The Importance of Biological Surveys in Managing Public Lands in the Western United States[1]

Michael A. Bogan,[2] Robert B. Finley, Jr.,[3] and Stephen J. Petersburg[4]

Abstract.—Despite previous studies, incomplete knowledge of the mammalian fauna of many national parks hinders our ability to understand the consequences of either management actions or natural disasters to such preserves. Faunal losses have occurred and can be expected to continue (Newmark 1986a, 1986b). Our studies in and near Dinosaur National Monument, one of the parks studied by Newmark (1986a, 1986b), have added 11 species to the known fauna. Some species have increased with human impact; other species have either disappeared or are declining. Finally, many species, which are uncommon and poorly known, may have rather specific habitat needs.

The equilibrium model of island biogeography (MacArthur and Wilson 1963, 1967) spawned a plethora of studies that examined ways in which various kinds of insular faunas behave (for mammals see Heaney and Patterson 1986). Some of the most interesting applications of the model have been to animals in islands of habitat, such as mountains in the Great Basin (Brown 1971, 1978). These studies revealed that such faunas often behave in contrast to the model, which predicts that the number of species on an island reflects an equilibrium between processes of origin, i.e., species emigrating to the island as a function of island size and distance from the mainland, and processes of extinction on the island. Such studies lend support to the contention that montane mammalian faunas in the Southwest are not in equilibrium (Brown 1986); rather, they are relicts derived by extinction from a set of colonizing species that reached the mountains when life zones were lowered during the Pleistocene.

Newmark (1986a, 1986b, 1987) recently examined ways in which western North American national parks also behave, biologically, as islands. Newmark's (1986a, 1986b) analysis of data for 29 parks (data from only 24 were used in most analyses) in the United States and Canada showed that the number of mammalian species in these parks is declining.

Newmark (1986a, 1986b) predicted that western national parks, under a program of minimal management, could lose up to 100% of the extant species of lagomorphs, carnivores, and artiodactyls in the next 100 to 200 years. This loss of species would be dependent upon the original size of the park (larger areas have more species and larger populations that persist better through time), the degree of insularization of the parks (although most parks presently are not completely isolated, the more isolated they are, the less likely they will be colonized from outside), and intensity of management both within and outside park boundaries.

One of the mammalian faunas included by Newmark (1986a, 1986b) in his analysis was that of Dinosaur National Monument (DNM), located in northwestern Colorado and adjacent Utah, where few studies of mammals have been conducted. General information is available in only a few sources (Cary 1911, Warren 1942, Lechleitner 1969, Armstrong 1972), each of which treats all Coloradoan mammals. Detailed studies of this area are not common and may be difficult to obtain (Durrant 1963, Bogan et al. 1983). This paucity of knowledge is frustrating not only to mammalogists, but also to land managers seeking to protect the resources under their care. In the absence of reliable information, land stewards may end up managing for a relatively small portion of the total fauna, primarily those that are rare or endangered, highly visible or popular, pests, or those of importance to hunters and trappers.

Our studies in DNM and adjacent Browns Park National Wildlife Refuge, conducted since 1980, have provided new information on the mammals of northwestern Colorado. In addition, our data can provide a perspective on 1) the severity of the problem of faunal loss as shown by Newmark (1986a, 1986b) for one area (DNM); and 2) the continuing need for a better data base from which to manage parks and their fauna and flora. We summarize the gradual acquisition of knowledge about mammals in DNM, the contribution of recent detailed studies to the faunal data base, and how some species seem to be responding to human activity. Finally, we comment on some of Newmark's (1986a, 1986b) data and conclusions for DNM.

[1]*Paper presented at symposium, Management of Amphibians, Reptiles, and Small Mammals in North America. (Flagstaff, AZ, July 19-21, 1988.)*

[2]*Michael A. Bogan is Wildlife Research Biologist, U.S. Fish & Wildlife Service, National Ecology Research Center, 1300 Blue Spruce Drive, Fort Collins, CO 80524-2098.*

[3]*Robert B. Finley, Jr., retired from the U.S. Fish & Wildlife Service, is Research Associate, The Museum, University of Colorado, Boulder, CO 80309.*

[4]*Stephen J. Petersburg is Resource Management Specialist, National Park Service, Dinosaur National Monument, P.O. Box 210, Dinosaur, CO 81610.*

Methods

Data were obtained from our studies conducted in northwestern Colorado since 1980. These studies, conducted in riparian and upland habitats in and near DNM, involved biological surveys for mammals and their sign. Mammals were observed, trapped and released, and collected. Specimens form a major part of our data base, confirming the actual presence of a species at a point in time.

Most habitats were sampled from one to three nights with 250 to 300 live or snap traps each night. Traps were set both in linear transects and opportunistically; mist nets and other methods were used for some species. Our study sites included campgrounds, subjectively categorized according to use by humans, as well as isolated areas rarely visited by humans. Although data from some sites are directly comparable and statistically testable due to standardizing numbers of traps and techniques, our purpose here is to present an overview of the mammals at DNM using all available information.

Data on distribution and abundance of mammals in this part of Colorado came from four primary sources; these are Cary (1911), Warren (1942; a slightly revised version of Warren 1910), Lechleitner (1969), and Armstrong (1972). Studies of nearby areas were consulted (Kirkland 1981, Finley et al. 1984, Finley et al. 1976). Original surveys of DNM by Durrant (1963) and Bogan et al. (1983) were of value, as were observations and reports by knowledgeable park visitors and specimens in collections. Historic accounts (e.g., Wishart 1979) of fur trappers and explorers of the nineteenth century were reviewed for additional information on the occurrence and disappearance of some game species undocumented by specimens.

Specimens of mammals from DNM are contained in the University of Utah Museum of Natural History (UU), the University of Colorado Museum (UCM), the Denver Museum of Natural History (DMNH), and the Biological Surveys Collection of the U. S. Fish and Wildlife Service in Washington, DC (USNM), and Fort Collins, CO (BS/FC). Original field notes, photographs, and catalogs form an important part of this data base and are available for inspection. Names of mammals follow Banks et al. (1987).

Table 1.—Numbers of species of mammals at Dinosaur National Monument per order as given in various reports on Colorado mammals (see text). Percentages in parentheses are the proportion of the total mammal fauna that a given order represents.

ORDER	REFERENCE					
	Cary 1911	Warren 1942	Lechleitner 1969	Armstrong 1972	Newmark 1986a	This paper 1988
INSECTIVORA (1.5%)	0	0	?	0	0	1
CHIROPTERA (21.5%)	4	3	7	8	13	14
LAGOMORPHA (6.1%)	3	3	3	3	4	4
RODENTIA (38.5%)	18	18	21	20	19	25
(SCIURIDAE	6	7	7	8	6	9)
(GEOMYIDAE	1	1	1	1	1	1)
(HETEROMYIDAE	1	2	2	2	2	3)
(CRICETIDAE	8	6	9	8	8	10)
(OTHER	2	2	2	1	2	2)
CARNIVORA (24.6%)	13	11	15	12	19	16
ARTIODACTYLA (7.6%)	4	4	4	4	6	5
TOTALS	42	39	50	47	62*	65
(%)	65	60	77	72	95	100

*Includes nine species that are not known from DNM.

Results and Discussion

Historic Data Acquisition

The growth in knowledge of the mammals of DNM is shown in table 1. Data in Cary (1911), who worked just east of the present Monument and used both specimen data and his own and others' reports, suggest that about 42 species (65% of the species listed in appendix 1) occurred in or near DNM. Warren (1942), who did limited work in northwestern Colorado, provides information suggesting that perhaps 39 species occurred there. Lechleitner's (1969) general treatise on Coloradoan mammals, although not intended to provide detailed information on distribution, supports an expected fauna of about 50 species. Armstrong (1972), in the first comprehensive study of Coloradoan mammals, and building upon a sixty-year data base, relied on specimen data to confirm the presence or absence of mammals in a given area and recorded 47 species (72% of those currently known) for DNM or nearby areas. Although some of these references perhaps should not be used to infer the specific occurrence of species in a given area, we think they are so used by land managers and others.

During the period covered by these references little actual work on the mammals of DNM was conducted. Exceptions were the work of Hayward et al. (1958), Durrant and Dean (1959, 1960), and Durrant (1963) who chronicled the only extant baseline data for many riparian areas along the Colorado River and its major tributaries (Green, Yampa) prior to the impoundments at Flaming Gorge and Glen Canyon.

Durrant (1963) surveyed for mammals in DNM and reported 24 species collected or observed, about 37% of the known fauna. Two later surveys for mammals and other vertebrates in the Monument produced 29 (Bogan et al. 1983) and 27 (Bogan unpubl. data) species, 45% and 42% of the presently known fauna. Many of the same species were obtained on both trips.

Contributions of Recent Surveys

The known fauna of DNM includes 65 species (appendix 1) based on specimens and reliable sight records. Three species *(Canis lupus, Ursus arctos,* and *Bison bison)* are now extirpated; we have omitted one species of dubious occurrence *(Mustela nigripes)*. The percentage of mammalian species at DNM by order is Insectivora, 1.5%; Chiroptera, 21.5%; Lagomorpha, 6.1%; Rodentia, 38.5%; Carnivora, 24.6%; and Artiodactyla, 7.7%. Horses *(Equus caballus)* and house mice *(Mus musculus)* occur at DNM; we have excluded these introduced species from our list.

What result have enhanced levels of faunal surveys had on the known fauna of DNM? Our work has added 11 species to the known fauna. These include two state records [*Perognathus parvus* and *Euderma maculatum* (Finley and Creasey 1982) from Browns Park National Wildlife Refuge, about 8 mi from DNM]; one county record *(Lepus californicus)* from DNM; seven Monument records in 1982 *(Myotis californicus, M. thysanodes, Lasionycteris noctivagans, Pipistrellus hesperus, Perognathus parvus, Microtus longicaudus,* and *M. montanus)*; and three records for the Monument in 1987 *(Sorex monticolus, Euderma maculatum,* and *Lemmiscus curtatus)*.

These 11 species represent an increase of 20.3% over the number previously known from DNM. Much of this increase (five species) has come by acquiring a better understanding of the bats. This has been possible because of better techniques of surveying for bats, an improved understanding of continental and regional distributions of bats, and an enhanced effort in surveying for bats at DNM. Additional knowledge of some other groups has come more slowly, primarily because we are approaching the asymptote with respect to species occurring in DNM. The number of cricetid rodents known or suspected to occur has increased from eight to ten in 75 years; that for sciurids has increased from six to nine. Armstrong (1972) reported 20 rodents known from DNM; our records reveal a rodent fauna of 25 species. For bats the figures are 8 in 1972 and 14 in 1987, an increase of 75%.

The extent to which surveys reveal previously unknown faunal components is both fortuitous and regulated by biological phenomena. The capture of the first records of shrews and spotted bats from DNM is partly luck, by being in the right place at the right time. Yet this ability to "test" distributions of mammals by examining (trapping) suitable habitats requires training, skill, and knowledge. In addition, the ability to find rare animals often requires removing the more abundant and common species.

For example, of the 1,469 specimens of small mammals that we have captured at DNM, 52.6% have been *Peromyscus maniculatus*. We have taken 1,049 *Peromyscus* (71.4% of the total trapped) as follows: *P. maniculatus*, 772; *P. truei*, 175; *P. crinitus*, 102. There may be many reasons why so many *Peromyscus* are taken; our techniques may be biased in favor of them, they are easily trapped, etc. Still, they are abundant relative to other species of mammals on the Monument.

We have no exact density figures for *P. maniculatus* in DNM but extrapolations are possible. The area of DNM is 827 km^2 or 82,700 ha; an average density for *P. maniculatus* might be 20/ha (French et al. 1975), or 1,654,000 deer mice. We suspect that the densities at DNM are higher, at least seasonally. A higher density of 50/ha (French et al. 1975) would yield 4,135,000 deer mice. If the average deer mouse weighs 20 g (a low estimate), then the deer mouse biomass at DNM is 33,080 kg to 82,700 kg; the equivalent of 144 to 360 adult elk *(Cervus elaphus)* weighing 230 kg each. The current resident elk population of DNM is 150 to 200; up to 600 may be resident seasonally.

This abundance has several implications. One is that the common species can fill the traps, reducing the possibility of captures of other species, and thus biasing the catch. More interestingly, an accurate understanding that there are a few abundant species and many uncommon ones can provide information of value in assessing impacts of human activities and management of the park, e.g., what species appear to be increasing, those that are decreasing or extirpated, those that are adjusting their ranges, and those for which we have insufficient information. Examples for these categories are discussed below.

Management Implications

Species Increasing in Abundance.— *Peromyscus maniculatus* has been suggested (Armstrong 1977, 1979) as one species that increases in areas disturbed by humans. It is a widespread and adaptable species; whether it has actually increased in some situations, such as in campgrounds, may be de-

batable. Armstrong (in litt.) has noted that deer mice are weed species and that rather than representing a moral failure, they represent a successful evolutionary strategy. *P. maniculatus* apparently always has been common in this part of Colorado; Cary (1911:103) stated that this species was "exceedingly numerous despite coyotes, hawks, and owls...in western Routt [now Moffat] and Rio Blanco Counties in 1906..." He reports (1911:103) that in one case their "excessive numbers all but prevented my securing topotypes" of another species, and that near Lodore they were everywhere a "great nuisance."

Our data from DNM reveal that the canyon mouse *(P. crinitus)* is a specialist of rocky canyon areas. It does penetrate to the upper reaches of some canyons but rarely does it spread much further. The pinon mouse *(P. truei)* is a specialist of pinon-juniper forests and occasionally becomes moderately abundant. Conversely, *P. maniculatus* is common in sagebrush (*Artemisia* sp.) flats, a common upland habitat at DNM. A comparison of relative abundance of this species in subjectively categorized "natural" and "campground" situations reveals an average of 22.4 animals/locality (n = 16) in areas where camping is of low intensity or absent, versus an average of 29.6 deer mice/locality in 14 heavily-used areas. Although these numbers cannot be tested for significance, due to non-uniform trapping procedures, there is a difference in relative abundance of *P. maniculatus*.

Another species that appears to show a "campground" effect is the golden-mantled ground squirrel *(Spermophilus lateralis)*. We have taken this species in many areas and it is widespread. Cary (1911:84) reported that this species was "said to be abundant" near Lily (just outside the present Monument), and 7 mi N of Lily they were reported to be "tolerably common," but Cary saw none there the previous year. They are so common in campgrounds of the Monument now that they are a nuisance, albeit an attractive one. They are fed by visitors and thus are encouraged to remain near the campgrounds. Our data from areas subjectively categorized in terms of human use reveals an average of 7.1 ground squirrels from eight areas heavily used by humans versus 1.2 animals/locality in six little-used areas. In areas where golden-mantled ground squirrels are very common we routinely close our traps during the day to prevent being overrun with these animals.

Species Declining or Disappearing.—Those elements of a fauna that disappear over time are clearly of concern, and may provide clues to habitat changes or other factors leading to faunistic changes. At least three mammalian species are now extirpated from DNM, and likely from Colorado. These are the gray wolf *(Canis lupus)*, the grizzly bear *(Ursus arctos)*, and the bison *(Bison bison)*. Armstrong (1972) cites a specimen of *C. lupus* from Douglas Spring, near the present-day Monument. That gray wolves were common is shown by the fact that about 50 were killed by hired trappers in Brown's Park in the winter of 1906-07 (Cary 1911). *C. lupus* was not included in the DNM fauna by Newmark (1986a).

No specimen of *U. arctos* from or near the Monument is known to us, but there are reports of sightings in the 1800s. About 60 fur trappers and 800 Indians wintered in Brown's Park in 1839-40, during which time they killed six grizzlies and 100 bison for meat (Dunham and Dunham 1977). Fresh tracks of grizzlies were seen in 1871 by members of the second Powell expedition in Lodore Canyon, a few miles above Echo Park (Dellenbaugh 1926); and in 1891 Ann Willis was rescued from a female grizzly with two cubs in Zenobia Basin (Murie and Penfold 1983).

Remains of *B. bison* were excavated from Hell's Midden, an occupation site of the Fremont Culture in Castle Park (Lister 1983). In addition, Walker (1983) reports the recovery of remains of bison, as well as black bear *(U. americanus)*, pronghorn *(Antilocapra americana)*, mule deer *(Odocoileus hemionus)*, wapiti *(Cervus elaphus)*, and bighorn sheep *(Ovis canadensis)*, from Fort Davy Crockett in Brown's Park. These remains date from between 1836 and 1842. Ashley saw several bison in Island Park in 1825 (Murie and Penfold 1983).

The dates of disappearance of these species are speculative. *B. bison*, which wintered in Brown's Park, was already in decline west of the Continental Divide in the late 1830s, as observed by concerned fur trappers (Wishart 1979). According to Wishart (1979), the Rocky Mountain trapping system in Wyoming and Colorado decayed not only because its main fur-bearer, the beaver, was depleted but also because the main source of provisionment, the mountain bison, was destroyed. Termination of the fur trade in 1840 allowed mountain bison to persist for several decades. The last bison killed in northwestern Colorado was at Cedar Springs west of Craig in 1884 (Armstrong 1972).

C. lupus seems to have disappeared by 1935-40 (Young 1944, Lechleitner 1969). The last report of *U. arctos* in northern Colorado was in 1920 in the Medicine Bow Range (Armstrong 1972). Both species were victims of increasing human encroachment and active predator control campaigns.

We have chosen to exclude the black-footed ferret, *Mustela nigripes*, from the known fauna of the Monument, for lack of specimens and sightings, although it was included by Newmark. Generally, the ferret appears to have been a victim of the active poisoning of its principal prey, prairie dogs (*Cynomys* spp.) in addition to other factors (Clark 1986, Flath and Clark 1986).

Newmark (1986a) stated that wapiti *(Cervus elaphus)* should be added to the list of mammals extir-

pated from DNM. Wapiti did occur in the Monument in the early nineteenth century and are there today, but their origin is questionable.

The present animals may be descended from remnant populations from elsewhere in parts of northern Colorado or Utah, or from later introduced wapiti from Wyoming. We suspect they may be of mixed descent.

Ovis canadensis occurring on the Monument today may likewise be of mixed descent. As noted by Pillmore (unpubl. ms.) bighorn were common and highly desired for food by trappers and explorers in northwestern Colorado in the first half of the 1800s, but were greatly reduced by the 1880s, when they were protected by the first game laws. Thereafter the herds slowly increased until heavy die-offs were caused by diseases from domestic sheep. Such losses occurred in Lodore Canyon between 1936 and 1945. By 1947 the superintendent at DNM was ready to "write them off." In 1954 the Colorado Game and Fish Department made two transplants in Lily Park and Zenobia Peak, and numbers since have increased in the Monument (Murie and Penfold 1983).

At least two species may be adjusting their ranges relative to each other in reciprocal fashion. We are aware of no reports of *Lepus californicus* in Moffat County prior to about 1980, although both specimens and sightings of *L. townsendii* exist. In 1972 in western Colorado, the northernmost locality for *L. californicus* was Mesa County (Armstrong 1972). In the summer of 1987, we captured both species, in close proximity, in DNM. Based on the pattern of replacement seen elsewhere, including the eastern plains of Colorado (Armstrong 1972), it is possible that the range of *L. townsendii* is contracting to the north and that of *L. californicus* is expanding to the north. This replacement is commonly tied to land use practices, especially breaking the ground for cultivation, or overgrazing, which may lead to increased amounts of *Opuntia* (Armstrong 1972). Whether *L. californicus* is actually replacing *L. townsendii* at DNM is debatable; what is not arguable is that *L. californicus* is extending its range northward in western Colorado.

Species for Which Information is Inadequate.—There are many species for which scant information exists. These species include most of the insectivores, bats, and rodents, together composing 61.5% of the mammalian fauna of the Monument. Of the 40 species in this category, almost one-third were unknown at DNM just 15 years ago. Much of this increase comes from a better understanding of the bats, but knowledge of their presence does not tell us if there are important hibernacula for bats on DNM, what proportion of the bats may be migratory, or how best to manage for this significant component (22%) of the fauna. Similar comments can be made for most of the other small mammals, although few are as vulnerable to mismanagement and destruction as are bats (Hill and Smith 1984).

Cottontails (*Sylvilagus* spp.) are commonly seen, even abundant at times, but it is difficult to identify animals with certainty as the two species (*S. audubonii* and *S. nuttallii*) occurring at DNM are externally similar. The two species overlap in northwestern Colorado between approximately 6500 ft and 7000 ft and specimens of both were collected by Warren at Douglas Spring. The nature of interactions between the two species of cottontail at DNM is unknown and studies based on specimens are needed.

The raccoon was likely absent from the park and probably the entire upper Colorado River basin prior to the 1950s (Durrant 1952, Long 1965). Specimens (BS/FC) indicate that they moved into the upper Green River and Brown's Park in the 1960s and 1970s, probably from eastern Wyoming.

Newmark's Analysis Applied to Dinosaur National Monument

Newmark's (1986a) analysis is important because it stimulates us to consider a problem and assess its magnitude, and also because he suggests some solutions. He predicts a depressing picture for some species in national parks and there is clear cause for concern. Still, it is useful to put his analysis in perspective. Newmark (1986a) lists 62 species of mammals as occurring in DNM, including *E. caballus* but not *M. musculus*. He (1986a:21) confined his analysis to only three orders, lagomorphs, carnivores, and artiodactyls "because these orders had the most complete park sighting records. Species of these orders tend to be more frequently reported because of their relatively large body size, non-fossorial nature, and popularity." He also used park sighting records as well as continental (Hall 1981), statewide (Armstrong 1972), and local (Anderson 1961) reports.

Those orders used by Newmark (1986a) in his analysis include 39% of the known mammalian species at DNM. The most diverse order (Rodentia) and the third most diverse order (Chiroptera) at DNM are excluded. Furthermore, the 22 species he does consider include the only faunal losses (5) he believes occurred in DNM. We believe that only three species are extirpated from DNM, and further suspect that most of the extinctions occurred prior to major expansion of the Monument's boundaries (1938).

However, the best management decisions will be derived from the most accurate data, and we should try to obtain such data. We also believe that a holistic approach to animal management on public lands is needed. This means including small and secretive species in our plans, as well as the large "glamorous" ones. Newmark recognizes this in his recommendations; he notes the need to develop a more extensive monitoring

program for vertebrate populations, including key species of every order.

An examination of Newmark's (1986a) data reveals that nine of the 62 species he lists for DNM do not occur there: *Plecotus rafinesquii* (an eastern bat perhaps listed due to a misunderstanding of its taxonomy), *Tadarida brasiliensis* (accidental at best, no records for northern Colorado), *Lepus americanus* (perhaps confused by an observer with *L. townsendii* in all-white winter pelage), *Glaucomys sabrinus* (may possibly occur in higher areas of Douglas Mountain at DNM but presently unknown), *Peromyscus boylii* (perhaps mistaken by an observer for the large-eared *P. truei*), *Vulpes velox* (no specimens north of Mesa County), *Gulo gulo* (there is a specimen from near the Utah-Colorado stateline, outside the Monument), *Mustela erminea*, and *Alces alces* (accidental stragglers only).

Why some of these species were included by Newmark is unknown, but in some cases it may have been because they were listed in park records, compiled from observations by visitors and staff. We reexamined the records at DNM and also found records (mostly sightings) of *Sorex cinereus*, *Tamias umbrinus*, *Perognathus flavescens*, *Ammospermophilus leucurus*, *Neotoma lepida* (perhaps juveniles of *N. cinerea*), and *Zapus hudsonius*. We know of no specimens to substantiate these records and do not include them in the fauna of the Monument.

These errors are not necessarily Newmark's, although he may have been uncritical in some instances, but likely stem from several sources. Among these are inadequate or lacking baseline surveys, inaccurate record-keeping by park staff, misunderstandings of current nomenclature by observers or recorders, unreliable observations, and human error. Nonetheless, these errors cloud our understanding of mammals at DNM and the management problems they present. Additionally, although all data and results age with time, Newmark did not have the most current information in many cases and thus was unaware of recent records of mammals from DNM.

Conclusion

Lists of species from a given area are subject to interpretation. We have taken a conservative approach relying on specimens (and giving reasons for inclusions and exclusions where appropriate) and have added significantly to the known mammalian fauna of DNM. Such lists are not trivial exercises because they are the raw materials for making land management decisions. Incorrect or missing data will diminish our ability to manage these lands and their faunas. We believe that biological surveys, resulting in verified records (preferably specimens, but sometimes other data), are the only reliable means to determine the presence of a species and to monitor population trends over time. We agree with Newmark (1986a) that such surveys need to be undertaken immediately, because the information is needed now; and where surveys have been initiated they should be continued on a regular basis. Monitoring of animal populations and the incorporation of accurate data into rational management plans is the only way to ensure that our public lands continue to support a diverse fauna that is as complete as possible.

Acknowledgments

Many people have contributed their time and efforts to learn more about the mammals of Dinosaur National Monument and vicinity. Chief among them are: R. B. Bury, G. H. Clemmer, R. D. Fisher, D. Finnie, K. Hammond, D. Hogan, J. Hogan, M. L. Killpack, C. A. Langtimm, D. Lanning, B. Lapin, D. Leibman, S. J. Martin, C. A. Ramotnik, B. R. Riddle, A. L. Riedel, D. E. Wilson, and D. Worthington. Our boatpersons, who also provided research support on several trips, included R. Buram, H. DeWitt, C. Frye, J. Rucks, and S. Walker. Reports from Cloudridge Naturalists, supplied by D. M. Armstrong, added materially to our understanding of mammals in DNM. J. Creasey, then-Refuge Manager of Browns Park NWR, provided much information and cooperative support for field work. Early inspirational support for this work came from A. R. Weisbrod of the National Park Service. We appreciate the comments of D. M. Armstrong, R. B. Bury, C. Jones, and F. L. Knopf on earlier versions of this paper.

Literature Cited

Anderson, Sydney. 1961. Mammals of Mesa Verde National Park, Colorado. University of Kansas Publications, Museum of Natural History, 14:29-67.

Armstrong, David M. 1972. Distribution of mammals in Colorado. Monograph, University of Kansas Museum of Natural History 3:1-415.

Armstrong, David M. 1977. Ecological distribution of small mammals in the Upper Williams Fork Basin, Grand County, Colorado. Southwestern Naturalist 22:289-304.

Armstrong, David M. 1979. Distributional checklist of rodents in Canyonlands National Park, Utah. Occasional Papers, The Museum, Texas Tech University 59:1-44.

Banks, Richard D., Roy W. McDiarmid, and Alfred L. Gardner (eds.). 1987. Checklist of vertebrates of the United States, the U.S. Territories, and Canada. U.S. Fish and Wildlife Service, Resource Publication 166:1-79.

Bogan, Michael A., Stephen J. Martin, and R. Bruce Bury. 1983. Baseline studies of riparian vertebrates of the Yampa and Green river corridors within Dinosaur National Monument, June and July 1982.

Final (unpublished) report submitted to Regional Office, Rocky Mountain Region, National Park Service, 16 p.

Brown, James H. 1971. Mammals on mountaintops: nonequilibrium insular biogeography. American Naturalist 105:467-478.

Brown, James H. 1978. The theory of insular biogeography and the distribution of boreal birds and mammals. Great Basin Naturalist Memoirs 2:209-227.

Brown, James H. 1986. Two decades of interaction between the MacArthur Wilson model and the complexities of mammalian distributions. Biological Journal of the Linnean Society 28:231-251.

Cary, Merritt. 1911. A biological survey of Colorado. North American Fauna 33:1-256.

Clark, Tim W. 1986. Technical introduction. The black-footed ferret. Great Basin Naturalist Memoirs 8:8-10.

Dellenbaugh, Frederick S. 1926. A canyon voyage. Yale University Press, New Haven, 277 p.

Dunham, Dick, and Vivian Dunham. 1977. Flaming Gorge country. Eastwood Printing and Publishing Company, Denver, 384 p.

Durrant, Stephen D. 1952. Mammals of Utah. University of Kansas Publications, Museum of Natural History 6:1-549.

Durrant, Stephen D. 1963. Mammals of Dinosaur National Monument. p. 69-77. In Woodbury, Angus M. (ed.), Studies of biota in Dinosaur National Monument Utah and Colorado. University of Utah, Division of Biological Sciences Miscellaneous Papers 1:1-77.

Durrant, Stephen D., and Nowlan K. Dean. 1959. Mammals of Glen Canyon. p. 73-103. In Woodbury, Angus M. (ed.), Ecological studies of the flora and fauna in Glen Canyon. University of Utah, Anthropological Papers (Glen Canyon Series Number 7) 40:1-228.

Durrant, Stephen D., and Nowlan K. Dean. 1960. Mammals of Flaming Gorge Reservoir Basin. University of Utah, Anthropological Papers 48:209-243.

Finley, Robert B., Jr., William Caire, and Dallas E. Wilhelm. 1983 [1984]. Bats of the Colorado oil shale region. Great Basin Naturalist 43:554-560.

Finley, Robert B., Jr., and James Creasey. 1982. First specimen of the spotted bat *(Euderma maculatum)* from Colorado. Great Basin Naturalist 42:360.

Finley, Robert B., Jr., Dallas E. Wilhelm, and William Caire. 1976. Mammals of the Colorado oil shale region. Annual Progress Report (Unpubl.), National Fish and Wildlife Laboratory, U.S. Fish and Wildlife Service, Fort Collins, xx p.

Flath, Dennis L. and Tim W. Clark. 1986. Historic status of black-footed ferret habitat in Montana. Great Basin Naturalist Memoirs 8:63-71.

French, Norm R., Dennis M. Stoddart, and B. Bobek. 1975. Patterns of demography in small mammal populations. p. 73-102. In Golley, Frank B., K. Petrusewicz, and L. Ryszkowski (eds.), Small mammals: their productivity and population dynamics. Cambridge University Press, Cambridge. 451 p.

Hall, E. Raymond. 1981. The mammals of North America. Volumes I, II. Second Edition. John Wiley and Sons, New York. 1181+90 p.

Hayward, C. Lynn, D. Elden Beck, and Wilmer W. Tanner. 1958. Zoology of the upper Colorado River basin. Brigham Young University Science Bulletin, Biological Series 1:1-74.

Heaney, Larry R., and Bruce D. Patterson. Eds. 1986. Island biogeography of mammals. Academic Press, New York. 271 p.

Hill, John E., and James D. Smith. 1984. Bats, a natural history. Univ. of Texas Press, Austin. 243 p.

Kirkland, Gordon L., Jr. 1981. The zoogeography of the mammals of the Uinta Mountains region. The Southwest. Naturalist 26:325-339.

Lechleitner, Robert R. 1969. Wild mammals of Colorado: their appearance, habits, distribution, and abundance. Pruett Publishing Company, Boulder. 254 p.

Lister, Robert. 1983. The ancients of the canyons. p. 48-57. In Stegner, Wallace (ed.), This is Dinosaur. Roberts Rinehart Inc. Boulder, Colorado, 93 p.

Long, Charles A. 1965. The mammals of Wyoming. University of Kansas Publications, Museum of Natural History 14:493-758.

MacArthur, Robert H., and Edward O. Wilson. 1963. An equilibrium theory of insular zoogeography. Evolution 17:373-387.

MacArthur, Robert H., and Edward O. Wilson. 1967. The theory of island biogeography. Monographs in Population Biology, Princeton University Press 1:1-203.

Murie, Olaus, and Joseph W. Penfold. 1983. The natural world of Dinosaur. p. 31-47. In Stegner, Wallace (ed.), This is Dinosaur. Roberts Rinehart, Inc., Boulder, Colorado, 93 p.

Newmark, William D. 1986a. Mammalian richness, colonization, and extinction in western North American national parks. Unpublished Ph.D. dissertation, University of Michigan, Ann Arbor. 172 p.

Newmark, William D. 1986b. Species-area relationship and its determinants for mammals in western North American national parks. Biological Journal of the Linnean Society 28:83-98.

Newmark, William D. 1987. A landbridge island perspective on mammalian extinctions in western North American parks. Nature 325:430-432.

Walker, Danny N. 1983. Faunal remains and subsistence practices at 5MF605, a fur trading post in northwestern Colorado. Southwestern Lore 49:6-29.

Warren, Edward R. 1910. The mammals of Colorado. G. P. Putnam's Sons, New York, 300 p.

Warren, Edward R. 1942. The mammals of Colorado. University of Oklahoma Press, Norman. Second revised edition. 330 p.

Wishart, David J. 1979. The fur trade of the American west, 1807-1840. University of Nebraska Press, Lincoln, 237 p.

Young, Stanley P. 1944. Their history, habits, economic status and control. p. 1-173. In Young, Stanley P., and Edward A. Goldman. The wolves of North America. American Wildlife Institute, Washington. 636 p.

Appendix 1

List of mammalian species from Dinosaur National Monument. Species are represented by specimens in collections unless otherwise noted in parentheses. Those specimens not in the U. S. Fish and Wildlife Service's Biological Surveys Collections in Fort Collins (BS/FC), or known only from near the Monument, are so noted in parentheses. See text for species excluded from this list. Additional information on specimens or sight records is available from the authors.

Sorex monticolus (Montane shrew)
Myotis californicus (California myotis)
Myotis ciliolabrum (Western small-footed myotis)
Myotis evotis (Long-eared myotis)
Myotis lucifugus (Little brown bat; 5 mi SE Elk Springs, UCM)
Myotis thysanodes (Fringed myotis)
Myotis volans (Long-legged myotis)
Myotis yumanensis (Yuma myotis)
Lasiurus cinereus (Hoary bat)
Lasionycteris noctivagans (Silver-haired bat)
Pipistrellus hesperus (Western pipistrelle)
Eptesicus fuscus (Big brown bat)
Euderma maculatum (Spotted bat)
Plecotus townsendii (Townsend's big-eared bat)
Antrozous pallidus (Pallid bat)
Sylvilagus audubonii (Desert cottontail)
Sylvilagus nuttallii (Nuttall's cottontail)
Lepus californicus (Black-tailed jackrabbit)
Lepus townsendii (White-tailed jackrabbit)
Tamias dorsalis (Cliff chipmunk)
Tamias minimus (Least chipmunk)
Tamias quadrivittatus (Colorado chipmunk)
Marmota flaviventris (Yellow-bellied marmot; Castle Park, UCM)
Spermophilus lateralis (Golden-mantled ground squirrel)
Spermophilus elegans (Wyoming ground squirrel; Two Bar Spring, DMNH)
Spermophilus tridecemlineatus (Thirteen-lined ground squirrel)
Spermophilus variegatus (Rock squirrel)
Cynomys leucurus (White-tailed prairie dog)
Thomomys talpoides (Northern pocket gopher; Pot Creek, DMNH)
Perognathus fasciatus (Olive-backed pocket mouse)
Perognathus parvus (Great Basin pocket mouse)
Dipodomys ordii (Ord's kangaroo rat)
Castor canadensis (Beaver)
Reithrodontomys megalotis (Western harvest mouse)
Peromyscus crinitus (Canyon mouse)
Peromyscus maniculatus (Deer mouse)
Peromyscus truei (Pinon mouse)
Onychomys leucogaster (Northern grasshopper mouse)
Neotoma cinerea (Bushy-tailed woodrat)
Microtus longicaudus (Long-tailed vole)
Microtus montanus (Montane vole)
Lemmiscus curtatus (Sagebrush vole)
Ondatra zibethicus (Muskrat; Castle Park, UCM)
Erethizon dorsatum (Porcupine; Pot Creek near Pat's Hole, DMNH)
Canis latrans (Coyote)
Canis lupus (Gray wolf, +; Douglas Spring, UCM)
Vulpes vulpes (Red fox; ca. Zenobia Peak, Cary 1911)
Urocyon cinereoargenteus (Gray fox; Castle Park, UCM)
Ursus americanus (Black bear)
Ursus arctos (Grizzly bear, +)
Bassariscus astutus (Ringtail; Castle Park, UCM)
Procyon lotor (Raccoon)
Mustela frenata (Long-tailed weasel; Castle Park, UCM)
Mustela vison (Mink; sightings in Lodore Canyon)
Spilogale gracilis (Western spotted skunk; Irish Canyon, ca. Lodore)
Mephitis mephitis (Striped skunk)
Taxidea taxus (Badger; Two Bar Spring, DMNH)
Lutra canadensis (River otter; Yampa Canyon, Warren 1942)
Felis concolor (Mountain lion; Greystone, UCM)
Felis rufus (Bobcat)
Cervus elaphus (Wapiti)
Odocoileus hemionus (Mule deer; Pot Creek, USNM)
Antilocapra americana (Pronghorn)
Bison bison (Bison, +)
Ovis canadensis (Bighorn sheep)

(+ = species is extirpated from the Monument)

United States
Department of
Agriculture

Forest Service

Rocky Mountain
Forest and Range
Experiment Station

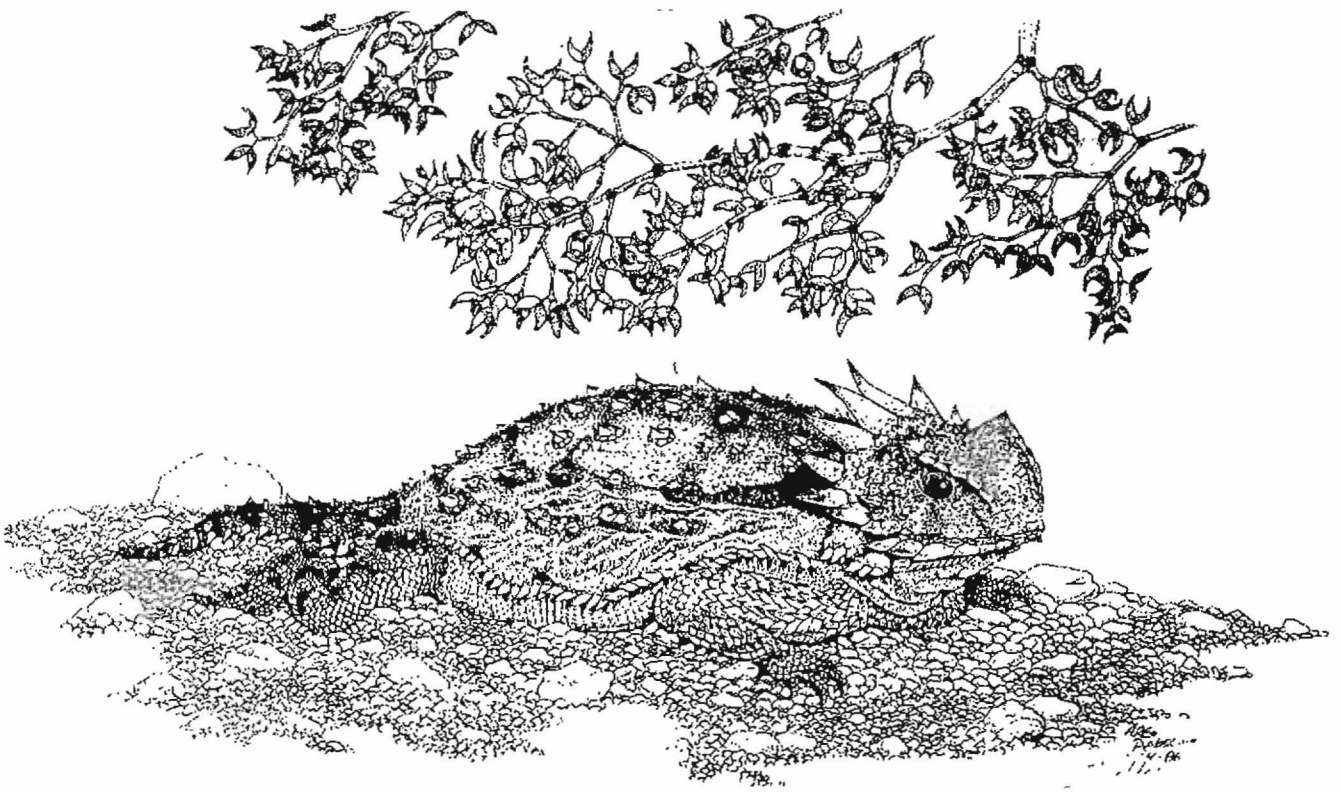
Fort Collins,
Colorado 80526

General Technical
Report RM-166

Management of Amphibians, Reptiles, and Small Mammals in North America

Proceedings of the Symposium

July 19-21, 1988
Flagstaff, Arizona



USDA Forest Service
General Technical Report RM-166

November 1988

Management of Amphibians, Reptiles, and Small Mammals in North America

Proceedings of the Symposium

July 19-21, 1988
Flagstaff, Arizona

Robert C. Szaro, Kieth E. Severson, and David R. Patton
technical coordinators[1]

Sponsored by:

Arizona Chapter of the Wildlife Society

Arizona Game and Fish Department

Northern Arizona University, School of Forestry

USDA Forest Service, Rocky Mountain Forest and Range Experiment Station

USDA Forest Service, National Wildlife and Fish Ecology Program

USDA Forest Service, Southwestern Region

[1]*Szaro and Severson are with the USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, at the Station's Research Work Unit in Tempe, in cooperation with Arizona State University. Patton is with the School of Forestry, Northern Arizona University, Flagstaff.*