# *Success or Failure? Ordered Probit Approaches to Measuring the Effectiveness of the Endangered Species Act*

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ABSTRACT

The Endangered Species Act (ESA) is one of the most controversial pieces of environmental legislation. Part of the controversy stems from doubts about its effectiveness in generating improvements in species viability. This paper uses ordered probit models to test whether the ESA has been successful in promoting species recovery. We find a negative correlation between listing and species recovery. Additionally, we find evidence of positive effects for species-specific spending and the achievement of recovery goals. The evidence also shows that recovery plan completion and the designation of critical habit are not correlated or negatively correlated with recovery.

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## I. INTRODUCTION

The Endangered Species Act (ESA, "the Act") is one of the strongest pieces of environmental legislation in the U.S., and potentially one of the most costly. Smith *et al*. (1993) and Bean (1991) report a $4.6 billion estimate of the cost of implementing the ESA for all listed species. If private expenditures and the costs of foregone economic projects were added, the cost would undoubtedly be much higher.

The ESA is also extremely controversial.[1] The controversy centers on four issues. First, some natural scientists argue that the ESA's focus on species, rather than ecosystems, may limit its effectiveness (Rohlf 1991, Smith *et al.* 1993, Noss 1991). Second, the ESA may target species after it is too late to implement recovery (Smith, *et al*. 1993, Rohlf 1991). Third, others have argued the ESA is flawed in its implementation (Smith *et al*. 1993, Simon *et al*. 1995). Fourth, the ESA is criticized for placing an inordinate share of the cost of species protection on private landowners and developers. Taken to its extreme, this argument suggests that the ESA is counterproductive to the progress of a species toward recovery, as it may generate perverse incentives for landowners to manage their land in a way that harms imperiled species (Mann and Plummer 1995, Polasky and Doremus 1998, Innes 2000, Polasky 2001, Lueck and Michael 2000).

Taken together, a substantive share of the ESA's critics express doubts about its effectiveness in preventing extinctions or generating improvements in species viability. In short, its critics argue that an ESA which is biologically misdirected, administered poorly or in a politically motivated fashion, or causes landowners to take actions deleterious to species recovery is not likely to be effective in achieving its stated goal of providing a framework for the conservation and recovery of endangered and threatened species (Mann and Plummer 1995).

Some of these arguments are voiced in several papers taking a political economy approach

[1] Since 1992, the ESA has been funded only on an annual basis due to the lack of agreement on whether to weaken or strengthen it or to modify some of its provisions.

to various aspects of the implementation of the ESA, including U.S. Fish and Wildlife (FWS) listing and funding decisions (Metrick and Weitzman 1996, 1998, Ando 1999, 2001, Cash 2001, Dawson and Shogren 2001). These papers provide evidence of the influence of non-scientific factors (e.g. species' charisma, special interest group pressure, political considerations) on these decisions, but stop short of analyzing the ESA's effectiveness.

This paper takes the next step and asks how the political economy of the ESA affects its performance. We examine empirically whether ESA implementation, subject to various non-scientific pressures, has been successful in achieving its objective of species recovery. We use data on changes in the status of vertebrates in the US to construct a measure of recovery, and then attempt to statistically explain this measure. Specifically, we analyze whether, and how, the recovery of threatened species is correlated to the various components of the management process stipulated by the ESA.

The few existing studies of the ESA that ask similar questions are based on simple correlation analysis (Rachinski 1997, Foin *et al*. 1998, Beissinger and Perrine 2001, Abbitt and Scott 2001), and thus fail to simultaneously account for the many likely determinants of species recovery. In this paper, we estimate the effect of ESA listing and management actions on species recovery, while controlling for the effect of species' baseline status and biological characteristics.

In section II of the paper, we establish a framework by discussing the political economy of the ESA and its potential implications for species recovery. Section III develops the score we use to measure species recovery status. Sections IV and V present, respectively, estimates of the effects of ESA listing and ESA management actions on species recovery. A summary of results and suggestions for future research end the paper.

## II. FRAMEWORK: THE POLITICAL ECONOMY OF THE ESA

The stated goal of the ESA is to protect species facing imminent danger of extinction and to promote their recovery to the point where the protection conferred by the Act is no longer necessary. To achieve this goal, the ESA prescribes that the FWS implement a management process for endangered species. The process starts with the listing decision, followed by fund allocations, designations of critical habitat, achievement of recovery objectives, and completion of a recovery plan.

In principle, this process eventually leads to recovery of listed species. However, the implementation does not take place in a vacuum. The political economy theory introduced by Stigler (1971) and Peltzman (1976) suggests that FWS decisions may be made by economic agents in pursuit of their own objectives. For instance, preferences over characteristics of the species may drive their choices. Furthermore, interest groups, responding to the costs and benefits associated with this management process, may attempt to influence FWS decisions by appealing to these objectives. Interest groups can attempt to influence FWS decisions through comments, requests for hearings, petitions, or indirectly through Congress (Ando, 1999).

Extant empirical analyses of FWS decisions provide evidence that this is an accurate description of ESA implementation. Ando (1999, 2001) finds that the timing of FWS listing decisions responds to pressure from interest groups. Public opposition slows down the listing process, whereas public support speeds it up. Delays in the listing process may reduce the likelihood of a species' recovery, but also postpone the costs. Delays may allow potentially affected parties to take irreversible actions to preempt restrictions following a listing. Furthermore, the probability that a species receives ESA protection appears to be affected by public pressure. Metrick and Weitzman (1996, 1998) show that both scientific and visceral elements enter into the listing decision. Purely scientific factors, such as uniqueness and degree of endangerment, have a significant effect on the listing decision, but so do existence value factors like size or the degree to which a species is considered a higher form of life[2].

Similar results are found for funding decisions. Metrick and Weitzman (1996, 1998) find that FWS spending choices are determined much more by visceral than by scientific characteristics. Cash (1991) finds that funding decisions are driven by political variables. Finally, Dawson and Shogren (2001) suggest that spending is insensitive to yearly variations in time-variant factors (e.g. endangerment levels, economic conflict), but that time-invariant factors (e.g. historical use, cultural value, size, charisma) do matter. This may indicate either that FWS is taking a long-term perspective based on species/ecosystems considerations, or responding to political pressures supporting certain species.

Thus, it has been clearly established that ESA listing and management implementation is subject to numerous pressures affecting FWS decisions. What does this imply for the status of imperiled species?  At first glance, it is hard to argue that listing alone has a significant effect on species' recovery. By 1999, with 1,746 species listed (FWS 1999), only twenty-seven had been delisted: seven because they went extinct, eleven because additional information revealed listing was unwarranted, and eight because they actually recovered (Abbitt and Scott 2001). Should the fact that only seven listed species have gone extinct be considered a success? Alternatively, should we regard only eight delistings due to recovery as a failure?

The effects of the funding decisions are equally ambiguous, as higher spending does not necessarily seem to buy more recovery (Baker 1999, Bean 1999). This can be seen in Table I, which shows the ten species receiving the most federal and state spending between 1989 and 1996, and the changes in their population status between 1990 and 1996[3] (FWS 1990a, 1996a).

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[2] However, Cash (1991) repeats the analysis performed by Metrick and Weitzman including only species listed since 1982 (when Congress mandated that taxonomic class could no longer be a criterion for listing), and finds that non-scientific variables lose their explanatory power.

[3] This does not include four listed runs of salmon managed by the National Marine and Fisheries Service, who does not provide the same information as the FWS on population status.

TABLE I: TOTAL SPENDING AND CHANGE IN STATUS

| Species | Total Spending (Millions $) | % Total | Change in status |
|---|---|---|---|
| Red Cockaded Woodpecker | 128.0 | 7.79 | Declining-Improving |
| Northern Spotted Owl | 108.3 | 6.59 | Declining-Declining |
| Bald Eagle | 72.4 | 4.40 | Improving-Improving |
| West Indian Manatee | 38.3 | 2.33 | Declining-Declining |
| Grizzly Bear | 37.8 | 2.30 | Stable-Stable |
| Mojave Desert Tortoise | 37.5 | 2.28 | Declining-Uncertain |
| Colorado Squawfish | 37.2 | 2.26 | Stable-Stable |
| American Peregrine Falcon | 35.9 | 2.19 | Improving-Improving |
| Marbled Murrelet | 33.4 | 2.03 | Declining-Declining |
| Loggerhead Sea Turtle | 29.4 | 1.79 | Declining-Uncertain |

These ten species represent 1.04 percent of all listed species in 1996, but received a third of total spending, about $558 million. Of these, only the red cockaded woodpecker (*Picoides borealis*) was doing noticeably better, while the status of most others had not changed.

This pattern suggests that the political economy context in which the ESA is implemented, by influencing FWS decisions, may hinder the Act's effectiveness in generating species recovery. In the following sections, we examine whether this is likely to be the case. To do so, we start by defining a usable measure of species recovery.

## III. MEASURING ENDANGERED SPECIES RECOVERY

To assess the extent of a species' recovery, we need to know how its status changes over time and relate these changes to the ESA's management process. Ideally, we would base our analysis on changes in relevant biological indicators, such as population size, genetic diversity, reproductive rates, etc. However, such information is unavailable for most species. Instead, we must rely on assessments of conservation status prepared by various organizations, including the FWS, the International Union for the Conservation of Nature and Natural Resources (IUCN), and the Nature Conservancy/Natural Heritage Network (NC).

The FWS classifies each *listed* species as 'improving', 'stable', 'declining', 'found only in captivity', 'extinct', or 'unknown'. The latter category reflects insufficient information to assign the species to any other category. Species are assigned to categories based on changes in population and the degree of threat in the wild. FWS periodically revises its classification (the latest available is FWS 1996a).

The IUCN's "Red List" focuses on *threatened* species and classifies them as 'endangered', 'vulnerable', 'rare', or 'extinct'. In addition, IUCN has broader categories for different degrees of uncertainty. Species classified as 'indeterminate' can be endangered, vulnerable or rare, whereas 'insufficiently known' means that there is not enough information to place the species in any category. The 'threatened' category includes endangered, vulnerable, rare, indeterminate, or insufficiently known species. IUCN assigns categories based on changes in species distribution, numbers, and degree and type of threat.

NC assessments are the most complete. NC ranks *all*, not just threatened or listed, vertebrate species, using a numerical ranking. The categories are 'critically imperiled' (1), 'imperiled' (2), 'vulnerable' (3), 'apparently secure' (4), and 'secure' (5). Non-numerical categories are 'presumed extinct' and 'possibly extinct'. NC rankings reflect the risk of extinction, and are based on an evaluation of threats, total population size and trends, number of different populations or occurrences, extent of habitat, and breadth of geographic range for each species.

We choose the NC ranking system to construct a recovery score because of its five advantages relative to FWS and IUCN. First, it does not have any "uncertain" categories, such as the 'unknown' (FWS) or 'indeterminate' (IUCN) rankings. Second, each NC category has a well-defined meaning, and NC tries to apply the rankings consistently. Third, it is broader than the FWS's ranking, since there are species considered endangered, but not listed, under the ESA, in part because of long delays in the listing process (Ando 1999). Fourth, Metrick and Weitzman (1996) use the NC ranking because they consider it "the most comprehensive and objective" measure of endangerment available. Finally, by using the NC ranking we maintain consistency with nearly all extant empirical studies of the ESA (Metrick and Weitzman 1996, 1998, Cash 2001, Dawson and Shogren 2001).

A potential disadvantage of using the NC ranking is data availability. To our knowledge, no record of the NC's rankings has been maintained over time. Therefore, we have rankings only for 1993 and 1996, limiting this study to changes in species' status in this short period. Further, the data almost exclusively contains species ranked between 1 and 3 in 1993. This hints at a potential sample selection problem, which we address below.

The simplest approach to using NC rankings to assess recovery is to determine whether a species' rank has increased, remained the same, or decreased from 1993 to 1996. However, this approach has serious drawbacks. Primarily, NC rankings show little temporal species-specific variation. Eighty six percent of species exhibit no change in ranking, eight percent a decline, and only six percent show an improvement. Thus, the simple approach may not provide enough information for econometric analysis.

The simple approach also masks important information by assuming it is equivalent if a species remains stable at a low (i.e. more endangered) ranking and if it remains stable at a higher (i.e. less endangered) ranking. However, endangered species with smaller populations are more vulnerable to stochastic events, such as changes in reproductive success, genetic makeup, weather, and food availability (Gilpin and Soulé 1986). In addition, species persisting in small populations are less able to fill their functions in an ecosystem. Thus, it is qualitatively different for a species to remain stable at a higher ranking than at a lower one.

Similarly, the simple approach assumes that it is equivalent if the ranking of a species changes from, say, 'critically imperiled' (1) to 'imperiled' (2) and if it changes from 'vulnerable' (3) to 'apparently secure' (4). However, achieving further recovery can be more difficult at higher rankings, because there is more room for improvement when species are closer to extinction than when they are fairly secure. Relatively simple management actions can have a significant effect on highly endangered species, whereas achieving progress for more stable species often requires addressing more complex issues and undertaking more complicated management actions. Consider, for example, that mortality rates for the endangered Florida manatee (*Trichechus manatus*) have increased significantly since the mid-1970s (Wallace 1994). Relatively simple actions, like establishment of protected areas and waterway slow-speed zones, can address the main human-related cause of mortality (collisions with boats) and likely achieve some initial recovery. However, further recovery must address habitat degradation and pollution, and these threats are related to complex underlying causes, like Florida's rapidly growing coastal population. Thus, improvement at higher rankings is qualitatively different from improvement at lower rankings.

We extract more information from NC ranking changes by constructing a detailed measure that differentiates between changes at different levels of endangerment. Specifically, we consider an improvement better than no change and no change better than a change for worse. Additionally, improvements are better at higher than at lower rankings, declines are worse at lower than at higher rankings, and no change at a higher ranking is better than no change at a lower ranking.

The resulting recovery score, which we call RSCORE, appears in the matrix below, showing all possible changes in NC rank. The changes actually contained in our data are shown in the shaded cells, along with the corresponding score we assign. The numbers in parentheses are the percentages of species in our data found in each category.

RSCORE

| NC Rank From / To | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1 | 6 (31.5%) | 9 (1.3%) | 11 (0.6%) | 15 (0.2%) | |
| 2 | 3 (1.3%) | 7 (23.1%) | 10 (1.7%) | 14 (0.4%) | 16 (0.2%) |
| 3 | 2 (3.0%) | 4 (4.3%) | 8 (30.8%) | 12 (0.9%) | 13 (0.4%) |
| 4 | | 1 (0.2%) | 5 (0.2%) | | |
| 5 | | | | | |

To illustrate RSCORE, consider a few specific examples. The Sonora Chub (*Gila ditaenia*) declined from rank 3 to rank 1 and receives RSCORE = 2; the California Condor (*Gymnogyps californicus*) remained stable at rank 1, with RSCORE = 6; the American Peregrine Falcon (*Falco peregrinus*) remained stable at rank 3 and has RSCORE = 8; and the American Black Bear (*Ursus americanus*) improved from rank 3 to rank 5, and receives RSCORE = 13.

The distribution of listed species across categories reflects the arguments of both the ESA's critics and supporters. The majority of species (85.4 percent) showed no change in status, receiving RSCORE = 6, 7, or 8. Critics point to this widespread stasis as evidence of ESA failure; others consider it evidence of success (Mann and Plummer 1995, Bean 1991)**.** Improvements in status (RSCORE = 9 to RSCORE = 16) are achieved by 5.7 percent of species, bolstering the arguments of ESA supporters. However, its critics could point to the deterioration in status (RSCORE = 1 to RSCORE = 5) by 9 percent of species. RSCORE thus provides a mixed picture of ESA performance. It also provides a means of empirically linking changes in species viability with specific actions taken under the ESA. In the following sections, we use RSCORE to examine the ESA's effectiveness in generating species recovery.

## IV. THE EFFECT OF LISTING ON RECOVERY

We begin by considering how RSCORE is related only to the listing decision. Individuals or organizations can propose a species as a candidate for listing. If the FWS is able to collect enough data and judges that the species merits protection, it places a proposal in the Federal Register and, after public comment, makes a final decision. The species is listed as "endangered" if it is "in danger of extinction throughout all or a significant portion of its range" or "threatened" if it is "likely to become endangered in the foreseeable future" (FWS 1993b). Different taxonomic units, species, subspecies, and populations, are eligible for listing.

Once listed, a species comes under several layers of protection, followed by a prescription of management actions. This prescription is variously applied depending on the species. In this section, we estimate the effect of listing, and leave a discussion of the effect of various management actions to the following section.

Properly estimating the effect of listing on species recovery cannot be done in isolation. We must also control for the biological characteristics of the species and its baseline status. Species recovery (or degradation) is somewhat random, particularly in the case of small populations[4] (e.g. Gilpin and Soulé 1986). However, the likelihood of extinction probably depends on population size (Shaffer 1981, Goodman 1987, Pimm *et al.* 1988), longevity (Pimm *et al*. 1988), population growth rate, and the variability of growth rate and density (Goodman 1987, Pimm *et al.* 1988). Data on most of these variables is not obtainable for all the vertebrates in the U.S. However, longevity and growth rate are highly correlated with body size, which is readily available (Cash *et al*. 1998). The precise relationship between these variables remains

[4] Specifically, population size may be subject to four sources of stochasticity: (1) demographic stochasticity, which refers to survival and reproductive success; (2) genetic stochasticity, which refers to random changes in genetic make-up; (3) environmental stochasticity, which refers to unpredictable changes in environmental factors such as weather, food supply, etc.; and (4) natural catastrophes, such as floods, droughts, etc.

controversial (Pimm *et al*. 1988, Tracy and George 1992, Bennet and Owens 1997). Due to data availability, we rely on Johst and Brandl's (1997) apparently unifying result, a U-shaped relationship between body size and extinction. We include body length (BODYLENGTH) and its square ($BODYLENGHT^2$) as explanatory variables. We also include indicator variables to control for taxonomic differences (MAMMAL, AMPHIBIAN, BIRD, REPTILE) and an indicator variable for monotypic species (MONOTYPIC). Finally, we use the IUCN categories from 1990 to control for population size, and other baseline ecological determinants of species recovery. The antecedent IUCN ranking is, *a priori*, exogenous to changes in species recovery from 1993 to 1996.

To estimate the effect of ESA listing on species recovery, we regress RSCORE on a vector of recovery determinants, including the indicator variable LISTED = 1 if the species is listed as endangered or threatened under the ESA. Since RSCORE is discrete and logically ordered, we use the ordered probit maximum likelihood method for estimation (see Appendix). We also pursue a strategy of estimating several versions of the model and testing for endogeneity and sample selection bias to determine whether the estimated effects of listing are robust. Table II provides definitions and descriptive statistics for all the variables we use.

TABLE II: VARIABLE DESCRIPTIONS AND SUMMARY STATISTICS

| *Variable* | *Description* | *Mean* | *St.Dev.* |
|---|---|---|---|
| LISTED | Dummy: Species listed | 0.42 | 0.3E-03 |
| TIMEL | Time species has been listed (years) | 18.03 | 9.29 |
| CONFLICT | Dummy: Conflict with development | 0.39 | 0.9E-03 |
| PRIORITY | FWS conservation priority ranking: 1-18 | 5.79 | 3.54 |
| Management: | | | |
| SPENDING | Total spending on species, 1989-1996 | 4108 | 12567 |
| HABITAT | Dummy: Critical habitat designated | 0.28 | 0.7E-03 |
| PLAN | Degree of recovery plan completion (1-6) | 4.47 | 1.88 |
| SOMEPLAN | Dummy: Recovery plan initiated, not complete | 0.45 | 0.9E-03 |
| FINALPLAN | Dummy: Final recovery plan completed | 0.52 | 0.9E-03 |
| OBJECTIVES | Percentage of recov. objectives achieved (1-4) | 1.46 | 0.80 |
| OBJECTIVES2 | Dummy: 26-50% of recov. object. achieved | 0.17 | 0.5E-03 |
| OBJECTIVES3 | Dummy: 51-75% of recov. object. achieved | 0.10 | 0.3E-03 |
| OBJECTIVES4 | Dummy: 76-100% of recov. object. achieved | 0.03 | 0.1E-03 |
| Baseline Status: | | | |
| ENDANGERED | Dummy: Red List endangered status | 0.12 | 0.1E-03 |
| VULNERABLE | Dummy: Red List vulnerable status | 0.13 | 0.2E-03 |
| RARE | Dummy: Red List rare status | 0.11 | 0.1E-03 |
| INDETERMINATE | Dummy: Red List indeterminate status | 0.02 | 0.2E-04 |
| UNKNOWN | Dummy: Red List unknown status | 0.02 | 0.2E-04 |
| REDLIST1 | Numerical values for Red List categories: 0-4 | 3.24 | 1.10 |
| Biological: | | | |
| BODYLENGTH | Species’ body length (cm.) | 64.9 | 284.68 |
| MAMMAL | Dummy: species is a mammal | 0.16 | 0.2E-03 |
| AMPHIBIAN | Dummy: species is an amphibian | 0.11 | 0.1E-03 |
| BIRD | Dummy: species is a bird | 0.22 | 0.2E-03 |
| REPTILE | Dummy: species is a reptile | 0.09 | 0.1E-03 |
| MONOTYPIC | Dummy: species is the only one in its genus | 0.07 | 0.8E-04 |

Table III presents the initial RSCORE ordered probit results, with four variants of the basic model. Turning first to the baseline and biological variables, Models 1-4 suggest, as expected, that species with a lower IUCN ranking (poorer baseline status) in 1989 are less likely to achieve more recovery, or a higher RSCORE. For example, in Models 1-3, the coefficient for IUCN’s ENDANGERED species is negative and statistically significant, while INDETERMINATE species have a positive, although insignificant coefficient. For biological determinants (Models 2-4), the results consistently suggest that REPTILE species are less likely to achieve higher levels of recovery, while other taxa coefficients are never statistically significant.

Consistent with Jost and Brandl's (1997) results, the estimates for BODYLENGTH and its square suggest a significant positive but diminishing relationship between species size and recovery. In addition, MONOTYPIC species appear to be less likely to achieve higher recovery scores.

TABLE III: EFFECT OF LISTING ON RECOVERY

| | MODEL 1 | MODEL 2 | MODEL 3 | MODEL 4 |
|---|---|---|---|---|
| Constant | 3.32 | 3.30 | 3.31 | 2.79 |
| LISTED | -0.63*** | -0.59*** | -0.58*** | -0.60*** |
| BODYLENGTH | 0.61E-02*** | 0.71E-02*** | 0.66E-02*** | 0.70E-02*** |
| $BODYLENGTH^2$ | -0.16E-04** | -0.18E-04** | -0.17E-04** | -0.18E-04** |
| REDLIST1 | ----- | ----- | ----- | 0.14*** |
| ENDANGERED | -0.42*** | -0.53*** | -0.54*** | ----- |
| VULNERABLE | -0.02 | -0.09 | -0.09 | ----- |
| RARE | -0.15 | -0.18 | -0.21 | ----- |
| INDETERMINATE | 0.50 | 0.49 | 0.49 | ----- |
| UNKNOWN | 0.11 | 0.27 | 0.27 | ----- |
| MAMMAL | ----- | 0.09 | 0.11 | 0.06 |
| AMPHIBIAN | ----- | -0.11 | -0.13 | -0.10 |
| BIRD | ----- | -0.18 | -0.17 | -0.23 |
| REPTILE | ----- | -0.42** | -0.41** | -0.42** |
| MONOTYPIC | ----- | ----- | -0.28E-02*** | -0.27E-02*** |
| Log Likelihood | -836.9 | -832.7 | -828.4 | -792.2 |
| Mc Fadden's $R^2$ | 0.04 | 0.05 | 0.05 | 0.05 |

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

Most notable is the estimated influence of LISTED. Over Models 1-4, LISTED's parameter estimate is significantly negative, suggesting a negative correlation between listing and species viability (additional models were estimated with different ways of including a species' Red List status in 1990, and the results remain robust). The calculated marginal effects (not shown) re-enforce this conclusion. The estimates show that a listed species has a lower probability of having an RSCORE>8, and a higher probability of decline, with RSCORE $\leq 7$.

To explore the robustness of the result that listing is negatively related to species viability improvement, we perform three additional experiments. First, although most species were listed before 1993, we test for the endogeneity of the listing decision, since a species with a lower RSCORE may be more likely to have been listed, and vice versa. Conducting a Hausman test (Greene 2000), we estimate a reduced-form probit model for the listing decision and obtain a predicted probability that each species is listed. We entered the difference between LISTED and the prediction as a regressor into Models 1-4. The t-statistics on the coefficients for this regressor ranged from –0.18 to –0.39, so we fail to reject the null hypothesis that LISTED is exogenous.

In a second experiment, we explore the possibility that the length of time a species is listed influences recovery. This effect cannot be captured when LISTED enters as an indicator variable. In Models 5-8, we interacted LISTED with the number of years a species has been listed, so that LISTEDxTIMEL is zero for non-listed species and the length of listing for listed species. The results, presented in Table IV, are nearly identical, with no substantive changes to the coefficients of any baseline or biological variables. The LISTEDxTIMEL coefficient is invariably negative and statistically significant, again suggesting a negative correlation between being listed and the longer a species has been listed the greater the impedance.

TABLE IV: EFFECT OF TIME LISTED ON RECOVERY

| | MODEL 5 | MODEL 6 | MODEL 7 | MODEL 8 |
|---|---|---|---|---|
| Constant | 3.16 | 3.22 | 3.24 | 2.55 |
| LISTEDxTIMEL | -0.02*** | -0.02*** | -0.02*** | -0.02*** |
| BODYLENGTH | 0.69E-02*** | 0.82E-02*** | 0.76E-02*** | 0.79E-02*** |
| $BODYLENGTH^2$ | -0.17E-04** | -0.19E-04** | -0.18E-04** | -0.18E-04** |
| REDLIST1 | ----- | ----- | ----- | 0.18*** |
| ENDANGERED | -0.56*** | -0.67*** | -0.69*** | ----- |
| VULNERABLE | -0.09 | -0.13 | -0.14 | ----- |
| RARE | -0.21 | -0.22 | -0.26* | ----- |
| INDETERMINATE | 0.36 | 0.37 | 0.36 | ----- |
| UNKNOWN | -0.07 | 0.15 | 0.12 | ----- |
| MAMMAL | ----- | 0.13 | 0.16 | 0.11 |
| AMPHIBIAN | ----- | -0.09 | -0.08 | -0.05 |
| BIRD | ----- | -0.18 | -0.13 | -0.18 |
| REPTILE | ----- | -0.51*** | -0.50*** | -0.53*** |
| MONOTYPIC | ----- | ----- | -0.28E-02*** | -0.28E-02*** |
| Log Likelihood | -820.6 | -823.8 | -810.5 | -779.7 |
| Mc Fadden's $R^2$ | 0.04 | 0.04 | 0.05 | 0.05 |

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

Third, we allow for the possibility that listing has a different effect on different taxa. This is consistent with the political economy literature showing that FWS favors different taxa (e.g. Metrick and Weitzman 1996,1998). We reestimated our models interacting the taxonomic dummies with the listing variables (e.g. MAMMALxLISTED). The results are presented in Table V.

TABLE V: EFFECT OF LISTING ON RECOVERY OF DIFFERENT TAXA

| | MODEL 9 | MODEL 10 | MODEL 11 |
|---|---|---|---|
| Constant | 3.25 | 3.25 | 2.87 |
| BODYLENGTH | 0.54E-02** | 0.51E-02** | 0.54E-02** |
| $BODYLENGTH^2$ | -0.15E-04** | -0.14E-04* | -0.15E-04* |
| REDLIST1 | ----- | ----- | 0.10** |
| ENDANGERED | -0.44*** | -0.44*** | ----- |
| VULNERABLE | -0.92E-02 | -0.63E-02 | ----- |
| RARE | -0.15 | -0.17 | ----- |
| INDETERMINATE | 0.43 | 0.44 | ----- |
| UNKNOWN | 0.12 | 0.12 | ----- |
| MAMMALxLISTED | -0.47** | -0.45** | -0.55*** |
| AMPHIBIANxLISTED | -0.79** | -0.78** | -0.93** |
| BIRDxLISTED | -0.59*** | -0.57*** | -0.64*** |
| REPTILExLISTED | -0.64*** | -0.62*** | -0.61** |
| FISHxLISTED | -0.69*** | -0.68*** | -0.68*** |
| MONOTYPIC | ----- | -0.28E-02*** | -0.28E-02*** |
| Log Likelihood | -836.2 | -831.9 | -800.7 |
| Mc Fadden's $R^2$ | 0.04 | 0.05 | 0.05 |

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

Remarkably, the parameter estimates for the interacted taxa and LISTED variables are all negative and statistically significant ($\alpha \leq .05$), and there are no substantive changes to the other parameter estimates. These results suggest the negative correlation between listing and recovery holds across different taxa, and there is no apparent pattern of differential effects for higher order taxa. This latter result may be surprising given the previous findings that the FWS seems to favor mammals, birds, and fish (Metrick and Weitzman 1996, 1998, Simon *et al*. 1995).

In a final experiment, we test for sample selection bias, since the dependent variable contains almost only species considered somewhat endangered by the NC, i.e. only species that have NC ranks of 1,2, or 3. We use Heckman's two-step procedure. In the first step, the selection equation is estimated. The dependent variable is RANK3 = 1 if NC rank $\geq$ 1 in 1993, 0 otherwise. The estimated coefficients are used to calculate the inverse Mills ratio, $\hat{\lambda}$. In the second step, we include $\hat{\lambda}$ as an additional regressor in the RSCORE ordered probit regression. The results appear in Table VI. The parameter estimates for $\hat{\lambda}$ are not statistically significant in Models 12-15, so we fail to reject the null of no sample selection bias. Even with these models, potentially corrected for sample selection bias, we find a negative correlation between listing and recovery. With the exception of MONOTYPIC, all of the other coefficients retain their signs and statistical significance.

TABLE VI: SAMPLE SELECTION BIAS TEST

| | MODEL 12 | MODEL 13 | MODEL 14 | MODEL 15 |
|---|---|---|---|---|
| Constant | 3.22 | 3.50 | 3.50 | 2.79 |
| LISTED | -0.61*** | -0.67*** | -0.66*** | -0.65*** |
| BODYLENGTH | 0.58E-02** | 0.73E-02*** | 0.74E-02*** | 0.75E-02*** |
| BODYLENGTH$^2$ | -0.16E-04** | -0.18E-04** | -0.18E-04** | -0.18E-04** |
| REDLIST1 | ----- | ----- | ----- | 0.16*** |
| ENDANGERED | -0.42** | -0.64*** | -0.63*** | ----- |
| VULNERABLE | -0.97E-02 | -0.20 | -0.19 | ----- |
| RARE | -0.16 | -0.34* | -0.34* | ----- |
| INDETERMINATE | 0.51 | 0.48 | 0.48 | ----- |
| UNKNOWN | 0.12 | 0.19 | 0.18 | ----- |
| MAMMAL | ----- | 0.11 | 0.11 | 0.07 |
| AMPHIBIAN | ----- | -0.19 | -0.19 | -0.13 |
| BIRD | ----- | -0.11 | -0.11 | -0.19 |
| REPTILE | ----- | -0.49** | -0.49** | -0.47** |
| MONOTYPIC | ----- | ----- | -0.06 | -0.07 |
| $\hat{\lambda}$ | 0.03 | -0.35 | -0.35 | -0.22 |
| t – statistic | (0.10) | (-0.93) | (-0.91) | (-0.75) |
| Log Likelihood | -827.3 | -822.7 | -822.6 | -791.9 |
| Mc Fadden's $R^2$ | 0.04 | 0.05 | 0.05 | 0.04 |

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

## V. SPECIES RECOVERY AND ALLOCATION OF RESOURCES

Commencing with ESA listing, a species may be the subject of several administrative actions, including designation of critical habitat, development of a recovery plan, species-specific spending, and other less-easily-measured methods of accomplishing recovery objectives. In this section, we estimate the effect of these management actions on species recovery.

**A. Management of endangered species under the ESA**

Designation of critical habitat links recovery to the importance of habitat and ecosystem protection. Section 4 of the ESA originally required that critical habitat be designated for each species listed. However, amendments enacted in 1982 require critical habitat designation only to the "maximum extent prudent and determinable". Furthermore, the amendments allow consideration of economic impact in the designation of critical habitat. Rohlf (1991), Clark (1994), Smith *et al*. (1993), and others criticize the FWS for failure to designate sufficient acreage or, for the majority of species, any acreage at all. Supporters of the amendment contend that designation of critical habitat has a negative effect on the economy. Moreover, Belovsky *et al*. (1994) contend that habitat loss is generally not decisive in species extinction when populations are already small. In 1996, 27% of listed vertebrates had critical habitat designated (FWS 1996a). We measure this management action with an indicator variable, HABITAT.

The second action triggered by listing is the preparation of a recovery plan. Section 4 requires the FWS to develop recovery plans for listed species, unless such plans would "not promote the conservation of the species." Recovery plans identify management tasks and research needs, and identify measurable criteria to determine when recovery objectives have been attained. Some species do not have recovery plans, either because a state management plan is used instead or because the FWS considers the species probably extinct. In 1996, 79% of listed vertebrates had a recovery plan (FWS 1996a). To measure this management action, we use the variable PLAN, a 1-6 discrete variable increasing as the recovery plans moves closer to completion.

The FWS has been widely criticized for recovery plan procedures and results. Tear *et al*. (1995) argue that most plans fail to provide biological data essential for recovery decisions, including species abundance, demographics and dynamics. Moreover, recovery plans are subject to lengthy delays (Smith *et al.* 1993). Plans frequently require five or more years for approval (Tear *et al*. 1995). The plan for the Northern Rocky Mountain wolf was 14 years in preparation. Furthermore, recovery plans are not binding agreements and critics argue that they are not implemented in many cases (Smith *et al.* 1993). Others argue that recovery plans sacrifice good biology for economic considerations or, alternatively, fail to address the political realities of species recovery (see Smith *et al*. 1993).

A third action is the allocation of federal and state dollars to promote recovery, such as habitat acquisition, censuses, mitigation, and scientific research. Species-specific spending was $348 million in 1995, an increase of over 800 percent since 1985 (Baker 1999). Some argue that current spending levels are inadequate to achieve the ESA’s stated goals, but that additional spending would lead to improvements (Smith *et al*. 1993, Mann and Plummer 1995, and Bean 1991). Critics argue that funds are poorly spent and the goals are impossible to achieve. Simon *et al*. (1995) find that species-specific spending is unrelated to FWS recovery rankings, but may reveal taxonomic biases. However, we are not aware of any studies directly testing the effectiveness of spending. Species-specific funding (SPENDING) is total federal and state expenditures directed toward the recovery of a species for the years 1989-1996 (FWS 1989, 1990b, 1991, 1992b, 1993, 1994b, 1995, 1996b). SPENDING includes all expenditures that are “reasonably identifiable” for a specific species, such as habitat acquisition, scientific research, population censuses, etc. Expenditures not assigned to a specific species and spending from private sources are not included.

An output-oriented measure of management action reported by FWS is the accomplishment of recovery objectives. It is important to distinguish between species recovery plans and recovery objectives. One can think of the elaboration of a recovery plan as more of a formal requirement, whereas recovery objectives are specific goals set for “on the ground” management of a species[5]. Furthermore, preparing a recovery plan is not a necessary condition for achieving recovery objectives. In 1996, the recovery plan for the least bell's vireo (*Vireo bellii pusillus*) was under development, but between half and three quarters of its recovery objectives had been achieved (FWS 1996a). The accomplishment of recovery objectives is measured discretely as OBJECTIVES = 1 if 0-25 percent of objectives were achieved as of 1996, 2 if 26-50 percent, 3 if 51-75 percent, and 4 if 76-100 percent.

We also control for three other factors. As in previous models, we interact the length of time the species has been listed with LISTED. Similarly, we include interaction variables for: CONFLICT=1 if the FWS determines that the recovery of the species with conflict with economic development, and PRIORITY, a FWS ranking of the priority assigned to a species' recovery.

**B. Estimated Effects of ESA Management Actions**

We estimate the effect of ESA management action variables in an ordered probit model of RSCORE. Management action variables are included as interactions with LISTED, so these variables are always zero for non-listed species. Parameter estimates for various model specifications appear in Table VII. In Models 16 and 17, both of the LISTEDxSPENDING and the LISTEDxOBJECTIVES coefficients are positive and statistically significant, suggesting that these management actions are effective in promoting recovery. Both the coefficients for LISTEDxHABITAT and LISTEDxPLAN are negative, although only the latter is statistically significant. This is an unexpected result, suggesting that management efforts to write a recovery plan are counterproductive.

To explore further, we estimate MODELS 18-19 with a separate intercept for LISTED species, to distinguish between species that are listed but have essentially been ignored by the FWS

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5 For instance, in the 1994 report to Congress the recovery objectives for the roseate tern (*Sterna dougallii dougallii*) included "increase nesting population to 5,000 pairs, including 6 productive colonies with more than 200 pairs, sustained for 5 years" (FWS, 1994a).

in measurable management procedure and those that are not listed. That is, spending may be zero for a species because it is not listed, and thus not eligible for funds, or because it is listed but has received no funds.

TABLE VII: EFFECT OF MANAGEMENT ACTIONS ON RECOVERY

| | MODEL 16 | MODEL 17 | MODEL 18 | MODEL 19 |
|---|---|---|---|---|
| Constant | 3.40 | 3.34 | 3.46 | 3.44 |
| LISTED | ----- | ----- | -0.73** | -0.76** |
| LISTEDxSPENDING | 0.19E-04*** | 0.19E-04*** | 0.23E-04*** | 0.23E-04** |
| LISTEDxHABITAT | -0.12 | -0.11 | -0.30* | -0.28* |
| LISTEDxPLAN | -0.09*** | -0.10*** | -0.03 | -0.02 |
| LISTEDxOBJECT. | 0.22*** | 0.20** | 0.19** | 0.19** |
| LISTEDxCONFLICT | 0.02 | 0.03 | -0.02 | -0.01 |
| LISTEDxTIMEL | -0.02*** | -0.02** | -0.01 | ----- |
| LISTEDxPRIORITY | 0.18E-02** | ----- | 0.03 | ----- |
| BODYLENGTH | 0.50E-02** | 0.51E-02** | 0.57E-02** | 0.45E-02* |
| BODYLENGTH$^2$ | -0.15E-04* | -0.15E-04* | -0.14E-04* | -0.13E-04 |
| ENDANGERED | -0.52*** | -0.51*** | -0.40** | -0.50*** |
| VULNERABLE | -0.12 | -0.09 | -0.08 | -0.09 |
| RARE | -0.17 | -0.17 | -0.26* | -0.30** |
| INDETERMINATE | 0.40 | 0.42 | 0.45 | 0.48 |
| UNKNOWN | -0.12 | -0.09 | -0.07 | 0.01 |
| MAMMAL | 0.05 | 0.05 | 0.09 | 0.13 |
| AMPHIBIAN | -0.09 | -0.09 | -0.10 | -0.15 |
| BIRD | -0.25 | -0.26* | -0.28* | -0.32** |
| REPTILE | -0.36** | -0.35** | -0.45** | -0.42** |
| MONOTYPIC | -0.02 | -0.02 | ----- | -0.30E-02*** |
| Log Likelihood | -811.87 | -814.23 | -792.44 | -789.25 |
| McFadden's $R^2$ | 0.06 | 0.06 | 0.07 | 0.07 |

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

In Models 18-19, the coefficient for LISTED is negative and statistically significant. This is consistent with the results from the previous section. As in Models 16-17, both of the LISTEDx SPENDING and the LISTEDxOBJECTIVES coefficients are positive and statistically significant, indicating that these management actions are effective in promoting recovery. However, the coefficients for LISTEDxHABITAT and LISTEDxPLAN are negative, but now the effect of habitat is statistically significant, albeit marginally so. The length of time a species has been listed always has a negative coefficient, but in Model 18 the effect is not significant. Similarly, the effect of FWS priority rankings is positive in models 16 and 18, but insignificant once listed and unlisted species are distinguished.

We tested models 16-19 for endogeneity of the listed and listed-management variables by estimating predicted values for these potentially endogenous variables and entering the difference between the variables and their predicted values as regressors in the models. The p-values for a Wald test of joint non-significance of these regressors range from 0.29 to 0.53, so the null of no joint endogeneity could not be rejected. We also tested for sample selection bias using the Heckman two-step procedure, and the null of no sample selection bias could not be rejected (the t-statistics for the inverse Mill's ratio ranged from 0.36 to 1.09).

We calculated marginal effects using estimates from Model 19 and find a consistent change in sign at RSCORE=6, with the direction of change depending on the sign of the variable's coefficient. Increases in SPENDING and achievement of recovery objectives decrease the probability of a lower recovery score (RSCORE $\leq$6) and increases the probability of a higher recovery score (RESCORE $\geq$7). Listing and critical habitat designation increase the probability of RSCORE $\leq$6, and decrease the probability of RSCORE $\geq$7.

## VI. SUMMARY AND DIRECTIONS FOR FUTURE RESEARCH

Prior research contains strong evidence that the implementation of the ESA is beset by problems of interest group and political pressure and possible bureaucratic biases. However, very little evidence exists on whether the ESA is effective in promoting species recovery. This paper contributes to filling this vacuum.

Our main empirical findings are as follows: First, a species listed under the ESA has poorer prospects for recovery than a species not so listed. Second, for listed species, some FWS management actions are effective in promoting recovery, some seem to have no effect, and some may be counterproductive. Species-specific spending and the achievement of recovery objectives are effective instruments for species recovery. Conversely, we find that designation of critical habitat and recovery plan completion have, at best, no effect on recovery. The finding of a positive marginal effect for spending indicates higher funding for endangered species could increase species viability, if the funds are directed in a species-specific manner. Thus, last year's cut of $9.1 million in the endangered species program budget (Associated Press 2001) could imply slower recovery.

Third, our results show that the existence of conflict with development and the time a species has been listed do not have a significant effect on recovery. The result concerning economic conflict is not easy to interpret. One possible explanation is that the FWS is in fact heeding the ESA mandate that economic considerations should not affect decisions concerning the management of endangered species. As for the time a species has been listed, our result may imply that once we control for the effect of the original listing decision, spending, and management effort, merely being listed longer does not increase the likelihood of recovery. That is, a species that is listed longer may receive more spending and management effort over time. This, and not the passage of time *per se*, may contribute to recovery.

The disturbing finding that listing and, perhaps, other management actions have deleterious effects on recovery suggests modifications of the ESA. Which modifications will be appropriate depend on the correct explanation for these findings. Although it is beyond the scope of this paper to explore why the ESA appears to fail in some cases, it is useful to outline prospects for future research.

Our finding could be purely statistical, the result of an unrepresentative sample, multicolinearity, or inadequate data. This is always possible and a strong case can be made for spending additional resources on collecting biological and economic data relevant to the ESA. However, this explanation is unlikely in our opinion. Our sample of NC rankings is large and comprehensive and has been used by others to obtain widely acknowledged results. Further, we also used changes in FWS rankings to construct a similar dependent variable and were never able to obtain a positive estimated listing effect. We have also subjected our models to several specification tests; the finding of a deleterious listing effect is robust.

The finding may support critics who say the ESA process is slow to respond to species in peril and, once a species is listed, administrative actions are weak. If "too little, too late" is the source of apparent ESA ineffectiveness, policy makers may consider allocating additional resources and speeding the listing process. This explanation could be tested by estimating models which allow for more negative listing effects for species in greater peril at the time of listing. Unfortunately, the requisite baseline data at the time of listing are absent. The vast majority of species were listed before 1993, the first year of NC rankings we used.

Finally, the finding is consistent with those who argue that an ESA listing (or its prospect) creates perverse incentives for private landowners to harm the species. If perverse incentives yield ineffectiveness, the ESA might be modified to provide more positive incentives. Negative incentives, if salient, are more likely to affect species existing on private land, so this explanation is testable by allowing the effect of listing to vary as the proportion of a species' range is more confined to public land. Unfortunately, the requisite data on species' ranges are unavailable for many listed and un-listed species.

Of course, a single study cannot provide conclusive evidence on ESA effectiveness. We hope that this paper piques the interest of economists, natural scientists, and statisticians to gather additional data to explore other models of the political, administrative, and biological basis of species viability.

APPENDIX: ECONOMETRIC DETAILS

Given the ordered nature of the dependent variable used in our analysis, the appropriate econometric model is the ordered probit. Specifically, the recovery of an endangered species can be specified as a function of various FWS management variables and of characteristics of the species: $y_i^* = \boldsymbol{\beta' x_i} + \varepsilon_i$, where $y_i^*$ is species recovery, $\boldsymbol{\beta}$ is a vector of parameters, $\boldsymbol{x_i}$ is a vector containing FWS management actions and species characteristics, and $\varepsilon_i \sim N(0,1)$ is the residual. Species recovery, $y_i^*$, is unobservable, but we can observe the corresponding recovery score, given by the variable RSCORE: $\text{RSCORE}_i = 1$ if $0 < y_i^* \le \mu_1$, $\text{RSCORE}_i = 2$ if $\mu_1 < y_i^* \le \mu_2$, … , $\text{RSCORE}_i = 16$ if $\mu_{15} \le y_i^*$ for $i = 1 \ldots n$ species, where the $\mu_j$ are threshold parameters to be estimated along with $\boldsymbol{\beta}$. The corresponding probabilities that each score is observed are given by

$\text{Prob}(\text{RSCORE1}_i = 1) = \text{Prob}(\varepsilon_i \le \mu_1 - \boldsymbol{\beta' x_i}) - \text{Prob}(\varepsilon_i < -\boldsymbol{\beta' x_i}) = \Phi(\mu_1 - \boldsymbol{\beta' x_i}) - \Phi(-\boldsymbol{\beta' x_i})$,

$\text{Prob}(\text{RSCORE1}_i = 2) = \text{Prob}(\varepsilon_i \le \mu_2 - \boldsymbol{\beta' x_i}) - \text{Prob}(\varepsilon_i < \mu_1 - \boldsymbol{\beta' x_i}) = \Phi(\mu_2 - \boldsymbol{\beta' x_i}) - \Phi(\mu_1 - \boldsymbol{\beta' x_i})$,

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$\text{Prob}(\text{RSCORE}_i = 16) = \text{Prob}(\mu_{15} - \boldsymbol{\beta' x_i} \le \varepsilon_i) = 1 - \Phi(\mu_{15} - \boldsymbol{\beta' x_i})$,

where $\Phi(.)$ is the cumulative density function of the standard normal distribution.

The likelihood function for this model is given by

$$L = \prod_{RSCORE=1}[\Phi(\mu_1 - \beta' x_i) - \Phi(-\beta' x_i)] \prod_{RSCORE=2}[\Phi(\mu_2 - \beta' x_i) - \Phi(\mu_1 - \beta' x_i)] \cdot \cdot \cdot$$

$$\cdot \cdot \cdot \prod_{RSCORE=15}[\Phi(\mu_{15} - \beta' x_i) - \Phi(\mu_{14} - \beta' x_i)] \prod_{RSCORE=16}[1 - \Phi(\mu_{15} - \beta' x_i)].$$

The parameter estimates are obtained by maximizing this likelihood function.

*Marginal Effects*

The marginal effects in the ordered probit model require careful interpretation, as they are not equal to the coefficients, nor do their signs necessarily correspond to the coefficients' signs. Specifically, the marginal effect for a continuous variable is given by

$$\frac{\partial \Pr(RSCORE = i)}{\partial x_j} = [\phi(\mu_{i-1} - \hat{\beta}' x) - \phi(\mu_i - \hat{\beta}' x)]\hat{\beta}_j \quad ,$$

where $\phi(\cdot)$ is the standard normal probability density function (Greene 2000).

To calculate the marginal effect for a discrete variable $x_j$, define $x_{js}$ and $x_{jf}$ as the starting and final values of $x_j$, respectively. Additionally, define $\overline{x_{-j}}$ as the vector of all regressors, except $x_j$, evaluated at their sample mean. Then

$$Pr(\text{RSCORE} = i|x_{js}) = \Phi[(\mu_i - \hat{\beta}_j x_{js} - \hat{\beta}_{-j}' \overline{x_{-j}})] - \Phi[(\mu_{i-1} - \hat{\beta}_j x_{js} - \hat{\beta}_{-j}' \overline{x_{-j}})]$$

$$Pr(\text{RSCORE} = i|x_{jf}) = \Phi[(\mu_i - \hat{\beta}_j x_{jf} - \hat{\beta}_{-j}' \overline{x_{-j}})] - \Phi[(\mu_{i-1} - \hat{\beta}_j x_{jf} - \hat{\beta}_{-j}' \overline{x_{-j}})]$$

The marginal effect of $x_j$ is $\Delta Pr(\text{RSCORE} = i) = Pr(\text{RSCORE} = i|x_{jf}) - Pr(\text{RSCORE} = i|x_{js})$ for $i = 1,\ldots, 16$ (Long 1997).

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