FACTORS INFLUENCING VARIATION AMONG STATES IN THE NUMBER OF FEDERALLY LISTED MAMMALS IN THE UNITED STATES

GORDON L. KIRKLAND, JR. AND RICHARD S. OSTFELD

Vertebrate Museum, Shippensburg University, Shippensburg, PA 17257 (GLK)
Institute of Ecosystem Studies, Box AB, Millbrook, NY 12545 (RSO)

We analyzed the relative importance of 12 extrinsic factors potentially influencing the number of federally listed and proposed mammalian taxa in individual states of the United States. We applied multiple regression analysis to four data sets: numbers of federally listed (threatened and endangered) mammals, federal candidate mammals, a combination of both lists, and for comparison, all federally threatened and endangered plants and animals in each state. Amount of area in state parks and percentage of forest cover were the only significant variables in regression models for all four data sets. Number of mammal species, latitude of state capital, and total human population were significant variables in three of the models. Three variables (percentage of original wetlands lost, human population density, and percentage of state in federal land) were not significant in any model. For federally listed mammals, four variables (landscape habitat diversity, loss of wetlands, area of state parks, and percent forest cover) were significant (R^2 = 57.5%). Seven variables (number of mammal species, total human population, latitude, topography, area of state parks, and percentage forest cover lost prior to 1908, and percent forest cover) were significant in the model for federal candidate taxa (R^2 = 80.7%). For combined listed and candidate mammals, the same seven variables were significant (R^2 = 79.6%). For the overall list of federally threatened-endangered plants and animals, five variables (latitude, area of state parks, number of mammal species, percent forest cover, and total human population) were significant (R^2 = 63.9%). Based on a positive relationship between the number of listed-proposed taxa and total human population, and negative relationship between number of listed-proposed taxa and latitude, we predict that substantial problems in conservation biology for mammals will be encountered in the southern United States, which are experiencing dramatic increases in human population.

Key words: threatened, endangered, candidate taxa, mammals, predictive models, conservation, geographic analysis

It has long been recognized that certain characteristics appear to predispose species or subspecies to threatened or endangered status (Ceballos and Brown, 1995; Colinvaux, 1978; Rabinowitz et al., 1986; Terborgh, 1974; Terborgh and Winter, 1980). These attributes can be thought of as intrinsic properties of individual species and can be used to predict which species or types of species are more likely to become imperiled. Among mammals, characteristics of threatened or endangered species typically include large body size, position high in food chains (e.g., second-order consumer), commercial value (either as products or threats to domesticated species), limited geographic range, initial rarity, loss of habitat, and trophic specialization. As a consequence, lists of threatened and endangered mammals do not represent random subsets of the faunas from which they are drawn.

In addition to such intrinsic features, we hypothesized that extrinsic factors also should influence the conservation status of individual mammalian species and the number of special-concern mammalian taxa within delimited areas such as individual states. Considerable variation exists among states in the number of federally listed taxa of plants and animals (United States Fish and Wildlife Service, 1993). Although states are political, rather than biological, entities, they vary in several features that we expected might influence numbers of federally listed mammals. For instance, states vary in size, latitude, size of the human population, and extent to which natural habitats have been altered or destroyed. To understand large-scale geographic patterns in the conservation status of mammals in the United States, we analyzed a set of extrinsic factors that potentially might contribute to the observed variation among states in numbers of taxa listed.

We initially sought to analyze state-by-state patterns using lists of special-concern mammalian taxa prepared by state wildlife or conservation agencies and Natural Heritage programs in individual states. However, we encountered considerable difficulty working with this database because of apparent variation among states in their approaches to listing taxa (e.g., some states were seemingly very conservative, and others appeared to be quite liberal in listing species). A further difficulty was the fact that state lists often were dominated by species whose distributions barely extended into a state, and thus those species apparently were listed on the basis of peripheral rarity rather than global rarity (Hayes, 1991).

To overcome this state-by-state inconsistency in the data set, we decided to use the list of mammalian taxa recognized as threatened or endangered by the United States Fish and Wildlife Service (1992) and mammalian taxa proposed for listing under the Endangered Species Act (United States Fish and Wildlife Service, 1991). Our objective was to improve our understanding of extrinsic factors that influence the conservation status of species. We believe that such an understanding will assist resource managers in preventing further declines toward extinction.

Materials and Methods

Our general approach was to use step-wise multiple regression analysis (SPSS, Inc., 1996) to determine which independent variables explained significant parts of the among-state variation in the numbers of federally listed or proposed mammalian taxa. Our principal challenge was to select an appropriate set of independent variables from a large number of potentially significant factors. We began with a set of four general independent variables that appeared to be important in influencing variation among states in the total number of federally listed plants and animals (United States Fish and Wildlife Service, 1989). These four variables were: latitude of state capital (Espenshade and Morrison, 1978), area of state, total human population, and human population density (Hoffman et al., 1989). In this and other analyses, we eliminated Hawaii due to its unique, disjunct, insular mammalian fauna and its near absence of native land mammals.

To increase the amount of variation explained by our models, we examined 10 additional independent variables that we suspected influenced the conservation status of mammalian species or subspecies. We included total number of mammal species per state to test if the number of listed mammals simply reflected the size of the total species pool for each state. The number of mammal species per state was based on our examination of distribution maps in Hall (1981). We used area protected in state parks (United States Department of Commerce, 1994) to test the hypothesis that the number of listed taxa should decrease with increasing area of state-protected land. The same rationale was used for including percentage of federal land in states (United States Department of Commerce, 1994). Although it was possible to create a variable that combined state and federal land set aside as protected areas (e.g., state and national parks; national wildife refuges), we chose not to do that because we wanted to assess the impact of state and federal protected land separately and because of the relative difficulty in summarizing those data compared with using two separate variables for state parks and total federal lands.

We included loss of wetlands, percentage of original wetlands lost by mid-1980s (Mitsch and Gosselink, 1993), and forested area lost between 1600 and 1908 (Kellogg, 1909) under the expectation that habitat loss would cause an increase in the numbers of listed taxa. We also included current percent forest cover (Darnay, 1992) to examine the role of a dominant North American habitat type. Those variables represented habitats naturally occurring in all states. We did not include habitats that were not represented universally among states (e.g., deserts, grasslands).

Because the extent of landscape heterogeneity may have influenced the probability of extinction in smaller habitat patches, we used the number of major Kuchler vegetation types (Espenshade, 1970) per state as a measure of a state's landscape heterogeneity. Although there were highly significant correlations between each dependent variable and both numbers of total and major Kuchler vegetation types, we used major Kuchler vegetation types because their correlation coefficients were consistently high (Table 1).

Initially, we considered areas of the state and topography (difference between lowest and highest elevations in each state) as potential independent variables. We subsequently decided to use only topography in our analyses. That eliminated the high autocorrelation between those two variables and the exceptionally high correlation between area of state and area set aside as state parks (Table 1).

We performed our analyses separately for federal threatened or endangered mammals (United States Fish and Wildlife Service, 1992); federal candidate mammals (United States Fish and Wildlife Service, 1991); combined threatened, endangered, and candidate mammals; and for comparison, total federal threatened or endangered plants and animals (United States Fish and Wildlife Service, 1993). For federally listed and proposed mammals, we included both species and subspecies.

Statistical analyses were performed using the SPSS statistical package (SPSS, Inc., 1996). In our step-wise regression analysis, we used adjusted R^2 values that more closely approximated the goodness-of-fit model and provided a more conservative estimate of R^2. The minimum criterion for entry of variables into regression equations was $P = 0.05$; the probability for removal of a variable was 0.10. Those probability levels represented default values for the step-wise regression analysis (SPSS, Inc., 1996).

Results

Our analyses revealed differences in the number and identity of significant independent variables, and in the percentage of explained variation among the three models for mammals: federally threatened-endangered taxa, federal candidate taxa, and combined federal threatened-endangered and candidate taxa (Table 2). The three models for mammalian taxa differed to varying degrees from that for all federally threatened-endangered taxa of plants and animals (Table 2). The number of significant variables ranged from four to six, and the amount of variation in the dependent variable explained by the models ranged from 57.5–80.7% (Table 2).

Two independent variables were significant in all four models. Area of state parks, which surprisingly was correlated positively in all cases, explained from 3.6 to 5.9% of the variation in the dependent variable in the three models for mammals but 18% of the variation in the model for all federally listed plants and animals (Table 2). Percent forest cover in a state explained from 2.7 to 4.8% of the variation in the dependent variable in the four models (Table 2).

Three other variables were significant in three of the four models: number of mammalian species, latitude of state capital, and total human population (Table 2). Number of mammalian species was the most important independent variable in models for federal candidate mammals and combined threatened-endangered and candidate taxa, but it was only the third most important variable in the model for all federally listed plants and animals (Table 2). Number of mammalian species was not included in the model for federally threatened-endangered mammals.

Latitude of state capital was a significant predictor variable in three of the models. It was relatively unimportant in models for

TABLE 1.—*Correlation matrix for 14 potential independent variables and 44 dependent variables used in the analysis.*

	Independent variables														Dependent variables			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1. Number of mammal species	—	−0.105	0.063	0.027	−0.096	−0.470**	0.186	−0.392**	−0.210	0.712**	0.769**	0.648**	0.300*	0.769**	0.391**	0.724**	0.694**	0.359*
2. Wetlands lost			0.429**	0.014	−0.453**	−0.080	0.398**	−0.139	0.565**	−0.419**	0.223	−0.294*	0.008	0.120	0.406**	0.115	0.173	0.374**
3. % original wetlands lost				−0.267	−0.335*	−0.198	0.387**	0.095	0.391**	−0.399**	−0.041	−0.312*	−0.350*	−0.159	0.020	0.140	0.124	0.210
4. Area of state parks					0.448**	−0.116	0.209	−0.028	−0.075	0.460**	−0.247	0.347*	0.852**	−0.352*	0.398**	0.267	0.303*	0.132
5. Latitude (of state capital)						−0.114	−0.213	0.007	−0.311*	0.364*	−0.232	0.298*	0.385**	−0.045	−0.255	−0.225	−0.240*	−0.568**
6. % forest cover							0.055	0.255	−0.193	0.284*	−0.349*	−0.264	−0.368**	−0.419**	−0.020	−0.125	0.112	−0.104
7. Total human population								0.195	−0.506**	−0.056	0.250	−0.080	0.020	0.225	0.406**	0.531**	0.531**	0.515**
8. Human population density									−0.042	−0.396**	−0.438**	−0.383**	−0.346*	−0.448**	−0.199	−0.118	−0.138	−0.096
9. Forest area lost by 1908										−0.399**	−0.051	−0.349*	−0.134	−0.097	0.062	−0.071	−0.050	0.228
10. Topography											0.535**	0.852**	0.659**	0.668**	0.278	0.479**	0.463**	0.125
11. Major Kuchler[a] types												0.475**	0.480**	0.928*	0.648**	0.648**	0.685**	0.532**
12. % federal land													0.513**	0.521*	0.252	0.449**	0.432**	0.129
13. Area of state														0.590**	0.397**	0.248	0.286*	0.086
14. Total Kuchler[a] types															0.618**			
15. Federal threatened-endangered mammal taxa																0.612**	0.640**	0.437**
16. Federal candidate mammal taxa																0.723**	0.805**	0.733**
17. Federal combined threatened-endangered and candidate mammal taxa																	0.992**	0.734**
18. Federal threatened-endangered plant and animal taxa																		0.765**

* $P \le 0.05$, ** $P \le 0.01$.

[a] Major Kuchler types and total Kuchler types (Espenshade, 1970) represent numbers of community types.

TABLE 2.—*Adjusted multiple* R^2 *values (expressed as percentage of explained variation) for multiple regression analyses of variation in number of federally threatened and endangered, federal candidate, combined federal threatened and endangered plus candidate mammal taxa, and federally listed plants and animals per state for the 48 conterminous United States plus Alaska. Negative signs denote variables for which the multiple correlation coefficient* (R) *was negative.*

	Dependent variables			
	Mammals			Plants and animals
Independent variables	Federal threatened-endangered taxa	Federal candidate taxa	Federal combined threatened-endangered and candidate taxa	Federal threatened-endangered taxa
Number of mammal species	ns	51.4	47.1	6.8
Loss of wetlands	6.2	ns	ns	ns
% original wetlands lost	ns	ns	ns	ns
Area of state parks	5.9	3.6	3.6	18.0
Latitude (of state capital)	ns	−1.5	−5.2	−30.9
% forest cover	4.7	2.7	3.5	4.8
Total human population	ns	16.0	16.3	3.4
Human population density	ns	ns	ns	ns
Forest area lost by 1908	ns	−2.5	−2.3	ns
Topography	ns	−3.0	−1.6	ns
Habitat diversity[a]	40.7	ns	ns	ns
% federal land	ns	ns	ns	ns
Total explained	57.5	80.7	79.6	63.9

[a] Major Kuchler community types (Espenshade, 1970) in state.

candidate and combined candidate and threatened-endangered mammals but accounted for nearly one-half of the explained variation in the model for all federally listed plants and animals (Table 2). In all cases, the relationship was negative, with lower latitude states having a greater number of listed taxa.

Total human population explained ca. 16% of the total variation in models for candidate mammals and combined threatened-endangered and candidate mammals, but it was the least important variable in the model for all federally listed plants and animals. The relationship was positive in all three models (Table 2).

Topography of state and forest area lost prior to 1908 were significant variables in two models. Both were associated negatively with number of candidate and combined candidate and threatened-endangered mammals, and they contributed relatively little (1.6–3.0%) to total variation explained in the two models.

Loss of wetlands and habitat diversity were included in only one model for federally threatened-endangered mammalian taxa. They were the two most important variables in that model, accounting for 46.9% of the variation explained (Table 2).

Three variables were not included in any models. They were percentage of original wetlands lost, human population density, and percentage of a state composed of federal land.

DISCUSSION

The number, identity, and importance of independent variables differed somewhat among models. This suggests that although the four lists of species on which the models were based shared certain taxa of special concern, the extrinsic factors impacting these different species groups varied. Nevertheless, the models tended to share independent variables. One variable (area of state parks) was included in all models. Three variables (number of mammal species, latitude, and and total human population) were included in three models. Two variables (topography and forest area lost prior to 1908) were significant in two models. Two variables (landscape diversity and loss of wetlands) were unique to a single model; however, those were the two most important variables in the model for federally listed mammals (Table 2).

Inclusion of area of state parks as a significant variable in all four models is enigmatic, especially in view of the positive relationship between area of state parks and numbers of listed and/or proposed taxa. We expected that if this variable was significant, the relationship would have been negative (i.e., fewer listed-proposed taxa with increasing area set aside as state parks). The reasons for this seemingly anomalous relationship are not evident and warrant further investigation. Two possibilities are that the level of protection in state parks is low and ineffectual for mammalian populations and the area of state parks constitutes an insignificant part of the total protected land in each state. Results of correlation analysis provided no insights, despite the fact that area of state parks was correlated positively with latitude, percentage of federal land, and topography (Table 1). Furthermore, even though area of state parks was included as an independent variable in all four models, it was correlated with only two of the dependent variables (federally listed mammals and combined proposed and listed mammals) in bivariate correlation analyses (Table 1).

Latitude of the state was related negatively to the number of proposed mammalian taxa and the combined list of proposed and federally listed mammalian taxa. Latitude was the most important explanatory variable for total numbers of plants and animals listed; however, it was never more than the third most important variable in two models for mammalian taxa (Table 2). This difference may reflect the substantial percentage of plants, reptiles, and amphibians compared with mammals listed in southern states (United States Fish and Wildlife Service, 1992). The observed negative correlation between latitude and number of listed plants and animals ($r = -0.568$, $P < 0.001$) would be expected if species at lower latitudes tend to have smaller geographic ranges (Rapoport's Rule—Stevens, 1989) and therefore should be more vulnerable to habitat loss. That pattern was evident also among mammals. Of 22 federally listed species or subspecies of mammals that are endemic to a single state, none has a range that extends north of 40° latitude (Hall, 1981; United States Fish and Wildlife Service, 1992).

Latitude also has special significance when viewed in the context of projections for growth of the human population in "Sunbelt" States from Florida to California. This assessment is consistent with the results of a recent fine-grained analyses of threatened-endangered species, which highlighted large numbers of federally listed taxa in counties in Sunbelt States (Dobson et al., 1997; Flather et al., 1994). Flather et al. (1994) predict continued increases in numbers of federally listed species in southern states.

We were somewhat disappointed in our ability to predict a priori which variables might significantly influence among-state variation in the number of federally listed or proposed taxa. Three of the 12 variables that we suspected might or should prove significant were not included in any model: percentage of original wetlands lost, human population density, and percentage of federal land. Despite our expectations, variables measuring loss of wetlands did not play a substantial role in determining the number of proposed or listed species. Loss of wetlands was included in only one model for federally listed mammals (Table 2).

It is perhaps not surprising that loss of wetlands was a significant variable for the threatened-endangered list, given the fact that this list historically has been sensitive to wetland species, e.g., the saltmarsh harvest mouse (*Reithrodontomys raviventris*), gray bat *(Myotis grisescens),* Indiana bat *(M. sodalis),* and silver rice rat (*Oryzomys argentatus).* Flather et al. (1994) documented that 23 of 68 federally listed mammals (34%) were associated with wetland habitats. The contribution of loss of wetlands appears to be due largely to Florida, which has numerous species and subspecies of rats and mice that inhabit fragmented and degraded wetlands (e.g., several subpecies of *Peromyscus polionotus* and *P. gossypinus, Microtus pennsylvanicus dukecampbelli, Oryzomys palustris natator = O. argentatus, Neotoma floridana smalli*— United States Fish and Wildlife Service, 1992). Although total size of the human population was a significant variable in three models, and was the second most important variable in the models for candidate mammals and combined federally listed and candidate taxa (Table 1), human population density was not included in any model. The exclusion of this variable from the models may reflect the fact that the highest human population densities are in smaller states, which have relatively few total mammalian species and therefore few listed taxa. Human population density was correlated negatively with number of mammalian species, with area of state, and with topography but was not correlated with total human population (Table 1).

Models for federally listed and candidate mammalian taxa differed substantially in terms of number and relative importance of independent variables (Table 2). Those models had only two independent variables in common (area of state parks and percent forest cover). Two additional variables in the model for federally listed mammals (landscape diversity and loss of wetlands) were not included in any other model. Those four variables yielded a model for federally listed mammals that explained only ca. 70% of the variation explained by the model for candidate mammals, which had seven significant variables (Table 2).

The model for candidate taxa included five variables that were not included in the model for threatened-endangered species: numbers of mammal species, latitude, total human population, forest area lost prior to 1908, and topography (Table 2). These all were included in the model for combined listed and proposed mammals. Overall, this suggests that the greater number of candidate taxa per state ($\bar{X}$ = 9.0) and variability among states (*CV* 127.1%) were more important than the number and variability of listed taxa ($\bar{X}$ = 2.3; *CV* = 103.5%) in determining the model for combined listed and candidate taxa.

Regarding the differences between these two models, we see two possible explanations, which we cannot yet resolve. First, perhaps the threatened-endangered list represents a more accurate estimation of the true number of imperiled taxa because it is compiled after thorough evaluation, whereas the candidate list may be more politically motivated and therefore less accurate. In contrast, the threatened-endangered list possibly reflects somewhat out-of-date information, or a bias toward large conspicuous species, and hence does not reflect more current human effects, whereas the candidate list is more reflective of true current trends in species status. Assessing these contrasting possibilities represents an important direction for future research.

In an analysis of species-endangerment patterns in the United States, Flather et al. (1994) focused on variables that directly contributed to the listing of individual species. In this regard, they adopted a narrower perspective than ours. They noted that the listing of 95% of 667 species of plants and animals was related at least in part to habitat loss or alteration. Thus, in their analysis, variables related to loss and alteration of habitat were important to the listing of mammals. These results stand in contrast to ours in which variables related to habitat loss were not associated strongly with listed taxa, either mammals or all species (Table 2). A reason for this difference may be the different scales of analysis employed in the two studies. Flather et al. (1994) employed a fine-grained approach emphasizing specific factors contributing to the listing of individual taxa, extending down to the county level, whereas our more coarse-grained approach examined factors at the level of the state. Thus, the lower limit of our analysis of habitat was at the biome level, whereas Flather et al. (1994) focused on subdivisions of biomes (e.g., deciduous, evergreen, and mixed forests). In addition, we analyzed only habitat variables common to the 49 continental United States, in contrast to Flather et al. (1994) who included all habitats that were associated with the listing of threatened-endangered taxa, regardless of how widespread they were within and among states.

Of the nine extrinsic factors determined to be significant predictors in at least one model in this study, six (number of mammal species, loss of wetlands, area of state parks, percent forest cover, forest area lost by 1908, and human population) were similar to extrinsic factors employed in an analysis of anthropogenic threats to biodiversity using the Global Conservation Analysis Package (Sisk et al., 1994). In their analysis, Sisk et al. (1994) included variables measuring numbers of species and endemics for mammals and butterflies, rankings of species richness and endemism, growth and density of the human population, and loss of forest cover to identify countries where there are critical threats to biodiversity from anthropogenic factors. Although the objectives and methods of analysis differed between our study and that of Sisk et al. (1994), we believe the similarity of the variables used in the two studies provides a critical independent test of our method of determining significant extrinsic factors that influence variation among states in the number of taxa of federally listed or candidate mammals.

Ceballos and Brown (1995) note that current global patterns of endangerment of mammals are difficult to interpret. We believe results of our analyses provide some insight into which extrinsic factors influence the number of threatened-endangered mammalian taxa. Significant factors in our analysis among states (e.g., total human population, topography, and latitude) also may be significant among countries.

It is obvious that numbers of imperiled mammalian species are affected by both intrinsic and extrinsic factors. Our approach contributes to the understanding of large-scale effects on conservation status by seeking broad patterns in a variety of taxa. The next step is to extend our analysis to other taxonomic groups and biogeographic regions. However, we caution that biological interpretation of data sets such as ours must account for the influence of political forces (e.g., changing criteria for listing—Ceballos and Brown, 1995), and the nature of political entities such as states, provinces, or countries.

Acknowledgments

We acknowledge students in the conservation biology course at Shippensburg University for their efforts during the initial phase of data analysis for this project. We also thank members of the American Society of Mammalogists' Conservation of Land Mammals Committee for their input and encouragement throughout this project. We especially thank committee members C. A. Jones and S. Sheffield, and reviewer M. V. Price for reviewing this paper and for providing useful suggestions for its improvement. The junior author would like to dedicate this paper to the memory of the senior author.

Literature Cited

Ceballos, G., and J. H. Brown. 1995. Global patterns of mammalian diversity, endemism, and endangerment. Conservation Biology, 9:559–568.

Colinvaux, P. 1978. Why big fierce animals are rare. Princeton University Press, Princeton, New Jersey.

Darnay, A. S., Jr. 1992. Statistical record of the environment. Gale Research Corporation, Detroit, Michigan.

Dobson, A. P., J. P. Rodriguez, W. M. Roberts, and D. S. Wilcove. 1997. Geographic distribution of endangered species in the United States. Science, 275: 550–553.

Espenshade, E. B., Jr. (ed.). 1970. Rand McNally world atlas. Goode's edition. Rand McNally and Company, Chicago, Illinois.

Espenshade, E. B., Jr., and J. L. Morrison (eds.).

1978. Goode's world atlas. 15th ed. Rand McNally and Company. Chicago, Illinois.

FLATHER, C. H., L. A. JOYCE, AND C. A. BLOOMGARDEN. 1994. Species endangerment patterns in the United States. United States Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experimental Station, Fort Collins, Colorado, General Technical Report RM-241, 42.

HALL, E. R. 1981. Mammals of North America. Second ed. John Wiley & Sons, New York, 1:1–600 + *90,* 2:601–1181 + *90.*

HAYES, J. P. 1991. How mammals become endangered. Wildlife Society Bulletin, 19:210–215.

HOFFMAN, M. S., J. FOLEY, AND T. MCGUIRE (EDS.). 1989. The world almanac and book of facts, 1990. Pharos Books, New York.

KELLOGG, R. S. 1909. The timber supply of the United States. United States Department of Agriculture, Forest Service, Circular 166:1–24.

MITSCH, W. J., AND J. G. GOSSELINK. 1993. Wetlands. Second ed. Van Nostrand Reinhold, New York.

RABINOWITZ, D., S. CAIRNES, AND T. DILLON. 1986. Seven forms of rarity and their frequency in the flora of the British Isles. Pp. 182–204, *in* Conservation biology: the science of scarcity and diversity (M. E. Soule, ed.). Sinauer Associates Inc., Publishers, Sunderland, Massachusetts.

SISK, T. D., A. E. LAUNER, K. R. SWITKY, AND P. R. EHRLICH. 1994. Identifying extinction threats. BioScience, 44:592–604.

SPSS, INC. 1996. SPSS for Windows. Base system user's guide. SPSS, Inc., Chicago, Illinois.

STEVENS, G. C. 1989. The latitudinal gradient in geographical range: how so many species coexist in the tropics. The American Naturalist, 133:240–256.

TERBORGH, J. 1974. Preservation of natural diversity: the problem of extinction prone species. BioScience, 24:715–722.

TERBORGH, J., AND B. WINTER. 1980. Some causes of extinction. Pp. 119–133, *in* Conservation biology: an evolutionary-ecological perspective(M. E. Soule and B. A. Wilcox, eds.). Sinauer Associates, Inc., Publishers, Sunderland, Massachusetts.

UNITED STATES DEPARTMENT OF COMMERCE. 1994. Statistical abstract of the United States 1994. United States Government Printing Office, Washington, D.C.

UNITED STATES FISH AND WILDLIFE SERVICE. 1989. Listed species by state/territory. 10/31/89. Endangered Species Technical Bulletin, XIV(8):10–11.

———. 1991. Endangered and threatened wildlife and plants; animal candidate review for listing as endangered or threatened species, Proposed Rule, 50 CFR Part 17, 21 November 1991. United States Fish and Wildlife Service, Washington, D.C.

———. 1992. Endangered and threatened wildlife and plants, 50 CFR 17.11 & 17.12, 29 August 1992. United States Fish and Wildlife Service, Washington, D.C.

———. 1993. Listed species by state/territory. As of 30 November 1993. Endangered Species Technical Bulletin, XVIII(4):26.

Submitted 14 May 1997. Accepted 1 November 1998.

Associate Editor was Janet K. Braun.