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Prioritizing the Research and Monitoring Needs of Terrestrial Mammals in National Parks

Introduction

National parks play an extremely important role in the preservation of many species of animals. Wright (1992) estimated that between one-third and one-half of the rare and endangered species in the USA are found in the National Park System. Wildlife managers in national parks face significant challenges and opportunities in the stewardship of wildlife resources for present and future generations.

Wildlife management priorities in the U.S. national parks have traditionally focused on the protection and enhancement of "glamorous" species, typically ungulates. Over 36% of all research, management studies, and management actions on birds and mammals in the national parks have involved ungulates, principally Rocky Mountain elk *(Cervus elaphus)*, white-tailed deer *(Odocoileus virginianus)*, mule deer *(Odocoileus hemionus)*, mountain goats *(Oreamnos americanus)*, and bighorn sheep *(Ovis canadensis)* (Wright 1990).

The ten most-studied mammals—typically those that are the most visible, of greatest visitor interest, or that adversely affect park plant communities—account for over 41% of all studies (Wright 1990; Wright 1992). This narrow focus has resulted in a corresponding neglect in the study of many other wildlife species.

The National Park Service (NPS) has recognized the need to develop a nationwide program to inventory and monitor the status of natural resources in national park units (Silsbee and Peterson 1991). However, while some monitoring data are available at the park level, this information is seldom synthesized at the national level. The lack of a broad picture of resource status and trends hinders the development of management priorities at the regional or national level. Public attitudes, more than actual need, often dictate resource management actions and funding priorities (Elfring 1985).

This situation suggests the need for a better way to objectively and consistently allocate available resources: focusing attention on those that have received little management or research attention, but which may be valuable components of the park ecosystem.

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Several different ranking systems have been developed by nongame biologists and ecologists to set priorities for conservation of wildlife species (e.g., Sparrowe and Wight 1975; Thompson 1984; Horak et al. 1992; Burke and Humphrey 1987; Niemi 1982; Mace and Lande 1991; Wood and Slater 1983; Millsap et al. 1990). Ranking systems have been used by state wildlife agencies to prioritize the limited amount of funding available for nongame species and to identify threatened and endangered species that are in need of active conservation measures.

The overall goal of this study was to develop a defensible methodology for establishing research and management priorities for terrestrial mammal species. Priorities are based on the biological vulnerability of a species, the current state of knowledge of its population status, and the extent of its management and research needs within a national park unit.

Methods

Development of the ranking system. We modified the ranking system developed by Millsap et al. (1990), and made it specific to national parks and the mammal species of concern by using components and ideas from other ranking systems (Sparrowe and Wight 1975; Thompson 1984; Wood and Slater 1983; Burke and Humphrey 1987). This system is based on two categories of variables: biological and park-specific. Point values, ranging from 0 to 10 were assigned for each variable and represented the range of variation.

Categories were created for each variable that described the range of variation within it. Points were assigned to each category within each variable. The point values of a variable ranged between 0 and 10 points. Point values followed Millsap et. al. (1990) except where categories were altered to fit the needs of this project. Categories were altered to make them specific to terrestrial mammal species. In these cases, point values were assigned by averaging the point values of the two combined categories or by creating an even spread from 0 to 10 based on the number of categories.

Biological variables. Seven variables were selected to measure characteristics of a species population status or life history, and thus its vulnerability to extinction across its entire geographic range. The contribution of each variable as a measure of biological vulnerability is supported by published wildlife literature (Table 1).

The biological variables (population size, population trend, range size, distribution trend, population concentration, reproductive potential for recovery, and ecological specialization) and the point values assigned to each are shown in Table 2. The biological score for each species is the total of all variable points.

Park-specific variables. Seven park-specific variables were selected to provide a relative measure of the

Table 1. Biological variables chosen for inclusion in the ranking process (with supporting literature citations).

Biological variable	Literature review
1. Population size	Important element in endangered species priority systems (Sparrowe and Wight 1975; Wood and Slater 1983), supported by studies in population genetics (Kimura and Ohta 1971)
2. Population trend	Important element in endangered species priority systems (Sparrowe and Wight 1975)
3. Range size	Important element in endangered species priority systems (Sparrowe and Wight 1975); species with restricted distribution may be predisposed to endangerment (Robinson and Bolen 1989)
4. Distribution trend	Important element in endangered species priority systems (Sparrowe and Wight 1975); species that were widespread in extent but are now local in their distribution pattern may not persist (Jones 1987)
5. Population concentration	Life history attribute; broad geographic distribution increases resilience to change and allows for local catastrophic events to occur without significantly threatening the total population (Salwasser 1988)
6. Reproductive potential for recovery	Life history attribute; number of young is determined by litter size, number of litters per year, and minimum breeding ages of individuals in the population (Dasmann 1964); most endangered species are k-selected (Robinson and Bolen 1989)
7. Ecological specialization	Life history attribute; specialized species are sensitive to changes in the environment and specialized adaptations may limit their ability to readily adjust (Bailey 1984); species with highly specialized physical, behavioral, or physiological adaptations may be predisposed to endangerment (Robinson and Bolen 1989)

status of each species population within a given park by examining the extent of protection afforded each one from harvest and the status of ongoing research and management efforts targeted at them (Table 3).

Table 2. Biological variables, categories within variables, and scores used in ranking species. All variables are based on the entire geographic range of the species.

	Point value
1. Population size: The estimated number of adults throughout the range of the species.	
(a) Extremely rare (0-500 individuals)	**10**
(b) Rare (501-1,000 individuals, or unknown but suspected to be small)	**8**
(c) Uncommon (1,001-10,000 individuals, or unknown but suspected to be uncommon, yet not rare)	**5**
(d) Common (10,001-50,000 individuals, or unknown but suspected to be large)	**2**
(e) Abundant (>50,000 individuals)	**0**
2. Population trend: The overall trend in the number of individuals throughout the species' range over the last two decades (or other appropriate interval considering species generation time). If population trend is unknown, consider trends in the availability and condition of the species' habitat as indicative of population trend.	
(a) Population known to be decreasing	**10**
(b) Trend unknown, but population suspected to be decreasing	**8**
(c) Population formerly experienced serious declines, but presently stable and increasing	**6**
(d) Population stable, or suspected to be stable or increasing	**2**
(e) Population known to be increasing	**0**
3. Range size: The size of the area over which the species is distributed during the season when distribution is most restricted (e.g., for a species that ranges over several thousand sq km in summer and winters over several hundred sq km, use the winter range).	
(a) <100 sq km	**10**
(b) 101-1,000 sq km	**9**
(c) 1,001-40,000 sq km (up to 25% the area of Florida)	**7**
(d) 40,001-100,000 sq km (up to 75% the area of Florida)	**4**
(e) 100,001-2,000,000 sq km (up to 25% the area of the continental USA)	**1**
(f) >2,000,000 sq km	**0**
4. Distribution trend: Percent change (since European settlement) in the area occupied by the species. (This is an estimate of change in the portion of the total range that is occupied or utilized; it may not equal the change in total range.)	
(a) Area occupied has declined very significantly (90-100%)	**10**
(b) Area occupied has declined significantly (75-89%)	**8**
(c) Area occupied has declined moderately (25-74%)	**5**
(d) Area occupied has declined very little (1-24%)	**2**
(e) Area occupied is stable or has increased	**0**
5. Population concentration: The degree to which individuals within populations congregate or aggregate seasonally.	
(a) Majority concentrates at a single location	**10**
(b) Concentrates at 1-25 locations	**6**
(c) Concentrates at >25 locations	**2**
(d) Does not concentrate	**0**

Table 2 *(continued)*

6. Reproductive potential for recovery. The ability of the species to recover from serious declines in population size.	
(A) Average number of young produced per adult female per year	
(a) <2 offspring	**5**
(b) 3-5 offspring	**3**
(c) 6-10 offspring	**1**
(d) >10 offspring	**0**
(B) Minimum age at which females typically first reproduce	
(a) >5 years of age	**5**
(b) 3-5 years of age	**3**
(c) 1-2 years of age	**1**
(d) <1 year of age	**0**
7. Ecological specialization: The degree to which the species is dependent upon certain environmental factors (e.g., strict requirements for hibernacula, dietary specialist, specific denning sites, reproductive specialization)	
(a) Highly specialized (requires three or more specializations)	**10**
(b) Moderately specialized (requires two specializations)	**7**
(c) Limited specialization (requires one specialization)	**3**
(d) Not specialized	**0**

Table 3. Park-specific variables, categories within variables, and scores used in ranking species.

	Point value
1. Percent of the species' total range that occurs in the national park. (Select the category that best applies.)	
(a) 40-100%	**10**
(b) 20-39%	**7**
(c) 10-19%	**4**
(d) 2-9%	**2**
(e) <2%	**0**
2. Trend in the species' population within the national park or in the immediate surrounding area. (Select the category that best applies.)	
(a) Known to be declining	**10**
(b) Trend unknown or suspecting to be declining	**8**
(c) Stable or increasing overall, but declining in some areas	**6**
(d) Formerly experienced serious declines but is presently stable or increasing	**4**
(e) Stable or suspected to be stable or increasing	**2**
(f) Known to be increasing	**0**
3. Knowledge of distribution in the national park (survey score).	
(a) Distribution is largely unknown	**10**
(b) Broad range limits or habitat associations are known, but local occurrence cannot be accurately predicted	**5**
(c) Distribution is well-known and occurrence can be accurately predicted throughout the range	**0**

Table 3 *(continued)*

4. Knowledge of the national park population's size and distribution (survey score).	
(a) Factors affecting population size and distribution are unknown or unsubstantiated	**10**
(b) Some factors affecting population size and distribution are known	**5**
(c) All major factors affecting population size and distribution are known	**0**
5. Ongoing management and research activities in the national park (management score).	
(a) No past or present research or management	**10**
(b) Limited management, but no research or feedback	**7**
(c) Limited research, limited management	**5**
(d) Extensively managed, but little research or feedback	**2**
(e) Extensively researched and managed	**0**
6. Knowledge of population trend within the national park (monitoring score).	
(a) Not currently monitored	**10**
(b) Monitored locally	**7**
(c) Extensive monitoring, but without statistical sensitivity	**4**
(d) Extensive monitoring with statistical sensitivity	**0**
7. Harvest of the species in areas immediately adjacent to the national park's boundaries. (Select the category that best applies.)	
(a) Harvested, with no legal protection	**10**
(b) No substantial harvest other than accidental take or harvest of nuisance animals; no legal protection	**7**
(c) Harvested, but harvest regulated	**4**
(d) Harvesting prohibited by regulation	**0**

The park-specific value for each species is the total of all the variable points. High park-specific values denote species about which little is known in a particular park, and which may therefore be in need of research or management measures.

Testing the methodology. The biological and park-specific variables were evaluated by external reviewers. The accuracy of the biological and park-specific point values assigned to each species was verified by applying the system to mammal species within two national parks, Glacier and Olympic. The parks were chosen to test the system based on their size, location, and the diversity of mammal species in them. Glacier National Park is currently inhabited by 60 terrestrial mammal species, 54 of which are non-volant. Glacier has maintained a natural sciences research program since 1967 (Coen 1992). Olympic National Park is currently inhabited by 49 non-volant terrestrial mammal species. Both parks are home to carnivore species that are either threatened, endangered, or of other special concern.

Biological information for many wildlife species is lacking because of limited funds and because of their being difficult to study in natural surroundings. Three options exist for dealing with insufficient biological or park-specific information: (1) delete poorly known species from the database, (2) consider all poorly known species to be either imperiled or secure until their status is known, or (3) substitute opinions of knowledgeable researchers for missing data (Millsap et al. 1990). Options 1 and 3 were used in this study. All species of the family Chiroptera occurring at Glacier and Olympic were originally included in this database but later eliminated when reliable biological information could not be obtained from researchers. Option 3 was employed in all other cases where necessary.

Biological information on species obtained through literature research and from interviews was reviewed by individual biologists knowledgeable about those species. Park-specific information on the current status of species in the two parks was obtained from a literature search and correspondence with selected biologists. Two biologists from each park were asked to assign point values to park-specific variables for the species in that park.

Scores for research and management variables were combined and compared with biological scores, providing a means of delineating research and management priorities; the same was done for scores for survey and monitoring variables. A Mann-Whitney U Test was used to determine differences between reviewers' responses on point values assigned for park-specific variables.

To examine the accuracy of the ranking system, we compared our scores with those of species ranked by the Natural Heritage Program, U.S. Fish and Wildlife Service (USFWS), and U.S. Forest Service (USFS).

Results

Glacier National Park. Fifty-four mammal species were scored at Glacier. Biological scores ranged from 28 (out of a potential maximum of 70) for grizzly bear *(Ursus arctos)* to 2 for meadow vole *(Microtus pennsylvanicus)*. Park-specific scores ranged from 58 (potential maximum of 70) for porcupine *(Erethizon dorsatum)* to 19 for gray wolf *(Canis lupus)*. The species with one of the highest biological scores—and the highest score for biological and park-specific variables combined—was fisher *(Martes pennanti)*, followed by lynx *(Lynx canadensis)*, wolverine *(Gulo gulo)*, and northern flying squirrel *(Glaucomys sabrinus)* (Table 4).

Comparisons of the two reviewers at Glacier revealed no significant difference on mean scores assigned to species for park-specific variables concerning park range, survey, research, management, monitoring, and harvest. There was a significant difference between reviewers for mean scores assigned to species when scoring park population trend ($U = 176.5$; $p = .000396$). Data were

Table 4. The ten most vulnerable mammal species in Glacier National Park. (See Garrett 1995 for total scores for mammal species, excluding Chiroptera.)

Species	Biological score	Park-specific score	Cumulative score
fisher	23	52	75
lynx	21	52	73
wolverine	25	42	67
northern flying squirrel	26	36	62
mountain lion	25	33	58
grizzly bear	28	26	54
northern bog lemming	20	34	54
bighorn sheep	20	33	53
marten	25	26	51
gray wolf	24	19	43

analyzed eliminating park population trend in the park-specific score total because of the variance introduced between reviewers. Determination of species with high biological scores (>19 points), research scores of 10 (limiting factors unknown), and park-specific scores (without park trend) above the mean of 35.8 yielded two species: fisher and lynx. By excluding park population trend from this categorization, the variance introduced between reviewers was eliminated.

Species occurring at Glacier that are listed by USFWS and USFS include the gray wolf (endangered), grizzly bear (threatened), fisher (sensitive), wolverine (sensitive), northern bog lemming *(Synaptomys borealis*, sensitive), and lynx (sensitive). Mean biological scores for unlisted species versus sensitive species differed significantly (U = 11.5; p = .003713). Park-specific scores for unlisted versus sensitive species did not differ significantly (U = 71.5; p = .40).

Plots of unlisted versus listed species revealed (1) an increase in mean biological scores from unlisted species to listed species; and (2) a decrease in park-specific scores for unlisted species through endangered species. A comparison of mammal species ranked by the Montana Natural Heritage Program and the mean biological score in this study indicated a general trend of decreasing biological scores from species that are critically imperiled to demonstrably secure.

Olympic National Park. Forty-nine mammal species at Olympic were assigned scores for biological and park-specific variables. Biological scores ranged from 26 (out of a potential maximum of 70) for northern flying squirrel to 2 for Norway rat *(Rattus norvegicus)*, forest deer mouse *(Peromyscus oreas)*, and southern red-backed vole *(Clethrion-*

omys gapperi). Park-specific scores ranged from 58 (potential maximum of 70) for coyote *(Canis latrans)* to 26 for black-tailed deer *(Odocoileus hemionus)* and mountain goat *(Oreamnos americanus)*. Species with the highest biological scores at Olympic are shown in Table 5. Individual species with the highest scores for biological and park-specific variables combined included marten *(Martes americana;* 79), mountain beaver *(Aplodontia rufa;* 77), northern flying squirrel (76) and mountain lion *(Felis concolor*, 68).

Comparisons of the two reviewers at Olympic revealed no significant difference on the following park-specific variables: park range, park trend, research, management, monitoring, and harvest. There was a significant difference between reviewers when scoring the variable survey ($U = 118$, $p = .000034$).

Discussion

Our ranking system correctly identified those same forest carnivore species that have been recognized by many researchers as being in need of research and management. Fishers are extirpated over much of their former range in the USA and eastern Canada (Dodge 1977). Many western populations have failed to recover despite decades of reintroductions (e.g., Oregon), protection from trapping (e.g., in the northern Sierra Nevada, Olympic Peninsula), or both (Ruggiero et al. 1994). The lynx was listed as threatened in Washington in October 1993 (Washington Department of Wildlife 1993) and USFS considers the lynx to be a sensitive species (Ruggiero et al. 1994). The American marten has a smaller distribution now than in presettlement historical times, and the total area of its geographic range appears to be at a historical low (Gibilisco 1994).

Table 5. The ten most vulnerable mammal species in Olympic National Park. (See Garrett 1995 for total scores for mammal species, excluding Chiroptera.)

Species	Biological score	Park-specific score	Cumulative score
marten	22	57	79
mountain beaver	20	57	77
northern flying squirrel	26	50	76
mountain lion	25	43	68
fisher	20	48	68
black bear	16	49	65
beaver	15	47	62
Olympic marmot	22	33	55
Roosevelt elk	15	34	49
mountain goat	16	26	42

Forest carnivore species are potentially sensitive to the effects of forest management because of their relatively large area requirements, their association with late-successional forests, and the relative lack of information available for conservation planning (Ruggiero et al. 1994). In addition, most of the geographic ranges of forest carnivores (about 65% for the marten and fisher) are found on public lands. The marten, fisher, and lynx have been judged to be at medium-to-high viability risk due to the reduction of old-growth forests in the Pacific Northwest (Thomas et al. 1993). These species would score high in any park where they occurred.

Using the data from Glacier, biological scores in the ranking system were validated by determining its ability to correctly identify federally listed species. Mean biological scores differed significantly for unlisted versus sensitive species, indicating that our ranking system could identify species listed as sensitive by others.

Plots of unlisted versus listed species indicated (1) higher biological vulnerability in listed species and (2) greater knowledge of endangered and threatened species within the national park, which reflects higher funding allocations for work on endangered species. A comparison of mean biological scores derived from our ranking system at Glacier compared with those of the Montana Natural Heritage Program indicated that our ranking system has accurately portrayed the relative status of species.

Research and management activities related to park resource objectives would be greatly enhanced by a database which could be used as the basis for a program to survey and monitor mammal species of the park (Beiswenger 1990). Our ranking system, developed specifically for setting priorities for mammal species in national parks, will assist biologists in determining where research, inventory, and monitoring monies should be allocated, and could be applied to other parks.

Species rankings based on variable scores are only as reliable as the data from which they are derived. Unfortunately, biological data for some species are inadequate and park-specific information on many species is sketchy at best. Our ranking system is an attempt to prioritize mammal species so that management and funding decisions can be made based on actual need within a national park, rather than on changing public attitudes. These decisions must and will be made whether concrete information is available or not.

Our ranking system will only be useful if biologists involved with the particular specific parks being evaluated are willing to assist in assigning point values for park-specific variables. Reliable knowledge of park-specific variables is critical to obtain reliable results and must be considered before a ranking system is initiated. Attributes of park biologists involved in the ranking process are important to consider as well. Reviewers often influence each other and this could affect results of the ranking process. Consultations between reviewers could be reflected in many species receiving similarly high scores, which would make prioritization difficult. Weighting of variables could be considered in future projects. A consensus of park biologists can be used to determine if weighting needs to be addressed, based on how each park-specific variable contributes to the ranking of species within a particular park.

Organizational steps involved in implementing our ranking system at NPS units would include:

- Assigning a coordinator to develop the biological database;
- Convening a panel of knowledgeable park biologists to assign point values to park-specific variables; and
- Continually updating variable scores as new information becomes available.

Our ranking system could be used to set specific objectives and measure progress within a wildlife program. An example of such an objective would be to lower, over a two-year period, the research score for fishers at Glacier to below 10 points. Progress towards this kind of objective can be measured, as more factors affecting population size and distribution become known. The ranking system is designed as an on-line computerized database that is dynamic, and periodic updates should be planned as new information becomes available.

Recommendations for further research include expanding the database of the ranking system to include all vertebrate taxa present in a particular national park. The ranking system variables would need modification in order to be applicable to all species, following the example of Millsap et al. (1990); however, results from a prioritized ranking of all species would be a valuable tool for all parks to maintain.

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