A Welfare Analysis of Conservation Easement Tax Credits

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Abstract

In North America the use of conservation easements to protect farmland, wetlands and forests is growing rapidly but there is growing public concern that the billions of dollars of easement tax credits exceed the environmental value of the protected land. Agreeing to a conservation easement is equivalent to a landowner selling her land's development rights for a cash payment from a local conservation agency and an income tax credit that is proportional to the implied transfer "gift". The landowner fails to internalize the external environmental value of the land, and the conservation agency fails to fully internalize the social value of the land's development option. In addition to these two offsetting externalities the easement market is distorted because of a binding budget constraint for the agency, private non-market valuation of the land by the landowner and monopsony pricing by the agency. The main result is that although an easement tax credit is socially valuable for environmentally sensitive land the marginal effectiveness can be potentially quite low due to crowding out and information rents. For a range of relatively low environmental values and relatively high tax credits and private non-market valuations, the landowner will agree to fully gift the easement, and the agency will accept the gift despite a decrease in social welfare. The real option that results from development value uncertainty and irreversible decision making bids up the easement price and lowers the effectiveness of the tax credit.

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

JEL classification: Q24, R14, H23, L14.

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1 Introduction

Public concern over land development continues to grow due to a shrinking supply of land for food production, wildlife habitat, biodiversity and green space. In North America 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.

In most cases a landowner donates the conservation easement to a land trust, and in exchange is provided with one or more tax credits relating to property, income and estate.[1] The value of the donation is typically calculated as the difference in the appraised value of the land without the easement versus with the easement. Subject to various restrictions, the value of the donated easement is treated as a charitable donation (e.g., a U.S. landowner in a 30 percent tax bracket who donates a $10,000 easement would earn a $3000 tax credit that can be carried over for up to five years). In high priority scenarios, the land trust will provide a cash payment to the landowner, in which case the tax credit is applicable to the residual easement gift (this is called "split receipting" in Canada and "bargain selling" in the U.S.).[2] A land trust may also use a

[1]See the U.S. Nature Conservancy website for details about the tax credits that are available to U.S. land owners: http://www.nature.org/about-us/private-lands-conservation/conservation-easements/all-about-conservation-easements.xml

[2]See pp. 39-40 of Hillyer and Atkins [2006] for the details about "split receipting" in Canada.

purchase-of-development rights (PDRs) program to ensure the protection of high priority land. In this paper no distinction is made between a land owner receiving a cash payment for signing a conversation easement and participating in a PDRs program because the two mechanisms are essential equivalent.[3]

Of interest in this paper are the welfare implications of conservation easement tax credits in situations where either cash payments or acceptance of donated easements are used by land trusts to secure the protection of farmland, wetland and forest land. This is an important issue to examine because there appears to be growing public concern about whether the rapid growth in the use of easements is in society's best interest. Of particular concern is the lost revenue for the federal and state governments that results from relatively generous tax credits, which have been gradually strengthening over time. For example, [Updike and Mick, 2016, note 3] note that approximately $11 billion of easement tax deductions were granted to easement holders between 2003 and 2009. Easements are also known to eliminate socially desirable development opportunities, are often criticized due to spotty monitoring and lack of easement enforcement by small-scale land trusts, and indirectly result in higher property tax rates and fewer locally-provided public goods for the local community[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.[4]

The market for conservation easements is characterized by multiple offsetting and reinforcing externalities and distortions. The obvious externality is that a landowner does not fully

[3]If the parcel of protected land is small with minimal opportunity for development then the landowner who agrees to a conservation easement may receive an upfront cash payment and no explicit tax credits. This is the standard procedure for Ducks Unlimited, who use easements to protect small pockets of wetland that are distributed throughout grain producing regions of Canada and the U.S. [Lawley and Towe, 2014].

[4]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.

internalize the external environmental value of her land when deciding whether to agree to an easement or instead eventually sell the land to a developer. A less obvious externality is that a conservation agency may fail to fully internalize the development value of land when negotiating an easement deal with a local landowner. This externality is most evident when an agency agrees to hold a donated easement because the environmental value of the land exceeds the cost of creating and maintaining the donated easement. In this extreme case the agency does not internalize any of the land's development value at the margin and thus overinvestment in the easement is a definite possibility. More generally, the easement price that is offered by the agency implicitly accounts for the land's development value because the development value is a key determinant of the landowner's opportunity cost of accepting the easement. An easement tax credit distorts the agency's implicit consideration of the land's development value, thus leading to inefficient easement decisions by the agency.

The first of three direct distortions is the inability of the agency to raise sufficient funds to pay the socially efficient price for the easement. The lack of budget that constrains most conservation agencies is due to the standard free rider problem when financing the provision of public goods such as protected land. This distortion causes the agency to underinvest in the easement, and it is this underinvestment that is the primary argument in favor of using generous easement tax credits to increase the level of investment. The second direct distortion is due to the landowner's private valuation of the non-market attributes of the undeveloped land. This private information results in information rents that accrue to inframarginal landowners who place a comparatively high value on the undeveloped land's non-market attributes and are thus being over-compensated for agreeing to the easement restriction. If the billions of dollars in easement tax deductions that were mentioned above primarily represent information rents then the easement tax credit program will primarily represent an income transfer from taxpayers to landowners rather than a mechanism that effectively addresses a market failure. The third of three direct distortions is the exploitation of market power by the agency. Similar to a standard monopsony problem this distortion results in underinvestment in the easement and thus a positive role for the tax credit to shift the equilibrium outcome toward a more efficient level.

Of particular interest in this analysis is a comparison between donated and purchased conservation easements. It is generally believed that easements are donated because conservation agencies have very tight budgets and thus limited options for purchasing an easement. Framed this way, donated easements may be a sign of severely underfunded conservation agencies and thus provide strong justification for public intervention with instruments such as an easement tax credit. A more critical perspective is that a donated easement is one for which the excess supply of easements by landowners who place a high value on the easement tax credit have driven the equilibrium price of the easement down to zero. The tax credit is most valuable to landowners whose private valuation of their lands' non-market attributes are highest. If the land in question does not have a particularly high external environmental value then the size of the environmental externality will be small relative to the size of the agency's pricing externality. In this case, a donated easement that is accepted by the agency could very well not be in society's best interest. Moreover, in this situation the easement tax credit increases rather than decreases the welfare loss This outcome appears to characterize the growing criticism of North America's rapidly growing conservation easement program.

Another defining feature of the easement market is uncertainty coupled with irreversibility . A landowner's decision regarding whether to agree to an easement or wait and eventually sell her land to a developer is complicated by the fact that the land's future development value is in most cases highly uncertain. The agency's decision regarding what price to pay for the easement is complicated by the fact that the land's future environmental value is uncertain. Coupled with this uncertainty is the fact that land development is normally fully irreversible. The easement is intended to be fully irreversible (and it is assumed to be for the purpose of the analysis below) although in reality some degree of reversibility is likely if the development value rises to a sufficiently high level. In any event, the combination of irreversible decision making and future uncertainty implies that real option considerations are likely to be of considerable importance in the market for conservation easements. Modeling the interplay between two interdependent real options (one for the development decision and one for the easement decision) is likely to generate some interesting and important results. Nevertheless, this approach is not followed in this analysis because it does not appear possible to obtain closed form results in this general case. The analysis is simplified to a single real option frontier by assuming that future environmental value of the land grows at a predetermine rate and there is no uncertainty in the rate of growth.

The effectiveness of the easement tax credit as an instrument to increase the probability of an easement outcome depends positively on the size of the equilibrium size of the easement gift, which in turn depends positively on the mean landowner valuation of the land's non-market attributes. Easement effectiveness also depends on the variance in the distribution of the landowner's valuation of the land's non-market attributes. At the one extreme if there is no spread then depending on the size of the land's external environmental benefits the agency will optimally offer either zero or just enough to entice the landowner to agree to the easement. In this case an increase in the easement tax credit will result in an equivalent decrease in the size of the agency's payment. With this perfect crowding out the increase in the tax credit is fully captured by the agency and there is no change in the probability of an easement outcome. At the opposite extreme, if the landowner's valuation of the land's non-market attributes is widely distributed then the implied demand for the easement by the landowner is relatively elastic. In this case the extent that the tax credit crowds out the agency's payment is much less than 100 percent and so the tax credit will be relatively effective at raising the probability of an easement outcome. In the first case of a perfectly informed agency there are no information rents for the landowner whereas in the second case there are sizable information rents. Thus, the effectiveness of the tax credit as an instrument for raising the probability of an easement outcome is also positive related to the level of information rents that are earned by the agency. The analysis also shows that crowding out is the largest and thus the tax credit is least effective when the environmental value of the land is relatively high. In other words, the tax instrument is the least effective in situations when the need for this instrument to correct the environmental market failure is highest.

An interesting variable that drives several of the results is the measure of the external environmental benefits that temporarily flow (i.e., until the land is developed) if the agency's one-time easement offer is rejected by the landowner. This variable is interesting because it is both a key determinant of the easement pricing outcome and is strongly linked to the real option feature of the analysis. For example, the more variable is future development value uncertainty the longer the landowner will choose to defer the development decision if the easement option is rejected. But delaying the development decision implies a longer temporary flow of environmental benefits, which in turn induces the agency to reduce the easement price it is willing to offer.

The real option framework that is central to this analysis straddles two separate strands of literature. The first literature, which includes a key paper by Capozza and Sick [1994] and 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. The second literature focuses on the socially optimal timing of natural resource exploitation when the decision to exploit is irreversible and when the future environmental benefits from the resource are uncertain [Arrow and Fisher, 1974, Reed, 1993, Conrad, 2000, Pindyck, 2002, Leroux, Martin, and Goesch, 2009]. 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.

In the next section the basis assumptions are laid out, the value of the development option is derived and the pricing problem facing the land trust is set up and solved. Section 3 is used to compare the easement market outcome of the agency with a hypothetical social planner in order to identify the market failure that is potentially correctable with an easement tax credit. The effectiveness of the tax credit as an instrument for reducing market failure is thoroughly examined in Section 4. Concluding comments are provided in Section 5.

2 Assumptions and Market Equilibrium

2.1 Basic Assumptions

A local conservation agency allocates its budget B between land preservation and an exogenous 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 a land's development rights from a local landowner at price P. The agency's valuation of the exogenous environmental project is λ per dollar of allocation. Thus, if the agency's easement offer is accepted by the landowner then the value of the external environmental project is $\lambda(B - P)$. If budgets are tight for all conservation agencies in the region then λ will take on a comparatively large value because a comparatively low aggregate allocation raises the marginal value of the external project. In the analysis below, λ will be treated as fixed parameter from the perspective of the optimizing agency but a higher value of λ is assumed to be associated with a lower value of B due to a positive association between the budget for the individual agency and all agencies in the region.

The timing of the game played in the easement market is as follows. At date 0 the parameters which define the undeveloped land (i.e., current profitability, current environmental value and commercial value if developed) can be fully observed by the conservation agency. The landowner's type is randomly drawn at date 0 but this information cannot be observed by the agency (details below). At date 1, after observing the land's parameters, the agency makes a take-it-or-leave-it offer to purchase the land's development rights, and this offer is either accepted or rejected by the risk neutral landowner. If the offer is accepted 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 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 and forfeits the market and non-market flows. The environmental value of the land permanently changes when the land is developed. To avoid confusion regarding the starting point for the various flows, assume the amount of time between date 0 and date 1 is arbitrarily small.

The landowner's type refers to her valuation of the land's non-market "lifestyle" amenities, which includes open space, quiet surroundings and some capacity to produce food.[5]

Let $s \in (0, \infty)$ denote the landowner's instantaneous valuation of the land's fixed and continuous flow of non-market amenities. Because the specific value of s is private information for the landowner the agency's easement offer may or may not be accepted by the landowner since the landowner's opportunity cost is uncertain when the agency formulates its offer price. It is for this reason that easement acceptance by the landowner is probabilistic rather than deterministic. When formulating its easement offer at date 1, the agency knows that s was randomly drawn (at date 0) from a probability density function, $g(s)$, and associated cumulative probability function, $G(s)$. Implicit in the above formulation is that the probability density for s is independent of the values of the parameters which define the land (e.g., environmental value) when these parameters are changed as part of the sensitivity analysis. This rather strong assumption is used to simplify the analysis. Some additional remarks about this assumption can be found in the concluding section of this paper.

The land's pre-development environmental value is the agency's valuation of the land's external benefits, including wildlife habitat, preserved biodiversity, green space and a carbon sink for greenhouse gas emissions. To simplify the analysis, the post-development environmental flow is fixed over time and, for convenience, is normalized to zero.[6] With an easement in place let ω denote the agency's valuation of the land' instantaneous flow of environmental benefits. The net present value of the environmental flow with the easement in place, (hereafter referred to as the land's "e-value"), is $\Omega = \omega/(\rho - g)$ where ρ is the agency's rate of discount (same as the

[5]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 would be the same if there were multiple landowners, each with a different type. Throughout the analysis reference will be made to the marginal landowner versus inframarginal landowners even though there is just one landowner when discussing information rents and other features of the equilibrium. In other words the "type" qualifier is often omitted when discussing the assumptions and the results in order to simplify the wording.

[6]In many situations the main objective of an easement is to prevent a negative environmental flow that results from the land's development. The main results of this analysis is expected to be qualitatively similar where the easement preserves an existing positive environment flow versus preventing a negative environmental flow.

landowner) and g is the non-stochastic rate of growth in the flow of environmental benefits over time. Without an easement the land generates a flow of environmental benefits until the land is developed. However during this pre-development period, the flow is scaled down relative to the case of an easement. This scaling occurs because the instantaneous flow is assumed to be more valuable to when the land is protected versus not protected (e.g., lower cost to negotiate public access and to add environmental improvements).[7] Specifically, without an easement the flow is valued at $\phi\omega$ where $0 < \phi \leq 1$. The expected present value of the flow between date 0 and when the land is developed at date T is denoted $W(V, s)$ – more details are provided below.[8]

As noted above, if the landowner rejects the agency's easement offer then she has an ongoing option to sell the land to a competitive developer at price, $V(t)$, where $V(0) = V$. Beyond date 0 assume the developer's offer price evolves stochastically over time according to the supply and demand fundamentals 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.[9] 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. Assume $V > \pi/\rho$, which implies that the date 0 development value of the land exceeds the fixed financial use value of the land.

2.2 Decision Variables for Landowner

A key determinant of the of landowner's easement decision and agency pricing of the easement is the easement tax credit. The one-time (date 0) tax credit at rate τ compensates the landowner

[7]As explained below, the scaling assumption ensures the second order conditions for the agency's optimization problem hold. Later in the analysis scaling is used when generating simulation results that are free of corner solutions.

[8]These functions depend on V and s because both of these variables determine the expect time of land development.

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

for "gifting" a portion of the current market value of the land to the agency.[10] 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 date 0 current use value of the land, π/ρ minus the easement payment, P. The analysis allows for a negative value for $H(V,P)$ because in this case the taxing authority will treat as taxable income any payment in excess of what is required to compensate the landowner for signing the easement rather than immediately selling the land to a developer. Accounting for the easement tax credit, a measure of wealth for a type s landowner who chooses to accept the easement can be expressed as $Z(V,s,P) = (\pi + s)/\rho + P + \tau H(V,P)$. After substituting in $H(V,P) = V - \pi/\rho - P$, this expression can be rewritten as

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

The agency's offer price, P, depends critically 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. This function contains the landowner's lifestyle variable, s, because independent of the option to develop the landowner values the land at $(\pi + s)/\rho$. 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 [1994], in Appendix A it is shown that expected utility for the landowner is maximized if the land is developed only if $V \geq V^D(s)$ where

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

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

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

Within equations (2) and (3) the expression for the β variable is given by[11]

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

[10] A real world easement gift tax refund 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.

[11] The $(V/V^D(s))^{\beta}$ variable in equation (3) discounts money received at the time of development back to date 0 while accounting for development trigger, V^D, and the uncertain time path of the land's development value. Similarly, the term $1 - (V/V^D(s))^{\beta}$ variable is a measure of the present value of a one dollar annuity from date

Recall that $Z(V, s, P)$ and $L(V, s)$ are 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. It is straight forward to establish that $Z(V, s, P) = (\pi + s)/\rho + P + \tau H(V, s)$ 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 (preferred for the current analysis) is that a critical value of s rather than P serves as the agency's choice variable. With this formulation, the easement is rejected (accepted) if the landowner's actual s value is less (greater) than the agency's critical s value, which is denoted $\hat{s}$. Consequently, the probability of easement acceptance can be expressed as $1 - G(\hat{s})$. Noting that the accompanying pricing function, $P(\hat{s})$, is implicitly defined by $Z(V, \hat{s}, P(\hat{s})) = L(V, \hat{s})$ where $Z(V, s, P) = (\pi + s)/\rho + P + \tau H(V)$ and $H(V, \hat{s}) = V - \pi/\rho - P(\hat{s})$, it follows that:

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

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.

2.3 Temporary Environmental Value without Easement

This section is used to derive an expression for $W(V, s)$, which is a measure of the expected present value of the environmental flow $\phi\omega$ between date 0 and the time of land development, assuming the easement is rejected by the landowner. If the land is never expected to be developed then $W(V, s) = \phi\Omega$ where $\Omega = \omega/(\rho - g)$. Let $\tilde{W} = \phi \int_0^{\tilde{t}} \omega e^{-(\rho-g)t} dt = \phi\Omega[1 - e^{-(\rho-g)\tilde{t}}]$

0 to the expected time of land development. Without uncertainty, 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 $(1 - e^{-\rho T})/\rho$.

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 $\tilde{W}$ assuming the land's date 0 development value is V and the landowner will exercise the development option if this development value rises to $V^D(s)$. 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 $\tilde{W} = \phi\Omega[1 - e^{-(\rho-g)\tilde{t}}]$ and use the resulting expression to show the probability that $\tilde{W} \leq \tilde{W}^0$, which is denoted $F(\tilde{W}^0; V, s)$, is equal to the probability that $\tilde{t} \leq -ln\left(1 - \frac{\tilde{W}^0}{\phi\Omega}\right)/(\rho - g)$. An expression for this latter probability, which depends on s and V, is derived in Appendix A using the generic expression for the distribution of first passage time for a geometric Brownian motion. The full formal expression for $f(\tilde{W}; V, s)$ is also shown in Appendix A.

Later in the analysis it is useful to restrict attention to the case of no development value uncertainty, which requires $\sigma = 0$ and $\beta = \rho/\alpha$,[12] and implies $\left(\frac{V}{V^D}\right)^\beta = e^{-\rho T^*}$ where T^* is the amount of time it takes the land's development value to move from its date 0 value, V, to the development trigger, V^D.[13] Using this result, it follows that in the absence of development value uncertainty

$$W(V, \hat{s})_{\sigma=0} = \left[1 - \left(\frac{V}{V^D(\hat{s})}\right)^\beta\right] \phi\Omega \tag{7}$$

3 Interior Market Equilibrium

In this section the equilibrium in the easement market is derived assuming an interior easement pricing outcome. A positive equilibrium easement price requires a sufficiently large e-value for the undeveloped land. The specific restriction on the minimum value of ρ that is required to achieve this outcome is provided later in the analysis.

[12]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 $\sigma^2 = 0$ it follows that $\beta = \rho/\alpha$.

[13]Substituting $\beta = \rho/\alpha$ into equation (2) and 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 $\left(\frac{V}{V^D}\right)^\beta$.

3.1 Optimal Pricing by the Agency

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

$$\Gamma(\hat{s}) = (1 - G(\hat{s}))\left[\Omega - F + \lambda(B - P(\hat{s}))\right] + G(\hat{s})\lambda B + \int_0^{\hat{s}} \int_0^{\phi\Omega} \tilde{w} f(\tilde{W}, V, s) g(s) d\tilde{W} ds \quad (8)$$

Within equation (8) recall that $1 - G(\hat{s})$ is the probability the easement will be signed, Ω is the land's e-value, and $\lambda(B - P(\hat{s}))$ and λB are the environmental value of the residual project with and without the easement, respectively. The F parameter in equation (8) is a measure of one-time (date 0) cost of setting up the easement. The last double integrated term in equation (8) is the expected environmental value of the land between date 0 and when the land is developed, conditional on the landowner rejecting the agency's easement offer.

Using $W(V, s) = \int_0^{\phi\Omega} \tilde{W} f(\tilde{W}; V, s) d\tilde{W}$ together with equation (6), the first order condition for the agency's optimal choice of $\hat{s}$ can be rearranged and written as

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

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 left side of equation (9) is the price of the easement that is offered by the agency. The first term on the right side is the expected increase in the environmental value of the land that results from the easement, $\Omega - W(V, \hat{s})$, adjusted by λ, which is a measure of the agency's opportunity cost of investing in the easement rather than the external project. Recall that at an industry wide level a higher value of λ is associated with a smaller budget for the agency. Thus, an agency with a tighter budget is expected to offer a lower price for the easement because of a relative scarcity of funds for addressing external environmental projects.

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. Indeed, if this term is moved to the left side of equation (9) then the resulting equation can be interpreted as a standard marginal outlay equal to marginal benefit condition of a monopsonist. In standard monopsony theory it is well known that the price discount is larger the less elastic is the supply of the upstream firm. In this case the supply of easement land by the landowner is less elastic if the development value of the land, V, is relatively close to the landowner's trigger point, $V^D(\hat{s})$. This outcome is expected because the lack of information about the landowner's non-market valuation of her land, s, is less important in the pricing decision when V is close to $V^D(\hat{s})$. The size of the price discount due to bargaining power is also inversely related to $g(\hat{s})/(1-G(\hat{s}))$, which the the hazard rate for the distribution of s. This result is also expected because in the context considered the hazard rate is proportional to the extensive margin supply elasticity.[14]

3.2 Social Planner Pricing

To assess the efficiency properties of the market equilibrium with the private agency it is necessary to derive the outcome with a social planner offering the easement contract. The social planner is assumed to face no budget constraint but does have a marginal social opportunity cost of using taxpayer revenue to fund the easement and the external project, $\lambda^g > 1$. The λ for the agency is also a measure of opportunity cost (investment in the easement rather than the external project) and so the λ values for the agency and social planner can be directly compared. Assume that industry wide budgets for organizations that fund environmental projects are comparatively small and thus λ for the agency exceeds λ^g for the social planner.

A second difference between the agency and the social planner is that the planner internalizes the welfare of the landowner as well as the environmental value of the land.[15] If the easement is signed then welfare for the landowner is measured by $Z(V, s, P) = (\pi + s)/\rho + P + \tau H(V)$. In the previous expression it is necessary to set the easement tax credit, τ, equal to zero for the case of a social planner because the planner can correct a market failure directly rather than using a pricing instrument. If the easement is not signed then the welfare of the landowner

[14]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 the supply elasticity, $(dQ/dP)(P/Q)$, can be expressed as $Zg(\hat{s})/(1-G(\hat{s}))$ where $Z = -P(d\hat{s}/dP)$.

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

is measured by $L(V,s)$, which is the date 0 value of the land including the development option value.

The objective function for the social planner can be expressed as[16]

$$\Gamma^g(\hat{s}) = (1-G(\hat{s}))\left[\Omega - F + \pi/\rho - (\lambda-1)P(\hat{s})\right] + \int_{\hat{s}}^{\infty} \frac{s}{\rho} g(s)ds \qquad (10)$$
$$+ \int_0^{\hat{s}} \left[\int_0^{\phi\Omega} \tilde{w} f(\tilde{W}, V, s) d\tilde{W} + L(V,s)\right] g(s)ds$$

Once again using $W(V,s) = \int_0^{\phi\Omega} \tilde{W} f(\tilde{W}; V, s) d\tilde{W}$ together with equation (6), the first order condition for the planner's optimal choice of $\hat{s}$ can be rearranged and written as

$$P(\hat{s})) = \frac{1}{\lambda^g}\left(\Omega - F - W(V,\hat{s})\right) - \left(\frac{\lambda^g - 1}{\lambda^g}\right) \frac{1-G(\hat{s})}{g(\hat{s})} \frac{1}{\rho} \left(\frac{V}{V^D(\hat{s})}\right)^{\beta} \qquad (11)$$

A comparison of equations (9) and (11) reveal that apart from the assumed differences in the values for λ and λ^g the only difference between the first order conditions for the planner and the agency is that last term is multiplied by $(\lambda^g - 1)/\lambda^g$ for the planner but there is no analogous adjustment for the agency.

3.3 Comparison of Agency and Planner Outcomes

Prior to comparing the easement outcomes for the agency and planner it is useful to specify a number of parameter restrictions. Using equation (6), the second order conditions (SOC) for the agency's optimization problem can be written as

$$SOC \equiv \frac{dP(\hat{s})}{d\hat{s}} + \frac{1}{\lambda}\frac{dW(V,\hat{s})}{d\hat{s}} - \mu(\hat{s})\frac{d^2P(\hat{s})}{d\hat{s}^2} - \frac{dP(\hat{s})}{d\hat{s}}\frac{d\mu(\hat{s})}{d\hat{s}} < 0 \qquad (12)$$

Within equation (12) note that $\mu(\hat{s}) = [1-G(\hat{s})]/g(\hat{s})$ is the inverse of the mills ratio. Following the usual procedure in the literature, $\mu(\hat{s})$ is assumed to be a decreasing function of $\hat{s}$. Knowing from equation (6) that $dP(\hat{s})/d\hat{s}$ takes on a negative value, it follows that equation (12)

[16]The external project is excluded from the planner's objective function because optimal funding of the easement and the external project are independent.

holds provided that the positive value for $dW(V,\hat{s})/d\hat{s}$ is not excessively large.[17] Assuming a sufficiently small value for the scaling parameter ϕ ensures the desired outcome.

Other parameter restrictions are as follows.

Assumption 1. *(a)* $V = \frac{\beta}{\beta-1}\frac{\pi}{\rho}$ *(b)* $\pi/\rho + \Omega \geq V - W(\hat{s})$ *(c)* $\lambda > \lambda^g$

Assumption 1(a) ensures that a landowner who values her land only for its flow of profits (i.e., $s = 0$) is indifferent between immediate and delayed development in the event the agency's easement offer is rejected. This assumption ensures that delayed development is optimal for all feasible values of s. Assumption 1(b) ensures that the social value of the land excluding the landowner's personal valuation of the land's attributes is higher with the status quo land use than with land development. Finally, Assumption 1(c) implies that the budget constraint for the agency is more restrictive than the budget constraint for the planner. To understand why this is the case recall the earlier discussion about the negative relationship between B and λ for the industry as a whole, and the positive relationship between B for the agency and average B for the industry as a whole.

The first formal result of the analysis can be stated as follows:

Result 1. *Assuming a positive equilibrium easement price and* $\tau = 0$ *(i.e., no easement tax credit), the probability of an easement outcome is smaller with the agency versus the planner. Formally,* $\hat{s}^* > \hat{s}^{**}$*, which implies* $1 - G(\hat{s}^*) < 1 - G(\hat{s}^{**})$.

Result 1 is established using Figure 1. Within this figure the upward (downward) sloping scheduled with the "Agency" label is a graph of the left (right) side equation (9). The schedules with the "Planner" label are the analogous schedules that correspond to the planner's first order condition. The slopes and positions of the various schedules are derived in Section C of the Appendix.[18] Figure 1 shows that the planner's upward-sloping schedule lies above the agency's

[17]Equations (2) and (7) can be used to establish the positive sign of $dW(V,\hat{s})/d\hat{s}$. for the case of zero development value uncertainty. This result continues to hold with uncertainty because as equation (2) shows the development trigger, $V^D(\hat{s})$ is an increasing function of $\hat{s}$.

[18]The proofs of all the formal results to follow are contained in Section C of the Appendix.

upward-sloping schedule due to the $\lambda^g < \lambda$ assumption. In contrast, the planner's downward-sloping schedule lies below the agency's downward-sloping schedule due to the absence of monopsony pricing by the planner. These two reinforcing effects ensure the $\hat{s}^* > \hat{s}^{**}$ outcome. The result that $1 - G(\hat{s}^*) < 1 - G(\hat{s}^{**})$ follows immediately given the assumed properties of $G(\hat{s})$.

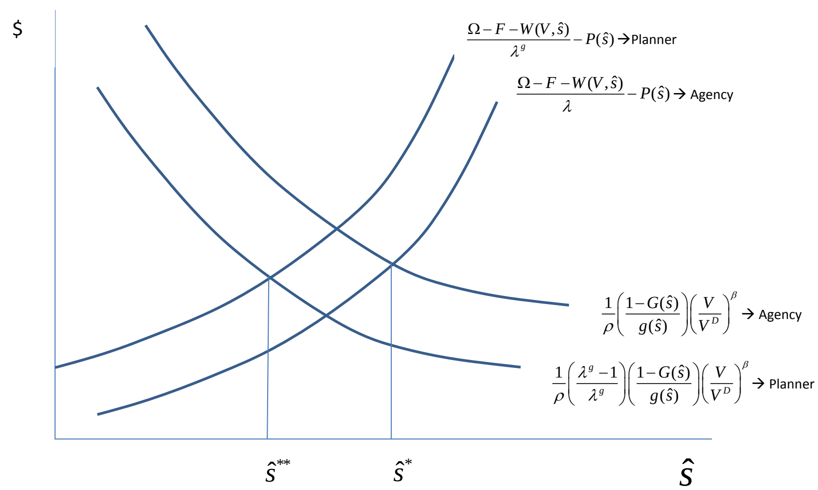

Figure 1: Comparison of Agency and Socially Planner Equilibrium

Result 1 emerges for two distinct reasons. First, the agency's budget is smaller than the planner's budget. The smaller budget implies a smaller allocation to the external environmental project and this smaller allocation (when aggregated across all conservation agencies) implies a higher marginal return for the external project. Consequently, the agency invests less in the easement project and more in the external project relative to the planner. This difference in allocation gives rise to the $\hat{s}^* > \hat{s}^{**}$ outcome. The second reason for 1 has to do with monopsony pricing by the agency. The agency ignores landowner welfare when pricing the easement whereas the planner does not. The agency and planner both utilize Ramsey pricing but given the differences in objectives it can be seen that equilibrium with the agency resembles a monopsony outcome whereas equilibrium with the planner resembles a competitive outcome. The lower easement price offered by the agency relative to the planner contributes to the $\hat{s}^* > \hat{s}^{**}$ outcome. In real world easement markets this latter reason for Result 1 appears to be of secondary importance.

4 Analysis of Easement Tax Credit

The easement tax credit is designed to make the easement outcome more attractive to the landowner. If the agency is budget constrained and thus invests in the easement at an inefficiently low level the easement tax credit has the potential to increase the efficiency of the easement outcome. Before formally stating how an easement tax credit improves the efficiency of the easement outcome it is useful to first examine the interactive relationship between the tax credit and the equilibrium price offered by the agency.

4.1 Relationship between Tax Credit and Easement Price

It is possible that a landowner is willing to pay the agency to obtain an easement if the tax credit is sufficiently generous. This case is ruled out by defining τ^0 as the value of τ that results in a zero value for the pricing function that is given by equation (5), and then assuming $\tau < \tau^0$. Solving equation (5) for τ gives $\tau^0 = \frac{L-(\pi+\hat{s})/\rho}{V-\pi/\rho}$. It is useful to note that $\tau^0 < 1$ given the earlier set of parameter assumptions.[19]

Although the analysis allows for a negative easement gift the previous assumptions rule out this possibility. This result can be established by substituting the equilibrium pricing function that is given by equation (5) into the easement gift function that is given by $H(V,\hat{s}) = V - \pi/\rho - P$. After substituting in the expression for L that is given by equation (3) and the $V = \frac{\beta}{\beta-1}\frac{\pi}{\rho}$ restriction the easement gift expression can be rewritten as

$$H(V,\hat{s}) = \frac{1}{\tau-1}\frac{1}{\beta-1}\left[\left(1-\left(\frac{V}{V^D}\right)^{\beta}\right)\frac{\pi}{\rho} + \left(\frac{V}{V^D}\right)^{\beta}\frac{\hat{s}}{\rho}\right] \tag{13}$$

It is immediately obvious from equation (13) that the equilibrium value of the easement gift is positive in sign.

[19] Using the expression for τ^0 it follows that $\tau^0 < 1$ requires $V > L - \hat{s}/\rho$. After substituting in the expression for L that is given by equation (3) and noting that $V^D(\hat{s}) = \frac{\beta}{\beta-1}\frac{\pi+\hat{s}}{\rho}$ this inequality can be rewritten as $\pi/\rho > \frac{\pi+\hat{s}}{\rho}(V/V^D)^{\beta}$. The $V = \frac{\beta}{\beta-1}\frac{\pi}{\rho}$ restriction allows this inequality to be rewritten as $\left(\frac{\pi}{\pi+\hat{s}}\right)^{\beta-1} < 1$, which clearly holds.

Notice that $1 - \tau$ appears in the denominator of equation (13), which implies that the gift is larger the higher tax credit. This result is expected because a higher tax credit reduces the payment by the agency, and a smaller payment implies a larger gift. Noting that the value of the tax credit to the landowner is $\tau H(V, \hat{s})$, the $\tau/(1-\tau)$ multiplier implies that a marginal increase in τ "rapidly" raises the value of the tax credit to the landowner. This does not necessarily imply that the tax credit is an efficient policy instrument because it must be recognized that an increase in the tax credit induces the agency to lower its payment. Consequently, a relatively large increase in the value of the tax credit is required to raise the probability of an easement outcome. It is useful to formally examine the extent that an increase in τ crowds out the agency's investment in the easement. Differentiate equation (5) with respect to τ, holding $\hat{s}$ fixed, gives

$$\frac{dP}{d\tau} = -\frac{V - \pi/\rho - P(\hat{s})}{1-\tau} = -\frac{H(V, \hat{s})}{1-\tau} \tag{14}$$

Equation (14) shows that the rate at which a marginally higher tax credit crowds out private investment is inversely proportional to $1 - \tau$ and is directly proportional to the size of the easement gift. Since crowding out reduces the effectiveness of the tax credit program, equation (14) shows that the marginal effectiveness of the tax credit program is likely to be least effective when the existing program is already relatively generous (i.e., a comparatively large value for τ and when the existing size of the easement gift is relatively large.

4.2 Pigouvian Properties of Tax Credit

Result 1 demonstrated that the probability of an easement outcome is inefficiently low due to the agency's budget constraint and exercise of market power. The easement tax credit is expected to work as an implicit subsidy of the easement and thereby raise the probability of an easement outcome, despite the lower easement payment. This result is stated formally as follows:

Result 2. *For $\tau < \tau^0$ and Ω large enough to ensure a positive easement price, a marginal increase in τ lowers the equilibrium value of $\hat{s}$, which in turn raises the probability of an easement outcome. Formally, $d\hat{s}/d\tau < 0$ when $P(\hat{s}^*) > 0$.*

In Figure 1, the upward sloping schedule for the private agency shifts up with a positive tax credit that reduces the value of $P(\hat{s})$. This shift results in an equilibrium value for $\hat{s}$ (i.e., $\hat{s}^*$ that is closer to the social planner's outcome,$\hat{s}^{**}$. Can the tax credit fully eliminate the distortion, thus ensuring $\hat{s}^* = \hat{s}^{**}$? The answer depends most importantly on the comparative size of λ and τ^0. If λ takes on a large value then the distortion is large and it is likely that $\hat{s}^* > \hat{s}^{**}$ when τ takes on its maximum value of τ^0. Conversely, with a relatively small value for λ the tax credit can be increased and the distortion fully eliminated prior to τ reaching τ^0.

4.3 Information Rent

The previous analysis has focused on the marginal landowner by comparing $\hat{s}^*$ with $\hat{s}^{**}$. Inframarginal landowners who accept the agency's easement offer earn an information rent because their private valuation of the land's non-market attributes are private information. Equation (5) shows the price that a type $\tilde{s}$ inframarginal landowner will receive when she accepts the agency's easement offer. This price is a function of the equilibrium value of $\hat{s}$. The minimum price that this landowner would accept in exchange for the easement opportunity is given by equation (5) with $\tilde{s}$ substituting for $\hat{s}$. The information rent that is earned by a type $\tilde{s}$, denoted $IR(\tilde{s})$, is the difference between the actual price and minimum price. After canceling terms, the desired expression can be written as

$$I(\tilde{s}) = \frac{\tilde{s} - \hat{s} - [L(V, \tilde{s}) - L(V, \hat{s})]}{1 - \tau} \tag{15}$$

The following result connects the size of the information rents for a particular inframarginal landowner to the size of the easement tax credit. There is no formal proof of this result because the result can easily be established using equation (**??**).

Result 3. *Consider a type $\tilde{s}$ landowner for which $\tilde{s} > \hat{s}$. This inframarginal landowner agrees to sign the easement and when doing so earns an information rent. The size of the information rent is an increasing function of the easement tax credit rate, τ.*

Result 3) demonstrates that an inframarginal landowner earns rents from both the agency (via the payment) and the easement tax credit. As the level of the tax credit increases thereby crowding out the agency's payment, the share of the rent that comes from the agency's payment decreases and the share that comes from the tax credit increases. The increase in information rents that comes from the tax credit increases faster than the decrease in the information rent that comes from the agency's payment. The net result is an overall increase in the information rent earned by an inframarginal landowner.

The above discussion implicitly assumes that τ is equal to or below the level the rate that is needed to eliminate the market distortion, $s^* > s^{**}$. In reality τ is the same for all agencies in different jurisdictions and all landowners since the easement tax credit is determined by the charitable giving component of the federal income tax legislation. This lack of targeting implies that for a given value of τ the $\hat{s}^* - \hat{s}^{**}$ distortion will vary across agencies and landowners and will take both positive (undershooting) and negative (overshooting) values. The overshooting implications of easement tax credits is formally analyzed in the next section.

4.4 Donated Easements

In real world easement markets the majority of easements are donated by landowners. Assuming the landowner is acting in her best interest and further assuming that the agency accepts the donated easement (incurring fixed cost F by doing so), then it is important to ask whether or not a donated easement is always in society's best interest. The answer is not obvious because as discussed above there are multiple offsetting externalities that must be considered. The main result that is established in this section is that a relatively generous easement tax credit has the potential to attract donated easements that are not in society's best interest. This result directly speaks to the concern that many critics of the conservation easement policy have voiced in recent years.

A donated easement can be interpreted as a $P^* = 0$ corner solution to the agency's optimization problem. But it is important to recognize that there are two types of corner solutions. The first type is where the agency finds it optimal to offer a zero easement price and to refuse to accept a donated easement because the fixed expense of managing the easement, F, exceeds the net expected environmental benefits. The second type, which is of particular interest in this analysis, is the same except in this case the agency agrees to accept a donated easement because the net environmental benefits exceed the easement's management cost.

To establish a formal result four threshold values are required. The first is s^d, which is the value of s that makes the landowner indifferent between donating an easement and demanding a positive price for easement acceptance. To obtain an expression for s^d set P equal to zero in the pricing equation that is given by equation (5), substitute equation (3) into the resulting expression and finally solve for the s variable:

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

Given the properties of $Z(V, s)$, which is a measure of a type s landowner's valuation of the easement, it follows that all landowner types for which $s < s^d$ demand a positive price for agreeing to the easement and all landowner types for which $s \geq s^d$ will agree to donating their easements. In the latter case the combined value of the land's non-market attributes and the tax credit exceeds the option to sell the land to a developer at some point in the future. Equation (16) shows the important role that τ plays in the supply of donated easements. Specifically, as would be expected, landowner types who value the non-market attributes of their land the most are the first in the pool to donate their easements. As $\tau \to 0$ it can be seen that the supply of donated easements approaches zero, and increases in τ above zero decreases $\hat{s}$ monotonically and thus raises the supply of donated easements.

The next two thresholds to be derived are values for Ω that make the agency and planner, respectively, earn zero surplus from holding a donated easement. Both types of agencies must anticipate that only those landowners from which $s \geq s^d$ will agree to supply a donated easement. Thus, all variables containing s must be integrated from s^d and above. To conserve on notation, if a function contains an s with a bar over it then that function should be interpreted as the expected value of that variable conditional on $s \geq s^d$. For example, $W(V, \bar{s}) = \int_{s^d}^{\infty} W(V, s) g(s) ds$. The agency earns zero surplus from holding a donated easement if $\Omega = \Omega^A$ where $\Omega^A = W(V, \bar{s}) + F$ (i.e., the expected net environmental benefits from the easement equal or exceed the easement's holding costs). The planner earns zero surplus from holding a donated easement if $\Omega = \Omega^P$ where $\Omega^P = \bar{W}(V, \bar{s}) + F + \bar{L}(V, \bar{s}) - \frac{\pi+\bar{s}}{\rho}$. Because environmental surplus is an increasing function of Ω it follows that the agency and the planner will agree to hold a donated easement if $\Omega > \Omega^A$ and $\Omega > \Omega^P$, respectively.

The final threshold is the value of Ω that makes $P = 0$ exactly satisfy the agency's first order condition for maximizing environmental surplus. The desired solution value, Ω^*, is derived by setting $s = s^d$ and $P = 0$ in equation (9) and then solving the resulting expression for Ω:

$$\Omega^* = \frac{1 - G(s^d)}{g(s^d)} \frac{\lambda}{\rho(1-\tau)} \left(\frac{V}{V^D(s^d)} \right)^\beta + W(V, s^d) + F \tag{17}$$

Independent of whether or not the agency wishes to hold a donated ($P = 0$) easement, for all $\Omega < \Omega^*$ a corner solution emerges and $P = 0$ is optimal for the agency.

The formal result for this section can now be stated as follows.

Result 4. *Suppose $\Omega \in \left[\Omega^A, min\{\Omega^*, \Omega^P\}\right]$ and $s \geq s^d$. In the absence of development value uncertainty and provided that the fixed easement cost (F) is not excessively large, the agency will agree to hold a donated easement even though doing so reduces social welfare.*

Result 4 is specific to the case of no development value uncertainty but it is expected to also hold under a wide set of parameter combinations for the more general uncertainty case. To understand Result 4 note that the agency exploits its market power to set the easement price P below the competitive level. For a sufficiently small value of Ω the optimal price offered by the agency is zero, which is a standard corner solution outcome for a monopsony. If the landowner agrees to $P = 0$ this is equivalent to the landowner proposing to donate her easement. If the corner solution is not binding to an excessive degree (i.e.,, Ω is not too small in value) then monopsony pricing will induce the agency to agree to hold the donated easement because of positive environmental surplus. In a standard monopsony problem overall surplus is not at a maximum with a monopsony outcome but nevertheless is still positive. A similar outcome emerges in this analysis if Ω takes on a sufficiently large value. For more moderate values of Ω (i.e., land that has some but not an abundance of environmental value) overall welfare is lower with the easement than without the easement. This occurs because when faced with a $P = 0$ corner solution the agency fails to account for the land's development value (present and in the future) when choosing whether or not to hold the donated easement. Establishing Result 4 is complicated by the offsetting properties of the $W(V, s)$ function, which also created a problem when establishing the second order conditions for the agency's pricing problem. This offsetting impact shrinks toward zero as the agency's fixed cost of holding the easement approaches zero. It is for this reason that Result 4 was established assuming a sufficiently small value for F.

4.5 Uncertainty Impacts

Development value uncertainty plays an important role in the analysis. It is important to note that within equations (5) and (9) uncertainty affects the landowner's demand for the easement and the agency's optimal choice of easement price through the β function, which is given by equation (4). It is straight forward to use this function to show that β is a decreasing function of σ, and thus $\frac{\beta}{\beta-1}$ is an increasing function of σ. The higher value of $\frac{\beta}{\beta-1}$ in turn raises the development trigger, $V^D(\hat{s})$ relative to the current development value of the land, V, as is shown by equation (2).

With most feasible parameter combinations, the higher development trigger both increases the expected time to development (i.e., raises the value of the option to delay the investment decision) and the value of the option to develop the land.[20]The longer the delay in development, the longer the period of time that environmental services will flow from the land before development in the event the landowner rejects the easement at date 0. Hence, $W(V, \hat{s})$ and σ are generally positively related. Similarly, the value of the land, $L(V, \hat{s})$, is also generally positively related to σ because larger σ generally raises the value of the option to develop the land. In the standard case this inward shift in the demand for the easement by the agency (because it can enjoy a longer benefit flow if the easement is rejected) and the higher opportunity cost of the landowner signing the easement (because the value to delay the investment decision is larger) reinforce each other and serve to both reduce the equilibrium price of the easement and the probability of a successful easement outcome.

[20]Sarkar [2000] shows that although a higher value of σ raises the investment threshold, there is also a higher chance that V will reach the investment threshold because of the higher volatility of V.

5 Conclusions

The market for conservation easements is likely characterized by multiple externalities and distortions. Without easements or other forms of land use regulation the negative environmental externality that characterizes land use results in an inefficiently high rate of land development. A market for easements would fully eliminate this externality and the outcome would be efficient if the conservation agency purchasing the easement was not budget constrained, priced the easement competitively and was able to accurately identify the landowner's valuation of the land's non-market amenities. The assumption that the landowner's non-market valuation is private information implies a probabilistic easement outcome and the existence of information rents in the easement market. The analysis also assumes a constrained budget and monopsony pricing for the agency, both of which induce underinvestment by the agency and thus an inefficiently low probability of an easement outcome. This underinvestment outcome provides the rationale for an easement tax credit.

Much of the analysis was devoted to analyzing the efficiency properties of the easement tax credit. For the tax credit to be effective at raising the probability of an easement outcome it must be the case that the equilibrium value of the easement gift is positive. A relevant question to ask is why would a self-interested landowner ever agree to a positive easement gift. This outcome occurs because the gift depends on the difference between the development value of the land and the current use value of the land and thus does not consider the landowner's valuation of the land's non-market amenities. This non-market valuation ensures that a positive easement gift is acceptable to the landowner. The marginal efficiency of the easement tax credit is lower the more the tax credit crowds out the payment for the easement that is chosen by the agency. The level of crowding out depends on the elasticity of landowner demand for the easement as calculated by the agency. A wider distribution of values of the landowner's valuation of the land's non-market amenities implies a more elastic demand for the easement, which in turn implies a relatively low degree of crowding out by the easement tax credit.

The assumption that the landowner's valuation of the land's non-market amenities is private information results in positive information rents for the inframarginal landowners. Not surprisingly, aggregate information rents are larger the wider the distribution of non-market valuations by the landowner. Part of the easement tax credit that is funded by taxpayers ends up as information rent and thus has no effect on the marginal landowner and the probability of a successful easement outcome. Real-world critics of easement tax credits argue that wealthy landowners who have no intention of selling their land for development are capturing the majority of the easement tax credit benefits. This criticism is well supported by the information rent result that emerges from analysis. In this respect the relatively high taxpayer cost of preserving the undeveloped land base is similar to the well documented high taxpayer cost of protecting environmentally sensitive land the U.S. Conservation Reserve Program.

One of the most important results that emerge from the analysis has to do with donated easements. A donated easement, which is equivalent to corner solution of the agency's optimal pricing problem, disconnects the agency's offer price from the development value of the land. With a corner solution outcome the agency compares the environmental value of the easement to the cost of establishing and monitoring the easement. If the comparison is favourable the agency will accept the donated easement even if the social value of the land is higher without the easement restriction. This outcome is most likely if the environmental value of the land is low but not too low (i.e., high enough to be attractive to the agency but low enough not to be worth preserving from society's perspective) and the landowner's non-market valuation is high enough to ensure that a donated easement is acceptable. Under these conditions the easement tax credit exacerbates the overinvestment problem by making the donated easement outcome more likely. Not only are taxpayer dollars being captured by inframarginal landowners in the form of information rents but the tax credit is pushing the marginal landowner toward a less rather than more efficient outcome.

The real option feature of the landowners easement versus development decision also plays an important role in the analysis. The main finding is that the real option raises the opportunity cost of the landowner agreeing to the easement and thus in equilibrium the easement outcome is less likely and the easement tax credit is less effective at raising the probability of an easement outcome. A more general model would endogenize the agency's choice of when to offer the easement and would also assume that the future environmental value of the land is uncertain.

This change in model structure would raise the opportunity cost of the landowner choosing to reject the agency's easement offer and thus result in a higher equilibrium offer price and a higher probability of an easement outcome. Without doing formal analysis it is difficult to know for sure but it is likely to be the case that in this more general model the social value of the easement tax credit would be reduced relative to the current set of results.

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Appendix

A Equations for Section 2.2

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

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

The value function is thus represented as 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 differential equation that is implied by the previous expression has the general form $L(V,s) = AV^\beta + (\pi+s)/\rho$ for $V < V^D(s)$ where

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

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). Substituting the expression for A^D into $L^D(V,s) = AV^\beta + (\pi+s)/\rho$ gives equation (3).

The next task is to derive an expression for $f(\tilde{w};V,s)$, which is the density function for the present value of the environmental flow between date 0 and the uncertain date that land development takes place. In Section 4.5 it was shown that the cumulative probability function for $\tilde{w}$, denoted $F(\tilde{w};V,s)$, is equal to $G(-ln(1-\tilde{w}/\phi\Omega)/(\rho-g);V,s)$ where $G()$ is the cumulative probability function for the first hitting time random variable, $T_V = inf(t : V = V^D)$. Using equation (15) from Grenadier [1996], an expression for $G()$ can be written as

$$\begin{aligned} G(T_V \le t) = {} & \Phi\left(\frac{-ln(V^D/V) + (\mu - 0.5\sigma^2)t}{\sigma t^{0.5}}\right) \\ & + \left(\frac{V^D}{V}\right)^{\frac{2(\mu-0.5\sigma^2)}{\sigma^2}} \Phi\left(\frac{-ln(V^D/V) - (\mu-0.5\sigma^2)t}{\sigma t^{0.5}}\right) \end{aligned} \tag{A.2}$$

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

$$f(\tilde{w}; V, s) = \begin{cases} 0 & if \quad V \geq V^D(s) \\ dF(\tilde{w}; V, s)d\tilde{\omega} & if \quad V < V^D(s) \end{cases} \tag{A.3}$$

B Properties of β Function

The objective is to determine how β in equation (A.1) changes with α and σ. It is obvious from equation (A.1) that β is a decreasing function of α. To determine the relationship with σ let $x = 1/\sigma^2$ and $Z = (0.5 - \alpha x)^2 + 2\rho x$. Using equation (A.1) it can be shown that

$$\frac{d\beta}{dx} = -\alpha Z^{-0.5}\left[Z^{0.5} + 0.5 - \alpha x - \rho x\right]$$

The expression in square brackets takes on a negative value if $(0.5 - \alpha x)^2 + 2\rho x < [\rho/\alpha - (0.5 - \alpha x)]^2$. This condition holds given the $\alpha < \rho$ assumption. Consequently, β is an increasing function of x and thus a decreasing function of σ because $x = 1/\sigma^2$.

C Proofs of Formal Results

Result 1

The purpose of this subsection is to establish the relative slopes and positions of the four schedules in Figure 1. With $\tau = 0$ the agency's first order condition, which is given by equation (9), can be rearranged as follows:

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

Given equation (12), which is the second order condition for the agency's optimization problem, it follows that the left side of equation (C.1) is an upward sloping function of $\hat{s}$ and the right side is a downward sloping function of $\hat{s}$.

Result 2

The proof of Result 2 requires standard comparative static analysis. Part of this analysis will utilize the expressions for $dP/d\hat{s}$ and $dP/d\tau$, which are given by equations (6) and (14), respectively. Differentiating equation (5) with respect to $\hat{s}$ a second time gives $\frac{d^2P}{d\hat{s}^2} = -\frac{\beta}{\pi+\hat{s}}\frac{dP}{d\hat{s}}$. Finally, differentiating equation (5) first with respect to $\hat{s}$ and then with respect to τ gives $\frac{d^2P}{d\hat{s}d\tau} = \frac{dP}{d\hat{s}}\frac{1}{(1-\tau)}$. To implement the comparative static analysis totally differentiate the agency's first-order condition, which is given by equation (9), and then solve for $d\hat{s}/d\tau$. The desired expression is

$$\frac{d\hat{s}}{d\tau} = \frac{\mu(\hat{s})\frac{d^2P}{d\hat{s}d\tau} - \frac{dP}{d\tau}}{SOC}$$

Within this expression recall that $\mu(\hat{s}) = \frac{1-G(\hat{s})}{g(\hat{s})}$ and SOC is the expression for the second-order condition for optimizing the agency's objective function as given by equation (12). The numerator of the previous expression can be made more explicit by substituting in the previously-derived expressions for $dP/d\tau$ and $\frac{d^2P}{d\hat{s}d\tau}$ along with the agency's first-order condition as given by equation (9). With these substitutions the differential of interest can be rewritten as

$$\frac{d\hat{s}}{d\tau} = \frac{\frac{1}{\lambda}(\Omega - W(\hat{s}) - (V - \pi/\rho)}{SOC}$$

The numerator of this expression takes on a positive value given Assumption 1(a) and based on equation (12) the denominator takes on a negative value. Hence, $\frac{d\hat{s}}{d\tau} < 0$.

Result 3

Result 3 can be signed by differentiating equation (3) with respect to τ and then signing the resulting expression positive. The desired differential is

$$\frac{d\textit{(Rent)}}{d\tau} = \frac{\textit{Rent}}{(1-\tau)^2} + \left[\frac{dL(V,\hat{s})}{d\hat{s}} - \frac{1}{\rho}\right]\frac{d\hat{s}}{d\tau}$$

Result 2 established that $d\hat{s}/d\tau < 0$. Thus, a sufficient condition for Result 3 is $dL(V/\hat{s})/d\hat{s} < 1/\rho$. Using equation (3) it can be shown that

$$\frac{dL(V,\hat{s})}{d\hat{s}} = \left[1 - \left(\frac{V}{V^D}\right)\right]\frac{1}{\rho} + \left[V^D - \frac{\pi+\hat{s}}{\rho}\right]\frac{d}{d\hat{s}}\left(\frac{\pi}{\pi+\hat{s}}\right)^{\beta}$$

It is straight forward to show that the value of this expression is less than $1/\rho$. Consequently, it necessarily follows that $d\textit{(Rent)}/d\tau > 0$.

Result 4

The $s \geq s^d$ assumption ensures the landowner agrees to donate her easement. Regarding the value of Ω, there are two possibilities: $\Omega^A \leq \Omega \leq \Omega^*$ and $\Omega^A > \Omega \leq \Omega^P$. In the first case, $\Omega \in [\Omega^A, \Omega^*]$ implies the agency agrees to hold a donated easement and this decreases welfare since necessarily $\Omega < \Omega^P$. In the second case $\Omega \in [\Omega^A, \Omega^P]$ implies the agency is willing to hold an easement that decreases welfare and the agency chooses to price the easement at zero since necessarily $\Omega \leq \Omega^*$.

Recall that $\Omega^A = W(V,\bar{s}) + F$ and $\Omega^P = \bar{W}(V,\bar{s}) + F + \bar{L}(V,\bar{s}) - \frac{\pi+\bar{s}}{\rho}$. A comparison of the Ω^P expressions with equation (17) reveals that the sign of $\Omega^* - \Omega^P$ is ambiguous. Nevertheless, what is important for the analysis is that $\Omega^A < \Omega^*$ and $\Omega^A < \Omega^P$ to ensure the set of values for Ω that give rise to Result 4 is non-empty. Similar to establishing the sign of the second order conditions in the analysis above the fact that $W(V,s)$ is an increasing function of s implies that the signs of $\Omega^A < \Omega^*$ and $\Omega^A < \Omega^P$ are ambiguous in the general case. The rest of this proof establishes that $\Omega^A < \Omega^*$ and $\Omega^A < \Omega^P$ for the case of no uncertainty ($\sigma \to 0$) and a sufficiently small value of F.

With no uncertainty the expression for $W(V,s)$ is given by equation (7). Substituting this expression into $\Omega^A = W(V,\bar{s}) + F$ and equation (17) and in each case solving for Ω results in the following pair of expressions:

$$\Omega^A = \int_{s^d}^{\infty} \frac{F}{\left[1 - \phi + \phi\left(\frac{V}{V^D(s)}\right)^{\beta}\right]} g(s)ds$$

and

$$\Omega^* = \frac{F}{1 - \phi + \phi\left(\frac{V}{V^D(s^d)}\right)^{\beta}} + \frac{\frac{1-G(s^d)}{g(s^d)}\frac{\lambda}{\rho(1-\tau)}\left(\frac{V}{V^D(s^d)}\right)^{\beta}}{1 - \phi + \phi\left(\frac{V}{V^D(s^d)}\right)^{\beta}}$$

If the second term in the Ω^* equation is ignored then because $V^D(s) = \frac{\beta}{\beta-1}(\pi + s)$ is an increasing function of s it follows that $\Omega^* < \Omega^A$. The second term in the Ω^* equation is positive and so it follows that a sufficiently small value of F ensures the desired $\Omega^* > \Omega^A$ outcome. Next compare $\Omega^P = \bar{W}(V,\bar{s}) + F + \bar{L}(V,\bar{s}) - \frac{\pi+\bar{s}}{\rho}$ with $\Omega^A = W(V,\bar{s}) + F$. If equation (3) is substituted into the first equation it is straight forward to show that $\Omega^P > \Omega^A$.