Toward More Effective Endangered Species Regulation

By

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Dissertation

Submitted to the Faculty of the

Graduate School of Vanderbilt University

in partial fulfillment of the requirements

for the degree of

DOCTOR OF PHILOSOPHY

in

Law and Economics

May, 2015

Nashville, Tennessee

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To my beloved wife Carrie

and

To my children Lily and Gideon

ACKNOWLEDGEMENTS

This work would not have been possible without financial and institutional support of Vanderbilt Law School and the Ph.D. Program in Law and Economics. I thank my colleagues in the program for constant support and Laurel Donahue and Amy Maples for lots of heavy lifting. I especially thank my family, including my wife Carrie, my children Lily and Gideon, and those who helped watch the kids—especially Joan, Beth, and my parents—so Carrie and I could make it through graduate schools.

I am grateful to my Dissertation Committee for providing me with valuable guidance and feedback. Professor J.B. Ruhl was a great example of leadership as the chair of my committee. Professors Kathryn H. Anderson, Cindy D. Kam, and W. Kip Viscusi were engaged, helpful, and challenged me to improve my work in all the right way. I could not have asked for a better dissertation committee.

For Chapter 1, I extend a special thank you to Professors Anderson and Skiba and classmates in the third-year research class where I got the ball rolling on this research project. I thank Dean Lueck and participants at the 2014 ALEA and SEA conferences for feedback. I also want to thank Timber Mart South for donating data on timber prices and Jacob Thornton and Lindsey Fox for GIS assistance.

For Chapter 2, I want to thank Professor Viscusi for helping me develop the experiment, secure funding, and make it through the IRB process. I want to thank Professor Kam for helping me streamline the experiment and take it into the field with logistical support of research assistants and use of the Research on Individuals, Politics, and Society lab at Vanderbilt. I also thank Elissa Gentry and Henri Rautonen for help running the experiment, the professors who let me recruit students from their classes, and Jason Shogren for helpful feedback.

For Chapter 3, I want to thank Professor Jones and classmates in the legal scholarship seminar where I started getting these ideas down on paper. I thank Professor Ruhl for helping me strengthen the legal argument and Professor Viscusi for providing feedback on my empirical work and showing me how to calculate the Value of a Statistical Turtle.

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LIST OF ABBREVIATIONS

ALEA: American Law and Economics Association

ATC: Average Treatment on the Control

ATE: Average Treatment Effect

ATT: Average Treatment on the Treated

CEQ: Council on Environmental Quality

CFR: Code of Federal Regulations

EPA: Environmental Protection Agency

ESA: Endangered Species Act

FIA: Forest Inventory and Analysis

FWS: Fish and Wildlife Service

NC: North Carolina

NEPA: National Environmental Protection Act

NMFS: National Marine Fisheries Service

NOx: Nitrous Oxides

OIRA: Office of Information and Regulatory Affairs

OLS: Ordinary Least Squares

OMB: Office of Management and Budget

OSB: Oriented-Strand Board

RCW: Red-Cockaded Woodpecker

SEA: Southern Economic Association

USC: United States Code

Introduction

The Endangered Species Act ("ESA") is a strong environmental law that gives federal agencies authority to conserve imperiled species by regulating private and public parties. One consequence of the ESA's regulatory force and structure, however, is a set of perverse incentives for private landowners to prevent endangered species from moving onto their properties by destroying potential habitat. In chapter one, I estimate the extent of habitat destruction by examining data from timber harvests near endangered woodpeckers in North Carolina and find that landowners are 25% more likely to harvest mature pine trees if there are woodpeckers nearby. I contribute to the literature with the first evaluation of a safe-harbor program intended to dampen the perverse incentive and find mixed evidence that the program encourages landowners to stop destroying habitat. I find stronger evidence that the safe-harbor program encourages landowners to manage their lands in ways that encourage wildlife habitat.

In chapter two, I use a computer-based experiment to compare the safe-harbor program with other regulatory regimes that could help align the incentives of landowners with those of federal regulators. I find that the safe-harbor program is an improvement for both landowners and endangered species over the status quo of strict regulation. Strong financial incentives are effective at encouraging landowner cooperation in habitat conservation efforts, but weak financial incentives are surprisingly ineffective. The findings of the experiment may have implications for proposed ESA regulations.

In chapter three, I explore the role of cost-benefit analysis of critical habitat designation under the ESA. The current agency methodology leads to estimates of low costs and zero benefits of critical habitat. I argue that agencies should use a broader concept of costs and benefits because it is a better reading of the ESA and can lead to more effective regulations. I focus on measuring benefits of critical habitat, which should include what people are willing to pay to conserve listed species and the value of ecosystem services that are protected because of the critical habitat.

The three chapters of this dissertation all aim to contribute to our understanding of how ESA regulations can more effectively achieve their goals. The first two chapters aim to encourage more cooperation with private landowners. The third chapter challenges the agencies that implement the ESA to use their limited resources more efficiently. In light of the expected challenges that climate change will place on both economic and ecological systems, the ESA will likely become a focal point of the tradeoff between conservation and economic activity. Therefore, it is important for imperiled species, for landowners, and for a range of interested parties to move forward: toward more effective endangered species regulation.

Chapter 1—Perverse Incentives and Safe Harbors in the Endangered Species Act: Evidence from Timber Harvests near Woodpeckers

I. Introduction

Natural resources such as wildlife and scenic green space provide valuable amenities to people and serve as important parts of ecosystems. Natural resources also serve as the building blocks for economic activity, so there can be a tradeoff between conserving natural resources and encouraging economic activity. For example, a conserved forest could serve as habitat for birds and host a scenic campground. Alternatively, the trees in the forest could provide timber to build new houses and the land could be converted to agriculture. Both the conservation and development uses of the forest are valuable to people, but there are often conflicting views about how to strike the right balance between these inconsistent uses.

One of the places with tension between conservation and development is the protection of endangered species. The Endangered Species Act (ESA) is one of the strongest environmental laws on the books in the United States. The ESA has cut through longstanding debates about resource use on public lands and forces federal agencies managing those lands to make difficult decisions regarding things like water use in the arid west and strip mining in the Appalachian Mountains. In addition to the impact on public land management, the ESA can also have a substantial effect on private land. Under the ESA, federal agencies can prevent landowners from building houses, cutting trees, or altering waterways if those changes are detrimental to populations of endangered species. If the private land includes potential habitat but no endangered species are established there, however, then the ESA does not create jurisdiction for the federal agencies to regulate that land. The stark contrast in regulatory outcomes depending on whether land currently supports endangered species or not can create perverse incentives for landowners to destroy habitat to prevent endangered species from using the property for its habitat values. Lueck and Michael (2003) find empirical evidence that this is not just a hypothetical concern, with landowners harvesting trees at higher rates when there are endangered species nearby.

In this paper, I look at how landowners respond when faced with various choices about whether to conserve or develop the natural resources on their lands. Using tree harvest data gathered by federal agencies, I analyze whether landowners are systematically destroying habitat of an endangered bird, the red-cockaded woodpecker (RCW). This paper contributes to the literature by controlling for unobserved heterogeneity in forest plots with a difference-in-difference model and using recent data to estimate current behavior. I find evidence of preemptive habitat destruction with a 25% increase in the probability of harvest for land near endangered birds. This paper also contributes to the literature with the first measurements of the effectiveness of a federal safe-harbor program designed to mitigate the incentive to destroy habitat. I find mixed evidence on the program's success at getting landowners who participate in the program to destroy less potential habitat and to manage land in ways that improve wildlife habitat.

The paper proceeds in Section II with a survey of the previous literature on perverse incentives of the ESA and attempts to measure effectiveness of ESA policies. Section III presents a brief description of the legal background that creates perverse incentives to destroy habitat for endangered species. In Section IV, I provide background information on the red-cockaded woodpecker and the safe-harbor program designed to help protect these birds. Section V contains a conceptual model that provides predictions for how the risk of endangered species regulation will affect decisions of private landowners to enter safe-harbor agreements and/or harvest trees. Section VI introduces the data on forest plots, woodpeckers, and timber prices. Empirical models to test the predictions from the theoretical model are laid out in Section VII. Section VIII provides results from these models, which indicate an increase in harvests near woodpecker colonies. There is not strong evidence that the safe-harbor program has succeeded at preventing habitat destruction, although there are indications that the program has encouraged more landowners to improve wildlife habitat. In Section IX, I discuss how this better understanding of the way landowners interact with federal agencies can suggest ways to improve the effectiveness of endangered species regulation on private lands. Section X concludes.

II. Existing Literature

Numerous scholars have noted that the Endangered Species Act may create perverse incentives. In the legal literature, Dana (1995) identifies the general incentive created by the ESA to engage in a "race to develop," but does not explore how widespread this phenomenon may be. Rachlinski (1997) discusses how endangered species that face economic pressures from conflicting use of resources are less likely to see improvements in recovery status. Ruhl (1998) explores the middle-ground of regulation under the ESA, between the poles of strict land-use regulations and no regulations, in which agencies and landowners can cooperate to protect habitat.

In the economics literature, theorists and empiricists have looked at the possibility of preemptive habitat destruction. Shogren (1998) presents a theoretical model that predicts landowners will engage in purposeful habitat destruction if the threat of Fish & Wildlife Service (FWS) regulation is high enough. He argues that the FWS should actively consider the economic incentives created by its policies when creating recovery plans for species and engaging in enforcement actions. Polasky and Doremus (1998) model the role of asymmetric information between landowners and regulators to show that compensation may be required to get private landowners to cooperate with regulators, and even then the efficient outcome is not assured. Smith and Shogren (2002) use tools from mechanism design to explore how regulators may get landowners to better cooperate, and caution that under many conditions regulators will have to offer high incentives to private landowners to get them to protect endangered species habitat.

Lueck and Michael (2003) and Zhang (2004) both empirically test whether landowners are changing their timber harvest patterns in response to the threat of ESA regulations. Zhang uses a survey to collect information on landowners' subjective beliefs about the presence of nearby RCWs and the threat of ESA regulation if those birds move onto their property. The landowners are also asked about their timber harvest patterns over the past ten years. Their responses indicate that landowners who have RCWs nearby and believe that the birds could move onto their property are more likely to use a shorter harvest rotation, thus preventing the birds from moving in.

Lueck and Michael attempt to answer a question similar to that asked by Zhang but using data on RCWs and timber harvests that come from federal agencies instead of from landowner surveys. Lueck and Michael find that a higher number of RCW colonies near a forest plot increases the probability that the plot will be harvested within a given period. This paper uses the Lueck and Michael analysis as a starting point for models of tree harvests near endangered species to test whether habitat destruction continues at a similar pace after the introduction of a safe-harbor program designed to help prevent preemptive habitat destruction.

Empirical tests of the impact of endangered species regulations can be difficult because it is hard to obtain good data on both outcomes and explanatory variables. Despite these challenges, some researchers have been able to empirically measure the effectiveness of some FWS actions under the ESA. Ferraro, McIntosh, and Ospina (2007) use matching methods to measure the effectiveness of listing species as threatened or endangered under the ESA. They find that listing species can be detrimental to species, presumably because of the perverse incentives that listing triggers, unless the listing is accompanied with government funding to help conserve the species. Langpap and Kerkvliet (2012) use a discrete ordered-variable model and matching methods to evaluate the effectiveness of habitat conservation plans, which are plans the ESA requires to be in place for landowners to be able to get permits for the incidental take of species. Langpap and Kerkvliet find that species tend to do better when there are habitat conservation plans in place for them, especially when those plans cover relatively large geographic areas.

No study to date has measured the effectiveness of safe-harbor programs, although researchers have used theory and survey data to better understand how landowners behave in voluntary programs. Langpap and Wu (2004) use a model to assess under what conditions incentives like money and assurances of no additional regulations are more effective at getting landowners to protect habitat than traditional regulations. They find that voluntary programs that offer assurances tend to outperform programs without assurances, although the resulting equilibrium is still sub-optimal. Langpap

(2006) surveys forest owners to find that the most promising incentive program is a mix of both financial incentives and regulatory assurance for landowner cooperation.

Greenstone and Gayer (2009) discuss the challenge of non-random distribution of species when trying to measure impacts of the ESA on landowner behavior. With species clustered in prime habitat areas, there is likely to be unobserved heterogeneity across sites that have species compared with sites that do not. Greenstone and Gayer propose using indices of species rareness separate from status under the ESA to help measure the causal impact of ESA protections. As discussed in Section VII, I take a different approach and attempt to control for unobserved heterogeneity with difference-in-difference models when measuring landowner response to the perverse incentives in the ESA and the effectiveness of the FWS safe-harbor program.

III. Legal Background

The ESA was passed in 1973 to conserve "ecosystems upon which endangered species . . . depend." 16 U.S.C. § 1531(b). The power of the ESA has been prominently displayed in cases like *Tennessee Valley Authority v. Hill*, 437 U.S. 153 (1978), in which a dam-building project was halted because it would damage habitat for the snail darter, an endangered fish. The ESA gives extensive authority to the FWS, a federal agency, to promote the purpose of the ESA by restricting actions of the government and of private landowners to prevent the "take" of listed species. The ESA defines "take" as "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct." § 1532(19). In *Palila v. Hawaii*, 852 F.2d 1106 (9th Cir. 1988), the Ninth Circuit held that it was within the FWS's authority to force the state of Hawaii to eradicate feral animals because those feral animals were causing "harm" to listed species by destroying habitat. In *Babbitt v. Sweet Home*, 515 U.S. 687 (1995), the U.S Supreme Court upheld the FWS definition of "harm" that includes "significant habitat modification or degradation that actually kills or injures wildlife." *Id.* at 798. As such, the FWS has jurisdiction to regulate land uses to prevent the destruction of habitat and can impose civil and criminal penalties on landowners who harm animals by disobeying the regulations. In *Arizona Cattle Growers Association v. United States Fish & Wildlife*, 273 F.3d 1229 (9th Cir. 2001), the Ninth Circuit struck down FWS restrictions on cattle grazing leases that were based on the historical presence of endangered species or the chance that endangered species would move onto the properties in question. *Id.* at 1243. Instead, the agency had to show with "reasonable certainty" that actual harm to endangered species would occur from the habitat modifications. *Id.* In the same case, the court upheld restrictions on properties for which the FWS had documented the presence of endangered species. *Id.* at 1248.

Courts have consistently held that FWS regulation does not constitute a taking of property that would require just compensation under the Fifth Amendment of the U.S. Constitution. *See Seiber v. United States*, F.3d 1356 (Fed. Cir. 2004). Actors who engage in activities that may cause the "take" of listed species can create a habitat conservation plan and apply to the FWS for an incidental take permit, but this is an expensive and lengthy process.

The stark contrast between the regulatory impacts of having established populations of endangered species or not has the potential to create three perverse incentives. First, landowners may be induced to destroy species or their habitat before the species are listed under the ESA. Second, landowners who have potential habitat of already listed species may destroy that habitat to prevent the protected species from moving onto their properties. Third, landowners who have listed species on their properties may illegally kill the species and hope that the FWS never finds out about it. In response to these concerns, the FWS has recently encouraged landowners to enter voluntary conservation agreements to obtain more regulatory certainty in exchange for the provision of quality habitat. To dampen the incentive to destroy species that are not yet listed under the ESA—candidate species—the FWS offers landowners a promise not to impose regulatory restrictions beyond those agreed to by landowners in negotiated agreements called candidate conservation agreements with assurances. To dampen the incentives to destroy habitat of listed species and illegally kill the species themselves, the FWS offers landowners safe-harbor agreements that promise not to increase regulatory burdens beyond those agreed to in these negotiated agreements. FWS currently has safe-harbor programs for a range of species, including the woodpecker introduced in the next section that is used to help measure responses to perverse incentives in the ESA.

IV. Red-Cockaded Woodpecker

The red-cockaded woodpecker (RCW) is a robin-sized bird that inhabits mature pine stands across the southeastern United States from North Carolina to Texas. RCWs are unique among North American woodpeckers in that they excavate their nesting cavities in live trees instead of dead trees. Excavating a hole in a live tree means that it takes a RCW several months to finish a cavity, but it allows the RCW to use a cavity for many years. The only trees that are suitable for these cavities are pines that are at least forty years old. RCWs make cavities in clusters called colonies. A colony typically consists of a mating pair, their immature young, and some helper adults. When young RCWs reach maturity and find a mate, they start a new colony in a stand of mature pine somewhere within ten miles of their parents' colony. This means that property with mature pine within ten miles of existing RCW colonies is potential habitat for a new colony. Landowners of properties in this area with pine trees that are not yet mature may also pay attention to the birds because their lands may become attractive habitat for RCWs as the trees age, especially for landowners following traditional harvest rotations of forty to fifty years.

RCWs require open mid-story for effective foraging. Stands of southern pine are suitable for this because they have substantial space between trees, and undergrowth is discouraged by a thick bed of pine needles and periodic low-intensity forest fires. Stands of pine mixed with hardwood trees are not suitable for RCW foraging because the hardwoods add too many branches and leaves in the mid-story so the RCWs cannot effectively catch insects. The optimal foraging area for an RCW colony is 300 acres, although scholars have found colonies to survive with as little as 150 acres (U.S. FWS 1985).

RCWs have many characteristics that make them an attractive species to study for evaluating the impacts of the ESA on landowner behavior. First, RCWs are picky about their nesting and foraging sites, so it is relatively easy to isolate potential habitat. Second, RCWs are the only listed endangered animal to inhabit wide areas of the pine forests of North Carolina, so it is easier to isolate the impact of these birds as opposed to endangered species in general.[1] Third, there is a clear conflict with maintaining habitat for RCWs and harvesting timber, which allows me to look at the impact of the species on an activity that has established economic models for landowner behavior.

In order to encourage RCW populations to expand, the FWS protects nesting and foraging habitat for each RCW colony (U.S. FWS 1985). This can deny the landowner of 100 acres a timber harvest worth $200,000. The land use restrictions imposed by the FWS can continue indefinitely because RCW colonies are very long-lived and the colonies can be passed on to subsequent generations of birds. The agency previously tried to protect 300 acres per colony, but has more recently scaled it back to 100 acres per colony to encourage landowner cooperation by lowering the threat of regulatory restrictions (U.S. FWS 2010).

As an additional measure to help protect the RCW, the FWS introduced a safe-harbor program in the Sandhills region of North Carolina in 1995. The program was intended to encourage cooperative relationships with landowners. The FWS desired to shed the adversarial approach that required it to expend significant resources on enforcement and resulted in popular and political backlashes to land-use restrictions (U.S. FWS 2010). To enter a safe-harbor agreement, landowners promise to maintain some suitable RCW habitat in exchange for a promise from the FWS not to impose more onerous restrictions if RCWs move onto the property in the future. The land-use restrictions in the agreements depend largely on the baseline of endangered species

[1] Although there are listed plants in the pine forests of North Carolina, such as the sweet pitcher plant, the ESA does not give FWS the same broad jurisdiction to protect plants as it does to protect animals, so private landowners are not threatened with the same onerous land-use restrictions.

residing on the property at the time of negotiation, so an agreement with a baseline of zero RCWs will have fewer obligations than an agreement with a baseline of three RCW colonies. Landowners can unilaterally leave these voluntary agreements at any time, although once they leave the landowner can face other ESA regulations just as landowners who had never entered agreements. Safe-harbor agreements, and some other contracts between FWS and landowners, come with "assurances" from the FWS that the landowner will not be required to comply with new regulations in the future. Because of this regulatory certainty, safe-harbor agreements can be attractive to landowners as insurance policies for regulatory outcomes.

Despite efforts by the FWS to work more with landowners using things like safe-harbor agreements, the threat of regulation may still have unintended consequences if landowners are destroying potential habitat to prevent the woodpeckers from moving onto their property in the first place. The next section lays out a framework for how a landowner with nearby RCWs may deal with the threat of FWS regulation.

V. Conceptual Model

A private landowner with a stand of pine trees has a set of decisions to make, as depicted in Figure 1.[2] One decision is whether to harvest for timber or let the trees grow another time period. The landowner discounts the future with the real interest rate *r* and maximizes the expected present value of timber harvests, both the trees currently standing and the trees that can be planted there in the future. For simplicity, the landowner's harvest decision is modeled as binary: either harvest all of the trees (clear-

[2] This model is similar to the two-stage decision tree in Lueck and Michael (2003), augmented with optimal-harvest variables and a stage involving safe-harbor agreements.

cut) or let them all grow another period.[3] The harvest value of timber on the property at time *t* is ω_t. The increase in timber value from time *t-1* to time *t* is given by ρ_t, which measures the marginal benefit of letting the trees grow another period. Young pine trees are used for pulp and paper, slightly older trees are used for chipboard, and mature trees are used for saw timber, with saw timber commanding the highest price and pulp the lowest price. As such, ρ_t is large when an extra period of growth allows the trees to enter a higher price category for a more lucrative use.

There is an element of uncertainty in the landowner's decision; in each period when there are standing trees on the property, there is a chance that endangered woodpeckers will move in and settle a colony there. If the FWS discovers the presence of the woodpecker colony, it invokes jurisdiction under the ESA to regulate the entire property. When the FWS regulates property, it forbids the harvest of any pine trees for the foreseeable future. In the model, γ is the probability that woodpeckers move in and the FWS discovers their presence and invokes jurisdiction to regulate.

In each period, the landowner must decide between harvesting and letting the trees grow, which can be written as:

[3] A more flexible model would allow the landowner to choose from a continuum of harvest options (*h*). This can be modeled as a dynamic problem with control variable $h \in [0,1]$ and the following Bellman equation: $V_t = h_t * \omega_t + \frac{(1-\gamma)}{(1+r)} V_{t+1}$ and state equation: $\omega_t = (1-h_{t-1})\omega_{t-1} + \rho_t$

In this model, the landowner chooses to harvest *h*% of her timber in each period. With standard assumptions, the predictions from this more complex model are the same as the simplified version presented in this paper.

$$\omega_t \qquad \text{vs.} \qquad \frac{(1-\gamma)}{(1+r)}(\omega_t + \rho_{t+1}) \tag{1}$$

harvest *let grow*

The other decision that landowners make is whether to enter into a safe-harbor agreement or not. If landowners enter into safe-harbor agreements, they limit the amount they can harvest in any period by a factor of λ, with $0< \lambda<100$. In exchange for limiting their harvest, landowners get assurance from regulators that the landowner will be able to continue harvesting even if woodpeckers do move onto the property, so γ becomes immaterial to them if they intend to stay in the agreement. For this paper, λ is assumed to be smaller, meaning there are fewer restrictions on harvest, for properties that are in the FWS target zone for landowner incentive programs.

This simple model generates predictions of how changes in parameters will impact the probability of harvest during a given time period by seeing how the attractiveness of different routes in Figure 1 change relative to each other. For example, increases in γ, the probability that the FWS regulates because of woodpecker presence, would tend to induce more landowners to harvest in the early period instead of waiting. This occurs because a high γ decreases the right-hand side of (1) but does not change the left-hand side. Intuitively, the greater threat of a logging ban decreases the expected value of future harvest, causing landowners to opt for the relative safety of harvesting now, even if that means foregoing increased timber value. Variations in γ can allow for empirical tests of this hypothesis. Property that has many endangered woodpeckers nearby is more likely to have woodpeckers move in, so these landowners have higher γ and are more likely to harvest at an early age; Prediction 1 is that ${dHarvest}/{d\gamma} > 0$.

Landowners who improve habitat for wildlife, such as by performing strategic thinning of trees and controlled burns, are more likely to have woodpeckers move in because their land is more attractive to the birds, increasing the γ for their properties. Prediction 2 is that landowners who are near woodpeckers are less likely to manage land in ways that improve wildlife habitat, so ${dImprove}/{d\gamma} < 0$.

Landowners who have entered safe-harbor agreements have less incentive to destroy woodpecker habitat and may be more likely to improve habitat for wildlife. Prediction 3 is that landowners who have lower λ, such as those who are actively recruited by the FWS for the program, are more likely to be in safe-harbor agreements and, consequently, less likely to destroy habitat: ${dHarvest}/{d\lambda} > 0$. Prediction 4 is that these landowners with lower λ are also more likely to improve wildlife habitat: ${dImprove}/{d\lambda} < 0$.

VI. Data on Forest Plots and Woodpeckers

Forest plot data come from the U.S. Forest Service, which conducts the Forest Industry and Analysis (FIA) survey annually. The Forest Service uses a random search algorithm to select approximately 500 active forestry sites per county, resulting in over 30,000 sites in the Piedmont and coastal regions of North Carolina. To conduct the survey, Forest Service agents visit the property and count and measure trees, take core samples to determine tree age, and sample soil to determine site productivity. FIA data include variables for whether trees have been harvested from the site in the past five years and whether the site has been managed to improve wildlife habitat. Land is coded as managed to improve habitat for wildlife if there was strategic thinning or controlled burns for the purpose of increasing quality of habitat, usually for things like deer and other game animals. Sites in the analysis were surveyed on a rolling basis between 1982 and 2013. Only FIA sites that are predominately pine, meaning 75% pine and higher, are retained for the analysis.

Data on RCWs come from the North Carolina Department of Environment and Natural Resources, which maintains a database of all known RCW colonies in the state. There are approximately 1,000 colonies spread across the Piedmont and coastal regions of North Carolina, with a large cluster in the Sandhills area. Forest plots and RCW colonies in the Piedmont and coastal regions of North Carolina are plotted in Figure 2.

Data on safe-harbor agreements were obtained from the FWS through a Freedom of Information Act Request. These data include location of properties that are or have been in safe-harbor agreements, the baseline of RCWs on the property, and the current status of the agreements. There are 145 safe-harbor agreements covering approximately 91,000 acres. Forest plots, RCW colonies, and safe-harbor agreements in the Sandhills and surrounding counties of North Carolina are plotted in Figure 3.

Controlling for market forces requires information on timber prices. Timber Mart South, a nonprofit affiliated with the University of Georgia, maintains timber price trends for the Southeast including North Carolina. These data are paired with information on tree diameter and tonnage in the FIA survey to construct variables that measure the value of timber and its growth. This can control for when the landowner would optimally harvest without woodpeckers. Tree and price data are used to construct a variable for the starting value of the standing timber on the site and a variable for the value of letting the trees grow another year.

After combining FIA site, RCW, and price information, the resulting data are a series of cross sections of forest plots. Summary statistics of the data are presented in Table 1. Panel A includes FIA sites from the Piedmont and coastal regions of North Carolina that were sampled between 2001 and 2013. In the five years prior to the survey, 18% of sites were harvested and 5% of sites were managed to improve wildlife habitat. The average forest plot has four woodpeckers within ten miles. The starting value of trees averages $290 per acre and the value of letting those trees grow an additional year averages $26 per acre. The majority of sites (69%) have loblolly pine on them. 41% of sites have water features on or near them, 10% have a steep slope, 22% are classified as having highly productive growing conditions, and 1% are more than a mile from an improved road. About a quarter of sites (24%) are lightly forested, meaning that canopy cover does not exceed 75% of the land area.

For empirical tests of the effectiveness of the safe-harbor program in the Sandhills area of North Carolina, the sample is narrowed to the twelve counties in and around the Sandhills area in the southern portion of the state. FIA data going back to 1982 are used to measure the effect of the program with observations from both before and after the program's start in 1995. Summary statistics of two of the key variables of interest for this sample are laid out in Panel B of Table 1.

Table 2 presents summary statistics of sites that have at least one RCW colony within ten miles and sites that have no RCW colonies within ten miles. Although some variables like probability of harvest and improvement are similar across the groups, other variables differ. Trees on sites near RCWs tend to be worth less, the sites are more likely to have water nearby, and are less likely to have steep slopes. These sites near RCWs also tend to have less productive growing conditions for trees. An ideal dataset would include sites that are similar in all aspects other than the presence of RCWs, but without random distribution of RCWs it is not surprising that there are systematic differences. Although regression analysis can control for observed differences in the forest plots, there are likely to be some differences that are not picked up in the forestry data. For example, landowners' tastes for the amenity value of forest and wildlife may differ across areas. A preference for wildlife could influence the probability of RCWs living nearby if landowners encourage RCW habitat, such as by having periodic controlled burns. The same tastes for wildlife would also impact the timber harvest decision of landowners, possibly leading to a biased estimate of the impact of RCWs on the timber harvest decision.

One way to try to deal with the heterogeneity of forest plots is to compare potential RCW habitat with plots that have similar forestry properties but are not at risk of RCWs moving in. Sites that are predominately pine but have hardwoods mixed in are not suitable habitat, as discussed in Section III. The probability of harvest differs substantially across sites depending on proximity to RCWs and mixture of tree types, as presented in Table 3. Pure pine sites that are near RCWs have a high probability of harvest at close to 20%. Pure pine sites that are not near RCWs have a 17% chance of being harvested. Mixed sites near RCW have a 15% chance of being harvested, while 13% of mixed sites not near RCW are harvested. Because RCW should not impact harvests on mixed sites that are not suitable habitats for the birds, the difference in harvest rates between mixed sites that are near RCW and those that are not is evidence that there might be some systematic differences in forest plots. Although the summary statistics in Table 3 suggest a relationship between RCW and tree harvests, regression analysis allows for more robust evidence with controls for confounding factors.

VII. Empirical Specifications

Models to test habitat destruction use recent data from a wide geographic area, while models to test the effectiveness of the safe-harbor program use data from a longer time period but smaller geographic area. There are three pertinent econometric models to test Predictions 1 and 2 from the conceptual framework. For these models, I use the more recent FIA data on sites that were surveyed after 2000 to get a sense of the recent landowner response to threats of ESA regulation.[4] A probit model similar to that used by Lueck and Michael (2003) tests whether nearby RCW colonies increase the probability of harvest in a given time period.

$$Prob(Harvest_{it}) = \Phi(\alpha + \theta RCW_i + \beta X_i + \tau T_t) \tag{2}$$

The variable *Harvest* is equal to one if the plot has been harvested in the five years preceding the survey. In the model, the probability of *Harvest* for a plot follows a standard normal distribution with the cumulative distribution function Φ with the following explanatory variables. The coefficient θ measures the impact of woodpeckers on the harvest decision. *RCW* is a variable for the number of red-cockaded woodpecker colonies within ten miles and serves as a measure for how likely it is that the

[4] A second benefit of the recent sample is that the North Carolina Department of Environment and Natural Resources feels that the RCW data are more accurate for later periods, decreasing the amount of measurement error.

woodpeckers will move to the property (γ in the conceptual model). Prediction 1 is that θ is positive. For controls, *X* is a vector of plot characteristics including the site's tree type and productivity of the land as measured by the U.S. Forest Service. A vector of year indicator variables, *T,* absorbs systemic changes over time.

Although the above model provides a test for whether RCWs impact the timber harvest decision, the model relies on an assumption that forest plots near RCWs are otherwise similar to plots that are not near RCWs after controlling for available variables within the model. With nonrandom distribution of RCWs, one may be concerned that there is heterogeneity across geographic areas that is not observed in the FIA data.

$$Harvest_{it} = \alpha + \delta RCW_i * PurePine_i + \theta RCW_i + \phi PurePine_i + \beta X_i + \tau T_t + \varepsilon_{it} \quad (3)$$

A difference-in-difference model, specified in Equation 3, can help control for this type of unobserved heterogeneity by comparing the difference in harvesting of pure pine sites that are near RCWs with the difference in harvesting of mixed sites near RCWs. Since RCWs will not nest or forage in pine forest that is mixed with hardwoods, landowners should not be concerned with proximity to RCWs. By comparing the differences in harvest rates between these two groups, one that is impacted by RCWs and one that is not, I can control for this unobserved heterogeneity. In this equation, the variable of interest is δ, which picks up the impact of RCW on pure pine sites as compared with mixed sites. The coefficient θ estimates the impact of RCW on sites that are not suitable habitat. The coefficient ϕ is the measure of how pure pine sites differ from mixed sites in ways other than RCW. The heteroskedasticity-robust error term ε follows.[5]

$$\mathrm{I}mprove_{it} = \alpha + \delta RCW_i * PurePine_i + \theta RCW_i + \phi PurePine_i + \beta X_i + \tau T_t + \varepsilon_{it} \quad (4)$$

Landowners of plots near RCW may be less likely to actively manage their land in ways that are favorable for wildlife habitat. This is true because managing land in ways that encourage wildlife like deer and game birds tends to improve conditions for RCW as well (U.S. FWS 2010). Equation 4 lays out a difference-in-difference model to test whether this prediction is true. The variable *Improve* takes a value of one for sites that have been managed in a way to improve habitat for wildlife in the past five years. Other variables in this equation take similar forms as those in Equation 3.

To test Predictions 3 and 4, I use the following models with data from a smaller geographic area, restricting to a dozen counties in and around the Sandhills area, but from a longer timeframe starting in 1982. This narrower and longer dataset allows me to look at habitat destruction both before and after implementation of the safe-harbor program using treatment and control areas that are close to each other and have similar terrain and features.

$$Harvest_{it} = \alpha + \delta RCW_i * Eligible_i * Post_t + \theta Interactions_{it} + \beta X_i + \tau T_t + \varepsilon_{it} \quad (5)$$

In Equation 5, the variable *Eligible* takes a value of one for sites that are in the six counties that are targeted for the safe-harbor program run by FWS. *Post* takes a value of one in years after 1995 when the safe-harbor program was started. The variable of

[5] Standard errors can also be clustered at the county level to allow for arbitrary correlation within counties and the same variables remain statistically significant. Running this and subsequent equations with a probit model also yields similar results.

interest is a three-way interaction between *Eligible*, *Post*, and the variable *RCW*. The coefficient δ measures the impact of the safe-harbor agreement on eligible landowners near RCW compared with those not eligible or not near RCW. *Interactions* are a set of two-way interactions and dummies for *Eligible*, *Post*, and *RCW* to control for the areas, times, and site characteristics of interest. Controls for other site characteristics and year dummies are also included. A heteroskedasticity-robust error term, ε, is the final variable in the model.

$$Improve_{it} = \alpha + \delta RCW_i * Eligible_i * Post_t + \theta Interactions_{it} + \beta X_i + \tau T_t + \varepsilon_{it} \qquad (6)$$

The safe-harbor program may also encourage landowners to manage land in ways that are favorable to wildlife, as in Prediction 4. Equation 6 takes a similar form as Equation 5, but tests for the impact of the safe-harbor program on the probability of improving wildlife habitat.

An alternative methodology to measure the impact of the safe-harbor program is to match sites that have entered safe-harbor agreements with similar sites that are not in safe-harbor agreements, then look at differences in outcomes across the groups. Selection issues preclude the use of simple models to test the effectiveness of the program because there are reasons to believe that landowners who choose to participate in safe-harbor agreements may differ from landowners who do not participate. Nearest-neighbor matching allows me to match sites based on a combination of factors including location, proximity to woodpeckers, the starting value of timber and value of growth, and tree type. Each site in a safe-harbor program is matched with the three most similar sites, all surveyed after 1995. If outcomes differ across the treatment group of sites in the safe-harbor program and the control group of matched sites, there is evidence of the effectiveness of the program. Matching estimators can measure the average treatment effect on the treated, which focuses on the sites within the treatment group, or the average treatment effect across the entire population. In this case, average treatment on the treated is a measure of whether the safe-harbor program is effective for landowners who have chosen to enter it, where average treatment effect is a measure of whether the safe-harbor program would make a statistically significant difference across the area of interest. Matching methods are also used to look at the effectiveness of the safe-harbor program on increasing management for wildlife habitat.

VIII. Results

Results from the probit model of harvest probability are presented in Table 4, alongside results from the 1990s sample analyzed in Lueck and Michael. While each additional woodpecker colony increased the probability of harvest by about 0.1% in the 1990s sample, there is not a statistically significant impact of RCWs in the 2000s sample. Coefficients on other variables maintain similar sign and significance across the two samples, so this model indicates that perhaps habitat destruction to avoid having RCWs move onto property has slowed down. This could be taken as a sign that the safe-harbor program has been successful. However, as mentioned in previous sections, the results from this model may be largely driven by unobserved differences between areas with RCW populations and areas without RCWs.

Table 5 presents results from the difference-in-difference model that controls for this heterogeneity and points to a continued impact of RCWs on timber harvests. The variable of interest of pure-pine sites interacted with RCWs has a positive and significant coefficient. With this preferred model of harvest behavior, pure pine sites that are near

RCWs are 25% more likely to be harvested than pure pine sites that are not near RCWs. Although the magnitude of the effect is about half the size of the effect found by Lueck and Michael with older data, there is evidence that Prediction 1 holds and landowners continue to destroy habitat to prevent RCWs from moving onto their property. The smaller magnitude of the coefficient may indicate some success of the safe-harbor program, as discussed below. The smaller effect of RCWs is also consistent with changes in the market for timber products that have occurred over the past twenty years, as described in Section IX.

Table 6 presents results of the difference-in-difference model of landowner behavior with respect to improving land as wildlife habitat. The variable of interest is again pure-pine sites interacted with RCWs, which has a negative and significant coefficient indicating that landowners near RCWs are about two percentage points, or 40%, less likely to manage their pure pine sites in a way that improves habitat for wildlife. Prediction 2 also appears to hold when describing recent landowner behavior.

Predictions 3 and 4 relate to the effectiveness of the safe-harbor program in the Sandhills area of North Carolina. Table 7 presents results of the triple-difference model that tests whether landowners with the option of a safe-harbor agreement are less likely to destroy RCW habitat. The variable of interest is the three-way interaction of RCW with sites that are in the area targeted for the safe-harbor program (*Eligible*), and surveyed in the years after the program was started (*Post*). This variable has a negative but insignificant coefficient, indicating a lack of strong evidence of the effectiveness of the program, although the negative coefficient is in the expected direction of Prediction 3. The interaction term between *Eligible* and *Post* is significant and negative, providing some evidence that landowners in the area may have reduced the amount of habitat destruction by approximately 6 percentage points, or a 33% decrease from the mean, following introduction of the program.

Table 8 presents results from the triple-difference model predicting whether landowners improve wildlife habitat on their land. The triple-difference variable of interest has a positive and significant coefficient indicating that landowners in the target area of the safe-harbor program after the program started are half a percentage point, or 10%, more likely to improve wildlife habitat compared with landowners who are not in the program's target area.

As presented in Table 9, matching estimators show mixed effectiveness of the safe-harbor program as well. Three control sites that are not in safe-harbor agreements are matched with each site in a safe-harbor agreement using nearest-neighbor matching based on location, number of RCW within ten miles, tree type, starting value of timber and value of an added year of growth. For harvest probabilities, the average treatment for landowners in the treatment area (ATT) is a statistically significant negative thirteen percentage points, which is a 72% reduction from the average harvest probability. This indicates that landowners who are in safe-harbor agreements have greatly curtailed their harvesting behavior. When looking at the average treatment effect for sites across the relevant area (ATE), there is no significant change in harvest probabilities across treatment and control sites. The average treatment on the control group (ATC) is positive but not statistically significant. This would mean that if landowners in the control groups were forced to enter safe-harbor agreements, those landowners may actually increase harvest behavior, perhaps as acts of defiance or distrust in the government. However, since these treatment effects are based on data from a voluntary program, it is difficult to say with confidence how well the results would apply to compulsory programs.

When looking at changes in improving wildlife habitat, the nearest-neighbor matching estimators do not show significant effects. The ATT estimate for landowners in the safe-harbor program is a positive seven percentage point increase in the probability of improving wildlife habitat. This estimate is in the expected direction, but is not statistically significant. The ATE estimate for landowners across the area is an eleven percentage point increase in the probability of improving wildlife habitat that is not statistically significant. The ATC estimate for landowners in the control group is similar.

IX. Explanations and Policy Implications

The results from this study suggest that private landowners continue to engage in preemptive habitat destruction. Although the estimate from a model similar to that used by Lueck and Michael does not show evidence of habitat destruction, the estimate from a model that controls for unobserved heterogeneity of forest plots points to a 25% increase in the probability of harvest for plots near RCWs. Although the FWS has decreased the acreage that is set aside for each RCW colony and offered voluntary agreements, as described below, to lessen the threat of regulation, landowners still appear to be avoiding ESA regulations by destroying habitat.

Changes in market conditions may be one factor working against efforts of the FWS to have a more cooperative relationship with landowners. Technological advances in wood products with things like oriented-strand board (OSB) allow landowners to harvest young timber with less of a penalty for not allowing trees to reach a diameter sufficient for saw timber. OSB and other alternative lumber products caused the price gap between chip and saw timber to narrow, so landowners can put trees on a thirty-year rotation and avoid the threat of RCWs moving in without suffering a large financial penalty for not allowing the trees to reach a diameter suitable for saw timber.

One way that the FWS has tried to encourage cooperation with landowners and mitigate the perverse incentive to destroy habitat is through safe-harbor agreements. One of the first safe-harbor programs in the country was for RCWs in the Sandhills area of North Carolina. This program therefore offers one of the richest data sources for empirical tests of the effectiveness of the program. As the above results describe, the variable of interest in the model of harvest behavior does not show the program having a significant impact on the landowners we would most expect to be affected, namely those who have RCWs nearby. Instead, the coefficient on a variable that interacts the area and time of the program shows a 33% decrease in harvest behavior in the treatment area after the program was started. This estimate uses the surrounding counties that are not in the safe-harbor target area as controls.

The lack of significance on the triple-difference variable in Table 7 means that this result is not driven by landowners with RCWs nearby, so it should not be considered strong evidence of the effectiveness of the program at decreasing habitat destruction through tree harvests. Instead, it may point to spillovers of conservation behavior to landowners who are not immediately threatened with RCWs, but may be in the future. FWS data on the safe-harbor agreements indicates that a third of the agreements are in place for properties that are not currently within ten miles of any existing RCW colonies, so these landowners are locking in an agreement with a zero baseline as an insurance policy. Although this behavior will tend not to have an immediate benefit to RCWs because these sites are outside the traditional range of fledgling RCWs searching for new colonies, it may have long-term benefits by promoting more mature pine in the area.

The matching estimators for harvest support the story that safe-harbor agreements are effective for landowners that choose to enter them, but the change in behavior is not large enough to make a detectable effect when looking at averages across the area. This finding suggests that expansion of participation in the safe-harbor program above the 145 sites currently enrolled may lead to larger differences.

There is stronger evidence that safe-harbor agreements encourage landowners to improve habitat for wildlife. Many landowners care about wildlife on their property, whether because of an inherent preference for wildlife or because of a taste for hunting. In areas like North Carolina where a majority of land is privately held and hunting clubs manage thousands of those acres, it is unsurprising that many landowners would like to manage forests in ways that encourage wildlife. This can be done by strategically thinning trees or performing controlled burns to clear underbrush, for example. The safe-harbor program appears to have led to a 10% increase in activity to improve wildlife habitat. Unlike the results of the harvest model, this result is driven by the landowners expected to respond the most to the safe-harbor program, namely those who have RCW colonies within ten miles. Matching estimators do not show significant results for the safe-harbor program on wildlife improvement, so evidence on the effectiveness in this realm is mixed as well.

When landowners are able to improve wildlife habitat without feeling threatened by regulation under the ESA, such as under the safe-harbor program, it provides a clear benefit to endangered species like the RCW. RCWs are able to forage more effectively when trees are thinned and controlled burns are performed, which are some of the improvement activities that landowners undertake to improve habitat for game species like deer and wild turkey. Some other endangered species may not benefit from these types of activities, so FWS should consider how complementary habitat improvement is for popular game species and the endangered species in question. All else equal, safe-harbor programs appear to hold more promise for species that have complementary habitat needs to game species because this safe-harbor program appears to encourage wildlife habitat improvement activities more than it mitigates the perverse incentive to adjust timber harvests to a shorter rotation.

X. Conclusion

The purpose of the Endangered Species Act is to conserve ecosystems of endangered species, but in some cases it leads to the destruction of those ecosystems. Preemptive habitat destruction is a relatively persistent response despite attempts such as the safe-harbor program to dampen the incentives that lead to this destruction. Landowners in North Carolina harvest mature pine near RCWs at a 25% faster rate than mature pine that is not near RCWs. If this behavior continues, there is a threat that RCWs will become isolated in existing colonies and on public lands.

The FWS has attempted to dampen the perverse incentive to destroy RCW habitat by offering safe-harbor agreements to landowners. There is not strong evidence that the safe-harbor program has prevented landowners from adjusting tree harvests to destroy habitat, although there may be spillovers in the targeted area as landowners who are not currently near RCWs enter agreements to lock in insurance policies with low land-use restrictions. There is stronger evidence that the safe-harbor agreements encourage landowners to manage land in ways that improve wildlife habitat with a 10% increase in this behavior. Since RCWs benefit from many of the same activities that landowners use to improve habitat for wildlife like deer and wild turkey, this represents a success for this endangered species program.

The ultimate effectiveness of the safe-harbor program depends on biological outcomes for RCWs that require a long time horizon to collect and are difficult data to measure. In the meantime, results in this paper indicate reasons to be cautiously optimistic about safe-harbor agreements and the possibility that they can encourage habitat improvement for endangered species. Safe-harbor agreements are one of a range of voluntary conservation tools that the U.S. Fish & Wildlife Service is using to attempt to encourage more cooperation with private landowners. Although there are still open questions about the effectiveness of these programs, they hold the promise of a win-win improvement over the current situation by allowing landowners to have more options as they balance conservation and the use of natural resources. Simultaneously, federal agencies can be better able to pursue the goals of strong and important environmental laws like the Endangered Species Act. Hopefully, endangered species like the red-cockaded woodpecker can thrive in this more cooperative environment as well.

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STATUTE AND CASES

Endangered Species Act, 16 U.S.C. § 1531.

Statute gives authority to the Fish and Wildlife Service (FWS) in the Department of the Interior to engage in a range of activities to preserve species and the habitats upon which they depend. Section nine grants the FWS authority to regulate the "take" of listed species on both public and private lands. To "take" includes to "harm" the species. FWS has interpreted "harm" to include habitat destruction.

Tennessee Valley Authority v. Hill, 437 U.S. 153 (1978).

U.S. Supreme Court held that construction of a dam should be enjoined under the Endangered Species Act because it would destroy critical habitat for the snail darter, an endangered species. "Congress has spoken in the plainest of words, making it abundantly clear that the balance has been struck in favor of affording endangered species the highest of priorities, thereby adopting a policy which it described as 'institutionalized caution.'" (p. 194).

Babbitt v. Sweet Home Chapter of Communities for a Great Oregon, 515 U.S. 687 (1995).

FWS was within its authority under the Endangered Species Act when it interpreted the ban on 'take' of endangered species to include habitat destruction.

Arizona Cattle Growers Association v. U.S. Fish & Wildlife, 273 F.3d 1229 (9th Cir. 2001).

FWS exceeded its authority under the Endangered Species Act when it imposed restrictions on grazing leases for properties that it had not shown with "reasonable certainty" were currently endangered species habitat.

Seiber v. United States, F.3d 1356 (Fed. Cir. 2004).

FWS restricted a landowner of a 200-acre tract of timber from harvesting trees due to the presence of spotted owls. The court held that this was not a regulatory taking because it did not deprive the landowner of all economic uses of the land.

Palila v. Hawaii, 852 F.2d 1106 (9th Cir. 1988).

FWS ordered the state of Hawaii to eradicate feral pigs that were destroying habitat for endangered species. The court held that this was within the authority of the agency under the ESA.

FIGURES AND TABLES

Figure 1—Landowner Decision Tree from Conceptual Model

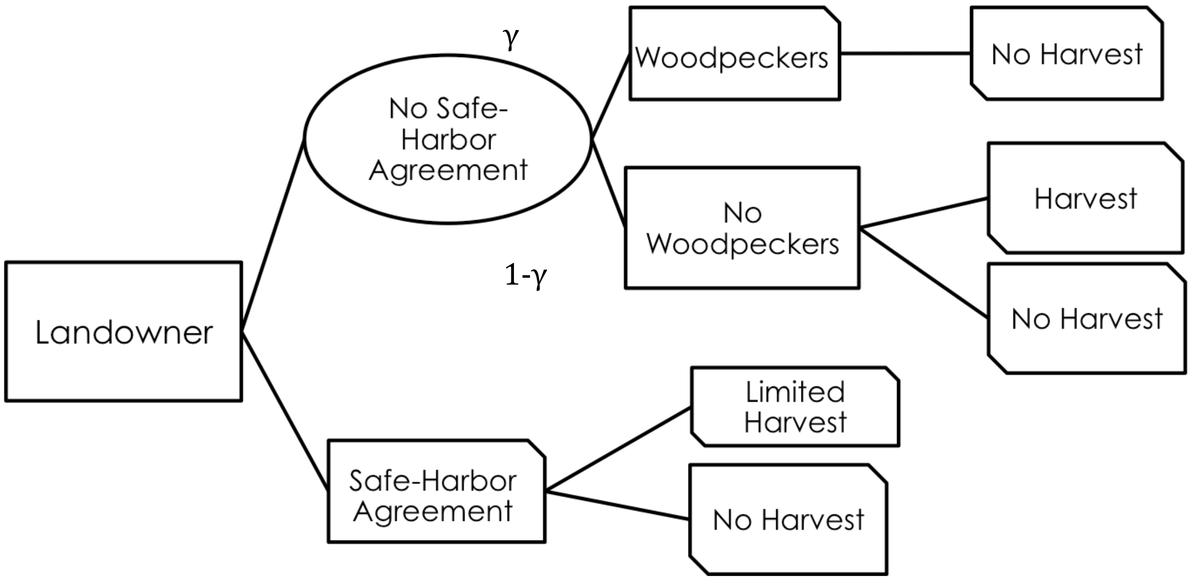
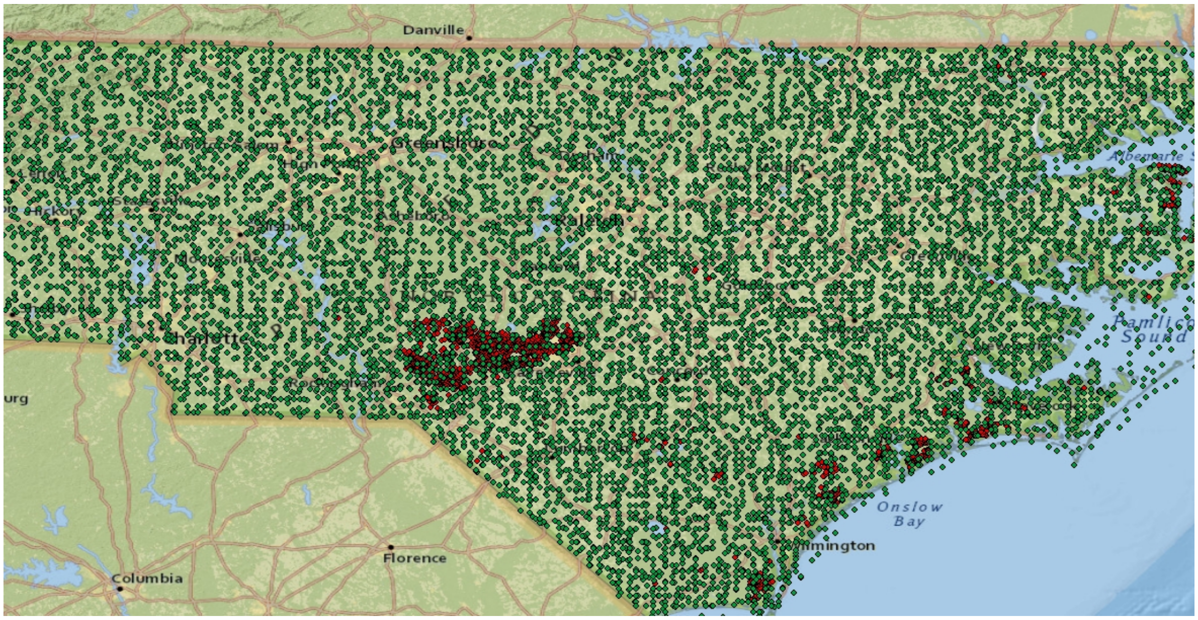
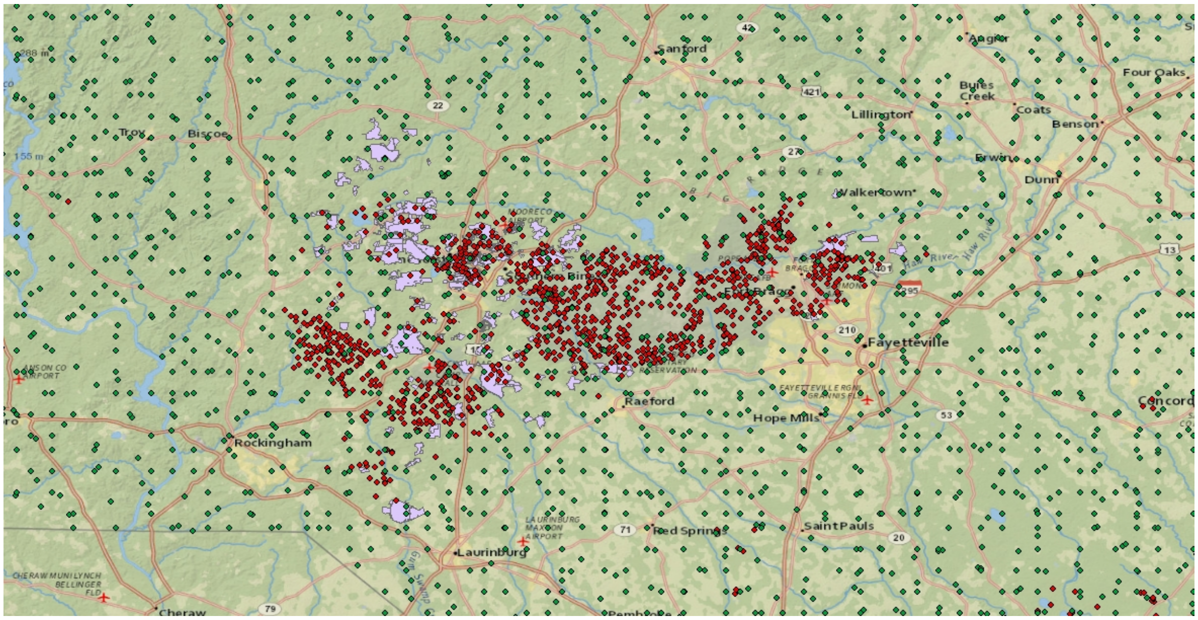


Figure 2—Forest Plots and RCW Colonies in North Carolina



Notes: RCW = red-cockaded woodpecker. Lighter green dots indicate FIA plots. Darker red dots indicate RCW colonies. Map created with ArcGIS. Data on forest plots come from the U.S. Forest Service FIA Database (2014) and RCW data come from the North Carolina Department of Environment and Natural Resources (2012). Forest plots that appear to be in the ocean are on barrier islands that are not depicted on the base map.

Figure 3—Forest Plots, RCW Colonies, and Safe-harbor Agreements in Sandhills Region of North Carolina



Notes: RCW = red-cockaded woodpecker. Lighter green dots indicate FIA plots. Darker red dots indicate RCW colonies. Pale purple polygons indicate properties in safe-harbor agreements. Map created with ArcGIS. Data on forest plots come from the U.S. Forest Service FIA Database (2014), RCW data come from the North Carolina Department of Environment and Natural Resources (2012), and safe-harbor agreement data come from the U.S. Fish & Wildlife Service (2013).

Table 1—Summary Statistics of Forest Plots

Panel A	2000s Sample
Harvest (% of sites)	0.18
	(0.38)
Improve Wildlife Habitat (% of sites)	0.05
	(0.21)
Number of RCW within 10 Miles	4.03
	(20.34)
Starting Value of Timber ($/acre)	290.06
	(437.08)
Value of Additional Year of Growth ($/acre)	25.96
	(20.10)
Site Characteristic Indicator Variables	
Loblolly Pine	0.69
	(0.46)
Near Water	0.41
	(0.60)
Steep Slope	0.10
	(0.29)
High Productivity	0.22
	(0.42)
Far from Road	0.01
	(0.09)
Lightly Forested	0.24
	(0.43)
N	3,821

Panel B	1980s – 2000s Sample
Site in Area Eligible for Safe-Harbor Program	0.27
	(0.44)
Sampled Post Implementation of Safe-Harbor Program	0.37
	(0.48)
N	5,272

Notes*:* RCW = red-cockaded woodpeckers. Standard deviations in parentheses. Data on forest plots come from the U.S. Forest Service FIA Database (2014) and RCW data come from the North Carolina Department of Environment and Natural Resources (2012). Panel A includes sites measured in 2001-2013 in Piedmont and coastal regions of NC. Panel B includes sites measured in 1982-2013 in Sandhills area of NC.

Table 2—Summary Statistics of Forest Plots Near RCW Colonies

	Full Sample	Sites near RCW	Sites not near RCW
Probability of Harvest	0.18	0.18	0.18
	(0.38)	(0.39)	(0.38)
Probability of Improving Wildlife Habitat	0.05	0.04	0.05
	(0.21)	(0.20)	(0.21)
Number of RCW within 10 Miles	4.03	20.17	0.00
	(20.34)	(41.79)	(0.00)
Starting Value of Timber ($)	290.06	219.31	307.74
	(437.08)	(322.26)	(459.68)
Value of Additional Year of Growth ($)	25.96	22.20	26.90
	(20.10)	(17.18)	(20.66)
Site Characteristics			
Loblolly Pine	0.69	0.70	0.69
	(0.46)	(0.46)	(0.46)
Near Water	0.41	0.58	0.37
	(0.60)	(0.81)	(0.67)
Steep Slope	0.10	0.03	0.11
	(0.29)	(0.17)	(0.31)
High Productivity	0.22	0.17	0.23
	(0.42)	(0.38)	(0.42)
Far from Road	0.01	0.02	0.01
	(0.09)	(0.14)	(0.07)
Lightly Forested	0.22	0.21	0.25
	(0.42)	(0.41)	(0.43)
N	3,821	764	3,057

Notes: RCW = red-cockaded woodpecker. Standard deviations in parentheses. Data on forest plots come from the U.S. Forest Service FIA Database (2014) and RCW data come from the North Carolina Department of Environment and Natural Resources (2012). Sample includes sites measured in 2001-2013 in Piedmont and coastal regions of NC. Plots are defined as near RCW if there are any RCW colonies within 10 miles.

Table 3—Harvest Probabilities for Plots Near RCW Colonies

	Pure Pine	Pine Mixed with Hardwood
RCW Within 10 Miles	0.191	0.153
	N=607	N=157
No RCW Within 10 Miles	0.168	0.135
	N=2,557	N=1,100

Notes: Reported statistic is the probability of harvest within the previous five years. Includes sites sampled between 2001 and 2013 in the Piedmont and coastal regions of NC.

Table 4—Probit Regression of Harvest Probability

	Lueck and Michael (1990s)	Current Sample (2000s)
# of RCW within 10 Miles	0.20**	0.04
	(0.10)	(0.10)
Value of Timber Growth	-0.33***	-0.22***
	(0.11)	(0.04)
Site Productivity	20.7***	5.11***
	(3.60)	(1.83)
Sample size	1,199	3,418

Notes: Coefficients, which report marginal effects, and standard errors multiplied by 100. Robust standard errors in parentheses. *** significant at 1%; ** significant at 5%. Sample includes sites in Piedmont and coastal regions of NC surveyed in 1984 to 1995 for Lueck and Michael (2005) and 2001 to 2013 for current sample. Additional controls include tree type, site characteristics, year dummy variables (both samples), stand age at initial sample (1990s sample) site steepness, proximity to water and roads, and lightly forested (2000s sample).

Table 5—Difference-in-Difference Regression of RCW Impact on Harvest

	Probability of Harvest
Pure Pine near RCW	4.46**
	(1.92)
Near RCW	-0.03
	(0.02)
Pure Pine	-10.70***
	(3.80)
Starting Value of Timber	0.02***
	(0.00)
Value of Timber Growth	-0.29***
	(0.03)
Loblolly	11.80***
	(3.43)
Lightly Forested	-7.99***
	(1.33)
Highly Productive Site	4.22***
	(1.73)
Sample size	3,418
R-squared	0.12

Notes: Linear probability model with dependent variable harvest = 1 if the site was harvested in the previous five years. Robust standard errors in parentheses. Coefficients and standard errors multiplied by 100. *** significant at 1%;** significant at 5%. Additional controls include year dummy variables and controls for site steepness and proximity to water and roads.

Table 6—Difference-in-Difference Regression of RCW Impact on Improving Habitat for Wildlife

	Probability of Improving Habitat for Wildlife
Pure Pine near RCW	-1.88*
	(1.13)
Near RCW	0.00
	(0.00)
Pure Pine	-5.15
	(3.13)
Starting Value of Timber	0.01***
	(0.00)
Value of Timber Growth	-0.12***
	(0.02)
Loblolly	-2.51
	(3.06)
Lightly Forested	0.16
	(4.12)
Highly Productive Site	-0.54
	(0.76)
Sample size	3,418
R-squared	0.05

Notes: Linear probability model with dependent variable harvest = 1 if the site was actively improved for wildlife habitat in the previous five years. Robust standard errors in parentheses. Coefficients and standard errors multiplied by 100. *** significant at 1%;* significant at 10%. Additional controls include year dummy variables and controls for site steepness and proximity to water and roads.

Table 7—Triple-Difference Regression to Test Impact of Safe-Harbor Program on Habitat Destruction in Sandhills of North Carolina

	Probability of Harvest
Safe Harbor Area * Post-Program * Near RCW	-0.06
	(0.28)
Safe Harbor Area * Post-Program	-6.34*
	(3.52)
Safe Harbor Area * Near RCW	0.01
	(0.14)
Post-Program * Near RCW	0.08
	(0.27)
Safe Harbor Area	2.75
	(2.15)
Post-Program	-11.50*
	(6.58)
Near RCW	-0.02
	(0.14)
Starting Value of Timber	0.02***
	(0.00)
Value of Timber Growth	-0.43***
	(0.02)
Loblolly	13.70***
	(4.14)
Lightly Forested	-6.82***
	(2.30)
Sample size	4,203
R-squared	0.13

Notes: Linear probability model with dependent variable harvest = 1 if the site was harvested in the previous five years. Robust standard errors in parentheses. Coefficients and standard errors multiplied by 100. *** significant at 1%;* significant at 10%. Additional controls include year dummy variables and controls for site steepness and proximity to water and roads.

Table 8—Triple-Difference Regression to Test Impact of Safe-Harbor Program on Improving Wildlife Habitat in Sandhills of North Carolina

	Probability of Improving Habitat for Wildlife
Safe Harbor Area * Post-Program * Near RCW	0.44***
	(0.15)
Safe Harbor Area * Post-Program	0.20
	(1.84)
Safe Harbor Area * Near RCW	-0.11
	(0.09)
Post-Program * Near RCW	-0.47***
	(0.15)
Safe Harbor Area	-0.31
	(0.94)
Post-Program	7.73*
	(3.67)
Near RCW	0.12
	(0.09)
Starting Value of Timber	0.01***
	(0.00)
Value of Timber Growth	-0.16***
	(0.01)
Loblolly	-1.86
	(3.07)
Lightly Forested	0.28
	(1.45)
Sample size	4,203
R-squared	0.06

Notes: Linear probability model with dependent variable harvest = 1 if the site was actively improved for wildlife habitat in the previous five years. Robust standard errors in parentheses. Coefficients and standard errors multiplied by 100. *** significant at 1%;* significant at 10%. Additional controls include year dummy variables and controls for site steepness and proximity to water and roads.

Table 9—Nearest-Neighbor Matching Estimators to Test Impact of Safe-Harbor Program on Harvest and Improving Wildlife Habitat in Sandhills of North Carolina

	Harvest	Improving Habitat for Wildlife
Safe Harbor: Average Treatment on the Treated (ATT)	-13.33* (6.99)	6.67 (10.33)
Safe Harbor: Average Treatment Effect (ATE)	7.53 (20.33)	10.52 (14.49)
Safe Harbor: Average Treatment on the Control (ATC)	7.72 (20.44)	10.55 (14.57)
Sample size	1,280	1,280

Notes: Nearest-neighbor matching estimator using location, number of RCW within ten miles, starting timber value and value of added year of growth, and tree type to match three control sites (not in safe-harbor) with each treatment site (in safe-harbor). Robust standard errors in parentheses. Coefficients and standard errors multiplied by 100. * significant at 10%.

Chapter 2—Experimental Evidence of Landowner Behavior in Endangered Species Habitat Programs

I. Introduction

The Endangered Species Act (ESA) is a powerful law, but the power of the law does not always lead to favorable results. In some instances, landowners face perverse incentives to destroy habitat of species that are or may be protected under the ESA (Lueck & Michael 2003). Private landowners who may have endangered species on their properties often find themselves in adversarial relationships with federal regulators like the Fish & Wildlife Service (FWS) because regulators restrict land uses to encourage conservation. Increased populations of endangered species are a goal for the FWS, while more endangered species mean more restrictions for the landowner. Landowners may try to avoid regulations by destroying habitat before species move onto it, by destroying species before they are listed as endangered, or by illegally destroying listed species and hoping not to get caught.

To alleviate these perverse incentives, regulators have tried to create regulatory tools that can foster more cooperative relationships with landowners. One of these tools is the safe-harbor agreement, a voluntary contract between landowners and regulators that can act like an insurance policy for landowners (U.S. FWS 2006). The landowner agrees to provide at least some endangered species habitat in exchange for a promise from the FWS not to impose more burdensome restrictions if more members of the endangered species move onto the property. Another tool that has been proposed is to create a market for tradable credits that would be issued to landowners who provide habitat for species. This paper contributes to the literature with the first experimental evidence of how landowners respond to existing and proposed policies to encourage the provision of endangered species habitat.

It is difficult to get an empirical measure of the effectiveness of different regulatory regimes regarding endangered species. While some policies have been in place in the real world for long enough for there to be sufficient data for hypothesis testing, many other policies have only been proposed and never implemented. Even where there are policies in place, it can be difficult to gather data and find sources of exogenous variation in the data that make it possible to empirically test for causal relationships. Although researchers have been able to confront these obstacles to answer some questions like the effectiveness of listing species as endangered or threatened (Ferraro, McIntosh, & Ospina 2007) and habitat-conservation plans (Langpap & Kerkvliet 2012), there are still many questions about which regulatory tools hold the most promise to decrease the adversarial nature of endangered species conservation.

Theoretical models can help assess the promise of alternative regulatory tools by predicting how landowners may respond to incentives. Langpap and Wu (2004) use a model of landowner behavior to find that voluntary agreements are likely to allow for more endangered species habitat, but that levels are still below the socially optimal amount. Polasky and Doremus (1998) model behavior relating to how landowners will share information with regulators, which has large practical implications in a world where landowners are likely to have more information about endangered species on their properties than regulators do. While these papers provide valuable clues about how landowners will respond to endangered species regulations, the models rely on untested assumptions. In this paper, I use a theoretical model to predict behavior, then test those predictions with data.

A common way to gather data to test predictions is to look at real-world interactions. Lueck and Michael (2003) use data from federal agencies to determine that landowners in North Carolina who have mature pine trees on their properties are more likely to harvest those pine trees if there are endangered woodpeckers nearby. While this methodology using revealed-preference data provides an empirical sense of what is going on in the world, it can only be used to look at policies that are in place and have been running long enough to generate adequate data.

Often revealed-preference data are unavailable, so researchers turn to methodologies using stated-preference data. Zhang (2004) uses a survey of landowners to assess the impact of red-cockaded woodpecker on wood harvests, much like Lueck and Michael had done with revealed-preference data, and finds similar results of habitat destruction through timber harvests. Langpap (2006) uses survey data to find that a combination of assurances of no new future regulations, which are much like safe-harbor agreements, and financial incentives hold the most promise to get private landowners to provide habitat.

A third way to gather data is to use experiments. Experiments allow researchers to impose an element of randomness to use as exogenous variation. For example, Newell and Swallow (2013) use a field experiment to help determine how much people value the attributes, including provision of wildlife habitat, of a wetland. They generate eighteen different true descriptions of two real wetland parcels, then use randomization to determine which description people would read before being asked how much they were willing to contribute to conservation of the wetland parcels. Parkhurst and Shogren (2007) use a computer-based experiment to find that landowners will respond to a policy that provides a bonus for the conservation of properties that are adjacent to other conserved properties.

This paper contributes to the literature with the first experimental tests of landowner behavior in the existing safe-harbor program and the proposed markets for endangered species habitat. The experiment takes advantage of random assignment into treatment and control groups to see how people respond to regulations in hypothetical scenarios. By tying performance in the scenarios to real money payoffs, participants have incentives to pay attention and try to take home as much money as possible (List et al. 2011).

The paper proceeds in Section II with a brief description of the legal background that creates the environment in which landowners and FWS are constantly at odds. Section III describes the methodology for the experiment I use to test how landowners respond to important elements of that legal environment and proposed changes to it. Section IV presents a theoretical model that provides predictions for how landowners will respond in the different regulatory regimes, specifically within the structure of the experiment. Section V provides results of the experiment, which are discussed in Section VI. Section VII concludes with implications of the results for existing and proposed endangered species policies, and specifically the FWS proposed rule to use tradable credits to create a market for the provision of habitat.

II. Legal and Economic Context

The ESA is known as the "pitbull of environmental laws" because it has teeth in situations where other environmental laws have failed to make much of a difference (Quarles 1998). The ESA gives authority to the FWS to promulgate rules to promote the conservation of species that are listed as endangered or threatened. Section 9 of the ESA prohibits the unauthorized "take" of listed species by either federal agencies or private actors. The FWS has defined take to include harming species, including habitat destruction. With this interpretation, private landowners can violate the ESA not only by purposefully killing or harming listed species, but also by engaging in economic activities like harvesting timber when that timber is habitat for a listed species. Some other protections afforded under the ESA, such as the Section 7 protections against jeopardy and adverse modification of critical habitat, apply to actions involving federal agencies, but the Section 9 restriction on take applies to private landowners as well.

With the Section 9 protections, it is not surprising that there is conflict between landowners and the FWS when the costs of protecting endangered species can fall largely on a small number of unlucky landowners. For example, when landowners in the coastal plain of North Carolina have mature pine on their properties, regulators set aside around 100 acres of land for each colony of red-cockaded woodpeckers (RCW), an endangered bird that resides there. Mature pine trees in this protected area can generally not be harvested, so landowners can be out up to $200,000 in present value of standing timber. More woodpecker colonies means more land that will be protected, so landowners tend not to have incentives to encourage the endangered species to succeed. Courts have consistently held that this regulation does not constitute a "taking" of property that would require just compensation under the U.S. Constitution. In short, a problem with protecting endangered species on private property is that the ESA is "all sticks and no carrots" (Langpap 2006). Landowners and regulators like the FWS thus consistently find themselves in adversarial relationships, and sometimes landowners avoid regulatory restrictions by preventing endangered species from inhabiting their properties.

The FWS recognized that strict regulation of endangered species on private land may be having unintended consequences such as habitat destruction, so the agency started exploring creative approaches to try to mitigate the perverse incentives created by the ESA. In 1995, the FWS rolled out a voluntary program of safe-harbor agreements that represented a new option for landowners who were facing possible regulation for certain listed species. To enter a safe-harbor agreement, landowners promise to provide habitat sufficient to support a "baseline" number of the species in exchange for a promise from the FWS not to increase the regulatory burden if more members of the species move onto the property in the future. For example, a landowner who has a 500-acre property with three RCW colonies on it could enter an agreement by agreeing to restrict timber harvests on 300 acres to support the baseline in exchange for the certainty that she could continue to harvest trees on the remaining 200 acres. Another way to structure the agreement might be to agree to switch timber harvests from a 45-year rotation to a 75-year rotation. Safe-harbor agreements can thus act as insurance policies against regulatory burdens, decreasing uncertainty for landowners for things like timber harvests.

Section 10 of the ESA provides FWS with authority to "permit . . . any taking . . if such taking is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity" when there is a habitat conservation plan in place for the species (16

U.S.C. § 1539(a)(1)). Habitat conservation plans are species-level plans that specify how land will be managed in a way that helps endangered species rather than hurting them. FWS has added other voluntary conservation tools like candidate conservation agreements that perform a similar role as safe-harbor agreements, but focus on protecting species that are candidates to be listed rather than species that are already listed as threatened or endangered.

Despite efforts by the FWS to use voluntary mechanisms to mitigate the perverse incentives of the ESA, there is still concern that habitat destruction on private land continues. The FWS has proposed a new policy that would reward landowners who provide habitat for species by providing the landowners with tradable credits (79 Fed. Reg. 42525 (July 22, 2014)). The policy is targeted at pre-listing conservation efforts, so landowners who provide habitat for species that have not been listed as endangered or threatened, but may be in the future, are potentially eligible for credits. The policy is in its nascent stages, with public comment recently closed on an advanced notice of proposed rulemaking, so the details have not been laid out yet. The idea of the rule is as follows: A landowner who provides pre-listing habitat for eligible species receives credits for that habitat. If the species is later listed, the landowner can use those credits to offset habitat modification, such as timber harvest or development, on another property. Alternatively, the landowner can sell the credits to others who may want to modify habitat. By creating a market for endangered species habitat, the policy intends to provide positive incentives for landowners who engage in conservation efforts. The FWS hopes tradable credits will be the sought-after carrot to get landowners to have better incentives to cooperate with the FWS in conservation efforts.

III. Experimental Design

To test how landowners may respond in various regulatory regimes, 139 participants were recruited from the student population at Vanderbilt University. Participants sat at computer stations for approximately 30 minutes as they engaged in the study. Participants were instructed to play a computer simulation in which they were landowners with 100 acres of mature pine trees. In each of 20 years of the simulation, landowners were asked how many of the 100 acres they would like to harvest. Trees became worth more as they grew older, as described in Table 1. Money from harvests was added to the landowners' accounts, which were paid to them in cash after they were done taking the study. All participants went through practice rounds that provided familiarity with the mechanics of harvesting trees and adding money to accounts.

In each year, there was a probability that an endangered woodpecker would move onto the property. This probability increased with the average age of the trees, with a 0% chance of woodpeckers for trees below 20 years old and gradually increasing to a 20% chance of woodpeckers for trees 50 years old. In each year, participants were given the option of investing $0.25 in habitat improvement to increase by 50% the chance that woodpeckers would move in during the next year.

Participants were randomly assigned to one of four groups and were informed of the following consequences of woodpeckers moving onto their property:

- **Group 1 (Strict Regulation)**: If woodpeckers moved onto the property, no more harvests were allowed and no additional money was added to the account.
- **Group 2 (Conservation Agreement)**: Same as Group 1, except also offered the choice of entering a conservation agreement in which the landowner agreed to

harvest no more than 5 acres in each year in exchange for regulators agreeing not to ban harvests if woodpeckers did move onto the property. Landowners could withdraw from the agreement in any year.

- **Group 3 (Low Financial Incentives)**: Same as Group 2, except also told that the landowner would receive a credit for each woodpecker that moved onto the property. If the landowner was in the agreement at the end of 20 years, each credit was worth between $1 and $2.
- **Group 4 (High Financial Incentives)**: Same as Group 3, except credits were worth between $3 and $4.

Landowners who were in conservation agreements were able to exit them in any year by entering a harvest amount larger than the 5 acres allowed in the agreement. If landowners who were in a conservation agreement entered a harvest amount that would break them out of their agreement, they were given a warning that this would result in them leaving the agreement and they would not be able to reenter. If they currently had woodpeckers residing on their property, they are given an additional warning that their harvest activity went against the purpose of the safe-harbor agreement that they entered, and that they would be sent to the end of the game if they continued with the harvest. However, these landowners were allowed to continue to break out of their agreements by harvesting more than 5 acres in that year before being sent to the end of the game. This meant that in the twentieth year of the simulation, landowners in agreements could break out of them and harvest all of their trees, even if there were woodpeckers residing on their property.

Summary statistics of participants are provided in Table 2. The sample is approximately two-thirds male and half of the participants are nonwhite. One-quarter of participants are Democrat, one-quarter are Republican, and half are independent or other. Forty percent describe themselves as environmentalists, ten percent are smokers, and about two-thirds are risk averse based on a question about how they would handle a windfall of money.

The next section lays out a framework for how a rational utility-maximizing actor would behave in the experiment.

IV. Predictions of Participant Behavior

To formalize the experiment in mathematical terms, this section describes how a utility-maximizing landowner may play the game. The landowner maximizes utility given by the following function:

$$U = \sum_{t=1}^{T} \beta^t u(x_t, c_t) \tag{1}$$

In this equation, the utility of the landowner is a function of money, x, which can go toward either general consumption or savings, and a taste for conservation, c. The utility function is assumed to be increasing in x and c, meaning the landowner is happier with more money and more conservation. The landowner discounts the future with factor β, so when β is below one there is a premium for utility in the earlier years over the later years. The landowner will choose actions that result in the set of pairs $\{x,c\}$ that give the highest overall utility level over the entire period.

Each year, the landowner decides how many acres of trees, $h \in [0,1]$, to harvest for use as timber. The harvest value of timber on the property at time t is ω_t, so the landowner receives $\omega_t * h_t$ for her harvest. The increase in timber value from time *t-1* to time *t* is given by ρ_t, which measures the marginal benefit of letting the trees grow another year. The value of the trees next year is thus given by $(1 - h_t) * (\omega_t + \rho_{t+1})$.

In each year, there is probability γ that endangered woodpeckers will move in. If woodpeckers move in, the FWS invokes jurisdiction under the ESA to regulate the entire property. When the FWS regulates property, the consequences vary depending on the randomly assigned group of the landowner, as described below. Table 1 provides values of ω and γ for selected tree ages.

For landowners in Groups 2 through 4, they also have to decide whether to enter into a safe-harbor agreement or not. If landowners enter into safe-harbor agreements, they limit the amount they can harvest in any period to 5 acres, so there is an added constraint that $h \leq 5$. In exchange for limiting their harvests, landowners get assurance from regulators that the landowner will be able to continue harvesting even if woodpeckers do move onto the property, so γ becomes immaterial to them if they intend to stay in the agreement. Landowners in Groups 2 through 4 are offered the opportunity to enter into a safe-harbor agreement in the first year and have the option of leaving any subsequent year, so each year they decide whether it is more beneficial to be in the agreement or not. The decision tree including the decisions to enter safe-harbor agreements and whether to harvest are depicted in Figure 1.

To solve this model for the optimal harvest and habitat improvement paths, I use backward induction to solve for the optimal final period behavior, then work forward until all periods have been solved. Optimal harvest and habitat improvement are calculated for landowners who have linear utility functions and place no independent value on conservation, meaning they maximize profit. No discounting is used ($\beta = 1$), as the time preference for money across the 20 years of the experiment is not likely to matter much in a game that is played in approximately 30 minutes. These optimal behaviors generate predictions for how players in the four groups will play the game.

Group 1 (Strict Regulation): The optimal harvest behavior for landowners in Group 1 who seek to maximize profit is to harvest a large number of trees, 30 acres, in the first year. This lowers the probability that woodpeckers move in to 1%. In each subsequent year, the landowner harvests 5 acres, keeping the probability of woodpeckers close to zero while slowly building money in the account. In the last period, the landowner harvests all 100 acres. The Group 1 landowner does not invest in habitat improvement. The expected profit by following this strategy is $20.44 with an average harvest of 11.0 acres per year and an expected 0.2 woodpeckers on the property at the end of the simulation.

Group 2 (Conservation Agreement): The profit-maximizing strategy for a landowner in Group 2 is to enter into a safe-harbor agreement and harvest zero acres per year for each of the first 19 years. In the 20th year, it is optimal for the landowner to break from the agreement and harvest 100 acres. The Group 2 landowner does not invest in habitat improvement. The expected profit by following this strategy is $25.09 with an average harvest of 5.0 acres per year and an expected 3.0 woodpeckers on the property.

Group 3 (Low Financial Incentives): The profit-maximizing strategy for a landowner in Group 3 is the same as that of a landowner in Group 2 for the first 19 rounds. The Group 3 landowner does not invest in habitat improvement. In the 20th year, the landowner should break out of the agreement and harvest all 100 acres unless there are more than 7 woodpeckers on the property (expected number is 3). Expected profit from following this strategy is $25.12, with an average harvest of 4.9 acres per year and an expected 3.0 woodpeckers.

Group 4 (High Financial Incentives): The optimal strategy for a landowner in Group 4 is to enter a conservation agreement and harvest zero acres per year for the first 19 years. The Group 4 landowner does invest in habitat improvement in each year. In the 20th year, the landowner should stay in the agreement and get paid for woodpecker credits unless there are fewer than 4 woodpeckers on the property (expected number is 5), in which case she should break out of the agreement and harvest all 100 acres. Expected profit from following this strategy is $25.87, with an expected harvest of 2.3 acres per year and an expected 4.5 woodpeckers.

General Predictions

The optimal harvest paths for landowners in the four groups exhibit properties that can be tested empirically. According to the model, there will be a monotonic decrease in the average harvest as the Group number increases. Group 1 is expected to harvest an average of 11 acres per year, Groups 2 and 3 are expected to harvest 5 acres per year, and Group 4 is expected to harvest an average of 2 acres per year. A second prediction about harvest behavior is that landowners in Group 1 will harvest more acres in the early years of the simulation than landowners in the other groups.

For habitat improvement behavior, the prediction is more stark: the first three groups are not expected to engage in any investment in habitat improvement, while landowners in Group 4 are expected to invest in habitat improvement.

While the above predictions are based on a risk-neutral landowner, the predictions remain similar for risk-averse landowners. For landowners who have a constant relative risk aversion utility function (Mas-Collel et al. 1995), behavior for Groups 1 through 3 remain the same. Landowners in Group 4 switch to a strategy that mimics that of Group 3 landowners when they have a coefficient of relative risk aversion of 1.3 or greater, as those landowners seek the sure profits from timber harvests rather than the uncertain profits from investing in woodpecker habitat.

When landowners derive utility from conservation, the utility function becomes more complicated and it is difficult to solve the model for optimal behavior. In general, a taste for conservation is likely to get landowners to harvest fewer acres of trees and invest more in habitat improvement.

V. Empirical Specifications

The simplest way to test the above predictions is through the use of summary statistics. Since players are randomized into groups, simple averages across groups should be able to tell most of the interesting results. However, regression techniques allow me to control for demographic variables. This can ensure that the experiment's randomization was successful and allow for additional tests of how demographic variables are correlated with behavior in the game.

When regressing harvest behavior on landowner group and player demographics, I use ordinary least squares (OLS) models of the following form:[6]

$$Harvest = \alpha_2 Group2 + \alpha_3 Group3 + \alpha_4 Group4 + X'\beta + \varepsilon \quad (1)$$

[6] I can also use a double-censored Tobit model for harvest to account for a dependent variable that runs from 0 to 100 and a Probit model for habitat improvement to account for a binary dependent variable. Results are similar with these models, and I report OLS for ease of interpretation of coefficients.

The variables of interest are the dummy variables for groups. The included variables, Groups 2 through 4, can be compared with the omitted category of landowners in Group 1 (Strict Regulation). X is a vector of demographic variables that includes age, sex, race, political party, smoking status, and self-reported risk preferences. Each observation is a participant-year, so each participant has multiple observations. Accordingly, standard errors are clustered at the participant level to allow for arbitrary correlation among the responses of each participant. Observations include only active participants, meaning that landowners who have been sent to the end of the game because they have woodpeckers on their property that is not currently in a conservation agreement are not included for those years as they had no choices in those years.

Regressions of habitat improvement use a similar model except with a binary dependent variable. Variables of interest and explanatory variables are similar and standard errors are again clustered at the participant level.

VI. Results

A. Harvest Behavior

As seen in Chart 1, landowners in all four of the groups tended to harvest a large number of acres in the final rounds, which fits with predictions for rational profit-maximizing behavior. There were also differences across the four groups in both harvest and habitat improvement activity, some of which are harder to explain with a simple profit-maximization model.

Landowners in Group 1 harvested an average of 30 acres over the first two years, which is significantly more than any other group.[7] This behavior fits with the profit-maximizing strategy of harvesting enough in the first few years to get the average age of trees low enough so the probability of woodpeckers moving in was close to zero. Landowners in the other three groups did not display this behavior of early habitat destruction, probably because most of the landowners in Groups 2-4 (91%) started in conservation agreements that mitigated the consequences if woodpeckers did move in.

As depicted in Table 2, the average annual harvest across the 20 years for those in Group 1 facing strict regulation was 8.8 acres.[8] Those in Group 2 harvested an average of 7.8 acres while those in Group 3 harvested 13.0 acres. Since landowners in Group 3 had a financial reason to favor woodpeckers relatively more than landowners in Group 2, it is difficult to explain substantially more harvest activity, which harms woodpeckers, in Group 3. The above profit-maximization model would predict that those offered cash for woodpeckers would harvest fewer trees. The average harvest for Group 4 was 5.8 acres, so higher financial incentives did seem to move landowners toward more habitat conservation.

Harvest behavior under the different groups can also be tested with a regression model, as reported in Table 4. Groups 2 and 4 have statistically significant coefficients that indicate landowners in these groups harvest an average of 2.4 to 2.9 fewer acres per

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[7] Statistically significant at 1% level compared with Groups 2 and 4 and at 5% level compared with Group 3 in an ordinary least squares (OLS) model of harvest controlling for age, sex, race, political party, environmentalist, and self-reported risk aversion.

[8] These averages include all landowners who are still active, excluding those who have been sent to the end of the game because they were not in agreements and had woodpeckers on the property.

year, which is a 44% to 53% decrease from the sample-wide average harvest level of 5.5 acres per year. Controlling for demographic and risk-tolerance variables did not meaningfully change the size or significance of coefficients on the variables for the randomly assigned groups.

As seen in the large spikes in the last periods in Chart 1, the average landowner harvests the majority of their trees in the final period. Many landowners (39%) in Groups 2-4 break out of conservation agreements to make these large harvests, with an average 91-acre harvest for this subsample. Table 5 reports regression results predicting which landowners break out of their conservation agreements in the final periods. The only meaningful significant result is that landowners in Group 4 are less likely to break out of their agreements than landowners in Groups 2 and 3.

B. Habitat Improvement Behavior

As shown in Table 6, landowners in Groups 1 and 2 did not engage in a substantial amount of habitat improvement, as expected because landowners tend to have no incentives (Group 2) or negative incentives (Group 1) to do so. With relatively weak financial incentives in Group 3, landowners start to invest more in habitat improvement with an average of 19% of landowners improving habitat each year. With stronger financial incentives in Group 4, 30% of landowners improve habitat each year.

Many landowners pair habitat improvement with a large harvest of trees. Of those who improve habitat, 7% of them have recently harvested 20 acres or more of trees. This percentage is even larger for those in groups 1 and 2, with 32% of the habitat improvement behavior coming immediately after a tree harvest over 20 acres. This goes against predictions of profit maximizing behavior, as it is not rational to invest in habitat improvement, which increases the probability of woodpeckers in a multiplicative fashion, directly after a large harvest because the probability of woodpeckers moving in is then zero.

The general result that Group 3 and, especially, Group 4 invest in habitat improvement is confirmed with regression analysis, as reported in Table 7. Those in Group 3 have an 11 percentage point increase in the probability of improving habitat, which is an 80% increase over the sample mean. Those in Group 4 are 20 percentage points more likely to improve habitat, which is a 154% increase over the mean.

C. Landowner Profits

The final profits of players in the different groups can tell us something about how well landowners will tend to fare financially in the alternative regulatory regimes. As seen in Chart 2, average profits increase as landowners make their way to later years in the simulation, with a spike in the final years as many landowners make large tree harvests or redeem credits for woodpeckers on their properties. As shown in Table 8, the average final payout is $16.22 for landowners in Group 1, $20.03 for those in Group 2, $20.33 for those in Group 3, and $22.00 for those in Group 4. All of these amounts are lower than the average payoffs for landowners who follow the optimal profit-maximizing strategy, with average profits about $4 to $5 lower than the predicted payoffs.

D. Woodpecker Populations

Although the simulation's simple model of woodpecker behavior only accounts for the average age of trees on sites, it can still be informative as a proxy for how much potential habitat there is for woodpeckers under the alternative regimes. Chart 3 shows the number of woodpeckers across the 20 years of the simulation for the four groups. In all of the groups, the average number of woodpeckers increases as the simulation progresses and more woodpeckers move onto properties. As shown in Table 9, the average number of woodpeckers in the final year is 1.3 for Group 1, 1.5 for Group 2, 1.8 for Group 3, and 2.1 for Group 4. As predicted in the model, woodpeckers fare better when landowners are offered safe-harbor agreements, and even better when financial incentives are offered.

VII. Discussion of Results and Deviations from Profit-Maximization

The results of the experiment suggest that there are regulatory tools that have promise at improving the current adversarial status quo under the ESA. Tools like safe-harbor agreements can decrease the amount of habitat destruction, which improves profits for landowners while providing benefits to endangered species. Financial incentives can further encourage landowners to actively invest in habitat improvement, especially when payoffs are high.

The results of the experiment also suggest that landowners may not always behave as profit-maximizers when responding to endangered species regulations. Perhaps most surprisingly, offering financial incentives to encourage endangered species may not always get landowners to provide more habitat for those endangered species. The conceptual model predicted that behavior of landowners in Groups 2 and 3 would be similar, with perhaps less harvest activity by those in Group 3 that are offered sellable credits for each woodpecker that moves onto their property. Instead, landowners in Group 3 harvested more than double the acreage of potential endangered species habitat per year even though they were offered the same agreement as landowners in Group 2 with an additional financial bonus for woodpeckers.

There is some evidence in the economics literature that offering either rewards or fines can move people towards thinking of the behavior in question as having a price attached to it.[9] If landowners in Group 3 started thinking of woodpeckers as a financial vehicle when they were told that credits for woodpeckers were worth \$1 to \$2, those landowners likely decided that, from a financial standpoint, it made more sense to invest in tree harvests than in woodpecker habitat. Meanwhile, landowners in Group 2 were simply told of conservation agreements that sounded like attractive insurance policies against regulatory restrictions. In other words, the offer of financial reward may have a framing effect on the way landowners think about woodpeckers. In terms of the conceptual model, landowners in Group 2 tended to think of woodpeckers in terms of the utility that they would get through the conservation of the birds (c in the model). Landowners in Group 3 instead may have thought of woodpeckers in terms of their financial value (x in the model) in a way that crowded out the role of c in the utility function. With the financial incentive ratcheted up to \$3 to \$4 per woodpecker for Group 4, the financial calculus tipped away from tree harvests and towards woodpeckers and we saw more of the behavior predicted by the profit maximization model. This first deviation from the model's predictions suggests that the assumption that c does not play in a role in the landowner's utility function probably does not hold. Instead, landowners seem to value how woodpeckers fare in ways outside of the financial consequences of woodpeckers on timber harvests, and providing a low financial incentive may crowd out some of this altruistic desire for conservation.

[9] See Gneezy and Rustichini (2000) in which daycares instituting fines for parents arriving late encourages more late pickups.

A second deviation from profit-maximizing behavior is that landowners often paid money to improve woodpecker habitat immediately after harvesting a large number of acres of trees in a way that did not make financial sense because they were paying \$0.25 to increase the probability of woodpeckers moving in from 0% to 0%. This behavior may suggest that the role of c in the utility function of landowners is more complex than a simple desire for woodpeckers to do well. There may be an element of "guilt avoidance" where landowners bring in a relatively large amount of money by harvesting many acres of trees, which harms woodpeckers by destroying potential habitat, but can avoid feeling guilty about it by contributing a token amount to improve woodpecker habitat. Even though this may not make sense financially, it could be a rational action if c enters the utility function in the form of disutility for actions that harm woodpeckers. If a small financial contribution can alleviate the disutility in c of feeling guilty more than it decreases the utility by dropping x by a small amount, then it is the rational thing for a landowner to do. This finding suggests that the preference for conservation enters the utility function in a way more complicated than a simple preference for woodpeckers to do well, and there may be an element of disutility from guilt when the landowners engage in activity that harms the woodpeckers.

An example of how landowner behavior sometimes tracked predictions can be seen in how landowners systematically broke out of safe-harbor agreements in the final years of the simulation. Thirty-nine percent of landowners who chose to enter conservation agreements also chose to leave them in the final years. When they did, they tended to harvest all of the trees on the property. Part of this result was likely driven by the setup of the experiment with a fixed timeframe. But it is an important aspect of any voluntary program that allows unilateral exit from agreements to understand what may drive landowners to leave those agreements or stay in them. Results from this study indicate that landowners who had strong financial incentives to stay in agreements were more likely to do so. In this study, landowners in Group 4 tended to stay in agreements so they could cash out valuable credits for woodpeckers. The weaker financial incentives in Group 3 were insufficient to effectively keep landowners in the agreements in the final periods. More research in this area could help delineate how much continued participation in voluntary conservation agreements was driven by financial incentives and how much was driven by social norms and other factors.[10]

Overall, the results of the experiment suggest that landowners will not always adjust behavior like harvesting timber in ways suggested by a profit-maximization model, although the predictions of that model do capture many of the general patterns about harvest and habitat improvement behavior.

VIII. Policy Implications and Conclusions

The results of the endangered species study described above may be relevant to regulators considering alternatives for how to promote a more cooperative environment for endangered species conservation. Specifically, the results may inform the FWS about its proposed credit program in several ways. Although the context of the experiment is not identical to the proposed policy, the study did involve landowners engaging with decisions on whether to participate in voluntary conservation efforts or destroy habitat. I highlight three implications that the FWS should consider.

[10] This line of research could tie into research of contract breach, such as Wilkensen-Ryan (2010).

First, offering financial incentives for conservation may not always lead to more conservation. As seen with the difference between harvest behavior of landowners in Groups 2 and 3, offering safe-harbor agreements plus money to encourage habitat conservation was less effective than safe-harbor agreements alone. The low harvest behavior of landowners in Group 4 indicates that higher financial incentives can be effective. As FWS determines how to distribute credits for voluntary conservation (or approve state programs that do so) and other parameters of the new regulation-driven market, it should keep this in mind. If credits are distributed broadly, it is more likely that the market price will be low and landowners will behave more like those in Group 3. Instead, more stringent standards for earning credits will make it more likely that the market price puts landowners in a situation similar to Group 4 where some decide to go all-in on endangered species habitat because of the financial incentive to do so. There is admittedly a difficult balance to strike between encouraging participation in the market, which means making it easy enough to obtain credits to make it preferable to habitat destruction, and encouraging a high enough market price to make the financial calculus favorable.[11] While there is great promise in the use of markets to encourage things like provision of wildlife habitat, there is also the possibility that market-driven incentives may crowd out other reasons why landowners may conserve wildlife habitat.

Second, FWS should consider how opportunities to trade habitat credits may crowd out more altruistic conservation in another way by providing a mechanism for guilt avoidance. As seen in the habitat improvement behavior of landowners who put a

[11] Salzman and Ruhl (2010) discuss the delicate balance required to encourage participation in a market while also having prices high enough to create incentives to affect behavior in meaningful ways.

token amount of money toward habitat improvement when they harvest a large amount of trees, even when it does not make financial sense to do so, the opportunity to contribute toward a habitat fund may in some cases prompt more habitat destruction because landowners can now do it without feeling as guilty about the plight of the endangered species. I am not suggesting that FWS or any other entity should ban conservation funds, mitigation banks, or other tools that provide people with opportunities to contribute to the conservation of habitat and species. I am suggesting that FWS should keep in mind that the opportunity to pay a penance for a sin may lead to more sins being committed, and perhaps organize policies in ways that discourage token contributions.[12]

Third, the FWS should keep in mind that there may be a flurry of activity right before or after a change in regulatory policy. As seen in Chart 1 with the large bars for harvest in the last period of the simulation, landowners were likely to respond to strong incentives that may accompany the end (or beginning) of a program. Part of this result was likely a product of the experimental design with a fixed time period of 20 years, after which the simulation was over. In the real world, landowners tend to think about property over long timeframes because at the end of a set period like 20 years, the landowner continues to manage the land, pass it on to loved ones, or sell it to someone who will care about the condition of the property.

However, the result of large harvests in the last periods, including landowners leaving conservation agreements, serves as a reminder to give forethought to what

[12] Some policy tools may naturally discourage token contributions by having relatively high fixed costs of using them. For example, conservation easements often require customized documents and bind a property in perpetuity, so there are probably not a lot of landowners entering token conservation easements.

incentives landowners may face directly before and after changes in regulatory policy. The FWS may want to use caution when considering policies that have set time horizons. Just like there is a flurry of comment letters submitted right before the closing of a public comment period on a proposed rulemaking, there may be dramatic changes in landowner activity immediately before the beginning or end of a regulatory program. If the FWS is able to predict some of this behavior, the agency can have policies in place to help handle the situation and mitigate negative consequences.

Agencies like the U.S. Fish & Wildlife Service have substantial challenges implementing a powerful law like the Endangered Species Act. The power of the law makes it a threat to landowners, so the relationship between landowners and regulators is often adversarial. Tools like safe-harbor agreements are intended to dampen the adversarial nature, and proposed market-based tools like tradable credits hold the promise of actually aligning incentives of landowners and regulators. This experiment provides evidence that safe-harbor agreements can get landowners to alter activities like timber harvests that destroy habitat. Sellable credits can also alter harvest behavior and additionally prompt landowners to actively invest in habitat improvement. However, there is a risk that low financial incentives may crowd out some of the other reasons landowners provide wildlife habitat, so regulation-driven markets should be designed with care. Despite the challenges in design and implementation, changes from the status quo hold the possibility of improving conditions for landowners and for endangered species. Win-win results like that could make the power of the Endangered Species Act an asset instead of a liability.

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FIGURES AND TABLES

Figure 1—Landowner Decision Tree from Conceptual Model

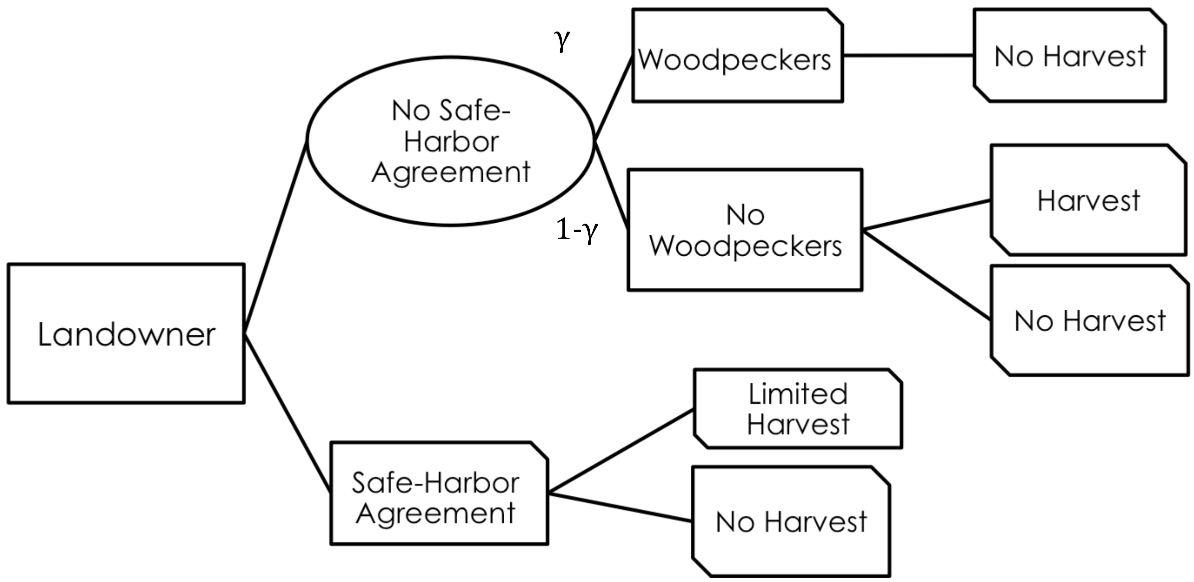
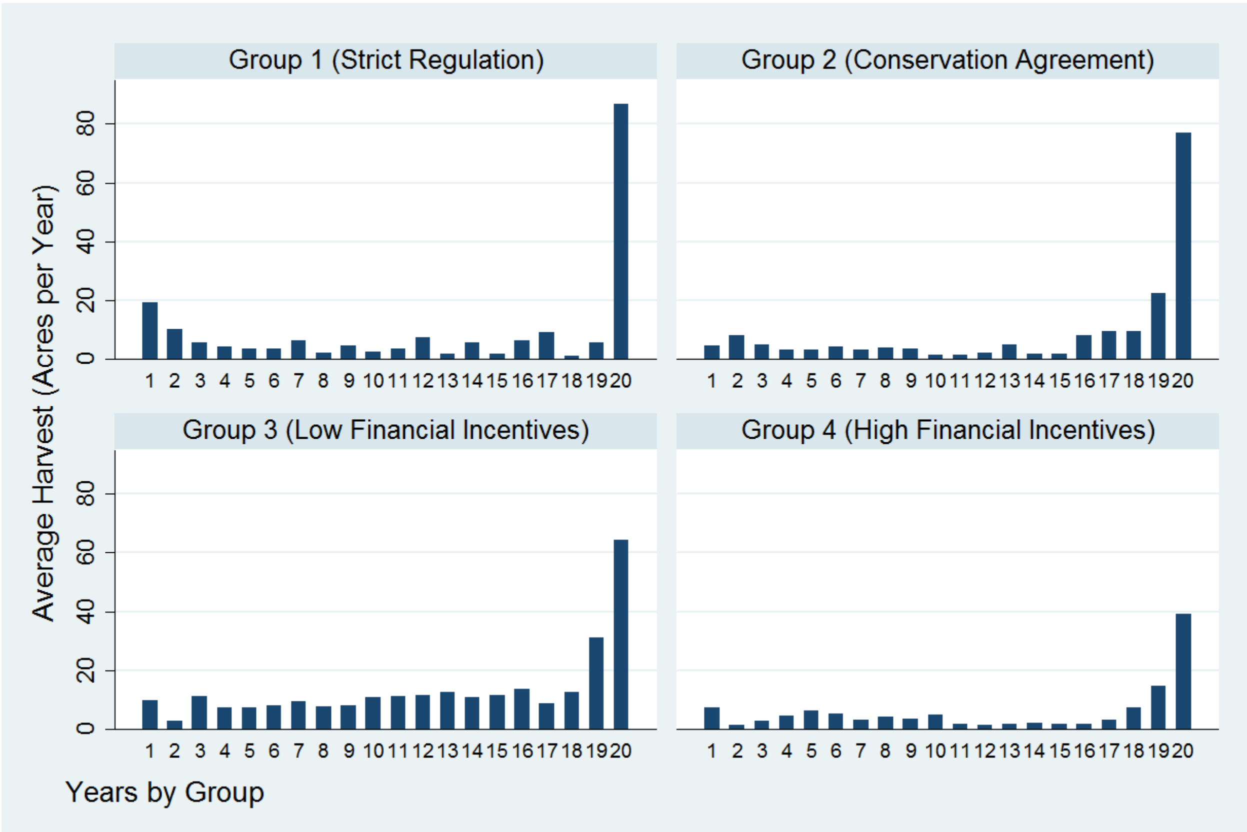


Chart 1—Harvest Behavior Over 20 Years By Group



Notes: Average harvest per year for all active landowners, excluding landowners after they were sent to the end of the game if woodpeckers moved onto properties not covered by agreements.

Chart 2—Landowner Profit Over 20 Years By Group

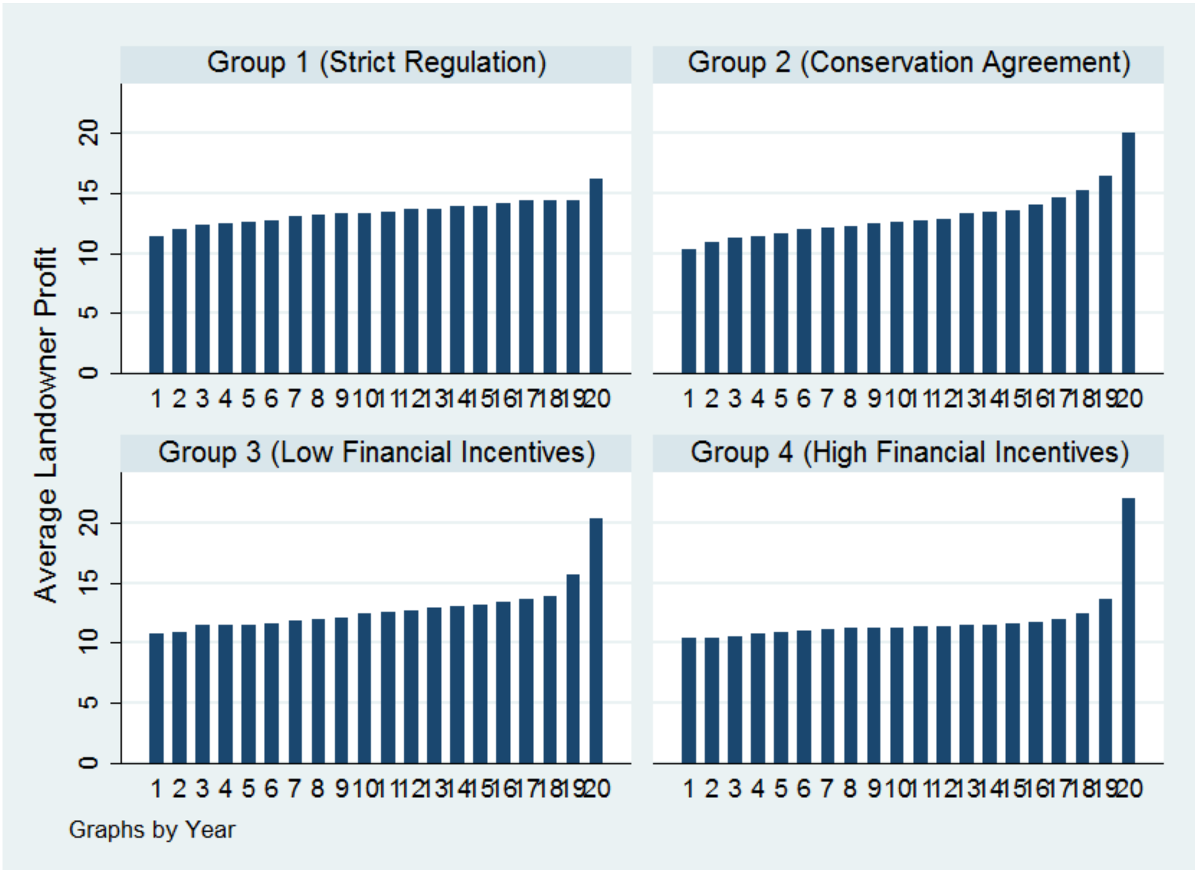


Chart 3—Average Woodpeckers on Property Over 20 Years By Group

Table 1—Timber Value and Woodpecker Probabilities by Tree Age

Tree Age	Value of Timber (ω)	Probability of Woodpeckers (γ)
20	$4.24	0%
25	$6.06	5%
30	$8.00	10%
35	$9.97	13%
40	$11.91	15%
45	$13.74	18%
50	$15.09	20%

Table 2—Summary Statistics of Participants

Group 1 (Strict Regulation)	0.29
	(0.46)
Group 2 (Conservation Agreement)	0.25
	(0.44)
Group 3 (Low Financial Incentives)	0.24
	(0.43)
Group 4 (High Financial Incentives)	0.22
	(0.41)
Age	19.65
	(2.49)
Male	0.64
	(0.48)
Nonwhite	0.49
	(0.50)
Republican	0.23
	(0.42)
Democrat	0.25
	(0.43)
Environmentalist	0.39
	(0.49)
Smoker	0.10
	(0.37)
Risk Averse	0.63
	(0.48)

Notes: N=139; Standard deviations in parentheses; All variables except age are indicator variables; Risk averse is based on a participant's response to a question about how to handle a windfall of money.

Table 3—Average Timber Harvests (Acres / Year)

Group 1 (Strict Regulation) N=599	**Group 2** (Cons. Agreement) N=646
8.816 (21.733)	7.837 (21.449)
Group 3 (Low Incentives) N=639	**Group 4** (High Incentives) N=597
12.994 (30.546)	5.762 (18.392)

Notes: Standard deviations in parentheses. Each observation is one landowner-year. Includes all active landowners, excluding landowners after they were sent to the end of the game because woodpeckers moved onto properties when they were not in agreements.

Table 4—Regression Predicting Harvest Behavior

	Harvest
Group 2 (Conservation Agreement)	-2.320***
	(0.812)
Group 3 (Low Financial Incentives)	3.770
	(4.033)
Group 4 (High Financial Incentives)	-2.830**
	(1.326)
Age	0.052
	(0.370)
Male	-0.520
	(1.403)
Nonwhite	0.437
	(2.061)
Republican	0.606
	(3.068)
Democrat	0.384
	(1.879)
Environmentalist	-2.157
	(2.499)
Smoker	-2.581
	(2.494)
Risk Averse	-1.840
	(1.979)
Constant	6.729
	(7.744)
R-squared	0.029

Notes: N=1,883; *** $p<0.01$, ** $p<0.05$. Standard errors reported in parentheses, clustered by participant. OLS model with dependent variable of harvest in acres. Each observation is one landowner-year for the first 15 years of the study. Includes all active landowners, excluding landowners after they were sent to the end of the game because woodpeckers moved onto properties not covered by agreements. Coefficients for Group dummy variables are relative to the omitted Group 1.

Table 5—Regression Predicting Exit from Conservation Agreement

	Exit from Conservation Agreement
Group 3 (Low Financial Incentives)	0.0006
	(0.0250)
Group 4 (High Financial Incentives)	-0.0432*
	(0.0245)
Risk Averse	-0.0378*
	(0.0225)
Constant	0.2160***
	(0.0695)
R-squared	0.017

Notes: N=491; *** p<0.01, * p<0.1. Linear probability model. Standard errors reported in parentheses, clustered by participant. The model includes controls for age, sex, race, political party, environmentalist, and smoking status, none of which have statistically significant coefficients. Each observation is one landowner-year for final 5 years of the study. Includes all active landowners in Groups 2-4, excluding landowners after they were sent to the end of the game because woodpeckers moved onto properties not covered by agreements. Coefficients for Group dummy variables are relative to the omitted Group 2.

Table 6—Investment in Habitat Improvement (% of Landowners Participating)

Group 1 (Strict Regulation) N=599	**Group 2** (Cons. Agreement) N=646
0.072 (0.258)	0.050 (0.217)
Group 3 (Low Incentives) N=639	**Group 4** (High Incentives) N=597
0.189 (0.392)	0.302 (0.459)

Notes: Standard deviations in parentheses. Each observation is one landowner-year. Includes all active landowners, excluding landowners after they were sent to the end of the game because woodpeckers moved onto properties when they were not in agreements.

Table 7—Regression of Habitat Improvement Behavior

	Habitat Improvement
Group 2 (Conservation Agreement)	-0.0229
	(0.0282)
Group 3 (Low Financial Incentives)	0.1030**
	(0.0457)
Group 4 (High Financial Incentives)	0.1980***
	(0.0572)
Age	0.0129*
	(0.0072)
Male	-0.0090
	(0.0356)
Nonwhite	-0.0527
	(0.0372)
Republican	-0.0241
	(0.0344)
Democrat	0.0047
	(0.0535)
Environmentalist	0.0159
	(0.0412)
Smoker	-0.0914
	(0.0573)
Risk Averse	-0.0974***
	(0.0357)
Constant	-0.0748
	(0.1410)
R-squared	0.105

Notes: N=2,424; *** p<0.01, ** p<0.05, *p<0.1. Linear probability model. Standard errors reported in parentheses, clustered by participant. Each observation is one landowner-year. Includes all active landowners, excluding landowners after they were sent to the end of the game because woodpeckers moved onto properties not covered by agreements. Coefficients for Group dummy variables are relative to the omitted Group 1.

Table 8—Average Landowner Profits ($)

Group 1 (Strict Regulation) N=41	**Group 2** (Cons. Agreement) N=36
16.22 (4.90)	20.03 (4.30)
Group 3 (Low Incentives) N=33	**Group 4** (High Incentives) N=30
20.33 (3.04)	22.00 (4.76)

Notes: Standard deviations in parentheses. Each observation is a landowner at the end of the simulation (after year 20).

Table 9—Average Number of Woodpeckers

Group 1 (Strict Regulation) N=41	**Group 2** (Cons. Agreement) N=36
1.29 (1.78)	1.50 (1.25)
Group 3 (Low Incentives) N=33	**Group 4** (High Incentives) N=30
1.79 (1.43)	2.07 (2.05)

Notes: Standard deviations in parentheses. Each observation is a landowner at the end of the simulation (after year 20).

Chapter 3—A Critical Balance: The Role of Economics in Protecting Habitat for Endangered Species

I. Introduction

A question on the General Social Survey asks respondents whether they agree or disagree with the following statement: "Natural environments that support scarce or endangered species should be left alone, no matter how great the economic benefits to your community through developing them commercially might be." As depicted in Chart 1, approximately 60% of respondents agree with the statement, 34% disagree, and 6% are unsure. As reported in the first two lines of Table 1, suburban and rural residents are more likely to agree with the statement than are people who live in urban areas. However, when the respondents live in regions with lots of endangered species (the interaction terms in the next two lines of Table 1), those preferences flip and rural and suburban people tend to view the tradeoff between conservation and economic development differently. People who live close to the land and are surrounded by nature seem to put higher value on protecting natural environments, except when protecting natural environments threatens inherited livelihoods like agriculture, forestry, and fishing. Unsurprisingly, those who are most likely to bear the burdens from conservation efforts are unwilling to give up their ways of life to protect imperiled species.

These results suggest a few things: first, people care about endangered species and the natural environments that support them. People enjoy interacting with wildlife, and even care that wildlife exists, even if they never plan to witness it or derive any material benefit from it. Second, people also care about the tradeoffs between protecting endangered species and engaging in other economic activities, especially in rural and suburban areas that may experience regulatory restrictions. In summary, data suggest that people care about both the benefits and costs of endangered species regulations.

Yet when federal agencies conduct cost-benefit analyses of endangered species regulations, the agencies almost always estimate zero benefits and nominal costs. The low estimates of both benefits and costs of endangered species regulations do not reflect the ways in which people care about the conservation of wildlife. This article describes how economic tools can help protect critical habitat for endangered species while lowering burdens on regulated parties. Economics can help achieve this win-win move by providing tools that help understand how one particular species—humans—interacts with natural resources. The use of economic tools is called for in the current language of the Endangered Species Act (ESA), so agencies can embrace the move toward more effective regulations without waiting for Congress to pass amendments to the ESA.

The ESA is a powerful environmental law that was passed in 1973 with the purpose of protecting "the ecosystems upon which endangered species and threatened species depend" (16 U.S.C. § 1531(b)). To achieve this purpose, Congress delegated authority to the Fish and Wildlife Service (FWS) and the National Marine Fisheries Service (NMFS) to regulate public and private parties that engage in activities that may affect endangered and threatened species.[13] The FWS and NMFS work to protect imperiled species by going through regulatory steps to determine whether the species warrant protection by being listed as endangered or threatened. For species that are listed,

[13] The FWS has authority over species on land and in freshwater. The NMFS has authority over marine species. The two agencies have joint authority over species that spend part of their time in marine environments and part of their time on land or in freshwater.

the agencies implement the statutory provisions that provide legal protections to threatened and endangered species. One of the major regulatory steps that the FWS and NMFS take to protect listed species is to designate critical habitat for those species. Critical habitat designation is done by the FWS and NMFS "on the basis of the best scientific data available and after taking into consideration the economic impact, the impact on national security, and any other relevant impact, of specifying any particular area as critical habitat" (16 U.S.C. § 1533(b)(2)).

The requirement to take "into consideration the economic impact" of critical habitat designation differs from the section of the ESA that calls for the FWS and NMFS to list species as endangered or threatened based "solely on the best scientific data available" (16 U.S.C. § 1533(b)(1)(A)). So the FWS and NMFS are charged with listing species as endangered or threatened without engaging in economic analysis, but are supposed to consider economic factors when designating critical habitat. Thus far, the FWS and NMFS have performed economic analysis of critical habitat designation by looking at the "incremental" change of protections for listed species (50 C.F.R. § 424.19). In practice, this has led to economic analysis that weighs low benefits against low costs because the protections afforded by critical habitat largely overlap with the protections for listed species. In most cases, the FWS and NMFS estimate benefits of proposed critical habitat as zero and costs as limited to some thousands of dollars per year for administrative costs. Commentators, such as Sinden (2004), have argued that a lack of extensive economic analysis is a good thing because more elaborate weighing of costs and benefits of critical habitat would use agency resources and may result in regulatory paralysis.

I argue in this article that more accurate economic analysis of critical habitat designation should instead weigh the broad benefits against the real costs of critical habitat. There are two main reasons why economic analysis should play more of a role in critical habitat decisions. First, statutory interpretation of the ESA points to a Congressional intent that would be best fulfilled with more accurate economic analysis. I define accurate economic analysis as the weighing of costs against benefits of proposed regulations, with measurements of costs and benefits that reflect social values of the expected changes due to the proposed policies. In Part II, I discuss statutory interpretation of the ESA to attempt to discern the intent of Congress when it comes to the role of economic analysis in critical habitat designation.

The second reason why economic analysis should play a more active role in the process of designating critical habitat is that accurate economic analysis can enable ESA regulations to be more efficient, allowing for more conservation with lower burdens on regulated parties. In Part III, I describe how cost-benefit analysis can help lead to win-win results by encouraging more effective ESA regulations. The expertise of economists can contribute to the protection of endangered species by focusing agency resources on the most promising actions that have the highest net benefits to society.

In Part IV, I turn to how to accurately measure costs and benefits of critical habitat under the ESA. I pay particular attention to measuring benefits, which tend to be more nebulous and difficult to measure than costs. The current agency estimates of zero benefits do not accurately reflect social preferences. Society values preserving imperiled species, and also values the benefits that flow from the areas protected as critical habitat. The most promising way to measure these benefits is by quantifying the values of ecosystem services like water filtration, carbon sequestration, and recreational opportunities. I argue that the best methodology for measuring benefits of critical habitat is to add together the values people place on: 1) the expected improvements to listed species due to the critical habitat designation, and 2) the value of the ecosystem services that are also protected due to the critical habitat designation.

In Part V, I provide an example of how to implement my proposed economic analysis using the recent economic analysis for critical habitat designation of the Northwest Atlantic population segment of the loggerhead turtle. As in most recent agency analyses, the estimates provided by the FWS in this analysis are of zero benefits and low costs. By using published estimates of the values of loggerhead turtles and ecosystem services that are likely protected by the proposed critical habitat, I arrive at an estimate of benefits that more accurately reflects the values society places on the proposed action of designating critical habitat along a major portion of the East Coast of the United States.

In Part VI, I conclude by discussing how more accurate economic analysis of critical habitat designation has the potential to change the dynamics of the often-lively debate that goes on between supporters and opponents of the ESA. With things like timber harvests and construction development at play, there are billions of dollars of economic activity at stake (Shogren 1998). Industries that face regulation under the ESA are quick to discuss how much economic value is lost from restrictions on timber harvest in the Pacific Northwest, solar power in the Mojave dessert, or water distribution in California. These quantified estimates lead to press coverage and statistics quoted on Capital Hill. On the other side of the conservation debate, proponents of more stringent endangered species protections talk mostly in moral terms about the importance of protecting species like spotted owls, desert tortoises, and delta smelt. Although these arguments may draw visceral responses in some audiences, they tend to provide few quotable statistics and get less press coverage. By engaging in more accurate economic analysis, the FWS and NMFS can help reframe the debate by providing credible statistics for both sides.

At the heart of the endangered species controversies are difficult tradeoffs between conserving imperiled ecosystems and developing resources in ways that affect quality of life for millions of people. By sidestepping these tradeoffs in economic analysis, the agencies implementing the ESA have missed out on an opportunity to target conservation efforts more effectively. Economic analysis can help the agencies improve the effectiveness of conservation efforts in ways that can lead to win-win situations compared with the current regime. These more accurate economic analyses can foster more balanced discussions of conservation controversies in ways that allow for better public involvement and, ultimately, more effective endangered species protections.

II. Interpreting the ESA's Call for Economic Analysis

The ESA requires economic analysis for critical habitat designation and the current practices of the agencies that implement the ESA follow the letter of the law, but not the spirit of it. This section considers different interpretations of the ESA and finds that the interpretation that best fits the intent of Congress is to have the FWS and NMFS engage in cost-benefit analysis that considers the broad benefits and real costs of critical habitat designations.

A. The Statute and Context

The ESA was passed in 1973 to provide "a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved" and to "provide a program for the conservation of such endangered species and threatened species" (16 U.S.C. § 1531(b)). The ESA requires agencies to use the "best scientific and commercial data available" when determining whether to list species as threatened or endangered. In *Tennessee Valley Authority v. Hill*, 437 U.S. 153 (1978), the U.S. Supreme Court explored Congressional intent behind the ESA and held that listing endangered species must be done based on the scientific data available and not subject to lots of exceptions. Congress endorsed this interpretation of the ESA by adding "solely" in front of "scientific and commercial data" to make it clear that the listing decision for species should not include economic factors.

At the same time, Congress was sensitive to the backlash against the decision in *Tennessee Valley Authority* because many people saw it as wasteful to prevent use of the nearly completed $100 million Tellico dam for the sake of a commercially worthless fish. So Congress passed a law explicitly exempting the Tellico dam from the ESA and started engaging in discussions about how the ESA should be amended (Salzman 1990). In 1978, Congress amended the ESA to require the implementing agencies to designate critical habitat based on the "best scientific data available *and after taking into consideration the economic impact* . . . of specifying any particular area as critical habitat" (16 U.S.C. § 1533(b)(2)(emphasis added)). The 1978 amendments to the ESA also added a committee that has authority to exempt certain activities from ESA regulations to prevent drastic outcomes like that in *Tennessee Valley Authority* (16 U.S.C. § 1538). This "God Squad" committee is usually described as an escape valve intended to prevent repeats of the Tellico dam situation (Salzman 1990).

B. Agency and Court Interpretations

As it has stood for over thirty years, the ESA allows for no role of economic analysis in the process of listing a species as threatened or endangered, but the statute requires the FWS and NMFS to engage in economic analysis when designating critical habitat of listed species. The FWS and NMFS have interpreted "taking into consideration the economic impact" in critical habitat designation as a call for analysis of the additional protections of critical habitat designation over the protections afforded to listed species under other provisions. Species listed as endangered or threatened are protected by Section 9 of the ESA from "take" by any person or organization and by Section 7 from "jeopardy" by actions involving federal agencies. To take a species is to "harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct" (16 U.S.C. § 1532(19)), which the agencies have interpreted to include habitat destruction (50 C.F.R. § 17.3). The protection against jeopardy means that agency actions must not be "likely to jeopardize the continued existence of any endangered species or threatened species" (16 U.S.C. § 1536(a)(2)). The FWS and NMFS consider these protections to be the baseline since economic factors are not supposed to be considered at that listing stage.

Critical habitat adds a protection that federal agencies may not engage in "adverse modification of habitat . . . that is deemed to be critical" (16 U.S.C. § 1536(a)(2)). As defined by the agencies in regulations, the prohibitions on take and jeopardy almost completely overlap with the adverse modification protection of critical habitat (50 C.F.R. § 17.3). With these definitions, any action that would be considered adverse modification of habitat under Section 7 would either be considered jeopardy under Section 7, take under Section 9, or both. Under this interpretation of the statute, economic analysis implemented using an "incremental" approach that looks at the benefits and costs of the added protections of critical habitat over the protections that come with listing as endangered or threatened (50 C.F.R. § 424.19), does not lead to high estimates of benefits and costs.

As a practical matter, the incremental approach leads to a narrow concept of costs and benefits because there is usually no additional increment of legal protection for critical habitat that was not already covered by the take and jeopardy protections of listing. Costs are usually limited to the administrative costs of handling critical habitat. Benefits are negligible and often left unquantified, but when quantified are usually zero. From a logistical standpoint, this allows the FWS and NMFS to avoid using extensive agency resources on economic analysis.

The incremental approach to cost-benefit analysis was challenged in *New Mexico Cattle Growers Association v. U.S. Fish & Wildlife Service*, prompting the Tenth Circuit to review the FWS's interpretation of the call for economic analysis in the ESA (248 F.3d 1277 (10th Cir. 2001)). In *New Mexico Cattle Growers*, the Tenth Circuit threw out the agency's incremental approach for taking too narrow of a view of the costs and benefits of critical habitat. According to the *New Mexico Cattle Growers* court, the narrow costs and benefits implied by the incremental approach went against Congress' intent for the FWS to use economic analysis for critical habitat designation. The FWS interpretation was not afforded substantial deference because the policy had not been implemented through notice-and-comment rulemaking. The Tenth Circuit instead held that "Congress intended that the FWS conduct a full analysis of all of the economic impacts of a critical habitat designation, regardless of whether those impacts are attributable co-extensively to other causes" (248 F.3d at 1285).

However, in *Gifford Pinchot Task Force v. U.S. Fish & Wildlife Service*, the Ninth Circuit upheld FWS's use of the incremental approach as a permissible reading of the ESA (378 F.3d 1059 (9th Cir. 2004)). Like the *New Mexico Cattle Growers* court, the Ninth Circuit did not give substantial deference to the agency's interpretation. However, when the *Gifford Pinchot* court interpreted the ESA, it found the incremental approach to be a permissible reading of the statute's call for economic analysis. So judicial reviews of the agency interpretation of economic analysis in the ESA have gone both ways, leading to a patchwork of permissible economic analysis for endangered species that would require different methodologies in Arizona and New Mexico.[14]

In an attempt to achieve a uniform national policy, the FWS and NMFS promulgated a joint rule in 2013 officially interpreting the ESA using the incremental approach with narrowly defined costs and benefits (78 Fed. Reg. 53,058 (2013)). The new method was promulgated by notice-and-comment rulemaking, so it should receive deference under *Chevron v. Natural Resources Defense Council*, which stands for the idea that courts must defer to reasonable agency interpretations when those

[14] Arizona is in the Ninth Circuit, so the FWS would be allowed to use the incremental approach there. New Mexico is in the Tenth Circuit, so the FWS would not be allowed to use the incremental approach in the neighboring state. This could be especially troubling for the FWS and NMFS with species like the Southwestern willow flycatcher that has critical habitat spanning these circuit splits.

interpretations are made with the force of law. This means that the *New Mexico Cattle Growers* case would likely come out differently if brought today because the court would give substantial deference to the agency's interpretation now that the incremental approach has gone through notice-and-comment rulemaking (*National Cable v. Brand X Internet Services*, 545 U.S. 967, 980 (2005)). If courts consider the incremental approach to be a reasonable interpretation of the ESA, the policy will likely pass judicial review going forward. Although the FWS and NMFS have used rulemaking to interpret the ESA to call for economic analysis using the incremental approach, that does not have to be the end of the discussion; there are multiple perspectives on the interpretation and the agencies could opt to promulgate new rules with different interpretations in the future.

C. Interpretations by Commentators

Various commentators outside the agencies and courts have also interpreted the ESA's call for economic analysis of critical habitat designation. Many environmental advocates have interpreted the economic analysis provision along the lines of the incremental approach and have applauded the evasion of more involved cost-benefit analysis. Sinden (2003) argues that the lack of economic analysis in the ESA is one of the law's strengths at protecting the environment. In this view, the incremental approach allows the agencies to bypass costly analysis that is often a hurdle for new regulations to cross. Resources that would have to be spent on putting prices on things that are inherently valuable for their own sake can instead be used to "put boots on the ground" actively conserving listed species.

Sinden (2003) prefers that the FWS and NMFS use "short-cut environmental standards" for economic analysis so cost-benefit analysis does not have to play a role in the ESA. Examples of short-cut methods include feasibility standards and limited balancing tests found in the Clean Air Act and Clean Water Act. She argues that Congress intended these short-cut methods in lieu of formal cost-benefit analysis. The ESA calls for “consideration of economic factors” and also charges the FWS and NMFS to consider “other relevant factors . . . based on such data as may be available at the time” (16 U.S.C. § 1533(b)(6)(C)(ii)). Sinden reads this language as evidence of Congressional intent to give the agencies implementing the law substantial flexibility in how they engage in economic analysis of critical habitat designation so that the agencies can act quickly. Sinden feels that formal economic analysis uses a lot of resources and is often used as an excuse for administrative paralysis, so she prefers an ESA that retains an element of absolutist methods to acheive its goals.

In a similar vein, Souder (1993) traces the use of economic analysis for ESA regulations and proposes that critical habitat designation should go through the public comment process spelled out in the National Environmental Protection Act (NEPA). He argues that this public involvement is preferable to formal cost-benefit analysis of endangered species regulations because estimates of the values of endangered species are difficult to pin down, so more direct appeals to public opinion on the matter can be a better way for agencies to determine whether proposed policies fit with society’s preferences. There is now a circuit split on the issue with the Tenth Circuit requiring NEPA analysis of critical habitat designation (*Catron County v. FWS*, 75 F.3d 1429, 1433 (10th Cir.1996)), and the Ninth Circuit not requiring it (*Douglas Cty. v. Babbitt*, 48 F.3d 1495 (9th Cir.1995)).

D. The Closest Fit to Congressional Intent

The current agency interpretation takes the prohibition on economic analysis for listing of species as a signal to start the economic analysis of critical habitat designation from a baseline with the species already listed and protected through those legal mechanisms. But the relationship between listing species and designating critical habitat is more complex than the few lines of text that describe them in the ESA. Designating critical habitat is required for listed species to the "maximum extent prudent and determinable" (16 U.S.C. § 1533(a)(3)(A)). Despite overlaps in the legal protections as outlined by FWS and NMFS regulations, in practice designating critical habitat has bite.

When a draft map of critical habitat for the golden-cheeked warbler in Central Texas was leaked by the San Antonio Express-News, there was a public outcry (Needham 1994). Although the golden-cheeked warbler had already been listed for some years and was protected against take and jeopardy, private landowners staged a protest at the state capital to express their displeasure with having their lands designated as critical habitat. Although the adverse modification protection only applies to activities that involve a federal agency, private landowners care about their lands being included in maps of critical habitat (Mann & Plummer 1995). Public responses to critical habitat designation are not limited to this instance; parties regularly file lawsuits relating to critical habitat, either trying to force FWS and NMFS to designate habitat for particular species, or challenging designations when they do take place. If critical habitat designation really had no bite, it seems unlikely that parties would be willing to incur the litigation costs of pursing these suits if the outcomes would not matter.

Despite the theoretical overlap in legal protections of listing and critical habitat, the designation of critical habitat causes changes in behavior in the real world. For example, Zabel and Paterson (2006) find a 37% decrease in applications for building permits on land in California that had been designated as critical habitat. List et al. (2006) estimate that properties that are included in critical habitat around Tucson, Arizona experience a 22% decline in property values.

When Congress included the requirement for agencies to consider "economic factors" in the critical habitat designation process, it is unlikely that the added requirement was intended to be a hollow bureaucratic hurdle. If Congress intended economic analysis the way the FWS and NMFS interpret it, then the requirement to consider economic factors becomes surplusage because an economic analysis that weighs no benefits against almost no costs for *all* proposed critical habitat designations does not provide helpful insight into *any* of those designations. When there is no variation across proposed designations, there is nothing informative about whether some proposals are preferable to others. Additionally, the same section of the ESA authorizes the agencies to exclude areas from critical habitat when "the benefits of such exclusion outweigh the benefits of specifying such area as part of the critical habitat" (16 U.S.C. § 1533(b)(2)). If FWS and NMFS always estimate costs and benefits to be near zero, it is difficult for the agencies to ever have estimates of benefits and costs of critical habitat that can justify excluding areas from critical habitat, as Congress intended by including that provision.[15]

[15] § 1533(b)(2) may also allow for FWS and NMFS to exclude areas from critical habitat for non-economic reasons, such as national security, although the section uses language about benefit tradeoffs in ways that suggest Congress was thinking about economics. The exclusions do not apply when it will result in extinction of the species.

In the wake of *Tennessee Valley Authority*, it is much more likely that Congress intended to amend the ESA by adding a method to address the important tradeoff between conservation and economic development. The requirement to consider economic factors when designating critical habitat can serve, like the “God squad,” as an escape valve from drastic outcomes like the Tellico Dam.

Congressional intent behind the call for economic analysis in critical habitat designation under the ESA can be discerned by considering the context of the 1978 amendments to the ESA and the timeline of agency actions. In the wake of *Tennessee Valley Authority*, Congress was explicit about economic analysis not playing a role in the listing process that, as described above, affords protections of species against take and against agency actions that involve jeopardy. At the same time, Congress was explicitly calling for economic analysis of critical habitat designation, which affords protection against agency actions that may adversely modify habitat.

The FWS and NMFS have interpreted jeopardy and adverse modification to mean similar things, although that is not the only reasonable interpretation of those terms (50 C.F.R. § 17.3).[16] But even taking those terms as identical, it could still make sense for Congress to simultaneously call for no economic analysis when listing species yet meaningful economic analysis when designating critical habitat. If Congress felt that economic factors are important but should be done at a later stage, it would make sense to exempt listing from economic analysis, but call for it in critical habitat designation.[17]

[16] One could easily imagine definitions of jeopardy and adverse modification that differ in levels of protection, which types of species are targeted, or other substantive differences.

[17] The ESA calls for the agencies to designate critical habitat concurrently with the listing of species unless it is “essential to conservation” to list the species “promptly” or critical habitat is

This avoids the need to perform economic analysis before listing, which might be important when we want to quickly give species protection, such as after an imperiled species has just been discovered and is under great threat.[18] Once species have some protections in place, Congress may have wanted the agencies to then turn to economic factors. Under this reading of the ESA, when imperiled species are discovered they are quickly listed and receive legal protections while the agencies engage in scientific research to determine the conservation needs of the species. The FWS and NMFS then decide where to designate critical habitat taking economic factors into consideration.

As mentioned above, Sinden has argued for the benefits of eschewing cost-benefit analysis when designating critical habitat in favor of short-cut environmental standards. However, Sinden's interpretation fails to give full effect to Congress's call for economic analysis. The language that she cites as "evidencing Congress's conscious decision to choose prompt agency action over regulatory perfection" (p.196) is in a portion of the statute that describes a one-year delay in implementation of the law to give the FWS and NMFS an opportunity to achieve success in meeting the statutory deadlines for critical habitat designation (16 U.S.C. § 1533(b)(6)(C)(ii)). Thus, the charge that the FWS "must publish a final regulation based on such data as may be available at the time" (16. U.S.C. § 1533(b)(6)(C)(ii)) is not strong evidence that Congress intended for the agencies to always prefer regulatory speed to regulatory effectiveness. Following the principle that courts should interpret statutory terms "in connection with . . . the whole statute," (*Dada*

"not then determinable" (16 U.S.C. § 1533(c)(6)(C)). In practice, designation of critical habitat usually occurs after listing.

[18] This was essentially the situation with the snail darter fish that held up operation of the Tellico Dam in *Tennessee Valley Authority*.

v. Mukasey, 554 U.S. 1, 2 (2008)) it is natural to read language in that portion of the statute about a one-year delay as describing how the agencies should proceed during the one-year delay. Taking language from that portion of the statute and applying it to other sections of the ESA is stripping it of the context of commanding agencies on how to implement the law during its nascent year.

Additionally, the language describing the process for critical habitat designation is very similar to the language that describes the listing process for species.[19] When considering this language within the whole act, there is a conflict if the language indicates Congress's intent for short-cut economic analysis of critical habitat designation, which is Sinden's preferred interpretation, but Congress uses the same language to show there should be no role for economic analysis in the listing process. Courts have consistently read the language in the listing process to mean economics has no role in the listing decision, so it would be incongruous to have very similar language used as a signal for short-cut economic analysis.

Interpreting "consideration of economic factors" in the ESA as a call for cost-benefit analysis is a better way to give effect to the intent of Congress to use economic tools as a factor in the decision to designate critical habitat. As discussed above, the current agency interpretation using the incremental approach does not lead to economic analysis being a meaningful factor in critical habitat decisions because the results of the methodology are always estimates of costs that are relatively low administrative costs weighed against approximately zero benefits. Without variation across proposed regulations, the current cost-benefit analysis does not offer insights into which

[19] Compare 16 U.S.C. § 1531(b) (listing species) with 16 U.S.C. § 1533(b)(6)(C)(ii) (critical habitat).

regulations best fit social preferences. It is unlikely that Congress intended this result when they called for economic analysis. Instead, Congressional intent points to a need for more accurate economic analysis. I define accurate economic analysis as a methodology that weights the expected costs of regulation against the expected benefits of regulation in a way that reflects social preferences. By measuring costs and benefits using estimates of how much people trade off environmental amenities for other things like money, the agency is able to pursue regulatory policies that best reflect the values of society.

E. How to Measure the Increment

Accurate economic analysis requires a way to measure the costs and benefits of critical habitat designation in relation to the protections against take and jeopardy that come from the listing of species. The current agency methodology assumes that the increment of protection for critical habitat is essentially zero because the adverse modification protection completely overlaps with either the Section 7 protection against jeopardy, the Section 9 protection against take, or both (78 Fed. Reg. 53,058 (2013)). However, there are other ways to measure the increment of protection from adverse modification that would give meaning to the language Congress included in the ESA to consider economic factors of critical habitat designation.

1. Non-Overlapping Protection of Adverse Modification

Courts have hypothesized (*Cape Hatteras Access Pres. Alliance v. Dep't of Interior*, 344 F. Supp. 2d 108, 130 (D.D.C. 2004)), and the FWS has acknowledged (U.S. FWS 2011), that there can be scenarios in which critical habitat designation provides protections for species that would not come from jeopardy and take protections. When areas are considered “essential to the conservation” of listed species (16 U.S.C. §

1532(5)(A)(ii)), but those areas are not currently inhabited by the species, there may be an increment of protection added by designating that land as critical habitat. FWS and NMFS acknowledge this possibility in economic analyses (U.S. FWS 2012a; U.S. NMFS 2013), but then generally avoid designating any land that is not currently occupied by the species. By doing this, the agencies are able to pay tribute to the idea that Congress intended for meaningful economic analysis of critical habitat designation, but argue that it does not apply in this particular designation. But as this appears to have become standard procedure for the agencies (U.S. FWS 2011, 2012a, 2012b, 2014; U.S. NMFS 2013), Congressional intent for economic analysis of critical habitat designation is still not being met by meaningful agency action.

2. Adverse Modification Protection in Isolation

The *New Mexico Cattle* Growers' court required FWS to measure costs and benefits of critical habitat even if those costs and benefits occurred concurrently through the protections for listed species. This essentially asks the agencies to pretend that jeopardy and take protections do not exist and measure how critical habitat designation affects behavior. There are two major challenges to this approach. First, measuring the costs and benefits of a proposed action in a vacuum goes against the White House guidance to measure costs and benefits of a proposed action against a baseline of what would occur if that action were not taken (OMB 2003). As such, methodology for economic analysis of critical habitat designation would differ in a major way from the methodologies used when performing economic analysis of other major agency actions.

The second major challenge to measuring costs and benefits of critical habitat in isolation is that it would be hard to implement. Species are always listed prior to or concurrently with critical habitat designation, so there are no examples of areas with the adverse modification protection but not the jeopardy and take protections. This makes it impossible to directly measure how the adverse modification protection in isolation affects behavior in the real world. The FWS has attempted to satisfy the *New Mexico Cattle Growers'* court by augmenting the standard economic analysis of critical habitat designation with additional information about the estimated costs and benefits of the "baseline," namely the jeopardy and take protections that come with listing the species (U.S. FWS 2014). By doing this, FWS has been able to satisfy the court's requirement to provide a broader picture of the costs and benefits of ESA protections while continuing to focus on the incremental analysis it uses in other circuits. After promulgating the 2013 rule specifying the incremental method as the preferred approach to economic analysis, the FWS may stop providing the additional detail for costs and benefits of baseline regulations (U.S. FWS 2014). With the legal and practical challenges associated with measuring the effects of critical habitat in isolation, it is unlikely that this methodology will reemerge in the near future.

3. Indirect Effects of Critical Habitat

A third way to measure the increment of protection for critical habitat is to estimate how much adverse modification protection will affect behavior by looking at empirical evidence of how people respond to critical habitat designation. As discussed above, people care about critical habitat designation in ways that suggest there are real-world consequences to these actions. When engaging in Section 7 consultations for the ESA, the FWS and NMFS estimate what indirect effects the action may have on listed species. Indirect effects are things that are "reasonably certain to occur" because of an action (U.S. FWS 1998). So if the Federal Highway Administration is consulting with the FWS about building a new highway that will run near habitat for an endangered frog, the agencies estimate how much the frog will be directly affected by construction of the road and indirectly affected by development that is spurred by the creation of the new road.

Likewise, agencies are charged with estimating indirect effects that are "reasonably foreseeable" to occur because of proposed actions as part of the NEPA review process (CEQ 2014). Indirect effects include "growth-inducing effects and other effects related to induced changes in the pattern of land use, population density or growth rate, and related effects on air and water and other natural systems, including ecosystems" (40 C.F.R. § 1508.8). For example, when the U.S. Forest Service proposes to lease a plot of land for a new ski area, the agency considers how the induced growth of new hotels, retail buildings, and housing outside of Forest Service land will affect nearby environmental amenities.

Since FWS and NMFS already engage in analysis that looks at what can be reasonably expected to occur because of an action when they engage in Section 7 consultations and NEPA reviews, the agencies already have expertise in making these predictions. Estimating the indirect effects of critical habitat designation does not pose the same methodological challenges that plague the critical habitat in isolation analysis because there are real-world examples of areas that first have only listing protections and then add the adverse modification protection. In fact, economists have already used situations like these to estimate how critical habitat affects behavior (Zabel & Paterson 2006; List et al. 2006). As discussed in Section V, these estimates can be used as a starting point for measuring the increment of protection that comes from critical habitat designation.

With accurate measurements of costs and benefits using an increment of protection based on how people respond to critical habitat designation, economic analysis can serve as the escape valve that Congress likely had in mind in the wake of the Tellico Dam experience. In addition to following with the intent of Congress, more accurate economic analysis can improve over the current approach by leading toward more effective ESA regulations.

III. Accurate Economic Analysis can Lead to More Effective Regulations

In this section, I argue that accurate cost-benefit analysis can help achieve win-win results by allowing for more conservation of endangered species while also lowering burdens on regulated parties. I draw from guidance published by the Office of Information and Regulatory Affairs, an office in the White House that specializes in economic analysis, and examine economic analyses of environmental laws performed by other agencies such as the Environmental Protection Agency.

A. Economic Analysis to Promote Effective Regulations

Economic analysis, often in the form of cost-benefit analysis, has the potential to make regulations more effective by encouraging regulations that have larger benefits with smaller costs. Both Republican and Democratic presidents have endorsed the idea that economic analysis is an important tool at promoting effective regulation. Cost-benefit analysis was originally introduced by the Reagan administration and has been utilized by every administration since. President Clinton issued Executive Order 12,866 calling for cost-benefit analysis of all major federal agency actions whenever it is possible (58

C.F.R. 51,735 (1993)). Cost-benefit analysis of proposed regulations can ensure that the expected benefits are large enough to justify the expected costs. There is not a strict rule that regulations must have positive net benefits, but it is seen as an indication of how effectively a proposed rule will achieve its regulatory goals.

The federal government's center of expertise in economic analysis of regulations is the Office of Information and Regulatory Affairs (OIRA) within the Office of Management and Budget (OMB) in the White House. The current guidance from OIRA on economic analysis is Circular A-4, which explains that the goal when estimating impacts of regulation is to measure the entire range of costs and benefits that accrue to people in the United States because of proposed regulations (OMB 2003). The preferred method for measuring benefits of regulation is to use measures of what people are willing to pay for improvements in quality of life. Costs are estimated by adding the expected administrative costs for the agency with the costs of additional burdens on regulated parties.

Cost-benefit analysis can help lead to win-win situations because resources can be focused on places where they are most effective, leading to more of the desired regulatory outcome with lower costs. Circular A-4 describes the goals of economic analysis as to "(1) learn if the benefits of an action are likely to justify the costs or (2) discover which of various possible alternatives would be the most cost-effective" (p. 2). By choosing the most cost-effective regulations, agencies are able to achieve better regulatory results.

To see how this can lead to a win-win outcomes, consider a hypothetical with an agency that is charged with protecting the national tree, the oak. This agency has the daunting task of figuring out how to protect a national symbol that is important to people and ecosystems, but also forms the basis of livelihoods from forestry to cooperage of wine barrels. Suppose that the agency is interested in pursuing a proposed policy A, where A could stand for improvement of oak savannah habitat or some other agency action. To assess whether proposed policy A to protect oaks is a net benefit to society, the agency can use economic analysis. Circular A-4 calls for the agency to clearly lay out alternatives to the proposed regulation, for example policy B that targets improvement of oak savannah habitat on federal land and policy C that is a no-action alternative. For each of the alternatives, the agency calculates the expected costs and benefits of the action. Once the expected costs are subtracted from the expected benefits, the agency has an estimate for the net benefit of each alternative. If the expected net benefit of policy A is -$50 million, then it is a signal that the rule may not be in the best interests of society. If alternative B has an expected net benefit of $50 million and alternative C has an expected net benefit of $0, then the economic analysis suggests that regulatory policy B is the preferred action. Compared with the original proposal of A, policy B can offer more effective protection of the oak that results in more benefits to society at lower costs. By moving forward with regulations that focus resources where they are most effective, the agency can do a better job fulfilling its mandate to protect our national tree.

B. Cost-Benefit Analysis of Other Environmental Regulations

The call for the FWS and NMFS to consider economic factors in critical habitat designation is similar to the calls for economic analysis in the Clean Air Act and Clean Water Act, both written around the same time as the ESA. Agencies and courts have interpreted this language for the past thirty years to mean agencies should use cost-benefit analysis when possible (U.S. EPA 2003).

To measure benefits of proposed regulations, the EPA typically relies on studies that look at how much a relevant population would be willing to pay to achieve a change in regulatory outcomes. To measure costs of proposed regulations, the EPA often relies on data provided by regulated industries to estimate the value of the burdens created by the new regulations.

For example, economic analysis of a proposed change in the standard for particulate matter in the air showed that the expected benefits of cleaner air and fewer premature fatalities caused by pollutants outweigh the expected costs by about ten to one (U.S. EPA 2012). The EPA who administers the program on air pollution considered an alternative standard that would have resulted in higher benefits, but also higher costs. By using economic analysis, the EPA had valuable information to help choose between the alternatives. Even when an agency chooses an alternative that does not have the highest net benefit, laying out the alternatives and considering the costs and benefits of them can be a valuable exercise in making thoughtful decisions that add transparency because the economic analyses are publicly available (U.S. EPA 2003).

This is not to say that cost-benefit analysis is without challenge or controversy. Measuring benefits of health and safety regulations often involves estimating the value of saving human lives, which can be a difficult exercise because, fortunately, people are not directly traded on markets. This means that economists have to estimate values of saving lives by looking at things like wage premiums for risky jobs and willingness-to-pay for safety features in consumer products. Many, such as Zelizer (2001), see estimating values of saving lives as a disrespectful practice because it appears to put a price on the value of people.

Like the EPA, the agencies that implement the ESA are likely to have some challenges and controversy when it comes to quantifying costs and benefits of proposed regulations. Despite these downsides, the FWS and NMFS can benefit from the valuable information that can be provided by accurate cost-benefit analysis of proposed critical habitat designations.

IV. Measuring Benefits of ESA Regulations

The FWS and NMFS only consider narrow categories of costs and benefits of critical habitat. This is a reasonable reading of the ESA, but it also risks missing the forest for the trees. This section discusses how broader measures of costs and benefits will lead to more accurate cost-benefit analysis that follows the guidance provided by OIRA and parallels the practices of other agencies that use economic analysis for environmental regulations.

A. Measuring Costs of Critical Habitat

The FWS and NMFS estimate that the costs of critical habitat are limited to the burdens on the agency to administer the areas. In the economics literature, people have argued that there are real costs to the ESA, including critical habitat designation. Shogren (1998) uses economic theory to show why there can be real costs to critical habitat designation for private landowners. Zabel and Paterson (2006) try to measure the empirical effect of critical habitat designation by looking at building permits issued in California before and after proposal and designation of critical habitat. They find evidence that builders expect development to be more expensive after land becomes critical habitat with a 37% decrease in the long-run supply of housing permits. This indicates that, at least on the cost side, the designation of critical habitat does matter in the market. List et al. (2006) look at the effect of critical habitat designation on property values and find a 22% decrease for properties that are within a critical habitat area in Arizona. Estimates of the magnitude of the costs of critical habitat will be used in Part V to help calibrate the scope of benefit estimates.

As pointed out in Viscusi (1992), measuring costs of regulations tends to be more of an accounting exercise than a discussion of abstract economic and policy considerations. Regulated industries and their trade associations tend to have strong incentives to quantify the estimated costs of proposed regulations and publicize those as part of their efforts to avoid or weaken regulatory restrictions. So when it comes to the ESA and critical habitat designation, groups like the American Forest Products Association, the American Builders Association, and the Oil and Gas Production Alliance are likely to be vocal with their (perhaps exaggerated) estimates of the costs. Because measuring costs is usually more straightforward than measuring benefits and there are already well-informed parties that have incentives to provide estimates of expected costs, I focus on the more vexing issue of how to measure benefits of ESA critical habitat.

B. Measuring Benefit Values of Listed Species

Following Circular A-4, the starting point for measuring benefits of ESA regulation is to use estimates of what people are willing to pay for the survival and recovery of the listed species. The benefit of the existence and revival of species can be measured through willingness-to-pay studies. Willingness-to-pay studies use various techniques to elicit from members of a relevant population how much they value a change in regulatory outcomes. When species are commercially valuable, such as salmon, estimates of benefits can be based on market prices (Loomis & Richardson 2008). More often, species are not traded on markets and benefit estimates are derived using other methods. Travel-cost studies look at how much people are willing to pay to travel to a particular place to have an experience interacting with a natural feature, such as how much a family is willing to pay to experience a whale sightseeing tour. Willingness-to-pay for travel can be used to back out how much people value the experience of seeing the whales. This can give researchers a sense for how much people value the existence and success of the species itself.

Stated-preference studies use surveys to ask people from relevant populations how much they are willing to pay for changes in regulatory outcomes. Stated-preference studies have the benefit of being flexible and allowing researchers to capture values for a range of species and scenarios, but the studies require careful attention to details like wording of questions (Arrow et al. 1993). Otherwise, estimates can vary greatly with small changes in methodology. Despite this drawback, stated-preference surveys are the most common way to measure benefits of endangered species because they are the only way to capture values for some species. For example, there are no market prices to signal the value of a commercially worthless species that people are never going to cross paths with. Yet, those same people may care about the existence of a bird in the Arctic National Wildlife Refuge that fits that description, even if the people never plan to travel there (U.S. NMFS 2002). If people care enough about that bird to pay money for its protection, then those values should count as benefits for regulatory protections for the bird.

Economists have estimated values of benefits for over forty different species (U.S. NMFS 2002). The average respondent in the studies was willing to pay an amount ranging from $12 (in 2014$) to save the Atlantic salmon in Maine to over $200 to prevent the extinction of the humpback whale. These studies can be used to calculate benefit values of protecting the species by extrapolating the survey responses over the relevant populations (Jakobsson & Dragun 1996).

Existing studies that measure willingness-to-pay for species provide starting points for estimates of benefits of protecting critical habitat of species. Although a new study for each species is the ideal way to estimate benefits of protecting species, this can prove to be cost and time prohibitive (U.S. EPA 2003). Fortunately, it is not necessary to do a new study for each species in each specific location. Benefits transfer measures can lead to reasonable estimates of benefits of saving species that have not been directly studied. OIRA's Circular A-4 recommends estimating benefits by using transfer calculations, which provide systematic ways to gather estimates from different contexts and use them to estimate benefits in a new context.

C. Measuring Benefits Values of Habitats with Ecosystem Services

This section describes why it is important to implement economic analysis with a broad sense of benefits. Benefits of endangered species are not limited to the values people place on the listed species themselves. The ESA is intended to protect "endangered species . . . and the habitats upon which depend" (16 U.S.C. § 1531(b)). So the benefits of these protections should not be limited to the benefits of the species that are listed under the ESA; when ecosystems are conserved because of the ESA, the benefits that flow from those ecosystems to people should all be counted as benefits of the regulation. For critical habitat designation, this can be done by using measures of ecosystem services like water filtration and carbon sequestration.

One way to interpret the language of the ESA is to think of the economic benefits that flow from the listed species and the ecosystems that are conserved because of the listed species. The conflict between loggers and environmentalists in the Pacific Northwest is not just about the listed Northern Spotted Owl. The conflict is about how we choose to balance economic values of harvesting old-growth timber versus the values of preserving these ecosystems that are unlikely to reappear if destroyed. There is a paradox in the current situation where the full economic value of harvesting timber is measured but the value of protecting the old-growth forest is limited to the benefits that accrue to a small handful of imperiled species. A reasonable way to measure the benefits of endangered species and the ecosystems they inhabit is to use the economic valuation tools that are often used in other fields. Ecologists think of the benefits that flow from ecosystems to people as ecosystem services (Nagle et al. 2013). Economists use various techniques to put values on these streams of services (Richardson & Loomis 2008). Using existing estimates of ecosystem services, the FWS and NMFS can start to measure some of the values of benefits that flow from the ecosystems upon which endangered species depend.

When the EPA measures benefits of air or water regulations, they measure the benefits of the reductions in the pollutant at issue (U.S. EPA 2012b). They also measure benefits of reductions in co-pollutants, meaning other pollutants that are not the direct subject of this regulation, but that are predicted to fall because of the regulation. For example, in air regulations to limit emissions of NOx, we also see drops in ground-level ozone. So the EPA estimates the benefits of lives that are saved because of reduced NOx and the benefits of lives that are saved because of reduced ozone.

The FWS and NMFS should follow suit and measure co-benefits of conservation efforts to capture the full range of benefits of critical habitat designation. They have done this a few times in the past when multiple listed species have overlapping critical habitat, like the Spotted Owl and salmon in the Pacific Northwest (U.S. FWS 2012). But this still fails to capture the full range of benefits of the regulations, just as the EPA failing to consider reductions in co-pollutants would not capture the full range of benefits for regulations that reduce NOx. The most accurate way to capture benefits of critical habitat protection is to measure the benefits of critical habitat to listed species, but also factor in a category of benefits from the conserved ecosystems.

The most promising way to measure benefits of critical habitat designation is to use metrics of ecosystem services such as carbon sequestration, water filtration and retention, and recreational values of critical habitat in addition to the existence values of the species themselves. These services provide large benefits to people who enjoy clean air, filtered water, and scenic vistas. Kareiva et al. (2012) and others have put numbers on the value of some of these ecosystem services by combining economic and ecological tools. Agencies can use these previously published valuations for ecosystem services to give a sense for what kind of benefits flow from the protection of critical habitat for endangered species. Going forward, agencies can also encourage more valuation efforts of other ecosystem service benefits.

Not all of the benefits from the ecosystems designated as critical habitat should be counted as benefits of critical habitat designation. As discussed above, the appropriate increment of protection for critical habitat should be based on how people actually respond to critical habitat designations.

There is little doubt that measuring the benefits of an old-growth ecosystem in the Pacific Northwest is not a simple accounting task because most of these benefits are not traded on markets that inform us of prices. Sometimes economists are able to estimate how those ecosystem services are used in production of goods and services in the market (Nunes et al. 2003). This can allow for backing out valuations that are based on market prices. So for something like water filtration, economists might look at how important clean water is to the input of industries that rely on clean water, such as agriculture, manufacturing, and recreation. One of the ways to put values on something like water filtration is to look at what it would cost to filter it with human technology.

Ecosystem services can also be valued with stated-preference studies, much like the benefits of species can be. Economists have estimated the value of carbon sequestration, water filtration, and a range of other services.

By accurately measuring the costs and benefits of critical habitat, the FWS and NMFS can focus conservation efforts on proposed actions that achieve high net benefits to society. This suggestion is more than a pipe dream because existing estimates of the values of species and ecosystem services can be used to improve the accuracy of economic analysis in the short term. In the long term, additional studies can provide more data points to allow more accurate quantification of costs and benefits for more species and situations.

V. Example: Critical Habitat for Loggerhead Turtles

This section provides an example of how to implement the proposed benefit measures by examining the recent economic analysis for the Northwest Atlantic population segment of loggerhead turtles. The FWS estimates the benefits of designating critical habitat along almost one-third of the Atlantic coast of the United States to be approximately zero. I use existing estimates of the benefits of protecting the turtle and the value of ecosystem services provided by the critical habitat to calculate a more accurate estimate of the benefits that flow from critical habitat designation. I estimate benefits of critical habitat designation for the North Atlantic population segment of loggerhead turtles to be around $46 million per year.

A. Current FWS Economic Analysis

Critical habitat consists of "specific areas" that are "essential to the conservation of the species" (16 U.S.C. § 1532(5)). In the case of the loggerhead turtle, critical habitat includes the coastal islands and the species of those islands that are connected to loggerhead turtles through the complex web of life. (U.S. FWS 2013). Loggerhead turtles also rely on the shallow waters and bays that are scattered along much of the Atlantic and Gulf coasts of the United States, so these marine ecosystems are proposed for designation as critical habitat by the NMFS. In total, about one-third of the coastal zone of the Southeast is proposed critical habitat for loggerhead turtles under either FWS or NMFS control.[20] The incremental approach of the agencies assumes that there are minimal costs

[20] For species like the loggerhead turtle that pass through both marine and coastal environments during their life cycles, the FWS and NMFS coordinate their regulation in ways that are in the best interests of the species.

and benefits of protections above a baseline of protections for listed species, so the estimated benefits of loggerhead turtle critical habitat are negligible.

The FWS estimates the costs of critical habitat by looking at the expected paperwork burdens of administering critical habitat. For the loggerhead turtle, this amounts to about $150,000 per year. Benefits are estimated to be unclear but negligible because there is so much overlap between protections of listed species and critical habitat. Hypothetical benefits are mentioned and described qualitatively, but are not quantified.

B. More Accurate Economic Analysis of Loggerhead Turtle Critical Habitat

As discussed in Part IV, there are advantages to measuring costs and benefits of proposed regulations using methods that accurately capture how society values the expected changes due to the regulation. A more accurate estimate of the benefits of critical habitat for the loggerhead turtle adds the values of better outcomes for loggerhead turtle to values of other ecosystem services that are preserved or improved because of the critical habitat designation.

There are two existing studies of willingness-to-pay for conservation of loggerhead turtles. Wallmo and Lew (2012) use a stated preference choice experiment on a nationally representative sample to estimate a household willingness to pay of $46.01 per year (2014$) to have loggerhead turtles recover to the point of not needing endangered or threatened status. Aggregated over 115 million households in the United States, this leads to a total annual benefit of $5.3 billion. Since the North Atlantic population segment has one-third of the world's loggerhead turtles, the benefit of saving the relevant population segment of loggerheads is $1.8 billion per year.[21]

Whitehead (1992) uses a contingent valuation model that accounts for uncertainty in recovery status of loggerhead turtles and finds that the median North Carolina household is willing to make a one-time payment of $57.36 to reduce the probability of extinction to zero for the next twenty-five years for loggerhead turtles. Assuming this response can be extrapolated to the other states that include loggerhead critical habitat, this leads to an estimated willingness to pay for loggerhead turtles of $1.09 billion, or $62.5 million per year.[22] Taken together, the studies indicate a substantial range of willingness-to-pay estimates for loggerhead turtles from $62.5 million per year to $1.8 billion per year. To address concerns noted in Arrow et al. (1993) that stated preference studies may tend to overestimate willingness-to-pay, I use the lower estimate in the range.

As discussed in Part IV, the benefits of critical habitat designation should not be limited to the listed species, but should also include benefits of ecosystem services of the critical habitat. Barbier et al. (2011) report valuations of ecosystem services for coastal wetlands. The ecosystem service of reducing storm surge is estimated to provide an annual benefit of approximately $20,000 annually per mile of coastal wetland. With

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[21] The Northwest Atlantic population segment of loggerhead turtles makes up one-third of the world population of loggerheads, but taking one-third of the total annual benefit likely underestimates willingness-to-pay for this segment because people probably care more about these domestic turtles than those overseas.

[22] $57 per household * 19.1 million households in NC, SC, GA, FL, AL, and MS. U.S. CENSUS BUREAU, USA Quick Facts 2013, *available at* http://quickfacts.census.gov/qfd/states/00000.html. Annual payment based on payments for 25 years using 3% discount rate.

approximately 2,600 miles in the loggerhead analysis, this amounts to $52 million in annual benefits.

Sandy intertidal beaches provide the ecosystem service of stabilizing sediment, which Mitsch and Gosselink (2008) estimate to be worth around $8,000 annually per mile of shore. The loggerhead analysis has 1,300 miles of beaches, so this results in $10 million in annual benefits.

But not all of these turtles, beaches, and wetlands would be destroyed without critical habitat designation. As discussed in Part II, the increment of protections of critical habitat has to be measured against the baseline of what would have been protected in a no-action alternative. The Zabel and Paterson (2006) results discussed in Part IV suggest that critical habitat designation can lead to a 37% drop in construction activity. Although this estimate is looking at the cost side of critical habitat designation, there is a close link between the opportunity costs of foregone development and the benefits of preserving an area as critical habitat. Namely, foregone development is likely to result in more natural environments and vice versa. Using this as a rough proxy of the impact of critical habitat on conservation behavior, I estimate that 37% of the values discussed above would be protected because of critical habitat designation.[23] This results in a preliminary estimate of the benefits of critical habitat designation for loggerhead turtles in the Southeast as $46 million per year.

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[23] More research is warranted in this area to get a better sense for the empirical impacts of critical habitat designation both in terms of costs imposed on regulated parties, such as in Zabel and Paterson (2006), and in terms of benefits to listed species and ecosystem services of land that is designated as critical habitat.

As studies provide valuations of additional services like shoreline recreation, the estimates of benefits can include these quantified ecosystem services as well. For now, the benefit measures can be thought of as lower bounds on the measures of benefits that flow from critical habitat. The estimate of $46 million per year of critical habitat for the North Atlantic population segment of loggerhead turtle more accurately reflects social preferences for turtles and benefits of coastal areas than the FWS estimate of approximately zero benefit for this designation.

VI. Conclusion

This section concludes with a discussion of how accurate economic analysis of critical habitat designation can help improve the discourse about the Endangered Species Act by helping focus the discussion on the tradeoffs that are at the heart of the ESA.

As discussed above, the FWS and NMFS should engage in more accurate economic analysis when designating critical habitat under the ESA. This is because it is a better fit with the language of the statute and can help lead to more effective regulations. Following these suggestions would put the FWS and NMFS more in line with guidance of the White House and practices of other agencies that implement environmental laws. The agencies have made policy choices to 1) only consider narrow incremental effects of critical habitat; and 2) value only the benefits that come from the listed species themselves. I argue that the agencies should reverse course on these two policies and promulgate a new rule that establishes a methodology of economic analysis that fulfills Congress’s call to consider economic factors when designating critical habitat. Benefits should be measured by looking at the value of listed species and the value of ecosystem services protected through critical habitat designation.

As seen with the example of the economic analysis of the loggerhead turtle, the tools for more accurate economic analysis are within reach. Current practices of the FWS and NMFS do not accurately capture the real costs and broad benefits that reflect society's feelings about the tradeoff between conservation and development. Additionally, economic analysis can be a tool that allows the FWS and NMFS to keep conserving beautiful places, but get rid of the worst of the burdens on landowners. By focusing first on regulations that provide large net benefits, the agencies can avoid some of the extreme results that get critics of the ESA really mobilized.

Climate change is likely to increase the stakes of endangered species regulation by straining both ecological and economic systems. With this additional strain, it will be increasingly important for the FWS and NMFS to be able to point to how their proposed regulations are benefiting society. Although some find it distasteful to try to put a price on nature, failing to do so often means that only opponents of conservation have numbers to wave in front of Congressional committees and the press. If the agencies that implement the ESA engage in accurate cost-benefit analysis, all sides of the argument can have more information to use when making decisions about how to best balance the conservation of resources against other social goals. Agency actions can be more transparent by clearly laying out proposed actions, alternatives, and estimated costs and benefits. All of these factors can help improve the discourse about the ESA by shifting from arguments about owls versus jobs to meaningful discussions about how to use ecosystems that are critical to improving outcomes for species and provide valuable products and services to people.

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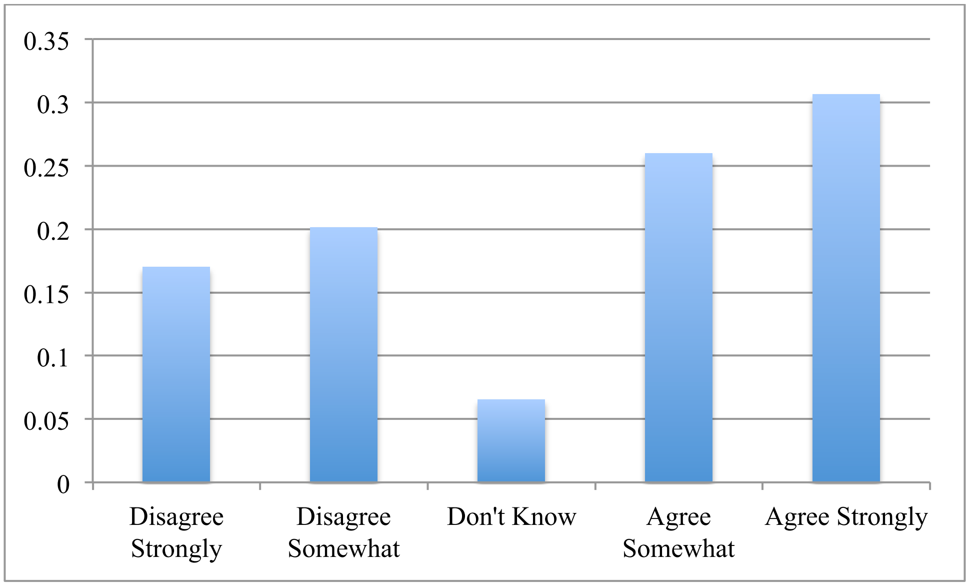
CHARTS AND TABLES

Chart 1—Public Opinion Regarding Protection of Natural Environments



Notes: Responses to General Social Survey (1998) question asking respondents how they feel about the following statement: “Natural environments that support scarce or endangered species should be left alone, no matter how great the economic benefits to your community from developing them commercially might be.”

Table 1 –Ordered Probit Regression of Desire to Protect Rare Natural Environments

	Support Conservation
Suburban	0.307***
	(0.106)
Rural	0.293***
	(0.115)
Listed species X suburban	-0.044*
	(0.025)
Listed species X rural	-0.069**
	(0.036)
Listed species	0.036
	(0.027)
Democrat	0.145*
	(0.086)
Low income	0.153
	(0.094)
High income	0.206***
	(0.073)
Education	0.028**
	(0.011)
Age	-0.003*
	(0.002)
Republican	0.065
	(0.087)
South	0.035
	(0.091)
West	-0.028
	(0.146)
Northeast	0.083
	(0.089)
Gun owner	0.356***
	(0.066)
Believes in not active government	-0.670***
	(0.064)

Notes: N=1,444. Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1; Listed species is number of threatened or endangered species in the census sub-region of the respondent. "Believes in not active government" is an indicator for those who disagree with statement that it is the role of government to provide consumers with safety information.