AN ABSTRACT OF THE DISSERTATION OF

Christian Langpap for the degree of Doctor of Philosophy in Agricultural and Resource Economics presented on December 6, 2002.
Title: Modeling Conservation Incentives for Private Landowners.

Abstract approved

Steve Polasky
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This dissertation consists of three papers on the use of incentives for conservation of endangered species on private land. The first paper examines incentives based on providing landowners with assurances regarding future regulation in exchange for their participation in a conservation agreement. The second and third papers are empirical analyses of landowners' decisions to participate in an incentives program, and of the effect of different types of incentives on the level of conservation effort provided by landowners.

The first paper examines when a landowner and a regulator reach a voluntary conservation agreement, and what level of conservation the agreement generates in the presence of uncertainty about future conservation benefits and irreversibility of habitat loss and species extinction. The results suggest that the likelihood of an agreement and the resulting conservation levels depend on the background threat of regulation, the cost advantage offered by voluntary agreements, and the availability of assurances regarding future regulation. In practice, conservation agreements that offer assurances

may generate higher levels of conservation and higher net social benefits than agreements that do not offer assurances. However, the resulting level of conservation will not be optimal, and may be lower than that attainable under regulation.

The second paper conducts an empirical analysis of the demographic and land characteristics that determine landowner participation in incentives programs using data obtained from a survey of non-industrial private forest owners in Oregon and Washington. The results suggest that targeting incentives programs to younger landowners who have acquired their property more recently, own more woodland, and are interested in conservation and providing wildlife habitat on their forests may be effective in attaining higher participation rates.

The third paper uses the data obtained from the survey to examine the potential of incentives programs to elicit conservation-oriented management choices from landowners. 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.

Modeling Conservation Incentives for Private Landowners

by

Christian Langpap

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I understand that my dissertation will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my dissertation to any reader upon request.

Christian Langpap, Author

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CONTRIBUTION OF AUTHORS

Dr. JunJie Wu was involved in the design, analysis, and writing of the first manuscript.

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CHAPTER 1

INTRODUCTION

Christian Langpap

The conservation of endangered species on private land remains a controversial topic. The restrictions imposed on private activity by Section 9 of the Endangered Species Act (ESA), as interpreted by the U.S. Fish and Wildlife Service (FWS), have raised vigorous opposition from property rights advocates. This opposition has made these restrictions a politically sensitive subject, hindering enforcement of Section 9 of the ESA. These enforcement difficulties could severely undermine endangered species recovery efforts, because more than half of the listed endangered species have at least 80% of their habitat on private land (FWS 1997).

Furthermore, it has been widely argued that the traditional approach to regulation embodied in Section 9 of the ESA, which is based on land-use restrictions, has failed to attain its objective of protecting endangered species. A common argument is that this approach 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. Another argument made against Section 9 of the ESA is that it attempts to deter harmful conduct by landowners, but does nothing to encourage and reward desirable behavior.

Thus, Section 9 of the ESA seems to grant inadequate protection to endangered species on private land and, at its worst, may even cause the very behavior it attempts to prevent. Hence, there has been a call for the use of incentives to complement the existing regulatory framework. Two main approaches have been suggested. One seeks to reform the ESA by providing landowners with assurances regarding future regulation. A second approach attempts to encourage positive behavior by offering the landowner both financial and non-financial incentives to manage his land in a way that is compatible with the survival and recovery of endangered species. The three papers in this dissertation examine various aspects of the implementation and effectiveness of these incentive schemes.

The first paper, *Voluntary Conservation of Endangered Species: When Does "No Surprises" Mean No Conservation?* analyzes incentives based on providing landowners with assurances regarding future regulation. Specifically, the paper uses a two-period model to analyze the interaction between a regulator and a landowner in a context characterized by uncertainty about future conservation benefits and regulation, as well as irreversibility of habitat loss. This model is used to compare conservation agreements that offer assurances with those that do not. The results suggest that the likelihood of an agreement depends on the availability of assurances regarding future regulation, as well as on the background threat of regulation and the cost advantage of voluntary agreements. The model also reveals that, under what is arguably the most common scenario for voluntary agreements in practice, incentives programs based on providing assurances may result in higher conservation and welfare levels than agreements that do not offer assurances. However, assurances-based agreements may yield inefficient levels of conservation, perhaps even lower than those attainable through regulation. Hence, the regulator faces a tradeoff: he may be able to encourage participation and increase conservation effort by offering assurances, but by doing so he loses the flexibility to use new information, and thus may have to settle for inefficient levels of conservation.

The second paper, *Conservation Incentives Programs for Endangered Species: An Analysis of Landowner Participation*, uses a survey of non-industrial private forest owners in western Washington and Oregon to analyze participation in an incentives program that asks landowners to manage their land in a way that benefits endangered species. The analysis carried out in this paper could help improve the effectiveness of incentive programs for conservation of endangered species by suggesting a framework to identify those segments of the population that are more likely to participate, and thereby allowing more effective targeting and marketing of these programs. The results suggest that younger landowners who have acquired their property more recently, own more woodland, and are interested in conservation and providing wildlife habitat on their forests are more likely to participate.

The third paper, *Conservation of Endangered Species: Can Incentives Work for Private Forestland Owners?* analyzes the likely effects of assurances, cost sharing, and compensation incentives on landowners' management decisions in the context of endangered species conservation. I use data from the survey of nonindustrial private forest owners to construct econometric models that measure the probable effect of these incentives on landowners' willingness to provide conservation effort. The results obtained suggest that incentives could effectively complement regulation in eliciting higher levels of conservation effort, particularly when landowners do not believe that land use restrictions are likely. 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 combining financial incentives with assurances may be the most effective way to encourage the desired management practices.

CHAPTER 2

VOLUNTARY CONSERVATION OF ENDANGERED SPECIES: WHEN DOES "NO SURPRISES" MEAN NO CONSERVATION?

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2.1 INTRODUCTION

The conservation of endangered species on private land has been a controversial subject for several years. The restrictions imposed on private activity by Section 9 of the Endangered Species Act (ESA), as interpreted by the U.S. Fish and Wildlife Service (FWS), have raised vigorous opposition from property rights advocates. This opposition has made these restrictions a politically sensitive subject, hindering enforcement of Section 9 of the ESA. On the other hand, protecting endangered species on private land may be instrumental in determining the overall success of recovery efforts under the ESA; more than half of the listed endangered species have at least 80% of their habitat on private land (FWS 1997).

Furthermore, it has been widely argued that the traditional approach to regulation embodied in Section 9 of the ESA, which is based on land-use restrictions, has failed to attain its objective of protecting endangered species. A common argument is that this approach generates perverse incentives that might compel landowners to manage their land in a way that harms endangered species. This argument has been made formally by Polasky and Doremus (1998), Polasky (2001), and Innes (2000), and anecdotal evidence of such behavior abounds (see, e.g., Bean and Wilcove 1997, Mann and Plummer 1995, Ruhl 1998, Bean 1998). Empirical evidence has also been found in the case of the red-cockaded woodpecker (Michael and Lueck 2000).

Another argument made against Section 9 of the ESA is that it attempts to deter harmful conduct by landowners, but does nothing to encourage and reward desirable behavior, i.e. that the ESA is "all sticks and no carrots". In numerous cases, the absence of harmful behavior may not be enough to address serious threats to endangered species. Many require active management of their habitat, such as prescribed burning, removal of exotic species, predator control, creation of dispersal corridors, or control of edge effects (Bean and Wilcove 1996, Bean 1998). These kinds of activities entail 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, at its worst, may even cause the very behavior it attempts to prevent. Hence, there has been a call for the use of incentives to complement the existing regulatory framework.

At present the most widely used incentives programs are based on reforms to the ESA that seek to eliminate perverse incentives and generate positive incentives for landowners by providing them with assurances regarding future regulation. These reforms take the form of voluntary agreements, such as Habitat Conservation Plans (HCP) with a "no surprises" policy, Safe Harbor Agreements, and Candidate Conservation Agreements with Assurances (Wilcove *et al.* 1996, Bean and Wilcove 1996, FWS 1999a, 1999b). A key characteristic of these programs is that the FWS and a landowner reach a voluntary agreement on a conservation program to be implemented by the landowner. In return, FWS guarantees to the landowner that he will not have to incur additional costs or be subject to further restrictions in the future.

Given that voluntary incentives programs, in particular HCPs, have become the main vehicle for implementation of the ESA on private land (Defenders of Wildlife 1998, Thomas 2001), it is important to ask under what conditions a landowner and a regulator will agree on such a program, and what levels of conservation one might expect as an outcome. The use of incentives for conservation of endangered species has been examined by Smith and Shogren (2001, 2002), who use the mechanism design approach to find an optimal incentive scheme under asymmetric information. Additionally, voluntary agreements have been analyzed in the context of pollution abatement (see, e.g. Arora and Cason 1995, Segerson and Miceli 1998, Wu and Babcock 1999), but these studies do not account for two issues that are particularly relevant in the context of endangered species conservation. The first one is the uncertainty inherent in the management of ecosystems and endangered species, which stems from our incomplete understanding of the biological world (Noss *et al.* 1997, Harding *et al.* 2001, Polasky and Doremus 1998). The second, and closely related one, is the potential irreversibility of habitat loss and extinction resulting from land use decisions. These issues have been examined extensively in the context of conservation decisions under uncertainty and irreversibility, and quasi-option values (see, e.g., Arrow and Fisher 1974, Fisher and Hanemann 1986, 1987, Hanemann 1989, Usategui 1990).

This paper builds on the methodology provided by Segerson and Miceli (1998) to analyze the interaction between a regulator and a landowner. We generalize their study by adding a second period to their model, which makes it possible to incorporate uncertainty and irreversibility. This allows us to compare conservation agreements that offer assurances with those that do not. Thus, this paper links the voluntary-agreements and conservation-under-uncertainty literatures by examining the tradeoff between encouraging participation in voluntary agreements and maintaining flexibility to respond to changing conservation needs.

Our analysis shows that one of the main results in Segerson and Miceli (1998), that a voluntary agreement is always reached as long as there is a positive probability of regulation, does not hold when uncertainty is taken into account. Specifically, we show that in the presence of uncertainty about future regulation and conservation benefits, the likelihood of an agreement depends on the availability of assurances regarding future regulation, as well as on the background threat of regulation and the cost advantage of voluntary agreements. Our model also reveals that, under what is arguably the most common scenario for voluntary agreements in practice, HCPs and other incentives programs based on providing assurances may result in higher conservation and welfare levels than agreements that do not offer assurances. However, assurances-based agreements may yield inefficient levels of conservation, perhaps even lower than those attainable through regulation. Hence, the regulator faces a tradeoff; he may be able to encourage participation and increase conservation effort by offering assurances, but by doing so he loses the flexibility to use new information, and thus may have to settle for inefficient levels of conservation.

The remainder of the paper is organized as follows. Section 2 presents the basic setup of the model, section 3 analyzes the interaction of regulator and landowner under a no-surprises scenario (i.e. when assurances are offered), while section 4 does the same for the case of no assurances. Section 5 concludes. The proofs of all the propositions are presented in section 6.

2.2 MODEL SETUP

We analyze the interaction between a regulator and a landowner using a two-period model, in which the second period represents the entire future time horizon. We assume that in period 1 there is a known set of conditions determining the status of an endangered species, and that in period 2 an unforeseen change in these conditions takes place, which alters the status of the species. This change, which reflects the uncertainty inherent in managing endangered species, may be caused by unpredictable variations in environmental factors such as weather, food supply, and natural catastrophes. For example, unprecedented low oxygen levels in seawater can cause a sudden die-off of fish (Palmer 2002), the intensity of El Niño weather patterns can affect the reproductive rates of migratory birds (Associated Press 2002a), and cold upwellings in the ocean can unexpectedly improve salmon runs (Associated Press, 2002b). To model this change in circumstances, we let ω_1 be the set of conditions, or state of the world, in period 1, and ω_2 be the state of the world in period 2. These variables measure factors that affect the status of a species, but are not caused by management decisions, such as ocean and weather conditions in the preceding examples. We assume that in period 1 both the regulator and the landowner know ω_1, but do not know ω_2. Because of the unexpected change in circumstances, management decisions made with the information available in period 1 may not be efficient *ex post.*

The sequence of events in the interaction between the regulator and the landowner is as follows. In period 1, the regulator and the landowner decide whether to enter into a voluntary conservation agreement (VCA) and bargain over the terms of this VCA. If an agreement is reached, the VCA specifies levels of conservation effort (c_{v1}, c_{v2}) for periods 1 and 2, respectively. The effort levels (c_{v1}, c_{v2}) can be thought of as a management plan for the landowner's property. If an agreement is not reached, then the landowner is regulated with probability p, and remains regulated in period 2[1]. The mandatory conservation levels imposed by regulation (c_{m1}^* and c_{m2}^*) are set on a period-by-period basis to maximize net social benefits. If the landowner is not regulated, he develops his entire property and no conservation takes place[2].

In period 2, the state of the world ω_2 becomes known, and the conservation level agreed upon in period 1 (c_{v2}) may turn out not to be welfare maximizing. Hence, the regulator might "surprise" the landowner and require that he supply a different level of conservation effort, which could be higher or lower than c_{v2}. The regulator's willingness and ability to implement this adjustment is unknown in period 1, so it is

[1] Regulation is probabilistic because the political environment may change and 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).

[2] Two additional scenarios might be considered here. First, the landowner could be regulated in period 2 if no agreement is reached in period 1. It is straightforward to add this scenario to our framework, but it does not change our results, so we omit it to keep the model simple. Second, the landowner could back out of a VCA in period 2. However, it is highly unusual in practice for landowners to back out of voluntary programs such as HCPs once an agreement has been reached (FWS 2002b), so for the sake of simplicity we omit this possibility as well.

uncertain whether a surprise will take place or not[3]. Additionally, a VCA includes a provision that specifies whether a surprise is allowed. We analyze how a "no surprises" provision would affect the likelihood that a VCA is reached and the resulting levels of conservation in both periods.

Let $B_t(c_t, \omega_t)$ be the benefits to society in period $t = 1, 2$ from conservation effort c_t, with corresponding state of the world ω_t. The conservation effort can include activities such as restoring or creating habitat for an endangered species, or setting land aside for conservation. The function $B(\cdot)$ can represent, for instance, the benefits to society of maintaining the resilience of ecosystems and their ability to provide life-supporting services by preserving their components. The argument ω_t in the benefit function will be omitted to simplify notation, and it is assumed that $B_t'(\cdot) > 0$ and $B_t''(\cdot) < 0$, where the derivatives are with respect to c_t.[4]

The cost of conservation is given by the compliance cost to the landowner, $a_i(c)$, $i = v, m$, which includes the cost of restoring or creating habitat for an endangered species and the opportunity cost of setting land aside for conservation[5]. Following Segerson and Miceli (1998) we assume that both total and marginal costs

[3] For instance, the regulator may not be able to modify an existing conservation plan for political reasons (e.g., it may antagonize private landowners), because not enough funds are available for the additional research and enforcement expenses, or if the landowner can successfully challenge an intended change in court.

[4] We abstract from possible non-convexities in conservation benefits (see, e.g., Wu and Boggess 1999). Allowing for these non-convexities would have the effect of increasing the minimum conservation levels acceptable to the regulator, the conservation levels that maximize net social benefits, and the minimum probability of regulation required for a VCA.

[5] For the sake of simplicity, we have left out the transaction costs to the regulator and assumed that the compliance costs are the same in both periods. These assumptions do not affect our results.

are no higher under a VCA than under regulation[6], and that costs of conservation are linear (i.e. $a_i(c)$=$a_i c$). The reasoning behind our assumption is similar to that of Segerson and Miceli. When a landowner agrees to a conservation plan voluntarily, he has more flexibility to decide how to implement it. For instance, he can choose which part of his property he prefers to set aside for conservation, or he can decide to purchase a different tract of land to implement the conservation plan if the opportunity cost of doing so on his property is too high[7]. This cost advantage implies that $a_v \leq a_m$. All benefits and costs corresponding to period 2 are present values.

Both the landowner and the regulator are risk-neutral. The landowner incurs costs from conservation, but derives no benefits. Thus, his objective is to minimize the costs of conservation. The regulator' s objective is to maximize net social benefits, which are $NSB_{it}(c_i)$= $B_t(c_i)$ - $a_i c_i$. This objective might seem at odds with the language of the ESA, which does not formally require consideration of costs and benefits in the decision to list an endangered species. However, other important components of the implementation of the ESA, such as critical habitat designation and recovery planning, do consider costs. Furthermore, empirical work on the political economy of the ESA suggests that benefit-cost considerations may find their way into the listing decision through interest group pressure as well (Ando 1999, 2001).

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[6] Voluntary Conservation Agreements are assumed to be more cost-effective than command and control regulation. However, this may not be true for other forms of market-based regulation, such as tradable development rights.

[7] A variant of this possibility, which highlights the flexibility offered to landowners by VCAs, is the use of a mitigation credit system. Under this arrangement, landowners who create habitat for conservation receive credits, which can be used later or sold to other landowners who need to mitigate development on their land. Landowners are also allowed to pay fees into habitat acquisition funds instead of conserving habitat on their own lands (Thomas 2001).

In the following sections, we will analyze the outcome of the interaction between the regulator and the landowner under two basic scenarios: when the regulator offers assurances to the landowner regarding additional conservation in period 2 (no surprises), and when he does not (surprises). Additionally, for each scenario we will examine how irreversibility affects the outcomes. Specifically, we define irreversibility by assuming that the conservation level in period 2 cannot exceed that from period 1: $c_{i2} \leq c_{i1}$. Intuitively, this implies that developed land cannot be converted back to wildlife habitat.

2.3 NO SURPRISES

2.3.1 No Irreversibility

In this section, we start by developing the two-period model of the interaction between the landowner and regulator, and show that under certain conditions it is equivalent to the model in Segerson and Miceli (1998). We assume that there is a "no surprises" clause in the agreement signed in period 1 by the regulator and the landowner. The regulator guarantees that the conservation effort in period 2 will be c_{v2}, as agreed in period 1, regardless of the new information that becomes available. Additionally, we assume that any actions taken in period 1 are fully reversible. This could be the case for activities such as water diversions.

Given these assumptions, the landowner enters into a VCA if and only if his cost under the VCA is no larger than his expected cost under regulation:

$$a_v c_{v1} + a_v c_{v2} \leq p(a_m c^*_{m1} + a_m E c^*_{m2}) \tag{1}$$

where $c^*_{m1} = arg\ max\{B_1(c) - a_m c\}$ is the conservation level under regulation in period 1, and $E c^*_{m2} = E[arg\ max\{B_2(c) - a_m c\}]$ is the expectation, in period 1, of the mandatory conservation level in period 2. Note that under regulation the mandatory conservation level in period 2 is determined after the state of the world is observed. However, in period 1 the landowner does not know the state of the world in the second period. Therefore, he has to formulate an expectation about the mandatory conservation level in period 2 when making decisions in period 1. As in Segerson and Miceli (1998), the levels of conservation under regulation are set to maximize the expected net social benefit in each period. The conservation levels (c^*_{m1}, $E c^*_{m2}$) are the only credible threat the regulator can make, since he would have an incentive to deviate from any other conservation levels. The regulator enters into a VCA if and only if the expected payoff from participating is higher than the expected payoff under regulation:

$$NSB_{v1}(c_{v1}) + E\ NSB_{v2}(c_{v2}) \geq p[NSB_{m1}(c^*_{m1}) + E\ NSB_{m2}(c^*_{m2})] \tag{2}$$

where $E\ NSB(\cdot)$ is the expected value of the net social benefits function, and $c^*_{m2} = arg\ max\ \{B_2(c) - a_m c\}$. Thus, $E\ NSB_{m2}(c^*_{m2})$ is the expected payoff if the choice of mandatory conservation for period 2 can be made after observing ω_2. $E\ NSB_{m2}(c^*_{m2})$ is no less than $Max\ E\ NSB_{m2}(c_m)$, which is the expected payoff if the choice has to be made in period 1. This indicates that there is a value to preserving regulatory flexibility if the regulator does not enter into a VCA.

Note that if we assume that there is no change in the state of the world, and therefore no uncertainty, and that $c_{i1} = c_{i2} = c_i$, $i = v, m$, conditions (1) and (2) can be rewritten as $2a_v c_v \leq 2pa_m c_m^*$ and $2NSB_v(c_v) \geq 2pNSB_m(c_m^*)$, respectively. These correspond to the case analyzed by Segerson and Miceli (1998). Thus, our model is a generalization of theirs.

Condition (1) can be used to define the acceptance set for the landowner:

$$S_L = \{(c_{v1}, c_{v2}) |\ c_{v1} + c_{v2} \leq p\, \frac{a_m}{a_v}(c_{m1}^* + E c_{m2}^*) \equiv \overline{C}\} \tag{3}$$

where $\overline{C}$ is the threshold level of total conservation effort that the landowner will agree to. This set contains all the combinations of conservation efforts in the two periods that are acceptable to the landowner. S_L is illustrated in Figure 1a.

Similarly, using condition (2) we can define the acceptance set for the regulator:

$$S_R = \{(c_{v1}, c_{v2}) | c_{v1} + c_{v2} \leq \frac{1}{a_v}[B_1(c_{v1}) + EB_2(c_{v2}) - p(NSB_m(c_{m1}^*) + ENSB_m(c_{m2}^*))]\} \tag{4}$$

This set contains all the combinations of conservation efforts in the two periods that are acceptable to the regulator. S_R is shown in Figure 1b. In section 6, we prove that S_R is a convex set (i.e. the upper boundary of S_R, $c^U(c_{v1})$, is concave, while the lower boundary, $c^L(c_{v1})$, is convex).

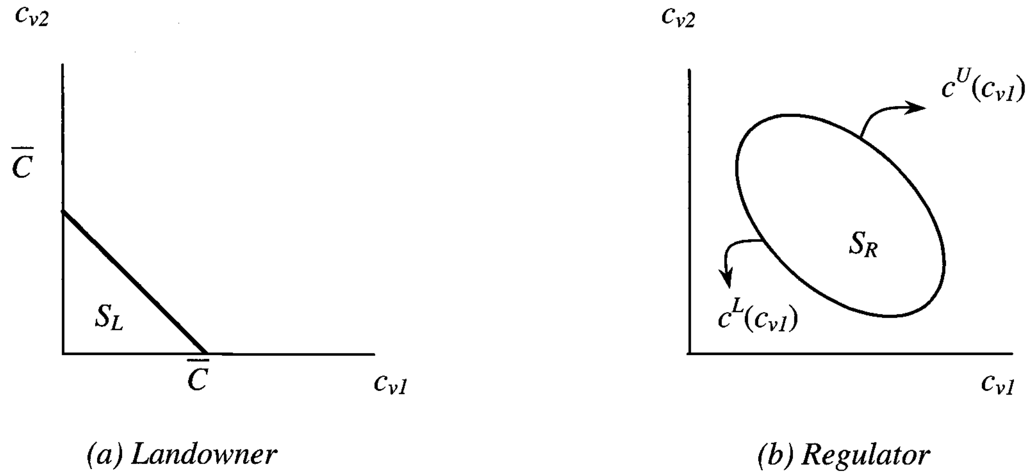

FIGURE 2.1
Acceptance Sets

A VCA is reached whenever there is an intersection between S_L and S_R (i.e. $S_L \cap S_R \neq \emptyset$), as shown in Figure 2 (henceforth, the upper boundary of S_R is not drawn to avoid cluttering the graph). A necessary condition for this is that $p < 1$ (i.e. there is regulatory uncertainty) or $a_v < a_m$ (i.e. a VCA offers some cost advantage). If $p = 1$ and $a_v = a_m$, a VCA will not be reached because $S_R = \emptyset$. Intuitively, the regulator would prefer regulation because it preserves flexibility in the face of uncertainty (the regulator can impose regulation after the state of world ω_2 is observed)[8]. Thus, the regulator is willing to enter into a VCA only if it offers some cost advantage and/or regulation is uncertain. In addition, an agreement requires that p be greater than zero. Otherwise, the landowner will not agree to any positive conservation level[9].

[8] We thank an anonymous referee for pointing this out.

[9] Note that if $p = 0$ there is a trivial agreement in which no conservation takes place, since $c_{v1} = c_{v2} = 0$ satisfy conditions (3) and (4). A non-trivial VCA with positive conservation requires $p > 0$.

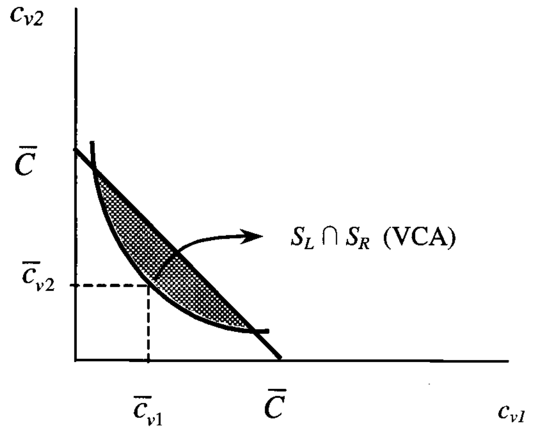

FIGURE 2.2
VCA Equilibrium

The conditions $0 < p < 1$ or $a_v < a_m$, however, are not sufficient for a VCA. A sufficient and necessary condition is that $\overline{c}_{v1} + \overline{c}_{v2} \leq \overline{C}$, where $\overline{c}_{v1}$ and $\overline{c}_{v2}$ are defined by $c^L(\overline{c}_{v1}) = \overline{c}_{v2}$ and $c^{L\prime}(\overline{c}_{v1}) = -1$ (see Figure 2). Intuitively, this condition implies that the lowest total conservation the regulator is willing to accept has to be lower than the maximum conservation the landowner is willing to accept ($\overline{C}$). To understand when this sufficient condition is satisfied, we examine how $\overline{C}$ and $\overline{c}_{v1} + \overline{c}_{v2}$ change with p. It is easy to see from condition (3) that $\overline{C}$ is increasing and linear in p. On the other hand, as we show in section 6, $\overline{c}_{v1} + \overline{c}_{v2}$ is increasing and convex in p. That is, as the background threat of regulation increases, the landowner's conservation threshold increases at a constant rate, and the minimum conservation level acceptable to the regulator increases at an increasing rate. This is illustrated in Figure 3. It is clear from the figure that a necessary and sufficient condition for a VCA is that the slope of

$\bar{c}_{v1} + \bar{c}_{v2}$ be smaller than that of $\overline{C}$ at $p = 0$, and that $p < p^*$, where p^* is defined by $\bar{c}_{v1} + \bar{c}_{v2} = \overline{C}$. This establishes the following proposition.

PROPOSITION 1. *Suppose that assurances are offered as part of a VCA and that the actions taken in period 1 are reversible. A VCA will be the equilibrium outcome of the interaction between landowner and regulator if and only if*

$$0 < p \leq min(1, p^*) \tag{5}$$

and

$$\frac{a_m}{a_v} \geq \frac{NSB_{m1}(c^*_{m1}) + ENSB_{m2}(c^*_{m2})}{[ENSB_{v2}'(0) - a_v](c^*_{m1} + c^*_{m2})} \tag{6}$$

The proof of Proposition 1, as well as all subsequent propositions, can be found in section 6.

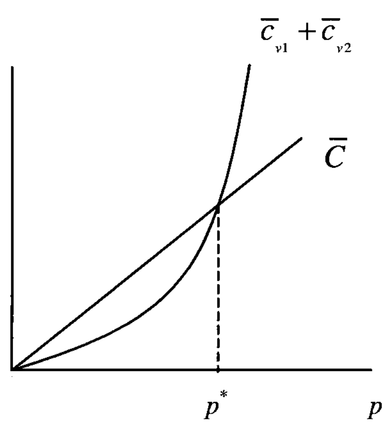

FIGURE 2.3
Threshold conservation levels

This result differs from that of Segerson and Miceli (1998), who found that an agreement is reached for any positive probability of regulation. This difference originates in the uncertainty introduced into the model by the change in state of the world. In the model examined by Segerson and Miceli (1998), both parties are better off joining a voluntary agreement because of the cost advantage. In the scenario examined here, the cost advantage of voluntary agreements may not suffice. Under mandatory conservation, the regulator maintains the option of reacting to the change in state of the world, whereas entering into a no-surprises VCA precludes this possibility. Thus, if the probability of regulation is high, and the cost advantage of a VCA is low, the regulator may prefer to preserve the flexibility provided by regulation and not participate in a VCA.

2.3.2 Equilibrium Outcomes

Up to now, we have shown that the regulator and the landowner reach a VCA for any $p \in (0, p^*]$, and any (c_{v1}, c_{v2}) combination in $\{S_L \cap S_R\}$ could be an equilibrium outcome. In this section, we turn our attention to the levels of conservation effort resulting from a VCA.

To determine what the conservation outcome from a VCA is, we assume that the regulator and the landowner bargain over the conservation effort to be supplied by the landowner in the context of an asymmetric Nash bargaining framework (Nash 1950, Roth 1979). The expected payoffs from an agreement are $NSB_{v1}(c_{v1}) + ENSB_{v2}(c_{v2})$ for the regulator and $-a_v(c_{v1} + c_{v2})$ for the landowner. The expected payoffs if an agreement is not reached are $p(NSB_{m1}(c_{m1}^*) + E\,NSB_{m2}(c_{m2}^*))$ for the regulator, and $-pa_m(c_{m1}^* + Ec_{m2}^*)$ for the landowner. The conservation effort levels (c_{v1}, c_{v2}) are chosen to maximize the Nash criterion function

$$N^{ns}(c_{v1}, c_{v2}) = [-a_v(c_{v1}+c_{v2})+pa_m(c^*_{m1}+E\,c^*_{m2})]^{\gamma}\times$$

$$[NSB_{v1}(c_{v1})+E\,NSB_{v2}(c_{v2}) - p(NSB_{m1}(c^*_{m1})+E\,NSB_{m2}(c^*_{m2}))]^{1-\gamma} \qquad (7)$$

where $\gamma\in(0, 1)$ measures the landowner's bargaining power[10], and the superscript "*ns*" indicates no surprises. The resulting conservation levels (c^{ns}_{v1}, c^{ns}_{v2}) are implicitly defined by the following first-order conditions[11]:

$$N^{ns}_1(c^{ns}_{v1}, c^{ns}_{v2}) = (1-\gamma)(B_1'(c^{ns}_{v1}) - a_v)[-a_v(c^{ns}_{v1}+c^{ns}_{v2})+pa_m(c^*_{m1}+E\,c^*_{m2})]$$

$$-\gamma a_v[NSB_{v1}(c^{ns}_{v1})+E\,NSB_{v2}(c^{ns}_{v2})-p(NSB_{m1}(c^*_{m1})+E\,NSB_{m2}(c^*_{m2}))] = 0 \qquad (8)$$

$$N^{ns}_2(c^{ns}_{v1}, c^{ns}_{v2}) = (1-\gamma)(E\,B_2'(c^{ns}_{v2}) - a_v)[-a_v(c^{ns}_{v1}+c^{ns}_{v2})+pa_m(c^*_{m1}+E\,c^*_{m2})]$$

$$-\gamma a_v[NSB_{v1}(c^{ns}_{v1})+E\,NSB_{v2}(c^{ns}_{v2})-p(NSB_{m1}(c^*_{m1})+E\,NSB_{m2}(c^*_{m2}))] = 0$$

where N^{ns}_i indicates the derivative of N^{ns} with respect to c_{vi}, $i = 1, 2$.

We use these first order conditions to examine the effects of changes in the different parameters on the levels of conservation effort resulting from a VCA. A comparative statics analysis reveals that (see section 6):

$$\frac{\partial c^{ns}_{vt}}{\partial \gamma} < 0,\ \ \frac{\partial c^{ns}_{vt}}{\partial p} > 0,\ \text{ and }\ \frac{\partial c^{ns}_{vt}}{\partial (a_m/a_v)} > 0,\ \ t = 1, 2.$$

That is, the equilibrium levels of conservation effort are lower when the landowner has more bargaining power and higher when the background threat of regulation and

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[10] Bargaining power can be created by factors that we have not modeled explicitly, such as bargaining tactics, the procedure of the negotiations, or the information structure (Muthoo 1999). Private information about a property can be important in determining conservation outcomes (Polasky and Doremus 1998, Smith and Shogren 2001, 2002), but we abstract from it here.

[11] As long as $0 < p \le p^*$, $(c^{ns}_{v1}, c^{ns}_{v2}) \in S_L \cap S_R$, because otherwise $N^{ns} < 0$. As a result, $(c^{ns}_{v1}, c^{ns}_{v2})$ does not maximize the Nash criterion function. As long as $(c^{ns}_{v1}, c^{ns}_{v2}) \in S_L \cap S_R$, $N^{ns} > 0$.

the cost advantage offered by voluntary agreements are high. Accordingly, we can show that the conservation level resulting from a VCA will be lower than that expected under regulation if p and a_m/a_v are small enough, as specified in the following proposition (see section 6).

PROPOSITION 2: *(i) In a no-surprises VCA, the conservation levels in both periods decrease as the bargaining power of the landowner increases. (ii) The conservation levels increase as the probability of regulation and the cost advantage provided by voluntary agreements increase. (iii) If* $p(a_m/a_v) < 1$ *the total conservation level will be lower than that expected under regulation.*

The intuition behind these results is straightforward. The landowner prefers lower levels of conservation effort, so the conservation outcome will be lower if he has more bargaining power. A higher probability of regulation and a larger cost advantage increase the expected cost of mandatory conservation, making the landowner more willing to supply higher levels of conservation effort under a VCA.

The results in Proposition 2 suggest that the parties' bargaining power can have a significant effect on the outcome of a voluntary conservation agreement. Conceivably most agreements of this type are initiated by landowners (Defenders of Wildlife 1998), which may increase their bargaining power. Furthermore, enforcing Section 9 of the ESA (the restriction on takings of endangered species on private land) may be quite difficult in practice due to information requirements, high burden of proof, and possibly political considerations (Polasky and Doremus 1998). This amounts to saying that p has traditionally been relatively low. This implies that the conservation levels achieved by no-surprises VCAs are likely to be inefficient, possibly below what could be expected under regulation.

2.3.3 Irreversibility

We now drop the assumption that the actions taken in period 1 are fully reversible. Specifically, we assume that the conservation level in period 2 can be no larger than that in period 1. This would be the case if, for example, the landowner is allowed to develop part of his forest in period 1 (e.g. build a house) as part of the VCA. Given the long time it takes a forest to regenerate and the cost involved, this outcome is, for all practical purposes, irreversible.

The set of acceptable conservation levels for the landowner and the regulator under irreversibility are given by

$$S_L^I = \{(c_{v1}, c_{v2}) | \, c_{v1} + c_{v2} \leq \overline{C}, \, c_{v2} \leq c_{v1}\}$$

$$S_R^I = \{(c_{v1}, c_{v2}) | c_{v1} + c_{v2} \leq \overline{C} + \frac{1}{a_v}[B_1(c_{v1}) + EB_2(c_{v2}) - p(B_1(c_{m1}^*) + E\,B_2(c_{m2}^*))], c_{v2} \leq c_{v1}\}$$

Note that $S_L^I \subset S_L$ and $S_R^I \subset S_R$. This has the effect of decreasing the number of combinations of c_{v1} and c_{v2} acceptable to the landowner and the regulator.

With irreversibility, $0 < p \leq p^*$ and (6) are no longer sufficient for a VCA to be reached, as would be the case if $\overline{c}_{v2} > \overline{c}_{v1}$ (see Figure 4). In this case, the regulator would prefer a VCA only under more stringent conditions (a larger cost advantage and/or a lower threat of regulation). In addition, irreversibility may affect the equilibrium levels of conservation resulting from the agreement. Specifically, by adding the constraint $c_{v2} \leq c_{v1}$ to the Nash bargaining problem, irreversibility limits the set of feasible bargaining outcomes to $\{ S_L^I \cap S_R^I \} \subset \{S_L \cap S_R\}$. This may further curtail the regulator's ability to obtain desirable conservation results under a VCA.

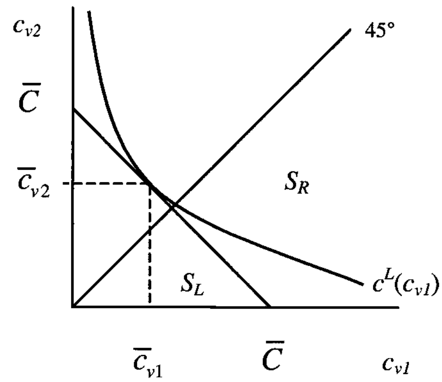

FIGURE 2.4
No VCA under irreversibility

There are many examples where irreversibility plays an important role. For instance, a number of HCPs in the southeastern United States are limited to translocating red-cockaded woodpeckers from private to federal forests, in order to harvest the former. However, critics of these plans contend that male woodpeckers do not adapt easily to their new surroundings, and often attempt to return to their original home (Kaiser, 1997). Of course, once their original habitat has been harvested, there is little else that can be done to correct the problem. This provides an argument for the regulator to exercise caution regarding the conditions he agrees to under a VCA.

2.4 SURPRISES

In this section we consider a setting in which "surprises" are possible, in the sense that in period 2 the regulator may request that the landowner supply a level of conservation effort other than that agreed to in period 1. This type of agreement characterized HCPs before the no-surprises policy was introduced in 1994. To illustrate the difference between the surprises and no-surprises scenarios, consider the case of the safe-harbor program for red-cockaded woodpeckers in the sandhills region of North Carolina (Defenders of Wildlife 1998). Under this program, participating landowners agreed to perform voluntary habitat management for woodpeckers that already occupied their property and to enhance habitat in other parts of the land not inhabited by the birds. Under a surprises scenario, further land-use restrictions would be imposed if additional woodpeckers occupied the newly enhanced habitat. However, given the assurances provided by the agreement under the no-surprises policy, any additional woodpecker settlements on the property will not trigger further restrictions. Another clear example is the case of the Washington Department of Natural Resources (WDNR) HCP (Defenders of Wildlife 1998). Although this HCP applies to state-owned rather than private lands, and is admittedly an extreme case, it serves to illustrate our point. The WDNR presented a management strategy designed for spotted owls, marbled murrelets, and salmon, and obtained an incidental take permit (exempting it from ESA Section 9 restrictions) for those species. Under a surprises scenario, if other species inhabiting WDNR land became listed, Section 9 of the ESA would prohibit any take of those species. However, under the no-surprises HCP signed by WDNR, the incidental permit includes each species that becomes listed during the 70 to 100 years of the agreement.

2.4.1 No Irreversibility

In a VCA that does not rule out surprises, the regulator and landowner agree on conservation effort levels c_{v1} and c_{v2} in period 1, but the regulator does not offer any assurances regarding the conservation effort in the second period. Specifically, with probability q, $0 < q \leq 1$, the regulator will surprise the landowner by requiring conservation effort c^*_{v2} instead of c_{v2} in period 2[12], where $c^*_{v2} = \arg\max \{NSB_{v2}(c_{v2})\}$ maximizes net social benefits in period 2. Note that c^*_{v2} may be larger or smaller than c_{v2}. That is, the landowner may be required to provide a higher conservation effort than expected, but he may also be allowed to conserve less[13]. We start by examining how the possibility of a surprise changes the acceptance sets of the regulator and the landowner.

Given the possibility of a surprise, the regulator will enter into a VCA if and only if

$$NSB_{v1}(c_{v1})+q\,E\,NSB_{v2}(c^*_{v2}) + (1\text{-}q)\,E\,NSB_{v2}(c_{v2}) \geq p[NSB_{m1}(c^*_{m1})+E\,NSB_{m2}(c^*_{m2})]$$

Thus, the acceptance set for the regulator can be written as

$$S_R' = \{(c_{v1},c_{v2}) | c_{v1} + c_{v2} \leq \overline{C} + \frac{1}{a_v}[B_1(c_{v1}) + E\,B_2(c_{v2}) - p(B_1(c^*_{m1}) + E\,B_2(c^*_{m2}))]$$

[12] We assume that the probability q is exogenous. It may be interpreted as characterizing the regulator's *a priori* unknown willingness or ability to request a change in conservation effort in period 2.

[13] In order to focus on the effect of surprises on first period decisions, we assume that the landowner will comply with the regulator's request in period 2. The underlying supposition is that, should the landowner refuse to comply, he will be regulated with probability one in the second period, and that the resulting costs (possibly including fines) would be high enough to deter him from not complying. This can be justified by noting that, by participating in period 1, the landowner reveals private information about his land to the regulator, thereby assuring that he will be regulated in period 2 if he does not comply.

$$+\frac{1}{a_v} q[E\,NSB_{v2}(c_{v2}^*) - E\,NSB_{v2}(c_{v2})]\} \qquad (9)$$

A comparison of S_R' with S_R reveals that the regulator is always more willing to enter into a VCA that does not offer assurances. To see this, note that the difference between S_R and S_R' is the third term on the right hand side of the inequality (inside the brackets) in (9), which is positive since c_{v2}^* maximizes $NSB_{v2}(c_{v2})$. This implies that the number of combinations of c_{v1} and c_{v2} acceptable to the regulator increases. The reason is that, by not offering assurances, the regulator retains the flexibility to use the information that becomes available in the second period and thereby increase net social benefits.

The landowner will enter into a VCA if and only if

$$a_v c_{v1} + q a_v E c_{v2}^* + (1-q) a_v c_{v2} \leq p a_m (c_{m1}^* + E c_{m2}^*)$$

Thus, the acceptance set for the landowner is

$$S_L' = \{(c_{v1}, c_{v2}) | c_{v1} + (1-q) c_{v2} \leq \overline{C} - qEc_{v2}^*\} \qquad (10)$$

A comparison of S_L' with S_L reveals that the effect of surprises on the landowner's willingness to participate in a VCA is ambiguous, as it depends on whether he expects the conservation level in the event of a surprise to be higher or lower than originally agreed upon. In practice, the most relevant scenario is one in which the level of conservation in case of a surprise (c_{v2}^*) is expected to be higher than originally agreed upon (c_{v2}), since landowners arguably enter into Habitat

Conservation Plans or Safe Harbor Agreements because they fear increasing, not decreasing, future conservation requirements. Hence, in what follows, we focus on this scenario and identify conditions under which a VCA is reached if assurances are offered, but not when surprises are possible. Specifically, we examine the effect of the magnitude of the expected conservation effort (Ec^*_{v2}), as well as that of the degree of uncertainty surrounding c^*_{v2}. We incorporate a measure of uncertainty into the model by assuming that c^*_{v2} has a normal distribution, i.e. $c^*_{v2} \sim N(Ec^*_{v2}, \sigma)$, and using the theorem of the moments of the truncated normal distribution (Greene 2000) to write the expected value of c^*_{v2} as a function of its mean and its standard deviation:

$$E[c^*_{v2} \mid c^*_{v2} > c_{v2}] = Ec^*_{v2} + \sigma \frac{\phi(\alpha)}{1-\Phi(\alpha)}$$

where $\alpha = (c_{v2} - Ec^*_{v2})/\sigma$, and $\phi(\cdot)$ and $\Phi(\cdot)$ are the probability and cumulative density functions for the standard normal distribution, respectively.

Suppose that a VCA is the equilibrium outcome in a no-surprises scenario. That is, consider a probability of regulation p that satisfies $0 < p \leq p^*$ and a cost ratio a_m/a_v that satisfies condition (6). This fixes $\overline{C}$, $c^L(c_{v1})$, and ($\overline{c}_{v1}$, $\overline{c}_{v2}$), and establishes that $\overline{c}_{v1} + \overline{c}_{v2} \leq \overline{C}$. As shown in section 6, for the same probability of regulation no agreement will be reached in a surprises scenario if

$$Ec^*_{v2} + \sigma \frac{\phi(\alpha)}{1-\Phi(\alpha)} > \overline{c}_{v2} + \frac{\overline{C} - (\overline{c}_{v1} + \overline{c}_{v2})}{q} \qquad (11)$$

Hence, a VCA will be the equilibrium outcome under no-surprises, but not in a surprises scenario, if the expected conservation effort is high enough. Furthermore, condition (11) is more likely to hold if the degree of uncertainty surrounding c_{v2}^*, as measured by the standard deviation σ, is higher. This establishes the following proposition.

PROPOSITION 3. *Suppose that $0 < p < p^*$ and that condition (6) holds. The regulator and the landowner will reach a VCA under no-surprises, but not in a surprises scenario, if condition (11) holds. This outcome is more likely when the degree of uncertainty surrounding c_{v2}^* increases.*

The intuition behind this result is that high and uncertain conservation requirements in the future translate into high and uncertain costs for the landowner. Thus, he becomes more willing to participate in a conservation agreement if it offers assurances. This suggests that offering assurances to landowners may increase the likelihood that they will enter into a VCA, particularly when there is significant uncertainty about future conservation needs. The actual experience with HCPs seems to confirm this intuition. Although HCPs were incorporated into the ESA in 1982, less than 50 plans had been requested and approved before the "no surprises" policy was announced in 1994. In 1995 this number shot up to close to 130 plans (Kaiser 1997). As of April of 2002, 379 HCPs covering 30 million acres and 200 species had been approved (FWS 2002a).

2.4.2 Equilibrium Outcomes

Here we assume that the regulator and the landowner have reached an agreement with no assurances, and once again use a Nash bargaining framework to examine the resulting conservation levels, (c_{v1}^{s}, c_{v2}^{s}), where the superscript "*s*" indicates "surprises". In particular, we are interested in comparing the conservation levels that the landowner and the regulator agree upon under a surprises and a no-surprises VCA, i.e. (c_{v1}^{s}, c_{v2}^{s}) and $(c_{v1}^{ns}, c_{v2}^{ns})$. The result of this comparison is stated in the following proposition.

PROPOSITION 4: *If* $E c_{v2}^{*} > c_{v2}^{s}$, *then* $c_{v1}^{ns} > c_{v1}^{s}$ *and* $c_{v2}^{ns} > c_{v2}^{s}$.

Proposition 4 suggests that if the conservation effort in the second period is expected to be higher than originally agreed upon, the levels of conservation effort will be higher in a no-surprises VCA than in a surprises VCA. As argued above, this is the relevant case in practice. The alternative scenario, in which the conservation level is expected to be lower than originally agreed upon, does not yield an unambiguous result.

To gain additional insight into Proposition 4, note that the regulator is always more "flexible" in a surprises than in a no-surprises scenario. If $E c_{v2}^{*} > c_{v2}^{s}$, the landowner is less flexible in a surprises scenario, since he is only willing to accept lower total conservation effort. Hence, since the landowner will always try to bargain for less effort, the total conservation effort can be expected to be lower in a surprises scenario.

Proposition 4 compares the outcome of surprises and no-surprises VCAs in terms of the total amount of conservation effort they generate. It would also be desirable to make a comparison based on the corresponding welfare levels (i.e. net social benefits). This comparison yields the following proposition.

PROPOSITION 5. *If* $E c_{v2}^{*} > c_{v2}^{s}$*, a no-surprises VCA generates higher expected net social benefits than a surprises VCA.*

To understand the intuition behind Proposition 5, consider the landowner's and the regulator's goals when bargaining over the outcome of a VCA (both surprises and no-surprises). The landowner will try to obtain the lowest possible levels of conservation effort, whereas the regulator will try to get as close as possible to the conservation levels that maximize expected net social benefits. Hence, as long as the landowner has any bargaining power, the resulting levels of conservation under a VCA will be no higher than those that maximize expected net social benefits. Therefore, the higher the resulting conservation levels, the closer they will be to those that maximize expected net social benefits. As argued in Proposition 4, a no-surprises VCA will yield higher conservation efforts than a surprises VCA if $E c_{v2}^{*} > c_{v2}^{s}$. An example where a no-surprises VCA is preferred is depicted in Figure 5, where (c_{v1}^{ns}, c_{v2}^{ns}), and (c_{v1}^{s}, c_{v2}^{s}) are depicted on progressively lower iso-net-social-benefit curves around (c_{v1}^{*}, c_{v2}^{E}), where the expected net social benefits from both periods are maximized (the dashed lines represent the no-surprises scenario and the solid lines represent the surprises scenario).

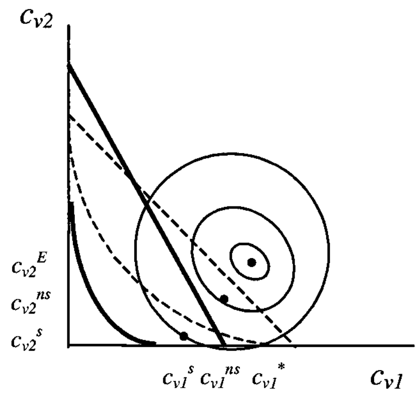

FIGURE 2.5
No-surprises VCA preferred to surprises VCA

2.4.3 Irreversibility

If we drop the assumption that the actions from period 1 are reversible, the acceptance sets for the landowner and the regulator have the same form as in (9) and (10), with the addition of the constraints $E c_{v2}^{*} \leq c_{v1}$, $c_{v2} \leq c_{v1}$. The analysis for this case is analogous to the corresponding case in the no-surprises scenario, so we do not repeat it. The basic result is that irreversibility reduces the likelihood of a VCA.

The preceding results suggest that policymakers face a tradeoff in designing conservation policy for private lands. Providing landowners with assurances regarding future conservation requirements limits the regulator's ability to incorporate new information into his management choices and may thereby preclude him from achieving desirable outcomes. It is well known that there is a value to preserving flexibility when facing future uncertainty and potentially irreversible outcomes (Arrow and Fisher 1974, Fisher and Hanemann 1986, 1987, Hanemann 1989). Accordingly, voluntary conservation agreements with no-surprises clauses have been criticized by biologists and environmentalists for ignoring the inherent uncertainty of the natural world, failing to build flexibility into management plans, and precluding the use of new information to address unforeseen impacts of previously approved actions (Kaiser 1997, Shilling 1997, Kostyack 1998).

On the other hand, landowners who face uncertain and potentially significant costs from additional conservation requirements may not be willing to commit to high conservation levels, and may even be unwilling to participate in an agreement at all. Assurances can provide an incentive for landowners to participate in conservation programs. Furthermore, if conservation plans cannot be modified to incorporate new information, possibly due to lack of political will, funding deficiencies, or legal challenges, no-surprises agreements may yield higher levels of conservation and welfare than agreements that do not provide assurances.

In practice, landowners usually expect conservation requirements to increase in the future. Furthermore, the FWS faces small and shrinking budgets for endangered species conservation, as well as increasing opposition to further land use restrictions that could be perceived as impinging on the property rights of private landowners. Our results indicate that, in such a scenario, agreements that offer assurances may be preferred to ones that do not. This suggests that the FWS's current approach of offering no-surprises agreements to landowners may be somewhat justified.

However, as argued in Section III, the conservation outcome from a VCA is likely to be inefficient if the landowner has more bargaining power than the regulator and the threat of regulation and the cost advantage provided by voluntary agreements are low. This suggests several ways in which the conservation outcome can be improved. For example, insofar as the landowner's bargaining power is created by private information about his land, efforts to improve the availability of information about private lands could increase the regulator's bargaining power. Another possibility is to increase the credibility of the background threat of regulation. This could be achieved, for example, through legislation to provide a statutory base for the background threat of regulation and by improving enforcement of existing regulations.

2.5 CONCLUSIONS

This paper analyzed the conditions under which the interaction between a regulator and a landowner leads to a VCA, and the conservation levels that may result from such an agreement. This was done in the context of uncertain and irreversible outcomes. The analysis showed that the likelihood that a VCA is reached depends on the cost advantage offered by voluntary agreements, the background threat of regulation, and whether assurances are offered as part of the agreement or not. In particular, offering assurances may increase the likelihood that a VCA will be reached, especially when there is a large degree of uncertainty regarding future conservation requirements.

Our analysis also showed that the conservation level generated by a VCA depends on the bargaining power of the parties, the background threat of regulation, and the cost advantage provided by voluntary agreements, as well as on the irreversibility of actions taken in the first period. Specifically, the conservation level will be lower when the landowner has more bargaining power, and higher when the probability of regulation and the cost advantage of VCAs are high. In addition, VCAs that do not offer assurances may result in lower conservation levels and social welfare than VCAs that do. Furthermore, we argued that in practice the conservation levels generated by a VCA are likely to be inefficient because the landowner has more bargaining power than the regulator and because the threat of regulation is low.

Although our analysis has focused on the specific issue of endangered species, the framework presented here should apply to other contexts in which uncertainty and irreversibility are relevant and assurances-based incentives are used to complement command-and-control regulation. For instance, industries negotiating plans for management of imperiled aquatic ecosystems have sought assurances against enforcement of the Clean Water Act, the Federal Power Act, and several other federal and state environmental laws. Similarly, the electric utility industry has lobbied Congress to include no-surprises clauses in relicensing agreements for hydroelectric facilities, so that the terms of the license could not be revised due to environmental reasons (Kostyack 1998).

2.6 PROOFS

2.6.1 Derivation of the Properties of the Regulator's Acceptance Set

First, we prove that if $S_R \neq \emptyset$, S_R is a convex set (i.e. $c^U(c_{v1})$ is concave and $c^L(c_{v1})$ is convex), as shown in Figure 1b. By definition,

$NSB_{v1}(c_{v1}) + E\,NSB_{v2}(c^j(c_{v1})) = p[NSB_{m1}(c^*_{m1}) + ENSB_{m2}(c^*_{m2})]$, $j = U, L$ (12)

Differentiating (12) twice with respect to c_{v1}, we obtain

$$\frac{d^2c^j(c_{v1})}{dc_{v1}^2} = -\frac{\dfrac{d^2NSB_{v1}(c_{v1})}{dc_{v1}^2} + \dfrac{d^2NSB_{v2}(c^j)}{dc_{v2}^2}\left(\dfrac{dc^j}{dc_{v1}}\right)^2}{\dfrac{dNSB_{v2}(c^j)}{dc_{v2}}}, j = U, L$$

Because $dNSB_{v2}(c^L)/dc_{v2} > 0$, $dNSB_{v2}(c^U)/dc_{v2} < 0$, and $NSB_v(\bullet)$ is concave, we have $d^2c^L/dc_{v1}{}^2 > 0$ and $d^2c^U/dc_{v1}{}^2 < 0$. This implies that $c^L(\bullet)$ is convex and $c^U(\bullet)$ is concave.

2.6.2 Derivation of the Properties of the Regulator's Conservation Thresholds

The point $(\overline{c}_{v1}, \overline{c}_{v2})$ is located on the lower boundary of the regulator's acceptance set, $c^L(c_{v1})$. Specifically, $\overline{c}_{v1}$ and $\overline{c}_{v2}$ are defined by $c^L(\overline{c}_{v1}) = \overline{c}_{v2}$ and $c^{L\prime}(\overline{c}_{v1}) = -1$ (see Figure 2).

To see that $\overline{c}_{v1} + \overline{c}_{v2}$ is increasing and convex in p, differentiate (12) with respect to p to obtain

$$\frac{\partial c^L_{v2}}{\partial p} = \frac{NSB_{m1}(c^*_{m1}) + ENSB_{m1}(c^*_{m2})}{ENSB'_{v2}(c^L_{v2})} > 0 \text{ and } \frac{\partial^2 c^L_{v2}}{\partial p^2} = -\frac{EB''_2(c^L_{v2})}{ENSB'_{v2}(c^L_{v2})}\left(\frac{\partial c^L_{v2}}{\partial p}\right)^2 > 0$$

(13)

Differentiating $c^L(\overline{c}_{v1}) = \overline{c}_{v2}$ with respect to p, we get

$$\frac{\partial c^L}{\partial p} + \frac{\partial c^L}{\partial \overline{c}_{v1}}\frac{\partial \overline{c}_{v1}}{\partial p} - \frac{\partial \overline{c}_{v2}}{\partial p} = 0$$

Substituting $c^{L\prime}(\overline{c}_{v1}) = -1$ into above equation, we get

$$\frac{\partial(\overline{c}_{v1}+\overline{c}_{v2})}{\partial p}=\frac{\partial c^L}{\partial p}.$$

This result, together with those in (13), implies that $\overline{c}_{v1}+\overline{c}_{v2}$ is increasing and convex in p.

2.6.3 Proof of Proposition 1

First, we prove that $0<p\leq min(1,p^*)$ and condition (6) are necessary. $p > 0$ is clearly necessary, because if $p = 0$, $S_L = \emptyset$. Below, we assume that $p^* < 1$, because if $p^*\geq 1, p\leq min(1,p^*)$ always holds. If $p > p^*$ or condition (6) does not hold, then $\overline{c}_{v1}+\overline{c}_{v2}>\overline{C}$, and $S_L \cap S_R = \emptyset$. This implies that a VCA cannot be reached. On the other hand, if $0<p\leq p^*$ and condition (6) holds, then $\overline{c}_{v1}+\overline{c}_{v2}\leq\overline{C}$, and $S_L \cap S_R \neq \emptyset$.

2.6.4 Proof of Proposition 2

To prove the proposition, we derive the comparative statics results. Note first that, from the first-order conditions in (8),

$(B_1'(c_{v1}^{ns}) - a_v) = (EB_2'(c_{v2}^{ns}) - a_v) =$

$$\frac{\gamma a_v[NSB_{v1}(c_{v1}^{ns})+ENSB_{v2}(c_{v2}^{ns})-p(NSB_{m1}(c_{m1}^*)+ENSB_{m2}(c_{m2}^*))]}{(1-\gamma)[-a_v(c_{v1}^{ns}+c_{v2}^{ns})+pa_m(c_{m1}^*+Ec_{m2}^*)]}>0 \tag{14}$$

where the positive sign of the expression follows from the fact that the Nash bargaining solution satisfies (strong) individual rationality (i.e. the gains from bargaining are positive) (Thomson 1994). Furthermore, (14) implies that

$$B_1'(c_{v1}^{ns}) = E\,B_2'(c_{v2}^{ns}) \tag{15}$$

We start with the comparative statics for the bargaining power parameter, γ. The procedure for the other parameters is the same, so we do not repeat it. Following Silberberg (1990), define the functions $\Phi(\gamma) = N^{ns}(c_{v1}^{ns}(\gamma),\ c_{v2}^{ns}(\gamma),\ \gamma)$ and $F(c_{v1}^{ns},\ c_{v2}^{ns},\ \gamma)$ $= N^{ns}(c_{v1}^{ns},\ c_{v2}^{ns},\ \gamma)$ - $\Phi(\gamma)$. Maximization of $F(\cdot)$ with respect to c_{v1}^{ns}, c_{v2}^{ns}, and γ yields the first-order conditions (function arguments are henceforth omitted when possible)

$$F_i = N_i^{ns} = 0,\ i = 1, 2 \tag{16}$$

$$F_\gamma = N_\gamma^{ns} - \Phi_\gamma = 0 \tag{17}$$

where the subscripts i and γ denote derivatives with respect to c_{vi}^{ns} and γ, respectively. The equations in (16) are the first-order conditions from the original problem (given in (8)), and (17) is an envelope condition. The second-order conditions indicate that the matrix

$$\begin{pmatrix} F_{11} & F_{12} & F_{1\gamma} \\ F_{21} & F_{22} & F_{2\gamma} \\ F_{\gamma 1} & F_{\gamma 2} & F_{\gamma\gamma} \end{pmatrix} = \begin{pmatrix} N_{11}^{ns} & N_{12}^{ns} & N_{1\gamma}^{ns} \\ N_{21}^{ns} & N_{22}^{ns} & N_{2\gamma}^{ns} \\ N_{\gamma 1}^{ns} & N_{\gamma 2}^{ns} & N_{\gamma\gamma}^{ns} - \Phi_{\gamma\gamma} \end{pmatrix}$$ is negative definite, which implies that

$$N_{\gamma\gamma}^{ns} - \Phi_{\gamma\gamma} < 0 \tag{18}$$

Rewriting the envelope condition (17) as an explicit function of γ gives $\Phi_\gamma(\gamma) =$ $N_\gamma^{ns}(c_{v1}^{ns}(\gamma),\ c_{v2}^{ns}(\gamma),\ \gamma)$. Differentiating with respect to γ, rearranging, and using (18) yields

$$\Phi_{\gamma\gamma} - N_{\gamma\gamma}^{ns} = N_{1\gamma}^{ns}(\partial c_{v1}^{ns}/\partial\gamma) + N_{2\gamma}^{ns}(\partial c_{v2}^{ns}/\partial\gamma) > 0 \tag{19}$$

Differentiating the first-order conditions in (8) with respect to γ, we obtain

$N_{1\gamma}^{ns}$ = -(B_1'(c_{v1}^{ns}) - a_v)[− a_v(c_{v1}^{ns} + c_{v2}^{ns})+pa_m(c_{m1}^{*} +$E\,c_{m2}^{*}$)] −

a_v[NSB_{v1}(c_{v1}^{ns})+E NSB_{v2}(c_{v2}^{ns})-p(NSB_{m1}(c_{m1}^{*})+E NSB_{m2}(c_{m2}^{*}))]

$N_{2\gamma}^{ns}$ = -(E B_2'(c_{v2}^{ns}) - a_v)[− a_v(c_{v1}^{ns} + c_{v2}^{ns})+pa_m(c_{m1}^{*} +$E\,c_{m2}^{*}$)] −

a_v[NSB_{v1}(c_{v1}^{ns})+E NSB_{v2}(c_{v2}^{ns})-p(NSB_{m1}(c_{m1}^{*})+E NSB_{m2}(c_{m2}^{*}))]

Therefore, using (15), we conclude that $N_{1\gamma}^{ns} = N_{2\gamma}^{ns} < 0$. Note that this and (19) imply that

$$\partial c_{v1}^{ns}/\partial\gamma + \partial c_{v2}^{ns}/\partial\gamma < 0 \tag{20}$$

Finally, rewrite (15) as $B_1'(c_{v1}^{ns}(\gamma)) = E\,B_2'(c_{v2}^{ns}(\gamma))$, differentiate with respect to γ, and rearrange to obtain

$$\frac{\partial c_{v1}^{ns}/\partial\gamma}{\partial c_{v2}^{ns}/\partial\gamma} = \frac{EB_2''(c_{v2}^{ns})}{B_1''(c_{v1}^{ns})} > 0,$$

so $\partial c_{v1}^{ns}/\partial\gamma$ and $\partial c_{v2}^{ns}/\partial\gamma$ must have the same sign. Thus, (20) implies that $\partial c_{v1}^{ns}/\partial\gamma,\ \partial c_{v2}^{ns}/\partial\gamma < 0$.

Repeating this procedure for the probability of regulation p yields $N_{1p}^{ns} = N_{2p}^{ns} > 0$, $\partial c_{v1}^{ns}/\partial p + \partial c_{v2}^{ns}/\partial p > 0$, and $\partial c_{v1}^{ns}/\partial p,\ \partial c_{v2}^{ns}/\partial p > 0$. Similarly, dividing the first-order conditions in (8) by a_v and repeating the procedure for the cost ratio $\alpha = a_m/a_v$ yields $N_{1\alpha}^{ns} = N_{2\alpha}^{ns} > 0$, $\partial c_{v1}^{ns}/\partial\alpha + \partial c_{v2}^{ns}/\partial\alpha > 0$, and $\partial c_{v1}^{ns}/\partial\alpha,\ \partial c_{v2}^{ns}/\partial\alpha > 0$.

Finally, to see that the outcome of a VCA will be lower than that expected under regulation if p and a_m/a_v are small enough, note that by individual rationality the gains from bargaining must be positive. For the landowner, this implies

$-a_v(c_{v1}^{ns}+c_{v2}^{ns})+pa_m(c_{m1}^{*}+Ec_{m2}^{*})>0$, or $p(a_m/a_v)>(c_{v1}^{ns}+c_{v2}^{ns})/(c_{m1}^{*}+Ec_{m2}^{*})$. Therefore, if $p(a_m/a_v)<1$, then $c_{v1}^{ns}+c_{v2}^{ns} < c_{m1}^{*}+Ec_{m2}^{*}$.

2.6.5 Proof of Proposition 3

The minimum conservation levels acceptable to the regulator in a surprises scenario are $(\bar{c}_{v1},\bar{c}_{v2})$, which are defined by $c_{v2}^{L}(\bar{c}_{v1})=\bar{c}_{v2}$ and $c_{v2}^{L\,\prime}(\bar{c}_{v1})=-1/(1-q)$. A VCA will not be reached if these conservation levels are not acceptable to the landowner, i.e. if

$$\bar{c}_{v1}+q\,E[c_{v2}^{*}\,|\,c_{v2}^{*}>\bar{c}_{v2}]+(1\text{-}q)\bar{c}_{v2}>\bar{C}$$

or

$$\bar{c}_{v1}+q\,[Ec_{v2}^{*}+\sigma\frac{\phi(\alpha)}{1-\Phi(\alpha)}]+(1\text{-}q)\bar{c}_{v2}>\bar{C}$$

Rearranging this expression gives condition (11).

2.6.6 Proof of Proposition 4

The conservation levels (c_{v1}, c_{v2}) are chosen to maximize the Nash criterion function

$$N^{s}(c_{v1},c_{v2})=[-a_v(c_{v1}+q\,Ec_{v2}^{*}+(1\text{-}q)c_{v2})+pa_m(c_{m1}^{*}+Ec_{m2}^{*})]^{\gamma}\times$$

$$[NSB_{v1}(c_{v1})+q\,E\,NSB_{v2}(c_{v2}^{*})+(1\text{-}q)\,E\,NSB_{v2}(c_{v2})-p(NSB_{m1}(c_{m1}^{*})+E\,NSB_{m2}(c_{m2}^{*}))]^{1-\gamma}$$

The resulting conservation levels (c_{v1}^{s},c_{v2}^{s}) are implicitly defined by the following first-order conditions:

$$N_1^s(c_{v1}^s, c_{v2}^s) = (1\text{-}\gamma)(B_1'(c_{v1}^s) - a_v)[- a_v(c_{v1}^s + q\, E c_{v2}^* + (1\text{-}q)\, c_{v2}^s) + p a_m(c_{m1}^* + E c_{m2}^*)]$$

$$-\gamma a_v[NSB_{v1}(c_{v1}^s) + qE\, NSB_{v2}(c_{v2}^*) + (1\text{-}q)E\, NSB_{v2}(c_{v2}^s) - p(NSB_{m1}(c_{m1}^*) + E\, NSB_{m2}(c_{m2}^*))] = 0$$

$$N_2^s(c_{v1}^s, c_{v2}^s) = (1\text{-}\gamma)(E\, B_2'(c_{v2}^s) - a_v)[- a_v(c_{v1}^s + q\, E c_{v2}^* + (1\text{-}q)\, c_{v2}^s) + p a_m(c_{m1}^* + E c_{m2}^*)]$$

$$-\gamma a_v[NSB_{v1}(c_{v1}^s) + qE\, NSB_{v2}(c_{v2}^*) + (1\text{-}q)E\, NSB_{v2}(c_{v2}^s) - p(NSB_{m1}(c_{m1}^*) + E\, NSB_{m2}(c_{m2}^*))] = 0$$

(21)

Note that a no-surprises clause in a VCA is equivalent to setting $q = 0$. Thus, we can compare the conservation outcomes of VCAs that offer assurances with those that do not by examining how the levels of conservation effort vary as q decreases. We use the same procedure as in the proof of Proposition 2 to obtain the comparative statics results for q. These are: $N_{1q}^s\,(\partial c_{v1}^s/\partial q) + N_{2q}^s\,(\partial c_{v2}^s/\partial q) > 0$, where, as before, $\partial c_{v1}^s/\partial q$ and $\partial c_{v2}^s/\partial q$ have the same sign. Differentiating the first order conditions in (21) with respect to q yields

$$N_{1q}^s = -(1\text{-}\gamma)a_v(B_1'(c_{v1}^s) - a_v)(E c_{v2}^* - c_{v2}^s) - \gamma a_v(E\, NSB_{v2}(c_{v2}^*) - E\, NSB_{v2}(c_{v2}^s)) \qquad (22)$$

$$N_{2q}^s = -(1\text{-}\gamma)a_v(E\, B_2'(c_{v2}^s) - a_v)(E c_{v2}^* - c_{v2}^s) - \gamma a_v(E\, NSB_{v2}(c_{v2}^*) - E\, NSB_{v2}(c_{v2}^s)) \qquad (23)$$

If $E c_{v2}^* > c_{v2}$, then the first terms in (22) and (23) are negative. Since the second term is positive, this implies that $N_{1q}^s = N_{2q}^s < 0$, and therefore that $\partial c_{v1}^s/\partial q < 0$ and $\partial c_{v2}^s/\partial q < 0$. Hence, because c_{v1}^{ns} and c_{v2}^{ns} are obtained by setting $q = 0$, the result follows.

2.6.7 Proof of Proposition 5

By Proposition 4, if $E c^{*}_{v2} > c_{v2}$, then $c^{ns}_{v1} > c^{s}_{v1}$ and $c^{ns}_{v2} > c^{s}_{v2}$. Therefore, we have

$$NSB_{v1}(c^{s}_{v1}) - NSB_{v1}(c^{ns}_{v1}) < NSB_{v1}'(c^{ns}_{v1})(c^{s}_{v1} - c^{ns}_{v1}) < 0 \qquad (24)$$

$$E\,NSB_{v2}(c^{s}_{v2}) - E\,NSB_{v2}(c^{ns}_{v2}) < E\,NSB_{v2}'(c^{ns}_{v2})(c^{s}_{v2} - c^{ns}_{v2}) < 0 \qquad (25)$$

The first inequalities in (24) and (25) follow from the concavity of $NSB(\cdot)$. The second inequalities follow from the fact that $NSB_{v1}'(c^{ns}_{v1}) > 0$ and $E\,NSB_{v2}'(c^{ns}_{v2}) > 0$ by the first order conditions in (8), and $(c^{s}_{v1} - c^{ns}_{v1}) < 0$ by Proposition 4. Thus, (24) implies $NSB_{v1}(c^{ns}_{v1}) > NSB_{v1}(c^{s}_{v1})$, and (25) implies $E\,NSB_{v2}(c^{ns}_{v2}) > E\,NSB_{v2}(c^{s}_{v2})$. Therefore,

$$NSB_{v1}(c^{ns}_{v1}) + E\,NSB_{v2}(c^{ns}_{v2}) > NSB_{v1}(c^{s}_{v1}) + E\,NSB_{v2}(c^{s}_{v2}).$$

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CHAPTER 3

CONSERVATION INCENTIVES PROGRAMS FOR ENDANGERED SPECIES: AN ANALYSIS OF LANDOWNER PARTICIPATION

Christian Langpap

3.1 INTRODUCTION

Eliciting the cooperation of private landowners has become a crucial part of the U.S. Fish and Wildlife Service's (FWS) efforts to protect rare species and bring about their recovery, as more than half of the listed endangered species have at least 80% of their habitat on private land (FWS 1997a). However, Section 9 of the Endangered Species Act (ESA), the main regulatory tool available to the FWS on private land, has raised strong opposition from property rights advocates. Section 9 of the ESA prohibits any private action that may directly result in the taking of an endangered species. Additionally, as interpreted by the FWS, it forbids any actions that may cause indirect harm through modifications of the species' habitat that hinder breeding, feeding, or other essential activities[14]. This prohibition can include activities that are otherwise lawful, such as construction, logging, or grazing, if they occur within the range of a listed species. These restrictions on private activity have become a politically sensitive subject, making the regulation hard to enforce.

Furthermore, Section 9 may generate perverse incentives that have the opposite effect than that intended by the ESA. That is, it might compel landowners to manage their land in ways that harm endangered species in order to avoid possible land-use restrictions (see Polasky and Doremus 1998, Innes 2000, and Polasky 2001). This argument is supported by ample anecdotal evidence (see, e.g., Bean and Wilcove 1997, Mann and Plummer 1995, Ruhl 1998, Bean 1998). One of the best-known examples is that of Benjamin Cone, a forest owner in North Carolina who lost close to

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[14] 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).

$2 million when he was denied logging rights on 1,560 acres of his property to protect the red-cockaded woodpecker. In response, Cone made clear his intention to "start massive clear cutting" and switch from an 80-year to a 40-year rotation (Sugg 1993). Lueck and Michael (2000) have found statistical evidence of precisely this type of behavior in the case of forest owners in the southeast and the red-cockaded woodpecker.

Section 9 of the ESA has also been criticized for focusing entirely on attempting to prevent undesirable behavior by landowners, but failing to encourage or reward positive behavior. This may be an important distinction when active management, such as prescribed burning, removal of exotic species, predator control, creation of dispersal corridors, or control of edge effects, is required to restore or maintain habitat for an endangered species.

In response to these apparent deficiencies of the ESA, there has been a call for reform, including the use of incentives-based voluntary programs to complement the existing regulatory framework. Two main approaches have been suggested. One seeks to reform the ESA by providing landowners with assurances regarding future regulation. The intent of these reforms, which take the form of Habitat Conservation Plans with a "no surprises" policy and Safe Harbor Agreements, is to eliminate the perverse incentives created by Section 9 (see, e.g., Melious and Thornton 1999, Wilcove *et al.* 1996, Bean and Wilcove 1996, FWS 1999a, 1999b). A second approach attempts to encourage positive behavior by offering the landowner both financial and non-financial incentives to manage his land in a way that is compatible with the survival and recovery of endangered species. These incentives include compensation payments, tax credits, cost sharing agreements, public recognition, and stewardship certification (see, e.g., Keystone Center 1995 or Vickerman 1998).

An optimal strategy for implementing these incentives programs should consider both the effect of the incentives on land management decisions and the participation rate induced by the program. The effect of incentives has been addressed extensively in the literature (see, e.g., Defenders of Wildlife 1994, Stone 1995, Sample 1994, Brockett and Gebhard 1999, Kennedy *et al.* 1996, Bourland and Stroup 1996, McNeely 1993, Kline *et al.* 2000, Smith and Shogren 2001, 2002, Zhang and Flick 2001). The decision to participate in an incentives program was examined in Ervin and Ervin (1982), who proposed a general framework for a landowner's decision to adopt conservation practices based on personal, physical (i.e. land), economic, and institutional factors. More specifically, participation in conservation and incentives programs has been analyzed in the case of soil conservation practices (e.g. Bromley 1980, Konyar and Osborn 1990, Parks and Schorr 1997), as well as in the case of forest owners and the Stewardship Incentives Program. Nagubadi *et al.* (1996) surveyed non-industrial private forest owners (NIPFs) in Indiana and found that owner characteristics had no significant effect on participation behavior in cost-share programs. The location of a residence on the landowner's woodland, commercial reasons for ownership, membership in forestry organizations, and a favorable attitude towards conservation easements all had positive effects on participation. Bell *et al.* (1994) performed a similar analysis for NIPFs in Tennessee. They found that income, experience with forestry, primary land use, and information about land-use programs had an effect on the likelihood of participation. Hardie and Parks (1996) examined reforestation decisions in southern pine plantations and their response to various levels of cost sharing. They found support for the notion that cost-sharing encourages tree planting that would not otherwise occur, and that there is a tradeoff between increasing the amount of cost-sharing and providing landowners with more information about existing incentives programs.

This paper uses a survey of NIPFs in western Washington and Oregon to analyze participation in an incentives program that asks landowners to manage their land in a way that benefits endangered species. It differs from previous studies in that it focuses specifically on the use of incentives to protect endangered species. This creates an important distinction, because it establishes a context characterized by the controversial and adversarial nature of the implementation of the ESA on private land, a context that is not shared by incentives programs analyzed in previous work. This may be particularly relevant for the area studied in this paper. The Pacific Northwest has been the center of two of the most prominent conflicts between private landowners and federal authorities seeking to enforce the ESA: the spotted owl controversy and, more recently, the restriction on release of irrigation water in the Klamath Basin. The persistent confrontation between private rights advocates and ESA supporters has generated an atmosphere of contempt and distrust for government-run environmental protection programs.

Furthermore, the nature of the incentives program considered here is different from those studied previously. In the case of soil conservation programs, the participation process may be set in motion when the landowner realizes he faces an erosion problem, which can have negative effects on returns and land-use values (Ervin and Ervin 1982). Similarly, in the case of forestry programs, the forest owner may be interested in reducing the costs of practices like tree planting, stand improvement, or preparation of sites for natural regeneration, with the ultimate objective of raising the supply of timber (Nagubadi *et al.* 1996). On the other hand, participation in an incentives program to protect endangered species may be driven by fear of stricter regulation in the future (Kline *et al.* 2000), or possibly even of civil or criminal enforcement proceedings (Zhang and Flick 2001). Accordingly, this paper allows for the possibility that a landowner's perceived risk of regulation influences his participation decision, a factor not taken into account in previous studies (with the exception of Nagubadi *et al.* 1996). Additionally, it includes compensation and assurances regarding future regulation as possible incentives in addition to cost-sharing, which is the type of incentive commonly considered in existing work.

In light of these distinctions, it is likely that at least some of the factors that have been used to explain participation behavior in the past may have different effects in the scenario considered here. For instance, Nagubadi *et al.* (1996) found that landowners who own forestland primarily for commercial purposes are more likely to participate in a forestry incentives program. One would not expect this to be true in an endangered species context, where a concern for wildlife habitat may be a more important factor. Similarly, Nagubadi *et al.* (1996) found that the total acreage owned has a positive effect on the likelihood of participation. However, if landowners with larger holdings are more likely to manage their land for profit, they may be less willing to participate in an incentives program that does not increase returns, as is the case of the program considered here. As a final example, Bell *et al.* (1994) expected that landowners with agriculture-related occupations would be more likely to participate in a forestry program. In the scenario considered here, landowners with agriculture- or timber-related occupations are more apt to harbor negative feelings towards the ESA and endangered species, and thus may be less likely to participate.

The analysis carried out in this paper could help improve the effectiveness of incentive programs for conservation of endangered species by suggesting a framework to identify those segments of the population that are more likely to participate, and thereby allowing more effective targeting and marketing of these programs. For instance, the results obtained here for Oregon and Washington suggest that younger landowners who have acquired their property more recently, own more woodland, and are interested in conservation and providing wildlife habitat on their forests are more likely to participate.

The remainder of the paper is organized as follows. Section 2 presents an analytical framework based on a random utility model. Section 3 discusses the survey and data, while section 4 develops the econometric model and presents the corresponding empirical results. Finally, a summary and policy implications are presented in section 5.

3.2 ANALYTICAL FRAMEWORK

In this section, I use a random-utility framework (see, e.g., Ben-Akiva and Lerman 1985, Train 1986) to analyze a landowner's decision whether to participate in an incentives program or not. This decision depends on the landowner's attitudes towards conservation, which may be shaped by personal characteristics such as age, income, education, etc., and the characteristics of his property.

Let s_i be the vector of demographic characteristics of landowner i (e.g. age, education, income). Additionally, let z_i be the vector of characteristics of landowner i's land, such as the number of acres he owns. Finally, define the indicator variable q = 0 if the landowner does not participate in the incentives program, and $q = 1$ if he participates, and let $U_{qi}(q, s_i, z_i)$, $q = 0, 1$ be landowner i's utilities from not participating and participating, respectively. Thus, landowner i will decide to participate in an incentives agreement if and only if

$$U_{1i}(1, s_i, z_i) \geq U_{0i}(0, s_i, z_i) \tag{1}$$

If the exact form of the landowner's utility function was known, and all the factors relevant to his decision were observable, then condition (1) would suffice to explain his choice. However, each of the arguments in the landowner's utility functions contains elements that are unobservable, and the exact form of the utility function is unknown. Thus, the preceding decision rule needs to be reformulated in a probabilistic framework. To do so, each of the arguments in the utility function can be partitioned into two vectors, one observable and the other not observable. Specifically, let r_i and y_i be the observable components of s_i and z_i, respectively. Additionally, $U(\bullet)$

can be decomposed into two functions, which are assumed to be additively separable: one depending on the observed elements, $V(\bullet)$, and one that is a function of the unobserved elements, given by $\varepsilon_{qi.}$ Thus, the landowner's utility can be rewritten as

$$U_{qi} = V(q, r_i, y_i) + \varepsilon_{qi} = V_{qi} + \varepsilon_{qi}, \ q = 0, 1$$

Now condition (1) can be reformulated in terms of the redefined function. Note that, since this function includes an unobservable component, this must be done in terms of choice probabilities. Let P_i be the probability that landowner i chooses to participate. Then

$$P_i = Pr(U_{1i} \geq U_{0i}) \tag{3}$$

Substituting in (2),

$$P_i = Pr(V_{1i}+\varepsilon_{1i} \geq V_{0i}+\varepsilon_{0i}), \quad \text{or}$$

$$P_i = Pr(\varepsilon_{0i} - \varepsilon_{1i} \leq V_{1i} - V_{0i}) \tag{4}$$

Note that ε_{qi} is a random variable, so $\varepsilon_{0i} - \varepsilon_{1i}$ is random as well. Thus, condition (4) gives a cumulative distribution. By choosing a specific distribution for the unobserved components of utility, one can estimate the probabilities that the landowner participates as a function of the characteristics of the landowner and his land. This is done in section 4 by assuming that the unobserved components have a standard normal distribution, and using a Probit model to estimate the participation probabilities.

3.3 SURVEY AND DATA

3.3.1 Survey

This section describes the survey instrument used to obtain the data. The names and addresses of NIPFs in 25 counties in western Washington and Oregon who owned at least 10 acres of land were obtained from county tax assessor's offices[15]. A mail survey was designed and conducted according to the Total Design Method (Dillman 1978) in the summer and fall of 2001. An initial version of the survey was pre-tested with two focus groups of NIPFs. A second version of the survey, incorporating changes suggested by the focus groups, was used for a further pre-test, which was mailed out to a subset of the sample. A final version of the survey was then mailed out to 1,500 NIPFs. This first mailing was followed by a reminder postcard and second and third mailings to non-respondents. Of the original 1,500 surveys mailed out, 101 surveys were undeliverable, so the final sample consisted of 1,399 forest owners. Of the 947 surveys that were returned, 737 were considered usable (i.e. they contained answers to the questions used to derive the dependent variables in the econometric analysis), which gives a response rate of 53% (or 49% of the entire sample of 1,500). Additionally, a sample of 137 non-respondents (30% of total non-

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[15] Ten acres was chosen as a cutoff point because the distribution of landowners shows 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.

responses) were contacted by phone and asked for information on characteristics that could influence response[16].

The survey asked NIPFs questions about characteristics of their property, past management practices, knowledge of incentives programs, perceived risk of ESA regulation, and demographic information. Additionally, the survey presented landowners with the possibility of entering into a hypothetical incentives program. As part of this program, landowners would agree to implement a management plan. In exchange for doing so, landowners were offered three types of incentives: cost-sharing on any expenditures generated by the management plan, compensation[17] for resulting income loss, and assurances regarding future land use restrictions or additional costs. After being provided with descriptions of the management plans and the different incentives, landowners were asked if they would be willing to manage part of their land under an incentives program. This question thus corresponds to the participation decision faced by a landowner, i.e. whether to participate in an incentives program or not.

3.3.2 Data

The dependent variable in the econometric model corresponds to the landowner's decision on whether to participate in an incentives program or not. Thus,

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[16] 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.

[17] In this study, "compensation" refers to payments received by the landowner as (partial or full) reimbursement for income lost (i.e. opportunity costs) because of participating in a voluntary conservation program. Note the difference with the way the term is interpreted in the takings literature (e.g. Polasky and Doremus 1998, Innes 2000, or Polasky 2001), where it refers to compensation for losses resulting from regulation.

define PARTICIPATE = 0 if the landowner does not want to participate, 1 if he does. This decision depends on characteristics of the landowner and of his land.

One factor that may affect the landowner's participation decision is his perceived risk of regulation under the ESA. On the one hand, he may be less willing to manage his land to benefit endangered species if he believes that the risk of regulation is high. On the other hand, he may be more willing to enter into an agreement that offers assurances if he believes that regulation is likely. The survey presented landowners with a 5-point scale ranging from "Very Unlikely" to "Very Likely", and asked them how likely they believed it was that the ESA might restrict activity on their property.

Another factor that may be important in determining a landowner's decision is the importance he attaches to different services provided by his forestland. A landowner that owns forest mainly for investment or commercial purposes may be less likely to enter into an incentives agreement than a landowner who owns forest mainly for aesthetic or recreation purposes. Likewise, a landowner who considers that the wildlife habitat provided by his property is important may be more likely to participate in an incentives program. The survey asked landowners to rank the importance of various services provided by their forest, including investment value, lumber and wood products, aesthetic enjoyment, recreation, and wildlife habitat.

Additionally, the model includes a number of demographic variables that may have an effect on the landowner's decision. First, age has been found to have a positive correlation with adoption of soil conservation practices (Ervin and Ervin

1982) and minimum tillage practices (Korsching *et al.* 1983). Nagubadi *et al.* (1996) argued that older (and thus more experienced) forest owners might be more likely to participate in forestry programs, but failed to find a statistically significant relationship between age and participation in a cost share program. Second, landowners with higher income may be better able to absorb out-of-pocket and opportunity costs of managing for endangered species. Additionally, Nagubadi *et al.* (1996) argued that income should be positively correlated with participation because higher income increases the capability to acquire more acres of woodland and to access information sources. However, they did not find a significant correlation between income and participation. On the other hand, Bell *et al.* (1994) found evidence that income has a positive effect on participation. Third, landowners who have a higher level of education might be more likely to participate because they may be better able to understand the benefits of participation (Nagubadi *et al.* 1996) or more willing to acquire the necessary expertise (Bell *et al.* 1994). Finally, a landowner's occupation may affect his willingness to participate. On the one hand, agriculture or forestry-related occupations may increase the likelihood of participation because of familiarity with government programs and farm or forestry practices and production factors (Bell *et al.* 1994, Nagubadi *et al.* 1996). On the other hand, landowners whose livelihood depends more directly on resource exploitation (such as farmers, ranchers, tree farmers, loggers, or even mill workers) may have a strong negative predisposition towards conservation of endangered species on private land. Thus, they might be less likely to participate in the incentives programs proposed in this study.

Finally, characteristics of the property may also play a role in a landowner's participation decision. Previous studies have included the total amount of acres owned (Korsching *et al.* 1983, Bell *et al.* 1994, Nagubadi *et al.* 1996), the amount of woodland acres owned, the presence of a residence on the property, and the number of years of ownership of the property (Nagubadi *et al.* 1996). Descriptions and summary statistics for all these variables are presented in Table 1. In the following section, I use this data to estimate an econometric model of the landowner's participation decision.

TABLE 3.1: VARIABLE DESCRIPTIONS AND SUMMARY STATISTICS

Variable	*Description*	*Mean*	*Std. Dev.*
REGULATE	Perceived threat of regulation: Very Unlikely (1) to Very Likely (5)	3.08	1.58
Forest			
INVEST	Importance of investment services provided by forest: Not Important (1) to Very Important (5)	3.89	1.21
LUMBER	Importance of lumber and wood products	3.52	1.33
AESTH	Importance of aesthetics	4.23	1.00
REC	Importance of recreation	3.77	1.18
HABITAT	Importance of wildlife habitat	4.09	1.03
Demographic			
AGE	Age of landowner	58.10	13.23
INCOME1-6	Dummies: income of landowner, less than $20,000 (1) to $100,000 or more (6). INCOME1 is used as reference group in the econometric model	-	-
EDUC1-6	Dummies: education level of landowner, elementary school (1) to graduate or professional school (6). EDUC1 used as reference group.	-	-
OCCUP	Dummy: occupation related to logging, ranching, farming, timber industry	0.13	0.2E-03
Property			
ACRES	Total acres owned	135.79	438.07
WOODLAND	Total woodland acres owned	95.89	271.02
RESIDE	1 if residence on property, 0 otherwise	0.78	0.41
YEARS	Number of years landowner has owned property	22.44	16.65
Knowledge			
KNOW	Dummy: familiar with incentives	0.41	0.3E-03
CURRENT	Dummy: currently participates	0.08	0.9E-04
PAST	Dummy: participated in the past	0.20	0.2E-03
Membership			
FORESTRY	Dummy: member of forestry organization	0.20	0.2E-03
CONSERV	Dummy: member of conservation organization	0.16	0.2E-03

3.4 ECONOMETRIC MODEL AND RESULTS

The probability that landowner *i* participates in an incentives program is given by $P_i = Pr[\varepsilon_{0i} - \varepsilon_{1i} \leq V_{1i}(1, \boldsymbol{r}_i, \boldsymbol{y}_i) - V_{0i}(0, \boldsymbol{r}_i, \boldsymbol{y}_i)]$ (see condition (4)), where $\boldsymbol{r}_i$ and $\boldsymbol{y}_i$ contain the characteristics of the landowner and his property described in Table 1. A probit model was used to estimate the participation probabilities. The explanatory variables were tested for heteroscedasticity using likelihood ratio tests, and the null hypothesis of homoscedasticity was rejected for the variables PAST, CURRENT, FORESTRY, CONSERVATION, and two of the education dummies. Table 2 presents the coefficient estimates for two specifications of the model, corrected for heteroscedasticity. In model 1, the null hypothesis that the parameter estimates for the dummies describing experience with incentives programs (KNOW, PAST, and CURRENT) are all equal to zero (the chi-squared statistic is 4.3) could not be rejected, so these variables were left out of model 2. The chi-squared statistic for overall fit indicates that both models significantly explain the participation decision.

3.4.1 Sample Selection Bias

Both models were tested for potential sample selection bias induced by survey non-response (Mitchell and Carson 1989, Messonier *et al.* 2000). If non-response occurs in such a way that the factors that determine a landowner's decision to participate and the factors that determine response are correlated, then the parameter estimates may be biased. The information collected in the 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). In the first step, a probit model of response to the survey was estimated. The parameter estimates were used to calculate the inverse Mills ratio (λ), which represents the probability of a landowner having responded (i.e. being in the sample). In the second step, the inverse Mills ratio was included as an additional regressor in Models 1 and 2. The test for sample selection bias consists of a simple *t*-test of the significance of the parameter estimate for λ. If it is not significantly different from zero, then the null hypothesis of no bias cannot be rejected. The results for the second step of the test for models 1 and 2 indicate that there is no evidence of sample selection bias (the *t*-statistics for λ are 0.37 and 0.28, respectively).

3.4.2 Results

The estimates presented in Table 2 suggest that the likelihood of participation is positively correlated with the importance a landowner gives to the wildlife habitat provided by his forest, with the number of acres of woodland he owns, and with membership in conservation organizations. Participation is negatively correlated with the landowner's age and the importance attached to aesthetic enjoyment of the forest. The estimates also provide some evidence that participation may be negatively correlated with years of ownership and total acreage. In contrast with the findings in Nagubadi *et al.* (1996) and Bell *et al.* (1994), participation is not correlated with dummies measuring importance of investment or commercial value of the forest, presence of a residence on the property, membership in forestry organizations, or income. It is also interesting to note that the perceived likelihood of ESA regulation does not have a significant effect on participation.

These results suggest that landowners who would participate in incentives programs designed specifically to benefit endangered species may respond to somewhat different motivations than those who participate in programs examined in previous work, such as the Stewardship Incentives Program. Specifically, HABITAT and CONSERVATION have positive, statistically significant parameters, whereas the parameters for INVEST, LUMBER, and FORESTRY are not statistically different from zero. This indicates that those landowners who are more likely to participate may be less concerned with managing their land for profit and more supportive of conservation of endangered species. The negative coefficient for aesthetic enjoyment provided by the forest (AESTH) is somewhat counterintuitive. It may be a response to the heavy thinning required by the management plans described in the survey, which might seem unappealing to landowners interested in managing for aesthetic purposes.

The negative coefficient for AGE indicates that younger landowners are more likely to participate. One possible explanation for this is that older landowners may be less inclined to set aside a part of their property for conservation for any significant length of time (the period suggested in the survey was 10 years), or less willing to actively manage their property. The education dummies have a positive sign, suggesting that highly educated landowners are more willing to participate, possibly because they are more aware of environmental concerns or better able to understand the conservation benefits of the proposed management plans. However, these variables are not statistically significant individually or as a group, which is consistent with the results in Bell *et al.* (1994) and Nagubadi *et al.* (1996). The occupation dummy has a negative sign, indicating that landowners with occupations that are related to farming, ranching, forestry, or logging may be less willing to participate. The coefficient on this variable, however, is not statistically different from zero either.

The sign pattern on ACRES and WOODLAND is not easy to understand. Landowners with larger properties may be more likely to manage their land for profit, and thus less willing to participate. Alternatively, more total acres do not necessarily imply more acreage of forest. Landowners who own large farms or ranches may have some forest on their property, but not be interested in managing it. On the other hand, those with more acres of woodland may be more inclined to participate because they are more involved in managing their forest, and because the opportunity costs of managing a stand for endangered species may be relatively smaller.

The negative sign on YEARS, which agrees with the result in Nagubadi *et al.* (1996), indicates that landowners who acquired their land more recently are more willing to participate. One possible explanation is that landowners who have owned the property for a shorter time may be less likely to have developed a particular way of managing their forest, and thus could be more willing to accept alternate management plans. Alternatively, this result could reflect changing demographics in the Pacific Northwest, as the wood products industry declines and high-tech industries take its place.

TABLE 3.2: PARAMETER ESTIMATES

Variable	*MODEL 1*		*MODEL 2*	
	Coefficient	*t-statistic*	*Coefficient*	*t-statistic*
CONSTANT	-0.79	-0.43	0.32	0.37
INVEST	-0.01	-0.37	0.06	0.14
LUMBER	0.24E-02	0.08	-0.28E-02	-0.06
AESTH	-0.10**	-2.22	-0.10*	-1.95
REC	0.03	0.91	0.98E-02	0.22
HABITAT	0.13***	2.94	0.16***	2.77
REGULATE	-0.77E-02	-0.41	-0.99E-03	-0.04
AGE	-0.01***	-2.66	-0.02***	-2.98
INCOME2	-0.34	-1.34	-0.43	-1.45
INCOME3	-0.28	-1.18	-0.31	-1.10
INCOME4	-0.31	-1.27	-0.43	-1.48
INCOME5	-0.04	-0.14	-0.17	-0.52
INCOME6	-0.33	-1.33	-0.32	-1.13
EDUC2	1.85	0.98	0.97	1.14
EDUC3	1.59	0.87	0.41	0.53
EDUC4	1.68	0.92	0.81	1.12
EDUC5	1.64	0.90	0.80	1.12
EDUC6	1.82	0.99	0.88	1.21
OCCUP	-0.20	-1.27	-0.15	-1.10
ACRES	-0.69E-03	-1.20	-0.57E-03*	-1.66

TABLE 2 - Continued

WOODLAND	0.13E-02*	1.79	0.11E-02**	2.11
RESIDE	0.03	0.40	0.05	0.52
YEARS	-0.49E-02*	-1.92	-0.53E-02*	-1.79
KNOW	0.15	1.63		
PAST	0.08	0.83		
CURRENT	-0.18*	-1.65		
FORESTRY	0.03	0.49	0.04	0.46
CONSERVATION	0.25**	1.99	0.33**	2.34
Log Likelihood	-307.68		-322.22	
χ^2 [a]	147.74		127.16	
Scaled R^2 [b]	0.25		0.21	
Observations[c]	571		576	

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

[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).

[c] Not all 737 respondents who answered the question used to derive the dependent variable answered all the other relevant questions.

Finally, the fact that the perceived likelihood of ESA regulation does not have a significant effect on the decision to participate is unexpected. One possible reason for this result is that 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.

Further insight into the effect of these landowner and property characteristics can be gained by examining their marginal effects. In the probit model, the marginal effect of a continuous variable (x_k) is given by

$$\frac{\partial \Pr(PARTICIPATE = 1)}{\partial x_k} = \phi(\beta' x)\beta_k$$

where $\phi(\cdot)$ is the standard normal density, and the derivative is calculated at the means of the regressors. The marginal effect for a dummy variable (D) is

$$\Pr(PARTICIPATE = 1 | D = 1) - \Pr(PARTICIPATE = 1 | D = 0)$$

with the probabilities evaluated at the means of the remaining variables. The marginal effects for the variables AGE, ACRES, WOODLAND, YEARS, and CONSERVATION in Model 2 are presented in Table 3. These marginal effects indicate that an additional year of a landowner's age will decrease the probability of participation by 0.71%. To put this number in perspective note that, for example, a 60 year-old landowner is 14% less likely to participate than a 40 year-old landowner. An additional acre of property decreases the probability of participation by 0.027%, whereas an additional acre of woodland in the property increases this probability by

0.055%. Thus, a landowner with a 250-acre property is only 6% less likely to participate than a landowner with a 50-acre property. However, a landowner with 250 acres of woodland is 12% more likely to participate than a landowner with only 50 acres of woodland. An additional year of ownership decreases the probability of participation by 0.25%. For example, a landowner who has owned his property for 40 years is 9% less likely to participate than one who has only owned his property for 10 years. Finally, membership in a conservation organization has the largest marginal effect: the probability that a landowner will participate is 33% higher if he is a member of a conservation organization than if he is not.

TABLE 3.3: MARGINAL EFFECTS

Variable	*Marginal Effect (Model 2)*
AGE	-0.71 E-02
ACRES	-0.27 E-03
WOODLAND	0.55 E-03
YEARS	-0.25 E-02
CONSERVATION	0.33

Thus, landowners who are younger, have larger amounts of woodland on their property, have acquired their land more recently, give importance to the wildlife habitat provided by their forest, and belong to conservation organizations have, in general, a higher predisposition to participate in an incentives program.

3.5 SUMMARY AND POLICY IMPLICATIONS

This paper used survey data to examine which characteristics of landowners and their properties determine their willingness to participate in conservation incentives programs. This information could be used to target incentives programs to those segments of the NIPF population that are more likely to participate, and thereby increase participation rates and thus attain higher program benefits.

In general, landowners who are younger, have acquired their property more recently, own more woodland, and are interested in conservation and providing wildlife habitat on their forests are more likely to participate. Areas in which landowners generally share some of these characteristics can be identified through census, tax, or property records. Additionally, regional and local chapters of conservation organizations could be tapped for membership records. Thus, a list of areas where participation is more likely could be compiled, and matched to existing lists of areas where conservation needs are more severe. Incentives programs could then be targeted to those areas where there is both a need for conservation and a reasonably high-expected rate of participation.

As an illustration, consider a simple example. Defenders of Wildlife has designated a number of "Conservation Opportunity Areas" in Oregon, based on identifying gaps in the existing conservation network, evaluating landscapes for their potential to address conservation priorities, and assessing opportunities to enhance management for biodiversity within these areas (Defenders of Wildlife 1998). This can be combined with data on landowner and land characteristics to determine which of these Opportunity Areas overlap with regions where, according to their characteristics, landowners are more likely to participate in an incentives program. Incentives can then be targeted to those areas. Table 4 shows the Conservation Opportunity Areas identified for western Oregon, and the counties where these areas are located. Table 5 shows, for each of these counties, the mean age, property and woodland acreage, and years of ownership for the forest owners in the sample used in this study. The data in these tables suggest, for instance, that the average age, acreage, and years of ownership are relatively lower in Columbia County than in Coos and Curry counties. Therefore, forest owners in the Columbia River Bottomlands Area may be more willing to participate than those in the Cape Blanco Area. Similarly, the average age in Lane and Jackson counties are very similar, the average acreage is lower and the average acreage of woodland is higher in Lane County. Hence, landowners in the Vida and West Eugene Wetlands areas may be more willing to participate than those in the Upper Applegate River or North Medford Plains Areas. This is, of course, a highly simplified example meant only as an illustration. A more thorough analysis could be done using data on other variables that affect the participation decision (such as membership in conservation organizations), and in more detail (for instance, using census tract data). Furthermore, although the survey used in this paper focused specifically on NIPFs in western Washington and Oregon, the methodology described here could easily be used to identify factors that affect participation decisions of various types of landowners in different regions.

TABLE 3.4: CONSERVATION OPPORTUNITY AREAS[18]

Conservation Opportunity Areas	**Counties**
Tillamook Bay Watershed	Tillamook, Washington
Nestucca River Watershed	Tillamook
Cape Blanco	Coos, Curry
Upper Illinois River	Josephine
Upper Applegate River	Jackson
North Medford Plains	Jackson
Umpqua Confluence	Douglas
Umpqua Headwaters	Douglas
Vida	Lane
West Eugene Wetlands	Lane
Muddy Creek	Benton
North Corvallis	Benton
Columbia River Bottomlands	Columbia

TABLE 3.5: LANDOWNER AND PROPERTY CHARACTERISTICS
(Sample Means)

County	*Age (years)*	*Acreage of Property*	*Acreage of Woodland*	*Years of Ownership*
Benton	60	262	205	27
Columbia	54	78	48	20
Coos	69	388	237	25
Curry	61	227	81	22
Douglas	62	133	95	21
Jackson	56	203	121	18
Josephine	60	89	69	19
Lane	57	153	132	29
Tillamook	67	50	40	45
Washington	55	63	53	21

Finally, the results obtained here highlight the fact that landowner participation in endangered species conservation programs may differ from that reported in the

[18] This excludes the Willamette River Floodplain, which includes small areas of various counties.

existing literature for more general forestry and conservation programs. This suggests that existing incentives programs may have to be modified or targeted differently to be more effective in encouraging protection of endangered species.

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CHAPTER 4

CONSERVATION OF ENDANGERED SPECIES: CAN INCENTIVES WORK FOR PRIVATE FORESTLAND OWNERS?

Christian Langpap

4.1 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[19]. 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., Bean and Wilcove 1997, Mann and Plummer 1995, Bean 1998). Michael and Lueck (2000) have found empirical evidence

[19] 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).

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 Habitat Conservation Plans with a "no surprises" policy, or Safe Harbor Agreements (Wilcove *et al.* 1996, Bean and Wilcove 1996). The second approach is based on offering the landowner both financial and non-financial incentives to manage his land in a way that is compatible with the survival and recovery of endangered species. These incentives include, for instance, 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, Brockett and Gebhard 1999, Kennedy *et al.* 1996, Bourland and Stroup 1996, and McNeely 1993). 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 suggest that incentives could effectively complement regulation in eliciting higher levels of conservation effort, particularly when landowners do not believe that land use restrictions are likely. 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 combining financial incentives with assurances may be the most effective way to encourage the desired management practices.

These results 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". They also imply 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. In section 2, I present an analytical framework to motivate the econometric analysis. In section 3, I discuss the data and the survey instrument used to obtain it. In section 4, I lay out the econometric model and presents the empirical results. In section 5, a simulation is conducted to analyze the implications of the empirical results for the design of incentives programs. Finally, in section 6, I discuss the main findings and conclude.

4.2 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 Fish and Wildlife Service (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 unpredictable event may alter the status of a species), and thus he may require that the management plan for period 2 be $c_{v2}^* > c_{v2}$. This occurs with probability q.[20] 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_{v2}^*.

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_{v2}^*), and compensation for opportunity costs of implementing the management plan. Note that "compensation" refers to payments received by the landowner as (partial or full) reimbursement for income lost because of participating in a *voluntary* conservation program. This is different from the way the term is interpreted in the takings literature (e.g. Polasky and Doremus 1998, Innes 2000, or Polasky 2001), where it refers to compensation for losses resulting from *mandatory* conservation imposed by regulation.

[20] The probability q may be interpreted as the likelihood that the population of a species, or some component of its environment such as food supply, reach some threshold that triggers additional conservation. It may also characterize the regulator's *a priori* unknown willingness or ability to require more conservation.

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[21]. If no 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 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

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

[21] 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).

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

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

This set can be interpreted as containing all the management plans (or all the combinations of conservation effort for both periods) that the landowner will accept as part of a conservation agreement. The set S_L is shown in Figure 1.

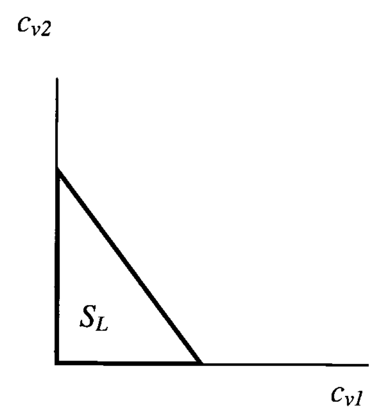

FIGURE 4.1: Landowner's acceptance set

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[22]. 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

[22] Langpap and Wu (2002) discuss the necessary and sufficient conditions for such an agreement.

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

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

and the acceptance set is

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

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. This possibility is shown in Figure 2. The management plan with cost sharing, compensation, and assurances 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.

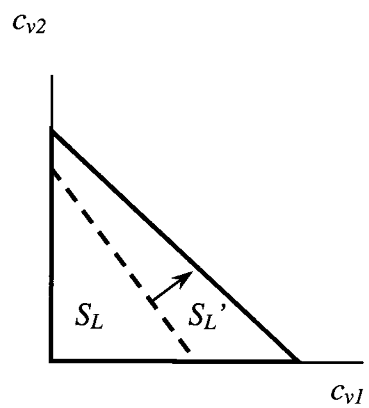

FIGURE 4.2: Effect of incentives

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 holding forestland, which may affect the opportunity cost of conservation. 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 for some landowners as well.

In the following sections, I examine empirically whether cost sharing, compensation, and assurances incentives can have an effect on the management plan that a landowner is willing to implement, as the results obtained here suggest. The role played by other factors, such as landowner and property characteristics, will be analyzed as well. I start by describing the survey instrument used to collect the data, and then present the econometric analysis.

4.3 SURVEY AND DATA

4.3.1 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 own at least 10 acres of land zoned as forest[23] were

[23] Ten acres was chosen as a cutoff point because the distribution of landowners shows 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 forest land.

obtained from county tax assessor offices[24]. 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. The suggested changes were incorporated into a second version of the survey, which was mailed out to a subset of the sample as a further pre-test. The final version of the survey was then 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 gives 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[25]. This information was used to conduct a test for sample-selection bias, which is described later.

As in the framework laid out in section II, 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 different levels of the various incentives, as well as a technical assistance attribute. Landowners

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[24] Landowners were classified as non-industrial if the tax rolls listed them as individuals rather than as businesses.

[25] 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.

also had the option not to accept any of the incentives programs offered (see the Appendix for an example). This choice was 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, perceived risk of ESA regulation, and demographic information.

4.3.2 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 understory vegetation such as grasses, shrubs, and unwanted trees. Implementation of these techniques may speed the development of forest structures required by endangered species commonly associated with the Pacific Northwest, such as spotted owls, marbled murrelets, and salmon (FWS 1992, 1997b, Ralph *et al.* 1995, USDA 1993, Tappeiner 2001, Nelson 2001, Hayes 2001, 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 understory 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 landowner's perceived likelihood of regulation is measured by the variable REGULATE. The survey asked landowners how likely they believed it was that the ESA might restrict timber harvesting, development, or other activities on their land. 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[26].

[26] 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.

TABLE 4.1: VARIABLE DESCRIPTIONS AND SUMMARY STATISTICS

Variable	*Description*	*Mean*	*Std.*
Incentives			
SHARE[27]	% 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-
SHXIN	Interaction Variable = Share x Income	4.63	3.37
COXSTS	Interaction Variable = Comp x Stand	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-
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 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-
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	Dummy: 1 if harvest in 20 to 40 yrs.	0.15	0.1E-03
HARV40	Dummy: 1 if harvest in 40 or more yrs.	0.19	0.1E-03

[27] 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).

4.4 ECONOMETRIC MODELS AND RESULTS

Given the ordered nature of the dependent variable, the model used for estimation is an ordered probit. A landowner's true willingness to supply conservation effort, y_i^*, can be written as $y_i^* = \boldsymbol{\beta}'\boldsymbol{x}_i + \varepsilon_i$, where $\boldsymbol{x}_i$ is a vector containing the regressors described in the preceding section (incentives, landowner and property characteristics), and $\varepsilon_i \sim$ N(0,1) is the residual. The true willingness to supply conservation effort, y_i^*, is not observed. What we do observe is the landowner's choice of a management plan, which is given by PLAN$_i$ = 0 if $y_i^* \leq 0$, PLAN$_i$ = 1 if $0 < y_i^* \leq \mu_1$, PLAN$_i$ = 2 if $\mu_1 < y_i^* \leq \mu_2$, PLAN$_i$ = 3 if $\mu_2 \leq y_i^*$ for i = 1 ... n landowners, where the μ_j are threshold parameters to be estimated along with $\boldsymbol{\beta}$, and $0 < \mu_1 < \mu_2 < \mu_3$.

Likelihood ratio tests revealed that some of the regressors (SHARE, ASSURE, ASSIST, SHXIN, ASXRE, STANDSIZ, HARV40) are heteroscedastic. To accommodate this, I use a general multiplicative formulation for the variance of the disturbances (Greene 2000): $Var[\varepsilon] = [\exp(\boldsymbol{v}'\boldsymbol{z})]^2$, where z is the vector of heteroscedastic variables. With this specification, the probabilities that each plan is chosen are

$$
\begin{aligned}
&Pr(\text{PLAN} = 0) = \Phi[-\boldsymbol{\beta}'\mathbf{x}/exp(\boldsymbol{v}'\boldsymbol{z})],\\
&Pr(\text{PLAN} = 1) = \Phi[(\mu_1-\boldsymbol{\beta}'\mathbf{x})/exp(\boldsymbol{v}'\boldsymbol{z})] - \Phi[-\boldsymbol{\beta}'\mathbf{x}/exp(\boldsymbol{v}'\boldsymbol{z})],\\
&Pr(\text{PLAN} = 2) = \Phi[(\mu_2-\boldsymbol{\beta}'\mathbf{x})/exp(\boldsymbol{v}'\boldsymbol{z})] - \Phi[(\mu_1-\boldsymbol{\beta}'\mathbf{x})/exp(\boldsymbol{v}'\boldsymbol{z})], \qquad (5)\\
&Pr(\text{PLAN} = 3) = 1 - \Phi[(\mu_2-\boldsymbol{\beta}'\mathbf{x})/exp(\boldsymbol{v}'\boldsymbol{z})].
\end{aligned}
$$

and the log-likelihood function for the model is

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

$$\sum_{PLAN=2} \ln[\Phi((\mu_2 - \beta' x)/e^{v'z}) - \Phi((\mu_1 - \beta' x)/e^{v'z})] + \sum_{PLAN=3} \ln[1 - \Phi((\mu_2 - \beta' x)/e^{v'z})] \quad (6)$$

where $\Phi(\bullet)$ 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). These were estimated using LIMDEP version 7.0 (Greene 1998), which uses the Davidson-Fletcher-Powell algorithm.

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.

4.4.1 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 as a first step. This participation model is based on demographic and property characteristics of survey respondents. A second Inverse-Mills Ratio (λ_2) is derived and then included as an additional regressor in Models 1 and 2. Once again, the results of the test show no evidence of selection bias: the *t*-statistics for λ_2 are 0.28, and –0.42 for models 1 and 2, respectively.

TABLE 4.2: 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)

Table 2 – Continued

INCOME3	0.05	0.05
	(1.36)	(1.25)
INCOME4	0.03	0.02
	(0.55)	(0.36)
INCOME5	-0.02	-0.01
	(-0.43)	(-0.24)
INCOME6	-0.02	-0.04
	(-0.38)	(-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	0.24E-03
	(0.45)	(0.65)
STANDAGE	0.35E-03	0.38E-03
	(1.27)	(1.40)
HARV20_40	-0.17E-02	-0.73E-02
	(-0.09)	(-0.40)
HARV40	0.04**	0.03**
	(2.36)	(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).

4.4.2 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. High-income landowners may be more responsive to this incentive than those with a relatively lower income level. 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. Finally, there is some evidence that a landowner's income level may have an effect on his willingness to implement a management plan. 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 6.

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 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 $\overline{z}_{-k}$ as the vector of heteroscedastic variables, except x_k, evaluated at their sample mean. Then

$$Pr(\text{PLAN} = i|x_{ks}) = \Phi[(\mu_i - \beta_k x_{ks} - \boldsymbol{\beta}_{-k}'\overline{x}_{-k})/exp(v_k x_{ks} + \boldsymbol{v}_{-k}'\overline{z}_{-k})] - \Phi[(\mu_{i-1} - \beta_k x_{ks} - \boldsymbol{\beta}_{-k}'\overline{x}_{-k})/exp(v_k x_{ks} + \boldsymbol{v}_{-k}'\overline{z}_{-k})]$$

$$Pr(\text{PLAN} = i|x_{kf}) = \Phi[(\mu_i - \beta_k x_{kf} - \boldsymbol{\beta}_{-k}'\overline{x}_{-k})/exp(v_k x_{kf} + \boldsymbol{v}_{-k}'\overline{z}_{-k})] - \Phi[(\mu_{i-1} - \beta_k x_{kf} - \boldsymbol{\beta}_{-k}'\overline{x}_{-k})/exp(v_k x_{kf} + \boldsymbol{v}_{-k}'\overline{z}_{-k})]$$

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 (5) 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).

TABLE 4.3: SIGNS OF MARGINAL EFFECTS FOR COMP AND ASSURE

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

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.

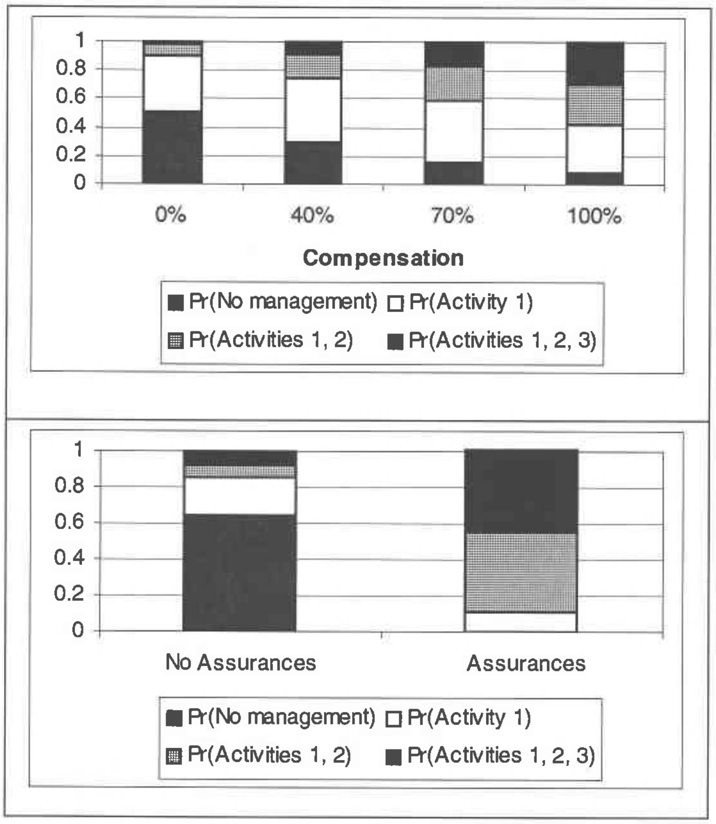

FIGURE 4.3: Marginal effects for compensation and assurances

4.5 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. The plan implemented by the landowner is that with the highest predicted probability. To show the effects of the different incentives clearly, I assume they are applied at the highest possible level. That is, under cost sharing the landowner incurs only 25% out the out-of-pocket costs of conservation, whereas compensation for forgone revenue is set at 100%. 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 and the corresponding prediction of which plan would be implemented. 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. The prediction in this scenario is therefore that Plan 0 (no conservation effort) would be implemented.

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%), and Plan 0 remains the most likely to be implemented.

Scenario 2 offers 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. The probability of Plan 1 is the highest, so this is the most likely plan to be implemented.

In scenario 3, the landowner receives 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. The prediction in this scenario is that Plan 2 would be implemented.

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 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. This scenario predicts that Plan 1 would be implemented. 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%. Thus, the prediction in this scenario is that Plan 3 would be implemented.

TABLE 4.4: SIMULATED CHOICE PROBABILITIES

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

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 most landowners 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.

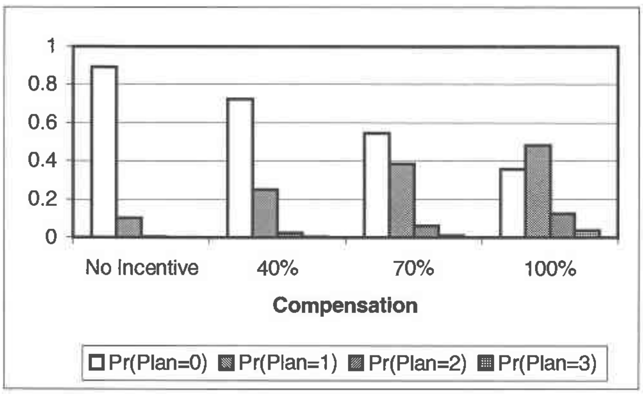

FIGURE 4.4a: Simulated choice probabilities
Compensation Only

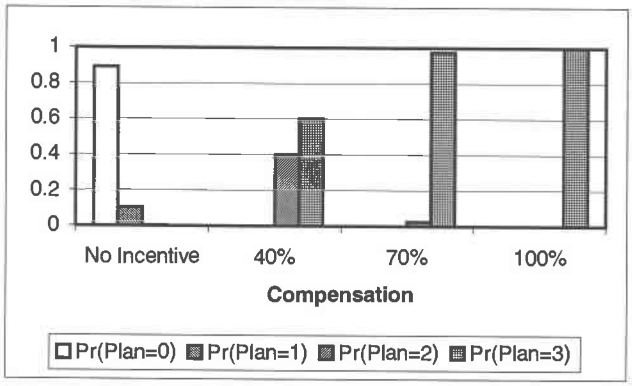

FIGURE 4.4b: Simulated choice probabilities
Compensation and Assurances

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. This suggests further avenues of research that examine both the effectiveness and efficiency of incentives programs.

4.6 DISCUSSION

The results presented in the preceding sections suggest that the incentives discussed 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[28]. 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

[28] 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".

to providing habitat on their land, 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.

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CHAPTER 5

CONCLUSION

Christian Langpap

The three papers in this dissertation have examined various aspects of the use of incentives to promote conservation of endangered species on private land. The first paper analyzed the conditions under which the interaction between a regulator and a landowner leads to a voluntary conservation agreement, and the conservation levels that may result from such an agreement. The results suggest that whether an agreement is reached depends on the cost advantage offered by voluntary agreements, the background threat of regulation, and the availability of assurances regarding future regulation. Our analysis also showed that the conservation level generated by a voluntary agreement depends on the bargaining power of the parties, the background threat of regulation, and the cost advantage provided by voluntary agreements. Specifically, the conservation level will be lower when the landowner has more bargaining power and higher when the probability of regulation and the cost advantage of voluntary agreements are high. In addition, agreements that do not offer assurances may result in lower conservation levels and social welfare than agreements that do.

The second paper uses survey data to examine which characteristics of landowners and their properties determine their willingness to participate in conservation incentives programs. This information could be used to target incentives programs to those segments of the landowner population that are more likely to participate, and thereby increase participation rates and thus attain higher program benefits. The results suggest that, in general, landowners who are younger, have acquired their property more recently, own more woodland, and are interested in conservation and providing wildlife habitat on their forests are more likely to participate. The methodology described in this paper could also be extended to identify factors that affect participation decisions of various types of landowners in different regions. Finally, the results obtained in this paper highlight the fact that landowner participation in endangered species conservation programs may differ from that reported in the existing literature for more general forestry and conservation programs. This suggests that existing incentives programs may have to be modified or targeted differently to be more effective in encouraging protection of endangered species.

The third paper uses survey data to examine the effectiveness of different incentives in promoting conservation of endangered species on private land. The results suggest that the incentives analyzed in the paper, cost sharing, compensation, and assurances, 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. Additionally, the results 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. 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. 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.

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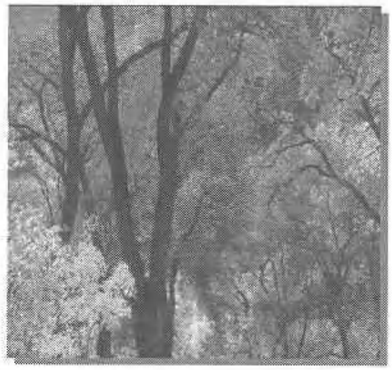
APPENDICES

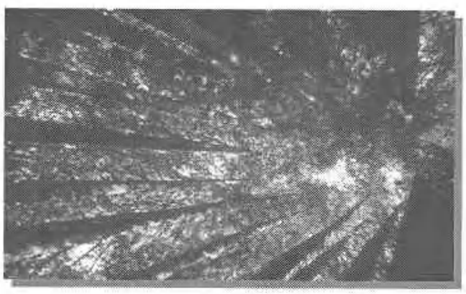
APPENDIX 1: SURVEY

OREGON STATE UNIVERSITY

Conservation Incentives for Private Forest Owners

We want your opinion





Oregon State University ? Department of Agricultural and Resource Economics

Incentives programs are *voluntary* arrangements in which a forest owner and another party, such as a conservation organization or a public agency, reach a mutual agreement which specifies certain management activities that the owner will carry out on *part* of his property. The specific activities and the portion of the property on which they would be carried out are determined jointly by both parties. To encourage the landowner to participate in such an arrangement, he or she is offered a variety of incentives. These could include, for example, a cost-share subsidy, compensation, or assurances regarding regulation. The specific nature and amounts of these incentives would be determined jointly by both parties as well.

The goal of this study is to learn how to design better incentives programs. In order to do so, we would like to know more about forest owners, their land, and their thoughts concerning incentives.

If you do not own forestland, please check the statement indicating so below, and return this questionnaire in the stamped, addressed return envelope provided. If you would like to share your thoughts on the subject, please do so in the space provided on the back page of the booklet. If you do own forestland, please answer all of the questions in this survey. This is your chance to share your thoughts on this important subject. Thank you for your cooperation.

____ **I DO NOT OWN FORESTLAND.**

1. Please indicate how important, if at all, you think each of the following services provided by your forestland are to you (*please circle one choice for each service*).

	NOT IMPORTANT		SOMEWHAT IMPORTANT		VERY IMPORTANT
a. Investment value	1	2	3	4	5
b. Aesthetic enjoyment	1	2	3	4	5
c. Lumber and other wood products	1	2	3	4	5
d. Recreation for you, your family, or friends	1	2	3	4	5
e. Wildlife habitat	1	2	3	4	5
f. Flood and erosion control	1	2	3	4	5
g. Natural heritage for future generations	1	2	3	4	5
h. Other (please specify below)....	1	2	3	4	5

____

Your Forest Land

An important aspect of designing incentive programs for private forest owners is learning about their land and how it is used. Therefore, we would like to ask you a few questions about your property. Your answers are strictly confidential and will only be used in the analysis of the survey.

The following questions apply to land you own in Oregon or Washington.

2. How many total acres of land do you own ?

   ______ ACRES

3. Approximately how many acres are woodland?

   ______ ACRES

4. How many years have you owned your land (if you own more than one property, answer for the one you have owned the longest)?

   ______ YEARS

5. Do you have a residence on your property?

   1 YES
   2 NO

6. Please indicate which of the following management practices you have used on your land, if any. (*Circle all that apply*)

		YES	NO
a.	Planted trees for reforestation	1	2
b.	Fertilized trees	1	2
c.	Pruned trees	1	2
d.	Controlled brush, grass, unwanted trees..................	1	2
e.	Removed trees for commercial purposes	1	2
f.	Removed trees to open up stands for wildlife	1	2
g.	Planted vegetation for wildlife	1	2
h.	Retained snags, down logs or uncut trees for wildlife habitat	1	2
i.	Other (please specify)	1	2

____

7. Have *all* the trees been harvested from any of your properties during the time you have owned them?

1 YES ⟶ GO TO QUESTION 8
2 NO

7a. If NO, please indicate how important, if at all, the following reasons were in your choice not to harvest. (*Please circle one choice for each reason*)

	NOT IMPORTANT		SOMEWHAT IMPORTANT		VERY IMPORTANT
a. Maintain value of land	1	2	3	4	5
b. Pass on natural heritage	1	2	3	4	5
c. Timber not mature	1	2	3	4	5
d. Provide wildlife habitat	1	2	3	4	5
e. Aesthetic enjoyment	1	2	3	4	5
f. Have not needed the income ...	1	2	3	4	5
g. Other (please specify below)	1	2	3	4	5

____

8. The Endangered Species Act is a federal law that prohibits damaging habitat used by endangered wildlife and plants. How likely, if at all, do you believe it is that the Endangered Species Act may restrict the following activities on your land in the next 10 years? (*Please circle one choice for each activity*).

	VERY UNLIKELY		EVEN CHANCE		VERY LIKELY
a. Timber harvesting	1	2	3	4	5
b. Land development	1	2	3	4	5
c. Other (please specify below)... ...	1	2	3	4	5

____

Incentives Programs

9. Have you read or heard about any land management incentives programs, such as the Wildlife Habitat Incentives Program (US Dept. of Agriculture), the Stewardship Incentive Program (US Dept. of Agriculture), or Habitat Conservation Plans (US Fish & Wildlife Service)?

   1 YES
   2 NO

10. Have you participated in any land management incentives programs in the past?

   1 YES
   2 NO

11. Do you currently participate in any land management incentives programs?

   1 YES
   2 NO

For the following section of the survey, suppose that a conservation organization or a public agency offered you a choice between different combinations of incentives in exchange for managing part of your forest to improve habitat for endangered species commonly associated with the Pacific Northwest, such as marbled murrelets, spotted owls, or salmon.

12. Specifically, suppose that you are offered one or more of the following incentives:

- **Cost sharing**: you would only pay for a part of the costs of the management plan.
- **Compensation**: if implementing the plan caused you to lose any income, you would be compensated for part or all of that loss.
- **Assurances**: you would receive a guarantee that you would not lose control of the management of the rest of your land, and that you would not incur any additional costs or have to carry out any additional management activities beyond those you agree to initially.

Please rank these incentives according to their importance to you (*write 1 for the most important, 2 for the next most important, and 3 for the least important incentive; use each ranking only once).*

		Incentive	IMPORTANCE (1, 2, OR 3)
a.	$	Cost sharing	_____
b.		Compensation	_____
c.		Assurances	_____

13. These incentives would be offered to you in exchange for implementing one or more of the following activities on *part* of your forest, and not harvesting that part for the duration of the program. The length of the agreement would be 10 years, with optional renewal at the end of that period.

- ACTIVITY 1: **Thinning** more than needed for commercial purposes, to approximately 50-75 trees/acre, depending on the conditions of your forest.
- ACTIVITY 2: Providing 2 to 4 **snags** and **logs** per acre on the forest floor by leaving existing ones or killing some of the larger trees.
- ACTIVITY 3: Managing **under story** vegetation (controlling unwanted brush, grass, or small trees).

These activities are designed to improve the habitat of marbled murrelets, spotted owls, and salmon.

Which of the following management plans would you consider most appropriate for implementation on your land (the tree pictured indicates the effect of the program on habitat, a larger tree means a more positive effect)? *Circle one choice.*

- Thinning to 50-75 trees/acre (Activity 1 only) 	- Thinning to 50-75 trees/acre, - 2-4 snags and logs/acre (Activities 1 and 2) 	- Thinning to 50-75 trees/acre, - 2-4 snags and logs/acre - Control under story (Activities 1,2, and 3) 	None
PLAN 1	PLAN 2	PLAN 3	4

14. As part of an incentives program, technical assistance may be offered to you. If it is, a forester or an extension agent would be available to help you implement the management plan you choose. How important would the availability of technical assistance be to you when deciding whether to participate in an incentives program or not?

	NOT IMPORTANT		SOMEWHAT IMPORTANT		VERY IMPORTANT
Technical assistance	1	2	3	4	5

15. Would you be willing to manage part of your land under an incentives program?

1 NO, UNDER ANY CONDITIONS ⟶ GO TO QUESTION 16

2 YES, GIVEN THE RIGHT INCENTIVES AND CONDITIONS

If YES, consider a specific stand in your forest where you would be willing to apply one of the management plans.

15 a. What is the approximate size of this stand? __________ ACRES

15 b. What is the approximate age of this stand? ___________ YEARS

15 c. In how many years from now do you intend to harvest this stand, if at all?

__________ YEARS

15 d. Approximately how many trees per acre are there in this stand?

______________ TREES/ACRE

15 e. Approximately what is the average size of the trees in this stand (in diameter at breast height)?

______________ INCHES

For the following pages, suppose that a private conservation organization or a public agency offered you various options of incentives programs. Each option offers different combinations of the following elements:

a. A management plan 

b. One or more of these incentives:

- Cost sharing: $
- Compensation: 
- Assurances: 

c. Technical assistance 

The following questions ask you to choose among different options. You will be asked to choose three separate times. Please approach each choice independently, as if it were the only one you were asked to make.

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

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

(*circle one*)

Please briefly describe the reason for your choice: ______________________________

____

17. 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 (Activities 1,2) 	- Thinning to 50-75 trees/acre, - 2-4 snags and logs/acre (Activities 1,2) 	- Thinning to 50-75 trees/acre, - 2-4 snags and logs/acre, - Manage under story (Activities 1,2,3) 	
You pay 100% of costs $	You pay 75% of costs $	You pay 50% of costs $	
No compensation	No compensation	No compensation	None
You receive assurances 	No assurances	No assurances	
No technical assistance	No technical assistance	Technical assistance 	

I prefer...	OPTION	OPTION	OPTION	OPTION
(*circle one*)	1	2	3	4

Please briefly describe the reason for your choice: ______________________________

____

18. 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, - Manage under story (Activities 1,2,3) 	- Thinning to 50-75 trees/acre, - 2-4 snags and logs/acre, - Manage under story (Activities 1,2,3) 	
You pay 75% of costs $	You pay 100% of costs $	You pay 25% of costs $	
No compensation	You are compensated for 70% of lost income 	You are compensated for 70% of lost income 	None
You receive assurances 	You receive Assurances 	No assurances	
No technical assistance	Technical assistance 	No technical assistance	

I prefer...	OPTION	OPTION	OPTION	OPTION
(*circle one*)	1	2	3	4

Please briefly describe the reason for your choice: ______________________________

____

A Few Questions About You

Finally, we would like to ask a few questions about you. This will help us to ensure that we have reached an adequate cross-section of private forest owners with this survey. Once again, your answers are strictly confidential and will only be used in the analysis of the survey.

19. What is your gender?

    1 MALE
    2 FEMALE

20. What is your age?

    __________ YEARS

21. Which is the highest level of formal schooling that you have completed?

    1 ELEMENTARY SCHOOL
    2 JUNIOR HIGH SCHOOL
    3 HIGH SCHOOL
    4 JUNIOR/COMMUNITY COLLEGE
    5 COLLEGE
    6 GRADUATE OR PROFESSIONAL SCHOOL

22. What is your occupation? ____

23. Are you a member of any conservation or environmental organizations (for example, the Nature Conservancy or the Sierra Club)?

    1 YES
    2 NO

24. Are you a member of any forestry organizations (such as a Small Woodlands Association, or the Society of American Foresters)?

    1 YES
    2 NO

25. What was your approximate household income from all sources, before taxes, last year?

1 LESS THAN $10,000	7 $60,000 TO $69,999
2 $10,000 TO $19,999	8 $70,000 TO $79,999
3 $20,000 TO $29,999	9 $80,000 TO $89,999
4 $30,000 TO $39,999	10 $90,000 TO $99,999
5 $40,000 TO $49,999	11 $100,000 TO $149,999
6 $50,000 TO $59,999	12 $150,000 OR MORE

Please turn to the back page if you want to make any comments on this questionnaire.

Comments

We would appreciate any comments you may wish to provide on the topics covered in this survey.

Thank you for participating in this study. When you have completed the questionnaire, please return it in the enclosed stamped addressed envelope.

APPENDIX 2: SUMMARY OF SURVEY RESULTS

Question 1: Importance of services provided by the landowner's forest

Table 1

Importance
% of total responses*

Service	Total Responses	Mean Response	Std.Dev.	*1*	2	*3*	*4*	*5*
Investment	798	3.9	1.2	6%	5%	26%	19%	44%
Aesthetics	795	4.2	1.0	2%	4%	16%	25%	53%
Lumber	794	3.5	1.3	10%	13%	23%	22%	31%
Recreation	793	3.8	1.2	5%	10%	23%	26%	35%
Habitat	794	4.1	1.0	2%	6%	18%	29%	45%
Flood control	792	3.6	1.3	8%	10%	24%	24%	32%
Nat. heritage	798	4.0	1.1	4%	6%	19%	24%	47%

* *1: Not Important, 3: Somewhat Important, 5: Very Important*

Property Characteristics and Management Practices

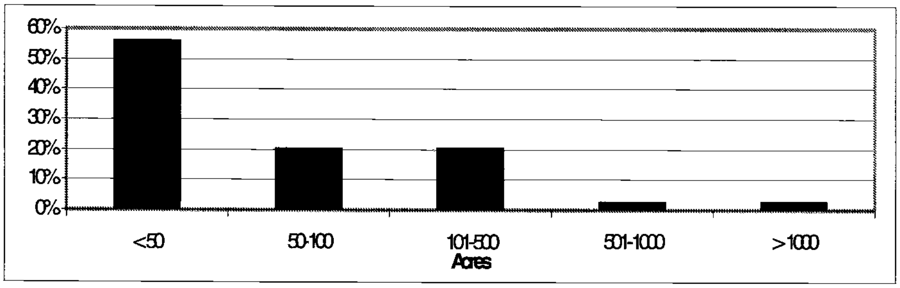
Question 2: Total Acres Owned (acres)

Table 2

Acres
% of total responses

Total Responses	Mean Response	Std. Dev.	*< 50*	*50-100*	*101-500*	*501-1000*	*> 1000*
820	*172*	*1132*	56%	20%	20%	2%	2%

Figure 1

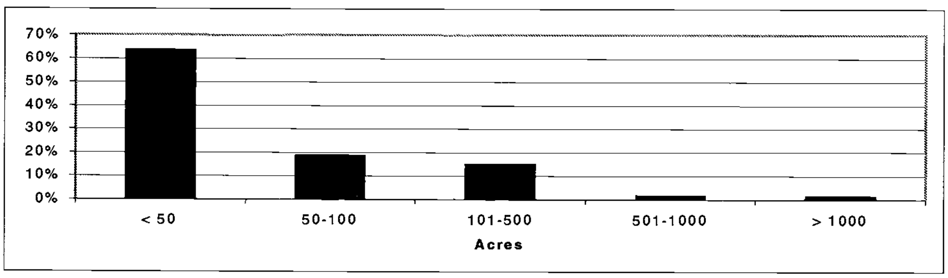


Question 3: Total Woodland Acres Owned (acres)

Table 3

			Acres % of total responses				
Total Responses	Mean Response	Std. Dev.	*< 50*	*50-100*	*101-500*	*501-1000*	*> 1000*
814	*127*	*915*	63%	19%	15%	2%	*1%*

Figure 2

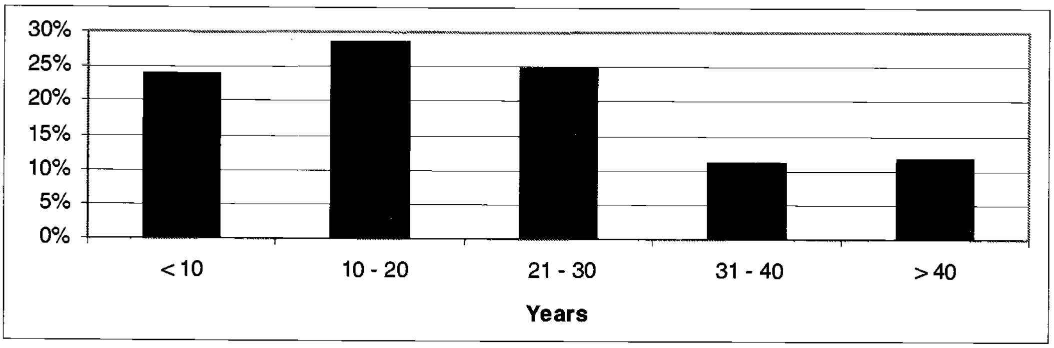


Question 4: Years of Ownership

Table 4

Total Responses	Mean Response	Std. Dev.	Years % of total responses *< 10*	*10-20*	*21-30*	*31-40*	*> 40*
818	*22.5*	*16.7*	24%	28%	25%	11%	*12%*

Figure 3



Question 5: Residence on the Property

Table 5

Total Responses	Mean Response	Std. Dev.	*Yes*	*% Total*	*No*	*% Total*
816	*1.2*	*0.4*	637	78%	179	22%

Question 6: Management Practices Used on Land

Table 6

Practice	Total Responses	Mean Response	Std.Dev	*Yes*	*% Total*	*No*	*% Total*
Reforest	792	1.2	0.4	604	76%	188	24%
Fertilize	742	1.7	0.5	221	30%	521	70%
Control brush	798	1.2	0.4	663	83%	135	17%
Commercial logging	786	1.4	0.5	451	57%	335	43%
Remove trees for wildlife	751	1.8	0.4	175	23%	576	77%
Plant vegetation for wildlife	749	1.8	0.4	175	245	572	76%
Snags, logs, uncut trees for wildlife	787	1.2	0.4	624	79%	163	21%

Question 7:Harvesting All Trees From the Property

Table 7

Total Responses	Mean Response	Std. Dev.	*Yes*	*% Total*	*No*	*% Total*
805	*1.9*	*0.3*	78	10%	727	90%

Question 7a: Reasons Not to Harvest

Table 8

Importance
% of total responses*

Reason	Total Responses	Mean Response	Std.Dev.	*1*	*2*	*3*	*4*	*5*
Maintain Value	686	3.7	1.3	9%	7%	24%	23%	37%
Nat. heritage	684	3.7	1.3	8%	9%	25%	21%	37%
Timber Not Mature	684	3.3	1.5	20%	9%	21%	19%	31%
Wildlife Habitat	687	3.7	1.2	6%	10%	25%	26%	32%
Aesthetics	689	4.1	1.1	4%	6%	18%	24%	48%
Not Needed Income	671	2.9	1.4	24%	11%	31%	17%	17%

* *1: Not Important, 3: Somewhat Important, 5: Very Important*

Question 8: Likelihood of ESA Regulation

Table 9

Likelihood
% of total responses*

Activity	Total Responses	Mean Response	Std.Dev.	*1*	*2*	*3*	*4*	*5*
Harvesting	795	2.8	1.5	31%	13%	25%	7%	25%
Development	784	2.8	1.6	34%	14%	18%	9%	25%

* *1: Very Unlikely, 3: Even Chance, 5: Very Likely*

Question 9: Familiarity With Incentives Programs

Table 10

Total Responses	Mean Response	Std. Dev.	*Yes*	*% Total*	*No*	*% Total*
810	1.59	0.49	333	41%	477	59%

Question 10: Past Participation in Incentives Programs

Table 11

Total Responses	Mean Response	Std. Dev.	*Yes*	*% Total*	*No*	*% Total*
810	1.8	0.4	167	21%	643	79%

Question 11: Current Participation in Incentives Programs

Table 12

Total Responses	Mean Response	Std. Dev.	*Yes*	*% Total*	*No*	*% Total*
808	1.9	0.3	67	8%	741	92%

Question 12: Importance of Incentives

Table 13

Incentive	Total Responses	Mean Response	Std.Dev	Importance % of total responses* 1	2	3
Cost Sharing	699	2.3	0.8	22%	25%	53%
Compensation	709	1.95	0.8	34%	36%	29%
Assurances	707	1.83	0.9	50%	17%	33%

* *1: Most Important – 3: Least Important*

Question 13: Choice of Management Plan

Table 14

Total Responses	Mean Response	Std.Dev	Plan % of total responses* 1	2	3	4
720	3.1	0.9	9%	13%	39%	39%

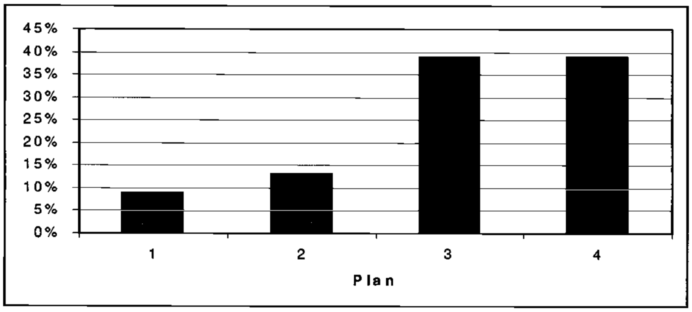
* *Plan 1: Thinning*

Plan 2: Thinning, providing snags and logs

Plan 3: Thinning, snags and logs, managing under story vegetation

Plan 4: No management

Figure 4



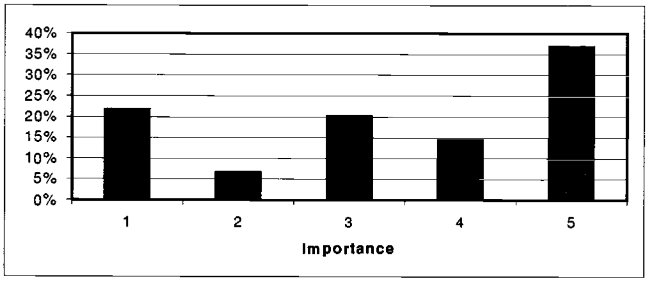
Question 14: Importance of Technical Assistance

Table 15

Total Responses	Mean Response	Std.Dev.	Importance % of total responses* *1*	*2*	*3*	*4*	*5*
757	3.4	1.6	22%	7%	20%	14%	37%

* *1: Not Important, 3: Somewhat Important, 5: Very Important*

Figure 5



Question 15: Willingness to Manage Land Under an Incentives Program

Table 16

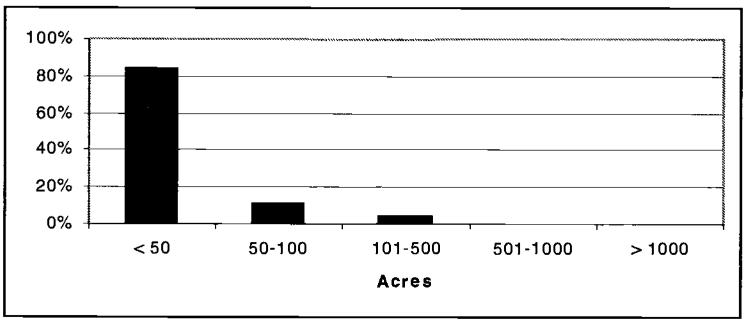
Total Responses	Mean Response	Std. Dev.	*Yes*	*% Total*	*No*	*% Total*
776	1.6	0.5	429	55%	347	45%

Question 15a: Size of Stand That Would be Managed Under Incentives Program

Table 17

Total Responses	Mean Response	Std. Dev.	Acres % of total responses *< 50*	*50-100*	*101-500*	*501-1000*	*> 1000*
405	*60.7*	*622*	84%	11%	4%	0%	*0%*

Figure 6



Question 15b: Age of Stand That Would be Managed Under Incentives Program

Table 18

Total Responses	Mean Response	Std. Dev.	Years % of total responses *< 25*	*25-50*	*51-75*	*76-100*	*> 100*
377	*36.3*	*30.8*	39%	42%	11%	6%	*2%*

Figure 7

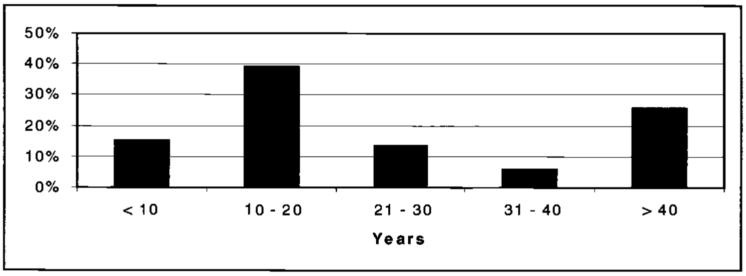
Question 15c: Years Before Stand is Harvested

Table 19

Total Responses	Mean Response	Std. Dev.	Years % of total responses *< 10*	*10-20*	*21-30*	*31-40*	*> 40*
267	*N.A.**	*N.A.**	15%	39%	13%	6%	*26%*

**Answers included "Never".*

Figure 8

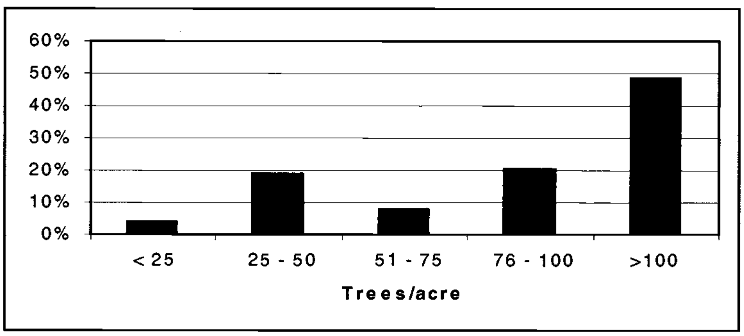


Question 15d: Tress per Acre in the Stand

Table 20

Total Responses	Mean Response	Std. Dev.	< 25	25-50	51-75	76-100	> 100
			Trees/acre % of total responses				
279	*160*	*145*	4%	19%	8%	20%	*49%*

Figure 9

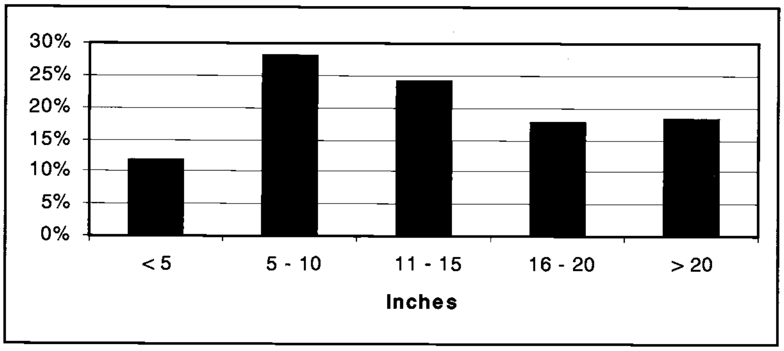


Question 15e: Size of Trees in Stand (Diameter at Breast Height)

Table 21

Total Responses	Mean Response	Std. Dev.	Inches % of total responses *< 5*	*5-10*	*11-15*	*16-20*	*> 20*
345	*15.2*	*18.7*	12%	28%	24%	18%	*18%*

Figure 10



Choice Experiment[29]

Question 16: Choice Experiment 1

Table 22

				Choice % of total responses			
Survey #	Total	Mean	Std. Dev.	*1*	*2*	*3*	*4*
1	190	3.4	0.8	3%	7%	33%	57%
2	175	3.3	1.0	9%	13%	15%	63%
3	199	2.9	1.4	34%	5%	4%	58%
4	205	2.9	1.0	2%	51%	2%	46%

Question 17: Choice Experiment 2

Table 23

				Choice % of total responses			
Survey #	Total	Mean	Std. Dev.	1	2	3	4
1	187	3.5	0.9	10%	2%	16%	73%
2	175	3.3	0.9	6%	10%	29%	55%
3	196	3.0	1.0	2%	46%	5%	47%
4	199	3.4	2.3	8%	16%	20%	57%

[29] See Chapter 4 for an analysis of the results of the choice experiment.

Question 18: Choice Experiment 3

Table 24

				Choice % of total responses			
Survey #	Total	Mean	Std. Dev.	1	2	3	4
1	186	3.4	0.9	4%	18%	15%	63%
2	167	3.4	0.9	7%	1%	20%	63%
3	191	3.0	1.2	23%	2%	26%	50%
4	193	3.3	1.0	11%	7%	23%	59%

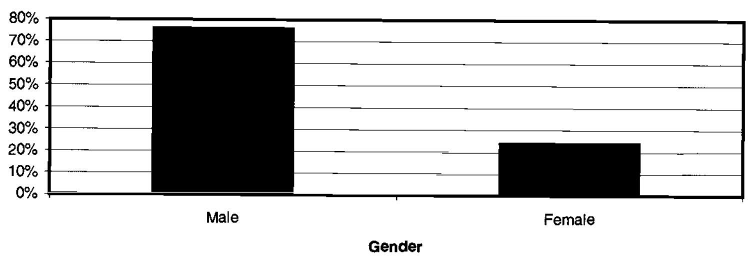
Demographic Information

Question 19: Forest Owner's Gender

Table 25

Total Responses	Mean Response	Std. Dev.	*Male*	*% Total*	*Female*	*% Total*
793	1.2	0.4	605	76%	188	24%

Figure 11

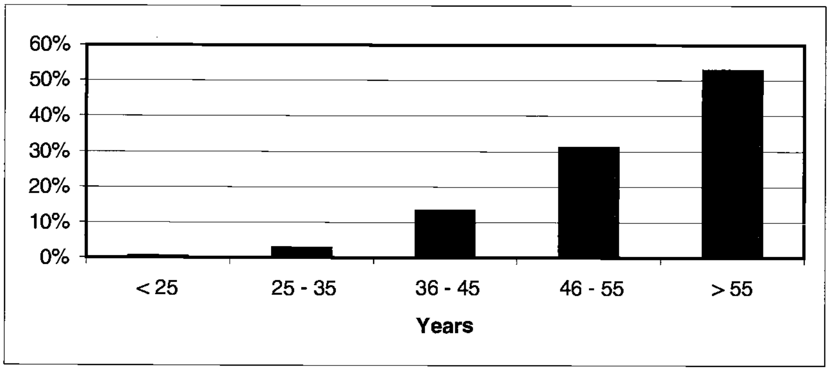


Question 20: Forest Owner's Age

Table 26

Total Responses	Mean Response	Std. Dev.	< 25	25-35	36-45	46-55	> 55
			Years (%) of total responses				
784	*58.1*	*13.2*	0%	3%	13%	31%	*53%*

Figure 12

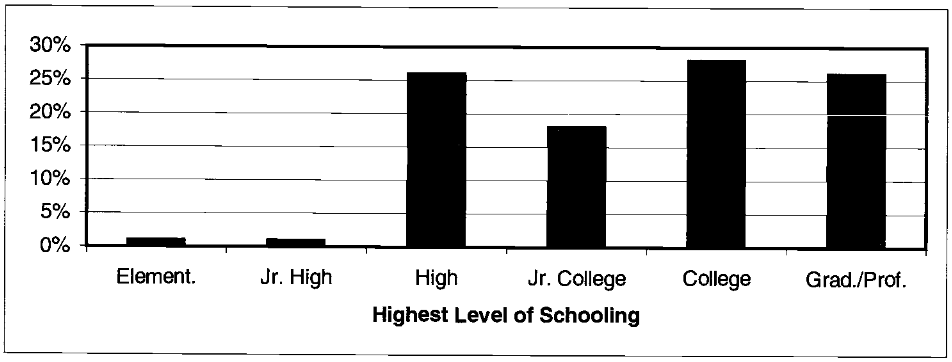


Question 21: Forest Owner's Education Level

Table 27

Total Responses	Mean Response	Std. Dev.	*Element. School*	*Junior High School*	*High School*	*Junior/ Comm. College*	*College*	*Grad./ Prof. School*
			Highest Level of Schooling % of total responses					
780	*4.5*	*1.2*	1%	1%	26%	18%	*28%*	*26%*

Figure 13



Question 22: Forest Owner's Occupation

Table 28

Total Responses	*Related to timber industry, logging, farming, ranching*	*% Total*	*Not related to timber industry, logging, farming, ranching**	*% Total*
764	103	13%	661	87%

* *Includes "Retired"*

Question 23: Membership in Conservation or Environmental Organization

Table 29

Total Responses	Mean Response	Std. Dev.	*Yes*	*% Total*	*No*	*% Total*
788	1.9	0.4	122	15%	666	85%

Question 24: Membership in Forestry Organizations

Table 30

Total Responses	Mean Response	Std. Dev.	*Yes*	*% Total*	*No*	*% Total*
791	1.8	0.4	158	20%	633	80%

Question 25: Forest Owner's Household Income

Table 31

Income ($ thousands)
% of total responses

Total Responses	Mean Response	Std. Dev.	< 10	10-19.9	20-29.9	30-39.9	40-49.9	50-59.9	60-69.9	70-79.9	80-89.9	90-99.9	100-149.9	> 150
661	6.9	3.3	2%	8%	7%	11%	10%	11%	9%	9%	4%	5%	13%	11%