Analysis of the listing of species as endangered or threatened under the Endangered Species Act
by Andrea L Easter-Pilcher

A thesis submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Biological Sciences
Montana State University

Abstract:
The Endangered Species Act of 1973 (Act) was sweeping in its purpose of mandating protection and conservation for endangered and threatened species and the ecosystems upon which they depend. Two decades later we recognize a breach between the promise of these mandates and the reality of implementation.

Behavior of the United States Fish & Wildlife Service (Service) in implementing the Act was examined. Specifically, an investigation was conducted to determine whether an objective and consistent methodology is implicit in the selection of species to list as endangered or threatened (Chapter 1). The priority guidelines criteria for selecting candidate species for listing consideration; and for selecting listed species for recovery efforts were also examined (Chapter 2).

Chapter 1: Federal Register (FR) final rules for four classes of animals [mammals (n=119), birds (n=39), fish (n=60), and reptiles (n=54)] listed from January 1, 1975 -June 21, 1991 were examined. All biological information reported in the FR and pertinent to the listing decisions were compiled and analyzed.

An abundance of missing data was found throughout the final listings. Variables (biological criteria) were not defined and were inconsistently used (both across classes and within classes) by the Service. Descriptive variable categories were not defined relative to each other and did not correlate with related quantitative variable values. There were no clearly defined biological thresholds distinguishing endangered species from threatened species. A jackknifed discriminant analysis of all variables misclassified 96 of the 272 listed species examined.

Chapter 2: Priority guidelines criteria for selecting petitioned and candidate species to consider for listing, and for selecting listed species for recovery actions were examined. The author found that the criteria, as set forth in the guidelines, are not specific enough to allow for objective and equitable ranking of species for listing consideration and recovery actions.

Systematic consideration of biological, objective, and defined criteria would significantly improve the scientific validity and the effectiveness of the listing process.

ANALYSIS OF THE LISTING OF SPECIES AS ENDANGERED OR THREATENED UNDER THE ENDANGERED SPECIES ACT

By

Andrea L. Easter-Pilcher

A thesis submitted in partial fulfillment
of the requirements for the degree

of

Doctor of Philosophy

in

Biological Sciences

MONTANA STATE UNIVERSITY
Bozeman, Montana

December 1993

APPROVAL

of a thesis submitted by

Andrea Lee Easter-Pilcher

This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

12/9/93
Date

Daniel Goodman
Chairperson, Graduate Committee

Approved for the Major Department

15 December 1993
Date

Robert S. Moore
Head, Major Department

Approved for the College of Graduate Studies

12/28/93
Date

R L Bowers
Graduate Dean

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ACKNOWLEDGEMENTS

I would like to thank Dr. Daniel Goodman for his critical yet diplomatic guidance, for the unselfish sharing of his time, and for his unequivocal support and encouragement as this project unfolded. These are hallmarks of an excellent advisor and I was the fortunate beneficiary.

I would also like to thank my other committee members, Dr. Peter Brussard, Dr. Michael Gilpin, Dr. Mark Shaffer and Dr. Jeff Banfield for their pertinent advice and thoughtful reviews of my proposal and the ensuing dissertation drafts.

My husband Brian Pilcher, has been my staunch advocate throughout this process, perceptively critiquing dissertation drafts, taking over care of our infant daughter and in general riding out the ups and downs of his wife's graduate work with great equanimity and boundless support and encouragement.

This dissertation is dedicated to my daughter, Emily Cady Pilcher. She and children of her generation will inherit the earth. The decisions that we, as scientists and policy makers, effect regarding our natural resources will impact that inheritance. We must be true to ourselves and true to them.

Partial funding for this project was provided by Environmental Protection Agency Cooperative Agreement: CR-820086 to Montana State University, Dr. Daniel Goodman, Principal Investigator.

TABLE OF CONTENTS

TABLE OF CONTENTS--Continued

LIST OF TABLES

LIST OF TABLES---Continued

LIST OF TABLES---Continued

LIST OF FIGURES

LIST OF FIGURES--Continued

LIST OF FIGURES--Continued

LIST OF FIGURES--Continued

LIST OF FIGURES--Continued

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ABSTRACT

The Endangered Species Act of 1973 (Act) was sweeping in its purpose of mandating protection and conservation for endangered and threatened species and the ecosystems upon which they depend. Two decades later we recognize a breach between the promise of these mandates and the reality of implementation.

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An abundance of missing data was found throughout the final listings. Variables (biological criteria) were not defined and were inconsistently used (both across classes and within classes) by the Service. Descriptive variable categories were not defined relative to each other and did not correlate with related quantitative variable values. There were no clearly defined biological thresholds distinguishing endangered species from threatened species. A jackknifed discriminant analysis of all variables misclassified 96 of the 272 listed species examined.

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DISSERTATION INTRODUCTION

The Endangered Species Act (Act) when signed into law on December 28, 1973 by President Richard Nixon was sweeping in its mandate of protection and conservation of endangered and threatened species and the ecosystems upon which they depend.

> The Congress finds and declares that-
> (1) various species of fish, wildlife, and plants in the United States have been rendered extinct as a consequence of economic growth and development untempered by adequate concern and conservation;
> (2) other species of fish, wildlife, and plants have been so depleted in numbers that they are in danger of or threatened with extinction;
> (3) these species of fish, wildlife, and plants are of esthetic, ecological, educational, historical, recreational, and scientific value to the Nation and its people...The purposes of this Act are to provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved....It is further declared to be the policy of Congress that all Federal departments and agencies shall seek to conserve endangered and threatened species and shall utilize their authorities in furtherance of the purposes of this Act.[1]

Conservation was defined as follows:

> The terms conserve, conserving, and conservation mean...the use of all methods and procedures which are necessary to bring any endangered species or threatened species to the point at which the measures provided pursuant to this Act are no longer necessary.[2]

Congress also delineated which organisms should be eligible for protection under the Act.

> The term fish or wildlife means any member of the animal kingdom, including without limitation any mammal, fish, bird,...amphibian, reptile, mollusk, crustacean, arthropod or other invertebrate....The term plant means any member of the plant kingdom.[3]

Historical Perspective

The Endangered Species Act of 1973 (Act) reflected the growing involvement of the Federal government in areas of wildlife management which had up until 1900 been the sole responsibility of the states. Evolving national attitudes regarding wildlife management, as reflected in the contents of federal acts passed since 1900, are embodied in the Act.

The Lacey Act (1900) was the first major piece of federal legislation concerning wildlife management. It was an attempt by the government to control interstate commerce in wildlife taken in violation of state law. The Lacey Act was followed in 1918 by the Migratory Bird Treaty Act which recognized both the need for federal acquisition of refuges for migratory birds and also the need to regulate the taking of migratory birds. The passage of the Fish and Wildlife Coordination Act (1934) was an attempt to compel consideration of development impacts on wildlife.

The Endangered Species Protection Act (1966) was the first attempt by the government to introduce legislation which dealt solely with endangered species. Its purpose was to restore, conserve and protect domestic species of fish and wildlife that were believed to be threatened with extinction. The major limitations of the 1966 Act were that it did not extend protection to foreign species, and it did not place any restrictions on the taking of endangered species or restrict

interstate commerce in same. The responsibility for restricting take was left up to the states. Federal agencies were required to protect applicable habitat only "insofar as is practicable and consistent with the primary purposes of such bureaus."[4]

The 1966 Act was replaced in 1969 by the Endangered Species Conservation Act. This Act expanded the scope of species protection to include those species threatened with extinction anywhere worldwide. Importation of such species into the United States was restricted. But, Federal agency requirements to protect applicable habitat remained as in the 1966 Act.

Motivation for passage of the 1973 Act was several-fold. Extension of protection to species that were vulnerable to extinction (threatened) as well as to all phyla of plants and animals was considered essential for successful species preservation (Bean 1983). It was also recognized that the obligation of Federal agencies to avoid adverse impacts on endangered species needed to be more specific (Bean 1983). The Federal government also recognized the need for greater control over the taking of endangered species. The concept of critical habitat was introduced in the 1973 Act. By the 1973 legislation, Federal agency actions were ordered not to modify or destroy critical habitat (Bean 1983).

The Act passed virtually unopposed at a time of high environmental enthusiasm (Yaffee 1982) when the majority of

the country had rallied around the bald eagle, the African elephant and other charismatic fauna. Given the pro-environmental climate of the times, full support of the Act was a safe, indeed even a sound, political move for both the President and members of Congress.

Since 1973, there have been numerous administrative, legislative and litigative attempts (see below) to weaken the mandate of the Act. The courts however, have consistently affirmed that:

> the plain language of the Act, buttressed by its legislative history, shows clearly that Congress viewed the value of endangered species as 'incalculable' ....The plain intent of Congress in enacting this statute was to halt and reverse the trend towards species extinction, whatever the cost.[5]

Today, in a recession-bound economy, the political climate across the country does not match that of 1973. The perceived and real economic and social costs of species and habitat conservation are thought, by many, to be greater than any potential benefit to be derived from that conservation. Legislators from districts which see themselves as impacted economically by endangered species decisions may court political suicide by fully endorsing the Act.

The Act will be considered for reauthorization in the next few months and is drawing fire from all sides. Much criticism of the Act at this important juncture in its history is well intentioned but misplaced.

> In the face of...political challenges it is important not to create the erroneous impression that the Act itself is the culprit, an impression that carries the real danger of becoming even more fuel for the fire of those who, claiming the Act 'doesn't work,' would like to scale back its provisions (O'Connell 1992).

We must clearly distinguish the sound statute that is the Act from what has been remarkably ineffective implementation of the same. It is in this spirit that this paper is written.

Dissertation Goals

The goal of this study is to examine the complete set of biological data presented in the final listings and then relate those data to Service listing decisions.

Wilcove, McMillan and Winston (1993) examined recent proposed and final listings of domestic species to determine the composition of these listings in terms of class groups (mammals, birds etc.) and taxonomic level (species, subspecies and populations). They also examined the rarity of these species by assessing the size and number of populations reported (given a numeric value) at the time of listing.

They found that 2%, 18% and 80% of recent listings comprised populations, subspecies, and species respectively. However, this finding was not consistent across classes. The majority of recent listings for mammals and birds were in fact subspecies or populations. They also found that reported population sizes (in FR proposed and final listings) varied significantly in magnitude at the time of listing. They

observed that many species, subspecies, and populations are not listed until their numbers are exceedingly low while other species are listed while there is still a sizeable number of individuals remaining.

Tear, Scott and Hayward (in press) have examined the biological data presented in the recovery plans to determine whether recent criticisms (vertebrate bias, lack of biological information etc.) leveled at those plans are justified. They find a paucity of biological data in the recovery plans and report that the importance of population size and numbers varies widely across taxonomic groups. They suggest that population goals have been set which are not "biologically defensible"...and which "risk management for extinction rather than away from it." Indeed, they report that median population size is substantially lower in revised recovery plans than in the original plans. They recommend, among other things, the incorporation of multiple species and ecosystem level concepts into the recovery plans (see Chapter 2).

This dissertation goes beyond the contribution of Wilcove et al. (1993) and examines the full complement of data (approximately 50 biological variables including population size and numbers) presented in the final listings from 1975 - 1991 for both foreign and domestic species. This complete set of biological data is then related to the FWS decision process of selecting species to list as endangered or threatened (Chapter 1).

Specifically, the data used for assigning species to degree-of-threat categories are analyzed to determine: (1) the scientific basis of the assignments; (2) the objectivity of the assignments; and (3) the consistency and equitability of the assignments across species. Assignment of a species to the category of endangered or threatened can significantly affect that species' level of protection, as well as affect the allocation of discretionary recovery monies under the Act. It is important, therefore, that the assignment of organisms to degree-of-threat categories be objective, scientific, and consistent across species to ensure that those in greatest need of protection and recovery funding receive just that.

The case will be made, based upon a thorough examination of the published record of final listing decisions as well as the law and regulations, that there is little evidence of objective standards against which decisions for selecting species to list as endangered or threatened can be measured.

In addition, this dissertation (Chapter 2) examines the 1983 priority guidelines criteria for selecting candidate and petitioned species to consider for listing and for selecting listed species for recovery actions. The intent of this examination was to determine whether the criteria, as set forth in the guidelines, are specific enough to allow for objective and equitable ranking of species for listing consideration and recovery actions.

Appendix A presents the procedural aspects of the listing process. Appendix B presents a profile of candidate and federally listed species. Appendix B also details delisting and emergency listing actions that have been implemented up through July 15, 1991. Appendix C presents the list of species considered for this study. Appendix D presents comparative histograms for the descriptive variables examined in this study. Appendix E presents a list of the category 3A candidate species (species now thought to be extinct). The data classification form is presented in Appendix F. Appendix G is a data codification form of the abstracted study variables and their categories. And, the original database is presented in Appendix H.

Dissertation Objectives

(1) Examine the listing results of the ESA from 1973 - 1991;

(2) Determine whether there is an objective and consistent methodology evident in the behavior of the Service when selecting species to be listed as endangered or threatened;

(3) Determine whether there are definitive biological differences between circumstances of organisms listed as endangered and organisms listed as threatened;

(4) Examine the priority guidelines criteria for selecting candidate and petitioned species for listing consideration;

(5) Examine the priority guidelines criteria for selecting listed species for recovery actions.

> ...a decision may be rational if it can be tested or 'verified' against criteria or data determined independently and if it satisfies a goal thought, on *a priori* grounds, to be appropriate for that science. The criteria and the data used are supposed to be 'objective' in the sense that they minimize interpretation and judgment so that, at least in principle, anyone who applies the same criteria to the same data will get the same result...(Sagoff 1987).

CHAPTER 1

ANALYSIS OF THE LISTING OF SPECIES AS ENDANGERED OR THREATENED UNDER THE ENDANGERED SPECIES ACT

Introduction

"The key determination from which all other consequences of the Endangered Species Act flow is the determination to list a species as endangered or threatened" (Bean 1983). Yet, there is no set process to guide the decision of whether a species is endangered or threatened (GAO 1989).

Authority to list species as endangered or threatened resides exclusively with the Secretaries of Interior and Commerce (Bean 1983). Implementation of the Act is overseen by the United States Fish & Wildlife Service (FWS) and the National Marine Fisheries Service (NMFS). Regulations issued by these two agencies govern how the Act is officially interpreted, how terms in the Act are defined, and how the Act is brought into play (Rohlf 1991).

Historical Perspective

Evolution of the Criteria Used to List Species as Endangered or Threatened

With the passage of the 1966 Endangered Species Protection Act (ESPA) the Secretary of Interior (Secretary) was enjoined to publish in the Federal Register (FR) the names of those species threatened with extinction. He was to make that decision upon determining that a "species' existence was endangered because its habitat is threatened with destruction, drastic modification,or severe curtailment, or because of overexploitation, disease, predation, or because of other factors...."[6] He was required to consult with states which would be affected by the listing and solicit advice from interested parties.

The 1969 Endangered Species Conservation Act (ESCA) required the Secretary to use the "best scientific and commercial information available to him...."[7] in selecting species to list as endangered. The standard of "best scientific and commercial information available" carried over into the 1973 Endangered Species Act.[8] The 1973 Act enjoined the Secretary to consider the following factors when considering species for listing as endangered or threatened:

> (1) The present or threatened destruction, modification, or curtailment of its habitat or range;
> (2) Over-utilization for commercial, recreational, scientific, or educational purposes;
> (3) Disease or predation;

> (4) The inadequacy of existing regulatory mechanisms; or
> (5) Other natural or manmade factors affecting continued existence.[9]

Amendment language in 1982 required that the Secretary base a species' listing "solely on the basis of the best scientific and commercial data available."[10] The addition of the word "solely" was intended to ensure that only those factors relating to the biological status of a species would be considered.

> The Committee strongly believes that economic considerations have no relevance to determinations regarding the status of species and intends that economic analysis requirements of Executive Order 12291[11] do not apply....Applying economic criteria to the analysis of these alternatives and to any phase of the species listing process is applying economics to the determinations made under section 4 of the Act and is specifically rejected by the inclusion of the word "solely" in this legislation.[12]

Conservation Law Foundation v. Watt (cited in Smith 1984) overturned an agency decision on grounds of failure to meet this requirement ("failure to use best scientific knowledge available violates not only procedural requirement, but also substantive mandate").

Degree-of-Threat Categories:
Endangered and Threatened

Just as the Convention on International Trade in Endangered Species of Wild Fauna and Flora did, the 1973 Act established degrees of vulnerability (two) which allowed for differing

levels of protection (Bean 1983). The Act also extended protection to all phyla of plants and animals.

Endangered and threatened species are defined as follows:

> Endangered species means any species which is in danger of extinction throughout all or a significant portion of its range. Threatened species means any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.[13]

That portion of a species' range which constitutes a "significant portion" remains undefined in the law and in the regulations. Implementing regulations promulgated by the Service give no guidance (Bean 1983). I recognized no readily apparent thresholds which would separate species "in danger of extinction" from those "likely to become endangered." Both definitions imply an element of likelihood of extinction with no statement as to how disparate that likelihood is.

While there are no apparent definitional thresholds to distinguish "endangered" from "threatened" species (an issue which this chapter will examine further) the protective measures of the Act treat the two categories quite differently. Protection of threatened species is at the discretion of the Secretary who determines and implements "such regulations as are necessary and advisable to provide for the conservation of such species."[14] Endangered species receive the full protection of the Act which includes prohibitions on importation into or exportation out of the United States, prohibitions on the taking of any species

within the United States, prohibitions on the taking of any species on the high seas, prohibitions on possessing, prohibitions on selling in interstate commerce or foreign commerce, and prohibitions on transporting or possessing species taken in violation of the Act in interstate or foreign commerce.[15]

Listing as endangered or reclassifying from threatened to endangered status affects priorities for recovery plans.

> The species with the highest degree of threat have the highest priority for preparing and implementing recovery plans...the high category means extinction is almost certain in the immediate future because of a rapid population decline or habitat... destruction.[16]

This statement implies, and has been interpreted as meaning, that species listed as endangered (highest degree of threat) will be given the highest priorities in terms of allocation of resources for development and implementation of recovery plans.[17] For example, the Schaus swallowtail butterfly (reclassified from threatened to endangered) "will benefit by giving increased priority to its recovery needs...."[18]

Because the endangered or threatened designation is considered when ranking a species for priority recovery action, it is important that the methods used to establish those levels be plainly understood and consistent (Mace & Lande 1991).

Objectives of Chapter 1

Chapter 1 examines the behavior of the Service in implementing the Act. Specifically, I investigate whether an objective and consistent methodology is implicit in the selection of species to list as endangered or threatened.

The Data

The Endangered Species Act requires that all data pertinent to the listing decisions be presented in the FR final listings.[19] Final listings average 5-6 pages in length and are presented in a standard narrative format in the FR. Data were collected from the FR for all endangered and threatened vertebrates from January 1, 1975 - June 21, 1991. The exceptions to this were those organisms listed on July 14, 1976 for which no data were provided. Final listings made prior to 1975 were not comparable and provided much less information.

Preliminary examination indicated that different biological criteria [variables (italicized throughout this paper)] were emphasized depending upon the class of organism (mammals, birds etc.) being considered for listing. Accordingly, species were separated into class-based groups.

Data from the final listings for 96 endangered mammals (of which 6 were marine), 23 threatened mammals (of which 3 were marine), 30 endangered birds, 9 threatened birds, 22

endangered reptiles, 32 threatened reptiles, 31 endangered fish, and 29 threatened fish comprise the database for this paper. Amphibians were not considered in this study because of the small sample size. There were only 7 amphibian listings to be examined. Reclassifications and delistings were not considered. A complete list of the species included in the database can be found in Appendix C.

Methods of Abstraction

Final listings (from the four classes delineated above) were examined, and all biological criteria (variables) apparently pertinent to the listing decision were recorded. This process was repeated twice (a total of three passes through the final listings) to ensure that no piece of information was overlooked.

Many of these variables were considered by the Service across all four classes while others were specific to one, two, or three classes. Several more of these abstracted variables were only used in a single listing (less than 1% use) or in a dozen or fewer listings (less than 5% use). Because of the extremely rare occurrence of these variables in the final listings, they were not included in the database or the analyses. However, these variables provide information regarding use, or lack thereof, of biological criteria by the Service. They are presented in Table 1. Also included in this table is the percent use for each of these variables

Table 1. Percent use within classes for rare variables. Rare variables were reported in less than 5 percent of all final listings and less than 10% of the final listings within each class. Total use = percent of all final listings which reported the variable, num = numeric value only, des = descriptive value only.

Variable		Percent use in final listings				
		Mammals	Birds	Reptiles	Fish	Total Use
Fecundity		1	2	0	2	1
Lambda and/or "r"		0	2	2	0	1
Ne: Effective population size	(num)	0	5	0	0	1
	(des)		3			
Longevity	(num)	0	5		8	4
	(des)		5	4		
Sex ratio		0	0	2	0	0.5
Reproductive rate	(num)	1	8	0	0	1
Adult mortality	(num)	0	5	2	0	1
Age class data	(num)	0	5	5	5	3
General class data: juveniles & adults	(des)			4	7	2
K-selected species		0	0	2	0	0.5
Monogamous		0	8	0	0	1
Clutches/generations per year		0	0	6	2	1
Declining physical fitness		1	0	2	0	1
Home range		3	2	0	0	2
Wide/year around territories		0	5	0	0	1
Carrying capacity		2	5	0	0	1
Pairs supported in future		0	5	0	0	1
Decline in nest numbers	(num)	0	2	2	0	1
Individuals/trap effort		4	0	4	5	4
Museum specimens, confirmed sightings, takes over decades		6	0	2	3	4
Basking/observation surveys		2	0	7	2	3
Mark/recapture surveys		0	0	2	0	0.5
Track density surveys		0	0	2	0	0.5
Individuals per hectare/acre		5	5	4	0	4
Percent of catch which is species in question		0	0	0	3	1
Catch to escapement ratio		0	0	0	2	0.5
Ocean harvest rate		0	0	0	2	0.5
TOTAL RECORDS:		119	39	54	60	272

within a class as well as across classes. All of these variables were reported in less than 5% of the 272 listings examined.

Variables included in the database and used for analyses are listed in Table 2. I also included, in the database, six additional variables which provide general information about the listing process. They are as follows: (1) the date of the initial petition and/or status review; (2) the date of the final listing; (3) whether a species had ever been thought to be extinct; (4) whether a species had been considered under emergency rule; (5) whether there are special rules allowing "take" of the species (post-listing); (6) and the major reasons, reported by the Service, for range and/or habitat loss (see Appendix F). These variables are discussed further in the following chapter and appendices.

Of the 51 variables used for the analyses, 5 variables were represented by discrete quantitative data (actual counts and/or quantitative estimates), 32 were represented by descriptive categorical data (qualitative descriptions and/or estimates) and 14 were represented by both discrete quantitative and descriptive categorical data. These latter variables were represented by both data types within single listings as well as across listings. For example, in the final listing for the Baluchistan bear[20], *number of endangered or threatened (e/t) individuals remaining* is given as "perhaps

Table 2. Variables abstracted from the Federal Register final listings for mammals, birds, reptiles, and fish from January 1, 1975 - June 21, 1991. Variables were considered by the Service for all four classes unless otherwise indicated by brackets.

Variables

FWS Listed Classification (use accepted taxonomic classification)
Listed Range & Numbers
Historic Numbers
Number of E/T Individuals Remaining
Number of E/T Populations Remaining
Smallest Population of Listed Species
Largest Population of Listed Species
Population Trend
Historic Range Lost
General Habitat Lost
Litter Number
Recruitment and/or Reproductive Success
Infant Mortality
Persistence Time
Historic Distribution
Current Distribution
Isolation/Contiguity of Populations
Expectation of Continued Range Loss
Habitat Specific
Distribution (status) of Habitat (patchiness etc.)
Expectation of Continued Habitat Loss
Forage/Prey Specific
Status of Forage/Prey
Past Impact of Catastrophe
Future Impact of Catastrophe
Past Impact of Predation by Humans
Future Impact of Predation by Humans
Past Impact of Non-exotic Species
Future Impact of Non-exotic Species
Past Impact of Exotic Species
Future Impact of Exotic Species
Past Impact of Pesticides/Pollution
Future Impact of Pesticides/Pollution
Past Impact of Disease
Future Impact of Disease
Genetic Problems
Demographic Stochasticity
Level of Legal Protection from "Take"
Effectiveness of Protection from "Take"
Protection from other Acts
Unique Habitat
Current Level of Habitat Protection
Ecological Association with other E/T or Candidate Species
Number of Associated E/T & Candidate Species
Nesting/Spawning Success [birds & fish]
Primary Reason for Nesting Failure [birds, reptiles & fish]
Female Age at Maturity [reptiles]
Number of Active Nests [birds]
Number of Occupied Tributaries [fish]
Number of Occupied Drainages [fish]
Number of Populations Lost [fish]

N = 51

fewer than 200 individuals." The bear is also described in the listing as being "evidently rare" in numbers.

Variables for which both data types (quantitative and descriptive) were reported (as with the Baluchistan bear above) were separated into these two data types in the database (see Appendices F and H). This was done to prevent information loss and to allow examination of the degree of correlation between the discrete quantitative and the descriptive categorical data values for each of these variables (see results).

Once all the possible apparent biological criteria (variables) had been identified for analysis (see Table 2), I began the task of identifying discrete categories within each descriptive variable which would accurately represent the qualitative, narrative information presented in the final listings.

Distillation of these discrete categories (gradations within each descriptive categorical variable) that would accurately reflect the narrative data presented in the final listings was an iterative process. The Service uses a plethora of undefined or loosely defined biological terms, non-biological terms, phrases and lengthy descriptions to describe the gradations within each such variable. Application of definitions to these terms ran the risk of making false assumptions about the behavior of the Service when selecting species to list as endangered or threatened.

The risk inherent in applying definitions to Service terminology (as mentioned above) is illustrated by the final listing for the Mount Graham red squirrel. The Service reports, in the listing, that the squirrel appears to be common only in scattered patches of the best habitat. However, the total estimate for the number of individuals remaining is reported (in the final listing) to be only 280 individuals in 16 localities. Or, an average of 17 squirrels per locality. This is not what I would define as common. Indeed, I would not have defined a total of 280 individuals remaining as common.

I then did not apply definitions to Service terminology, but simply identified specific "core" terms which were used by the Service throughout the final listings to describe a specific descriptive variable. These core terms became the basis for the discrete categories for that descriptive variable (see Appendices F and G).

To illustrate, a descriptive variable *current distribution* has been abstracted, by the author, from the language of the listings. The Service uses terms such as: limited, endemic, restricted, relict, one area, island, widespread, disjunct/isolated, or a combination of these terms to describe the gradations within this variable.

The discrete categories for this variable (see Appendices F and G) were abstracted from terms which were most common (core terms) throughout the listings. For this variable, an

initial set of 5 discrete categories was created from the core terms found throughout the listings. The five initial discrete categories were: widespread, restricted, relict, endemic, and a single area. Discrete categories were, in a few cases, not mutually exclusive.

The reader is referred to the data codification form (Appendix G) for a detailed explanation of the hierarchical assignment of a species to a particular discrete category when more than one distinct core term or phrase was found in a listing.

Additional, less frequently used, single terms were added to a particular discrete category when they appeared with the original "core" term to describe a particular criterion. For example, the word "limited" often appeared in conjunction with the core term "restricted." And, the word "island" often appeared together with the core term "single area." These two additional words, "limited" and "island," were added to the discrete categories of "restricted" and "single area" respectively. The solo use of one of these terms could then also trigger assignment to that particular discrete category.

In some instances, a core term could be present in the verbiage, but the presence of an additional, new biological adjective would necessitate the creation of a new discrete category. For example, a description of *current distribution* that delineated a single area (breeding ground) for a species with migratory status necessitated the addition of a new

category that recognized that migratory status (see Appendices F and G). Another example is the frequent inclusion of the word "isolated" in several listing descriptions of *current distribution*. A species may be described as having a relictual distribution and as being distributed only in isolated areas within its remaining range. I established a 6th category for *current distribution* to enable recognition of the isolated and/or disjunct nature of these range distributions.

If a "core" term (as described above) was not found in a listing, then the verbiage or single word was translated either into an existing or, if necessary, a new discrete category. Often there was enough information in a listing to place it into an already existing category even though a core term was not used. For example, the phrase "historically known only from" was translated into "endemic" and the species was placed into that already existing discrete category. But a description of *current distribution* as "captive populations only" demanded the addition of a new discrete category.

The data codification form (Appendix G) contains a complete examination of the words and phrases that triggered assignment of a species to a particular discrete category within a descriptive categorical variable.

The first term presented within each discrete category in the data codification form is the core term. The following words or phrases separated by a backslash (/) are the other

words and/or phrase translations which triggered assignment to that particular category. Definitions are provided if they clarify distinctions between categories.

This data codification form can be used in conjunction with the data classification form (Appendix F) and with the database (Appendix H). The capitalized acronyms associated with each variable name in the data codification form are the column headings in the database (Appendix H) and are also found in the data classification form (Appendix F).

Because the verbiage was not generally consistent from one listing to the next, the process described above was necessarily iterative and many-tiered. Once all the descriptive variables and their discrete categories were established, the data classification form was developed (Appendix F).

One of the more intriguing aspects of the final listings is the biological information that is not reported. To allow examination of this aspect of the final listings, three types of unreported variables (see Appendix F) were defined as follows: (1) the variable was not reported by the Service because it was not applicable to the species in question; (2) the variable was applicable to the species in question but was not mentioned by the Service; (3) the variable was reported by the Service as being applicable to the species in question but the Service had no information regarding same. Examination of the amount and type of unreported variables allowed the

investigator to determine whether there was systematic and consistent consideration of variables within and across classes.

The developed data classification form was used to reprocess and codify all of the final listings to ensure consistency and accuracy. This included codification of the unreported variables as described above. The resultant database is presented in Appendix H.

Methods of Analysis

Quantitative and Descriptive Data

Discrete quantitative and descriptive categorical data found in a single listing for specific variables (as with the Baluchistan bear above) were analyzed to determine whether quantitative ranges could be inferred for and applied to the discrete variable categories. This would allow for conversion of the two data types into one data type for analysis of these variables.

Missing Data

Incidence of missing data was determined for all variables both across all applicable listings and within the four designated classes. For those variables which reported both quantitative and discrete data values, the percent use of each data type was determined.

Designation of Species as Endangered or Threatened

Due to the large amount of unreported variables (missing data) within and across classes and across all variables, histograms, scatterplots, stem-leaf plots and summary statistics were initially employed in an attempt to identify thresholds between endangered and threatened species.

Linear discriminant analysis (developed by R. A. Fisher cited in Mardia et al. 1979) was then used to explore various combinations of the biological criteria in an effort to determine whether and to what degree different combinations of these criteria might effectively discriminate endangered species from threatened species. Discriminant analysis produces linear combinations of the predictor variables which serve to classify observations into distinct groups.

Presumably, the assessment of several variables leads to the decision to list a species as endangered or threatened. Therefore, while recognizing that the large amount of missing data argues against doing parametric multivariate analyses, this discriminant analysis was done to ensure investigative thoroughness.

Chan (1972) concluded that, for discriminant analysis, substituting the mean values for each variable is one of the best treatments for missing data (the other being principal components analysis). In these analyses, the missing data values were replaced by the empirical means for each variable.

A jackknife procedure (developed by J. W. Tukey cited in Sokal and Rohlf 1981) was then used to obtain an improved estimate of the misclassification rate produced by the original discriminant analysis. The jackknife procedure leaves out one observation at a time, and calculates the discriminant function on the remaining N-1 observations (Norusis 1985). The withheld observation is then classified. This produces a less biased estimate of the misclassification rate since the observation being classified has not been considered in the calculation of the function.

Pieces of Biological Information

Final listings were sorted into groups based upon the number of pieces of biological information (number of variables) found in them (Table 3). These mutually exclusive groups ranged from 5 to 32 pieces of biological information per listing. For example, 6 listings were found to contain 5 pieces of biological information (variables), while 1 listing was found to contain 32 pieces of biological information or variables.

Variable use, within these groups, was examined to identify the type of biological information utilized. This allowed identification of the specific biological variables used in final listings when those listings contained only a small number of variables. For example, for those 6 listings which reported only 5 variables, identification of those 5

Table 3. Percent variable use within groups of listings which were sorted according to the number of pieces of biological information (variables) found in them. Listings were found to have anywhere from 5 to 32 pieces of biological information. Total number of listings per group is presented at the bottom of the table. For example, 6 listings were found to contain 5 pieces of biological information while only 1 listing reported 32 pieces of information. Historic distribution was reported in 83% of those listings which contained 5 variables.

	PIECES OF BIOLOGICAL INFORMATION (VARIABLES)																			
Variables	5	6	7	8	10	11	12	15	16	17	20	21	22	25	26	27	28	29	30	32
Historic Number	0	0	0	0	33	10	0	7	18	14	17	53	31	42	63	60	100	50	67	0
Current Number	17	0	14	29	58	47	92	71	73	36	75	73	69	92	87	100	67	100	67	100
Historic Distribution	83	100	11	86	100	95	100	100	100	100	100	100	77	100	100	100	100	100	100	100
Current Distribution	83	100	86	86	92	89	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Number of Populations	0	20	43	43	33	63	69	71	82	100	83	100	77	92	100	100	100	100	100	100
Isolated/Contiguous Pops.	0	0	29	0	25	47	38	50	82	64	67	73	61	67	63	100	100	50	100	100
Population Trend	0	0	43	86	42	53	69	57	45	78	92	73	85	100	75	100	100	100	100	100
Historic Range Lost	0	40	0	14	33	42	31	43	36	7	92	40	69	83	75	100	100	100	67	100
Expected Range Loss	0	20	0	0	0	5	8	14	0	7	33	7	23	17	0	60	100	100	0	100
Habitat Specific	17	20	29	14	33	32	38	78	54	64	58	93	100	100	100	100	100	100	100	100
Status of Occupied Habitat	0	20	14	0	25	37	31	57	64	57	42	87	69	75	100	100	100	100	100	100
Habitat Lost	83	60	86	57	83	79	77	78	91	93	92	93	92	100	100	100	100	100	100	100
Expected Habitat Loss	83	20	71	57	50	58	61	64	64	57	75	80	92	100	100	100	100	100	100	100
Prey Specific	0	0	14	0	0	5	0	21	45	50	25	67	31	42	50	80	67	50	33	100
Status of Prey	0	0	0	0	0	5	0	21	27	28	25	13	23	25	37	20	33	0	33	100
Past Impact of Catastrophe	0	0	0	0	0	0	0	0	9	7	17	0	23	17	25	40	67	50	100	100
Future Impact of Catastrophe	0	0	0	0	0	0	0	0	18	7	33	0	15	17	13	80	33	50	100	100
Past Impact of Human Pred.	33	20	43	43	75	74	77	78	64	78	83	80	92	100	100	80	100	100	100	100
Future Impact of Human Pred.	0	20	43	29	50	74	77	57	64	78	83	93	92	100	87	80	100	100	100	100
Past Impact of Non-exotic Spp.	17	0	0	0	17	0	0	14	36	50	50	60	77	42	100	60	100	100	100	100
Future Impact of N-e Spp.	17	0	0	0	0	0	0	14	36	43	50	60	77	42	87	60	100	100	100	100
Past Impact of Exotic Spp.	0	0	14	14	8	5	31	36	36	57	8	40	54	67	87	40	67	50	100	0
Future Impact of Exotic Spp.	0	0	0	0	0	5	15	28	36	57	25	47	46	67	87	40	67	50	100	0
Past Impact of Pollution	0	0	0	29	0	5	0	0	9	7	25	20	54	100	50	40	67	50	100	0
Future Impact of Pollution	0	0	0	57	0	10	0	0	9	7	17	27	38	100	50	60	67	50	100	0
Past Impact of Disease	0	0	14	0	17	5	0	28	36	43	42	73	77	75	87	60	33	100	100	100
Future Impact of Disease	0	0	0	0	0	5	0	28	36	43	50	73	77	83	75	60	33	100	100	100
Genetic Problems	0	0	0	0	8	0	0	21	0	0	17	7	8	0	13	60	67	50	67	100
Demographic Stochasticity	0	0	0	0	0	0	0	0	0	0	8	7	0	0	25	40	33	0	33	100
Litter #/Reprod. Rate	0	0	0	0	0	0	8	0	0	7	42	27	31	25	87	60	67	100	100	100
Infant Mortality	0	0	0	0	0	0	0	14	9	57	25	20	31	67	37	40	33	50	100	100
Persistence Time	0	0	0	0	0	0	8	0	9	7	0	7	8	0	13	20	0	0	0	100
Legal Protection from "Take"	17	60	14	29	67	74	85	71	82	86	100	93	100	100	100	80	100	100	100	100
Protection from Other Acts	0	20	0	29	42	42	31	64	45	57	58	33	31	25	63	40	0	50	0	100
Effectiveness of Protection	17	80	14	29	58	68	69	50	54	50	75	67	69	83	50	80	100	100	33	100
Protection of Habitat	0	0	0	0	8	10	0	50	54	14	83	93	61	33	100	80	100	100	100	100
Unique Habitat	33	0	57	71	42	42	54	86	54	71	83	80	100	100	100	100	100	100	100	100
Ecol. Assoc. with E/T Spp.	0	0	0	0	0	5	23	14	9	7	25	20	23	67	25	40	0	50	0	0
# Assoc. E/T Or Candid. Spp.	0	0	0	0	0	5	8	7	9	7	25	20	15	58	0	40	0	50	0	0
TOTAL # LISTINGS IN GROUP	6	5	7	7	12	19	13	14	11	14	12	15	13	12	8	5	3	2	3	1

variables was possible. This also allowed identification of the specific biological variables used in final listings when those listings contained a considerably larger number of variables.

Once final listings were sorted by the number of pieces of biological information (as described above), they were then sorted within year groups. This allowed identification of changes in the amount of biological information considered over the years. For example, in the years from 1975 - 1979, the greatest number of listings used 11 variables, while the greatest number of listings in the year group from 1985 - 1989 used 24 variables.

Variable use within these year groups was also examined to identify changes in the type of biological information considered over the years. For example, the variable *amount of habitat protected* was considered in 11% of the listings from 1975 - 1979, and 80% of the listings from 1985 - 1989.

Variable use was also summed over all listings to allow ranking of same from the most commonly reported variable to the least commonly reported variable. Examination of within-class variable use identified criteria which were emphasized for mammals, birds, reptiles, and/or fish.

Results

Quantitative and Descriptive Data

At least 20 listings contained both quantitative and descriptive data values for each of 4 variables (Table 4). Because quantitative and descriptive data did not correlate, values could not be assigned to "core" categorical terms. Two variables are presented.

Both quantitative and descriptive data values for *population trend* were presented in 22 listings. Population trend was described as in decline in 7 listings, in significant decline in 7 listings and in precipitous decline in 8 listings. The associated ranges of quantitative values were similar at 50-99%, 50-99% and 66-95% respectively. The application of analogous quantitative ranges to three discrete categories of decline may reflect the differences of biological opinion involved in defining decline as just that or as significant or precipitous. It should be noted that the time period over which a given decline was measured was often not stated and if stated was not constant across listings.

Thirty-one listings presented both descriptive and quantitative values for *number of individuals remaining*. Number of individuals was described as "possibly extinct" (1 individual) in 1 listing; as "extremely rare" (14-7000 individuals) in 9 listings; as "rare", or "low" in numbers (30-12,500 individuals) in 19 listings, and as "abundant"

Table 4. Counts of final listings which contained either a a quantitative value, a descriptive value or both for a given variable. Overall percent of use is also given for each variable. Note: This table only includes variables for which both quantitative and discrete values were found in the final listings.

Variables	Quant	Discr	Both	Use (%)
Historic Numbers	10	51	1	23
Numbers of Individuals Remaining	71	72	31	64
Numbers of Populations Remaining	131	71	5	76
Population Trend	4	159	22	68
Historic Range Lost	11	105	20	50
General Habitat Lost	8	212	17	87
Litter Number/Reproductive Rates	6	31	12	18
Infant Mortality	3	43	6	19
Persistence Time	5	5	2	4
Habitat Protection (mammals, birds, reptiles & fish)	3	40	74	43
Total number of listings = 272				
Nesting Success (birds, reptiles & fish)	5	42	7	35
Total number of listings = 153				
Occupied Tributaries (fish only)	23	6	3	53
Total number of listings = 60				

(millions of individuals) in 1 listing. Eight of the species in the "rare" category (30-12,500) had quantitative values of less than 500. The general separation of discrete categories is evident. However, the overlap and breadth of both the "rare" and "extremely rare" categories demonstrates the need for application of numerical ranges to these discrete categories.

Missing Data

The percent of final listings within classes that did not mention a particular variable is presented in Table 5. These percentages do not include variables that were not applicable nor do they include those variables for which it was stated that no information was available.

Not surprisingly, descriptive variables had an overall higher incidence of being considered than did quantitative variables.

Fifty-four percent of descriptive variables were mentioned in greater than 50% of the listings within a class, compared to only 14% of the quantitative variables.

Discrete values for *historic distribution, current distribution*, and *impact of past human predation* were mentioned in 90% or more of the listings in all classes. No quantitative variable was mentioned in 90% or more of the listings in all classes.

Table 5. Percent of Federal Register final listings in which variable is not mentioned (Q = quantitative value, D = descriptive value). This does not include variables that were mentioned as not being applicable and/or variables for which it was stated that information was not available. Na=variables for which the quantitative and/or descripitve value was not applicable. Variables were mentioned in less than 50% of applicable listings.

	Mammals		Birds		Reptiles		Fish	
Variable	Q	D	Q	D	Q	D	Q	D
Historic numbers	94	84	79	51	81	76	90	60
# e/t individuals	54	28	23	10	59	48	80	43
Historic distribution	na	4	na	3	na	0	na	3
Current distribution	na	3	na	0	na	0	na	0
# e/t populations	58	36	38	23	52	20	32	8
Population isolation	na	47	na	33	na	35	na	37
Smallest e/t population	70	58	38	33	61	50	63	42
Largest e/t populaton	71	60	43	41	59	52	65	48
E/T population trend	92	41	64	15	81	30	93	20
Historic range lost	89	42	90	41	93	81	78	42
Expect future range loss	na	76	na	82	na	94	na	87
Habitat specific	na	53	na	15	na	39	na	7
Habitat status	na	47	na	54	na	50	na	13
Habitat lost	93	15	79	5	93	13	90	8
Expect future habitat loss	na	32	na	10	na	35	na	3
Prey specific	na	84	na	67	na	44	na	62
Prey status	na	88	na	90	na	61	na	90
Past catastrophe	na	85	na	87	na	94	na	82
Future catastrophe	na	82	na	87	na	91	na	77
Past human predation	na	9	na	8	na	5	na	3
Future human predation	na	20	na	10	na	5	na	0
Past interspecific predation	na	56	na	31	na	48	na	27
Future interspp predation	na	58	na	31	na	48	na	32
Past exotic species impact	na	82	na	46	na	50	na	42
Future exotic impact	na	84	na	54	na	50	na	42
Past impact of pollution	na	86	na	67	na	89	na	43
Future impact of pollution	na	86	na	64	na	89	na	32
Past impact of disease	na	53	na	33	na	61	na	27
Future impact of disease	na	55	na	38	na	61	na	27
Genetic problems	na	79	na	92	na	98	na	92
Demographic stochasticity	na	96	na	97	na	98	na	90
Litter number	97	90	79	64	87	85	97	75
Infant mortality	97	96	92	64	96	54	93	83
Persistence time	97	96	95	92	96	96	100	97
Legal protection from "take"	na	15	na	5	na	13	na	2
Protection effectiveness	na	23	na	8	na	37	na	57
Habitat protection	86	71	51	43	85	68	18	3
Ecological association with other e/t species	na	92	na	69	na	81	na	32
# associated e/t species	92	na	69	na	89	na	38	na
Active nests	na	na	79	na	96	na	na	na
Nesting success	na	na	87	43	96	56	88	73
Reason nest failure	na	na	na	43	na	52	na	72
Age at maturity	na	na	na	na	89	na	92	na
Occupied drainages	na	na	na	na	na	na	2	na
Occupied tributaries	na	na	na	na	na	na	25	15
Populations lost	na	na	na	na	na	na	68	na

Four quantitative variables were mentioned in at least 75% of the listings within a class: *number of e/t individuals* (birds) and *percent of habitat protected, number of occupied drainages* and *number of occupied tributaries* (fish).

Eleven descriptive variables were mentioned in at least 75% of the listings within a class: *habitat lost, potential impact of future predation by humans,* and *level of protection from take* (all classes); *number of e/t populations* (birds, reptiles, and fish); *effectiveness of protection from take* (mammals and birds); *population trend, expectation of habitat loss,* and *habitat specificity* (birds and fish); *number of e/t individuals* (birds) and *status of remaining habitat, and number of occupied tributaries* (fish).

Variables that were mentioned in less than 50% of applicable listings are highlighted in Table 5. In addition, no quantitative variable exceeded 50% mention for mammals or reptiles.

These occasionally used criteria generally require extremely detailed and often unavailable historical, reproductive, genetic, or demographic information, or an assessment of past and future impact from various phenomena.

Some of these occasionally used criteria are class specific measures of similar biological phenomena. Consideration of a single measure of the phenomena would be beneficial for comparison and ranking across classes. As an example: a reproductive measure generally applicable to all

classes would be preferable to the myriad measures (eggs/clutch, clutches/year, young per pair, litter number, productivity etc.) that now appear sporadically in the listings. I would suggest *realized natality* as one to consider.

Designation of species as endangered or threatened

In an effort to elucidate e/t thresholds, summary statistics were examined for quantitative variables which were utilized in at least 10% of applicable listings (Table 6).

No variable demonstrated complete division of the distributions for endangered and threatened species. This is not surprising, since presumably (as mentioned above) the assessment of several variables leads to the listing of a species as endangered or threatened. However, some of the trends are worth noting.

It should be noted that the levels of missing data are quite high for these quantitative variables (see Table 5). These are simply trends found in the data which were reported.

No species listed as threatened had fewer than 150 individuals remaining while 32% of species selected to be listed as endangered had fewer than 150 individuals. Fifty percent of threatened species had more than 2000 individuals remaining compared to only 15% of endangered species.

Table 6. Summary statistics across or within classes for quantitative variables which were utilized in at least 10% of applicable listings. Does not include missing values.

Variable	E/T	Obs.	Avg	Min	Max	Median	Quartiles
Individuals remaining							
all classes	e	79	1646	0	16000	300	100, 875
	t	22	65613	159	1300000	2189	600, 7000
mammals	e	44	1753	0	15800	400	170, 720
	t	5	277643	1500	1300000	13718	7000, 66000
birds	e	22	2049	14	16000	321	100, 1680
	t	8	4456	159	15800	1921	500, 6076
reptiles	e	8	663	30	4500	88	50, 250
	t	6	2871	350	6324	2525	1000, 4500
fish	e	5	494	1	1300	100	67, 1000
	t	3	797	441	1500	450	441, 1500
Populations remaining							
all classes	e	94	3.83	1	46	1	1, 4
	t	42	6.52	1	43	3	1, 7
mammals	e	43	3.60	1	16	1	1, 4
	t	3	3.00	1	5	3	1, 5
birds	e	19	6.95	1	46	2	1, 9
	t	5	2.80	1	10	1	1, 1
reptiles	e	11	2.45	1	11	1	1, 2
	t	14	8.29	1	43	2.5	1, 4
fish	e	21	2.19	1	12	1	1, 2
	t	20	6.75	1	30	3.5	1, 8
Drainages (#) (fish only)	e	24	1	0	2	1	1, 1
	t	20	1	1	5	1	1, 1
Tributary (#) (fish only)	e	13	2	0	10	1	1, 3
	t	13	7	0	30	4	3, 5
Population decline (%) all classes	e	17	79	3	99	90	70, 95
	t	9	73	50	99	79	63, 83
Range lost (%) all classes	e	15	69	0	99	80	60, 96
	t	14	42	0	94	30	0, 85

No threatened mammal had fewer than 1500 individuals, while 82% of endangered mammals did. Twenty-three percent of endangered mammals had fewer than 150 individuals remaining.

Thirty-two percent of endangered birds had fewer than 150 individuals, while no threatened bird had fewer than 150 individuals remaining. Eighty-eight percent of endangered reptiles had 300 or fewer individuals, while no threatened reptile had fewer than 300 individuals remaining.

Mammals selected for listing as threatened had dramatically higher numbers of individuals remaining than did birds, reptiles, or fish (see Table 6). This may be a reflection of historical public support for charismatic megafauna which has overshadowed less conspicuous life forms.

A single remaining population was the mode for both endangered and threatened species at 52% and 43% respectively. However, the second and third quartile values were consistently lower for endangered species (with the exception of birds).

It should be noted that a single remaining population does not necessarily indicate one population remaining for the entire species or subspecies in question. It does indicate that within the listed portion of that species or subspecies there is only one population left.

A majority of endangered fish (61%) occupied 0 or 1 tributaries, while a majority of threatened fish (85%) occupied 3 or more tributaries. A majority of endangered

species (80%) realized a range loss of at least 60% while a majority of threatened species (64%) had lost no more than 40% of their historic range.

Histograms were examined to compare the percentage of times that a core term (descriptive variable category) was applied to an endangered or threatened species. Appendix D presents comparative histograms for descriptive variables. The histogram for *number of e/t individuals* remaining is presented (Fig. 1). There was considerable overlap in the application of core terms to both endangered and threatened species within all descriptive variables. The least amount of overlap was found in the descriptive variable categories presented in Table 7. Some categories present unexpectedly higher values for threatened species. Core terms that were applied frequently to both endangered and threatened species are presented in Table 8. Extreme categories of habitat-related variables were used more frequently for both endangered and threatened species than population- or threat-related variables. Awareness by Service biologists of the crisis of dwindling habitat for many vulnerable species may have led to this common consideration of habitat.

Discriminant analysis of all variables, used by the Service for mammals, birds, fish & reptiles (n=53), correctly classified 76% of the endangered species and 75% of the threatened species (Table 9). Sixty-five species (24%) were misclassified. However, 96 species (35%) were misclassified