Conservation of Endangered Species: Can Incentives Work for Private Landowners?

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Paper prepared for presentation at the American Agricultural Economics Association Annual Meeting, Montreal, Canada, July 27-30, 2003

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Abstract

It has been argued that the traditional regulatory approach of the Endangered Species Act, based on land-use restrictions, has failed to protect endangered species on private land. In response, there has been a call for the use of incentives to complement this regulatory approach. This paper examines the potential of incentives programs to elicit conservation-oriented management choices from landowners. Data obtained from a survey of non-industrial private forest owners in Oregon and Washington is used to examine the effectiveness of various incentives. The results indicate that incentives, in particular compensation and assurances, can be effective in increasing the conservation effort provided by landowners. The results also suggest that conservation policy for private lands could be improved by relying on a combination of incentives, including financial incentives and assurances, rather than exclusively on the threat of regulation.

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INTRODUCTION

The conservation of endangered species on private land remains a controversial topic. Section 9 of the Endangered Species Act (ESA) prohibits any private action that may directly result in the taking of endangered species. Additionally, as interpreted by the U.S. Fish and Wildlife Service (FWS), it restricts any activity that may indirectly harm a species by modifying its habitat in ways that hinder essential activities, such as feeding and breeding[1]. These restrictions can encompass otherwise lawful activities such as logging, construction, or grazing, and thus have raised vigorous opposition from property rights advocates. As a result, enforcement of Section 9 has become increasingly difficult. This could severely undermine endangered species recovery efforts under the ESA, because more than half of the listed endangered species have at least 80% of their habitat on private land (FWS 1997a).

Furthermore, it has been widely maintained that a common reaction by landowners to the prospect of these restrictions is to "shoot, shovel, and shut up". That is, the traditional approach to regulation may generate perverse incentives that compel landowners to manage their land in ways that discourage the presence of endangered species, in order to avoid land-use restrictions. This argument has been made formally by Polasky and Doremus (1998), Innes (2000), and Polasky (2001), and anecdotal evidence of such behavior abounds (see, e.g., Mann and Plummer 1995, Bean and Wilcove 1997, Bean 1998).

[1] This interpretation was upheld by the Supreme Court in Babbitt v. Sweet Home Chapter of Communities for a Great Oregon, 515 U.S. 687 (1995).

Michael and Lueck (2000) have found empirical evidence of this behavior in the case of private forest owners in the southeast and the red-cockaded woodpecker.

Another potential drawback of Section 9 of the ESA is that it is "all sticks and no carrots", since its goal is to prevent harmful conduct by landowners rather than encourage desirable behavior. For many endangered species, benign neglect might be insufficient to bring about recovery, as they require active management of their habitat (Bean and Wilcove 1996, Bean 1998). This can give rise to costs that even well-meaning landowners might not be willing to undertake. Additionally, there are opportunity costs of forgone revenue from the most profitable use of the property.

Thus, Section 9 of the ESA seems to grant inadequate protection to endangered species on private land, and may even cause the very behavior it attempts to prevent. Hence, there has been a call for the use of incentives-based voluntary programs to complement the existing regulatory framework. Two main approaches have been suggested. The first one is based on agreements that provide landowners with assurances regarding future regulation, such as "no surprises" Habitat Conservation Plans or Safe Harbor Agreements (Wilcove *et al*. 1996, Bean and Wilcove 1996). The second approach is based on offering the landowner incentives to manage his land in a way that is compatible with the survival and recovery of endangered species. These incentives include, for example, compensation payments, tax credits, cost sharing agreements, public recognition, and stewardship certification (see, e.g., Keystone Center 1995 or Vickerman 1998).

Much of the existing literature on incentives for conservation has focused on their application on farmland. For instance, McLean-Meyinsse *et al.* (1994) examine small farmers' willingness to participate in the Conservation Reserve Program (CRP), and Cooper and Osborn (1998) analyze re-enrollment in the CRP as a function of the rental rate paid. Smith (1995) uses mechanism design theory to characterize the properties of a least-cost CRP, and Wu and Babcock (1996) derive optimal payment schedules for an environmental stewardship program.

The use of incentives has been examined in the case of private forest owners as well. Boyd (1984) evaluates the impact of cost-sharing and forester assistance on non-industrial timber supply. Royer (1987) shows that the reforestation decisions of landowners are responsive to cost-sharing assistance. Hardie and Parks (1996) analyze how cost sharing could have affected investment in pine regeneration between 1971 and 1981. Kluender *et al.* (1999) find that landowners who manage their forest for timber would engage in forestry practices regardless of assistance payments.

There is also a growing literature that specifically addresses the use of incentives to promote management that benefits endangered species (see, e.g., Smith and Shogren 2001, 2002, Defenders of Wildlife 1994, Stone 1995, Kennedy *et al*. 1996, Bourland and Stroup 1996). However, there have been relatively few formal empirical analyses of the effect of incentives on private landowners' decisions. Kline *et al*. (2000) examine the willingness of non-industrial private forest owners (NIPFs) to forego harvesting to improve habitat for endangered salmon. Zhang and Flick (2001) measure the impact of both the ESA and cost-share and tax incentives on the reforestation investment behavior of NIPFs.

This paper adds to this literature by analyzing the likely effects of assurances, cost sharing, and compensation incentives on landowners' management decisions in the specific context of endangered species conservation. I used data from a survey of NIPFs in Oregon and Washington to construct econometric models that measure the probable effect of these incentives on landowners' willingness to provide conservation effort. This allowed me to assess the potential of these incentives as a policy tool for managing endangered species on private land. Additionally, the estimates from the econometric models were used to examine the effectiveness of different incentive program designs.

The results obtained provide evidence that conservation policy for protecting endangered species on private land could be improved by offering “carrots” to landowners to complement the existing regulatory “sticks”. Specifically, the analysis indicates that compensation and assurances could have a significant effect on landowner’s management decisions, but cost sharing may not. Furthermore, the results suggest that policy makers can design more effective incentives programs by combining financial incentives with assurances about future regulation.

The remainder of this paper is organized as follows. First, I present an analytical framework to motivate the econometric analysis, followed by a description of the data and the survey instrument used to obtain it. After that, I present the econometric model and the empirical results. Then, a simulation is conducted to analyze the implications of the empirical results for the design of incentives programs. Finally, I discuss the main findings and conclude.

ANALYTICAL FRAMEWORK

In this section, I assume that a landowner has voluntarily agreed to participate in a conservation agreement, and I use a simple model to examine how different incentives can affect the amount of conservation effort the landowner is willing to supply. This analysis will provide a basis for the development of the survey instrument and the empirical models that follow.

Following Langpap and Wu (2002), I use a two period model of the interaction between a landowner and a regulator, in which the first period represents the present and the second period represents the entire future time horizon. Suppose that at the beginning of period 1 a regulator, such as the FWS, approaches a landowner and proposes that he voluntarily participate in a conservation agreement and supply conservation effort levels c_{v1} and c_{v2} for periods 1 and 2, respectively. To fix ideas, suppose that c_{v1} and c_{v2} represent a specific management plan for the property.

At the beginning of period 2 the regulator may learn that a change in the management plan is necessary (for instance, new knowledge about a species may become available, or an unforeseeable event may alter the status of a species), and thus he may require that the management plan for period 2 be $c_2^* > c_{v2}$. This occurs with probability q.[2] Although the required changes are not known until the second period, in period 1 the landowner forms an expectation about the alternative management plan, denoted by Ec_2^*.

In exchange for participating and supplying conservation effort, the landowner is offered one or more of three incentives: cost sharing on out-of-pocket costs of implementing the management plan, assurances that no additional conservation effort will be required in period 2 (i.e. that the management plan in period 2 will be c_{v2}, as originally agreed, rather than c_2^*), and compensation for opportunity costs of implementing the management plan.

The landowner may reject the proposition. If he does, he faces the possibility that, with probability p, the regulator will impose mandatory conservation levels c_{m1}^* and Ec_{m2}^*, which could represent restrictions on harvesting or development on the property[3]. If no

[2] The probability q characterizes the regulator's *a priori* unknown willingness or ability to require more conservation. For instance, the regulator may be unwilling or unable to modify an existing management plan for political reasons or due to lack of funding for additional research and enforcement expenses.

[3] Regulation is uncertain because the regulator may be unable or unwilling to enforce the law due to information requirements, high burden of proof, or political considerations (Polasky and Doremus 1998).

mandatory conservation is imposed, the landowner develops his property, and thus does not supply any conservation effort.

Let a_i and b_i be the unit out-of-pocket and opportunity costs of conservation, respectively, for $i = v$, m. Out-of-pocket costs include, for example, labor and machinery costs of thinning a stand of forest. Opportunity costs include, for example, the revenue forgone when a stand of forest is not harvested. Additionally, let γ be the fraction of out-of-pocket costs incurred by the landowner under a cost-sharing incentive. Similarly, let α be the portion of opportunity costs incurred by the landowner under a compensation incentive. I assume that the costs of conservation are linear, and that it is cheaper to provide a given conservation effort under a voluntary agreement than under a mandatory agreement, i.e. $a_v + b_v < a_m + b_m$. The reasoning behind this assumption is that a voluntary agreement provides more flexibility for the landowner to choose the most cost-effective way to provide any given level of conservation effort. The landowner will accept the regulator's proposition and implement management plan (c_{v1}, c_{v2}) if and only if

$$(\gamma a_v+\alpha b_v)c_{v1}+q(\gamma a_v+\alpha b_v)E c_2^* +(1 - q)(\gamma a_v+\alpha b_v)c_{v2} \leq p(a_m+b_m)(c_{m1}^* + E c_{m2}^*) \tag{1}$$

The cost sharing, compensation, and assurances incentives are thus given by $\gamma < 1$, $\alpha < 1$, and $q = 0$, respectively. Decision rule (1) can be rearranged to define the landowner's acceptance set

$$S_L = \{(c_{v1}, c_{v2})|c_{v1} + (1- q)c_{v2} \leq p \frac{a_m + b_m}{\gamma a_v + \alpha b_v} (c_{m1}^* + E c_{m2}^*) - qE c_2^* \} \tag{2}$$

This set can be interpreted as containing all the management plans that the landowner will accept as part of a conservation agreement. The set S_L is shown in Figure 1.

Suppose that the regulator and the landowner reach an agreement, under which the landowner will provide the maximum conservation effort he is willing to supply[4]. That is, condition (1) holds with equality. This means that the management plan (c_{v1}, c_{v2}) is on the upper boundary of the set S_L in Figure 1. If this management plan does not coincide with the regulator's first choice of conservation effort (for instance, that which maximizes net social benefits from conservation, as in Langpap and Wu 2002), the regulator may try to elicit higher conservation effort by using cost sharing, compensation, and assurances incentives. To understand the potential effect of these incentives, I examine how changes in the incentive parameters γ, α, and q affect decision rule (1) and the acceptance set S_L. Starting from a base scenario in which no incentives are offered, i.e. $\gamma = \alpha = 1$ and $q > 0$, the regulator can increase the level of conservation effort by setting $\gamma' < 1$ and $\alpha' < 1$ and by offering assurances, which sets $q = 0$. Thus, decision rule (1) becomes

$$(\gamma' a_v + \alpha' b_v)c_{v1} + (\gamma' a_v + \alpha' b_v)c_{v2} \leq p(a_m + b_m)(c^*_{m1} + E\, c^*_{m2}) \tag{3}$$

and the acceptance set is

$$S_L' = \{(c_{v1}, c_{v2}) | c_{v1} + c_{v2} \leq p \, \frac{a_m + b_m}{\gamma' a_v + \alpha' b_v} (c^*_{m1} + E\, c^*_{m2})\} \tag{4}$$

By comparing conditions (1) and (3), and sets (2) and (4), it is clear that cost sharing and compensation ($\gamma' < \gamma$, $\alpha' < \alpha$) can increase the conservation effort provided by the landowner by decreasing the cost of conservation. Additionally, Langpap and Wu (2002) show that offering assurances can increase the conservation effort supplied by the landowner when additional conservation is expected in the second period. The effect of these incentives is shown in Figure 2. The management plan with cost sharing, compensation, and assurances

[4] Langpap and Wu (2002) discuss the necessary and sufficient conditions for such an agreement. The landowner participates because of the cost advantage offered by voluntary agreements (as long as the expected future conservation requirements are not too large).

incentives is on the upper boundary of the set S_L' (the solid line), which is above that of the set S_L (the dashed line), corresponding to the case of no incentives. This indicates that a higher level of conservation effort is supplied when incentives are offered.

There are other factors, not considered explicitly in this simple model, which can affect the landowner's response to these incentives. For instance, the availability of technical assistance may lower the cost of conservation for some landowners. The opportunity cost of conservation may depend on characteristics of the landowner's property, such as size, or, in the case of a forest, the age of the trees. Additionally, landowners may derive utility from conservation, which could affect the opportunity cost. This utility, and therefore the opportunity cost, can depend on the landowner's original management plan for the property, as well as demographic characteristics such as age, occupation, or income. Furthermore, the landowner's perceived threat of regulation can affect the parameter p in the model, and thereby have an effect on the response to the incentives. Finally, other factors, such as the availability of technical assistance, could affect the cost of conservation as well.

In the following sections, I examine empirically whether cost sharing, compensation, and assurances can have an effect on the management plan that a landowner is willing to implement, as the results from this simple model suggest. The role played by other factors, such as landowner and property characteristics, will be analyzed as well.

SURVEY AND DATA

Survey

A survey instrument was designed to examine how landowners' management decisions would respond to cost sharing, compensation, and assurances incentives. The study area included 25 counties in western Oregon and Washington. The names and addresses of all NIPFs who owned at least 10 acres of land zoned as forest[5] were obtained from county tax assessor offices. A mail survey was designed and conducted according to the Total Design Method (Dillman 1978) in the summer and fall of 2001. A first version of the survey was pre-tested with two focus groups of NIPFs. A second version of the survey was mailed out to a subset of the sample as a further pretest. The final version of the survey was mailed out to 1,500 NIPFs, followed by a reminder postcard, and second and third mailings to non-respondents. Of the original 1,500 mailings, 101 surveys were undeliverable, so the final sample consisted of 1,399 forest owners. Seven hundred and thirty seven of the returned surveys were usable, which yields a response rate of 53% (or 49% of the entire sample of 1,500). Finally, a sample of 137 non-respondents (30% of total non-responses) were contacted by phone and asked for information on characteristics that could influence response[6]. This information was used to conduct a test for sample-selection bias, which is described below.

As in the analytical model, survey recipients were asked if they would be willing to participate in a conservation agreement, and presented with a choice of three hypothetical "incentives programs". Respondents who answered that they would not be willing to participate, regardless of the incentives offered, were excluded from the sample. Each program contained a management plan and some combination of the various incentives, as well as a technical assistance attribute. Landowners also had the option not to accept any of the incentives programs offered (see the Appendix for an example). This choice was

[5] Ten acres was chosen as a cutoff point because the distribution of landowners showed that there are relatively large numbers of landowners with small properties (up to 10 acres) and comparatively few owners with larger properties. Thus, a random sample that included all acreages would have resulted in larger landowners, who own most of the acreage, being underrepresented. Additionally, smaller holdings are more likely to be held as rural-residential properties, and not as forestland.

[6] Specifically, I obtained information on importance given to services provided by the landowner's forest, total acres owned, years they have owned the property, knowledge of incentives programs, perceived likelihood of regulation, age, occupation, and income.

presented three times to each survey recipient, and the composition of the incentives programs was varied across different versions of the survey. This setup makes it possible to observe how the landowners' willingness to implement different management plans varies as the levels of the various incentives change, and thus to measure the effect of these incentives on the level of conservation effort supplied. Additionally, to take into account other factors that may influence the landowner's response to the incentives, the survey included questions on characteristics of their land, their perceived risk of regulation under the ESA, and demographic information.

Data

The three management plans presented to landowners in the survey consisted of one or more of three silvicultural techniques: thinning, providing snags and downed logs, and managing under story vegetation. Implementation of these techniques may speed the development of forest structures required by endangered species commonly associated with the Pacific Northwest, such as spotted owl, marbled murrelet, and salmon (FWS 1992, 1997b, USDA 1993, Hayes *et al.* 1997). Plan 1 consists only of thinning, Plan 2 includes thinning and providing snags and logs, and Plan 3 consists of thinning, providing snags and logs, and managing under story vegetation. A key feature of these management plans is that they are progressively more complex, and hence increasingly beneficial to the species and costly to the landowner as well. These management plans are a proxy for the landowner's readiness to supply conservation effort. The increasing complexity provides a sense of ordering that makes it possible to measure whether incentives can elicit higher conservation effort. The resulting measure is the dependent variable in the model, PLAN = 0, 1, 2, or 3, where PLAN = 0 represents no conservation effort.

The main independent variables (SHARE, COMP, ASSURE) measure the levels of cost sharing, compensation, and assurances incentives offered. To account for the possibility that the effectiveness of these incentives may vary with income levels, opportunity costs, and the perceived probability of regulation, the incentive regressors were allowed to interact with these variables. Additionally, a landowner's choice of management plan may depend on the availability of technical assistance. Thus, the model includes a variable that indicates whether assistance is available or not (ASSIST).

The survey asked landowners how likely they believed it was that the ESA might restrict timber harvesting, development, or other activities on their land. The variable REGULATE is the likelihood of regulation given by the landowner on a 5-point scale, ranging from "Very Unlikely" to "Very Likely". The model also includes a number of demographic and land-characteristic variables that may have an effect on the cost of conservation. Finally, landowners were asked to consider a specific stand on their property where they might be willing to implement a management plan, and to provide information about this stand. The size and age of this stand (STANDSIZE, STANDAGE) are included to control for opportunity costs of participating in the incentives program. In addition, I control for alternative uses of the stand by including two dummy variables that describe the landowner's harvesting plans. A description of all these variables, along with summary statistics, is presented in Table 1[7].

[7] Earlier versions of the model explored the role of variables measuring the importance given by the landowner to various services provided by his forest, variables describing the landowner's knowledge of and experience with incentives programs, and variables controlling for membership in forestry and conservation organizations. None of these had a significant effect on management decisions, so they were left out of the models presented here.

ECONOMETRIC MODELS AND RESULTS

Given the ordered nature of the dependent variable, the model used for estimation is an ordered probit. Likelihood ratio tests revealed that some of the regressors (SHARE, ASSURE, ASSIST, SHXIN, ASXRE, STANDSIZ, HARV40) were heteroscedastic. To accommodate this, I used a general multiplicative formulation for the variance of the disturbances (Greene 2000): $Var[\varepsilon] = [\exp(\boldsymbol{v'z})]^2$, where $\boldsymbol{z}$ is the vector of heteroscedastic variables. With this specification, the log-likelihood function for the model is

$$\ln L = \sum_{PLAN=0} \ln \Phi(-\beta' x/e^{v'z}) + \sum_{PLAN=1} \ln[\Phi((\mu_1 - \beta' x)/e^{v'z}) - \Phi(-\beta' x/e^{v'z})] +$$

$$\sum_{PLAN=2} \ln[\Phi((\mu_2 - \beta' x)/e^{v'z}) - \Phi((\mu_1 - \beta' x)/e^{v'z})] + \sum_{PLAN=3} \ln[1 - \Phi((\mu_2 - \beta' x)/e^{v'z})] \qquad (5)$$

where $\boldsymbol{x_i}$ is a vector containing the regressors described in the preceding section (incentives, landowner and property characteristics), μ_1 and μ_2 are threshold parameters to be estimated along with $\boldsymbol{\beta}$, and $\Phi(\bullet)$ is the cumulative density function for the standard normal distribution. Table 2 shows the maximum likelihood estimates for two versions of this model (corrected for heteroscedasticity).

In model 1, the null hypothesis that the parameter estimates for age, education, occupation, and the variables for property characteristics are all equal to zero could not be rejected (the p-value for the Wald test is 0.91), so these variables are left out of model 2. The income dummies are not significant independently, but the null hypothesis that they are jointly equal to zero can be rejected ($p = 0.096$). The chi-squared statistics for overall fit and the scaled R^2 statistics indicate that the models have good explanatory power.

Sample Selection Bias

Models 1 and 2 were also tested for potential sample selection bias induced by survey non-response, a common problem with mail-administered surveys (Mitchell and

Carson 1989, Messonier *et al.* 2000). If non-response occurs in such a way that the factors that determine a landowner's choice of management plan and those that determine response are correlated, then the parameters estimated in the preceding models may be biased. The information obtained in the follow-up phone survey of non-respondents was used to conduct a two-step Heckman test for sample selection bias (Heckman 1979, Edwards and Anderson 1987, Mesonnier *et al.* 2000). The first step consists of a probit model of participation in the survey. The resulting parameter estimates are used to calculate the inverse Mills ratio (λ_1), which represents the probability of a recipient having responded (i.e. being in the sample). The inverse Mills ratio is then included as an additional regressor in Models 1 and 2 in the second part of the procedure. The test for sample selection bias is based on a *t*-test of the significance of the parameter estimate for λ_1. If it is not statistically significant, then the null hypothesis of no sample selection bias cannot be rejected. The results of this test for models 1 and 2 show that there is no evidence of sample selection bias: the *t*-statistics for λ_1 are -0.43, and –0.24, respectively.

An additional selection bias test is necessary because those survey respondents who answered that they would not participate in a conservation agreement regardless of the incentives offered were excluded from the sample. The two-step Heckman test is repeated, using a probit model of participation in the conservation agreement based on demographic and property characteristics of survey respondents. Once again, the results of the test show no evidence of selection bias: the *t*-statistics for λ_2 (the second inverse Mills ratio) are 0.28, and – 0.42 for models 1 and 2, respectively.

Results

The results presented in Table 2, which are consistent across both models (and others which are not reported), show that the coefficients of COMP and ASSURE are significantly different from zero, suggesting that compensation and assurances incentives would have an effect on the probability that landowners supply conservation effort. The coefficient of SHARE is not significantly different from zero, but that of the interaction variable for cost sharing and income (SHXIN) is. This suggests that the effect of cost sharing depends on the level of income. Additionally, the coefficient of HARV40 is significant, suggesting that landowners who plan to harvest in 40 or more years are more likely to manage the stand for endangered species than those who have medium- or short-term harvesting plans. It is also interesting to note that the coefficients of ASSIST and REGULATE are not significant, suggesting that technical assistance and the perceived likelihood of regulation may not affect the landowners' management decisions. These results are discussed further in section VI.

To understand the effects of the significant incentive variables (COMP and ASSURE) on the dependent variable, marginal effects were computed as follows. For a discrete variable that appears in $\boldsymbol{x}$ and $\boldsymbol{z}$, say x_k, define x_{ks} and x_{kf} as the starting and final values of x_k, respectively. Additionally, define $\bar{x}_{-k}$ as the vector of all regressors, except x_k, evaluated at their sample mean. Similarly, define $\bar{z}_{-k}$ as the vector of heteroscedastic variables, except x_k, evaluated at their sample mean. Then

$$Pr(\text{PLAN} = i|x_{kj}) = \Phi[(\mu_i-\beta_k x_{kj} - \boldsymbol{\beta}_{-k}'\bar{x}_{-k})/exp(\nu_k x_{kj} + \boldsymbol{\nu}_{-k}'\bar{z}_{-k})] - \Phi[(\mu_{i-1}- \beta_k x_{kj} - \boldsymbol{\beta}_{-k}'\bar{x}_{-k})/exp(\nu_k x_{kj}+\boldsymbol{\nu}_{-k}'\bar{z}_{-k})], \quad j = s, f.$$

The marginal effect of x_k is $\Delta Pr(\text{PLAN} = i) = Pr(\text{PLAN} = i|x_{kf}) - Pr(\text{PLAN} = i|x_{ks})$ for i = 0, 1, 2, 3 (Long 1997). Table 3 gives the signs of these marginal effects, and Figure 3 shows the probabilities in that each plan is chosen for the different values of the compensation and assurances incentives. The marginal effects for the compensation and assurances incentives suggest that increasing the level of compensation and providing assurances decrease the probability of no effort and a small amount of effort (PLAN=0 and PLAN =1) and increase the probability of higher levels of conservation effort (PLAN = 2 and PLAN = 3).

These results indicate that incentives could be used effectively to increase the level of conservation effort supplied by private landowners. They also suggest that some incentives may be more effective than others. For instance, in the particular scenario examined here, compensation and assurances would have a more significant effect than cost sharing. This raises the question of how to optimally design incentives programs by combining different incentives to achieve the largest effect on landowners' management decisions.

DESIGN OF INCENTIVES PROGRAMS

The parameters and marginal effects estimated in the preceding section are based on the incentives programs presented to landowners in the survey, which included different combinations of cost sharing, compensation, and assurances incentives. Designing conservation policy based on incentives may involve having to choose only one type of incentive (for instance, Habitat Conservation Plans, which provide assurances to landowners, generally do not offer financial incentives as well), or finding the most effective mix of incentives. Thus, it is useful to examine how a representative landowner's willingness to provide conservation effort changes for different combinations of incentives.

I conduct a simulation of the probabilities that each plan is implemented given different combinations of incentives, keeping all the other variables constant at their sample mean. To show the effects of the different incentives clearly, I assume they are applied at the highest possible level (75% for cost sharing and 100% for compensation). Additionally, I assume that no technical assistance is offered (there is no qualitative change in the results if assistance is included).

Table 4 shows the simulated probabilities that each plan is chosen. The base scenario is one in which no incentives are offered. In this case, it is most likely that the landowner would supply no conservation effort or low effort: the probabilities that he would choose Plan 0 or Plan 1 add to 99%, whereas the probability of high conservation effort (Plan 3) is zero. In scenario 1, only cost sharing is offered. This has the effect of decreasing the probability of no conservation effort (Plan 0) and increasing that of medium or high levels of effort (Plans 2 and 3). However, the probability that no effort or low effort is supplied remains high (the probabilities of Plan 0 and Plan 1 add to 77%). Scenario 2 offers only compensation. Relative to the base scenario, the probability of no effort (Plan 0) decreases considerably, whereas the probability that low or medium conservation effort is forthcoming (Plans 1 and 2) increases. The probability of high effort (Plan 3) increases modestly, but remains small. In scenario 3, the landowner receives only assurances. The probability of no conservation effort (Plan 0) decreases to zero, whereas the probability of low or medium conservation effort is high (the probabilities of Plan 1 and Plan 2 add to 98%). The probability of high conservation effort (Plan 3) increases slightly relative to the base scenario, but remains small.

These scenarios suggest that, although all three types of incentives can have an effect on landowners' decisions, cost sharing provides the weakest incentive, compensation has a somewhat stronger effect, and assurances is the most effective incentive. However, neither of these incentives, when used alone, is sufficient to significantly increase the probability that a high level of conservation effort (Plan 3) is provided.

In scenarios 4 and 5 the financial incentives, cost sharing and compensation, are combined with assurances. In Scenario 4, a combination of cost sharing and assurances decreases the probability of no conservation effort (Plan 0) and increases the probability of low and medium effort (Plans 1 and 2) considerably more than the cost sharing incentive alone. Finally, in Scenario 5 a combination of compensation and assurances is offered. This combination would be the most effective in eliciting conservation effort, as the probability of Plan 3 (high effort) increases to 100%.

These results suggest that the effectiveness of financial incentives can be increased by combining them with assurances. Adding assurances may increase the marginal effect of these incentives, making additional amounts of cost sharing or compensation payments more effective than they would be on their own. This can be seen in Figure 4, which shows the effects of increasing levels of compensation on the probabilities that each plan is implemented. In Figure 4a compensation is offered on its own, while in Figure 4b it is combined with assurances. Although in Figure 4a the probability of Plan 0 decreases as compensation increases, Plan 0 remains the most likely alternative up to a compensation level of 70%. It would take full compensation (100%) for a representative landowner to implement Plan 1. The effect on the probabilities of Plan 2 or Plan 3 being implemented is small. Figure 4b shows that increasing the level of compensation is considerably more effective when assurances are offered as well. Plan 3 is the most likely alternative at all levels of compensation, so compensation of 40% would be sufficient to elicit the highest level of conservation effort.

This analysis has focused on examining the effectiveness of various combinations of incentives in eliciting conservation effort from private landowners. Another important issue, which lies outside the scope of this paper, is the efficiency of the different incentive options from a social perspective. The various incentives may have different implications for social welfare, which are not addressed in the models presented here. For instance, funding compensation or cost sharing payments, conceivably through taxation, can generate a deadweight loss due to administrative costs and to distortions that could make these incentives less attractive. Providing assurances may also generate opportunity costs to society if the flexibility to correct management plans when conditions change in the future is curtailed. Thus, the most effective combinations of incentives, as evaluated here, may not necessarily be the most socially efficient.

DISCUSSION

The results presented in the preceding sections suggest that the incentives examined in this paper could be effective in encouraging landowners to manage their property in a way that is beneficial to endangered species. Specifically, offering compensation and assurances incentives could increase the likelihood that landowners supply higher levels of conservation effort. On the other hand, cost sharing may not be as effective in eliciting conservation effort from landowners. One possible explanation for this result is that the landowners' strong feelings about property rights, government intervention, and perceived unfairness of land use regulation may make compensation and assurances more relevant to them. Additionally, out-of-pocket costs may be small relative to the lost income and the perceived future impacts of regulation.

The coefficient for ASSIST is not statistically different from zero either. This indicates that offering technical assistance may not be effective in inducing landowners to supply higher levels of conservation effort. One possible explanation for this is that the landowners may be knowledgeable enough about managing their property to consider assistance unnecessary. On average, landowners rated the availability of technical assistance as only “somewhat important” in determining their management decisions. Additionally, comments made by landowners in the survey suggest some animosity towards the government and foresters or extension agents, often citing negative experiences in the past[8]. Thus, landowners may want to keep the government out of their land, and may distrust foresters or extension agents.

The coefficient for the perceived likelihood of regulation (REGULATE) is not significant, implying that the “stick” of regulation may not be as effective as the incentive “carrots” in eliciting conservation effort from landowners. This may be because landowners do not seem to feel greatly threatened by the ESA: on average, they ranked the likelihood of regulation between “unlikely” and “even chance”, and 60% of them feel that there is no more than an even chance that the ESA will restrict activity on their property. Furthermore, landowners may view other regulations at the state or local level, such as the Oregon Plan for salmon or Washington’s Forest and Fish rules, as more immediate regulatory threats. This may explain why the results show that assurances are important to landowners, although they don’t consider ESA regulation likely.

Finally, the results of the simulation suggest that, although incentives like compensation and assurances may work on their own, a combination of incentives may be more effective in compelling landowners to manage their property for endangered species. In particular, better results can be achieved by combining financial incentives with assurances. In this specific case, the most effective combination would include compensation and assurances, since landowners would not be as responsive to the cost sharing incentive. Many landowners may not be opposed to providing habitat on their land,

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[8] For instance, landowners commented that they “want no part of any government agency because they lie, cheat, steal”, that there is “too much government in land now; they do a terrible job”, and that “the managing of private land should be left entirely to the landowner”.

but hesitate to do so because they fear government intervention or question the fairness of having to assume the costs of providing a public good. The combination of compensation and assurances may be the most effective because it addresses these concerns by lowering the opportunity cost of managing for endangered species, and allowing landowners to keep control over land management decisions.

These results have interesting implications for conservation policy and the design of incentives programs. They suggest that the threat of regulation may not suffice to compel landowners to manage their property in a way that is beneficial to endangered species, in particular when landowners do not perceive that the threat of regulation is high. On the other hand, the use of incentives could be highly effective. Specifically, compensation for lost income and assurances about future regulation can play a significant role in eliciting conservation effort. Furthermore, combining financial incentives with assurances could have a larger positive effect on landowners than using either type of incentive on its own. Thus, conservation policy on private land might be improved by relying on a combination of incentives, including financial incentives and assurances, rather than exclusively on the threat of regulation.

An alternative option, of course, would be to make the threat of regulation more real by bolstering enforcement. This would conceivably increase the importance of assurances as an incentive. Landowners may not be willing to enter into agreements that include financial incentives but no assurances, since managing for endangered species given heightened enforcement would increase the risk of facing land use restrictions. On the other hand, an increased threat of regulation may make landowners more willing to enter into incentives programs that do include assurances. Thus, waving a heavier regulatory stick could be effective in encouraging landowners to manage for endangered species as long as the carrot of assurances is offered as well.

This paper is a first step in evaluating the likely effectiveness of incentives programs. The framework used here could be applied to other incentives, such as tax breaks, different types of land, like wetlands or farmland, and different regions. This would further improve our understanding of the usefulness of these programs.

APPENDIX

16. Suppose that you are presented with *only* the following choice. Compare the four options and consider which one you would be most likely to choose.

Option 1	**Option 2**	**Option 3**	**Option 4**
- Thinning to 50-75 trees/acre, - 2-4 snags and logs/acre, - Manage under story (Activities 1,2,3)	- Thinning to 50-75 trees/acre, - 2-4 snags and logs/acre (Activities 1,2)	- Thinning to 50-75 trees/acre (Activity 1)	None
You pay 100% of costs $	You pay 75% of costs $	You pay 50% of costs $	
No compensation	You are compensated for 40% of lost income	You are compensated for 70% of lost income	
You receive assurances	You receive assurances	No assurances	
Technical assistance	No technical assistance	Technical assistance	

I prefer ... OPTION 1 OPTION 2 OPTION 3 OPTION 4

(*circle one*)

Please briefly describe the reason for your choice: ______________________________

____

FIGURE 1: LANDOWNER'S ACCEPTANCE SET

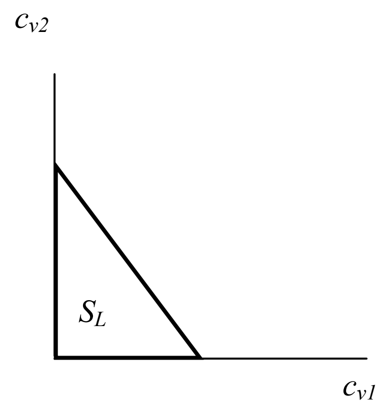


FIGURE 2: EFFECT OF INCENTIVES

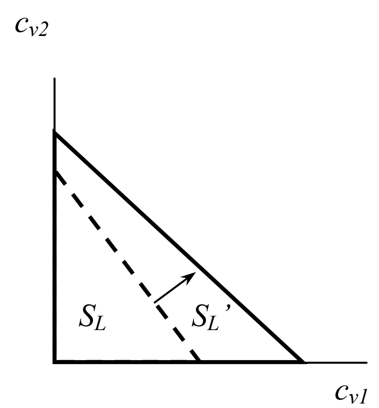


FIGURE 3: MARGINAL EFFECTS FOR COMPENSATION AND ASSURANCES

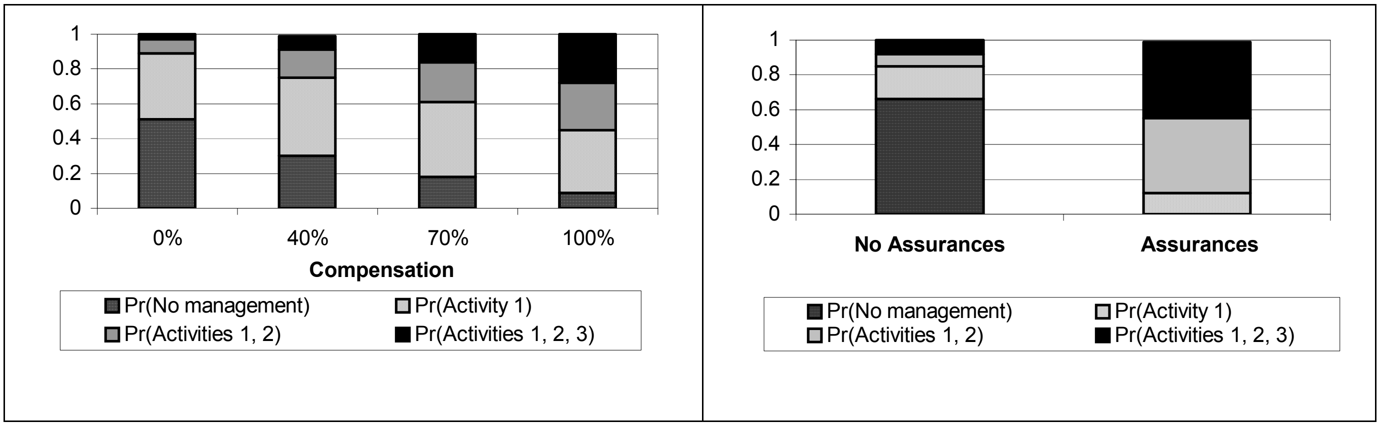
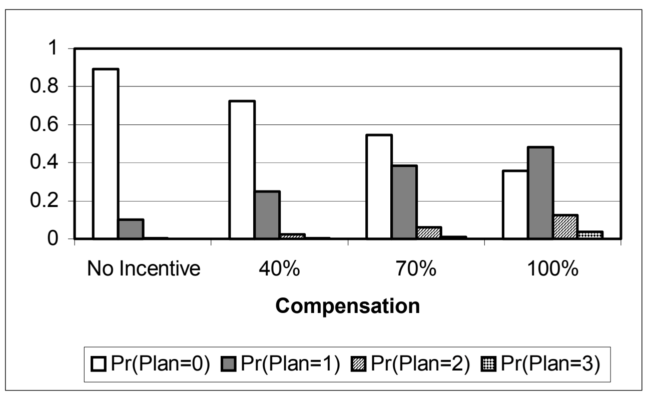


FIGURE 4: SIMULATED CHOICE PROBABILITIES

4a: Compensation Only



4b: Compensation and Assurances

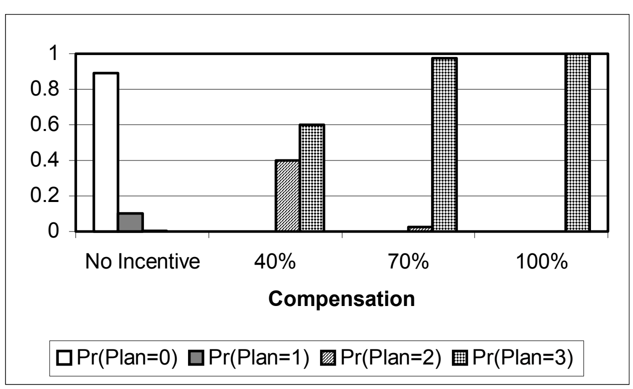


TABLE 1: VARIABLE DESCRIPTIONS AND SUMMARY STATISTICS

Variable	*Description*	*Mean*	*Std. Dev.*
Incentives			
SHARE[9]	% of cost paid by landowner: 25, 50, 75, 100%	0.65	0.33
COMP	% of lost income compensated: 0, 40, 70, 100%	0.46	0.41
ASSURE	1 if assurances offered, 0 otherwise	0.51	0.18E-03
SHXIN	Interaction Variable = Share x Income	4.63	3.37
COXSTS	Interaction Variable = Comp x Stand size	11.10	21.11
COXSTA	Interaction variable = Comp x Stand age	16.05	26.75
ASXRE	Interaction Variable = Assure x Regulate	1.44	1.77
ASSIST	1 if tech. assistance offered, 0 otherwise	0.38	0.17E-03
REGULATE	Perceived threat of regulation: Very Unlikely (1) to Very Likely (5)	2.82	1.54
Demographic			
AGE	Age of landowner	58.10	13.22
EDUC1-4	Dummies: education level, elementary school (1) to graduate or professional school (6)		
OCCUP	Occupation of landowner: 1 if related to logging, ranching, farming, timber industry, 0 otherwise.	0.14	0.5E-04
INCOME1-6	Dummies: income level		
Property			
ACRES	Total acres owned	135.79	437.89
WOODLAND	Total woodland acres owned	95.89	270.91
RESIDE	1 if residence on property, 0 otherwise	0.78	0.7E-04
YEARS	Number of years landowner has owned property	22.44	16.64
Stand			
STANDSIZE	Size of stand chosen for management (acres)	29.86	43.15
STANDAGE	Age of stand chosen for management	36.38	30.77
HARV20_40	1 if plans to harvest in 20 to 40 yrs., 0 otherwise	0.15	0.1E-03
HARV40	1 if plans to harvest in 40 or more yrs., 0 otherwise	0.19	0.1E-03

[9] The levels of cost sharing offered by existing programs vary, but a common upper bound (e.g. the Wildlife Habitat Incentives Program or the Stewardship Incentive Program) is 75% (Environmental Defense Fund 2000).

TABLE 2: ORDERED PROBIT MAXIMUM LIKELIHOOD ESTIMATES

Variable	MODEL 1	MODEL 2
Constant	-0.26	-0.27
SHARE	-0.03	-0.04
	(-0.50)	(-0.75)
COMP	0.24***	0.25***
	(4.11)	(4.22)
ASSURE	0.31***	0.33***
	(4.40)	(4.58)
SHXIN	0.02**	0.02**
	(2.25)	(2.40)
COXSTS	-0.65E-03	-0.72E-03
	(-1.02)	(-1.15)
COXSTA	-0.74E-03	-0.74E-03
	(-1.15)	(-1.18)
ASXRE	0.82E-02	0.71E-02
	(0.64)	(0.55)
ASSIST	0.83E-03	0.01
	(0.06)	(0.70)
REGULATE	-0.56E-02	-0.55E-02
	(-0.47)	(-0.46)
AGE	-0.17E-03	
	(-0.24)	
EDUC2	-0.03	
	(-1.56)	
EDUC3	0.67E-02	
	(0.37)	
EDUC4	-0.46E-02	
	(-0.22)	
OCCUP	-0.01	
	(-0.52)	
INCOME2	0.04	0.04
	(1.27)	(1.29)
INCOME3	0.05	0.05
	(1.36)	(1.25)
INCOME4	0.03	0.02
	(0.55)	(0.36)

Table 2 – Continued

INCOME5	-0.02 (-0.43)	-0.01 (-0.24)
INCOME6	-0.02 (-0.38)	-0.04 (-0.65)
ACRES	0.13E-04 (0.41)	
WOODLAND	-0.24E-04 (-0.48)	
RESIDE	-0.30E-02 (-0.18)	
YEARS	0.30E-03 (0.53)	
STANDSIZE	0.17E-03 (0.45)	0.24E-03 (0.65)
STANDAGE	0.35E-03 (1.27)	0.38E-03 (1.40)
HARV20_40	-0.17E-02 (-0.09)	-0.73E-02 (-0.40)
HARV40	0.04** (2.36)	0.03** (2.03)
Log Likelihood	-622.10	-639.69
$\chi^{2\ a}$	692.92	696.21
Scaled $R^{2\ b}$	0.69	0.69
Sample Size	724	739

t-statistics in parenthesis

*, **, *** indicate significance at $\alpha = 0.1$, 0.05, and 0.01

[a] Test statistic for H_0: all parameters except the constant are zero

[b] Scaled $R^2 = 1 - (\log Lu / \log Lr)^{-(2/N)\log Lr}$, where *Lu* and *Lr* are the unrestricted and restricted (all parameters equal to zero) likelihood functions (Estrella 1998).

TABLE 3: SIGNS OF MARGINAL EFFECTS FOR COMP AND ASSURE

	ΔPr(PLAN=0)	ΔPr(PLAN=1)	ΔPr(PLAN=2)	ΔPr(PLAN=3)
COMP	–	–	+	+
ASSURE	–	–	+	+

TABLE 4: SIMULATED CHOICE PROBABILITIES

		Prob. (Plan 0)	Prob. (Plan 1)	Prob. (Plan 2)	Prob. (Plan 3)
Scenario 0:	No Incentives	0.89	0.10	0.01	0.00
Scenario 1:	Cost Sharing	0.67	0.10	0.05	0.18
Scenario 2:	Compensation	0.35	0.48	0.13	0.04
Scenario 3:	Assurances	0.00	0.20	0.78	0.02
Scenario 4:	Cost Sharing + Assurances	0.20	0.40	0.22	0.18
Scenario 5:	Compensation+ Assurances	0.00	0.00	0.00	1.00

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