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When the Truth Hurts: Endangered Species Policy on Private Land with Imperfect Information[1]

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Current species conservation policy gives landowners little incentive to cooperate with information collection and may result in little conservation occurring on private land. Modifying the current system by paying compensation to landowners or forcing landowners to provide information before developing, improves equilibrium efficiency. With symmetric but imperfect information about conservation value, combining elements of compensation and information requirements in a regulatory scheme, similar to the current incidental take provisions of the Endangered Species Act, can generate an efficient outcome. When landowners have private information about land value and compensation cannot be based on species conservation value, an efficient outcome cannot be assured. © 1998 Academic Press

I. INTRODUCTION

For several years, the Endangered Species Act (ESA) has been the center of a fierce debate. On one side, groups representing various economic interests have called for radical reform of the law in order to reduce economic impacts and to protect private property rights. On the other side, environmental groups vehemently oppose any weakening of the current law, contending that it must be maintained or strengthened to ensure the long-term survival of endangered species.

The Endangered Species Act is a prime example of a general tension in environmental regulation between private rights and social responsibilities. According to one estimate, 70% of species listed under the ESA depend on nonfederal land for the majority of their habitat (Natural Heritage Data Center Network [22]). Any effective species preservation policy will require conservation on private land. Fundamentally, the question is who should bear the costs of that conservation, assuming society decides to endorse it as a social goal. In our legal regime, this question translates into a choice between public rights to conservation of species

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and landowner rights to engage in activities that may harm species. In static settings with complete information and no transactions costs, this choice raises only distributional issues; an efficient outcome can be achieved regardless of whether the law confers a conservation entitlement on the public or a development entitlement on landowners.[2] When complete information about the benefits of either conservation or development is not available, however, the choice between initial entitlements becomes important to reaching an efficient outcome.[3]

Uncertainty is a central component of the conservation issue. We do not know how many species the world holds, even to an order of magnitude, much less the range and habitat each species inhabits. Conservation proponents favor greater efforts to collect information about the status of species, including location and health of populations and habitats (e.g., Wilson [30], pp. 13–17). By contrast, property rights advocates vociferously attack any move to expand government information collection efforts, such as the short-lived National Biological Survey (NBS). Emotions run so deep on this issue that employees of the NBS (which is now the Biological Resources Division of the United States Geological Survey) may fear not only for their jobs but also for their physical safety:

> [A] survey scientist spoke about his work in a public meeting near Houston. A man rose at the end to say he didn't have any questions, but wanted to alert everyone in the room. The man had heard the biological survey had entered into an agreement with the Girl Scouts of America to do survey work for them on private land. Why? "Because landowners would be more reluctant to shoot them than a bureaucrat." (*The Kansas City Star*, November 20, 1994)

Such extreme opposition to an agency with no regulatory power may seem surprising. However, under current conservation rules, information is a prerequisite to regulation. Therefore, as a result, property owners and regulators have sharply divergent views of the desirability of increased information about species status and distribution.

In this paper, we explore the impacts of various legal rules regarding both information collection and the definition of (conservation or development) rights on achieving an efficient outcome. We outline the current legal regime in Section II. We summarize the ESA's restrictions on private actions and the information necessary to enforce the ESA on private property. In Section III, we analyze a model of information collection and conservation decision making under alternative legal regimes. We first analyze a model with symmetric but imperfect information.[4] We demonstrate that the current legal structure for conserving species on private land results in an inefficient outcome. However, an alternative set of rules similar to the existing incidental take permit approach but imposing a lesser informational burden on regulators results in an efficient outcome. In the latter part of the section, we analyze a model where the landowner has private information about land value. With asymmetric information, an efficient outcome cannot

[2] This result follows from Coase [2]. Defining the institutional rules defines whether property rights reside with the individual or with the government (representing social interests). However, as long as the individual and the government can negotiate over conservation policy, an efficient outcome can result.

[3] Farrell [6] contains a clear explanation of problems with the Coase theorem with incomplete information.

[4] Polasky, Doremus, and Rettig [24] contains an informal discussion of the issues raised in the model with symmetric information.

be achieved unless compensation to landowners can be based on the species conservation value of the land, which we argue is impractical. Beginning with Blume, Rubinfeld, and Shapiro [1], most of the economics literature on takings and compensation focuses on the effect of compensation on landowner investment decisions (see also Miceli and Segerson [21], Hermalin [9], Innes [12] and references cited therein). Except for Hermalin [9], this literature does not analyze cases with imperfect or asymmetric information. Our model differs from this prior literature because we analyze a model with endogenous acquisition of information. In Section IV, we discuss the implications of our analysis for species conservation policy. We discuss ways of implementing species conservation policies with desirable efficiency properties. We also consider additional factors such as fiscal illusion, landowner investment and equity concerns.

II. THE CURRENT LEGAL REGIME

A. *Endangered Species Act Restrictions on Private Actions*

1. *The Prohibition on Taking and the Duty not to Jeopardize*

Two provisions of the ESA impact nonfederal activities, one directly and one indirectly. First, Section 9 directly restricts private actions, forbidding any person to take an endangered species without a permit. Plainly, Section 9 prohibits the hunting of listed species. In addition, as interpreted by the U.S. Fish & Wildlife Service (FWS), it also prohibits significant alteration of their habitat in a manner that kills or injures listed creatures by interfering with essential activities such as breeding, feeding, or sheltering (50 C.F.R. Section 17.3 (1995)).[5] This prohibition on habitat modification potentially applies to many otherwise lawful land-use activities, including grazing, logging, agriculture, mining, and construction, when carried out within the range of a listed species.

Section 9 does not require or even permit cost-benefit comparison; activities which take listed species are prohibited no matter what their economic benefits may be. The ESA does provide an exception to this sweeping prohibition, however. It requires that FWS issue a permit, called an incidental take permit, authorizing some taking incidental to other activities if the landowner submits an adequate habitat conservation plan (HCP) and meets other statutory requirements. The HCP must, among other things, ensure that the taking ''will not appreciably reduce the likelihood of the survival and the recovery of the species in the wild'' (16 U.S.C. Section 1539(a)(2)(b)(iv)).

The other significant impact of the ESA on private land comes indirectly from the requirements the statute imposes on federal actions. Under Section 7, federal agencies must ensure that their actions are not likely to jeopardize the continued existence of a listed species or adversely affect its critical habitat (16 U.S.C. Section 1536(a)(2)). This duty can be overridden in extreme circumstances through action of the Endangered Species Committee, if the action is of regional or national

[5]The Supreme Court upheld this regulation in Babbitt v. Sweet Home Chapter of Communities for a Great Oregon, 515 U.S. 687 (1995).

significance, there is no reasonable alternative, and the benefits of the action clearly outweigh the benefits of any alternative consistent with conservation of the species (16 U.S.C. Section 1536(h)(1)). Although nominally imposed only on federal actors, this requirement affects many private parties because it applies to issuance of federal permits authorizing private activities, including incidental take permits under Section 10.

The prohibitions of the ESA are backed by potentially stringent civil and criminal sanctions. Each knowing violation may bring a civil penalty of up to $25,000 (16 U.S.C. Section 1540). Criminal penalties including up to a year in prison and six-figure fines are also possible (18 U.S.C. Sections 3559, 3571). Alternatively, the criminal fines may be set at up to twice the defendant's pecuniary gain from the violation (18 U.S.C. Section 3571).

2. *Constitutional Limits on the Reach of the Endangered Species Act*

The Fifth Amendment to the United States Constitution forbids the taking of private property for public use without payment of just compensation.[6] The current state of takings law is such that in many cases neither the property owner nor the government can know for sure whether a regulation is vulnerable to a takings challenge. Although there may be some exceptions, most species protection regulations would probably survive such a challenge.

Although Fifth Amendment takings jurisprudence is widely recognized as a difficult area of the law to predict or explain, some generalizations are possible. Three major factors determine whether a government action requires payment of compensation: (1) the nature of the intrusion; (2) its impact on the value of the property;[7] and (3) the nature of the public purpose it serves.

If the government either authorizes or carries out a physical occupation of the property, it must provide compensation no matter how small the impact (Loretto v. Teleprompter Manhattan CATV Corp., 458 U.S. 419 (1982)). By contrast, the government must compensate for regulatory intrusions only if they ''go too far'' (Pennsylvania Coal Co. v. Mahon, 260 U.S. 393, 415 (1922)). The courts rely on a case-by-case analysis to determine whether a regulation exceeds this threshold, focusing on the second and third factors.

The Supreme Court has generally imposed a stringent test for regulatory takings, limiting compensation to circumstances in which all economically viable use of the property has been denied. Most regulations designed to protect listed species survive this test. While they may require that the owner set aside a portion of the property, such as streamside corridors, to protect habitat, they generally leave much of the property available for use. Only on small parcels are such regulations likely to deprive an owner of all economic use.

A majority of the Supreme Court (including four current justices) has signaled a willingness to reconsider its limitation of regulatory takings claims to cases in which all economically viable use is lost (Lucas v. South Carolina Coastal Council,

[6]''Taking'' of property in this sense should not be confused with the ''taking'' of species prohibited by Section 9 of the ESA.

[7]The impact on property values is often evaluated by reference to the owner's reasonable investment-backed expectations. (Kaiser Aetna v. United States, 444 U.S. 164, 175 (1979)).

505 U.S. 1003, 1016 n.7 (1992)). The federal court of appeals with jurisdiction over most takings claims against the federal government has picked up on this suggestion and now evaluates those claims on the basis of whether, under the circumstances, the economic impact on the landowner is fair (Florida Rock Indus. v. United States, 18 F.3d 1560 Fed. Cir. (1994)). This test potentially makes species protection regulations more vulnerable.[8]

The third important factor in regulatory takings cases is the purpose served by the regulation. The law has long imposed some restrictions on property use in order to protect neighbors and the public from harmful spillover effects. Under what is called the nuisance exception to the takings clause, such restrictions do not trigger the compensation requirement even if they deprive a landowner of all economically viable use. At one time, the Supreme Court suggested that any regulation which could rationally be said to protect the public from a harmful use of property, rather than to secure a public benefit at private expense, would survive a takings challenge. Recognizing the malleability of the concepts of harm and benefit, the Court in *Lucas* limited the exception to prohibitions already incorporated into background principles of state law. *Lucas* requires compensation for new restrictions imposed in response to newly recognized problems if those restrictions deprive the owner of all economically viable use.

Because legislation protecting species habitat is relatively new, land-use restrictions implementing the ESA likely will not meet the *Lucas* test of inhering in the title itself.[9] Thus, if they take all economically viable use, such restrictions will likely subject the government to a duty to provide compensation.

B. *Information Required to Enforce the Endangered Species Act*

In order to impose sanctions or to obtain an injunction under the ESA, regulators must prove that the defendant has committed, or is about to commit, a violation. Proof by a preponderance of the evidence is sufficient in the civil context, but criminal penalties must be supported by proof beyond a reasonable doubt. Where the alleged violation is a direct killing, as in the case of a hunter who shoots a bald eagle, proof of the offense is a relatively straightforward, though not always easy, process. However, where the alleged take arises from habitat modification, proof of violation can present special difficulties. To establish harm, regulators must show by a preponderance of the evidence both that a listed species uses the area and that the challenged activity will adversely impact the species or a member of it. Both steps in this proof may be contentious. Regulators must show not only that the species occurs in the vicinity, but more particularly that it uses the land at

[8] In a dissenting opinion in the Sweet Home case, Justice Scalia wrote that the regulatory definition of harm under the ESA ''imposes unfairness to the point of financial ruin—not just upon the rich, but upon the simplest farmer who finds his land conscripted to national zoological use'' (Babbitt v. Sweet Home Chapter of Communities for a Great Oregon, 515 U.S. 687, 115 S.Ct. 2407, 2421 (1995)).

[9] Houck [11] argues that because wildlife protection laws in general are long established, restrictions on land use to protect endangered species pass muster under *Lucas*. This view of the relevant legal background appears unlikely to persuade the *Lucas* majority.

issue for some essential behavior.[10] In other words, testimony to the effect that a nest has been located on the site or a member of the listed species has been seen feeding there may be required. It would probably not be enough for regulators to show simply that the type of habitat found on the site is consistent with the species' requirements, and that the species' historic range includes the area of the site.

Two contrasting cases may serve to illustrate the evidentiary requirements, and the opportunity they provide for courts to exercise their discretion. In Marbled Murrelet v. Babbitt, 83 F.3d 1060 (9th Cir. 1996), the plaintiffs showed to the satisfaction of the court that logging in an old-growth forest would harm the threatened marbled murrelet. They did so with the landowners' own survey data, required for a state timber harvest permit. The court found the surveys had deliberately understated murrelet activity. Nevertheless, they had produced over one hundred murrelet sightings, and many instances of the types of behavior associated with nesting. At the other extreme, in Morrill v. Lujan, 802 F. Supp. 424 (S.D. Ala. 1992) the plaintiff was unable to persuade the court that development of an Alabama shore would harm the endangered Perdido Key beach mouse. The plaintiff submitted evidence that the mouse once inhabited the property to be developed, and that at least some of the property remained suitable habitat. However, she could not provide a recent sighting on the property. Without that, the court refused to find that development would harm the mouse.

Having shown that the land in question serves some essential function for the species, regulators must go on to establish a causal connection between the challenged activity and an adverse impact on the species. While it must be likely, the harm need not be direct or immediate. For example, if timber harvest near nest trees is likely to cause a listed bird to abandon its nests, failure to leave an adequate buffer zone constitutes a take (Sierra Club v. Yeutter, 926 F.2d 429, 438 (5th Cir. 1991)). Cumulative or incremental impacts present especially difficult issues of proof. For example, if reduced flow in a river makes breeding more difficult for a listed fish, one could argue that every person who diverts water above the spawning ground violates Section 9. Alternatively, perhaps only recent diverters, whose diversions can be shown to have reduced breeding success, have violated the ESA.[11]

These evidentiary complications can make it difficult to enforce Section 9. They presumably account, at least in part, for the dearth of enforcement actions to date based on habitat modification. No doubt the political repercussions of habitat-based prosecutions have also contributed to the government's reluctance to undertake them.

[10] In what may be the judicial high water mark for Section 9, a federal district court held that sheep grazing that prevented regeneration of habitat not currently occupied by a listed species but essential for its future recovery was a taking of the species. Palila v. Hawaii Dept. of Land & Natural Resources, 649 F. Supp. 1070 (D. Haw. 1986). The Ninth Circuit affirmed the decision on the alternative ground that the sheep destroyed existing occupied habitat, declining to reach the question of whether preventing recovery of a population to viable size violates Section 9. Palila v. Hawaii Dept. of Land & Natural Resources, 852 F.2d 1106 (9th Cir. 1988). In her concurring opinion in *Sweet Home Chapter*, Justice O'Connor specifically rejected the concept that preventing regeneration of habitat not currently inhabited by a listed species could violate Section 9. Sweet Home Chapter, 63 U.S.L.W. at 4673 (O'Connor, J., concurring).

[11] The Ninth Circuit declined to find a violation by the United States Navy in this circumstance, noting that the plaintiff Native American tribe was also a diverter. Pyramid Lake Paiute Tribe v. United States Dept. of the Navy, 898 F.2d 1410 (9th Cir. 1990).

C. *Means of Obtaining Information*

Information about species distribution comes chiefly from field observations, which can be conducted at varying levels of precision with corresponding levels of intrusion on the property surveyed. A rough estimate of species distribution, and of the biological value of particular parcels to species, can be generated using satellite or aerial mapping of vegetation types, combined with information about climate, soil type, habitat preferences, and historic collection data. (For description of procedures used to infer the range of species see Scott *et al*. [25] and Margules and Austin [19]). Surveys based on satellite or aerial photography data present no special legal obstacles.

More information is needed, however, to precisely confirm the value of a parcel to a particular species. Direct examination of the area is usually needed to locate species of interest accurately and to determine their population density. This kind of ground-truthing through field visits does face legal barriers.

1. *Open Fields and Trespass*

In many cases, the Fourth Amendment does not impede the government's ability to conduct biological surveys on private land. The constitution allows searches of ''open fields,'' a category that generally includes any unoccupied or undeveloped land away from the private areas of a dwelling (Oliver v. United States, 466 U.S. 170 (1984)). The large landholdings and undeveloped areas most likely to harbor rare species would fall under this definition. Accordingly, government agents could lawfully stand at the edges of these areas and survey them visually with binoculars or spotting scopes. Furthermore, if government agents were to sneak on the property and survey it, they could use the results in enforcement proceedings.[12]

However, the open field doctrine does not give government agents the right to enter the land in violation of state trespass law. Typically, a landowner is entitled to exclude all others from her property, subject to a few limited exceptions. Intrusion of government biological surveyors without the consent of the owner would often constitute a civil trespass. At a minimum, such an intrusion would invite an ugly confrontation between the landowner, perhaps joined by the local sheriff, and the surveyors. For that reason, the government is unlikely to push the limits of its authority to survey private lands. In fact, Congress has regularly barred the use of federal funds to conduct biological surveys of private property without consent, even going so far as to prohibit federal funding of aerial surveys unless requested by the landowner (Public Law No. 104-134, Section 2901(c)).

2. *Searches with or without Landowner Consent*

The government can satisfy the requirements of both trespass law and the constitution by obtaining either the landowner's consent or a search warrant. However, as a practical matter, these possibilities are not likely to lead to much

[12] In United States v. Rapanos, 115 F.3d. 367 (6th Cir. 1997), the court held that the open fields doctrine applied to a large parcel that had been cleared and fenced in preparation for building. Accordingly, the defendant, who was charged with illegally filling wetlands, had no constitutional right to prevent a warrantless entry and search of the premises.

information. Landowners who fear increased restrictions on the use of their property may not consent. Moreover, a warrant usually will not be an option for informational surveys. To obtain a warrant, the government must show probable cause to believe that an offense has been committed and that evidence of the offense will be found at the site. Thus, FWS can use search warrants to verify (or dispel) suspicions based on evidence gathered by other means, as it did, for example, when land in California's San Joaquin valley on which state agency employees had spotted endangered species was suddenly plowed (Woody [31]). However, the probable cause requirement limits the usefulness of warrant searches as an initial means of gathering information about the presence of listed species.

The government may conduct limited warrantless inspections of highly regulated industries to monitor compliance with the law. These inspections must be authorized by statute, necessary to enforce the regulatory scheme, and limited in scope. Some commercial operations likely to impact listed species may be sufficiently regulated to be subject to warrantless inspections.[13] However, Congress has not explicitly authorized such inspections under the ESA, and FWS has not shown any inclination to undertake them.

3. *Requiring the Landowner to Provide Information*

Regulators can, under certain circumstances, compel regulated persons to supply information. For example, factories must report their pollution emissions under the Clean Air and Clean Water Acts. Regulators currently require that landowners provide information, or allow regulators to gather it, in the context of some actions that may affect listed species. For example, in Oregon timber harvest proposals must be approved by state officials. If harvest will occur near a stream or identified listed species site, the landowner must permit state inspection of the site (Oregon Administrative Rules 629-24-113, 629-24-699).[14] Similarly, federal guidelines prohibit wetlands filling unless the landowner provides sufficient information to show the fill will not have an unacceptable adverse impact (40 C.F.R. 230.1, 230.12). Regulators could make more aggressive use of information mandates in the endangered species context.

III. MODELS OF CONSERVATION ON PRIVATE LAND

In this section, we analyze a model of information collection and land use that builds on the discussion of the ESA contained in Section II. In Section A, we analyze a model with uncertainty about the species conservation value of a land parcel. In Section B, we analyze a model where the landowner has private information about land value that cannot be observed by the regulator.

[13]A Department of Commerce regulation requiring tuna fishing vessels to accept federal observers for the purpose of, among other things, collecting information regarding compliance with the Marine Mammal Protection Act, has been upheld on the grounds that commercial fishing is a closely regulated industry subject to appropriately limited warrantless searches (Balelo v. Baldridge, 724 F. 2d 753 (9th Cir. 1984)).

[14]A restrictive definition lessens that impact of this requirement. A listed species site is one for which the state provides clear evidence of actual use. For example, a spotted owl nest site must either be known to contain a nest or have been reliably identified based on repeated observations of a pair of owls or nesting behavior.

A. *The Model with Symmetric Imperfect Information*

Suppose a single parcel of private land can either be used in an economic activity or conserved in its natural state. Let $M \geq 0$ be the market value of the parcel if devoted to economic activity and let $S \geq 0$ be the species conservation value of the parcel if conserved in its natural state.[15] Therefore, as an example, consider recent battles over endangered species policy in the Pacific Northwest. A parcel covered with old-growth forest could either be logged or preserved in its current condition. The market value, M, is the present value of profits from timber operations. Preserving the old-growth forest provides habitat for a variety of species and yields a species conservation value S.

Establishing a species conservation value presents several fundamental challenges. The first, identical to the enforcement problem described earlier, is determining whether the parcel provides habitat to a listed species, and if so, how the proposed change in land use would affect the species. Population biology models can be used to estimate species survival probabilities as a function of landscape pattern (e.g., Lamberson *et al*. [14], Lande [15]). The models typically require knowledge of the life history of the species, its habitat preferences, and detailed information on landscape pattern. Sufficient data to estimate how alternative landscape patterns would affect species survival probability rarely exist.

The second challenge is assigning a value to a given decrease in species population or likelihood of survival. For most species, much of their value is neither traceable to any use nor traded in any existing market. There is an on-going debate about the accuracy of estimates of nonmarket and nonuse values (e.g., Diamond and Hausman [5], Hanemann [8]).

Current endangered species policy sidesteps the difficulties of the valuation issue. If an action will ''harm'' a listed species, it is simply prohibited unless the actor has an incidental take permit. A permit must be granted if the take is incidental to a lawful activity and will not cause jeopardy. One way to think about current law is that it assigns a large value (possibly infinite) to S in the case where the land parcel provides habitat essential for the survival of a listed species and assigns a zero value to S when the land parcel is not essential for survival.

Because species locations, habitat requirements, and the value of species to society may be unknown, we assume that the conservation value of the land parcel is a random variable. Let $f(S)$ and $F(S)$ represent the *ex ante* probability density function and cumulative distribution function of this random variable of which S is a realization.

The model has two players, the landowner and the regulator, and two decision stages, information collection and land use. Prior to any action by the landowner or the regulator, the institutional rules (laws) are set. The rules specify who is eligible to make information collection and land-use decisions as well as defining any net payment between the regulator and the landowner. In the information collection stage, a decision is made to survey the parcel or not. For simplicity, we assume that

[15] We abstract from intermediate uses of land that allow economic use while maintaining some conservation value. The insights of the model developed here apply as long as there is some degree of conflict between species conservation values and development values. In addition, the production set for economic activity and conservation on a single parcel may be nonconvex so that it would be optimal to choose a corner solution.

for a cost of C a biological survey will reveal S. In the land-use stage, a decision is made to develop or to conserve.

After the land-use decision, payoffs to the landowner and the regulator are realized. The landowner's goal is to maximize her expected payoff. The landowner receives M with development but receives no return with conservation.[16] The landowner also receives net payments as defined under the compensation rule and pays C if she undertakes a survey. We assume the regulator's goal is to maximize expected social returns, which are equal to M with development or S with conservation, minus C if a survey has been undertaken.

1. *Characterizing an Efficient Outcome*

Given full information about both M and S, a parcel of land should be conserved if and only if $S \geq M$ (we assume that ties go to the species). With imperfect information about S, a decision about whether to develop or to conserve the parcel must be made using only the probability distribution. Let $E(S)$ represent the expected conservation value: $E(S) = \int_0^\infty Sf(S)\,dS$. Assuming risk neutrality, the *ex ante* efficient decision rule with imperfect information is to conserve the parcel when the expected species conservation value is at least as large as the market value: $E(S) \geq M$. With imperfect information, *ex post* some mistakes will be made. Some parcels that should be conserved will be developed and some parcels that should be developed will be conserved. The expected benefit of a survey equals the benefit of avoiding these mistakes,

$$B = \int_0^M (M - S)f(S)\,dS \quad \text{if } E(S) \geq M$$

$$= \int_M^\infty (S - M)f(S)\,ds \quad \text{if } E(S) < M. \tag{1}$$

It is efficient to survey the site prior to making the land-use decision whenever $B \geq C$.

2. *Implementing an Efficient Decision under Free Choice of Institutional Rules*

Given a clean slate upon which to define the rules, implementing an efficient outcome in this model is simple. One approach is to give all decision-making authority to the regulator. An efficient outcome will be achieved because, by assumption, the regulator's objective is efficiency and the regulator has as much information as the landowner. There are three problems with this approach. First, contrary to the assumptions of the model, the regulator may pursue goals other than efficiency. For example, the regulator may weigh species benefits that accrue to the public more heavily than development benefits that accrue to the landowner. Not giving adequate weight to private benefits (''fiscal illusion'') has been discussed by Blume, Rubinfeld, and Shapiro [1], Fischel [7], and others. We return to this point in Section IV. Second, the regulator may have less information than the

[16] Conservation can yield financial benefits to the landowner (e.g. tourism). It is difficult for the landowner to capture the full benefits of conservation (see Defenders of Wildlife [4], McNeely [20], and Sedjo [26]).

landowner. In this case, it is not efficient to have decision making in the hands of the regulator, who is the less informed party. We discuss a case where the landowner has private information in Section B. Third, giving all decision-making authority to the regulator may be viewed as heavy-handed government interference in the management of private land and does not seem realistic in the current political climate.

A second approach is to let the landowner make all decisions but to align landowner and social payoffs through an appropriate compensation scheme. Suppose a compensation scheme is defined as follows: (i) when S is known, let the difference in net payments from the regulator to the landowner with conservation versus development be S; (b) when S is unknown, let the difference in net payments from the regulator to the landowner with conservation versus development be $E(S)$. Note that the landowner's relative benefits of conservation versus development, and of collecting information, match those of society. Therefore, the landowner will make efficient land use and information collection decisions.[17] It is important to note that obtaining an efficient solution does not require the distribution of gains between the regulator and the landowner to be specified. What is necessary to achieve an efficient result is to make the difference in returns between conservation and development the same for the landowner as for society. Whether the landowner pays for the right to develop, or is compensated when conservation is mandated, is immaterial from an efficiency standpoint (though of great importance from a distributional standpoint).

Despite its simplicity and intuitive appeal to economists, policymakers have not seriously considered a compensation scheme based on conservation value. Basing compensation on conservation value requires an objective method for measuring that value. As explained previously, biological and economic complications make it extremely difficult to estimate the conservation value of a parcel of land. The cost of determining this value, the high probability that the regulator and the landowner will disagree about it, and the expense of litigation to resolve those disagreements, make basing compensation on the conservation value impractical.

3. *Equilibrium under Alternative Burden of Proof and Market Value Compensation Rules*

Given the difficulties outlined in the preceding text, we focus on rules that: (i) give most decision-making authority to landowners; and (ii) do not base compensation on species conservation value. Consistent with current law, the landowner is given the important decisions at the information collection and land-use stages. The landowner decides whether to cooperate with the regulator and allow the regulator to become informed about the species conservation value. Cooperation can take one of two forms: (i) the landowner can undertake a survey and agree to share the results with the regulator, or (ii) the landowner can agree to let the regulator survey the property. Under the second option the regulator then decides

[17] Previously, Blume, Rubinfeld, and Shapiro [1] and Hermalin [9] have shown a similar result in models with investment prior to a land-use decision. Hermalin [9] also points out that only payment of the maximum difference in private valuation between development and conservation, not the full value of species conservation, is required to align incentives. This fact is potentially significant as species conservation values could be quite large in some cases.

whether or not to undertake a survey. At the land use stage, the landowner decides whether to develop or not. However, the regulator may mandate conservation under certain circumstances and levy sanctions against the landowner if she violates the mandate.

In the analysis that follows, we consider several different compensation rules. The compensation rule defines the net payment between the regulator and the landowner as a function of the realized conservation value and the actions of the landowner. We analyze several alternatives including: (i) no payments, (ii) the regulator pays compensation equal to market value when conservation is mandated, and (iii) rule (ii) plus the landowner pays a development fee when she develops. In all cases, if the landowner develops when conservation has been mandated by the regulator, the landowner is fined an amount ϕ, which we assume is greater than M.

We also consider several different ''burden of proof'' rules. The burden of proof rule specifies the evidence a regulator must produce in order to mandate conservation. We analyze cases where the burden of proof rests on the regulator (i.e., where the regulator must prove that development will harm a listed species in order for conservation to be mandated), on the landowner (i.e., where the landowner must prove that development will not harm a listed species before development will be allowed), and an intermediate case that assigns the burden of proof on the basis of *ex ante* information.

a. No compensation and the regulator must prove harm. Previously discussed in Section II, current law is probably closest to the case where no compensation is required and the burden of proof lies on the regulator. At the land-use decision stage, if the regulator does not have information about S, he lacks the ability to mandate conservation. In this case, the landowner will choose to develop and receive a payoff of M. On the other hand, if the regulator has information about S, the regulator will mandate conservation on parcels for which $S \geq M$. When $S \geq M$, the landowner will choose to conserve, receiving a payoff of 0, rather than develop and receive a payoff of $M - \phi < 0$. The probability that the conservation value exceeds the market value is equal to $\int_M^\infty f(S)\,dS = 1 - \int_0^M f(S)\,dS = 1 - F(M)$. The expected payoff to the landowner with an informed regulator is $F(M)M$, which is less than M for $F(M) < 1$. Therefore, if there is any chance that a survey will show that the species conservation value exceeds the market value, the landowner should not allow biological information to be gathered. Because the regulator does not learn the value of S, the regulator cannot mandate conservation. Further, under these rules a landowner would also not voluntarily choose to conserve. These results are summarized in the following proposition.

PROPOSITION 1. *When the regulator must prove that the species conservation value exceeds the market value before the landowner can be required to conserve, and no compensation is paid to a landowner required to conserve, the regulator will not become informed about the species conservation value and no conservation will occur on private land.*

Always allowing development is efficient only if $E(S) < M$ and the cost of surveying exceeds the expected benefits. The major problems with this set of rules are that landowners have no incentive to cooperate at the information collection stage and information is a prerequisite to conservation. One way to improve upon

these rules is to use the carrot of compensation if information shows conservation to be desirable. Another way is to use the stick of sanctions unless the landowner proves before developing that the market value exceeds the conservation value. We consider each in turn in the following text.

b. Compensation and regulator must prove harm. With compensation equal to M when conservation is mandated, the landowner will receive M regardless of whether the regulator is informed or not about the actual value of S. Therefore, an equilibrium decision for the landowner at the information collection stage is to cooperate with the regulator. The landowner, however, will not pay for a survey since she is indifferent about whether the regulator is informed or not. The regulator will decide whether to survey depending on whether the expected gain from becoming informed is at least as large as the cost of the survey.

Without information, the regulator cannot mandate conservation and the parcel will be developed, yielding a value of M. Therefore, the expected benefit of a survey is $B = \int_M^\infty (S - M)f(S)\,ds$. Comparing this expression to that shown is Eq. (1) we can see that the expected benefit of a survey is the same as the expected benefit in the efficient solution when $E(S) < M$. When $E(S) > M$, however, the expected benefit of a survey exceeds the expected benefit in the efficient solution (shown in Eq. (1)),

$$\int_M^\infty (S - M)f(S)\,dS - \int_0^M (M - S)f(S)\,dS$$

$$= \int_0^\infty (S - M)f(S)\,dS = E(S) - M.$$

Without information, the default land-use decision is to develop, which yields a lower expected value than conservation (because $E(S) > M$ in this case). In order to avoid this inefficient default land-use decision process, the regulator has an added incentive to survey. We summarize this discussion in the following proposition.

PROPOSITION 2. *When the regulator must prove that species conservation value exceeds market value and pay compensation equal to market value to mandate conservation, the landowner will cooperate with information collection activities. However, when the expected conservation value exceeds the market value, an ex ante inefficient land-use decision will be made when the regulator is not informed and the regulator may collect information when it is inefficient to do so.*

When the burden of proof is on the regulator, allowing compensation improves conservation land-use decision making on private land. The regulator can gain information and conservation can occur when $S \geq M$. In fact, the equilibrium outcome is efficient when $E(S) < M$. When $E(S) \geq M$, however, the outcome may be inefficient.

c. No compensation and the landowner must prove no harm. Suppose the landowner must prove that $S < M$ before being allowed to develop without being fined. If information is not provided to the regulator, the landowner will choose to conserve rather than to develop and be fined. With a survey, however, the landowner may develop without penalty when $S < M$, which occurs with probabil-

ity $F(M)$. The expected payoff for the landowner when the regulator is informed is $F(M)M$. In the information collection stage, either the regulator or the landowner could survey. From the regulator's perspective the expected net benefit of a survey is $\int_0^M (M - S)f(S)\,ds - C$. When this expression is positive, it is possible for the landowner to decline to survey knowing that the regulator will have an incentive to survey. When the expression is negative, however, the landowner may still want to survey even though she has to pay for it. The expected net benefit to the landowner of completing a survey is

$$\int_0^M Mf(S)\,dS - C = MF(M) - C.$$

Because a landowner may wish to survey even when the regulator does not, we compare the landowner's expected net benefit of a survey with the expected net benefit of a survey in the efficient case. If $E(S) \geq M$, the expected net benefit of a survey in the efficient case is

$$\int_0^M (M - S)f(S)\,dS - C = MF(M) - \int_0^M Sf(S)\,dS - C,$$

which is less than the expected net benefit for the landowner. If $E(S) < M$, the expected net benefit of a survey in the efficient solution is

$$\int_M^\infty (S - M)f(S)\,dS - C = \int_M^\infty Sf(S)\,dS - M(1 - F(M)) - C.$$

The difference between the expected net benefit of a survey to the landowner and the expected net social benefit in the efficient solution is

$$MF(M) - C - \int_M^\infty Sf(S)\,dS + M(1 - F(M)) + C = M - \int_M^\infty Sf(S)\,dS.$$

This expression must be positive because the last term on the right-hand side is less than $E(S)$, which in this case is less than M. These results lead to the following conclusions.

PROPOSITION 3. *When no compensation is paid and the landowner must prove that the market value exceeds the species conservation value to develop without a fine, the landowner will cooperate with information collection activities. However, information may be collected when it is inefficient to do so. Further, when the market value exceeds the expected conservation value, an ex ante inefficient land-use decision will be made when the regulator is not informed.*

Just as with paying compensation, changing the rules on the burden of proof corrects the incentives to cooperate at the information stage. However, because the expected payoff to a landowner from surveying is even greater than it was for a regulator in the case with compensation, there is increased potential for excessive surveying here relative to the case with compensation.

d. Assigning property rights on the basis of ex ante information. Providing compensation or changing the burden of proof to the landowner improves the expected equilibrium outcome relative to the status quo. Combining elements of both can

improve performance further. Consider the following set of rules: (i) when $E(S) < M$, the regulator must show that $S \geq M$ before mandating conservation and then must provide a payment of M to the landowner; (ii) when $E(S) \geq M$, the landowner must show that $M > S$ before being allowed to develop without a fine and then must provide a payment of λM to the regulator, where λ is a positive constant. These rules are akin to assigning property rights to either the public or to the landowner depending on the relationship between the expected species conservation value and the market value. The party without the property right compensates the right-holder when they take an action that damages the right-holder.

From Section b, we know that when $E(S) < M$, the regulator has the burden of proof and the regulator pays compensation of M to the landowner when conservation is mandated, the equilibrium outcome is efficient. On the other hand, when $E(S) > M$, putting the burden of proof on the regulator, with compensation to the landowner with conservation, did not yield an efficient outcome. Instead, when $E(S) > M$, suppose that the burden of proof is put on the landowner as in Section c. In addition, suppose the landowner must pay compensation (a development fee) equal to λM to the regulator if they develop. Setting a positive λ lowers the excessive incentive to survey on the part of the landowner. In fact, by setting λ at the right level, the correct incentive to survey can be given to the landowner. The net benefit of a survey for the landowner under these rules is $\int_0^M M(1 - \lambda)f(S)\,dS - C$. This value will be equal to the net benefit of a survey in the efficient case when

$$\lambda = \frac{\int_0^M Sf(S)\,dS}{\int_0^M Mf(S)\,dS} = \frac{E(S \mid S < M)}{M},$$

where $E(S \mid S < M)$ is the expected value of S conditional on $S < M$. The landowner can be given the correct incentive to survey by requiring payment of a development fee equal to $E(S \mid S < M)$. We summarize this discussion in Proposition 4.

PROPOSITION 4. *An efficient equilibrium outcome occurs when the rules are defined as follows*:

(i) *when the expected conservation value is less than the market value, the regulator must show that the conservation value is at least as great as the market value before mandating conservation and must then provide compensation equal to the market value to the landowner*;

(ii) *when the expected conservation value is at least as large as the market value, the landowner must show that the market value exceeds the conservation value before being allowed to develop and must then provide a payment* (*development fee*) *to the regulator equal to the expected conservation value conditional on it being less than the market value*.

Proposition 4 shows that an efficient outcome can be achieved with a fairly simple regulatory scheme even with imperfect information as long as information is symmetric. One part of the scheme that may be difficult to implement is setting λ equal to $E(S \mid S < M)$. Not setting λ equal to $E(S \mid S < M)$ results in the landowner having an incorrect incentive to survey. However, note that this rule does not base payments on S. Rather, it requires only that *ex ante* information

about the distribution of S be utilized, both to assign the property rights and to set the development fee when the regulator holds the property right.

B. *A Model with Asymmetric Information*

The symmetric information model applies when the landowner is interested in commercial development, such as resource extraction or real estate development. However, the market value may not represent the landowner's value of the property when the primary interest in the land is for personal use. A particular parcel may have special value to an individual because of family history or some unique characteristics of the land. Here, we consider a model in which the landowner has private information about the value to her of development or conservation. Let N represent the landowner's unique development value (i.e., the difference between the landowner's value and the market value when the land is developed), and let T represent the landowner's unique conservation value. Total development value (both to the landowner and society) is $M + N$ and total conservation value is $S + T$.[18] Both N and T are private information known only by the landowner. Because they are determined by the idiosyncratic preferences of the landowner, N and T cannot be credibly conveyed to the regulator. In what follows, it is often the difference between development and conservation values that matters. Define Z as the net difference in value between development and conservation that is private information to the landowner: $Z = N - T$.

1. *Characterizing an Efficient Outcome*

Just as in the symmetric information model, characterizing an efficient outcome is simple. At the land-use decision stage, conservation should be chosen if and only if $S \geq M + Z$, with full information about S. Without information about S, conservation should be chosen if and only if $E(S) \geq M + Z$. At the information collection stage, the expected benefit of a survey is

$$B = \int_0^{M+Z} (M + Z - S) f(S)\, dS \quad \text{if } E(S) \geq M + Z$$
$$= \int_{M+Z}^{\infty} (S - M - Z) f(S)\, dS \quad \text{if } E(S) < M + Z.$$

It is efficient to survey the site whenever $B \geq C$.

2. *Implementing an Efficient Decision under Free Choice of Institutional Rules*

When the landowner has private information, an efficient solution can be achieved only if both information collection and land-use decisions are made by the landowner. Because the regulator's decision rule cannot take Z into account, he may mandate conservation when it is efficient to develop or he may allow

[18] Conservation value for the landowner may include both an appreciation of the land in its natural condition as well as value for species conservation. When species conservation value for the landowner is not 0, we can reinterpret S as the external species conservation value, i.e., the aggregate value for all members of society excluding the landowner.

development when it is efficient to conserve. The landowner, however, will necessarily make efficient decisions only when her payoffs are aligned with social payoffs. This result can be achieved when a landowner who conserves rather than develops receives a net benefit equal to $E(S)$ when she does not survey or S if she surveys. However, as this scheme relies on paying compensation based upon the species conservation value, S, it is unlikely to be feasible, for reasons previously discussed. Without basing compensation on S, landowner payoffs will not be aligned with social payoffs so the landowner will make incorrect decisions for some parameter values. We summarize this discussion in the following ''impossibility'' proposition.

PROPOSITION 5. *When the landowner has private information about her value of development or conservation and when compensation cannot be based on the species conservation value, it is impossible to achieve an ex ante efficient equilibrium outcome for all parameter values*.

3. *Equilibrium under Alternative Burden of Proof and Market Value Compensation Rules*

In this section, we find equilibrium outcomes under alternative sets of rules when compensation cannot be based on S and where most decision-making authority is given to the landowner. We do not analyze the outcome under the current rules where the burden of proof is on the regulator and there is no compensation. Because, as in the symmetric information model, under these rules there is no incentive for the landowner to cooperate with information collection activities and conservation cannot be mandated. The only difference is that the landowner will wish to conserve when $M + Z \leq 0$. With each of the other sets of rules, private information affects the results in a more fundamental way.

a. *Compensation and regulator must prove harm*. In this part, we show the various inefficiencies created when the burden of proof is on the regulator and compensation equal to market value is paid. If the regulator is not informed about S at the land-use decision stage, the landowner may choose whether or not to develop. The landowner receives a payoff of $\text{Max}(M + N, T)$ because development yields a payoff of $M + N$, while conservation yields a payoff of T. On the other hand, if the regulator is informed, conservation will be mandated if $S \geq M$. In this case, the landowner will choose between receiving $M + N - \phi$ with development and $M + T$ with conservation. When $S < M$, the landowner's payoff is exactly the same as when the regulator is not informed.

Whether the landowner wishes to cooperate at the information collection stage depends on the relative magnitudes of N and T. If $N > T$ and $F(M) < 1$, the landowner will get a higher expected payoff by not cooperating at the information collection stage,

$$\text{Max}(M + N, T) = M + N > \text{Max}(M + N - \phi, M + T).$$

Because the landowner prefers development to conservation by more than the market value, compensation equal to the market value is not enough to induce cooperation at the information collection stage. However, when $N < T$, the landowner prefers an informed regulator in the hope that $S \geq M$ is found. If

conservation is mandated, the landowner is compensated and receives a payoff of $M + T > \text{Max}(M + N, T)$.

When $N < T$ $(Z < 0)$ and the landowner cooperates with information collection, the regulator may make an inefficient survey decision.[19] When $E(S) < M + Z$, the difference between the expected benefits of a survey under the current rules and the expected benefits of a survey in the efficient case is

$$\int_M^\infty (S - M - Z) f(S)\, dS - \int_{M+Z}^\infty (S - M - Z) f(S)\, dS$$
$$= -\int_{M+Z}^M (S - M - Z) f(S)\, dS.$$

This expression is negative because with $Z < 0, S > M + Z$ over this range. Unlike the symmetric information case, the regulator has an underincentive to survey. Because the regulator cannot observe the landowner's private values favoring conservation, the regulator mandates less than the efficient level of conservation, which generates less benefit from a survey. When $E(S) \geq M + Z$, the difference between the expected benefits of a survey under the current rules and the expected benefits of a survey in the efficient case is

$$\int_M^\infty (S - M - Z) f(S)\, dS - \int_0^{M+Z} (M + Z - S) f(S)\, dS$$
$$= (E(S) - M - Z) - \int_{M+Z}^M (S - M - Z) f(S)\, dS.$$

This expression can be either positive or negative. Therefore, as in the symmetric information case, the regulator has added incentive to conserve relative to the efficient case when the *ex ante* efficient land-use decision is to conserve $(E(S) - M - Z \geq 0)$. However, asymmetric information gives rise to the final term, which is negative, as previously explained.

Regardless of whether information is collected or not, an *ex ante* inefficient land-use decision may result. It is *ex ante* efficient to require conservation when $E(S) \geq M + Z$. However, when $Z > 0$, the landowner will not allow information to be collected and development will result. When $Z < 0$, it is possible for development to be chosen even though it is efficient to conserve. This result occurs when $M + Z \leq S < M$.

In sum, inefficient information collection and land-use decisions are likely with private information. Because the landowner has private information, compensation may be too little to induce the landowner to cooperate, which occurs when the landowner prefers development to conservation by more than the market value of the property. On the other hand, when the landowner has private information that favors conservation, cooperation can occur but may still result in inefficient information collection and land-use decisions.

[19] It is possible that the landowner would choose to survey even when the regulator does not. Following a similar approach it can be shown that the landowner may also make an inefficient survey decision.

b. No compensation and the landowner must prove no harm. Under these rules, if no information is collected the landowner will receive T if she conserves and $M + N - \phi$ if she develops. With information, if $S < M$, the landowner will be allowed to develop without being fined so her payoff is $M + N$ with development and T with conservation. If $S \geq M$, her payoff is the same as without information.

At the information collection stage, when $E(S) \geq M + Z$, the difference between the expected benefit of a survey for the landowner and the expected benefit in the efficient case is

$$\int_0^M (M + Z)f(S)\,dS - \int_0^{M+Z} (M + Z - S)f(S)\,dS$$

$$= (M + Z)[F(M) - F(M + Z)] + \int_0^{M+Z} Sf(S)\,dS.$$

For $Z < 0$, this expression must be positive. This expression is likely to be positive for $Z > 0$ also. Similar to the case with symmetric information, the landowner has an overincentive to survey, with a possible exception for large values of Z. However, there is less overincentive for the landowner to survey with asymmetric information than with symmetric information. The difference in expected benefit of a survey for the landowner and the expected benefit in the efficient case can be rewritten as

$$\int_0^M Sf(S)\,dS + \int_M^{M+Z} [S - M - Z]f(S)\,dS \quad \text{for } Z > 0,$$

$$\int_0^M Sf(S)\,dS + \int_{M+Z}^M [M + Z - S]f(S)\,dS \quad \text{for } Z < 0.$$

The first integral is identical to the difference in the expected benefit of a survey in the symmetric information case. The second integral is negative both for $Z > 0$ and $Z < 0$.

When $E(S) < M + Z$, the difference between the expected benefit of a survey for the landowner and the expected benefit in the efficient case is

$$\int_0^M (M + Z)f(S)\,dS - \int_{M+Z}^{\infty} (S - M - Z)f(S)\,dS$$

$$= (M + Z)[F(M) + F(M + Z)] - \int_0^{M+Z} Sf(S)\,dS.$$

This expression can be rewritten as

$$M + Z - \int_M^{\infty} Sf(S)\,dS + \int_M^{M+Z} (S - M - Z)f(S)\,dS \quad \text{for } Z > 0,$$

$$M + Z - \int_M^{\infty} Sf(S)\,dS + \int_{M+Z}^M (M + Z - S)f(S)\,dS \quad \text{for } Z < 0.$$

The difference in expected benefit of a survey for the landowner versus the efficient case is always greater with private information than with symmetric information. Comparing the foregoing expressions with the equivalent expression

from the symmetric case, we find that the additional excess benefit of a survey for the landowner is

$$Z + \int_{M}^{M+Z} (S - M - Z) f(S)\, dS \quad \text{for } Z > 0,$$

$$Z + \int_{M+Z}^{M} (M + Z - S) f(S)\, dS \quad \text{for } Z < 0.$$

These expressions must be nonnegative because the largest negative value that the integral term could take is $-Z$. Because the landowner had excessive benefits from surveying with symmetric information, she will certainly have excessive benefits with asymmetric information.

At the land-use decision stage, inefficient choices may be made whenever $Z \neq 0$. When $Z > 0$ and the regulator has information about S, if $M \leq S < M + Z$, conservation will be chosen even though it is efficient to allow development. On the other hand, when $Z < 0$ and the regulator has information about S, if $M + Z < S < M$, development will be allowed even though it is efficient to conserve.

While inefficient outcomes will occur when the burden of proof is on the landowner, whether asymmetric information increases the degree of inefficiency as compared to the case with symmetric information depends upon parameter values. When $E(S) \geq M + Z$, asymmetric information may improve the expected outcome because there is reduced excessive incentive to survey by the landowner. This result does not hold when the inequality is reversed, however.

c. Summary. With asymmetric information, an efficient outcome cannot be guaranteed once compensation based on species conservation value is ruled out. Because the regulator cannot know the landowner's private valuation, the land-use decisions will be inefficient for some parameter values. The possibility of inefficient land-use decisions creates the incorrect incentive to survey at the information collection stage. Neither paying compensation to the landowner nor placing the burden of proof on the landowner yields an efficient outcome. Further, combining elements of both sets of rules, as was done in the symmetric information case to yield an efficient solution, will not do so here. With asymmetric information, rules that place the burden of proof on the landowner may fare better than rules that require compensation when conservation is mandated. Paying compensation equal to the market value may not be enough to entice the landowner to cooperate at the information collection stage. Without such cooperation, no conservation will occur.

IV. DISCUSSION

The model previously analyzed shows that with imperfect information about species distribution simple regulatory schemes can lead to inefficient conservation decision making. The current ESA, in which the burden of proof is on the regulator and compensation is provided only in extreme cases, gives landowners little incentive to cooperate with information collection activity. Under these conditions, both information collection and species conservation on private lands are likely to occur at less than optimal levels. It hardly seems surprising under the

circumstances that political maneuvering has gutted government information collection activities and that stories of property owners who ''shoot, shovel, and shut up'' are rampant.

One way to address this problem is to provide compensation for landowners who forego development in order to provide habitat for listed species. Compensation need not be cash but may come in the form of tax credits or payment in kind (e.g., land swaps). A range of analysts, from conservatives to conservationists, have argued that conservation policy should reward landowners who conserve rather than punish those who are unfortunate enough to have endangered species discovered on their land (e.g., McNeely [20], Stroup [28]). In theory, paying landowners an amount equal to the conservation value can yield an efficient solution, even when a landowner has private information. In practice, when the government acquires property by eminent domain, it typically pays only fair market value. Compensation equal to market value, however, need not result in an efficient solution.

An advantage of a compensation approach is that it improves the outcome when regulators suffer from fiscal illusion (see, for example, Section V of Blume, Rubinfeld, and Shapiro [1], or Fischel [7]). If the costs of land-use restrictions to protect species are not paid by the government, regulators may be too willing to impose restrictions on private lands. Compensation forces regulators to fully account for costs imposed by such restrictions.[20]

Fiscal illusion, however, assumes that the regulator is nonbenevolent, i.e., that the regulator has goals other than maximizing social welfare or efficiency. The model presented here assumes that regulators act benevolently. If we remove that assumption, the problem of achieving an efficient solution, or even describing the problem, becomes much more difficult because nonbenevolence can take many forms. For example, one form of nonbenevolence is regulatory capture by special interests (Stigler [27]). If regulators are captured by landowners, who have a large financial stake in the regulatory decision, then too little rather than too much land will be conserved (and vice-versa, if environmentalists capture the regulator).

A disadvantage of compensation schemes is that, as the recent literature on regulation with incomplete information has stressed, often there is a real resource cost associated with the use of government funds, perhaps because funds are raised through the use of distortionary taxes. With costly government funds, paying compensation will not yield a first best solution. In general, the regulator will face a tradeoff between providing incentives and extracting rents.[21] Further, if there are significant budget rigidities in the short-run, requiring compensation may yield a large short-run decrease in the amount of conservation accomplished on private land.

Rather than paying compensation, an alternative approach is to switch the burden of proof from regulators to landowners who propose to develop. A permitting scheme, like the one currently in place under Section 10 of the ESA, could implement this approach. FWS must issue an incidental take permit if the

[20]An example of regulators choosing not to regulate when faced with paying the full costs is the ultimate fate of David Lucas' coastal lots. After being forced by the courts to purchase those lots from Lucas, South Carolina sold them for development rather than preserving them (Lucas [18]).

[21]See Laffont and Tirole [13] for a discussion of regulation with imperfect information and costly funds and see Lewis [16] for a discussion of this topic applied to environmental regulation.

landowner shows to the agency's satisfaction that the taking will be minimized, and will not appreciably reduce the likelihood of species survival and recovery. This standard allows FWS to require that the landowner provide a complete biological survey, or whatever information is necessary to assure that development will not lead to extinction. If one accepts the ESA's tacit assumption that the loss due to extinction of a species virtually always outweighs the value of development but that losses short of extinction are trivial, the showing required for an incidental take permit is equivalent to a demonstration that the market value exceeds the conservation value. Whether this tacit assumption is justified is a subject worthy of further consideration but is beyond the scope of the present paper.

We showed in Section III, though, that permitting by itself will not yield an efficient solution. There is an excessive incentive to survey in order to find out whether development should be allowed. In addition, permitting may increase administrative costs and potentially give rise to costly delays in decisions on development.

In Proposition 4, we showed that an efficient outcome can be achieved in the case with symmetric information by combining elements of compensation and permitting. The regulatory scheme outlined in Proposition 4 is akin to granting property rights to the landowner or regulator based on whether or not the market value exceeds the expected conservation value. Under Proposition 4, when the expected conservation value is at least as great as the market value, landowners would be required to obtain a permit to develop. Otherwise they would be free to develop as they pleased. Under current law, however, regulators cannot force landowners to obtain an incidental take permit unless they have sufficient information to prove that the development will cause a take. Because this information is often difficult to obtain, landowners may escape the permitting process despite high conservation values. This problem could be addressed by changing the informational prerequisites regulators must satisfy in order to require development permits. Information currently available to regulators through remote sensing, which can delineate vegetation or habitat types with reasonable accuracy, could provide an appropriate coarse filter for determining initial property rights. These data could allow regulators to focus on landowners whose property features vanishing habitat types or habitat types likely to harbor listed species.[22] Such landowners could then be required to obtain an incidental take permit as a prerequisite to development.

This coarse-filter scheme could be implemented through a modification of the current ''critical habitat'' provision of the ESA. Current law directs regulators to identify critical habitat, defined as the areas essential to the species' conservation, for each listed species at the time of listing (16 U.S.C. 1533(a)(3)). Once critical habitat has been formally designated, federal activities may not adversely modify that habitat. The critical habitat provisions of the ESA have not proven successful to date. Critical habitat is often not designated, despite the statutory requirement (Houck [10]). The perception that critical habitat is locked up has excited intense opposition to designation.

[22] On biological grounds as well, there may be distinct advantages to targeting habitats rather than individual species as the policy instrument. See, for example, Scott *et al*. [25].

Two relatively simple modifications would turn the critical habitat provision into an effective regulatory coarse filter. The first change is to the definition of critical habitat. Regulators should be directed to identify those areas within the species' historic range that seem suitable for the species on the basis of remote sensing. The second change is to the impact of habitat designation. Landowners within the designated region would be forbidden to modify habitat without a permit, which could be granted under the current incidental take process. Landowners outside the region could develop without a federal permit. Of course regulators would retain the authority to condemn or to purchase property outside the critical habitat area for conservation.

The efficient outcome described in Proposition 4 also requires that the landowner who gains the right to develop in a sensitive habitat area pay a development fee equal to the expected conservation value. The existing incidental take permit process provides a means for implementing this requirement. An applicant for an incidental take permit must both minimize and mitigate, to the extent practicable, the extent of the taking. This provision should be read to require that the applicant replace, to the extent possible, the conservation value destroyed by development. This replacement could occur in kind, through preservation or restoration of habitat, or through a monetary payment to be used to fund habitat acquisition or restoration. Requirements for in-kind mitigation or through fees, typically based on the expected market cost of purchasing replacement land for preservation, are a feature of many of the habitat conservation plans currently approved or being considered (e.g., Thompson [29], p. 380; Lin [17], pp. 438–439). If they approximate the expected conservation values destroyed through development, these mitigation requirements should encourage efficient decisions.

Under both compensation and permitting schemes, there is a danger that landowners will manipulate the regulatory scheme to their advantage through investment decisions. For example, suppose that a landowner can invest to raise market value prior to observation of this value by the regulator. Blume, Rubinfeld, and Shapiro [1] showed that paying compensation equal to fair market value would lead to overinvestment by the landowner. On the other hand, if a landowner must pay expected or actual species conservation value when she develops, the landowner has an incentive to invest to lower this value.[23] Further, neither paying compensation based on market value nor paying a fee equal to conservation value would give a landowner any incentive to manage the land to increase conservation value. The regulatory scheme proposed in Proposition 4 is particularly vulnerable to manipulation by landowner investment. Under this scheme, a landowner would have a strong incentive to lower expected species conservation value or to raise market value in order to be granted the initial property rights, which allow the landowner to be compensated if conservation is mandated rather than paying a fee to develop. Only paying the landowner compensation equal to actual or expected conservation value when conservation is mandated does not introduce distortions to investment incentives.[24]

[23] Dana [3], pp. 694–695, recounts some of the anecdotal evidence that landowners have rushed to destroy habitat before species were either listed or discovered on their property.

[24] For more on investment incentives in the context of takings and endangered species conservation see Innes [12] and Polasky [23].

In order to prevent manipulation of the scheme via investment, the landowner must not be able to invest prior to the regulator observing initial market and expected species conservation values. Basing conservation decisions on the coarse filter we described, which rests on preexisting knowledge of habitat type rather than on the presence of a listed species, reduces the ability of landowners to manipulate values prior to observation. It may be difficult to significantly alter the habitat type without being observed. In many cases, the only way for landowners within the sensitive area to entirely eliminate a species from an area, and thus ensure the ability to develop, would be to significantly alter the habitat.

In addition to problems raised by landowner investment, asymmetric information can also prevent an efficient solution from being obtained. In Proposition 5, we showed that it is impossible to achieve an efficient outcome when the landowner has private information and compensation cannot be based on species conservation value. We believe this problem is a relatively small one, because it is likely that only a small percentage of the land needed for species conservation is held by landowners whose private valuation significantly differs from market value. Nonetheless, both efficiency and equity considerations may warrant further attention to the problems of regulation of such lands, which probably chiefly consist of small single parcels.

Though this paper has been about the efficiency consequences of alternative regulatory regimes, equity issues are prominent in the debate over endangered species policy. The intensity of the debate over compensation is fueled by the potentially large distributive consequences of alternative rules, as well as by philosophical differences over whether species conservation is a public good or a landowner responsibility (Polasky, Doremus, and Rettig [24], pp. 73–75).

Notwithstanding its efficiency consequences, the differential treatment of landowners based on the comparison of initial market and expected conservation values under Proposition 4 may raise objections on equity grounds. Landowner X, whose property is picked out by the coarse filter, must conserve without compensation, while Landowner Y, who escapes this first level of scrutiny, is paid if regulators subsequently decide that her property should be conserved. Landowner X, at least, is likely to consider this difference unfair. However, it may not be unfair to differentiate between X and Y. The fact that X's property is picked out by the coarse filter suggests that it is more readily foreseeable that protected species require X's property for survival than that they require Y's. Perhaps X could have anticipated this regulation, while Y could not. The ability to foresee regulation has long been recognized as a factor that works in favor of the government in constitutional takings cases (e.g., Polasky, Doremus, and Rettig [24], p. 74). In some respects, the coarse-filter approach could even improve horizontal equity. Currently, regulators exercise a great deal of discretion in choosing the targets of ESA enforcement. There is some evidence that large property owners, who are likely to have greater political influence, fare better than small ones (Thompson [29], p. 334). Basing the coarse filter on objective standards may reduce this type of unfairness.

If differential treatment of landowners X and Y is considered inequitable, that inequity could potentially be corrected through a tax imposed on those who are permitted to develop their land. Funds raised through such a tax could be used to compensate those whose land is caught in the coarse filter. Such a scheme would of course suffer from the problems associated with the use of government funds.

Moreover, it would probably be difficult, both politically and institutionally, to implement any form of federal development or parcel tax.

In conclusion, both the current legal regime for enforcing the ESA on private lands and alternative proposals require that regulators or private landowners develop information about the value of species preservation. Analysis of the incentives that arise for information collection and resulting decision making gives rise to a different set of conclusions than analysis of decision making under complete information. When landowners control access to information, the legal regime must provide an incentive to the landowner to cooperate with the collection of information as well as providing incentives to collect the right amount of information. An approach similar to the current incidental take permit system, but requiring less information at the initial stage to make landowners subject to the permit requirement, could provide appropriate incentives when asymmetric information and prior landowner investment problems are not severe.

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