

## MAMMALIAN FAUNA OF THE NCAR SITE

REPORT TO CITY OF BOULDER DEPARTMENT OF OPEN SPACE/REAL ESTATE

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When you're confronted with nature. . .you  
don't try to compete with it. You try to  
join with it. . . .--I. M. Pei

## INTRODUCTION

The foothills of the Eastern Slope of the Colorado Front Range are a unique ecological and biogeographic phenomenon. The area known as NCAR Mesa is an eastward extension of these foothills and therefore an integral part of a broader pattern.

Boulder's foothills backdrop is a magnificent and enduring legacy. It provides an esthetic amenity, with opportunities for both active recreation and for quiet solitude. Moreover, it provides habitat for diverse and abundant wildlife, among which are potentially as many as 62 species of native mammals.

The wildlife resource contributes to the esthetic and recreational value of the area. In addition, it can serve as an indicator of environmental quality. A fauna that is an intact, functioning, symbiotic whole attests to the quality of land maintenance and management.

The amount of mammalogical research that has been done in the foothills immediately west of Boulder is not large, considering proximity to a major research university with a history of excellence in field biology. However, some work has been published. In the 1870s, pioneer naturalist Martha A. Maxwell made a collection of mammals around Boulder that was exhibited at the Philadelphia Centennial Exposition of 1876; perhaps some of her specimens (described by Coues, 1879) were obtained on what is now NCAR Mesa. Beyond some unpublished student projects, however, the only extensive work in the immediate vicinity has been on Abert's squirrel (e. g., Farentinos, 1974; Snyder, 1990) and the mule deer (e. g., Weinberg, 1985; Mooring, 1989). Simms (no date) published observations of mammals on NCAR Mesa, which probably are accurate save for attribution of tracks on the Mesa to snowshoe hares (p. 19), an unlikely occurrence.

There is, of course, an abundance of literature on comparable areas along the Front Range, so we are not wholly ignorant of the mammalian fauna of the site. Cary (1911) made observations around Boulder as part of his biological survey of Colorado; indeed, he outfitted at Boulder for his travels

westward into more remote parts of the state. Pioneer collectors in the Boulder area sent specimens to the Smithsonian Institution for study by such distinguished mammalogists as C. Hart Merriam. Gold Hill is the type locality for two subspecies of mammals (Tamias minimus operarius and Neotoma mexicana fallax), Ward for two (Clethrionomys gapperi galei and Tamias umbrinus montanus), and Boulder for another (Eptesicus fuscus pallidus). The pioneering mammalogical work of E. R. Warren (as summarized in 1942) in the vicinity of Colorado Springs applies to the situation about Boulder with only minor exception. Quick (1964) and Mutel (1976) reviewed some aspects of mammalian ecology in Boulder County generally; Lanham (1974) commented briefly on mammals of Enchanted Mesa, just north of NCAR Mesa. Armstrong (1972) summarized the distribution of mammals in Boulder County as part of a statewide study, based on examination of museum specimens, and later (1987) he reviewed the biology of many local species in semi-technical accounts of mammals of Rocky Mountain National Park and vicinity. Fitzgerald et al. (in press) will provide a comprehensive treatment of the mammalian species that contribute to the fauna of NCAR Mesa.

#### METHODS

This report concerns the area known locally (if unofficially) as NCAR Mesa, comprising parts of sec. 7 (T. 1 S, R. 70 W) and sec. 12 (T. 1 S, R. 71 W), Boulder County, Colorado. The site is bordered on the north by Boulder Mountain Parks and the National Institute for Standards and Technology (NIST), US Department of Commerce, on the west by Boulder Mountain Parks, and on the south by City of Boulder Open Space. The site is drained by Bear and Skunk creeks. Elevations range from about 6340 to 5640 feet.

The usual method of ascertaining the mammalian fauna of a site includes livetrapping for the smaller, secretive species. Such studies were not conducted in the present instance, however, because the intense human recreational use of the study area would likely have made such studies labor-intensive and expensive (because disturbance of traplines seemed highly probable, based on my experience working on recreational lands elsewhere in the area, including Rocky Mountain National Park--Armstrong, 1993b). Further, such studies were deemed unnecessary because there have been studies of small mammals in the general area (Armstrong and Freeman, 1982) and I have conducted extensive studies in comparable situations in Boulder and Larimer counties for a number of years. Therefore, I proposed to characterize the fauna of the NCAR site based on field reconnaissance (conducted in April and October) and review of the literature.

Armstrong and Freeman (1982) summarized studies of mammals of Boulder Mountain Parks by mammalogy students at the University of Colorado. The study involved field reconnaissance, live-trapping, and review of the literature on species and the broader context. Two of the actual field sites were in the immediate vicinity of NCAR Mesa: a grassland-woodland ecotone west of NCAR

and talus at the base of the Third Flatiron. In addition, there were transects in Gregory and Long canyons and at the south end of the Mesa Trail (above South Boulder Creek, east of Eldorado Springs). Some of the introductory, historical material above is paraphrased from that earlier report. Copies of Armstrong and Freeman (1982) are available from the senior editor, and he retains the primary data on file.

## RESULTS AND DISCUSSION

Table 1 indicates the potential natural mammalian fauna of NCAR Mesa, annotated by ecological community-type: grassland, ponderosa pine woodland, montane shrubland, and riparian habitats. Potential natural fauna is a concept analogous to the potential natural vegetation of Kùchler (1967). It represents an hypothesis as to the fauna of a site if (1) ecological succession were to be telescoped into a single instant and (2) effects of humans were to be removed from the scene. In the present case, the potential natural fauna probably is very close to the actual fauna of the site, except that a few larger species (denoted with an asterisk in Table 1) have been extirpated since European settlement in the area. The general homogeneity of the grasslands of the Mesa at this time may restrict actual species richness. Further, a few of the species on the list are to be expected only occasionally in the community-types represented on the Mesa, as dispersers or occasional wandering individuals. These are indicated in the table as such with a double asterisk (\*\*).

Table 1 includes 62 species. Few areas of comparable size in temperate North America could claim so great a faunal list. The richness of the potential mammalian fauna is due to topographic and consequent ecological diversity. Boulder's mountain backdrop is not just dramatic scenery, not just "another pretty place"; is rich ecological opportunity because of the mosaic of contrasting habitats (Armstrong and Freeman, 1982).

Armstrong and Freeman (1982) noted that the community-types in Boulder Mountain Parks with the greatest mammalian species richness were ponderosa pine woodland and the woodland-grassland ecotone (situations characteristic of the western portion of NCAR Mesa). The most distinctive community-type was plains grassland (as represented in large measure by the eastern slopes of NCAR Mesa). Despite its small size, because of the particular mosaic of habitats represented, NCAR Mesa has a potential natural mammalian fauna including nearly three-quarters of the species (62 of 88) to be expected on the entire system of Boulder Mountain Parks.

From a zoogeographic standpoint, it is obvious that species occur where they do because (1) they could get there and (2) they could prevail. Over much of the Earth, a third factor has come to be of co-equal importance with those ecological factors. That is a cultural aspect. Species occur where they do because humans tolerate them and protect their habitat (or at least they do not

actively destroy it). This human cultural factor is of fundamental importance to the mammalian fauna in the vicinity of Boulder.

Boulder is unique among Front Range cities in the extent to which the richest of its natural ecosystems--the mosaic of ecosystems that form the foothills backdrop--have been preserved. That preservation took foresight which has been largely lacking elsewhere; cities like Fort Collins, for example, are only now beginning to wake up to the value of these ecosystems to the quality of human life (let alone wildlife). Armstrong and Freeman (1982) expressed the opinion that the uniqueness of the Boulder Mountain Parks makes their stewardship an even greater responsibility, because--as an example of what a local community can do to protect and enhance the natural environment--the Mountain Parks are more than just a local resource; they are a national treasure. That observation clearly would extend to much of City of Boulder Open Space, parts of Boulder County Parks and Open Space, and NCAR Mesa.

Armstrong (1992) presented a broad review of the ecology and biogeography of the foothills of the Colorado Front Range. Chronic and Chronic (no date) described the geologic setting of NCAR Mesa. NCAR Mesa--a remnant of uneroded Cretaceous Pierre shale liberally strewn with boulders mostly from the Paleozoic Fountain conglomerate--supports the easternmost extension of foothills habitats at its particular latitude. The foothills are a complex ecological phenomenon, in many aspects understudied, misunderstood, and perhaps under-appreciated (Armstrong, 1992).

#### Habitats for Mammals

Habitat is usually (and appropriately) described by the mosaic of vegetation in the landscape. Vegetation of the foothills has been described in a number of general accounts of the Front Range (e. g., Benedict, 1991; Mutel and Emerick, 1984; Rodeck, 1964). Gregg (1963) published a summary of the ecology of Colorado as a basis for biogeographic analysis of ants and provided a thorough review of literature. Krebs (1973) described vegetation of Boulder County; K uchler (1965) provided a general context.

Cary (1911) mapped the ecology of Colorado in terms of Merriam's classical "life zones," grossly merging the unique communities of the foothills of the Eastern Slope with sagebrush steppe and ponderosa pine woodlands as the "Transition Zone." Vestal (1917) recognized the complexity and distinctiveness of the foothills, but most subsequent authors (e. g., Benedict, 1991; Marr, 1961; Mutel and Emerick, 1984, 1992) have emphasized the foothills as transitional rather than highlighting their uniqueness. Although Costello (1954) described mountain shrublands as a distinctive habitat-type, he still emphasized transition: "brushlands are dominant in the transitions between grassland and semi-desert at their lower limits and woodland or conifer forest at their upper borders" (p. vii).

To dismiss the foothills as merely transitional is misleading, however. To be sure, there are some species in common with the plains to the east and the higher mountains to the west (especially in riparian communities), but in a real sense the foothills are unique in their ecology and their biogeography--a system sui generis, to be understood on its own terms.

Marr (1961) reviewed ecological studies of the Front Range and provided the most detailed descriptions to date of vegetation of the area. Based on work at several sites on a transect between Boulder and Lefthand creeks, he described vegetation of the Eastern Slope in terms of four "climax regions" (Lower and Upper Montane Forest, Subalpine Forest, and Alpine Tundra) and four adjacent "ecotone regions" (Grassland-Lower Montane, Lower Montane-Upper Montane, Upper-Montane-Subalpine, Subalpine-Alpine). Although some today would argue with his vocabulary (choosing to speak of "community-types" or some other unit rather than "climax regions," and thus obviating potentially contentious discussion of the stability of "climax" stands, for example), the pattern which Marr described is real, and he provided a baseline study of remarkable and revealing detail. NCAR Mesa lies in Marr's "Grassland-Lower Montane Ecotone Region."

The biotic community-types of the foothills represent a response to patterns of slope, aspect, soil texture and moisture relationships, and disturbance history (including human landuse). Although described on the basis of vegetation, each of the community-types supports a diverse biota beyond plants: fungi, microbes, and animal life, including mammals. (For details on general ecology and wildlife beyond mammals, see especially Mutel and Emerick, 1992.)

Ponderosa Pine Woodland.--Ponderosa pine (Pinus ponderosa) woodlands cover much of the foothills of the Front Range. Their lower limit is often associated with grassland on fine-textured soils. The woodlands have been well-studied, in part because some stands are commercially valuable as rough lumber, millwork, and fuelwood. Fire ecology of the stands is fairly well known. Marr (1961:27) observed that "lumbering, fires, mining, and unsuccessful attempts at agriculture have disturbed this region so much that not a single acre has retained its primeval character." Each of these forms of disturbance is richly evident on NCAR Mesa. Veblen and Lorenz (1991) emphasized ponderosa pine woodlands in their uniquely valuable study of ecosystems of the Front Range, stressing the important natural influence of fire on ponderosa pine stands, and raising the question of the "primeval character" of these stands. A principal message of their striking re-photography of local landscapes is the great increase in the extent and density of ponderosa pine woodland.

Ponderosa pine on NCAR Mesa exemplifies this expansion. It includes a somewhat older, denser stand to the west and a fringe of discontinuous patches of mostly smaller trees along the

margins of the mesa. The shrub understory is minimally developed except at the upper end of the Mesa and, as a consequence, the woodland provides marginal habitat for a number of species typical of ponderosa pine habitat (see Table 1).

As many as 41 species constitute the potential natural mammalian fauna of ponderosa pine woodlands on NCAR Mesa. Symbiotic systems between mammalian species and ponderosa pine have received the attention of a number of researchers. In particular, intensive studies of Abert's squirrel (Farentinos, 1974; Snyder, 1990) and porcupines (Habeck, 1990) are directly relevant to the study area and have deepened our understanding of community dynamics of ponderosa pine woodland. Neither Abert's squirrels nor porcupines appear to be abundant on the Mesa. Additional research is needed on the relationship between Abert's squirrels and fox squirrels, the latter a relative newcomer to the Front Range (Armstrong, 1972).

Foothills Shrubland.--The potential natural mammalian fauna of foothills shrublands (Table 1) includes some 35 species. Benedict (1991) reviewed the ecology of foothills shrublands. In terms of species composition, this is a highly variable community-type. South of about Morrison, the predominant shrub is Gambel oak (Quercus gambelii). North of Morrison, mountain mahogany (Cercocarpus montanus) dominates many shrublands. On NCAR Mesa, however, the most frequent shrubs in the community are such species as skunkbush sumac (Rhus trilobata), wax currant (Ribes cereum), native plum (Prunus americana), snowberry (Symphoricarpos spp.), and hackberry (Celtis reticulata).

Foothills shrublands typically occur on dry, rocky sites with poorly developed soils, in dense, often single-species stands, with a sparse understory except in openings, where a fair diversity of herbs occurs. Shrublands also extend along the sides of canyons in the foothills, where they may merge with riparian shrublands and woodlands on canyon bottoms.

Shrublands are a critical piece of the mix of habitats, insofar as the mammalian fauna is concerned. Shrubs provide important browse for the ubiquitous mule deer as well as Nuttall's cottontail. Especially on exposed slopes, shrublands expand cover for small mammals, including the northern rock mouse. Further, shrublands provide a reliable fruit crop, attractive to mammals as diverse as bears and mice in autumn. Mule deer have brozed shrubs severely on NCAR Mesa, where plants with stems as large as 1-2 cm. in diameter may be only 20-30 cm. high.

Although they are not especially well-developed on the study site (or in Boulder County generally--see Mutel 1976), one should not underestimate the importance of foothills shrublands. They are both ecologically interesting and important to biodiversity. Further--highlighting the importance of NCAR Mesa--on a regional basis, these are not extensive stands, sometimes forming a band less than a kilometer wide. Krebs (1973) published a vegetation

map of Boulder County (1:96,000) based on working maps at a scale of 1:24,000. At the published scale, scrub communities simply vanished, and the impression was left that the foothills are clothed with a mixed coniferous forest. That is, of course, not the case.

One of the most conspicuous mammals on NCAR Mesa is the mule deer, which are almost never out of sight of even the casual observer. Bedgrounds are especially frequent in patches of shrubs of a variety of species. The deer of NCAR Mesa have attracted some behavioral and ecological study (e. g., Weinberg, 1985; Mooring, 1989) and a great deal of management attention.

A frequent physiographic situation for shrublands is canyon walls. Armstrong (1992, in press, and elsewhere) has emphasized the ecological importance of the canyons carved by the eastward flowing streams that drain the Front Range. They contribute to the existence and maintenance of the biodiversity of the foothills corridor. Canyons in the foothills frequently are narrow and steep. These characteristics help to produce a pronounced "canyon effect," with marked abiotic and biotic differences between north- and south-facing slopes (see Stinson, 1978). On north-facing slopes, one observes dense vegetation with Douglasfir (Pseudotsuga menziesii) and other mesic-adapted species, but intense reradiation forces cold air drainage away from south-facing canyon walls, contributing to a microhabitat that favors the species of southwestern affinities so characteristic of the foothills (Armstrong, 1972, 1992, in press). To be sure, in the vicinity of NCAR Mesa, Skunk and Bear creeks are too small to have carved appreciable canyons and hence do not contribute much "canyon effect." However, NCAR Mesa is a piece of a corridor of habitats generally favorable to these foothills species, connecting outstanding habitat on south-facing walls of South Boulder (Eldorado) and Boulder canyons. Isolated boulders and patches of deciduous shrubs are habitat on NCAR Mesa for such southwestern species as Mexican woodrats and rock mice as well as for mountain species like yellow-bellied marmots.

Grasslands.--Foothills grasslands are complex, reflecting pre- and post-settlement patterns of fire, soil texture, and moisture complicated by effects of grazing and cultivation (Johnson, 1945). On NCAR Mesa, a history of heavy grazing is hinted by the presence of yucca (Yucca glauca) and pricklypear (Opuntia sp.) as well as lanceleaf sage (Salvia reflexa), cheatgrass (Bromus tectorum), and other "increasers." The potential natural mammalian fauna of NCAR Mesa includes some 20 grassland species (Table 1).

Black-tailed prairie dogs are typical of grasslands on the Colorado Piedmont, where they represent a kind of "keystone species," modifying the landscape and providing habitat for numerous other species. Once prairie dogs surely were a part of an ecosystem dominated by the American bison, and since the demise of the bison they remain typical of habitats that are heavily grazed, as is now done by domestic livestock. In many

areas, prairie dogs range into the grasslands of the foothills of the Front Range. However, they seem not to be present on NCAR Mesa. Indeed, I have not even seen evidence of past occupation, despite ground-level search on three occasions. As a consequence, some typical mammalian associates of prairie dogs, such as thirteen-lined ground squirrels, northern grasshopper mice, and hispid pocket mice, may be scarce or absent on the mesa. Still, prairie dogs (and their commensals) clearly are part of the potential natural mammalian fauna of the NCAR site, as they occur in analogous situations not far distant, such as the valley between the "Red Rocks" and the Dakota Hogback, between Boulder and Sunshine canyons.

Due to apparently uniform management (insofar as grazing and fire are concerned) and soils, the grasslands of NCAR Mesa are fairly monotonous and uniform. There is microrelief, however, and apparent variation of moisture relationships. Frequent swales appear to have greater moisture and higher productivity. Virtually all such situations investigated were liberally marked with runways of voles, probably prairie voles (although the depth and strong definition of some of the the runways suggests that montane and/or meadow voles may be present as well).

Riparian Habitats.--NCAR Mesa is bounded on the north by Skunk Creek and on the south by Bear Creek. Both of these streams are seasonal (Skunk Creek being smaller and quite ephemeral) and neither has a particularly well developed riparian zone, although both have a diverse and dense shrub synusia. The ravines do bring such montane species as mountain maple (Acer glabrum) and Douglasfir to low elevation. There also is a complement of exotic woody species, including viburnum (Viburnum lantana) and Chinese elm (Ulmus pumila). At two points under the heavy cover of riparian woodland in Skunk Canyon I encountered remains of deer that probably had been cached by mountain lions. In both cases, skeletons had been picked clean, probably by birds, but long bones had not been crushed, as is typical of carcasses encountered fresh by coyotes.

Good riparian woodlands are present along Bear Creek, but neither stream supports the wetlands and meadow situations characteristic of overbank deposits on floodplains. In the absence of such habitats, one would not expect such species as jumping mice (probably not the western jumping mouse, Zapus princeps, and certainly not the meadow jumping mouse, Z. hudsonius) or resident populations of beaver or muskrat.

It is not certain that this pattern of drainage has always been the case. Channel morphology (well-vegetated but relatively sharp, deep, V-shaped channels on relatively broad floodplains) suggests fairly recent stablization after previous active downcutting (perhaps a consequence of heavy grazing in prior decades). The relatively broad floodplains might once have had the capacity to support meadows with their typical fauna. Table 1 suggests that the potential natural mammalian fauna of these systems near NCAR Mesa includes some 24 species.



Riparian woodland sometimes shows floristic similarity to shrublands well upslope on the Mesa. The woodland often draws species of mountain forests down to relatively low elevations. An example would be the presence in Skunk Canyon of black bear (as revealed by typical droppings consisting mostly of chokecherry seeds, observed on 11 October 1993).

Also, riparian systems of the foothills often provide a corridor for invasion of the mountains by expansive eastern species like the fox squirrel and the raccoon. This occurs in rather dramatic fashion along Bluebell and Boulder canyons, and probably somewhat along Bear Creek (if not Skunk Creek). Eastward from NCAR Mesa, riparian habitat along these drainages is highly modified by urbanization and is discontinuous at best, however. Bear Creek flows into Boulder Creek just northeast of the intersection of 47th Street and Arapahoe Road, having traversed a more or less artificial channel for several miles. Skunk Creek flows through the NIST site and ends in storm drainage structures on the University of Colorado Campus. Therefore, one would not expect the less tolerant species of riparian woodland (such as eastern cottontails) to have access to the upper reaches of these drainages.

Patterns of Biodiversity.--Due to complex ecology and history, the foothills of the Colorado Front Range support high species richness in a number of well-studied taxa, including butterflies, ants, birds, and mammals (Armstrong, 1992). Statewide, saxicoline shrublands are second only to piñon-juniper woodlands in mammalian species richness, with 43 percent of the Coloradan fauna (Armstrong, 1972). Foothills shrublands and ponderosa pine woodlands support 43 and 54 percent, respectively, of the 91 mammalian species of Boulder County (Armstrong, unpublished). This richness is due in part to the fact that the foothills are to some degree transitional between the grasslands of the Great Plains and the forests of the Southern Rocky Mountains. However, the foothills are not only transitional but distinctive, providing habitats for a biota more typical of southwestern United States and northern México (Armstrong, 1972, 1992, in press).

Along the Front Range, habitat suitable for species of southwestern affinities narrows markedly to a band of foothills habitats at most a few kilometers wide, extending tenuously up major canyons in restricted habitats, especially on exposed south-facing walls. Mammalian species of this "Chihuahuan Intrusive" fauna include the Colorado chipmunk, rock squirrel, Mexican woodrat, northern rock mouse, Abert's squirrel, gray fox, western spotted skunk, and perhaps ringtail. These species are part of the actual and potential natural fauna of NCAR Mesa (Table 1). The shrublands and woodlands of the foothills of the Front Range comprise a peninsula of habitats structurally reminiscent of the Southwest and northern interior México. Mammals of this foothills corridor exhibit a pronounced "peninsular effect," with numbers of species attenuating

northward. Enrichment of the biodiversity of the foothills with this Chihuahuan fauna underscores the complexity of the foothills and their interest for their own sake, not simply as a transition between plains and mountains.

#### CONCLUSIONS AND RECOMMENDATIONS

Despite its small size, the NCAR Site encompasses a remarkable biotic diversity, potentially including 62 species of native mammals. Although not the most diverse site along Boulder's mountain front (in part because the grassland is so homogeneous), the area is highly interpretable. The site is an important link in a corridor of foothills habitats at the dramatic interface between the Colorado Piedmont and the Front Range. The ecological and biogeographic interest of the site is great, and its value is greatly enhanced by its situation immediately adjacent to an intensively modified and densely settled urban landscape.

Human use of the site is rather intensive. Foot traffic at the moment appears to be poorly controlled. For several reasons, including maintenance of habitat for native wildlife, I would recommend more stringent control of pedestrian traffic, especially confinement to properly constructed trails. Informal trails on Benton and Pierre shales are particularly damaging to adjacent habitats.

Opportunities for interpretation of the natural history of the NCAR site are legion. A small and preliminary sampling is provided in Table 2. A start on developing interpretive information on the mammalian species and phenomena noted is available in Armstrong (1993a), Armstrong and Freeman (1982), and Fitzgerald et al. (in press). Baiting wildlife for observation is to be discouraged, for esthetic and philosophical reasons, as well as the safety of wildlife and the public; someone has suspended peanuts in trees along the NCAR Trail just west of the site, presumably to feed or bait species unknown to me.

Opportunities for research are also available on the site, and if tied to interpretation this could be a valuable adjunct to any programming proposed. Among numerous mammalogical phenomena of interest (and possible management importance) on the site are:

1. Habitat relationships and behavioral interactions between Abert's and fox squirrels (the latter a recent arrival).
2. Identity of voles in grassy swales on the face of NCAR Mesa (and habitat relationships between species if more than one species is present).
3. Effect of mule deer on morphology and productivity of shrubs (by means of browsing exclosures, for example).
4. Habitat relationships of the two species of cottontails

likely present on the site.

5. Dynamics of distribution of Mexican woodrats and perhaps northern rock mice on habitat islands provided by colluvial boulders derived from Fountain Formation.

6. Effects of wandering housecats on populations of native mammals (and other species).

7. Distribution of northern pocket gophers relative to microtopography, soils, and/or vegetation.

Webb and Foster (1991) presented results of a 1990 symposium on urban wildlife ecology sponsored by the Denver Museum of Natural History and the Thorne Ecological Institute. Various participants had insights of importance to management of open space along the Colorado Front Range, including NCAR Mesa. In particular, Knight (1991) reviewed seven ecological principles applicable to the maintenance of urban biotic diversity. These are listed here in closing because of their direct relevance to management of the NCAR Site.

1. The species composition of a community on an area varies with the successional stage of the ecosystem that occur on the area.

2. Changing the abundance of one or more species in a community will result in changes in the relative abundance of the other members of the community.

3. The successful addition of a new species into a community will change the pattern of relative abundance and often the species composition of the natural members of the community.

4. The number of species in a community is affected by the area of the ecosystem in which the community exists.

5. The species composition of the community in a fragmented ecosystem is affected by how isolated the ecosystem fragments are from each other.

6. The shape of an ecosystem fragment affects the species composition of the community that exists in the fragment.

7. The vertical and horizontal vegetative complexity of an ecosystem fragment affects the species composition that exists in that fragment.

Attention to these principles will help planners and managers to remain true to the vision of I. M. Pei, world-renowned architect of the NCAR Mesa Laboratory, as articulated in the epigram that heads this report.

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Table 1. Ecological distribution of potential natural mammalian fauna of NCAR Mesa, Boulder County, Colorado. (Key: G = Grassland; S = Montane Shrubland; P = Ponderosa Pine Woodland; R = Riparian Habitats)

	G	S	P	R
INSECTIVORA--SORICIDAE: SHREWS				
Masked Shrew-- <u>Sorex cinereus</u>				X
Merriam's Shrew-- <u>Sorex merriami</u>		X		
Montane Shrew-- <u>Sorex monticolus</u>		X	X	X
Dwarf Shrew-- <u>Sorex nanus</u>		X	X	
CHIROPTERA--VESPERTILIONIDAE: COMMON BATS				
Western Small-footed Myotis-- <u>Myotis ciliolabrum</u>		X	X	
Long-eared Myotis-- <u>Myotis evotis</u>		X	X	
Little Brown Bat-- <u>Myotis lucifugus</u>		X	X	X
Fringed Myotis-- <u>Myotis thysanodes</u>		X	X	
Long-legged Myotis-- <u>Myotis volans</u>		X	X	X
Hoary Bat-- <u>Lasiurus cinereus</u>			X	
Silver-haired Bat-- <u>Lasionycteris noctivagans</u>			X	
Big Brown Bat-- <u>Eptesicus fuscus</u>		X	X	X
Townsend's Big-eared Bat-- <u>Plecotus townsendii</u>		X	X	
LAGOMORPHA--LEPORIDAE: RABBITS AND HARES				
Desert Cottontail-- <u>Sylvilagus audubonii</u>	X			
Nuttall's Cottontail-- <u>Sylvilagus nuttallii</u>		X	X	
White-tailed Jackrabbit-- <u>Lepus townsendii</u>		X	X	
RODENTIA--SCIURIDAE: SQUIRRELS				
Least Chipmunk-- <u>Tamias minimus</u>		X	X	
Colorado Chipmunk-- <u>Tamias quadrivittatus</u>		X	X	
Yellow-bellied Marmot-- <u>Marmota flaviventris</u>		X	X	X
Golden-mantled Ground Squirrel-- <u>Spermophilus lateralis</u>		X	X	
Rock Squirrel-- <u>Spermophilus variegatus</u>		X	X	
Black-tailed Prairie Dog-- <u>Cynomys ludovicianus</u>	X			
Fox Squirrel-- <u>Sciurus niger</u>				X
Abert's Squirrel-- <u>Sciurus aberti</u>			X	
Pine Squirrel, or Chickaree-- <u>Tamiasciurus hudsonicus</u>			X	
GEOMYIDAE: POCKET GOPHERS				
Northern Pocket Gopher-- <u>Thomomys talpoides</u>	X	X	X	

HETEROMYIDAE: POCKET MICE AND ALLIES

Olive-backed Pocket Mouse--  
Perognathus fasciatus X  
 Hispid Pocket Mouse--Chaetodipus hispidus X

CASTORIDAE: BEAVER

Beaver--Castor canadensis\*\* X

MURIDAE: RATS AND MICE

Western Harvest Mouse--  
Reithrodontomys megalotis X  
 Deer Mouse--Peromyscus maniculatus X X X X  
 Northern Rock Mouse--Peromyscus nasutus X X  
 Northern Grasshopper Mouse--  
Onychomys leucogaster X  
 Mexican Woodrat--Neotoma mexicana X X  
 Southern Red-backed Vole--  
Clethrionomys gapperi X  
 Long-tailed Vole--Microtus longicaudus X  
 Montane Vole--Microtus montanus X  
 Prairie Vole--Microtus ochrogaster X  
 Meadow Vole--Microtus pennsylvanicus X  
 Muskrat--Ondatra zibethicus\*\* X

ZAPODIDAE: JUMPING MICE

Western Jumping Mouse--Zapus princeps X

ERETHIZONTIDAE: PORCUPINES

Porcupine--Erethizon dorsatum X

CARNIVORA--CANIDAE: DOGS AND ALLIES

Coyote--Canis latrans X X X X  
 Gray Wolf--Canis lupus\* X X X X  
 Red Fox--Vulpes vulpes X  
 Gray Fox--Urocyon cinereoargenteus X X

PROCYONIDAE: RACCOONS AND ALLIES

Raccoon--Procyon lotor X  
 Ringtail--Bassariscus astutus X

URSIDAE: BEARS

Black Bear--Ursus americanus X X X  
 Grizzly Bear--Ursus arctos\* X X X X



MUSTELIDAE: WEASELS AND ALLIES

Short-tailed Weasel-- <u>Mustela erminea</u>	X	X	X	X
Long-tailed Weasel-- <u>Mustela frenata</u>	X	X	X	X
American Badger-- <u>Taxidea taxus</u>	X			
Striped Skunk-- <u>Mephitis mephitis</u>	X	X	X	X
Western Spotted Skunk-- <u>Spilogale gracilis</u>		X	X	

FELIDAE: CATS

Mountain Lion-- <u>Felis concolor</u>		X	X	
Bobcat-- <u>Lynx rufus</u>		X	X	

ARTIODACTYLA--CERVIDAE: DEER

Elk, or Wapiti-- <u>Cervus elaphus</u> **	X		X	
Mule Deer-- <u>Odocoileus hemionus</u>	X	X	X	X
White-tailed Deer-- <u>Odocoileus virginianus</u>				X

BOVIDAE: CATTLE AND ALLIES

Bison-- <u>Bison bison</u> *	X			
Bighorn Sheep-- <u>Ovis canadensis</u> **	X	X	X	

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TOTAL = 62 Species	20	35	41	24
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Comments and notes: This list does not include or adventives (e. g., Old World rats and mice, feral dogs, cats). Nomenclature and annotations of ecological distribution generally follow Fitzgerald et al. (in press); \* = extirpated within historic time; \*\* = to be expected as occasional dispersers only (suitable habitat on site lacking).

Table 2. A spectrum of mammalian species and communities of possible interpretive interest on the NCAR site.

Species/Community	Location	Principle/theme
Grassland without prairie dogs	Grasslands throughout site	Keystone species, comparison with Open Space sites elsewhere along mountain front
Voies (meadow mice)	Moist, grassy swales throughout site	Micro-grazers, population density, population fluctuations
Mule deer	Throughout site	Population dynamics, predator-prey imbalance
	Shrub stands	Pruning by browsing, shrub response
Raccoons	Skunk Canyon	Feeding habits
Riparian community	Skunk Canyon	Mixture of plains, foothills, mountain species; exotic species; "reading the landscape"
Abert's & fox squirrels	Ponderosa pine woodland	Specialist/generalist; invasive species
Woodrats	Fountain boulders & outcrops	"trade rat" behavior, food habits
Marmots	Larger boulders & outcrops	Low elevation occurrence of mountain species
Bear, mountain lion	Skunk Canyon	Tracking



North  
←

1" = 200'

4' contour interval