Optimal Compensation for Endangered Species Protection under Asymmetric Information

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INTRODUCTION

This paper addresses the problem of how to optimally structure economic incentives for landowners to enhance bio-diversity protection on private lands and to cooperate with Endangered Species legislation. It is motivated by two observations relating to regulation under asymmetric information. Firstly, even if landowners are compensated for regulatory losses to reduce perverse incentives for species conservation, any compensation scheme that may be adopted must anticipate possible strategic behavior on part of the landowners. Secondly, compensation payments on the basis of the opportunity cost of the land do not guarantee the protection of the most valuable habitats, when the owners have private information on the habitat value of their lands. The problem of optimally structured incentive schemes and the existing knowledge on regulation under asymmetric information has not yet been formally explored in the ESA literature. The paper applies a standard principal-agent framework to design a compensatory contract scheme, which induces landowners to reveal privately held information on conservation value of their land and to self-select a contract according to their underlying marginal conservation costs.

The Endangered Species Act (ESA) of the United States continues to generate controversy in the literature. It has received considerable criticism as a regulatory instrument for species conservation, since its success in terms of species recovery and de-listing is judged to be only moderate (Brown and Shogren, 1998; Polasky et al, 1997; Segerson, 1997; Fox and Adamowicz, 1997). Economists criticize the ESA for its missing economic rationale for species prioritization in the light of constrained public budgets and the perverse incentives for private landowners[1] (Brown and Shogren, 1998; Segerson, 1997; Merrifield, 1996). The current design of the ESA lacks almost completely the theoretical underpinnings that might reasonably guide policy (Metrick and Weitzman, 1998). Moreover, "Shoot, shovel and shut-up" is documented as one of landowners' strategies to avoid costly regulation. This is interpreted as a response to uncompensated land use restrictions in favor of habitat conservation under the current legislation.

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1 Landowners play a vital role in endangered species conservation, since more than 50% of the listed endangered species are found on private lands (Defenders of Wildlife, 1994)

Some authors have argued that the Endangered Species Act itself has become a significant threat to endangered species protection.

The discouraging conservation success of the ESA, and the ‘fairness debate’ lead by property rights advocates, have motivated the 'compensation' discussion. Compensating landowners for regulatory losses incurred under the ESA legislation, it is argued, will reduce polarization and increase acceptance of conservation programs, as some experimental evidence on wolf protection in the Northern Rocky Mountains shows (Defenders of Wildlife, 1994). Linking public benefits form habitat protection to private economic decision-making, will presumably correct the skewed incentives and increase the landowners' needed cooperation for species conservation.

Ultimately, the question of whether to compensate or not has to be resolved in a democratic process. Settling this question, however, does not exhaust the larger debate of how to optimally structure any compensation scheme that may be adopted to ensure the desired regulatory results. The purpose of this paper is to investigate the conditions and the specific design requirements if compensation is granted to private landowners. Landowners can be expected to hold superior information not only on their compliance with the existing regulations, but also on species and habitat value of their property. This information is needed by the regulator to achieve an efficient regulatory outcome. However, the ESA literature lacks formal attempts to investigate optimally structured incentives for landowners to reveal this privately held information. This information, once revealed by the landowners, can potentially be used to reduce the social costs of endangered species conservation.

COMPENSATION AND INFORMATION

Economic theory suggests conditions of uncertainty and informational asymmetries between economic parties require incentive compatible compensatory schemes to reduce inefficient resource allocations (Lewis, 1996; Wu and Babcock. 1996; Sappington, 1991; Spulber, 1988; Stiglitz, 1987; Shavel, 1987; Holmstroem, 1979; Mirrlees, 1976). Originally researched in the context of private making decision delegation, the basic results of this literature equally apply to a regulatory context, when conservation tasks are delegated to private individuals or groups thereof.

The endangered species literature recognizes asymmetric information between the regulator and the private landowners. The argument is used for favoring as well as for rejecting compensation of private landowners for land use restrictions under the ESA. As the discussion in the literature shows, privately held information by the landowners has implications for both, the effectiveness of conservation and regulatory efficiency. Consequently, compensation payments per se cannot entirely solve regulatory problems of the endangered species legislation.

Some authors argue in favor of landowner compensation to increase the effectiveness of conservation regulation because full monitoring of landowners' compliance with ESA stipulations is prohibitively costly, and even impossible (Innes, Polasky and Tschirhart, 1998; Stroup, 1997) They conclude that failure to compensate for costly regulation defeats the purpose of the legislation as it creates the perverse incentive for landowners to deliberately modify habitat or even extinguish species on their land to avoid costly regulation. Polasky and Doremus (1998) analyze the relationship between compensations and the burden to proof violations of endangered species legislation. Unsurprisingly, they find that if the regulator has to proof harm before imposing costly regulation, landowners are unlikely to cooperate in information collection neither on the exiting species nor on possible harms that an intended land use might impose. They suggest compensatory measures under certain conditions to increase landowners' cooperation.

On efficiency grounds, however, full compensation for regulatory losses must be rejected, because of the underlying informational asymmetries and the associated moral hazard problem (Cohen and Radnaff, 1998; Miceli and Segerson, 1996; Blume et al. 1984).[2] In the prospect of being fully

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[2] Moral hazard arises when individual economic actors engage in risk sharing under conditions in which privately taken actions affect the probability distribution of the outcome (Holmstrom, 1979). The classical example of moral hazard originates in the insurance literature and describes ..."the tendency of insurance protection to alter an individual's motivation to prevent loss" (Shavell, 1979, p. 541).

compensated for regulation, investors have a reduced incentive to avoid irreversible investment decisions (Miceli and Segerson, 1996). Inefficient over-investment in potentially regulated (and, therefore, risky) lands is the anticipated result of such regulation. Instead of receiving a compensation from the regulator, some argue, the risk of incurring a regulatory taking can potentially be mitigated through risk sharing via private insurance markets (Cohen et al., 1998).

Innes et al. (1998) addresses the problem of landowner compensation and asymmetric information when landowners hold private information regarding their personal valuation for conserving their property. They argue, that landowners value endangered species conservation and are potentially willing to accept a compensation payment lower than the opportunity cost of the land. Their individual conservation valuation, however, differs and realizing the political unpopularity and the associated deadweight losses of raising public funds, the regulator would like to separate the landowners according to their willingness to accept lower payments. In contrast, the landowners have an incentive to conceal this information to extract a surplus when being compensated.

IMPLICATIONS OF HIDDEN HABITAT CHARACTERISTICS FOR REGULATORY EFFICIENCY

Habitat conservation implies a partial or full surrender of alternative land uses, such as agriculture, forestry, mining and real estate development. Net social economic benefits over both alternatives are maximized when attaining a socially optimal level of habitat conservation for endangered species at minimum forgone benefits from alternative land uses. This is particularly relevant when sites are heterogeneous in habitat qualities.

Suppose it is possible to prioritize endangered species in terms of their social value[3] and to translate conservation value into a point scheme of potential habitat value per hectare. The potential habitat value per ha is expressed as a quality index, which consists of long-term habitat value indicators, such as the physical, biological and other environmental site characteristics for certain species targeted.

Moreover, it is used to specify the conservation actions that must occur to assure the persistence of those species[4]. Individual sites are likely to differ in their ecological features and, thus, their habitat qualities and their suitability for endangered species. The point system allows a ranking of land parcels according to their conservation value. Each site can be assigned a potential amount of individual conservation units (θ_m). The socially optimal level of total conservation units, Θ^*, is achieved where social marginal conservation costs and benefits are equal, $C'(\Theta^*)$, are equal to social marginal benefits, $B'(\Theta^*)$.

In the economic analysis, differences in the sites' index values per ha translate into differences in individual marginal conservation costs, $mc^i(\theta)$, for a given amount of conservation units. Regulatory efficiency requires equal marginal costs across sites, $mc^i(\theta) = mc^j(\theta)$, implying higher levels of conservation units per ha the lower the marginal conservation cost, given a constant price per unit θ.

While subsidy payments potentially achieve efficiency, they do so only if the regulator has perfect and certain knowledge on social marginal habitat conservation costs, $C'(\Theta)$, and benefits, $B'(\Theta)$. This raises the question on optimal subsidy rates and their structure, if habitat quality and the corresponding marginal conservation costs differ across sites, the regulator is not able to perfectly distinguish amongst them, and cannot derive the social marginal costs of habitat provision.

Public agencies have only restricted access to private land, making owners likely to be quantitatively and qualitatively better informed about the conservation value of their properties (Polasky et al., 1997). They are better able to observe the ecological features of their parcels, the quantities and qualities of endangered species the property hosts, their feeding, mating, and breeding habits, their locations etc. Consequently, landowners are privately informed on individual marginal conservation costs, $mc^i(\theta)$. This information is needed by the regulator not only to establish a socially optimal subsidy rate

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3 For a further discussion on the issue of prioritizing endangered species see Metrick and Weitzman 1996 and 1998.

4 For a detailed description of the biological considerations on determining the conservation value in terms of conservation units see Olson et al. (1994)

per ha of retired land (s*), but also to obtain a more complete picture on the habitat potential in the economy.

A complication is added, if neighboring plots mutually influence their habitat values. For example, conservation effort by one owner can increase not only the attractiveness of his own property for endangered species, but also the attractiveness of neighboring plots. Vice versa, if one property owner decides not to exert conservation efforts, her neighbor's attempts to conserve may be fruitless. It is likely that the regulator is not able to fully observe these interactions.

The theoretical literature on asymmetric information suggests that private marginal cost information leads to strategic behavior on part of the landowners in pursuit of information rents. Landowners with low marginal conservation cost can increase their net benefits by pretending to be 'high cost' habitat providers. As a result, they provide less conservation units, θ, per ha than socially efficient and receive lower total subsidy payments, but still pocket a surplus as the subsidy per conservation unit exceeds their individual marginal cost. Consequently, total habitat conservation, Θ, is non-optimally low, while landowners extract information rents and additional benefits from non-optimally high 'productive' land uses. Paying compensation based on market opportunity costs of the land does not quite capture this point. It does not necessarily induce private landowners to reveal additional habitat quality information and it does not guarantee habitat conservation differentiated according to the conservation value. Essentially, compensation must be paid on the basis of the conservation performance of the landowner and the problem of hidden 'type' information can be mitigated.

OPTIMAL CONTRACT DESIGN FOR SPECIES CONSERVATION

As suggested in the mechanism design literature (Kreps, 1990; Tirole, 1997, D'Asperemont, 1999), the regulator can mediate the informational efficiency problems by a clever design of a menu of contracts from which landowners self select according to their individual marginal conservation costs. To avoid strategic behavior of the low cost agents, the contracts must be specified in terms, which are attractive solely for the cost type targeted. The role of incentives, therefore, is not only to compensate the landowners for private losses, but also to extract and use this privately held information to improve the regulatory efficiency.

Basic assumptions of an optimal incentive model

Assume an agricultural setting in which land can be dedicated to both, agricultural production and habitat conservation. Landowners, who participate in a land retirement program commit to well-defined land use restrictions on or complete surrender of their plots[5]. Accordingly, they provide habitat conservation units at a technically determined ratio. They forgo (net present) benefits from alternative land use, which captures the cost (marginal trade-off) of alternative land uses and habitat conservation[6]. In return, landowners receive a compensation payment as well as the benefits from the (reduced) alternative land uses[7].

Plots are assumed to be homogeneous in their non-conservation use value[8]. They differ, however, in marginal conservation cost functions, according to their habitats values/c characteristics. For simplicity, assume two plot types (T^i) only with 'high' and ‘low’ marginal conservation costs, $mc^h(\theta)$ and $mc^l(\theta)$. The regulator knows the types of marginal conservation cost functions and can assign a probability distribution, p^i, for each type. Therefore, she is able to derive marginal social costs of habitat conservation; furthermore, we assume the regulator to perfectly know social marginal conservation benefits. However, she is not able to perfectly distinguish between them and, neither, to perfectly observe the underlying conservation action, a_k (with k = l, h, of each participating owner). Conservation outcome, θ_m, with m = l, h, or an exact index thereof, however, is assumed to be perfectly observable and a perfect signal of the underlying conservation action[9].

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5 The model follows the idea of habitat conservation plans (HCP) as suggested by the collection of articles by Defenders of Wildlife (1994)

6 For example, the conservation value per ha agricultural or forested land differs, depending on site management intensity.

7 Subsidy payments and returns from alternative land uses are assumed to be certain.

8 I.e. if no habitat is conserved profits per ha are equal across sites.

9 If a high conservation outcome is observed then a high conservation action was taken with certainty and vice versa.

Objective functions

The regulator's objective

The regulator's objective is to maximize social welfare from habitat conservation and alternative land use. The objective function is written as $\max_{\{H\}} W \equiv B(\Theta) - C(\Theta)$, where $B(\Theta)$ denote social benefits and $C(\Theta)$ the forgone benefits from alternative land uses. At the optimum, $B'(\Theta^*) = C'(\Theta^*)$, yielding the marginal social value, s^*, per conservation unit, θ.

To minimize social costs while achieving Θ^*, the regulator wishes to separate the plots according to their marginal conservation costs, such that high cost types provide low levels of conservation units, θ_l, per ha, choosing a_l accordingly, and vice versa. Maximum social welfare is attained when high cost plots provide low levels of habitat units and low costs plots provide high levels of habitat units:

$$\text{Max } W \equiv T^{h*}(\theta_l) + T^{l*}(\theta_h).$$

Notice, that the trade-off between agriculture and conservation is captured in the marginal cost curves of providing habitat. Therefore, the optimal levels of habitat implicitly capture the optimal levels of agricultural production.

The landowners' objective

Landowners maximize net benefits from compensation payments for participating in the land retirement program, $S(\theta_m)$, and the costs of the program in terms of the forgone benefits from agricultural production, $C^i(\theta_m)$, i.e.

$$\pi^i = S(\theta_m) - C^i(\theta_m), \qquad \text{with } C^i(\theta_m) = \pi^i_0 - \pi^i(\theta_k)$$

where type i = l implies k, m = h, and type i = h implies k, m = l. Participation in the program must yield at least positive profits: $\pi^i = S(\theta_m) - C(\theta_m) \geq 0$, or, alternatively $\pi^i = S(\theta_m) + \pi^i(\theta_k) \geq \pi^i_0$, where π^i_0 indicates the reservation profit, i.e. not participating in the land retirement program.

Contract Specification under Symmetric Information

Firstly, consider the case when the regulator can perfectly distinguish between types and thus, knows individual marginal conservation cost functions. She knows which type of conservation outcome is required for each type to achieve a socially optimal conservation level. The solution is to establish a target-outcome of conservation units for each agent that meets their reservation constraints. The regulator offers each type a specific contract, consisting of compensation payment and an according level of habitat protection, $[S^h,\theta_l]$ and $[S^l,\theta_h]$, for the high cost and low cost agent, respectively. She maximizes net benefits from habitat protection subject to the agents' reservation constraints

(1) $\text{Max}_{\{S^h(\theta l), S^l(\theta h)\}}$ $\quad p^h[\theta_l - S^h(\theta_l)] + p^l[\theta_h - S^l(\theta_h)]$

(2) s.t. $\quad S^h(\theta_l) - C^h(\theta_l) \geq 0$ $\quad$ for high cost plot types

(3) $\quad S^l(\theta_h) - C^h(\theta_h) \geq 0$ $\quad$ for low cost plot types

The cost minimizing solution is to set $S^h(\theta_l) = C^h(\theta_l) = \pi^h_0 - \pi^h(\theta_l)$ and $S^l(\theta_h) = C^l(\theta_h) = \pi^l_0 - \pi^l(\theta_h)$. Each landowner will produce the targeted amount of conservation.

Optimal Compensation Payments under Asymmetric Information[10]

Under asymmetric information, the regulator does not know the group identity of any individual landowner. As she is assumed to know social marginal costs and benefits of habitat conservation, she establishes a socially optimal level of habitat conservation, Θ^*, and a social price per habitat conservation unit, s*, which we normalize to 1. She offers a menu of contracts, $[S^i, \theta^i]$, that induces self-selection and self-identification of the landowners the desired conservation outcome on each plot. What are the exact terms of such contracts?

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[10] The model follows largely Varian (1992) on hidden information, in which the regulator assumes the role of the 'monopolistic' principal and the land owners the role of the agents.

In addition to the constraint that each agent receives her reservation profit per hectare, self-selection constraints need to be imposed on the problem to induce each owner to commit to the 'correct' level of habitat provision and to self-select the corresponding contract:

(4) $S(\theta_l) - C^h(\theta_l) \geq S(\theta_h) - C^h(\theta_h)$ for high cost plot types

(5) $S(\theta_h) - C^l(\theta_h) \geq S(\theta_l) - C^l(\theta_l)$ for low cost plot types,

Assuming that the landowner with higher total conservation costs also has higher marginal costs for every unit of habitat provided[11], the self-selection constraints induce high cost land owners to prefer low conservation outcomes and low cost owners the prefer high conservation outcomes, and to receive the corresponding compensation payments.

The regulator's objective is to maximize net social benefits from habitat conservation, i.e. total social costs minus total benefits. However, as individual cost functions are not a priori observable, the compensation payments offered to each agent differ from the actual habitat conservation costs incurred by each agent.

The regulator, maximizes (1), subject to (2) to (5).

(1) $\text{Max}_{\{S^h(\theta l),\, S^l(\theta h),\, \theta l,\, \theta h\}}$ $p^h[\theta_l - S^h(\theta_l)] + p^l[\theta_h - S^l(\theta_h)]$

s.t. participation constraints

(2) $S(\theta_l) - C^h(\theta_l) \geq 0$ PC for high cost plot types

(3) $S(\theta_h) - C^h(\theta_h) \geq 0$ PC for low cost plot types

incentive compatibility constraints

(4) $S(\theta_l) - C^h(\theta_l) \geq S(\theta_h) - C^h(\theta_h)$ for high cost plot types

(5) $S(\theta_h) - C^l(\theta_h) \geq S(\theta_l) - C^l(\theta_l)$ for low cost plot types,

The solution to this maximization problem is treated by Varian (1992). The optimal payments are derived by solving the binding constraints (2) and (5) for $S(\theta_m)$:

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11 It follows from the assumed single crossing property for the landowners' utility function $u^i (s^i, c^i) = s(\theta_m)\text{-}c^i(\theta_m)$.

$S^*(\theta_l) = C^h(\theta_l)$ and

$S^*(\theta_h) = S(\theta_l) + C^l(\theta_h) - C^l(\theta_l)$,

which implies $S^*(\theta_h) > C^l(\theta_h)$ and $S^*(\theta_h) > S(\theta_l)$.

For high cost plots, the compensation payments are equal to the private costs (= social costs) of habitat provision. The payments to the low cost type, however exceed private costs of habitat provision, increasing social costs of habitat provision beyond private costs

The optimal levels of habitat conservation of each agent are given by

$C'^l(\theta_h) = 1 = s^*$ for the low cost landowner

and

$C'^h(\theta_l) = 1+p^l/p^h[C'^l(\theta_l) - C'^h(\theta_l)] < 1 = s^*$ for the high cost landowner.

This implies that low cost types provide the socially optimal levels, whereas high cost plots provide less habitat than socially optimal.

The solution to this problem separates the different types according to their marginal costs. It shows, however, that the structured incentives do not fully accommodate the inefficient outcomes resulting from asymmetric information. Some inefficiency remains in that total habitat conservation, Θ, is less than optimal and the low cost types extract information rents, i.e. the compensation payments exceed the private costs of providing high levels of habitat. Given the informational constraints the solution describes the second-best provision of habitat.

DISCUSSION AND FURTHER EXTENSIONS

The suggest approach for optimally structuring compensation payments in the context of endangered species protection is a first formalized step towards addressing the implications of informational asymmetries between the regulator and the landowners regarding the habitat value. The standard result is derived that the compensation incentives for the low cost landowners need to exceed their conservation costs in order to avoid inefficient levels of habitat provision.

Several points deserve discussion and need to be extended for further development of the approach. Firstly, the standard model assumes that habitat values between landowners are completely independent of each other. This implies that contracts can be formulated on a one to one basis between the regulator and the landowner. More realistically, however, habitat values of individual plots within a defined area are mutually dependent on conservation levels on surrounding sites. This implies that the level of habitat provided by other landowners enters the habitat production function of all individuals who consider participating in the program. The conservation externalities between different landowners must be explicitly accommodated by the incentive scheme to avoid free riding of the landowners on each others' conservation contributions or a complete disinterest of the landowners in the program.

Secondly, it is prohibitively costly to fully monitor each individual conservation outcome and conservation outcome is likely to be randomly disturbed by nature beyond the landowners' control. As the landowners' individual conservation decisions affect the probability distribution of the conservation outcome, a potential moral hazard problem arises when conservation outcome is not a perfect signal of the underlying conservation effort (and the opportunity cost) by the owner.

Both aspects raise the question on how the conservation performance should be evaluated and its implications for the incentive schemes. Conservation performance should be based on objectively measurable indicators, which establish a relationship between (a) (imperfectly) monitored habitat value and the actual habitat value; (b) the monitored total habitat value and the individual conservation contributions on each plot; (c) the individual conservation outcome and the actual incurred cost of conservation. For example, a multi tier compensation scheme could be designed that consists of a flat rate for participation and variable premiums according to the individual and group conservation successes.

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