Chapter 1

North American Rodents

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Role of rodents

Despite being the most numerous, widespread, and diverse group of mammals on earth, the importance of rodents (gnawing mammals) remains poorly understood and unappreciated by the general public. Rodents are mostly small and active at night, and so are rarely seen by most people. Human contact with rodents is often negative: they are pests that feed on our crops and stored grains, or hosts for parasites that transmit diseases to us and our domestic animals. There are some offsetting economic values of rodents: as furbearers (beaver and muskrat), as food for other furbearers, as subjects of medical research (laboratory rats and mice), and as game (particularly squirrels). However, the value of rodents goes well beyond such economic concerns or the fondness that many of us hold for certain groups of rodents. Because they are widespread in diverse habitats throughout the world, and are often the most abundant mammals in those habitats, rodents are a critical link in a food chain that leads from plants up through carnivorous predators, and thus sustain major portions of ecosystems. For example, the Paiute ground squirrel (*Spermophilus mollis*) is a "keystone species" that supports entire carnivore food webs in southwestern Idaho (Yensen *et al.* 1992), and it has been estimated that prairie dogs (*Cynomys* spp.) support up to 170 associated species (Miller *et al.* 1994). Seemingly minor ecological roles of rodents may have critical environmental effects: the prolific burrowing of pocket gophers strongly affects soil aeration and fertility and allows penetration of ground water (Dalquest 1948, Ingles 1949, 1952); chipmunks, voles, and flying squirrels play an integral role in forest health through their relationships with mycorrhizal fungi (Maser *et al.* 1978, Maser C. *et al.* 1986, Maser Z. *et al.* 1986).

Diversity of North American rodents

How many species of rodents are there? Of the 4629 known species of mammals on earth, 2021 (or 43.7%) are rodents (Wilson and Reeder 1993). The proportion is even higher in North America (north of Mexico; hereafter referred to simply as North America): 206 of 347 native land-mammal species (59.4%) are rodents. North America is not particularly rich in mammal diversity: although it possesses nearly 15% of land area on earth, it has only 7.5% of the world's mammal species. However, its rodents are both numerous and distinctive, including the most primitive of all living rodents (mountain beavers of the family Aplodontidae, found only in western North America) and two families that are found only in North America and Middle America (pocket gophers, family Geomyidae; and kangaroo rats, kangaroo mice, and pocket mice, family Heteromyidae). Compared to the rest of the world's mammal fauna, North America is conspicuously rich in these New World families and in the squirrels (family Sciuridae), which are found in both the Old and New World. The other common family of North American rodents, rats and mice of the family Muridae, is by far the most common family on earth. Fully 96.6% of the North American rodents belong to just four of its eight rodent families: Muridae, Sciuridae, Heteromyidae, and Geomyidae (Table 1.1).

The distribution of rodent species is not uniform across North America, but instead reflects the diversity of habitats and topography of different areas of the continent. Where the land is relatively flat and habitats are continuous over vast areas, as in the eastern United States and northern North America, there are relatively few species of rodents.

Table 1.1. Distribution of rodent species (*n*) in IUCN regions of North America north of Mexico (NA); families are listed in order of their relative contribution to the regional rodent fauna (%).

	North America		North-western		South-western		Eastern	
Family	***n***	**%**	***n***	**%**	***n***	**%**	***n***	**%**
Muridae	81	39.3	45	41.3	57	34.5	25	56.9
Sciuridae	67	32.5	41	37.6	54	32.7	11	25.0
Heteromyidae	37	18.0	10	9.2	37	22.4	2	4.5
Geomyidae	14	6.8	7	6.4	11	6.7	2	4.5
Dipodidae	4	1.9	3	2.8	3	1.8	2	4.5
Castoridae	1	0.5	1	0.9	1	0.6	1	2.3
Erethizontidae	1	0.5	1	0.9	1	0.6	1	2.3
Aplodontidae	1	0.5	1	0.9	1	0.6	0	0
Species (*n*)	206		109		165		44	
% of n_{NA}	100.0		52.9		80.1		21.4	
Area (10^6 km^2)	21.7		12.4		2.9		6.4	
n / 10^6 km^2	9.5		8.8		56.9		6.9	
Provinces (P)[1]	35		14		20		7	
P / 10^6 km^2	1.6		1.1		6.9		1.1	

[1] number of mammal provinces (Hagmeier 1966) that are ≥50% within region

Where the land is a jumbled mix of high mountains, deep canyons, and broken vistas, as in western North America, diverse habitats are crowded into small areas, and there are many rodent species. Wilson (1974) demonstrated that the loss of species diversity at higher latitudes reported by Simpson (1964) is seen primarily in bats, and is not evident in the quadrupedal mammals until north of 40°N latitude. Wilson (1974) found that species diversity in quadrupedal mammals is correlated instead with topographic relief and low actual evapotranspiration. Topographic relief increases regional habitat complexity and doubtlessly enhanced the disruptive influence of Pleistocene (Ice Age) climatic shifts. In dry regions slight differences in available water become more significant to organisms. Although the three IUCN regions of North America (Northwestern, Southwestern, and Eastern; Fig. 1.1) were defined following political rather than geographic or biotic boundaries, they are roughly coincident with mammal province boundaries defined by Hagmeier (1966), and exhibit striking differences in rodent species diversity (Table 1.1). Of the eight families of rodents in North America, all are found in all three regions except the mountain beavers, which are restricted to the west coast. The Southwestern Region, which has the highest number of rodent species packed into the smallest regional area, is particularly rich in desert rodents of the family Heteromyidae, reflecting the arid lands of the Southwest. The Northwestern Region is rich in two groups that occur in cold, steppe grasslands of both the Old and New Worlds: arvicoline rodents (voles and lemmings) and ground squirrels. Although there are relatively few rodents in the Eastern Region, over half of the species that do occur there are in the family Muridae.

Figure 1.1. IUCN Rodent Specialist Group Regions of North America (Northwestern, Southwestern, and Eastern) and surrounding areas.

Rodent conservation efforts in North America are still hampered by lack of basic knowledge. Although the mammals of North America are relatively well-studied compared to other areas of the world, extensive surveys are still required to document the distribution, relationships, and abundance of rodents in many areas of the continent, particularly in the Northwestern Region. Much of Alaska and northern Canada has not yet been adequately surveyed, and new discoveries have resulted from more intense survey of supposedly well-sampled areas. For example, two technical books on the mammals of New Mexico have been written: Bailey (1931), based on personal experience and efforts of the United States Bureau of Biological Survey, and Findley *et al.* (1975), based on all earlier studies and collections combined with intensive statewide surveys conducted between 1955 and 1970. However, subsequent intense and targeted survey efforts revealed that the meadow jumping mouse (*Zapus hudsonius*), once thought extinct from the Rio Grande Valley of New Mexico, persists at virtually all historical sites as well as new localities (Morrison 1992). In recent years, four species of mammals have been reported for the first time from New Mexico: the New Mexico grasshopper mouse (*Onychomys arenicola*; Hinesley 1979, Sullivan *et al.* 1986), the least shrew (*Crytotis parva*; reviewed in Hafner and Shuster 1996), Preble's shrew (*Sorex preblei*; Kirkland and Findley 1996) and the big long-nosed bat (*Leptonycteris nivalis*; Hoyt *et al.* 1994). Further, mammalogists have discovered isolated populations of at least five rodent species (thirteen-lined ground squirrel, *Spermophilus tridecemlineatus*; desert pocket gopher, *Geomys arenarius*; yellow-faced pocket gopher, *Cratogeomys castanops*; hispid pocket mouse, *Chaetodipus hispidus*; and meadow vole, *Microtus pennsylvanicus*) that have presumably survived since the cool, wet times of the last glacial period. Clearly, basic survey work is far from finished.

Changing distributions of North American rodents

In an attempt to understand the distribution of animals and plants, and the reasons for such patterns, scientists have documented the distribution of each species, examined the number of species that occur in specific areas, and tried to group ecologically similar species into mammalian provinces. Thus, for North America there are maps that depict the distribution of mammals (e.g., Hall 1981), the species density of mammals (e.g., Simpson 1964, Wilson 1974), and the distribution of mammalian provinces (e.g., Hagmeier 1966, Findley and Caire 1977). Climatic maps depict long-term averages of such factors as annual precipitation (e.g., Steinhauser 1979) and potential vegetation maps attempt to reconstruct the flora that existed prior to modification by humans (Küchler 1970). All of these maps, either by design or perhaps wishful thinking, ignore both the extensive human impacts on the environment and natural climatic changes. Massive modification of the natural habitat of North America is dramatically evident in the forests of the Appalachian Highlands, where widespread forests have been clear cut and dissected into isolated patches, or in the Interior Plains, where only small fragments of the prairies remain along the margins of the continent's "bread basket." These two regions suffered the brunt of the early colonization and initial expansion of European humans across North America, and conservation concerns in these regions are largely geared at preserving remnants of once-widespread ecosystems. In the meantime, human pressures have shifted to the west coast of the continent (particularly affecting the San Joaquin Valley desert; coastal chaparral, saltmarshes, and rain forests; and the Columbia Basin) and to the Florida peninsula.

Often lost in the struggle between development and preservation of natural areas is the fact that the climate continues to change, affecting both the distribution and survival of species. For example, populations of plants and animals that require a cool, wet climate persist on small patches of habitat on mountains surrounded by the southwestern deserts, awaiting either cooling trends that would permit expanded range down slope, or warming trends that could spell extinction. Even species that do not move very far in an individual lifetime (such as rodents) can exhibit surprisingly large movements over short periods: some small mammals have expanded their ranges as much as 450km over the last several decades in response to increased average precipitation in the southern Interior Plains (Frey 1992, Hafner and Shuster 1996).

It may appear contradictory that such numerous, diverse, and widespread mammals as rodents could ever be considered to be of conservation concern. Yet the great diversity of rodents is due in part to the many species that have become closely adapted to very specific habitats. The close dependency of many rodents on their particular habitat renders them susceptible to any changes in that habitat. In North America, agricultural conversion, urbanization, and other human impacts have modified or destroyed massive tracts of previously widespread ecosystems. Those species with restricted distributions are particularly vulnerable to adverse human impact.

Rodents as biological and biogeographic indicator species

Rodents can provide an important tool for monitoring the status of current habitats, detecting changes in those habitats (whether due to human impact or climatic change), and reconstructing past environments and records of environmental change. Because rodents tend to stay in one

small area throughout their lives, and a particular species is often closely tied to a very specific habitat, they are often sensitive indicators of that habitat. Rather than attempting to measure all of the complex environmental measures that define a particular habitat, we may use certain rodents as indicators, monitoring their density and distribution to detect changes in the habitat: for example, the saltmarsh harvest mouse (*Reithrodontomys raviventris*) may be an excellent indicator of healthy saltmarsh habitat; Stephens' kangaroo rat (*Dipodomys stephensi*) for open grassland in coastal sage; or the Key Largo woodrat (*Neotoma floridana smalli*) for mature tropical hammock forest. Fossil records of those same rodent species provide a clue that the same habitat probably existed at the fossil site. Indeed, much of the reconstruction of past environments has been based on such "indicator species" (e.g., Harris 1985, Hafner 1993*a,* 1993*b*). Other small mammals with restricted ecological distributions may also serve as indicator species, but rodents are most readily available due to their abundance, diversity, and wide distribution. The distribution of threatened taxa of rodents (Vulnerable or higher category of threat; Fig. 1.2) is an indication of the geographic distribution of threats to North American ecosystems.

It is difficult, and usually impossible, to separate the environmental effects of human impacts (e.g., overgrazing, fire suppression, irrigation, channelization, the greenhouse effect) from "natural" climatic change (e.g., changing precipitation patterns or temperature shifts related to shifts in ocean currents or the behavior of the earth in its annual orbit around the sun, termed the Milankovitch cycle). For example, we are currently more than half way through an interglacial interval in a glacial age (Pielou 1991). This interglacial interval peaked about 6,000 years ago, when global climate began to cool. However, overlain on this cooling trend have been several climatic cycles of shorter duration: one of about 2500-year periods and another of about 200-year periods, both possibly due to variations in the sun's output, and an 11-year sunspot cycle (Pielou 1991). The effects of these natural climatic cycles are perhaps most evident in the Southwestern Region, where slight changes in precipitation patterns can produce dramatic shifts in the boundary between grassland and desert regions, and temperature changes cause pronounced shifts in the size of isolated patches of montane vegetation. At the same time that a natural drying or warming trend may turn grassland into desert, overgrazing can speed desertification, and the relative contribution of human vs "natural" effects may be impossible to tease apart.

Very few of the rodents included in this report as species of conservation concern were the direct targets of eradication campaigns by humans. Instead, most are closely tied to habitats that have been severely impacted by human actions, those that were restricted due to natural climatic change, or those that have suffered a synergistic combination of both. By taking appropriate actions that will mitigate or reverse negative human impacts on these habitats and monitoring the rodent status as a sensitive indicator of the success of those actions, we can better preserve the overall biodiversity.

Figure 1.2. Distribution of taxa of threatened rodents (Vulnerable and higher levels of threat) in North America north of Mexico; shaded areas may include more than one species of rodent (e.g., California and Florida).