.25 million. Because the easement was donated the easement gift would be deemed to equal $750,000. At the federal level the landowner receives a tax deduction, which means the $750,000 gift can be used to shelter income for up to 15 years, at a rate of 100 percent year if at least 50 percent of income comes from agricultural activities, and at a rate of 50 percent otherwise. Federal estate taxes will also be reduced because this tax will be based on the lower $1.25 million dollar value rather than the $2 million dollar value. Moreover, because the reduction in the land's value is greater than 30 percent as a result of the easement, up to 40 percent of the $1.25 million dollar current value of the land will be exempt from federal estate taxes. For a landowner who earns $100,000 of net farm income each year and has a 28 percent marginal federal income tax rate, the donated easement has a present value federal tax savings (assuming 5 percent discount) equal to $255,600.

The State of Colorado provides a tax credit for donated easements, which reduces taxes owing dollar for dollar, and which can be carried forward for up to 20 years [Colorado Open Lands, 2017]. Up until 2014 the total tax credit was 50 percent of the value of the gift up to a maximum of $375,000. As of 2015 landowners can claim a credit of 75 percent of the value of the gift on the first $100,000 and 50 percent on the remaining balance, up to a maximum of $1.5 million. If landowners are not able to use the tax credit they can sell it in a secondary market at a rate of $0.83 per dollar of credit. Continuing with the landowner example, the present value of Colorado tax savings (based on a 4.63 percent flat rate) is equal to $57,700 and the present value of the residual tax credit that can be sold is $255,150. The total tax federal and state tax savings are obviously sizeable and thus makes the cost of the easement gift much less of a disincentive for the landowner. If the land has high environmental value and is under development pressure then the set of tax credits that reduce the likelihood of land development are expected to be in society's best interest. In the opposite case where the land has low environmental value and there is low development pressure then the net impact of the set of tax credits on social welfare is likely to be negative.

In addition to the view by some that conservation easements facilitate tax evasion [Swift, 2010], these instruments have been criticized for eliminating socially desirable development opportunities, spotty monitoring and lack of easement enforcement by small-scale land trusts. Similarly, easements have been criticized because they result in higher property tax rates and fewer locally-provided public goods[Raymond and Fairfax, 2002, Anderson and King, 2004, Merenlender, Huntsinger, Guthey, and Fairfax, 2004, Fishburn, Kareiva, Gaston, and Armsworth, 2009]. McLaughlin [2004] shows how tax incentives favour high income landowners, which goes against the principle of helping cash poor landowners resist the temptation to sell their land for development for purely financial considerations.[2]

The real option framework that is featured in the analysis below includes a key paper by Capozza and Sick [1994]. This paper, which builds on earlier work by McDonald and Seigel [1986] and Dixit and Pindyck [1994], focuses on privately optimal land development and the associated pricing of land. It should be noted that Tenge, Wiebe, and Kuhn [1999] analyze the minimum level of compensation that is required to induce a landowner to voluntarily sign an easement when development value is uncertain. Their approach to value undeveloped land is similar to the approach used in this paper. Anderson and King [2004] use a simple game theoretic framework and laboratory experiments to describe how a private market easement decision is expected to result in non-optimal levels of community welfare because of a property tax externality.

[2] King and Anderson [2004] and Anderson and Weinhold [2008] argue that the tax-based social cost of the easement may be overstated in the literature because easements generally increase the market value of non-easement properties. Sundberg and Dye [2006] find that the tax advantages of an easement usually more than compensates the landowner for the reduced market value of the land.

3 Assumptions and Market Equilibrium

3.1 Basic Assumptions

A local conservation agency allocates its budget B between land preservation and an external environmental project (e.g., wetland restoration) in order to maximize environmental surplus for the general public. Land preservation implies using a conservation easement to purchase the development rights for a parcel of land from a local landowner at price $P \geq 0$. The agency's valuation of the external project is equal to λ per dollar of allocation. Thus, if the landowner agrees to the easement proposal then the external project generates environmental surplus $\lambda(B - P - F)$ for the agency where F is the fixed administrative cost of setting up the easement. The agency views λ as a fixed parameter when constructing its easement offer but in the comparative static analysis below the values of B and λ are assumed to be negatively correlated due to diminishing marginal value of the external project (e.g., a high value for λ implies an agency with a tight budget).

The game unfolds as follows. At date -2 the landowner's type is randomly drawn by nature and revealed to the landowner. The agency does not observe this random draw but otherwise is fully informed. If the observed environmental value of the land is sufficiently high, then at date -1 the agency makes a take-it-or-leave-it offer to purchase the land's development rights. The offer price, P, will either be a positive (interior) value or a zero (corner solution) value. At date 0 the agency's offer is either accepted or rejected by the risk neutral landowner. If the offer is accepted then the landowner receives price P from the agency, a tax credit from the taxing authority and status quo market and non-market flows from the undeveloped land into perpetuity. If the offer is rejected then the landowner waits until the optimal time to sell her land to a local developer. When the sale eventually occurs at stochastic date T the landowner receives a one time payment V from the developer and forfeits the existing market and non-market flows. To avoid confusion regarding the discounting of the various flows, assume the amount of time between date -1 and date 0 is arbitrarily small.

The landowner's type, $s \in (s^{min}, \infty)$, refers to her valuation of the land's non-market "lifestyle" amenities, which includes open space, quiet surroundings and possibly some capacity to produce food.[3] The specific value of s is private information for the landowner but the agency knows that s was drawn from a probability density function, $g(s)$, with corresponding cumulative density function, $G(s)$. Because the agency's offer is based on expected s rather than actual s easement acceptance by the landowner is probabilistic rather than deterministic. To simplify the analysis assume $G(s)$ is independent of the other parameters, especially the land's environmental value.[4]

While the land is undeveloped, external environmental benefits for the general public are assumed to flow at rate ω as of date 0 and grow at a constant rate $g \geq 0$ over time.[5] These external benefits include wildlife habitat, preserved biodiversity, green space and a carbon sink for greenhouse gas emissions. With an easement in place the agency's date 0 valuation of the perpetual external benefit flow is equal to $\Omega = \omega/(\rho - g)$ where ρ is the agency's rate of discount (same as for the landowner). If the easement is rejected environmental benefits will flow between date 0 and stochastic development date T. The date 0 discounted expected value of this temporary flow is denoted $W(V, s)$. This function depends on V and s because both of these variables determine the development trigger and thus the expected time to development. As will be explained below, the external benefit flow per unit of time without the easement is assumed to be a fraction ϕ of the benefit flow with the easement (e.g., $W(V, s) \rightarrow \phi\Omega$ as $T \rightarrow \infty$).[6]

As noted above, if the landowner rejects the agency's easement offer she then has an ongoing option to sell the land to a competitive developer at price, $V(t)$, where $V(0) \equiv V$. Beyond

[3]Although there is just one landowner in the model the assumption of private information implies there are a continuum of different types from the perspective of the agency. The results of the analysis are expected to be similar for the case of multiple heterogeneous landowners.

[4]Assuming a positive relationship between the mean value of s and the land's environmental value would be more realistic.

[5]A more general version of the model would allow for both positive pre-development environmental flows and negative post-development flows. Assuming zero post-development flow is unlikely to be important for the results because it is the differential in the flow before and after development that matters most.

[6]This $0 < \phi < 1$ restriction is reasonable because an easement is likely to magnify external environmental benefits such as less restricted access for hunters and enhanced biodiversity due to stronger incentives for long-term environmental management initiatives.

date 0 assume the developer's offer price evolves stochastically over time according to various random supply and demand shocks in the developed land market. Specifically, $V(t)$ evolves continuously over time as geometric Brownian motion with drift parameter $\alpha \in (0, \rho)$ and volatility parameter σ. This assumption implies that $dV = \alpha V dt + \sigma V dz$ where $dz = \epsilon_t \sqrt{dt}$ is the increment of a Wiener process.[7] Let π denote the fixed and instantaneous flow of profits from the undeveloped land to the landowner at date 0 and all future points of time that the land remains undeveloped. Assume $V > \pi/\rho$ to ensure that the date 0 development value of the land exceeds its fixed financial use value.

3.2 Decision Variables for Landowner

The easement tax credit is an important component of the landowner's decision. The one-time (date 0) tax credit at rate τ compensates the landowner for "gifting" a portion of the current market value of the land to the agency.[8] The date 0 easement gift, $H(V, P) = V - \pi/\rho - P$, is the difference between the date 0 development value of the land, V, and the fixed non-developed use value of the land, π/ρ, minus the easement payment, P. Note that $H(V, P) < 0$ corresponds to a relatively large easement price, a portion of which is deemed taxable income. Accounting for the easement tax credit, a measure of well-being for a type s landowner who chooses to accept the easement can be expressed as

$$Z(V, s, P) = \frac{\pi + s}{\rho} + P + \tau(V - \pi/\rho - P) \tag{1}$$

The agency's offer price, P, depends on $Z(V, s, P)$ and also on $L(V, s)$, which is the landowner's date 0 opportunity cost of giving up the option to eventually sell the land to the developer. The value of the option to wait and develop the land at an optimal time in the future, $L(V, s) - V$, is derived using a standard real options framework. Following Dixit and Pindyck

[7]Standard models of real estate development such as Capozza and Sick [1994] make similar assumptions about real estate price uncertainty.

[8]Depending on the jurisdiction, the tax credit may depend on the landowner's taxable income (i.e., a tax deduction rather than a tax credit), be spread out over multiple years if the credit exceeds taxes owing and be transferable.

[1994], it is shown in Appendix A that the expected wealth of a landowner who rejects the easement offer is maximized if the land is developed when V rises to level $V^D(s)$ where

$$V^D(s) = \frac{\beta}{\beta - 1}\frac{\pi + s}{\rho} \tag{2}$$

Moreover, the option-inclusive value of the land at date 0 can be expressed as

$$L(V, s) = \left[1 - \left(\frac{V}{V^D(s)}\right)^\beta\right]\frac{\pi + s}{\rho} + \left(\frac{V}{V^D(s)}\right)^\beta V^D(s) \tag{3}$$

Appendix A shows that within equations (2) and (3) the expression for the β variable is given by[9]

$$\beta = \frac{1}{2} - \frac{\alpha}{\sigma^2} + \sqrt{\left(\frac{1}{2} - \frac{\alpha}{\sigma^2}\right)^2 + 2\frac{\rho}{\sigma^2}} \tag{4}$$

As noted above, the variables $Z(V, s, P)$ and $L(V, s)$ are date 0 measures of the well-being of a type s landowner with and without an easement, respectively. When formulating its easement offer the agency must anticipate that the landowner will accept its offer if $Z(V, s, P) \geq L(V, s)$ and reject it otherwise. Note that $Z(V, s, P) = (\pi + s)/\rho + P + \tau H(V, P)$ is an increasing function of both s and P, and $L(V, s)$ is an increasing function of s. Hence, the easement will be rejected (accepted) by a type s landowner if the agency's offer price is less (greater) than a predetermined critical value for P, which is defined implicitly by $Z(V, s, P) = L(V, s)$.

An inverse formulation of this problem is that a critical value of s serves as the agency's choice variable. With this more convenient formulation, the easement is rejected (accepted) if the landowner's actual s value is less (greater) than the agency's chosen s value, which is denoted $\hat{s}$. For the remainder of the analysis the variable s refers to a particular landowner's type whereas $\hat{s}$ refers to the type of the landowner who is indifferent between accepting and rejecting the agency's easement offer. With this specification the probability of easement acceptance can be expressed as $1 - G(\hat{s})$.

[9]Within equation (3) the variable $(V/V^D(s))^\beta$ is a stochastic discount factor because it discounts money received at the expected time of development back to date 0, and the variable $1 - (V/V^D(s))^\beta$ is a measure of the present value of a one dollar annuity from date 0 to the expected time of land development. These expressions are analogous to the no uncertainty case where the present value of one dollar received at time T is $e^{-\rho T}$ and the present value of a one dollar continuously compounded annuity between date 0 and date T is $(1 - e^{-\rho T})/\rho$.

Substituting the expressions for $Z(V, s, P)$ and $L(V, s)$ as given by equations (1) and (3) into the $Z(V, \hat{s}, P) = L(V, \hat{s})$ condition for the indifferent landowner gives rise to the following expression for the easement pricing function:

$$P(\hat{s}) = \frac{L(V, \hat{s}) - \tau V - (1-\tau)(\pi/\rho) - \hat{s}/\rho}{1-\tau} \tag{5}$$

Equations (3) and (5) together imply

$$\frac{dP(\hat{s})}{d\hat{s}} = -\frac{1}{\rho(1-\tau)} \left(\frac{V}{V^D(\hat{s})} \right)^{\beta} \tag{6}$$

Equations (5) and (6) are used in the next section to derive the market equilibrium conditions.

4 Interior Market Equilibrium with $\sigma = 0$

In this section a series of formal results are derived assuming a purchased easement and no development value uncertainty (i.e., $\sigma = 0$). The case of a donated easement and $\sigma > 0$ are examined later in the analysis. It is important to note that if the agency's easement offer is rejected, delaying development is typically still optimal for the landowner in the absence of uncertainty provided there is positive growth in V. Indeed, $\sigma = 0$ implies $\beta = \rho/\alpha$, which in turn implies $V^D = \frac{\rho}{\rho-\alpha} \frac{\pi+\hat{s}}{\rho}$.[10]

4.1 Optimal Pricing by the Agency

The agency's objective is to choose $\hat{s}$ to maximize $\Gamma(\hat{s})$, which is the discounted expected environmental benefits that flow from the undeveloped land and the external project:

$$\Gamma(\hat{s}) = (1 - G(\hat{s}))\left[\Omega + \lambda(B - F - P(\hat{s}))\right] + G(\hat{s})\lambda B + \int_{s^{min}}^{\hat{s}} W(V, s)_{\sigma=0} g(s) ds \tag{7}$$

Within equation (7) recall that $1 - G(\hat{s})$ is the probability the easement will be signed, Ω is the date 0 environmental stock value if the easement is signed, and $\lambda(B - F - P(\hat{s}))$ and λB are the environmental values of the external project with and without the easement, respectively. As

[10] According to Dixit and Pindyck [1994], β is the solution to the following second order differential equation: $0.5\sigma^2 F"(V)V^2 + \alpha F'(V)V - \rho F(V) = 0$ where $F(V) = AV^{\beta}$. With $\sigma = 0$ it follows that $\beta = \rho/\alpha$.

well, $W(V, s)_{\sigma=0}$ is the discounted expected environmental flow from the land between date 0 and when the land is developed. Specifically, (see Appendix B):

$$W(V, s)_{\sigma=0} = \left[1 - \left(\frac{V}{V^D(s)}\right)^{\frac{\beta(\rho-g)}{\rho}}\right] \phi\Omega \tag{8}$$

Using equation (6), the first-order condition for the agency's optimal choice of $\hat{s}$ can be rearranged and written as

$$P(\hat{s})) = \frac{1}{\lambda}\left(\Omega - W(V, \hat{s})\right) - F - \frac{\mu(\hat{s})}{\rho(1-\tau)}\left(\frac{V}{V^D(\hat{s})}\right)^{\beta} \tag{9}$$

Within equation (9) the variable $\mu(\hat{s})$ is substituted for $[1 - G(\hat{s})]/g(\hat{s})$ and the subscript $\sigma = 0$ has been dropped from $W(V, s)$ to make the notation more compact. It is shown in Appendix C that $\phi\omega < \lambda\pi/\beta$ is sufficient to ensure the second-order condition for the agency's maximization problem holds. The second order condition may fail to hold if ω is large and ϕ takes on a value close to 1 because in this case for all values of $\hat{s}$, when $\hat{s}$ is raise the benefit to the agency in the form of a lower easement payment to the landowner and longer temporary flow of environmental benefits should the easement be rejected more than offsets the costly lower probability of a successful easement outcome.

Equation (9), together with equation (5), implicitly define the equilibrium payment, $P(\hat{s}^*)$, and the critical value, $\hat{s}^*$, which defines the probability of a successful easement outcome, $1 - G(\hat{s}^*)$. The first term on the right side of equation (9) is the expected net increase in the environmental value of the land that results from the easement, $\Omega - W(V, \hat{s})$, adjusted by λ. This scaling factor shows that an agency with a tighter budget and thus higher λ will offer a lower price for the easement because funding the easement rather than the external environmental project has a higher opportunity cost. The last term on the right side of equation (9) is a measure of the amount the agency lowers its offer price because of its market power. The agency exploits its ability to make a now-or-never easement offer to maximize environmental surplus and the effect on pricing is equivalent to standard monopsony pricing (i.e., marginal outlay equal to marginal benefit). Equation (9) shows that the price discount is larger the less elastic is the landowner's demand for the easement. Indeed, $\mu(\hat{s})^{-1} \equiv g(\hat{s})/(1 - G(\hat{s}))$ is the hazard rate for the distribution of s, which is known to be proportional to the extensive margin demand elasticity.[11]

To conclude this section additional restrictions on the parameters of model are required. The first issue to consider is whether land preservation or land development is socially optimal. The initial assumption is that land preservation is socially optimal for all landowner types (this assumption is relaxed below when donated easements are considered). Assuming a type s landowner, permanent land preservation generates surplus for society equal to $\Omega + (\pi + s)/\rho$, and development generates surplus for society equal to $L(V, s) + W(V, s)$. The net gain from preservation, which is denoted $\Delta(s)$, can therefore be expressed as

$$\Delta(s) = \Omega + (\pi + s)/\rho - [L(V, s) + W(V, s)]. \tag{10}$$

Assume $\Delta(s) > 0$ for all landowner types. It is also natural to assume that $\Delta(s)$ is an increasing function of s because a higher non-market amenity value should correspond to higher social surplus with preservation versus development. A sufficient condition to ensure that equation (10) is increasing in s is $\frac{1}{\beta-1}\frac{\pi+s^{min}}{\omega} > \phi$.[12] The parameter restriction which ensures $\Delta(s) > 0$ for all $s \geq s^{min}$ is $\Omega > \frac{1}{\beta-1}\frac{\pi+s^{min}}{\rho}$. It is also useful to assume that $V < V^D(s)$ for all s since this ensures that in the event of easement rejection, some delay in the development decision is optimal. Using equation (2), delay is optimal for all landowner types if $V < \frac{\beta}{\beta-1}\frac{\pi+s^{min}}{\rho}$. This set of parameter restrictions can be combined with the previous $V > \pi/\rho$ and $\beta\phi < \lambda\pi/\rho$ restrictions to obtain the following:

Assumption 1. *(a)* $\frac{\pi}{\rho} < V < \frac{\beta}{\beta-1}\frac{\pi+s^{min}}{\rho} < \beta\Omega < \frac{\lambda\pi}{\phi\rho}$; *(b)* $\lambda < \frac{\beta}{\beta-1}\frac{\pi+s^{min}}{\pi}$

It is straight forward to show that the set of parameters which are consistent with Assumption 1 is relatively large.

[11]The fraction of landowner types which agree to accept the easement is $1 - G(\hat{s})$. If this term is interpreted as the Q variable then $dQ = -g(\hat{s})d\hat{s}$. Equation (6) shows that $dP = -\frac{1}{\rho(1-\tau)}\left(\frac{V}{V^D}\right)^\beta d\hat{s}$. Dividing these two expressions to eliminate $d\hat{s}$ allows the inverse elasticity expression to be written as $\frac{dP}{dQ}\frac{Q}{P} = \mu(\hat{s})\frac{P^{-1}}{\rho(1-\tau)}\left(\frac{V}{V^D}\right)^\beta$.

[12]After substituting in equation (8), the expression for $\Delta(s)$ in equation (10) can be rewritten as $\Delta(s) = (1 - \phi)\Omega - \left[V^D - \frac{\pi+s}{\rho} - \phi\Omega\right]\left(\frac{V}{V^D}\right)^\beta$. Substitute equation (2) for V^D and then simplify to obtain the parameter restriction.

4.2 Social Planner Pricing

To assess the efficiency properties of the market equilibrium it is necessary to derive the outcome with a social planner rather than the agency offering the easement contract. The social planner has no budget constraint but does have a marginal social opportunity cost, $\lambda^g > 1$, when using funds obtained from taxpayers to finance the easement. In contrast to the agency, the planner internalizes the welfare of the landowner as well as the environmental value of the land.[13] The planner does not use a tax credit and so the date 0 welfare of the landowner is equal to $(\pi + s)/\rho + P$ if the easement is accepted and $L(V, s)$ if the easement is rejected. It is natural to assume that $\lambda^g < \lambda$ because of the implicit assumption that the agency operates with a restrictive budget.

Ignoring the external project since it is irrelevant for easement pricing, the objective function for the planner can be expressed as

$$\Gamma^g(\hat{s}) = (1 - G(\hat{s}))\left[\Omega + \pi/\rho - (\lambda^g - 1)P(\hat{s}) - \lambda^g F\right] + \int_{\hat{s}}^{\infty} \frac{s}{\rho} g(s)ds \qquad (11)$$
$$+ \int_0^{\hat{s}} \left[W(V, s) + L(V, s)\right] g(s)ds$$

Similar to the case of the agency, the first order condition for the planner's optimal choice of $\hat{s}$ can be rearranged and written as

$$P(\hat{s})) = \frac{1}{\lambda^g}\left(\Omega - W(V, \hat{s})\right) - F - \left(\frac{\lambda^g - 1}{\lambda^g}\right)\frac{\mu(\hat{s})}{\rho}\left(\frac{V}{V^D(\hat{s})}\right)^{\beta} \qquad (12)$$

A comparison of equations (9) and (12) reveal that apart from the assumed differences in the values for λ and λ^g, and no tax credit for the agency, the only structural difference between the first order conditions for the planner and the agency is that the last term is multiplied by $(\lambda^g - 1)/\lambda^g$ for the planner whereas there is no analogous adjustment for the agency. This difference is expected given the theory of Ramsey−Boiteux pricing in the public finance literature [Laffont and Tirole, 2000].

The first formal result can now be established (see Appendix D for the proofs of Result 1 and the subsequent formal results):

[13]The welfare of the land developer is zero due to competitive bidding and can thus be ignored when calculating social welfare.

Result 1. *Assume the parameters satisfy Assumption 1 and ensure a positive equilibrium easement price with* $\tau = 0$. *Given Assumption 1 the probability of an easement outcome with an agency decision maker is inefficiently low. Formally,* $\hat{s}^* > \hat{s}^{**}$, *which implies* $1 - G(\hat{s}^*) < 1 - G(\hat{s}^{**})$.

The under-investment outcome that is implied by Result 1 emerges first because the agency's opportunity cost of investing in the easement is higher than that of the planner (i.e., $\lambda > \lambda^g$) and second because the agency fails to account for the welfare of the landowner when formulating its easement offer. Similar to a standard monopsonist, the agency prices where its budget-adjusted marginal outlay is equal to the expected net marginal environmental benefit, whereas the planner prices competitively subject to a positive social cost of using taxpayer funds.

4.3 Analysis of Easement Tax Credit

Given Result 1, the easement tax credit is expected to implicitly subsidize the landowner's opportunity cost of holding an easement, and in doing so raise the probability of an easement outcome. The marginal effectiveness of the tax credit is directly related to the size of the easement gift and thus it is necessary to examine the determinants of the gift size in order to assess tax credit effectiveness. If there was no tax credit and the agency knew the landowner was type $s = 0$ with certainty then it would offer $P = L(V, s) - \pi/\rho$ because this would ensure the landowner is indifferent between accepting and rejecting the offer. In this particular case the easement gift would take on a negative value because $H(V, P(s)) = V - \pi/\rho - [L(V, s) - \pi/\rho] = -[L(V, s) - V] < 0$. In contrast, if the agency knew that $S > 0$ and V is such that development would be immediate if the easement is rejected, then $L(V, s) = V$ and the agency would offer $P = V - (\pi + s)/\rho$. In this case the easement gift would take on a positive value because $H(V, P(s)) = V - \pi/\rho - [V - (\pi + s)/\rho] = s/\rho > 0$. In the general case with incomplete information, there are two offsetting forces that determine the size of the easement gift. A larger value for $\hat{s}^*$ implies a larger easement gift because the payment from the agency to the landowner is reduced but this reduction is not recognized by the taxing authority when determining the size of the easement gift. In contrast, a larger real option as measured by $L(V, \hat{s}^*) - V$ implies a smaller easement gift because the payment from the agency to the landowner is increased but this increases is also not recognized by the taxing authority.

The ambiguous sign the easement gift can be established for the more general case by substituting into $H(V, P(\hat{s})) = V - \pi/\rho - P(\hat{s})$ the agency's first-order condition as given by equation (9) and the $\Delta(\hat{s})$ net welfare function as given by equation (10):

$$\begin{aligned} H(V, P(\hat{s})) = &\frac{\hat{s}}{\rho} - [L(V, \hat{s}) - V] - \Delta(\hat{s}) + F + \frac{\mu(\hat{s})}{\rho(1-\tau)} \left(\frac{V}{V^D}\right)^{\beta} \\ &+ \left(\frac{\lambda - 1}{\lambda}\right)(\Omega - W(V, \hat{s})) \end{aligned} \tag{13}$$

The first two terms on the right side of equation (13) once again highlight the importance of the non-market amenity valuation, $\hat{s}$, and the real option, $L(V, \hat{s}) - V$ when assessing the sign and size of the easement gift. The following numerical example provides additional context. Assume s is drawn from an exponential distribution to ensure a fixed inverse hazard rate, μ. Also assume $s^{min} = 0.25$, $\alpha = 0.0333$ ($\beta = 3$), $\pi = 1$, $\rho = 0.1$, $g = 0$, $V = 11$, $\lambda = 1.5$, $\tau = 0$, $\mu = 8$, $\phi = 0.1$ and $F = 0$. These parameter values satisfy the restrictions implied by Assumption 1 above. With a comparatively low environmental value for the land, $\Omega = 15$, the easement price is $P = 0.809$, the marginal landowner has type $\hat{s}^* = 0.561$, and the easement gift, $H(V, P(s)) = 0.191$, takes on a positive value. However, if the environmental value of the land is raised to $\Omega = 30$ then the agency raises its price to $P = 0.809$, the marginal landowner type decreases to $\hat{s}^* = 0.226$ and the easement gift, $H(V, P(s)) = -0.312$, takes on a negative value.

The above example shows that the easement gift is smaller and possibly negative for more environmentally valuable land. To establish this result more formally, it can be seen from the easement gift function, $H(V, P(\hat{s})) = V - \pi/\rho - P(\hat{s})$, and the equation (5) pricing function that Ω affects $H(V, P(\hat{s}))$ only through its effect on $\hat{s}^*$. To examine this impact totally differentiate equation (9) with respect to $\hat{s}$ and Ω and then solve for $d\hat{s}/d\Omega$ evaluated at $\hat{s} = \hat{s}^*$:

$$\frac{d\hat{s}}{d\Omega} = -\frac{1}{\lambda} \frac{1 - \phi\left[1 - \left(\frac{V}{V^D(\hat{s}^*}\right)^{\frac{\beta(\rho - g)}{\rho}}\right]}{-SOC} \tag{14}$$

Equation (14) takes on a negative value because the variable SOC represents the second-order condition for the agency's maximization problem, which is necessarily negative (see Appendix C). A higher environmental value for the land thus results in a lower value for $\hat{s}^*$, which in turn causes a higher value for $P(\hat{s}^*)$. This higher easement price necessarily reduces the size of the easement gift.

The effectiveness of the easement tax credit as an instrument for reducing failure in the easement market can now be examined. The results to follow implicitly assume that τ is at a level for which the probability of an easement outcome is inefficiently low (i.e., $\hat{s}^* > \hat{s}^{**}$). By virtue of Result 1 this scenario must exist for τ sufficiently close to zero. It is easy to envision a situation where the value of τ is inefficiently high, in which case social welfare will worsen with an increase in τ that further reduces $\hat{s}^*$ below $\hat{s}^{**}$. An second obvious result is that due to lack of targeting the value of τ may be inefficiently low for some landowner types and inefficiently high for other landowner types. These obvious results are not featured in the analysis below.

Given the $\hat{s}^* > \hat{s}^{**}$ assumption it follows that a negative sign for $d\hat{s}^*/d\tau$ implies an efficient policy instrument and a positive sign implies an inefficient policy instrument. Efficiency at the margin can be formally examined by totally differentiating equation (9) with respect to $\hat{s}$ and τ and then solving for $d\hat{s}/d\tau$ evaluated at $\hat{s} = \hat{s}^*$. After substituting in equation (6) and the expression for the easement gift, $H(V, P(\hat{s})) = V - \pi/\rho - P(\hat{s})$, the differential can be written as

$$\frac{d\hat{s}}{d\tau} = \frac{-H(V, P(\hat{s}^*)) + \frac{\mu(\hat{s}^*)}{\rho(1-\tau)} \left(\frac{V}{V^D(\hat{s}^*)} \right)^{\beta}}{-(1-\tau)SOC} \tag{15}$$

The following result follows from equation (15).

Result 2. *A marginal increase in the easement tax credit rate, τ, efficiently raises the probability of an easement outcome as measured by $1 - G(\hat{s}^*)$ if and only if the equilibrium easement gift, $H(V, P(\hat{s}^*))$, is sufficiently positive. The impact of higher τ on $1 - G(\hat{s}^*)$ is small and possibly negative if the environmental value of the land as measured by Ω is sufficiently high.*

The first part of Result 2 is expected because as noted above a tax credit has the properties of an implicit easement subsidy. The second part is more important because it shows that tax credit effectiveness is lowest for the most environmentally sensitive land. Even worse, it is possible that raising the tax credit may worsen rather than improve social welfare if the land's environmental value is sufficiently high. The fact that tax credit effectiveness is low when the easement gift is low is not surprising because the size of the tax credit payment is proportional to the size of the easement gift. The negative relationship between the size of the easement gift and the environmental value of the land is a central feature of Result 2.

The result that a marginally higher tax credit can move the equilibrium away from the planner's outcome rather than toward it can be attributed to tax credit crowding out of agency payments. A higher easement tax credit crowds out the agency's payment first because the tax credit payment is higher per dollar of easement gift and second the smaller payment that results from the crowding out raises the size of the landowner's gift and hence the value of the tax credit. In fact, the unexpected positive sign for $d\hat{s}/d\tau$ that is featured in Result 2 is a direct result of crowding out in excess of 100 percent. This latter result is less obvious and thus deserves a more detailed examination.

To formally examine crowding out let $N(\hat{s}^*, \tau) = P(\hat{s}^*) + \tau(V - \pi/\rho - P(\hat{s}^*))$ denote combined landowner receipts from the agency and the taxing authority. Of interest is the comparative static result, $dN/d\tau$, since the sign of this expression identifies if crowding out is less than or greater than 100 percent. Specifically, $dN/d\tau > 0$ implies less than 100 percent crowding out because in this case the increase in taxpayer expenditures more than offsets the decrease in the easement price offered by the agency. The opposite is true for $dN/d\tau < 0$.

Result 3. *An efficient (inefficient) marginal tax credit implies less (more) than 100 percent crowding out. Formally,* $d\hat{s}^*/d\tau < 0 \Leftrightarrow dN/\tau > 0$ *and* $d\hat{s}^*/d\tau > 0 \Leftrightarrow dN/\tau < 0$.

Results 2 and 3 together imply that tax credit effectiveness may be limited both because the associated easement gift is small and the crowding out of the agency payment is high. Unfortunately both of these effects are most prominent for land that has the highest environmental value. Excess crowding out is necessarily strategic on the part of the agency because this could not occur if there was straight pass-through of the subsidy (i.e., a competitive market outcome). Presumably the higher tax credit rate makes the landowner's demand for the easement less elastic, and this reduction in the elasticity induces the agency to reduce its offer price by a relatively large amount.

5 Development Value Uncertainty and Donated Easements

The purpose of this section is to relax two key assumptions from the previous section: (1) the parameters ensure a positive equilibrium price for the easement; and (2) there is no development value uncertainty. The alternative to a positive easement price is a $P = 0$ corner solution, which is equivalent to a donated easement. Analyzing donated easements is of particular importance because the majority of real world easements are donated, especially when the land trust is regional with a local community focus. These two topics are now formally examined in reverse order.

5.1 Development Value Uncertainty

In the previous section the $\sigma = 0$ assumption was important because it facilitated closed form solutions. The analysis in this section primarily relies on numerical simulations to illustrate key theoretical linkages for the case of positive development value uncertainty (i.e., $\sigma > 0$). Before presenting the simulation results it is useful to highlight the intuition as to how development value uncertainty affects tax credit effectiveness.

Higher uncertainty affects the real option of the landowner's development decision. Specifically, higher uncertainty will increase the expected time to development because similar to a standard investment scenario (e.g., Dixit and Pindyck [1994]) the value of waiting is higher in an uncertain environment with an irreversible decision. Under a wide range of parameter values higher uncertainty will also increase the option-inclusive value of the land, $L(V, s)$. The combination of these two impacts imply a lower value of the easement gift due to a higher price of the easement, and less crowding out of the agency payment by the easement tax credit. The smaller gift size makes the tax credit less effective but the reduced crowding out makes the tax credit more effective. Consequently, the net impact of higher uncertainty on tax credit effectiveness is ambiguous.

To place more structure on these arguments equations (2) and (4) can be used to show that a higher value for σ raises the value of the development threshold $V^D(\hat{s}^*)$ relative to V. This change necessarily implies a longer expected time to development should the easement be rejected by the landowner. Similarly, it is straight forward to show that for a fixed value of s the stochastic discount factor, $\left(\frac{V}{V^D(\hat{s})}\right)^\beta$, is a decreasing function of σ. In the expression for $L(V, \hat{s})$ that is given by equation (3), notice that a smaller stochastic discount factor implies more weight on the pre-development flow, $(\pi + \hat{s}^*)/\rho$, and less weight on the post-development stock value, V^D. The combination of less weight on V^D and a higher value for V^D implies that the effect of more uncertainty on $L(V, \hat{s})$ is theoretically ambiguous. Nevertheless, under a wide range of feasible parameters the latter effect dominates and thus $L(V, \hat{s})$ increases with higher values for σ.

There are two pathways that a longer expected time to development and a higher value for $L(V, \hat{s})$ impacts the easement price. A longer time to development implies a longer flow of temporary environment benefits as measured by $W(V, \hat{s})$. A higher value for $L(V, \hat{s})$ implies a higher opportunity cost for the landowner who contemplates signing the easement. The $W(V, \hat{s})$ pathway puts downward pressure on $P(\hat{s}^*)$ and the $L(V, \hat{s})$ pathway puts upward pressure on $P(\hat{s}^*)$. The parameter restrictions implied by Assumption 1 ensure the latter effect dominates the former and thus higher σ results in a higher value for $P(\hat{s}^*)$. As discussed above, a higher value for $P(\hat{s}^*)$ reduces the size of the easement gift, $H(V, P(\hat{s}^*))$, which in turn reduces tax credit effectiveness.

Recall that the numerator of equation (15) decomposes the impact on $\hat{s}^*$ from a marginal increase in τ into an easement gift component (first term) and a crowding out component (second term). As noted, the easement gift is smaller with higher uncertainty and this results in a smaller absolute value for $d\hat{s}^*/d\tau$. However, the crowding out component, which is proportional to the stochastic discount factor $\left(\frac{V}{V^D(\hat{s})}\right)^\beta$, becomes smaller with higher values for σ and this reduction serves to increase the absolute value of $d\hat{s}^*/d\tau$. It is for this reason that higher development value uncertainty has an ambiguous impact on tax credit effectiveness. It should be noted that crowding out is closely related to the elasticity of the landowner's demand for the easement. The last term in equation (9), which is also proportional to the stochastic discount factor, shows the extent that the agency reduces its easement offer price because of its bargaining power. A longer expected time to development that results from higher σ implies a more elastic demand for the easement by the landowner and thus both less aggressive price discounting and a smaller price decrease by the agency in response to an increase in τ.

To illustrate these linkages numerically it is necessary to have an expression for $W(V, \hat{s})$, which requires modeling the distribution of the stochastic development time, T. The modeling details and the actual expression for $W(V, \hat{s})$ can be found in Appendix B. To proceed with the numerical analysis once again assume that s is selected from an exponential distribution with a fixed inverse hazard rate μ. Consistent with Assumption 1, assume: $s^{min} = 0.25$, $\alpha = 0.04$, $\pi = 1$, $\rho = 0.1$, $g = 0$, $V = 20$, $\lambda = 1.2$, $\lambda^g = 1.1$, $\mu = 1$, $\phi = 0.2$, $F = 3$ and $\Omega = 16$.

Panel A of Table 1 shows for the case of $\tau = 0$ the equilibrium values for the non-market amenity flow, $\hat{s}^*$, the option-inclusive value of the land, $L(V, \hat{s}^*)$, the expected temporary flow of environmental benefits, $W(V, \hat{s}^*)$, the easement price, $P(\hat{s}^*)$ and the easement gift, $H(V, \hat{P}(s^*))$, for alternative values of σ. Notice that the values for $\hat{s}^*$, $L(V, \hat{s}^*)$ and $W(V, \hat{s}^*)$ are all increasing functions of σ. The increasing values of $\hat{s}^*$ implies a declining value for $1-G(\hat{s}^*)$ and thus a decreasing probability of an easement outcome. Because $L(V, \hat{s}^*)$ increases faster than $W(V, \hat{s}^*)$ the equilibrium easement price (fifth column) also increases and this necessarily causes the easement gift (last column) to decrease in value with higher uncertainty.

Panel B of Table 1 shows the impact of a $\tau = 0.1$ tax credit on $\hat{s}^*$ and $1 - G(\hat{s}^*)$ for alternative values of σ. The desired reduction in $\hat{s}^*$ that results from the tax credit is larger with higher uncertainty (third column). Similarly, the desired increase in $1 - G(\hat{s}^*)$ that results from the tax credit is larger with higher uncertainty (last column). Consequently, it must be the case that the positive crowding out linkage between σ and tax credit effectiveness is more than offsetting the negative easement gift linkage. In this particular example, the tax credit is more effective with higher uncertainty primarily because the less elastic demand for the easement allows for a more competitive pass through of the tax credit to the landowner.

Panel A: $\tau = 0$

σ	$\hat{s}^*$	$L(V, \hat{s}^*)$	$W(V, \hat{s}^*)$	$P(\hat{s}^*)$	$H(V, P)$
0.025	0.721	21.92	1.925	4.706	5.294
0.05	0.730	22.11	1.971	4.810	5.190
0.075	0.745	22.41	2.037	4.962	5.038
0.10	0.769	22.83	2.116	5.143	4.857
0.125	0.802	23.36	2.200	5.336	4.664
0.15	0.846	23.99	2.285	5.533	4.467
0.175	0.902	24.75	2.369	5.728	4.272
0.20	0.971	25.63	2.451	5.916	4.084

Panel B: $\tau = 0$ versus $\tau = 0.1$

σ	$\hat{s}^*_{\tau=0}$	$\hat{s}^*_{\tau=0.1}$	$\Delta\hat{s}^*$	$1 - G(\hat{s}^*_{\tau=0})$	$1 - G(\hat{s}^*_{\tau=0.1})$	$\Delta[1 - G(\hat{s}^*)]$
0.025	0.721	0.706	-0.015	0.486	0.493	0.007
0.05	0.730	0.713	-0.016	0.482	0.490	0.008
0.075	0.745	0.727	-0.018	0.475	0.483	0.009
0.10	0.769	0.748	-0.021	0.464	0.473	0.010
0.125	0.802	0.777	-0.025	0.448	0.460	0.011
0.15	0.846	0.816	-0.029	0.429	0.442	0.013
0.175	0.902	0.867	-0.035	0.406	0.420	0.014
0.20	0.971	0.930	-0.042	0.379	0.395	0.016

Table 1: Simulated Outcomes for Different Levels of Development Value Uncertainty, σ

5.2 Donated Easements

As discussed in the Introduction, the majority of U.S. conservation easements are donated by landowners. What is not clear from casual observation is whether a donated easement has positive or negative social value. If the land has high environmental value and the agency has zero budget to pay for the easement then it is quite likely that a donated easement has positive social value. In contrast, if the land has low environmental value and an agency with a positive budget is therefore choosing to offer $P = 0$, then it is quite likely that a donated easement has negative social value. The analysis in this section proceeds by analyzing tax credit effectiveness for these two extreme types of donated easements. Donated easements which lie between these two extremes are likely to be characterized by both sets of results.

First consider the case where lack of budget by the agency is the reason for the donated easement. Given Assumption 1, provided that the fixed cost of managing the easement, F, is not excessively large then it must be the case that the protection of undeveloped land through use of a donated easement has positive social value. Equation (9) shows that this type of donation outcome will emerge if the agency's budget constraint parameter, λ, is sufficiently large. The following result formalizes the effectiveness and efficiency of the easement tax credit in this specific scenario.

Result 4. *If an agency's budget is sufficiently restrictive then an easement with positive social value, $\Delta(\hat{s}^*) > 0$, will be donated, $P(\hat{s}^*) = 0$, with probability $1 - G(\hat{s}^*)$. In this case a marginal increase in the easement tax rate, τ, increases $1 - G(\hat{s}^*)$ by a larger amount as compared to the case where the easement is purchased at a marginally positive price.*

Result 4 is important but rather obvious. If the agency is offering a zero price for the easement (i.e., is soliciting donations) then a marginal increase in the easement tax rate transfers the full benefit of the tax credit increase to the landowner because the agency is not able to respond by decreasing its offer price. In other words, with a corner solution there is no crowding out and as such a dollar of tax credit raises the probability of an easement outcome by a relatively large amount. If real world easements are typically donated because conservation agencies have highly restricted budgets then Result 4 is a strong argument in favour of using an easement tax credit as a public policy instrument.

Next consider the more controversial case where donated easements are not desirable from society's perspective. Instead of assuming that an easement is donated because of lack of budget for the agency assume instead that a corner solution emerges because the agency has zero willingness to pay due to a sufficiently low environmental value of the land. Let Ω^c denote the critical value of Ω that generates the corner solution. Specifically, for $\Omega \leq \Omega^c$ the corner solution binds and the agency's offer price is zero. This threshold value can be defined by simultaneously choosing $\hat{s}$ and Ω such that equation (9) is satisfied and equation (5) is equal to zero. The resulting expressions can be rewritten as follows:

$$\hat{s}^c/\rho = \left[(\beta-1)\tau(V-\pi/\rho)\left(\frac{\beta-1}{\beta}V\right)^{-\beta}\right]^{\frac{-1}{\beta-1}} - \pi/\rho \tag{16}$$

and

$$\Omega^c = \mu(\hat{s}^c)\frac{\lambda}{\rho(1-\tau)}\left(\frac{V}{V^D(\hat{s}^c)}\right)^{\beta} + W(V,\hat{s}^c) + \lambda F \tag{17}$$

Noting that a landowner will donate the easement only if $s \geq s^c$ it follows from equation (16) that a positive value for τ is required for the existence of a donated easement. Moreover, a larger value for τ implies that a greater range of landowner types will choose to donate. Whether or not the agency will accept the donated easement depends on the specific value of Ω. The agency will certainly accept the easement if $\Omega = \Omega^c$ because by construction Ω^c satisfies the agency's condition for optimization. At the opposite extreme, the agency would not accept a donated easement if $\Omega = 0$ because doing so would result in negative environmental surplus after accounting for the fixed cost of holding the easement, as measured by F. This means there must exist a value for Ω, call it Ω^*, such that for $\Omega < \Omega^*$ the agency will refuse to hold a donated easement and for $\Omega^* \leq \Omega < \Omega^c$ the agency will agree to hold a donated easement.

To obtain an expression for Ω^* note that the agency must account for the temporary environmental flow that will result if the donation is not accepted. Let $E\{W(V,s)\} = \int_{s^c}^{\infty} W(V,s)g(s)ds$ denote the expected value of this temporary flow. The agency will accept a donated easement only if $\Omega - E_s\{W(V,s)\} \geq F$. Consequently, the desired expression is $\Omega^* = E_s\{W(V,s)\} + F$.

Suppose $\Omega \in (\Omega^*, \Omega^c)$ and a type $s^0 > \hat{s}^c$ landowner agrees to donate her easement after being offered $P = 0$ by the agency. Does this easement outcome decrease social welfare? The answer is yes if $\Omega - E_s\{W(V,s)\} - F + \frac{\pi+s^0}{\rho} < L(V,s^0)$. Substituting in $\Omega^* = E_s\{W(V,s)\} + F$ allows this inequality to be rewritten as $\Omega - \Omega^* < L(V,s^0) - (\pi + s^0)/\rho$. After substituting equation (3) for $L(V,s^0)$, this restriction can rewritten again as $\Omega^* < \Omega < \Omega^{**}$ where

$$\Omega^{**} = \Omega^* + \frac{1}{\beta - 1}\frac{\pi + s^0}{\rho}\left(\frac{V}{V^D(s^0)}\right)^{\beta} \tag{18}$$

The following result can now be established.

Result 5. *The equilibrium outcome involves a donated easement that lowers social welfare if* Ω *is selected from a range with lower bound* Ω^* *and upper bound* $min\{\Omega^{**}, \Omega^c\}$.

Result 5 highlights a second important externality that can distort the outcome in the easement market. The obvious externality, which was central to the above results, is that the landowner fails to account for the land's environmental value when deciding when to develop the land. The less obvious externality is that the conservation agency fails to account for the land's development value when deciding whether or not to accept a donated easement. Suppose a plot of land has low environmental value but high non-market amenity value for the landowner. Also suppose the easement tax credit is reasonably generous Because of the low environmental value the agency is not willing to pay for the easement, and because of the high non-market amenity value and generous easement tax credit the landowner is willing to donate the easement to the agency. The agency will accept the easement provided that the net environmental value covers the management cost, F. If the development value of the land is relatively high or if the expected time to development is relatively long then the donation of the easement will lower social welfare.

In this current context, what are the welfare implications of a higher easement tax credit rate, τ? Result 4 showed that raising τ has a comparatively large impact on the probability of an easement outcome when in a $P(\hat{s}^*) = 0$ corner solution. The situation is the same for Result 5. But in this case the large impact is inefficient because the donation of an easement decreases rather than increases social welfare. In other words, when the tax credit is raised the lack of crowding out is desirable from a public policy perspective if the donated easement is in society's best interest and the probability of a donation is sub-optimally low. In contrast, the lack of crowding out is not desirable from a public policy perspective if the donation of the easement is not in society's best interest.

6 Conclusions

A conservation easement tax credit has considerable appeal as an instrument for preserving farmland, forest land and other land that is rich in biodiversity. Budget-constrained conservation agencies are only partially effective at protecting land and so it is natural to consider subsidies in the form of tax credits. Over the past two decades, major U.S. conservation agencies such as the Nature Conservancy have been successful at convincing the federal and various state governments to expand tax credit coverage. Landowner response has been rapid, and it is only recently that policy makers have begun questioning in a meaningful way whether this rapid response belongs in the "intended" or "unintended" category. The literature on conservation easements and their associated tax credits is mostly found in law journals and as such lacks economic rigour. This paper appears to be the first to model in a comprehensive economics framework an easement tax credit program and the conditions which lead to socially desirable and undesirable outcomes.

Two important results emerge from this analysis. First, the size of the easement gift is smallest and thus the effectiveness of the tax credit program is lowest for land that has the highest environmental value. This relationship is unfortunate because policy makers would undoubtedly prefer a positive correlation between program effectiveness and the land's environmental value. Second, socially undesirable land may by drawn into the easement market via a donation because the conservation agency fails to internalize the land's development value. This scenario is most likely to be relevant when a landowner has high private valuation of the land's non-market amenities because in this case she values the tax credit high relative to the developer's offer. The potential for this new type of market failure to reduce welfare is important to consider because as previously noted the majority of easements are donated rather than sold.

A secondary result is that market power by the agency distorts tax credit pass-through to the landowner (i.e., crowding out) in a way that reduces tax credit effectiveness. If the land's environmental value is large enough to give rise to a negative easement gift then the crowding out distortion is so severe that the raising the tax credit rate will decrease rather than increase the probability of an easement outcome. This result represents an extreme because the conservation agency is assumed to have all of the bargaining power (i.e., is able to make a take-it-or-leave-it offer). In a more realistic setting where the agency and landowner bargain over the easement price, the previous crowding out result is expected to weaken, possibly to the extent that it is no longer possible for an increase in the tax credit to push the market outcome away from the welfare maximizing outcome rather toward it.

The impact of the landowner's real option for land development gives rise to a set of interesting secondary results. Perhaps most importantly, easements are more expensive to purchase and thus the likelihood of an easement outcome is lower when there is higher development value uncertainty. This occurs because uncertainty raises the opportunity cost of the landowner signing the easement. Higher development value uncertainty also results in a longer expected time to development, and this extra delay works in the agency's favour because the environmental benefits that temporarily flow between the date the easement is rejected and the date when the land is developed is lengthened. These real option results are considered secondary rather than primary because they depend on a two rather strong assumptions which underlie the model. The first assumption is that the timing of the agency's easement offer is fixed exogenously at date 0 rather than emerging endogenously at a time that maximizes joint surplus for the agency and the landowner. The second assumption is that there is no uncertainty in the land's future environmental value. If these two assumptions are relaxed then the landowner would face a stochastic easement offer price from the agency as well as a stochastic offer price from the developer. While this scenario is both realistic and important, modeling this type of scenario would be complex and quite likely require extensive numerical analysis because the landowner would face a two-dimensional, inter-related real option problem.

The realism of the assumption that the easement decision is fully irreversible is open to debate. From a legal perspective, an easement contract is perpetual and not designed to be reversed. Moreover, there is little evidence that reversals are actually taking place. Nevertheless, it is reasonable to assume that in a priority situation a reversal of the easement will occur. It is easy to imagine a scenario where a piece of land that is protected by an easement becomes very valuable in a development context. Promising to obtain the development rights from neighboring land in exchange for eliminating the easement requirements for the land in question, and further promising to repay the original easement tax credit, is a scenario that might be agreeable to the various parties and will potentially raise overall market welfare when implemented. The problem is that if a precedent for this type of activity became established then the expectations of a perpetual agreement will be distorted and the effectiveness of the tax credit program will be weakened. This topic should be considered in future research.

In summary, critics of easements tax credits are well justified in worrying about how social benefits compare with social costs. The tax credit program has strong potential to reduce the premature development externality but there are a number of complexities and unintended consequences that must be considered when assessing the overall desirability of this program. Improved landowner targeting and requiring eased land to have a minimum level of environmental value would go a long way toward improving program effectiveness. It is important to note that this analysis focused exclusively on direct financial costs. The fact that there is no or little coordination regarding which land is protected by an easement results in a patchwork of developed land, and this will necessarily raise the cost of development. The cost of utilizing second best development options when first best options are not available is likely to be sizeable and will continue to grow in importance as more and more easements are enacted. Certainly this topic is in need of both additional theoretical analysis and rigorous empirical analysis.

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Appendix

A Real Option Equations

Following Dixit and Pindyck [1994], begin by constructing a Bellman equation for the following dynamic programming problem:

$$L(V,s) = \max\left\{V, \pi + s + (1+\rho dt)^{-1}\, E\left[L(V+dV,s)|V\right]\right\}$$

Notice that the value function is the maximum of the land's immediate development value, V, and expected deferred development value, which includes the instantaneous profit and non-market amenity flow that accrues to the landowner. The solution to the corresponding differential equation has the general form $L(V,s) = AV^{\beta} + (\pi + s)/\rho$ for $V < V^D(s)$ where the expression for β is given by equation (4)

Simultaneously solving the value matching condition, $AV^{\beta}+(\pi+s)/\rho = V$, and the smooth pasting condition, $d(AV^{\beta})/dV = 1$, for A and V, gives $A^D(s)$ and $V^D(s)$, respectively. The expression for $V^D(s)$ is reported as equation (2) and $A^D = \frac{1}{\beta}\left(\frac{\beta}{\beta-1}\frac{\pi+s}{\rho}\right)^{-(\beta-1)}$. Substituting the expression for A^D into $L(V,s) = AV^{\beta} + (\pi+s)/\rho$ gives equation (3).

B Temporary Environmental Flow

This section is used to derive an expression for $W(V,s)$, which for the case of a rejected easement is a measure of the expected present value of the environmental flow from date 0 until when the land is developed. Note that the environmental flow begins at rate $\phi\omega$ at date 0 and grows continuously at rate g until the time of land development. If the land is never expected to be developed then $W(V,s) = \phi\Omega$ where $\Omega = \omega/(\rho - g)$. Let $\tilde{W}(\tilde{t}) = \phi\int_0^{\tilde{t}} \omega e^{-(\rho-g)t}dt = \phi\Omega[1 - e^{-(\rho-g)\tilde{t}}]$ denote the present value of the environmental flow for a particular development time outcome, $\tilde{t}$. As well, let $f(\tilde{W}; V, s)$ denote the probability density that governs $\tilde{W}$, acknowledging that $\tilde{t} = \inf(t : V = V^D)$ is defined as the first time that $\tilde{V}$ rises up to level $V^D(s)$. It follows that $W(V,s) = \int_0^{\phi\Omega} \tilde{W} f(\tilde{W}; V, s) d\tilde{W}$. To derive the expression for $f(\tilde{W};V,s)$ invert $\tilde{W}(\tilde{t}) = \phi\Omega[1 - e^{-(\rho-g)\tilde{t}}]$ and use the resulting expression to show the probability that $W \leq \tilde{W}$ is equal to the probability that $\tilde{t} \leq -\frac{1}{\rho-g}ln\left(1-\frac{\tilde{W}}{\phi\Omega}\right)$. Thus, $F(W;V,s) = \Psi(-\frac{1}{\rho-g}ln(1-\frac{W}{\phi\Omega});V,V^D)$ where $\Psi(\tilde{t};V,V^D)$ is the cumulative probability function for $\tilde{t}$. Using equation (15) from Grenadier [1996], an expression for $\Psi(\tilde{t};V,V^D)$ can be written as

$$\Psi(\tilde{t};V,V^D) = \Phi\left(\frac{ln(V/V^D)+(\mu-0.5\sigma^2)t}{\sigma t^{0.5}}\right) + \left(\frac{V}{V^D}\right)^{\frac{-2(\mu-0.5\sigma^2)}{\sigma^2}}\Phi\left(\frac{ln(V/V^D)-(\mu-0.5\sigma^2)t}{\sigma t^{0.5}}\right)$$

Within this expression, $\Phi()$ is the cumulative probability function for a normal random variable. The desired expression for $f(W;V,s)$, accounting for the fact that all of the probability mass is centered on $W=0$ when $V \geq V^D(s)$, can now be expressed as

$$f(W;V,s) = \begin{cases} 0 & if \quad V \geq V^D(s) \\ dF(W;V,s)/dW & if \quad V < V^D(s) \end{cases}$$

The next step is to derive an expression for $W(V,s)_{\sigma=0}$, which is relevant for the case of zero development value uncertainty. The derivations in note 10 imply $\beta = \rho/\alpha$ when $\sigma = 0$. If T^* denotes the amount of time it takes V to reach V^D it can be shown that $\left(\frac{V}{V^D}\right)^\beta = e^{-\rho T^*}$.[14] The expression for $\tilde{W}(\tilde{t})$ that was derived above is the desired expression for $W(V,s)_{\sigma=0}$ after substituting the expression for T^* for $\tilde{t}$. If $e^{-\rho T^*} = \left(\frac{V}{V^D}\right)^\beta$ is substituted into $\tilde{W}(\tilde{t}) = \phi\Omega[1 - e^{-(\rho-g)\tilde{t}}]$ and β substituted for ρ/α the resulting expression for $W(V,s)_{\sigma=0}$ is given by equation (8) in the text.

C Second-Order Condition

To derive the second-order condition for the agency's maximization problem it is useful to first substitute the expression for $dP/d\hat{s}$ that is given by equation (6) into the agency's first-order

[14]Substituting $\beta = \rho/\alpha$ into equation (2) gives $V^D(s) = (\pi+\hat{s})/(\rho-\alpha)$. Thus T^* is the solution to $Ve^{\alpha T} = \frac{\pi+\hat{s}}{\rho-\alpha}$. Rearrange this expression to obtain $e^{-\rho T^*} = \left[\frac{(\rho-\alpha)V}{\pi+\hat{s}}\right]^{\rho/\alpha}$. It is straight forward to show that the right side of this expression is equal to $\left(\frac{V}{V^D}\right)^\beta$.

condition, which is given by equation (9). The second order condition (SOC) can now be written as

$$SOC \equiv \frac{dP(\hat{s})}{d\hat{s}} + \frac{1}{\lambda}\frac{dW(V,\hat{s})}{d\hat{s}} - \mu(\hat{s})\frac{d^2P(\hat{s})}{d\hat{s}^2} - \frac{dP(\hat{s})}{d\hat{s}}\frac{d\mu(\hat{s})}{d\hat{s}} < 0 \tag{C.1}$$

Within equation (C.1) note that the decreasing function $\mu(\hat{s})$ replaces the inverse hazard rate function $[1 - G(\hat{s})]/g(\hat{s})$. Knowing from equation (6) that $dP(\hat{s})/d\hat{s}$ takes on a negative value and $d^2P(\hat{s})/d\hat{s}^2$ takes on a positive value, it follows from equation (C.1) that the second-order condition holds if $\frac{dP(\hat{s})}{d\hat{s}} + \frac{1}{\lambda}\frac{dW(V,\hat{s})}{d\hat{s}} < 0$. Equation (8) shows that $\frac{1}{\lambda}\frac{dW(V,\hat{s})}{d\hat{s}}$ is positive and a decreasing function of the g growth parameter. It is therefore sufficient to construct a restriction for the second-order condition for the special case of $g = 0$.

The first step for signing $\frac{dP(\hat{s})}{d\hat{s}} + \frac{1}{\lambda}\frac{dW(V,\hat{s})}{d\hat{s}}$ is to make more explicit the expression for $dP(\hat{s})/d\hat{s}$ within equation (C.1), assuming $\tau = 0$. Substitute the expression for $L(V,s)$ that is given by equation (3) and the expression for $V^D(\hat{s})$ that is given by equation (2) into the expression for $P(\hat{s})$ that is given by equation (5) and then simplify. The resulting expression is $P(\hat{s})_{\tau=0} = \frac{V}{\beta}\left(\frac{V}{V^D}\right)^{\beta-1}$. The next step is to note that $\frac{d}{d\hat{s}}\left(\frac{V}{V^D}\right)^{\beta} = -\beta\left(\frac{V}{V^D}\right)^{\beta}\frac{1}{\pi+\hat{s}}$. This expression can be used together with equation (8) to show that $\frac{dP(\hat{s})}{d\hat{s}} + \frac{1}{\lambda}\frac{dW(V,\hat{s})}{d\hat{s}} < 0$ is equivalent to $\frac{1}{\pi+\hat{s}}\left(\frac{V}{V^D}\right)^{\beta}\left(\beta\phi\frac{\Omega}{\lambda} - \frac{\pi+\hat{s}}{\rho}\right) < 0$. It follows directly that a sufficient condition for this inequality to hold is $\beta\phi < \lambda\pi/\omega$ where $\omega = \rho\Omega$. Because $\frac{dP(\hat{s})}{d\hat{s}} + \frac{1}{\lambda}\frac{dW(V,\hat{s})}{d\hat{s}} < 0$ is sufficient for the second-order condition to hold it follows that $\beta\phi < \lambda\pi/\omega$ is also sufficient for the second-order condition to hold.

D Proofs of Formal Results

Result 1

Using equation (9), the agency's first order condition with $\tau = 0$ can be rearranged as follows:

$$\frac{1}{\lambda}\left(\Omega - W(V,\hat{s})\right) - F - P(\hat{s})) = \mu(\hat{s})\frac{1}{\rho}\left(\frac{V}{V^D(\hat{s})}\right)^{\beta} \tag{D.1}$$

Similarly, the first-order condition for the planner, which is given by equation (12) can be rewritten as

$$\frac{1}{\lambda^g}\left(\Omega - W(V,\hat{s})\right) - F - P(\hat{s})) = \frac{1-\lambda^g}{\lambda^g}\mu(\hat{s})\frac{1}{\rho}\left(\frac{V}{V^D(\hat{s})}\right)^{\beta} \tag{D.2}$$

Using the results from section C of this Appendix it follows that the left sides of equations (D.1) and (D.2) are both increasing functions of $\hat{s}$ given the restriction $\beta\phi < \lambda\pi/\omega$. Similarly, maintaining the previous assumption that $\mu(\hat{s})$ is a decreasing function of $\hat{s}$ it follows that the right sides of equations (D.1) and (D.2) are both decreasing functions of $\hat{s}$. For a given value of $\hat{s}$ the left side of equation (D.2) takes on a larger value than the left side of equation (D.1) because $\lambda > \lambda^g$ by assumption. Similarly, for a given value of $\hat{s}$ the right side of equation (D.2) takes on a smaller value than the right side of equation (D.1) because the former expression is multiplied by $(\lambda^g - 1)/\lambda^g$, which has a value less than one. These two differences combined with the slope properties of equations (D.1) and (D.2) imply that $\hat{s}^* > \hat{s}^{**}$ and $1 - G(\hat{s}^*)) < 1 - G(\hat{s}^{**}))$.

Result 2

To establish the first part of Result 2 note that $1 - G(\hat{s})$ is a decreasing function of $\hat{s}$ and, according to equation (15), a sufficiently large and positive value for $H(V, P(\hat{s}))$ is required for $d\hat{s}^*/d\tau < 0$. To establish the second part of Result 2 first note that $d\hat{s}^*/d\tau$ within equation (15) decreases in absolute value as $H(V, P(\hat{s}))$ diminishes in value. The easement gift, $H(V, P(\hat{s})) = V - \pi/\rho - P(\hat{s})$ is necessarily a decreasing function of Ω because $H(V, P(\hat{s}))$ is a decreasing function of $P(\hat{s})$, which in turn is a decreasing function of $\hat{s}$, which in turn is a decreasing function of Ω, as established by equation (14). Equation (15) shows that a negative value of $H(V, P(\hat{s}))$ is sufficient to ensure that $d\hat{s}^*/d\tau$ switches sign from negative to positive. Examples of negative values of $H(V, P(\hat{s}))$ that are consistent with the Assumption 1 parameter restrictions were presented below equation (13). These two results together are sufficient to establish the second part of Result 2.

Result 3

Use $N(\hat{s}^*, \tau) = P(\hat{s}^*) + \tau(V - \pi/\rho - P(\hat{s}^*))$ to show that $\frac{dN}{d\tau} = V - \pi/\rho - P(\hat{s}^*) + (1-\tau)\frac{dP}{d\tau}$ where $\frac{dP}{d\tau} = \frac{dP}{d\tau}|_{\hat{s}fixed} + \frac{dP}{d\hat{s}^*}\frac{d\hat{s}^*}{d\tau}$. Use equation (5) to show that $\frac{dP}{d\tau}|_{\hat{s}fixed} = -\frac{H(V,\hat{s})}{1-\tau}$ and $dP/d\hat{s} = [(1-\tau)\rho]^{-1}$. Making the required substitutions gives $\frac{dN}{d\tau} = -\frac{1}{\rho}\frac{d\hat{s}^*}{d\tau}$. The inverse relationship between $\frac{dN}{d\tau}$ and $\frac{d\hat{s}^*}{d\tau}$ is now obvious.

Result 4

The proof of Result 4 begins with deriving an expression for $d\hat{s}/d\tau$ with the assumption that $P(\hat{s}^*)$ is fixed at zero. Set equation (5) equal to zero and totally differentiate the resulting expression with respect to $\hat{s}$ and τ. The resulting differential can be reorganized as follows:

$$\frac{d\hat{s}}{d\tau} = -\frac{H(V,0)}{\frac{1}{\rho}\left(\frac{V}{V^D}\right)^{\beta}} \tag{D.3}$$

The proof of Result 4 requires showing that the absolute value of $d\hat{s}^*/d\tau$ in equation (D.3) is larger than the absolute value of $d\hat{s}^*/d\tau$ in equation (15) in the limiting case of $P(\hat{s}^*) \rightarrow 0$. The denominator of this latter differential requires the SOC expression, which is given by equation (C.1). Using equation (6) together with the parameter restrictions implied by Assumption 1 it can be seen that the denominator of equation (15) in the limiting case of $P(\hat{s}^*) \rightarrow 0$ is larger than the denominator of equation (D.3). It can also be seen that the numerator of equation (15) in the limiting case of $P(\hat{s}^*) \rightarrow 0$ is smaller than the numerator of equation (D.3). These two conditions are sufficient to establish the claim made in Result 4.

Result 5

To establish Result 5 it is sufficient to show that $\Omega^* < min\{\Omega^{**}, \Omega^c\}$ because $\Omega \in (\Omega^*, \Omega^c)$ is the condition for a donated easement equilibrium, and $\Omega < \Omega^{**}$ is the condition for a reduction in social welfare with a donated easement outcome. By construction $\Omega^* < \Omega^c$ (see discussion below equation (17)) and equation (18) shows that $\Omega^* < \Omega^{**}$. It therefore follows that $\Omega^* < min(\Omega^{**}, \Omega^c)$.