

Status Survey and Conservation Action Plan

North American Rodents

Compiled and edited by
David J. Hafner, Eric Yensen and Gordon L. Kirkland, Jr.



IUCN/SSC Rodent Specialist Group

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Published by: IUCN, Gland, Switzerland, and Cambridge, UK

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Citation: Hafner, David J., Yensen, Eric and Kirkland, Gordon L., Jr. (Compilers and editors). (1998) *North American Rodents. Status Survey and Conservation Action Plan*. IUCN/SSC Rodent Specialist Group. IUCN, Gland, Switzerland and Cambridge, UK. x + 171 pp.

ISBN: 2-8317-0463-4

Cover photo: The Florida mouse, *Peromyscus floridanus*, a species endemic to the Florida peninsula, is largely limited to fire-maintained, xeric, upland vegetation. Its Vulnerable status is the result of habitat loss over the last 50 years and the projected continuation of this through real estate and agricultural development. Photo by F. Sunquist.

Produced by: The Nature Conservation Bureau Ltd, Newbury, UK.

Printed by: Information Press, Oxford, UK.

Available from: IUCN Publications Services Unit
219c Huntingdon Road, Cambridge CB3 0DL, UK
Tel: +44 1223 277894, Fax +44 1223 277175
E-mail: info@books.iucn.org
WWW: <http://www.iucn.org>
A catalogue of IUCN publications is also available.

The text of this book is printed on 115 gsm Zone Silk, which is rated as 4-star under the Eco-Check system and is made from 100% sustainable fibre sources using chlorine-free processes.

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Foreword

The roots of this Action Plan extend back to 1980, the year the Rodent Specialist Group was organized by Ken Myers at the annual meeting of the American Society of Mammalogists in Rhode Island. James N. Layne and William Z. Lidicker, Jr. were appointed as co-chairs. In 1989, the Rodent Specialist Group published "Rodents: a world survey of species of conservation concern," edited by Lidicker and based on a workshop held at the Fourth International Theriological Congress in Edmonton, Alberta, Canada in 1985. It consisted of summaries of the status of rodents by coordinators of 13 regions.

The next task to be undertaken by the Rodent Specialist Group was the development of regional Action Plans, derived from detailed recommendations by the mammalogists most knowledgeable about the ecological threats to the rodents of concern. J. Mary Taylor, Director of the Cleveland Museum of Natural History and a member of the Rodent Specialist Group since its inception, became Chair of the Group in 1989. She has been largely responsible for guiding, encouraging, and coordinating this intensive effort. In 1995, David J. Hafner, Eric Yensen, and Gordon L. Kirkland, Jr. began the task of collating the diverse species accounts and providing overviews and summaries. The final manuscript was improved immeasurably by the careful reading and editing of Sandra Hails and Elise Blackburn at IUCN headquarters in Switzerland.

Although the rush to publish this Action Plan may have introduced small errors and omissions, it is warranted by the continuing and accelerating threat to North

American rodents and their habitat. As we write this foreword, Hurricane Opal lashes the coast of the Alabama and Florida panhandle, where several taxa of endangered rodents are cornered in their last remaining patches of dune habitat, and a wildfire rages out of control near Inverness, California, threatening the last refuge of two other rodent taxa at Point Reyes National Seashore. In both places, human development and alteration of critical habitat has placed entire ecosystems in jeopardy of eradication by a natural catastrophic event. Erosion of the remaining habitat of many other threatened rodent species is undoubtedly continuing in a less dramatic but insidious fashion. At the same time, the Congress of the United States considered one bill that would open the Arctic National Wildlife Refuge to oil and gas exploration and another that would severely weaken the Endangered Species Act (ESA), the foundation of federal conservation measures. In late October 1995, Congress placed a moratorium on the ESA, not allowing any new candidate (C2) taxa, and designating all current C2 taxa as "at risk." Although the ESA survived the 1996 legislative session essentially intact, it is certain to be assailed in future sessions. It is with a strong sense of urgency that we have rushed this Action Plan to publication and into your hands. We urge the reader to consider this a working document, to be used and revised, with the goal of preserving our critically valuable biodiversity.

Joseph G. Hall and David J. Hafner

Editors' Notes and Acknowledgments

Development of this Action Plan required the dedicated service of a number of mammalogists over many years. We would like to acknowledge, in particular, the efforts of Joseph G. Hall, who solicited and edited numerous species accounts of the more threatened taxa of the Southwestern Region, and worked tirelessly on the Rodent Specialist Group for nearly 12 years; J. Mary Taylor, who coordinated the efforts of the three North American regional groups and IUCN headquarters in Switzerland; and Joseph A. Cook and David W. Nagorsen, who contributed many of the Northwestern Region accounts and assisted in editing of all species accounts from that region.

Many experts involved in the study and conservation of rodents provided information and comments on various aspects of this Action Plan, for which we are most grateful. Although any errors or omissions are our own, we wish to acknowledge the assistance of the following: **Southwestern Region:** David M. Armstrong, James S. Findley, Robert B. Finley, Jr., Jennifer K. Frey, John R. Gustafson, Pat Heisler, Donald F. Hoffmeister, Peggy Horner, Kimberly A. Kime, Philip Leitner, Charles W. Painter, Bruce Palmer,

James L. Patton, Eric A. Rickart, Brett R. Riddle, Robert M. Timm, Daniel F. Williams, and Terry L. Yates; **Eastern Region:** Becky Anderson, David Baker, April Bossert, John S. Millar, Nancy D. Moncrief, Soren Bondrup-Nielsen, Donald Thomas, and Kim Van Fleet; **Northwestern Region:** Sandy Andelman, Doug Backlund, Edgar P. Bailey, Vic Barnes, Steve Brockman, Andrew Bryant, Judy Bush, Mary Clausen, Cory Craig, Rod Flynn, Kerry R. Foresman, Patricia Freeman, Eleanor Gaines, Chris Garber, Diana Hwang, Richard E. Johnson, Barry Keller, Jim Kenagy, Randy Kreil, William F. Laurance, Rosemary Leach, Bob Luce, Brendan McManus, Jim Michaels, Gary Miller, Mary Neighbours, Peggy O'Connell, Jim Reichel, Mark Schroeder, Ellie Steinberg, Jim Stevenson, Dick Taylor, B. J. Verts, Jeri Williams, Don Youkey, and Denny Zweifelhofer. Photographs were contributed by Troy L. Best, Vernon Bleich, S.E. Braun, Richard A. Fridell, John H. Harris, David G. Huckaby, W.P. Leonard, Robert E. Martin, Bob Miles, B. "Moose" Peterson, Aryan I. Roest, Howard S. Shellhammer, F. Sunquist, Tom Tutt, R.W. Van Devender, and Eric Yensen.

Executive Summary

David J. Hafner, Eric Yensen, Gordon L. Kirkland, Jr.,
Joseph G. Hall, Joseph A. Cook and David W. Nagorsen

Rodents are the most numerous, widespread, and diverse group of mammals on Earth. Although most rodents do not enjoy a positive reputation as charismatic creatures, they make up a critical link in many food chains, and have an enormous influence on many terrestrial ecosystems by virtue of their numbers and variety. An ecosystem approach should emphasize the important ecological roles occupied by rodents. Rodents are important in soil aeration, soil fertility, and penetration of ground water into the soil (pocket gophers); as prey for furbearers and predatory birds, as keystone species supporting entire carnivore food webs (ground squirrels); and as keystone species supporting up to 170 associated species (prairie dogs). They play an integral role in forest health through their relationships with mycorrhizal fungi (chipmunks, voles, flying squirrels).

In many cases, conservation of more popular species depends first and foremost on preservation of the rodent community that sustains them. Rodent species are often highly adapted to live in a narrowly defined habitat, and the diversity of rodents reflects the diversity of available habitats. The wealth of knowledge about rodents and their accessibility for research make them ideal candidates as indicators of the status of many terrestrial ecosystems.

Rodent conservation must be a concern of every state, province, and territory in North America. Much of eastern and central North America has suffered extensive habitat destruction in the past, and populations of native rodents survive in pockets of remaining habitat. Other regions, particularly California and Florida, are currently under siege from agricultural and urban development and introduction of exotic species. Finally, more remote regions, such as northern Canada and Alaska, must be surveyed to provide a more precise view of natural ecosystems in order to mitigate anticipated human impacts.

This is the first comprehensive treatment of North American rodents of conservation concern. This Action Plan summarizes the rodent fauna of North America (north of Mexico and including Greenland), and provides available information on every rodent taxon that recently has been considered to be of conservation concern by state, provincial, federal, and private conservation agencies and regional experts. Taxa that are no longer valid or are secure throughout most of their range (47 species and 68 subspecies) are set apart from those of conservation concern (34 species and 147 subspecies of concern), which are assigned to levels of vulnerability based on the 1994 IUCN Red List criteria (Appendix 2). We present information on

the classification, distribution, threats, current actions, and conservation needs of 168 taxa of 86 species of rodents in North America. Of these, eight subspecies are Extinct, ten species and 48 subspecies are threatened (Critically Endangered, Endangered, or Vulnerable), 17 species and 42 subspecies are at Lower Risk (conservation dependent or near threatened), and seven species and 49 subspecies do not have sufficient data to make a judgment (Data Deficient). One species and 36 subspecies are probably inseparable from other, non-threatened taxa; 45 species and 12 subspecies have been considered threatened due to peripheral distribution in a particular political region, but are wide-ranging and secure elsewhere; and studies have demonstrated that the status of one species and 20 subspecies is secure.

In nearly all cases, known threats to North American rodents are related to habitat loss and include agricultural conversion of habitat, urbanization, grazing, fire suppression, and other habitat modifications. Most of the taxa of concern have historically small geographic ranges, much of which has been adversely altered by human activities. Conservation actions are recommended for all taxa of concern, and more elaborate plans are discussed for taxa of higher conservation priority. Lack of knowledge regarding basic taxonomy, distribution, and abundance of many species indicates the need for additional basic studies, particularly modern faunal inventories, which should be a high priority in many areas.

It is imperative that the conservation actions recommended in this Action Plan be implemented immediately. Nearly one-half of North American rodent species (86 of 206) warranted inclusion in this Action Plan. Nearly one in five (39 of 206) species is threatened at the species or subspecies level. Ten species are currently threatened, five other species listed as Lower Risk (near threatened) have threatened subspecies, and 24 species of least concern have subspecies that are threatened. Another 28 species have at least one subspecies that is dependent on ongoing conservation efforts, near-threatened, or suspected of being threatened but for which data are lacking.

Our hope is that this comprehensive treatment will serve as common ground for the diverse governmental and private conservation agencies and promote active cooperation among those agencies. By using rodents to assess and monitor habitats and ecosystems, we hope to further encourage the shift from conservation strategies that target single charismatic species towards preservation and management of entire ecosystems.

Introduction

Eric Yensen and David J. Hafner

In an earlier report of the IUCN/SSC Rodent Specialist Group, Lidicker (1989) posed the question, “Is rodent conservation a viable issue?” His question had several facets: the common perception of rodents as unwanted pests; the general lack of public enthusiasm for rodents as compared to more “charismatic” species; and the assumption that rodents are less vulnerable to extinction. Although the public perception of rodents has not improved noticeably since 1989, there has been an increased understanding among public and private conservation agencies that more focus should be placed on preservation of habitat than on individual species. This new strategy may involve some risks: for example, too broad a focus in mitigation or management may result in the loss of particular species. In general, however, this strategy appears to be more efficient and more inclusive, with the promise of preserving more biodiversity. It also has moved rodents into a more prominent role than many of the more charismatic species: the diversity and abundance of rodents coupled with their frequent reliance on specific habitats makes them suitable indicators of those habitats. Thus, rodents may be monitored to indicate the health of a biotic system, and may serve as “canaries in the coal mines,” warning of an imperiled ecosystem.

North America has suffered tremendous habitat alteration as a result of human activities. Hidden beneath these human-induced alterations have been natural climatic changes that continue to affect species distribution: long-term changes in average temperature or precipitation patterns that are nearly imperceptible to us. As species distributions change, we are still struggling to get a firm grip on the distributional patterns: many areas of North America have been surveyed only poorly, and even well-studied areas are capable of yielding surprises from more intensive survey work. Finally, the notion that a species’ distribution can be accurately depicted by a single distribution map may be an elusive, and false, grail: there is a growing realization that species are constantly modifying their distribution with changing environmental parameters, including those that would have occurred without human influence. The best we can do is get a glimpse of the current distribution of each species, identify those regions where adverse human impacts are most threatening to species through habitat alteration, and seek to prevent, mitigate, or reverse those impacts.

For the purposes of the IUCN/SSC Rodent Specialist Group, the North American region covered here includes three of the original 13 Rodent Specialist Group Regions: Northwestern North America, Southwestern North

America, and Eastern North America. Although Mexico is geographically part of the North American continent and shares many rodent species and areas of concern, action plans for Mexican rodents will be included in the IUCN/SSC rodent Action Plan for Middle America and are not treated here.

The objectives of this Action Plan are:

- to determine which rodent taxa are of global conservation concern (facing a threat to their continued existence throughout their entire geographic range), based on a single set of consistent criteria;
- to provide a concise summary of relevant distributional, taxonomic, and biological information on each species or subspecies of concern for use by persons concerned with rodent conservation;
- to review the known threats faced by each taxon of concern and its current status;
- to report on action plans in place for recovery for the few taxa that have them; and
- to develop action plans for their survival where appropriate.

In North America, a variety of schemes are in use for classifying the level of threat to a species or subspecies. In the United States, the Endangered Species Act of 1973 provided a series of threat categories in use by the U.S. Fish and Wildlife Service (U.S. Fish and Wildlife Service 1993a). Although the federal system of threat classification has influenced some state systems, many states have developed their own systems, resulting in a bewildering array of status codes that are rarely consistent even among neighboring states. In Canada, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) uses one classification scheme for national designation, while the provinces and territories use different systems. The Nature Conservancy’s Natural Heritage Program designations are used by the Heritage Program Conservation Data Center in each state in the United States and some Canadian provinces, and the system has been adopted by, or influenced, some state conservation agencies. At the international level, the Convention on International Trade in Endangered Species (CITES) categorizes species depending upon the severity of threat with the intention of regulating trade. None of these systems correspond exactly to the traditional IUCN Red List Categories, or to those newly adopted by IUCN (1994).

The plethora of systems of threat categories and inconsistent criteria make it difficult at best to obtain a precise global picture of a species’ status. A great deal is

left to subjective judgment, and, at worst, the inconsistency of applying the categories may undermine the credibility of conservation efforts. In order to provide an objective system that may be used universally with consistent results, IUCN has revised (Mace and Lande 1991, Mace *et al.* 1992, Mace and Stuart 1994) and adopted (IUCN 1994) new Red List categories and definitions for threatened species. In applying these new categories to North American rodents, we have noted their improved utility over previous definitions, and found only one recurrent difficulty with the new definitions. The extensive range in body size in threatened mammals (from shrews of 2.5g to elephants of up to 7500kg) translates into an enormous range in what might be considered as minimal necessary area for the taxon. Rodents, which are usually of small body size, often occupy very small patches of habitat that may not be under any direct, immediate, or even foreseeable threat from human disturbance. Thus, there may be a tendency to exaggerate the vulnerability of populations of small body size. In the rare instances where we have chosen to depart from strict application of the new Red List definitions, we have invariably reduced the level of threat category, and stated such in the *IUCN Red List Category* section of that species account.

We know of no previous comprehensive national or North American list of rodents of conservation concern. For the Eastern Region, we drew on previous reports for Canada (Clough 1989, D. Morris, J. S. Millar, S. Bondrup-Nielson, and D. Thomas unpublished), the eastern United States (G. L. Kirkland, Jr. and K. Van Fleet unpublished), and Florida and the Gulf Coast (Layne 1978, U.S. Fish and Wildlife Service 1987, Humphrey 1992*a*). The Southwestern Region report began with a list compiled by Hall (1989), while the Northwestern Region report began with the taxa mentioned in Johnson (1989).

In an effort to include all taxa of conservation concern, we contacted state conservation agencies and compiled

lists of rodents of conservation concern to the various states and provinces, and included all nationally-listed taxa. To this list we added taxa with very restricted ranges (usually island or mountain-top endemics) for which we felt there was some reason for concern or for which there was virtually no information, and rodents that were brought to our attention as taxa of concern. We then eliminated taxa from these lists that are not globally threatened. These include invalid taxa, taxa that have been found to be secure based on recent studies, and taxa that appear on state, provincial, or national lists due only to their peripheral distribution there. We have listed these taxa separately in Chapter 6 so that it will be clear why we do not consider them to be globally threatened at this time. Provisional lists of threatened and secure taxa and species accounts were made available for open review and comment at the 1995 annual meeting of the American Society of Mammalogists in Burlington, Vermont; we thank those who provided helpful comments during that open review.

We followed Wilson and Reeder (1993) for the sequence, nomenclature, and taxonomic treatment of families, genera, and species, and Hall (1981) for subspecies. Where there have been recent taxonomic changes, references are cited in the species accounts. Common and scientific names for mammal species follow Jones *et al.* (1992).

We consider the list of taxa included here to be provisional. Our knowledge of the distribution and status of rodents remains fragmentary, and we expect and welcome frequent revisions of this Action Plan to reflect new information. Also, changing environmental parameters, the effects of accumulating threats to our ecosystems, and any positive results of conservation efforts should bring many changes to the status of our rodent fauna. We hope that this Action Plan can stimulate studies to clarify the status of our fauna, as well as provide additional plans for its protection.

North American Rodents

David J. Hafner and Eric Yensen

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 (%).

Family	North America		North-western		South-western		Eastern	
	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%
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 (<i>n</i>)	206		109		165		44	
% of <i>n</i> _{NA}	100.0		52.9		80.1		21.4	
Area (10 ⁶ km ²)	21.7		12.4		2.9		6.4	
<i>n</i> / 10 ⁶ km ²	9.5		8.8		56.9		6.9	
Provinces (<i>P</i>) ¹	35		14		20		7	
<i>P</i> / 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 Haggmeier (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., Haglemeier 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 (*Neotomafloridana 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 1993a, 1993b). 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).

Rodents of Northwestern North America

Eric Yensen, Joseph A. Cook, and David W. Nagorsen

Habitat diversity of the Northwest

The Northwestern North American Region as defined by the IUCN/SSC Rodent Specialist Group includes Greenland; Yukon Territory, the Northwest Territories (MacKenzie, Keewatin, Franklin Districts), British Columbia, Alberta, Saskatchewan, and Manitoba in Canada; and the states of Alaska, Washington, Oregon, Idaho, Montana, Wyoming, North Dakota, South Dakota, and Nebraska in the United States (Fig. 2.1). This region of over 12 million km² includes the northern Great Plains, Black Hills, northern Rocky Mountains, northern Great Basin, Cascade Mountains, coast ranges, Northwest Coast archipelagos, Aleutian Islands, Alaska Range, Yukon Basin, Brooks Range, Arctic Coast, the Canadian Shield, the Hudson Bay Lowlands of western Hudson Bay, the low and high arctic island archipelagos, and Greenland. The corresponding range of habitats includes short-grass and tall-grass prairie, shrub-steppe desert, several kinds of coniferous forests, and Arctic and alpine tundras. The region spans some 40° of latitude and 140° of longitude (Alaska alone crosses 30° of

latitude and 42° of longitude). Consistent with the considerable topographic variation, this vast region contains diverse climates and faunal influences.

Vegetational diversity is limited in the high arctic, but diversity of species and habitats generally increases toward the south throughout the region. Alaska is divided into four major floral areas: the coniferous forest of southeast and south central Alaska; the boreal forest of interior Alaska; the tundra of the Arctic slope; and the treeless vegetation of the shores of the Bering Sea, Aleutian Islands, Alaska Peninsula, and part of Kodiak Island (Hultén, 1968). Further south, British Columbia has 13 biotic provinces (Cowan and Guiguet 1965), and Oregon and Washington together have 15 (Franklin and Dyrness 1988).

Species diversity is highest along the western coast (British Columbia, Washington, and Oregon) and declines inland (Pojar 1993). This is due to prevailing westerlies, which bring heavy precipitation to the coast and to western slopes of interior mountain ranges, supporting temperate coniferous forests. Precipitation decreases on eastern slopes of the coast ranges, and



Figure 2.1. Northwestern North America Rodent Specialist Group Region, which includes Greenland, western provinces of Canada, and northwestern states of the United States.

especially in the interior valleys of British Columbia and east of the Cascade Mountains. Northern Great Basin desert occurs at lower elevations in the Columbia Basin of eastern Washington, east of the Cascades in eastern Oregon, and in southern Idaho and southwestern Wyoming. Parts of British Columbia and Alberta, central and northern Idaho, western Montana, and western Wyoming are dominated by coniferous forests and, at higher elevations, alpine tundras of the Rocky Mountains. To the east (in the remainder of Alberta, Montana, and Wyoming, east through Saskatchewan, Manitoba, the Dakotas, and Nebraska), stretch the Great Plains, broken only by isolated mountains and hills, such as the Black Hills of South Dakota. The Great Plains were originally grasslands with trees along river courses but have been largely converted to agriculture. To the north, the Canadian Shield is covered by vast tracts of taiga (northern boreal forest). In the Mackenzie River drainage of Yukon Territory and western Northwest Territories, tree line extends to nearly 68°N; further east, maritime effects from Hudson Bay limit the tree line to about 55°N.

In the West, the chaotic array of high mountains (many of which are actively orogenic), river valleys and intermontane basins, fiords, and near-shore islands promotes a complex mixture of temperature and moisture regimes. The rugged topography and rivers act as barriers to movement by rodents; as a result, many taxa have small geographic ranges. For example, the Snake River in southern Idaho is a major barrier for rodents where it is more than 200m wide (Davis 1939). East of the Rocky Mountains and in the northern reaches of the continent, the landscapes, habitats, and fauna become more uniform and continuous. Rodent diversity decreases to the north and east across the more or less homogeneous Canadian Shield. Hudson Bay and the many straits that separate the arctic islands and Greenland are major barriers to rodent dispersal. Although ice-covered much of the year, these water barriers nevertheless act as filters for faunal interchange. For example, McClure Strait, Viscount Melville, and Lancaster Sounds together form a significant dispersal barrier that isolates the high arctic islands (Queen Elizabeth Islands) from the low arctic archipelago (Banks, Victoria, and Baffin islands). In the extreme north, Greenland and the high arctic islands of Canada have only a single rodent species, the Greenland collared lemming (*Dicrostonyx groenlandicus*).

Although topographic and climatic parameters explain much of the rodent diversity of the region, the Pleistocene glacial periods also have had an influence. As recently as 10,000 years ago, most of Canada and much of the northern third of the contiguous United States were buried under ice as much as 3500m thick (Porter 1983). The Rocky Mountains, Intermountain West, and Pacific Coast had mountain glaciers and cooler climates than at present. Some areas must have

been inhospitable for rodent species. Whole floras and faunas were either displaced south of the ice sheets and glaciated mountains, or persisted in refugia such as that in northwestern Alaska and northern Yukon Territory, where they came in contact with Old World floras and faunas across the emergent Bering land bridge (Beringia). The possibility that other refugia also existed, particularly along the northwestern coast of Alaska, may explain the high level of endemism in that area (Heusser 1989, MacDonald and Cook 1996). In the high arctic, the Pearyland refugia in northern Greenland and possibly Ellesmere Island may have contributed to speciation in *Dicrostonyx* (MacPherson 1965).

With the return of warmer climates, ice sheets retreated northward and to higher elevations. The displaced plants and animals, as well as immigrants from the Old World, colonized newly exposed land areas, spreading rapidly over continuous areas. Thus, large, continuous areas of the central plains are characterized by a uniform flora and fauna, and by species that are relatively undifferentiated over vast expanses. Recolonization proceeded more slowly through the rugged topography of western regions, and left gaps and barriers that promoted isolation of small populations and high genetic diversity.

The distribution of flora and fauna in glaciated mountainous regions reflects probable dispersal routes into the region along either montane corridors or river valleys. During glacial maxima, boreal species survived in refugia, were forced south by glaciation and climatic change, and may have lived on exposed continental shelves of the Pacific Coast. With the return of warmer conditions, some populations of these became isolated on off-shore islands. Return of warmer conditions also isolated populations of many northern species at higher elevations on southern mountain ranges.

Apparently rodents were minimally affected by the Pleistocene extinctions that eliminated many of the larger species at the end of the last glaciation. For example, fossil remains of rodents from caves and archeological sites in the Great Basin and the Columbia Basin indicate that extant rodent species were present up to 20,000 years ago (Lyman and Livingston 1983, Henry 1984, Grayson 1987). Despite the climatic changes during the past 12,000 years (Davis 1984, Davis *et al.* 1986), scientists are not aware of extinctions of rodent species, although their abundance at different locations (and presumably their geographic distributions) has changed (Henry 1984, Grayson 1987). The present rodent fauna has thus had a long period of adaptation to the Northwestern Region.

The fauna is typical of the Nearctic realm, although Alaska and the Yukon Territory lie at the crossroads between two continents and the Holarctic character of the region's fauna and flora reflect extensive interchange with Asia. The region has a strong boreal element,

augmented by many southwestern and eastern species that reach their distributional limits within the region.

Diversity of Northwestern rodents

The Northwestern Region includes over half (109 of 206; 52.9%, Table 1.1) of the rodent species found in North America north of Mexico (Wilson and Reeder 1993) and over a third (494 of 1370, 36%) of the subspecies (Hall 1981), making it intermediate in diversity between the Southwestern and Eastern Regions. Three groups of rodents that are common in grasslands of northern latitudes in both the Old and New Worlds characterize the Northwestern Region: ground squirrels (*Spermophilus* spp.), marmots (*Marmota* spp.), and arvicoline mice such as voles (*Microtus* spp.) and lemmings (*Dicrostonyx* spp.). Of the rodents found in North America north of Mexico, the following are found within the Northwestern Region:

- all six species of marmots (*Marmota*);
- 18 of 21 species of ground squirrels (*Spermophilus*);
- 34 of 42 species of arvicoline mice;
- 8 of 9 pocket gophers of the genus *Thomomys*;
- all four North American species of jumping mice (family Dipodidae);
- only 10 of 37 species of desert rodents of the family Heteromyidae (pocket mice, kangaroo mice, and kangaroo rats); and
- only 14 of 43 species of sigmodontine murids (typical rats and mice).

Thirty species of rodents (including at least 50 subspecies) are endemic to the Northwestern Region: 15 species of arvicoline mice, eight ground squirrels (*Spermophilus*), three marmots (*Marmota*), two deer mice (*Peromyscus*), a chipmunk (*Tamias*), and a pocket gopher (*Thomomys*). Many more species are not endemic but have their centers of distribution in the Northwestern Region. Their ranges extend south into forested habitats along western mountain ranges. In addition, 13 species are found along the Pacific Coast in Oregon and California, and have ranges that extend inland to the Cascade-Sierra Nevada mountain chain, north into southwestern British Columbia, or south into Baja California.

The rodent fauna of Northwestern North America is the least-studied on the continent. This is especially true for Alaska. In most cases, subspecific taxonomy was based only on a small number of specimens and is outdated. Often, taxonomic decisions were based exclusively on size and pelage coloration, characters that are known to be highly variable and unreliable in some genera (e.g., pocket gophers, *Thomomys*; Smith and Patton 1980). Most of the taxa in the Northwestern Region are in need of careful taxonomic re-evaluation in studies that include larger sample sizes and utilize cranial morphometrics, bacula,

karyotypes, and molecular genetic techniques. Many of the rodent taxa found in Alaska have not been included in recent taxonomic revisions, and are especially in need of study.

Major threats in the Northwestern Region

Much of the vast Northwestern Region supports a fauna that has been relatively unperturbed by humans. However, major threats to rodents in the region are direct results of human-induced habitat loss, particularly large-scale habitat manipulation. Chief among these are: 1) conversion of native habitat to agricultural land, particularly in the Columbia Basin of eastern Washington and adjacent Oregon; 2) expansion of urban centers usurping critical habitat of restricted endemic subspecies; 3) the effects of habitat manipulation and introduction of exotic species on island endemics; 4) fire suppression in coniferous forests, gradually eliminating species dependent upon the herbaceous understory of the forest; 5) logging of old growth forest, endangering species dependent on large, old trees; and 6) grazing of domestic livestock in riparian areas. Control campaigns using rodenticides have adversely affected two taxa.

Agricultural development in the Great Plains and intermontane valleys and logging (particularly of forests in southeastern Alaska) have had negative impacts on a number of taxa. Additionally, the extensive maritime region of Alaska and British Columbia includes numerous islands with isolated biotas. Many rodent taxa in this region are island endemics; their restricted distributions may make them particularly sensitive to disturbance. The effects of oil and gas exploration on rodent populations in arctic ecosystems need to be evaluated.

Rodents of conservation concern in the Northwestern Region

In the Northwestern Region, there has been little conservation action to date for rodents. One species, the Vancouver marmot (*Marmota vancouverensis*), is federally listed as endangered in Canada and the United States; one subspecies (a southern bog lemming, *Synaptomys cooperi relictus*, of Nebraska) is listed as C3A (extinct) by the U.S. Fish and Wildlife Service; and 13 taxa are, or have been, candidates for listing under the U.S. Endangered Species Act. The states and provinces list 52 rodents as of conservation concern. Often taxa on the U.S. federal list are not on state lists, and vice versa; indeed, the two sets of lists share only 10 taxa.

Of the four Canadian provinces and two territories in the region, only British Columbia and Alberta have

Table 2.1. Rodents of conservation concern in the Northwestern Region.

Species that are widespread and secure throughout most of their range, but have subspecies of conservation concern in this region, are considered to be of Lower Risk and least concern, and are listed as LR(lc). IUCN Red List Category codes are defined in Appendix 2.

	Historical distribution	Red List Category	Species account (p.)
APLODONTIDAE			
<i>Aplodontia rufa</i>	USA: CA,NV,OR,WA Canada: BC	LR(nt)	30
SCIURIDAE			
<i>Cynomys ludovicianus</i>	USA, Canada, Mexico	LR(nt)	35
<i>Glaucomys sabrinus</i>	USA, Canada	LR(lc)	37
<i>G. s. griseifrons</i>	USA: AK	EN:A1c;A2c;B1;B2c	
<i>Marmota caligata</i>	USA, Canada	LR(lc)	39
<i>M. c. sheldoni</i>	USA: AK	DD	
<i>M. c. vigilis</i>	USA: AK	DD	
<i>Marmota vancouverensis</i>	Canada: BC	EN:C2b;D	40
<i>Spermophilus brunneus</i>	USA: ID	EN:B2d;B3d	43
<i>S. b. brunneus</i>	USA: ID	CR:B1;B2d	
<i>S. b. endemicus</i>	USA: ID	VU:B1;B3d	
<i>Spermophilus elegans</i>	USA	LR(lc)	45
<i>S. e. nevadensis</i>	USA: ID,NV,OR	DD	
<i>Spermophilus lateralis</i>	USA, Canada	LR(lc)	46
<i>S. l. wortmanni</i>	USA: CO,WY	DD	
<i>Spermophilus parryii</i>	USA, Canada	LR(lc)	49
<i>S. p. kodiacensis</i>	USA: AK	DD	
<i>S. p. lyratus</i>	USA: AK	DD	
<i>S. p. nebulicola</i>	USA: AK	DD	
<i>Spermophilus townsendii</i>	USA: WA	DD	51
<i>Spermophilus tridecemlineatus</i>	USA, Canada	LR(lc)	51
<i>S. t. alleni</i>	USA: WY	DD	
<i>Spermophilus washingtoni</i>	USA: OR,WA	VU:A1a;B1;B2d;C2a	52
<i>Tamias minimus</i>	USA, Canada	LR(lc)	54
<i>T. m. selkirki</i>	Canada: BC	VU:D2	
CASTORIDAE			
<i>Castor canadensis</i>	USA, Canada, Mexico	LR(lc)	59
<i>C. c. phaeus</i>	USA: AK	DD	
GEOMYIDAE			
<i>Thomomys idahoensis</i>	USA: ID,MT,UT,WY	LR(nt)	63
<i>T. i. confinus</i>	USA: MT	LR(nt)	
<i>Thomomys mazama</i>	USA: CA,OR,WA	LR(nt)	63
<i>T. m. couchi</i>	USA: WA	VU:B1;B2c	
<i>T. m. glacialis</i>	USA: WA	VU:B1;B2c	
<i>T. m. helleri</i>	USA: OR	LR(nt)	
<i>T. m. louiei</i>	USA: WA	CR:A1c;C2b	
<i>T. m. melanops</i>	USA: WA	LR(nt)	
<i>T. m. pugetensis</i>	USA: WA	VU:B1;B2c	
<i>T. m. tacomensis</i>	USA: WA	EX	
<i>T. m. tumuli</i>	USA: WA	VU:B1;B2c	
<i>T. m. yelmensis</i>	USA: WA	VU:B1;B2c	
<i>Thomomys talpoides</i>	USA, Canada	LR(lc)	66
<i>T. t. douglasi</i>	USA: WA	VU:B1;B2c	
<i>T. t. limosus</i>	USA: WA	LR(nt)	
<i>T. t. segregatus</i>	Canada: BC	LR(nt)	
HETEROMYIDAE			
<i>Microdipodops megacephalus</i>	USA: CA,ID,NV,OR,UT	LR(lc)	79
<i>M. m. atrireluctus</i>	USA: ID	VU:D2	
MURIDAE			
<i>Arborimus albipes</i>	USA: CA,OR	DD	86
<i>Clethrionomys gapperi</i>	USA, Canada	LR(lc)	87
<i>C. g. solus</i>	USA: AK	DD	
<i>Dicrostonyx exsul</i>	USA: AK	DD	87
<i>Dicrostonyx nunatakensis</i>	Canada: YT	DD	88
<i>Dicrostonyx unalascensis</i>	USA: AK	DD	89
<i>D. u. stevensoni</i>	USA: AK	DD	
<i>D. u. unalascensis</i>	USA: AK	DD	
<i>Microtus abbreviatus</i>	USA: AK	DD	89
<i>M. a. abbreviatus</i>	USA: AK	DD	
<i>M. a. fisheri</i>	USA: AK	DD	

Table 2.1 ... continued			
	Historical distribution	Red List Category	Species account (p.)
<i>Microtus longicaudus</i>	USA, Canada	LR(lc)	93
<i>M. l. coronarius</i>	USA: AK	DD	
<i>Microtus montanus</i>	USA, Canada	LR(lc)	96
<i>M. m. codiensis</i>	USA: MT,WY	DD	
<i>M. m. zygomaticus</i>	USA: WY	DD	
<i>Microtus oeconomus</i>	USA, Canada	LR(lc)	97
<i>M. o. amakensis</i>	USA: AK	DD	
<i>M. o. elymocetes</i>	USA: AK	DD	
<i>M. o. innuitus</i>	USA: AK	DD	
<i>M. o. popofensis</i>	USA: AK	DD	
<i>M. o. punukensis</i>	USA: AK	DD	
<i>M. o. sitkensis</i>	USA: AK	DD	
<i>Microtus pennsylvanicus</i>	USA, Canada	LR(lc)	
<i>M. p. admiraltiae</i>	USA: AK	LR(nt)	
<i>M. p. kincaidi</i>	USA: WA	LR(nt)	101
<i>Microtus townsendii</i>	USA: CA,OR,WA	LR(nt)	
	Canada: BC		
<i>M. t. cowani</i>	Canada: BC	LR(cd)	
<i>M. t. pugeti</i>	USA: WA	LR(nt)	
<i>Neotoma floridana</i>	USA	LR(lc)	102
<i>N. f. baileyi</i>	NE	LR(nt)	
<i>Onychomys leucogaster</i>	USA, Canada, Mexico	LR(lc)	106
<i>O. l. durranti</i>	USA: OR,WA	DD	
<i>Synaptomys borealis</i>	USA, Canada	LR(lc)	119
<i>S. b. artemisiae</i>	USA: WA	LR(nt)	
	Canada: BC		
<i>Synaptomys cooperi</i>	USA, Canada	LR(lc)	120
<i>S. c. relictus</i>	USA: NE	EX	
DIPODIDAE			
<i>Zapus hudsonius</i>	USA, Canada	LR(lc)	120
<i>Z. h. campestris</i>	USA: MT,SD,WY	VU:B1;B2c	
<i>Z. h. preblei</i>	USA: CO,WY	EN:B1;B2c	
<i>Zapus trinotatus</i>	USA: CA,OR,WA	LR(nt)	123
	Canada: BC		

prepared lists of rodents at risk. Canada has no federal endangered species legislation, and the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) supplies that function. Status reports and national designations have been completed by COSEWIC for only nine of the rodent species found in the region (1 endangered, 5 vulnerable, 3 not at risk).

The Vancouver marmot (*Marmota vancouverensis*) and northern Idaho ground squirrel (*Spermophilus brunneus brunneus*) are the only species with existing conservation action plans. We know of no action being undertaken in the field for the conservation of any other Northwestern rodent. Thus, much remains to be accomplished in rodent conservation in Northwestern North America; the rodents of conservation concern identified by this Action Plan represents a starting point (Tables 2.1, 2.2). However, enlisting support for less charismatic species such as pocket gophers and ground squirrels will be difficult because these have been long regarded as vermin. Future conservation action for rodents may be further impeded by the bitter controversy over spotted owls and logging of old-growth forests. This debate has generated negative feelings in the region toward the conservation of endangered species.

Table 2.2. Rodent taxa of concern in the North-western Region.

“Species of concern” here include only those that are of concern at the global level, and do not include those that are LR(lc). Numbers of taxa listed at the species level are indicated in boldface. Families are listed in order of their contribution to the North American rodent fauna.

Family	Total species (n)	IUCN Red List Category						
		EX	CR	EN	VU	LR(cd)	LR(nt)	DD
Muridae	45	1				1	1	5
Sciuridae	41		1	2	1	2	1	1
								8
Heteromyidae	10				1			
Geomyidae	7	1	1		6		2	5
Dipodidae	3			1	1		1	
Castoridae	1							1
Erethizontidae	1							
Aplodontidae	1						1	
Totals	109	2	2	2	10	1	6	6

Rodents of Southwestern North America

David J. Hafner

Habitat diversity of the Southwest

The Southwestern North America Region as defined by the IUCN/SSC Rodent Specialist Group includes the states of California, Nevada, Utah, Arizona, Colorado, New Mexico, Kansas, Oklahoma, and Texas (Fig. 3.1). Enclosing nearly 3 million km² and extending from the Pacific Coast of California to the southern Great Plains of Texas, it embraces two major mountain ranges (Sierra Nevada and southern Rocky Mountains) and seven major arid regions: California chaparral, Mojave Desert, San Joaquin Valley, Colorado Plateau, most of the Great Basin, and parts of the Sonoran and Chihuahuan deserts.

The varied biotic regions of the Southwestern Region are further fragmented west of the Great Plains into a complex mosaic of montane, desert, and riparian habitats (Crowley 1967, Küchler 1970). Three major influences together have produced this biotic diversity: 1) the extreme topographic diversity of the west; 2) its geographic position spanning mediterranean to continental climates (west-east) and boreal to subtropical climates (north-south); and 3) the shifting distributions of these major climatic regions associated with Quaternary glacial-interglacial oscillations.

The jumbled topography of the Southwestern Region west of the Rocky Mountains had its birth in Late Tertiary

plate tectonic events (Coney 1983). According to Coney, “widespread regional uplift and extensional block-faulting, and associated strike-slip faulting, which collapsed and fragmented large segments of the rising southwestern Cordillera,” produced this complex admixture of mountains, valleys, and plateaus, and “there is nothing quite like [the region] anywhere else on the planet.” This topographic diversity created a wide range of climatic regimes: adiabatic cooling with rising elevation produces cool, mesic mountaintops that in turn produce arid rainshadows on their leeward sides; rivers fed by montane glaciers above tall forests nurture lowland riparian corridors that ribbon through deserts and grasslands.

The Southwestern Region is a great meeting ground of distinct and ancient biotic associations, where east meets west and north meets south. Lush coastal forests of the Pacific Coast, extensive forests of the Sierra Nevada and Rocky Mountains, and scattered high-mountain pockets of cool, mesic habitat stand in stark contrast to the generally dry Southwestern climate. Even the arid regions are remarkably diverse, ranging from eastern grasslands and northern shrub-steppe to southern arboreal deserts and coastal chaparral.

The final ingredient in this biotic goulash is *time*. During the last 1.6 million years, the Southwestern Region



Figure 3.1. Southwestern North America Rodent Specialist Group Region. This region shares many rodent taxa with the states of northern Mexico, which are included in the Middle American Region.

has been swept repeatedly by waves of cool, mesic climate during glacial-pluvial maxima, which then retreated north and up slope during interglacial intervals. Boreal flora and fauna spread south along mountain ranges and across high-elevation plateaus and plains during cooler intervals, while southeastern grassland species spread west along with wetter climates (Harris 1985, 1989, Hafner 1993a, Hafner and Sullivan 1995). With the return of warm, dry conditions, southern species regained the northern lowlands, leaving cool- and wet-adapted species stranded on mountaintops or along rivers and isolated desert springs.

It is abundantly clear from fossil evidence that mammals currently restricted to mesic or montane habitats in the arid Southwestern Region enjoyed a far broader distribution during glacial or pluvial intervals of the Pleistocene (Harris 1985, Hafner 1993a, 1993b). However, it would be incorrect to assume that boreal and arid species simply shifted complementary ranges in response to Pleistocene climatic changes. Instead, the generally equable climate of pluvial periods resulted in mixtures of what we recognize today as two faunal elements (Graham and Mead 1987). Thus, a major component of Southwestern rodent communities during more mesic periods today persists on small, isolated patches of favorable habitat throughout the region.

Diversity of Southwestern rodents

Simpson (1964) and Wilson (1974) each identified a region of elevated mammalian species diversity in North America north of Mexico as occurring between the Rocky Mountains and the Pacific Coast, and between 30° and 40°N: essentially the Southwestern Region. The high species diversity of Southwestern mammals is expressed most dramatically among the rodents, and particularly within three families: Sciuridae (squirrels and relatives); Heteromyidae (desert rodents); and Geomyidae (pocket gophers). Of the rodents found in North America north of Mexico, the following are found within the Southwestern Region:

- 20 of the 22 species of chipmunks (*Tamias*);
- two-thirds of the ground squirrels (*Spermophilus*);
- all species of prairie dogs (*Cynomys*), antelope ground squirrels (*Ammospermophilus*), and tree squirrels (*Sciurus* and *Tamiasciurus*);
- all 37 species (and four genera) of heteromyid rodents; and
- all three genera (11 of 14 species) of pocket gophers.

Although less than one-fifth the size of the rest of the North America north of Mexico, the Southwestern Region has 80.1% of the total species and nearly six times the number of species per area (Table 1.1). In fact, this is an underestimate of the true diversity of Southwestern mammals, as many geographically isolated populations

Table 3.1. Comparison of number of rodent species, area, habitat types (Küchler 1970), number of separate patches of different habitat types, and average patch size for states in the Southwestern Region.

State	Species (n)	Area (10 ³ km ²)	Habitat types	Separate patches	Patch size (10 ³ km ²)
California	88	411	22	224	1.83
New Mexico	71	315	14	108	2.92
Arizona	68	295	16	128	2.30
Utah	62	220	19	106	2.07
Texas	57	692	18	50	13.84
Colorado	55	270	17	100	2.70
Nevada	55	286	12	115	2.49
Oklahoma	43	181	14	52	3.48
Kansas	34	213	8	18	11.84

are not recognized at the species level. For example, populations of various chipmunks (*Tamias*) and tree squirrels (*Sciurus* and *Tamiasciurus*) are often found on montane “islands” peppered across regional deserts, and small populations of voles (e.g., *Microtus californicus* and *M. pennsylvanicus*) persist in isolated riparian “oases” in arid regions.

The effects of habitat fragmentation and diversity on rodent species diversity can also be seen within states of the Southwestern Region (Table 3.1). Area of each state is, by itself, a poor indicator of species diversity ($r = 0.315$; $P = 0.408$). Similarly, state area is a significant predictor of neither the number of habitat types nor of patches of different habitat (as depicted by Küchler 1970) included in the state. The number of habitat types included in each state reflects the diversity of biotic influences and is a better indicator of species diversity ($r = 0.721$; $P = 0.028$). However, the best indicator of species diversity is the number of sites or patches of habitat in each state ($r = 0.913$; $P = 0.0001$). This measure incorporates all three of the factors effecting high biotic diversity of the Southwestern Region: topographic diversity, varied habitat types, and time. The average size of sites or habitat patches in each state is a measure of population diversity, and avoids bias as to whether or not an isolated population has speciated (for species-level analysis) or has been recognized as a distinct subspecies. The more homogeneous nature of habitats in states east of the Rocky Mountains (particularly Kansas and Texas) is reflected in their larger average patch size as compared to the Southwestern Region states of the Rocky Mountains and west.

Human-induced vs “natural” extinction

Although humans are certainly a natural part of the world biota, conservation agencies often make a distinction between anthropogenic and “natural” effects on

populations. Anthropogenic effects are clear in those cases where human activity directly targets species or specific regions. Examples among Southwestern rodents would include *Cynomys parvidens*, which was the specific object of poisoning campaigns, and rodents of the San Joaquin Valley desert, which were indirect victims of agricultural development of the region. However, separation of “human” and “natural” effects are more difficult for populations that represent relicts of cool, mesic pluvial intervals. Habitat loss for these populations may result from human activities such as overgrazing, deforestation, fire-suppression, and reduction of local water resources, or by natural drying trends that followed the last pluvial cycle. Realistically, the two classes of processes are probably inseparable and synergistic in effecting habitat loss for relictual populations. However, the Southwestern Region would seem to be an ideal region in which to study the relative contribution of human-induced and “natural” processes in the “desertification” (El-Baz 1983) of Southwestern grasslands, the reduction in wetlands habitat, and the loss of isolated montane populations.

Rodents of conservation concern in the Southwestern Region

The majority of rodents of conservation concern in this region (Table 3.2) are found in California, either in the San Joaquin Valley, in arid chaparral or desert habitats bordering the Los Angeles and San Diego metropolitan areas, or in wetlands and rainforest habitats along the northern California coast. Hall (1989) felt that this bias reflected “better communication with authorities in that state” as well as “regional differences in attitude and concern about threatened species,” and that the “relative severity of the biological circumstances [elsewhere in the Southwestern Region] is greater than we now recognize.” Comprehensive evaluation of all regional taxa of concern, however, reveals that the situation in California accurately reflects an unfortunate coincidence of intensive development in a region of high biodiversity. Not only has California, with the highest number of native mammal species among the United States, been subjected to the most extensive urban and agricultural development of all western states during the last 150 years, but that development has been focused most intensively on regions of highest biodiversity within the state. In addition, California’s native species have suffered from the onslaught of nearly 1000 species of invasive introduced species of plants (Vitousek *et al.* 1996). Elsewhere in the Southwestern Region, agricultural or grazing impacts have affected taxa with naturally restricted distributions. In Nevada, four of the taxa of concern are located in mountains or wetlands surrounding the rapidly expanding Las Vegas urban area.

A large proportion of desert rodents (family Heteromyidae) are listed as taxa of concern (Table 3.3). This reflects primarily the threatened nature of arid habitats in California (San Joaquin Valley, coastal chaparral, and northwestern Mojave Desert), but also grazing or agricultural impacts on desert rodents elsewhere in the Southwestern Region. Relative to the other North American regions, rodents of the Southwestern Region are often restricted to small patches of appropriate habitat, for example, isolated springs or mountaintops surrounded by deserts. For many of these taxa, no current threat is known, and they are listed as either Lower Risk (least concern) or Data Deficient. Onset of urban or agricultural development could drastically alter that status: for example, construction of an observatory atop Mount Graham in southern Arizona has placed at least two rodent taxa in jeopardy.

Major threats in the Southwestern Region

Urban and agricultural development

It is not surprising that over one-half of the endangered rodents of the Southwestern Region are from California (Table 3.2). By 1975, California had nearly four times the average population density of Southwestern states, and California’s population has grown faster than the rest of the United States for the past two decades. According to the 1993 census, that growth has reduced, but population growth in the western states continues to be above the national average, with Nevada now in the lead in this dubious competition. Thus, the adverse impact suffered by California rodent populations can be expected to be repeated in other states as human population growth continues, and is already being observed in areas surrounding the rapidly expanding Las Vegas urban area of Nevada.

San Joaquin Valley Desert. The San Joaquin Valley desert is rapidly disappearing in the face of agricultural development (Williams *et al.* 1992). All 15 endemic arid-adapted rodents in the valley (Williams and Kilburn 1992) could be considered as endangered on the basis of dwindling habitat; seven species are included here (*Ammospermophilus nelsoni*, *Dipodomys ingens*, *D. nitratoides*, *D. heermanni*, *Perognathus inornatus*, *Onychomys torridus*, and *Neotoma fuscipes*).

The San Joaquin Desert has been considered as a consequence of post-Wisconsin (altithermal) invasion of neighboring Mojave Desert species, followed by quantum evolution due to intense selection in extremely hot, summer-drought conditions (Axelrod 1966, 1967, Raven and Axelrod 1978, D. I. Axelrod pers. comm. 1980). Axelrod (1966) estimated that effective isolation of the San Joaquin

Table 3.2. Rodents of conservation concern in the Southwestern Region.

Species that are widespread and secure throughout most of their range, but have subspecies of conservation concern in this region, are considered to be of Lower Risk and least concern, and are listed as LR(lc). Status codes are defined in Appendix 2.

	Historical distribution	Red List Category	Species account (p.)
APLODONTIDAE			
<i>Aplodontia rufa</i>	USA: CA,NV,OR,WA Canada: BC	LR(nt)	30
<i>A. r. nigra</i>	USA: CA	VU:B1;B2d;B2e	
<i>A. r. phaea</i>	USA: CA	VU:B1;B2e	
SCIURIDAE			
<i>Ammospermophilus nelsoni</i>	USA: CA	EN:A1a;B1;B2c	33
<i>Cynomys ludovicianus</i>	USA, Canada, Mexico	LR(nt)	35
<i>Cynomys parvidens</i>	USA: UT	LR(cd)	36
<i>Glaucomys sabrinus</i>	USA, Canada	LR(lc)	37
<i>G. s. californicus</i>	USA: CA	DD	
<i>Spermophilus elegans</i>	USA	LR(lc)	45
<i>S. e. nevadensis</i>	USA: ID,NV,OR	DD	
<i>Spermophilus lateralis</i>	USA, Canada	LR(lc)	46
<i>S. l. wortmanni</i>	USA: CO,WY	DD	
<i>Spermophilus mohavensis</i>	USA: CA	VU:B1;B3d	47
<i>Spermophilus tereticaudus</i>	USA, Mexico	LR(lc)	50
<i>S. t. chlorus</i>	USA: CA	DD	
<i>Tamias canipes</i>	USA: NM,TX	LR(nt)	54
<i>Tamias minimus</i>	USA, Canada	LR(lc)	54
<i>T. m. atristriatus</i>	USA: NM	CR:A1a;B1;D	
<i>Tamias palmeri</i>	USA: NV	VU:A2c	55
<i>Tamias quadrivittatus</i>	USA: AZ,CO,NM,UT	LR(lc)	56
<i>T. q. australis</i>	USA: NM	VU:C2a;D2	
<i>Tamias umbrinus</i>	USA	LR(lc)	57
<i>T. u. nevadensis</i>	USA: NV	CR:A1a	
<i>T. u. sedulus</i>	USA: UT	DD	
<i>Tamiasciurus hudsonicus</i>	USA, Canada	LR(lc)	58
<i>T. h. grahamensis</i>	USA: AZ	CR:B1;C2b	
GEOMYIDAE			
<i>Geomys arenarius</i>	USA: NM	LR(nt)	60
<i>Geomys personatus</i>	USA: TX Mexico	LR(nt)	61
<i>G. p. fuscus</i>	USA: TX	LR(nt)	
<i>G. p. maritimus</i>	USA: TX	VU:D2	
<i>G. p. streckeri</i>	USA: TX	VU:D2	
<i>Geomys texensis</i>	USA: TX	LR(nt)	62
<i>G. t. bakeri</i>	USA: TX	LR(nt)	
<i>Thomomys mazama</i>	USA: CA,OR,WA	LR(nt)	63
<i>Thomomys umbrinus</i>	USA: AZ,NM Mexico	LR(lc)	67
<i>T. u. emotus</i>	USA: NM	LR(nt)	
HETEROMYIDAE			
<i>Chaetodipus californicus</i>	USA: CA Mexico	LR(lc)	68
<i>C. c. femoralis</i>	USA: CA Mexico	DD	
<i>Chaetodipus fallax</i>	USA: CA Mexico	LR(lc)	69
<i>C. f. fallax</i>	USA: CA Mexico	DD	
<i>C. f. pallidus</i>	USA: CA	DD	
<i>Dipodomys elator</i>	USA: OK,TX	VU:B1;B2c	69
<i>Dipodomys heermanni</i>	USA: CA	LR(lc)	70
<i>D. h. berkeleyensis</i>	USA: CA	VU:B1;B2c	
<i>D. h. dixonii</i>	USA: CA	LR(nt)	
<i>D. h. morroensis</i>	USA: CA	CR:B1;B2c;D	

Table 3.2 ... continued

	Historical distribution	Red List Category	Species Account (p.)
<i>Dipodomys ingens</i>	USA: CA	CR:A1a;B2c	72
<i>Dipodomys merriami</i>	USA, Mexico	LR(lc)	74
<i>D. m. collinus</i>	USA: CA	DD	
<i>D. m. parvus</i>	USA: CA	DD	
<i>Dipodomys microps</i>	USA	LR(lc)	74
<i>D. m. alfredi</i>	USA: UT	DD	
<i>D. m. leucotis</i>	USA: AZ	VU:B1;B2c	
<i>Dipodomys nitratoides</i>	USA: CA	LR(nt)	76
<i>D. n. brevinasus</i>	USA: CA	LR(nt)	
<i>D. n. exilis</i>	USA: CA	CR:B1;B2c	
<i>D. n. nitratoides</i>	USA: CA	CR:A1c	
<i>Dipodomys stephensi</i>	USA: CA	LR(cd)	78
<i>Microdipodops megacephalus</i>	USA: CA, ID, NV, OR, UT	LR(lc)	79
<i>M. m. nexus</i>	USA: NV	DD	
<i>Microdipodops pallidus</i>	USA: CA, NV	LR(lc)	80
<i>M. p. restrictus</i>	USA: NV	VU:D2	
<i>Perognathus alticola</i>	USA: CA	LR(nt)	81
<i>P. a. alticola</i>	USA: CA	CR:B1;B2b	
<i>P. a. inexpectatus</i>	USA: CA	LR(nt)	
<i>Perognathus flavus</i>	USA, Mexico	LR(lc)	82
<i>P. f. goodpasteri</i>	USA: AZ	LR(nt)	
<i>Perognathus inornatus</i>	USA: CA	LR(lc)	82
<i>P. i. neglectus</i>	USA: CA	LR(nt)	
<i>P. i. psammophilus</i>	USA: CA	LR(nt)	
<i>Perognathus longimembris</i>	USA, Mexico	LR(lc)	83
<i>P. l. bangsi</i>	USA: CA	DD	
<i>P. l. brevinasus</i>	USA: CA	VU:B1;B2c	
<i>P. l. internationalis</i>	USA: CA	DD	
<i>P. l. pacificus</i>	Mexico USA: CA	CR:B1;B2c;C1;C2a;C2b	
MURIDAE			
<i>Arborimus albipes</i>	USA: CA, OR	DD	86
<i>Arborimus pumo</i> (=longicaudus)	USA: CA	DD	86
<i>Microtus californicus</i>	USA: CA, OR Mexico	LR(lc)	90
<i>M. c. mohavensis</i>	USA: CA	VU:A1d;A2d;D2	
<i>M. c. scirpensis</i>	USA: CA	VU:B1;B3c;B3d	
<i>M. c. stephensi</i>	USA: CA	DD	
<i>M. c. vallicola</i>	USA: CA	LR(nt)	
<i>Microtus longicaudus</i>	USA, Canada	LR(lc)	93
<i>M. l. bernardinus</i>	USA: CA	DD	
<i>M. l. leucophaeus</i>	USA: AZ	DD	
<i>Microtus mogollonensis</i>	USA: AZ, CO, NM, TX, UT	LR(lc)	95
<i>M. m. hualpaiensis</i>	USA: AZ	VU:B1;B2c;D2	
<i>Microtus montanus</i>	USA, Canada	LR(lc)	96
<i>M. m. arizonensis</i>	USA: AZ, NM	LR(nt)	
<i>M. m. fucosus</i>	USA: NV	VU:D2	
<i>M. m. nevadensis</i>	USA: NV	VU:D2	
<i>M. m. rivularis</i>	USA: UT	LR(nt)	
<i>Neotoma fuscipes</i>	USA: CA, OR Mexico	LR(lc)	103
<i>N. f. annectens</i>	USA: CA	DD	
<i>N. f. luciana</i>	USA: CA	DD	
<i>N. f. riparia</i>	USA: CA	CR:B1;B2c	
<i>Neotoma lepida</i>	USA, Mexico	LR(lc)	104
<i>N. l. intermedia</i>	USA: CA Mexico	DD	
<i>Ondatra zibethicus</i>	USA, Canada, Mexico	LR(lc)	106
<i>O. z. ripensis</i>	USA: NM, TX Mexico	DD	

Table 3.2 ... continued			
	Historical distribution	Red List Category	Species Account (p.)
<i>Onychomys torridus</i>	USA, Mexico	LR(lc)	107
<i>O. t. ramona</i>	USA: CA Mexico	DD	
<i>O. t. tularensis</i>	USA: CA	DD	
<i>Peromyscus maniculatus</i>	USA, Canada, Mexico	LR(lc)	110
<i>P. m. anacapae</i>	USA: CA	LR(nt)	
<i>P. m. clementis</i>	USA: CA	LR(nt)	
<i>Peromyscus truei</i>	USA, Mexico	LR(lc)	113
<i>P. t. comanche</i>	USA: TX	LR(nt)	
<i>Reithrodontomys raviventris</i>	USA: CA	VU:A1c;A2c;B2c	114
<i>R. r. halicoetes</i>	USA: CA	LR(cd)	
<i>R. r. raviventris</i>	USA: CA	EN:A2c;B1;B2c	
<i>Sigmodon arizonae</i>	USA: AZ,CA Mexico	LR(lc)	116
<i>S. a. arizonae</i>	USA: AZ	EX	
<i>S. a. plenus</i>	USA: AZ,CA	LR(nt)	
<i>Sigmodon fulviventor</i>	USA: AZ,NM Mexico	LR(lc)	117
<i>S. f. goldmani</i>	USA: NM	EX	
<i>Sigmodon hispidus</i>	USA, Mexico	LR(lc)	118
<i>S. h. eremicus</i>	USA: AZ,CA Mexico	LR(nt)	
<i>Synaptomys cooperi</i>	USA, Canada	LR(lc)	120
<i>S. c. paludis</i>	USA: KS	EX	
DIPODIDAE			
<i>Zapus hudsonius</i>	USA, Canada	LR(lc)	120
<i>Z. h. luteus</i>	USA: AZ,NM	LR(nt)	
<i>Z. h. preblei</i>	USA: CO,WY	EN:B1;B2c	
<i>Zapus trinotatus</i>	USA: CA,OR,WA Canada: BC	LR(nt)	123
<i>Z. t. orarius</i>	USA: CA	LR(cd)	

Table 3.3. Rodent taxa of concern in the South-western Region.								
"Species of concern" include only those that are of concern at the global level, and do not include those that are LR(lc). Numbers of taxa listed at the species level are indicated in boldface. Families are listed in order of their contribution to the North American rodent fauna.								
Family	Total species	IUCN Red List Category						
	(n)	EX	CR	EN	VU	LR(cd)	LR(nt)	DD
Muridae	57	3	1	1	1 5	1	8	2 9
Sciuridae	54		3	1	2 1	1	2	5
Heteromyidae	37		1 5	1	1 4	1	2 6	9
Geomyidae	11				2		4 3	
Dipodidae	3			1		1	1	1
Castoridae	1							
Erethizontidae	1							
Aplodontidae	1						1	
Totals	165	3	1 9	1 2	4 14	2 2	10 18	2 23

flora from that of the Mojave occurred as recently as 3,000 years ago. Documented introgressive hybridization between San Joaquin and Mojave forms of leopard lizards (*Gambelia*; Montanucci 1970, 1978) is consistent with this interpretation. However, at least some San Joaquin taxa may be far older: Friesen's (1979) Vicariant Model postulates entry of ancestral desert taxa into the San Joaquin Valley prior to the middle Pleistocene uplift of the Tehachapi Mountains, which then isolated San Joaquin and Mojave taxa.

Most of the San Joaquin Valley floor has been converted for agricultural or urban use. Remaining patches of desert habitat, mostly nestled against the hills lining the western edge of the valley, are subjected to livestock grazing, invasion of weedy exotic plants, and pesticide overdrift from neighboring agricultural fields (Williams *et al.* 1992). The San Joaquin Valley desert is a clear example of human impact. While the current natural climatic cycle would favor expansion and success of desert biota, agricultural and urban development is rapidly destroying this desert habitat.

Southern California Coastal Chaparral. Like the San Joaquin Valley desert, the narrow coastal belt of chaparral

habitat and pockets of desert vegetation in intervening valleys are suffering rapid habitat loss despite favorable climatic conditions. Urban development is the primary culprit, resulting in direct habitat loss and the more insidious invasion of introduced exotic species, including weedy plants and an extremely successful predatory species, the feral house cat. Areas not directly subjected to urban development suffer grazing pressures and agricultural development, particularly in arid valleys, while suppression of natural fire cycles in chaparral undoubtedly alters the vegetative community. Eleven species of coastal chaparral and desert rodents are included in this report: *Spermophilus tereticaudus*, *Chaetodipus californicus*, *C. fallax*, *Dipodomys heermanni*, *D. merriami*, *D. stephensi*, *Perognathus longimembris*, *Microtus californicus*, *Neotoma fuscipes*, *N. lepida*, and *Onychomys torridus*. Loss of the coastal chaparral and associated arid habitat is not limited to southern California: further south, in northern Baja California, Mexico, another coastal species of rodent, *Dipodomys gravipes*, may be near extinction due to loss of the same coastal desert habitat (Best and Lackey 1985).

Northwestern Mojave Desert. Although urban developers undoubtedly consider this region to be the edge of a far larger Mojave Desert, and perhaps less in need of protection, that does not appear to be the case at least for some species. Instead, desert taxa paradoxically may represent relicts of cool, mesic pluvial intervals. Hafner (1992) has postulated that this corner of the Mojave Desert served as a cold-desert refugium for at least one species, the Mohave ground squirrel, (*Spermophilus mohavensis*) during pluvial intervals. The current zone of contact between this species and its sister-taxon, *S. tereticaudus* (Hafner and Yates 1983) has shifted no more than 30km beyond the full-pluvial system of lakes and rivers that isolated the two forms and disappeared at least 6,000 years ago. It is reasonable to assume that the same area served as a refugium for the white-eared pocket mouse, *Perognathus alticola*, which is related to the northern, cold-desert *P. parvus*. Unlike *S. mohavensis*, which occupies the Mojave Desert floor, *P. alticola* is restricted to patchy desert habitat in the adjacent Tehachapi and Transverse ranges. It is certainly possible that other cryptic species shared a full-pluvial refugium here, and persist in the northwestern Mojave Desert and bordering ranges. Adequate survey, however, must race with explosive urban development of this region from the Los Angeles Basin, the most populous area of California. Both species (*S. mohavensis* and *P. alticola*) are included in this report.

Pacific Coast Wetlands and Rainforest. Five species included in this report appear to have had limited ranges prior to human development of coastal habitats, and it is not clear when they became restricted to these areas. Saltmarsh habitat surrounding San Francisco Bay had suffered tremendous loss (about 80%) from human development of the bay's margin before measures were

taken to conserve remaining saltmarsh to which the saltmarsh harvest mouse, *Reithrodontomys raviventris*, is restricted. It is unknown whether other rodent species shared a similar restriction, and disappeared before they ever were detected.

Habitat loss along the narrow strip of rainforest along the northern California coast has been less severe, but populations of mountain beaver (*Aplodontia rufa nigra* and *A. r. phaea*), red tree mice (*Arborimus pomo*), and jumping mice (*Zapus trinotatus orarius*) are restricted to this mesic area. All of these species undoubtedly enjoyed a somewhat broader distribution during wetter pluvial times. The two subspecies of mountain beaver are particularly isolated and vulnerable to increased urban development of the coast. Habitat restriction also renders these populations vulnerable to natural catastrophes: the effects of a 1995 wildfire on populations of *Zapus* and *Aplodontia* in Point Reyes National Seashore is not yet known.

Grazing impacts

In less populous areas of the Southwestern Region, adverse human impacts are often less obvious, and more difficult to separate from climatic change. The prolonged and widespread practice of livestock grazing on open range has certainly modified grasslands, particularly those that were already marginal and suffering from reduced annual precipitation. However, most arid grassland rodents have broad geographic ranges, and the gradual degradation of grasslands has probably resulted in an overall reduction in densities rather than reduced distribution. This more subtle effect is more obvious in taxa with small geographic distributions. In central New Mexico, for example, the hispid pocket mouse, *Chaetodipus hispidus*, persists in patches of grassland along railroads and at the base of the Sandia Mountains in the Rio Grande Valley, but has been eliminated from most of the valley by a combination of overgrazing and reduced precipitation. Two taxa with limited distributions that appear to suffer from, or are vulnerable to, grazing pressures are included in this report, *Dipodomys elator* and *D. microps leucotis*, the Texas kangaroo rat and the House Rock Valley kangaroo rat.

Post-glacial warming

Desert Oases and Sky Islands. Full-glacial relicts abound in arid regions of the Southwestern Region, either in riparian zones associated with rivers and springs, or on isolated mountaintops. At least 53 species (nearly one-third of all Southwestern Region rodents) have one or more isolated, relictual populations in the region that date from pluvial intervals; 23 of these species are included in

this Action Plan. Populations of nine species are (or were) restricted to low-elevation riparian or remnant grassland sites (*Geomys arenarius*, *G. personatus*, *G. texensis*, *Microtus californicus*, *Ondatra zibethicus*, *Sigmodon arizonae*, *S. fulviventor*, *S. hispidus*, and *Synaptomys cooperi*), and isolated populations of 13 others persist in mesic montane areas (*Sciurus arizonensis*, *S. nayaritensis*, *Tamias canipes*, *T. minimus*, *T. palmeri*, *T. quadrivittatus*, *T. speciosus*, *T. umbrinus*, *Tamiasciurus hudsonicus*, *Thomomys umbrinus*, *Microtus mexicanus*, *M. montanus*, and *Peromyscus truei*). Relictual populations of an additional species, *Zapus hudsonius*, survive in both montane strongholds and patchy marshlands in Colorado, Arizona, and New Mexico.

It is highly probable that more of these isolated populations will be discovered as the result of increased survey efforts, particularly in remote areas of the Southwestern Region. During the last decade, previously unreported relict populations of various rodents have been discovered on mountaintops and at isolated riparian areas in the Southwestern Region: e.g., *Microtus mexicanus hualpaiensis* (Kime *et al.* 1992), *M. pennsylvanicus* (R. A. Smartt pers. comm. 1993), *Zapus hudsonius luteus* (Morrison 1992), and *Spermophilus tridecemlineatus* (T. L. Best pers. comm. 1991).

Although less than half of the 53 species with relict populations have attracted the attention of conservation biologists, all relictual populations should be considered as vulnerable to both increasing drying or warming trends and human-induced effects that would reduce these restricted habitats. It is axiomatic that species with small geographic distributions and low ecological tolerances are most vulnerable to habitat loss. Due to its high topographic diversity and dynamic climatic history, the Southwestern Region has numerous rodent taxa with patchy distributions. From the perspective of agricultural and urban developers, these small, often cryptic populations are unmarked landmines, and endangered species lists largely document contact between development and vulnerable populations. In the future, conservationists and developers will have to choose which patches of habitat can be protected from development, which must be sacrificed because of economic demands, and which should be studied to determine the effects of climatic trends on relictual populations. Such choices are not often palatable, particularly where a habitat patch and its relictual populations may be sacrificed. However, this would seem preferable to the current system (or lack thereof) in which vulnerable populations await accidental

discovery by uninformed developers, who then enter into a confrontation with conservationists who attempt to halt the planned development. Where a necessary choice must be made between these habitat patches, factors should include the “Alamo” issue (is this the “last stand” for any of the involved species?) and cost-efficiency (how many isolated populations are affected?).

Extermination programs

Rodents have seldom been the target of the trapping or poisoning campaigns that have endangered a number of carnivore species. However, prairie dogs (*Cynomys* spp.) were a major exception in the West, where they were considered a competitor for food with domestic livestock (Bailey 1931). Fagerstone and Biggins (1986) reported a reduction of prairie dog (*C. ludovicianus* and *C. leucurus*) geographic range from 283 million ha in the late 1800s (Merriam 1902) to 0.6 million ha by 1971 (Cain *et al.* 1971). Findley *et al.* (1975) and Cockrum (1960) describe the extirpation of blacktail prairie dogs (*C. ludovicianus*) from Arizona and southwestern New Mexico as a result of widespread poisoning by the United States Bureau of Biological Survey, beginning in 1915 (Day and Nelson 1929). Prairie dog populations in Kansas, Oklahoma, and Texas had already declined prior to poisoning campaigns as a result of cultivation and livestock grazing, as indicated by the earlier disappearance of black-footed ferrets from these areas (Anderson *et al.* 1986). Populations of black-footed ferrets (*Mustela nigripes*) declined precipitously as a result of the systematic eradication of *Cynomys*, their principal prey (Anderson *et al.* 1986, Henderson *et al.* 1969). Simultaneously, prairie dogs repeatedly suffer catastrophic population losses due to sylvatic plague (Hubbard and Schmitt 1984), and increasing aridity which has decreased the productivity of peripheral grasslands.

The Utah prairie dog (*Cynomys parvidens*) was particularly vulnerable to all of these effects (poisoning, cultivation, overgrazing, disease, and increasing aridity) due to its smaller geographic range, and it is now the target of recovery efforts (United States Fish and Wildlife Service 1991a). Although the other prairie dog species have suffered extreme habitat loss, it is unlikely that any protective measures would have been considered for these species except for their importance to black-footed ferrets. For example, prairie dogs are considered “infestations” on North and South Dakota Indian lands (Martin 1973).

Rodents of Eastern North America

Gordon L. Kirkland, Jr.

Habitat and species diversity

The Eastern North America Region as defined by the IUCN/SSC Rodent Specialist Group, includes the six eastern Canadian provinces of Quebec, Ontario, Prince Edward Island, Nova Scotia, New Brunswick, and Newfoundland (including Labrador), the 31 eastern U.S. states and the District of Columbia west to (and including) Minnesota, Iowa, Missouri, Arkansas, and Louisiana (Fig. 4.1). Most of the region of about 6.4 million km² is characterized by large tracts of relatively uniform climate

and topography. Historically this was reflected in the large, continuous tracts of natural vegetation, ranging from evergreen forests in the north to mixed deciduous and evergreen forests in the south (Küchler 1970). Mammals of the region follow a similar pattern: the region includes only seven mammal provinces, all of which are distributed as broad east-west bands (Hagmeier 1966). Only the Florida Peninsula once possessed the patchy distribution of diverse natural vegetation that is so common in western North America: pockets of pine and bald cypress forests alternated with extensive saw grass and marsh grass over much of the



Figure 4.1. Eastern North America Rodent Specialist Group Region, which includes eastern provinces of Canada and eastern states of the United States.

Table 4.1. Rodents of conservation concern in the Eastern Region.

Species that are widespread and secure throughout most of their range, but have subspecies of conservation concern in this region, are considered to be of Lower Risk and least concern, and are listed as LR(lc). Status codes are defined in Appendix 2.

	Historical distribution	Red List Category	Species Account (p.)
SCIURIDAE			
<i>Glaucomys sabrinus</i>	USA, Canada	LR(lc)	37
<i>G. s. coloratus</i>	USA: NC,TN,VA	VU:A2c;B1;B2c	
<i>G. s. fuscus</i>	USA: VA,WV	VU:A2c;B1;B2c	
<i>Sciurus niger</i>	USA, Canada, Mexico	LR(lc)	41
<i>S. n. avicennia</i>	USA: FL	LR(cd)	
<i>S. n. cinereus</i>	USA: DE,MD,PA	LR(cd)	
<i>S. n. shermani</i>	USA: FL	LR(nt)	
<i>S. n. vulpinus</i>	USA: CT,MD,NJ,NY,PA,VA,WV	DD	
GEOMYIDAE			
<i>Geomys pinetis</i>	USA: AL,FL,GA	LR(lc)	61
<i>G. p. colonus</i>	USA: GA	LR(nt)	
<i>G. p. cumberlandius</i>	USA: GA	VU:D2	
<i>G. p. fontanelus</i>	USA: GA	VU:D2	
<i>G. p. goffi</i>	USA: FL	EX	
MURIDAE			
<i>Clethrionomys gapperi</i>	USA, Canada	LR(lc)	87
<i>C. g. maurus</i>	USA: KY	LR(nt)	
<i>Microtus breweri</i>	USA: MA	LR(nt)	90
<i>Microtus chrotorrhinus</i>	USA, Canada	LR(lc)	
<i>M. c. carolinensis</i>	USA: NC,TN,VA,WV	LR(nt)	92
<i>M. c. rarus</i>	Canada: LB	DD	
<i>Microtus pennsylvanicus</i>	USA, Canada	LR(lc)	99
<i>M. p. dukecampbelli</i>	USA: FL	VU:D2	
<i>M. p. provectus</i>	USA: RI	LR(nt)	
<i>M. p. shattucki</i>	USA: ME	LR(nt)	
<i>Neofiber alleni</i>	USA: FL,GA	LR(nt)	
<i>Neotoma floridana</i>	USA	LR(lc)	102
<i>N. f. haematoreaia</i>	USA: GA,NC,SC	LR(nt)	
<i>N. f. smalli</i>	USA: FL	EN:B2c;C2b	
<i>Neotoma magister</i>	USA: AL,CT,GA,IL,IN,KY,MD,NC,NY,OH,PA,TN,VA,WV	LR(nt)	105
<i>Oryzomys palustris</i>	USA, Mexico	LR(lc)	
<i>O. p. natator</i>	USA: FL	DD	108
<i>Peromyscus gossypinus</i>	USA	LR(lc)	
<i>P. g. allapaticola</i>	USA: FL	VU:D2	
<i>P. g. restrictus</i>	USA: FL	EX	109
<i>Peromyscus leucopus</i>	USA, Canada, Mexico	LR(lc)	
<i>P. l. ammodytes</i>	USA: MA	DD	110
<i>Peromyscus polionotus</i>	USA: AL,FL,GA,MS,SC	LR(lc)	
<i>P. p. aliohyris</i>	USA: FL	EN:B1;B2c	
<i>P. p. ammobates</i>	USA: AL	EN:B1;B2c	
<i>P. p. decoloratus</i>	USA: FL	EX	
<i>P. p. leucocephalus</i>	USA: FL	LR(nt)	
<i>P. p. niveiventris</i>	USA: FL	LR(nt)	
<i>P. p. peninsularis</i>	USA: FL	EN:B1;B2c	
<i>P. p. phasma</i>	USA: FL	EN:B1;B2c	
<i>P. p. trissyllepsis</i>	USA: AL,FL	CR:B1;B2c	
<i>Podomys floridanus</i>	USA: FL	VU:A1a;A2d	
<i>Sigmodon hispidus</i>	USA, Mexico	LR(lc)	
<i>S. h. insulicola</i>	USA: FL	LR(nt)	118
<i>Synaptomys borealis</i>	USA, Canada	LR(lc)	
<i>S. b. sphagnicola</i>	USA: ME,NH Canada: PQ,NB	LR(nt)	

peninsula, while coastal environments ranged from pine or bald cypress forests and saltmarsh to coastal dunes and mangroves. However, the existing vegetation of the Eastern Region bears little resemblance to that viewed by the first European colonists. The extensive tracts of forests have been reduced to small, isolated stands, while farmland, cropland, and urban sprawl now cover much of the region.

In addition, introduced exotic species pose a major threat to native habitats: Florida (along with California) leads the continental United States, each with nearly 1000 species of invasive introduced species of plants (Vitousek *et al.* 1996).

Of the 44 species of rodents that occur in the Eastern Region, 17 (38.6%) are of concern in at least some portion of the region (Table 4.1). One-half of the 36 threatened

Table 4.2. Rodent taxa of concern in the Eastern Region.

“Species of concern” include only those that are of concern at the global level, and do not include those that are LR(lc). Numbers of taxa listed at the species level are indicated in boldface. Families are listed in order of their contribution to the North American rodent fauna.

Family	Total species (n)	IUCN Red List Category						
		EX	CR	EN	VU	LR(cd)	LR(nt)	DD
Muridae	25				1		3	
		2	1	5	2		9	3
Sciuridae	11							
					2	2	1	1
Heteromyidae	2							
Geomyidae	2							
		1			2		1	
Dipodidae	2							
Castoridae	1							
Erethizontidae	1							
Aplodontidae	0							
Totals	44				1		3	
		3	1	5	6	2	11	4

taxa are found in Florida, which has ten threatened species of rodents, including three subspecies that are believed to be extinct. Compared to the other North American regions, a higher proportion of the Eastern Region taxa of concern are in the more threatened Red List categories (Table 4.2). This probably reflects the longer history of urban and agricultural development of the Eastern Region.

Eastern Canada

Diversity and history of rodent faunas

Twenty-four native rodent species comprising 86 subspecies are currently found within the 3.1 million km² portion of Canada included in the Eastern Region (Peterson 1966, Banfield 1974). Two introduced species, the Norway rat (*Rattus norvegicus*) and house mouse (*Mus musculus*), are widespread commensals with humans in this region.

Two types of rodent faunas occur in eastern Canada. In southern Ontario, populations of typically Carolinian species occur at the northern limits of their geographic distributions. These include abundant populations of the eastern gray squirrel (*Sciurus carolinensis*) and white-footed mouse (*Peromyscus leucopus*), isolates of the eastern fox squirrel (*S. niger*) and woodland vole (*Microtus pinetorum*), and low densities of the southern flying squirrel (*Glaucomys volans*). The Maritime Provinces and the north are dominated by boreal rodents whose distributions often span the entire northern half of the continent. Typical members include the southern red-backed vole (*Clethrionomys gapperi*), deer mouse (*Peromyscus*

maniculatus), woodland jumping mouse (*Napaeozapus insignis*), red squirrel (*Tamiasciurus hudsonicus*), northern flying squirrel (*Glaucomys sabrinus*), and meadow vole (*Microtus pennsylvanicus*). The island of Newfoundland is distinct in having a single native rodent (*Microtus pennsylvanicus terraenovae*). Recently, however, other species (*Tamiasciurus hudsonicus*, *Peromyscus maniculatus*) have successfully colonized that island, or have been introduced (eastern chipmunk, *Tamias striatus*). Only one species of rodent, the Labrador collared lemming (*Dicrostonyx hudsonius*) has its entire geographic range within eastern Canada (Hall 1981).

Canada’s rodents occupy diverse landscapes that reflect the nation’s recent glacial history. Except for coastal refugia in what is now the Gulf of St. Lawrence, and possibly scattered mountain nunataks (e.g., the Torngat Mountains of Labrador, the Long Range Mountains of Newfoundland, the Shickshock Mountains on the Gaspé Peninsula, and in the highlands of Cape Breton Island), virtually all of eastern Canada was covered by the huge Laurentide ice sheet 18,000 years ago (Pielou 1991). Some areas in Quebec and Labrador have been free of continental glaciers for less than 7000 years. Many parts of eastern Canada, most notably the Hudson Bay Lowlands, are still in a state of isostatic rebound. Other glacial reminders include vast expanses of muskeg in the north and in Newfoundland, highly eroded mountain ranges, innumerable lakes and ponds, immense dried lake beds in northern Ontario, and underlying the predominant forest vegetation, a network of moraines, eskers, and glacial outwash (Pielou 1991).

Major threats in Eastern Canada

The eastern Canadian distributions of all mammals are thus of relatively recent origin. Many species that now have disjunct distributions were sympatric only a few thousand years ago (Graham 1986). It is likely that extensive glacial refugia along the Atlantic coast (including the Grand Banks of Newfoundland, and the Sable Island and Georges Banks off Nova Scotia) harbored numerous species of northern rodents. Following the last glacial maximum, “coastal plains” on the currently submerged continental shelf existed as large isolated islands whose faunas may have been extirpated by rising sea levels (Pielou 1991). Many of the larger islands in the Gulf of St. Lawrence had no post-glacial connections to the mainland and must have been colonized by rodents crossing a salt water barrier (Cameron 1958). The most convincing evidence for this comes from the relatively low species diversity but high frequency of rodent subspecies recorded on these islands. Many of these rodent taxa are restricted in distribution and warrant continued vigilance to ensure their survival. None is currently threatened.

Elsewhere, most species and subspecies continue to occupy large geographic ranges. The survival and conservation of some of these taxa may be of local concern, or in the case of *Microtus chrotorrhinus* and *Glaucomys volans* in New Brunswick and Nova Scotia, of regional concern, but none is in imminent danger. Yet all are jeopardized, to some extent, by human activities. In the south, natural forest and wetland habitats have been largely displaced by agriculture and urban encroachment. In more northern areas, natural habitats continue to be modified and fragmented by extensive forestry, associated road networks, and energy transmission corridors. Large expanses of terrestrial habitats have either been flooded, or are under the threat of flooding, by massive hydro-electric power developments. Deciduous and mixed forests in the south are stressed by acid precipitation. Problems of atmospheric pollution are shared by the northern ecosystems, although to a lesser extent.

Even so, Canada is a pristine land by international standards. Natural communities of rodents are widespread throughout the boreal forests of Newfoundland and Labrador, Quebec, and Ontario. Tracts of northern wilderness, including arctic tundra, sub-arctic barrens, and taiga, remain in all three provinces. Mixed forests in the maritime provinces support reasonably diverse rodent assemblages, but the land has lost most of its wilderness character.

Rodent diversity is highest in the south where natural communities cling to isolated woodlots and parks. Many forest species, especially those of deciduous woodlands, now occur in only a fraction of their original abundance. Probabilities of continued survival for the members of these communities are lowest in the heavily populated agro-industrial corridor that runs from southern Ontario through southwestern Quebec. There is no cause for immediate alarm for specific taxa because most are widely distributed either farther north, or in the northern United States. Nevertheless, we should anticipate long-term indirect effects through the disruption of what are likely to be relatively simple food webs (Pimm 1991).

The ability to deal with conservation issues varies dramatically among political jurisdictions in Canada. Nationally, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) determines the national status of wild species and subspecies. One rodent, *Glaucomys volans*, occurs on the 1990 COSEWIC list. Although listed as "vulnerable" in Canada, the majority of this species' range occurs in the eastern United States where it is abundant. Two Provinces, Ontario and Quebec, have conservation data centers sponsored by the Nature Conservancy of Canada. A current mammal atlas project in Ontario should help to update the status of all mammals in that province. Conservation activities in other provinces are much less developed. It should be noted, however, that the need for conservation in

much of Canada is less acute than it is in southern Ontario.

Fourteen taxa of eastern Canadian rodents were considered for inclusion in this report. These are *Castor canadensis michiganensis*, *Glaucomys sabrinus goodwini*, *Glaucomys volans volans*, *Marmota monax johnsoni*, *Microtus chrotorrhinus chrotorrhinus*, *M. c. ravidus*, *M. pennsylvanicus magdalenensis*, *Napaeozapus insignis gaspensis*, *Peromyscus leucopus caudatus*, *P. maniculatus anticostiensis*, *P. m. argentatus*, *P. m. eremus*, *P. m. plumbeus*, and *Synaptomys borealis sphagnicola*. Most of these taxa have relatively limited distributions in the region of the Gulf of St. Lawrence. The taxonomy of many of these taxa is debatable, and a careful re-evaluation of many rodent subspecies in eastern Canada is overdue. Most of the rodent subspecies in Labrador, for example, have not been re-evaluated since they were described at the turn of this century. We probably understand even less about the distribution and ecological associations of most rodents in the rest of northeastern Canada. After evaluating the above taxa in the context of threats to survival and the criteria employed for rodents of the eastern United States, only two were considered to be sufficiently threatened to warrant inclusion in this report. These are *M. c. ravidus* and *S. b. sphagnicola*, the rock vole and the northern bog lemming. The other taxa should not be ignored but warrant additional research to evaluate their taxonomic and survival status.

Eastern United States

Diversity and History of Rodent Faunas

Thirty-seven native species of rodents, including two monotypic species, and 151 subspecies occur in the United States portion of the Eastern Region. Of these, 32 subspecies representing 13 species plus four monotypic species were considered to be sufficiently of concern to warrant inclusion in this report. Represented are members of the following twelve genera: *Glaucomys*, *Sciurus*, *Geomys*, *Clethrionomys*, *Microtus*, *Neofiber*, *Neotoma*, *Oryzomys*, *Peromyscus*, *Podomys*, *Sigmodon*, and *Synaptomys*.

This region of the eastern United States has a land area of approximately 1.3 million km² and encompasses much of the temperate deciduous forest region of North America. Northern regions of New York and New England grade into the coniferous forest biome (Cox 1993). The western portion of the area includes ecotonal regions between the deciduous forest and prairie biomes. In the southeastern United States there are southern evergreen, subtropical, and mangrove forests. Average annual rainfall varies from approximately 60–200cm, and the altitude ranges from sea level to 2038m on Mt. Mitchell, North Carolina.

The northern one-third of the eastern United States was covered by glaciers as recently as 13,000 years ago (Pielou 1991). This included all of present-day New England and Michigan, virtually all of New York, Illinois, and Indiana, and northern portions of Pennsylvania and Ohio (Chapman and Sherman 1967). As is the case in eastern Canada, the mammalian fauna of this sub-region is thus of relatively recent origin. Only one of the eastern United States taxa included in this report, the Allegheny woodrat (*Neotoma magister*), has a range that includes this previously glaciated region.

Major threats in the eastern United States

Threatened habitats for rodents within this region include fresh and salt water marshes, coastal dunes, barrier islands, coastal forests, and relict boreal coniferous forests in the higher elevations of the Appalachian Mountains. The importance of coastal islands is reflected

in the fact that 15 taxa of nine rodent species of conservation concern in the Eastern Region are restricted in distribution to islands along the Atlantic and Gulf coasts, nearly one-half of the threatened rodent taxa of the entire region.

Habitat degradation and loss are the principal threats to the rodent taxa of the eastern United States included in this report. Loss of habitat has occurred because of forest fragmentation (clearcutting), agriculture, suburban sprawl, wetland drainage, channelization of streams and rivers, pollution, and fire suppression. Of particular importance has been the extensive conversion of coastal habitats for vacation and retirement homes. Coastal areas are naturally unstable, and human development makes them even more so. Many of the rodent taxa included in this report are endemic, habitat specialists on coastal islands. In addition to habitat loss, competition for resources with other species, predation by larger animals, both domestic and wild, and exploitation in the form of hunting are other factors that can adversely affect rodent populations.

Summary Descriptions of Rodents of Conservation Concern

edited by David J. Hafner, Eric Yensen and Gordon L. Kirkland, Jr.

The following species accounts are the heart of this report: they summarize existing knowledge about the status of threatened taxa and recommend specific actions necessary to conserve those taxa. Critical information is lacking for many of these species, and it is important for the reader to understand the often great degree of subjectivity involved in determining the status of each taxon. If a reader is aware of available information that would be of use in revising this report, please notify one of the editors.

The editors have used a free hand in revising some of the reports, and have added information to accounts of some subspecies in order to provide overviews of each species. The necessity for speed in getting this report published and into the hands of conservation agencies sometimes precluded the opportunity for further review by the authors, and we apologize for any mistakes that we may have introduced. In an effort to provide as uniform and consistent a classification of threatened status as possible, we have also taken the liberty of assigning each taxon to an IUCN Red List Category (defined in Appendix 2): authors may not agree with our assignment in every instance. We have tried to avoid assigning taxa to the Data Deficient category, believing it preferable to apply a more informative category while further information is being sought. There almost certainly will be deficiencies in the assignment of some taxa as a result of this approach, but these should be corrected in future revisions. It is important to understand that any taxon that has been considered to be of conservation concern, including those whose status we have judged to be of lower risk as well as those assigned to any of the categories of threat, is at least more vulnerable to threat than those not mentioned in this report. By assigning taxa to less critical levels of threat, we do not intend to diminish the importance of any taxon. Instead, we have attempted to provide some idea of the relative threat to which the taxa are subjected, and thus provide some guidance for development of conservation priorities.

The current IUCN *Red List Categories* (IUCN 1994) were developed and adopted after the preparation of most of these species accounts, and specific information necessary for assignment to an appropriate category was often lacking. We strongly recommend that status and distribution surveys incorporate Red List Category parameters as goals, as these data (e.g., number and size of

populations, degree of population fluctuation, extent of occurrence, rate and cause of decline) are valid indicators of the health of a taxon. Further, by employing the Red List Category criteria, the various agencies involved in rodent conservation can avoid unnecessary confusion and inconsistency.

Despite the objective criteria established for most of the new IUCN Red List Categories, subjectivity necessarily remains, particularly between two categories of *Lower Risk: near threatened* and *least concern*. We assigned species or subspecies to the *Lower Risk (near threatened)* category if the taxon had a restricted range, but no immediate threats to its continued survival were known. These should be regarded as vulnerable to threat (as opposed to the Red List *Vulnerable* category, which refers to taxa that are vulnerable to extinction). There are many species included in this chapter which are assigned to the *Lower Risk (least concern)* category at the species level because they are widespread and apparently free of immediate threat, but have one or more subspecies in the *Lower Risk (near threatened)* or a higher category.

All rodents that have been included on state, provincial, or federal lists of species of conservation concern were evaluated in this report. We had originally hoped to provide a comprehensive listing of state, federal, and Red List status for each taxon of concern, and a full definition of each classification level for schemes employed by the different governmental and private agencies. However, state conservation agencies in the United States have adopted or created a startling diversity of codes and categories to designate level of threatened status, and the task of compiling all of those codes and definitions proved bewildering. The Nature Conservancy is currently assembling such a list (C. Reynolds pers. comm., 1996). Rather than delay publication of this Action Plan, we have chosen to describe the state level of threat in the narrative of each species account (Conservation status), and have included only the standardized and universal coding systems (Red List, Endangered Species Act, and The Nature Conservancy) in tabular form (Table 5.1; codes defined in Appendix 2). We strongly recommend that state, provincial, and federal agencies agree upon a single classification scheme, in order to facilitate comparison and set priorities among taxa, and to promote cooperative conservation programs among agencies.

Table 5.1. North American rodents of conservation concern.

Species that are widespread and secure throughout most of their range, but have subspecies of conservation concern, are considered to be of Lower Risk and least concern, and are listed as LR(lc). Status codes are defined in Appendix 2.

	Historical distribution	The Nature Conservancy		Federal status	Red List Category
		State	Global		
APLODONTIDAE					
<i>Aplodontia rufa</i>	USA: CA,NV,OR,WA Canada: BC	OR: S4 NV: SU CA,WA: S?	G5	-	LR(nt)
<i>A. r. nigra</i>	USA: CA	CA: S1	G5T1	E	VU:B1;B2d;B2e
<i>A. r. phaea</i>	USA: CA	CA: S2	G5T2	C2	VU:B1;B2e
SCIURIDAE					
<i>Ammospermophilus nelsoni</i>	USA: CA	CA: S2	G3	C2	EN:A1a;B1;B2c
<i>Cynomys ludovicianus</i>	USA Canada Mexico	AZ: SH NM: S2? KS,OK,WY: S3 MT: S3S4 NE,TX: S4 CO,SD: S5 ND: SU	G4	C2	LR(nt)
<i>Cynomys parvidens</i>	USA: UT	UT: S1S2	G1G2	T	LR(cd)
<i>Glaucomys sabrinus</i>	USA Canada		G5		LR(lc)
<i>G. s. californicus</i>	USA: CA	CA: S?	G5T2T3	C2	DD
<i>G. s. coloratus</i>	USA: NC,TN,VA	NC,TN,VA: S1	G5T1	E	VU:A2c;B1;B2c
<i>G. s. fuscus</i>	USA: VA,WV	VA: S1 WV: S2 MD: SP	G5T2	E	VU:A2c;B1;B2c
<i>G. s. griseifrons</i>	USA: AK	AK: S2?	G5T2?	C2	EN:A1c;A2c;B1;B2c
<i>Marmota caligata</i>	USA Canada		G5		LR(lc)
<i>M. c. sheldoni</i>	USA: AK	AK: S3?	G5T3?	-	DD
<i>M. c. vigilis</i>	USA: AK	AK: S3?	G5T3?	-	DD
<i>Marmota vancouverensis</i>	Canada: BC	-	-	E	EN:C2b;D
<i>Sciurus niger</i>	USA Canada Mexico		G5		LR(lc)
<i>S. n. avicennia</i>	USA: FL	FL: S2	G5T2	C2	LR(cd)
<i>S. n. cinereus</i>	USA: DE,MD,PA,VA?	MD,DE,VA: S1 PA: SX	G5T3	E, XN	LR(cd)
<i>S. n. shermani</i>	USA: FL,GA	FL: S2 GA: S?	G5T2	C2	LR(nt)
<i>S. n. vulpinus</i>	USA: CT,MD,NJ,NY,PA,VA,WV	PA: SU	G5T4T5	-	DD
<i>Spermophilus brunneus</i>	USA: ID	ID: S2	G2	-	EN:B2d;B3d
<i>S. b. brunneus</i>	USA: ID	ID: S2	G2T2	C2	CR:B1;B2d
<i>S. b. endemicus</i>	USA: ID	ID: S2	G2T2	C2	VU:B1;B3d
<i>Spermophilus elegans</i>	USA		G5		LR(lc)
<i>S. e. nevadensis</i>	USA: ID,NV,OR	OR: SX ID: S2? NV: S?	G5T4	-	DD
<i>Spermophilus lateralis</i>	USA Canada		G5		LR(lc)
<i>S. l. wortmanni</i>	USA: CO,WY	CO: S1 WY: S4	G5T4	-	DD
<i>Spermophilus mohavensis</i>	USA: CA	CA: S2S3	G2G3	C2	VU:B1;B3d
<i>Spermophilus parryi</i>	USA Canada		G5		LR(lc)
<i>S. p. kodiacensis</i>	USA: AK	AK: S3	G5T3	-	DD
<i>S. p. lyratus</i>	USA: AK	AK: S3	G5T3	-	DD
<i>S. p. nebulicola</i>	USA: AK	AK: S3?	G5T3?	-	DD

Table 5.1 ... continued					
	Historical distribution	The Nature Conservancy State	Global	Federal status	Red List Category
<i>Spermophilus tereticaudus</i>	USA		G5		LR(lc)
<i>S. t. chlorus</i>	Mexico USA: CA	CA: S1S2	G5T1T2	C2	DD
<i>Spermophilus townsendii</i>	USA: WA	-	-	-	DD
<i>Spermophilus tridecemlineatus</i>	USA		G5		LR(lc)
<i>S. t. alleni</i>	Canada USA: WY	WY: S1	G5T1?	C2	DD
<i>Spermophilus washingtoni</i>	USA: OR,WA	OR,WA: S2	G2	C2	VU:A1a;B1;B2d;C2a
<i>Tamias canipes</i>	USA: NM,TX	TX: S2S3 NM: S3	G3	C2	LR(nt)
<i>Tamias minimus</i>	USA		G5		LR(lc)
<i>T. m. atristriatus</i>	Canada USA: NM	NM: SX	G5TX	-	CR:A1a;B1;D
<i>T. m. selkirki</i>	Canada: BC	-	-	-	VU:D2
<i>Tamias palmeri</i>	USA: NV	NV: S2	G2	C2	VU:A2c
<i>Tamias quadrivittatus</i>	USA: AZ,CO,NM,UT		G5		LR(lc)
<i>T. q. australis</i>	USA: NM	NM: S1	G5T1	C2	VU:C2a;D2
<i>Tamias umbrinus</i>	USA		G5		LR(lc)
<i>T. u. nevadensis</i>	USA: NV	NV: SH	G5TH	C2	CR:A1a
<i>T. u. sedulus</i>	USA: UT	UT: S1	G5T1	C2	DD
<i>Tamiasciurus hudsonicus</i>	USA		G5		LR(lc)
<i>T. h. grahamensis</i>	Canada USA: AZ	AZ: S1	G5T1	E	CR:B1;C2b
CASTORIDAE					
<i>Castor canadensis</i>	USA		G5		LR(lc)
<i>C. c. phaeus</i>	Canada Mexico USA: AK	-	-	-	DD
GEOMYIDAE					
<i>Geomys arenarius</i>	USA: NM,TX	TX: S2	G3	C2	LR(nt)
	Mexico	NM: S3			
<i>Geomys personatus</i>	USA: TX	TX: S4	G4	-	LR(nt)
	Mexico				
<i>G. p. fuscus</i>	USA: TX	TX: S2	G4T2	-	LR(nt)
<i>G. p. maritimus</i>	USA: TX	TX: S2	G4T2	C2	VU:D2
<i>G. p. streckeri</i>	USA: TX	TX: S1	G4T1	C2	VU:D2
<i>Geomys pinetis</i>	USA: AL,FL,GA		G5		LR(lc)
<i>G. p. colonus</i>	USA: GA	-	-	-	LR(nt)
<i>G. p. cumberlandius</i>	USA: GA	GA: S?	G5THQ	C2	VU:D2
<i>G. p. fontanelus</i>	USA: GA	GA: S4	G5TX	-	VU:D2
<i>G. p. goffi</i>	USA: FL	FL: SH	G5TXQ	(C3A)	EX
<i>Geomys texensis</i>	USA: TX	TX: S2	G3	-	LR(nt)
<i>G. t. bakeri</i>	USA: TX	TX: S2	G3T2	C2	LR(nt)
<i>Thomomys idahoensis</i>	USA: ID,MT,UT,WY	UT: S1S2 MT: S3 WY: S3S4 ID: S4?	G5Q	-	LR(nt)
<i>T. i. confinus</i>	USA: MT	-	-	-	LR(nt)
<i>Thomomys mazama</i>	USA: CA,OR,WA	CA,OR: S?	G4G5	-	LR(nt)
		WA: S4			
<i>T. m. couchi</i>	USA: WA	WA: S1	G4G5T2	-	VU:B1;B2c
<i>T. m. glacialis</i>	USA: WA	WA: S1	G4G5T1	C2	VU:B1;B2c
<i>T. m. helleri</i>	USA: OR	OR: SU	G4G5T1T2	C2	LR(nt)
<i>T. m. louiei</i>	USA: WA	WA: S1	GG4G5T1	C2	CR:A1c;C2b
<i>T. m. melanops</i>	USA: WA	WA: S?	G4G5T?	-	LR(nt)
<i>T. m. pugetensis</i>	USA: WA	-	-	-	VU:B1;B2c
<i>T. m. tacomensis</i>	USA: WA	WA: S?	G4G5TX	C2*	EX
<i>T. m. tumuli</i>	USA: WA	WA: S1	G4G5T1	-	VU:B1;B2c
<i>T. m. yelmensis</i>	USA: WA	-	-	-	VU:B1;B2c

Table 5.1 ... continued					
	Historical distribution	The Nature Conservancy State	Global	Federal status	Red List Category
<i>Thomomys talpoides</i>	USA Canada		G5		LR(lc)
<i>T. t. douglasi</i>	USA: WA	WA: S?	G5T1	-	VU:B1;B2c
<i>T. t. limosus</i>	USA:WA	WA: S?	G5T3?Q	-	LR(nt)
<i>T. t. segregatus</i>	Canada: BC	-	-	-	LR(nt)
<i>Thomomys umbrinus</i>	USA: AZ,NM Mexico		G5		LR(lc)
<i>T. u. emotus</i>	USA: NM	NM: S1	G5T2?	-	LR(nt)
HETEROMYIDAE					
<i>Chaetodipus californicus</i>	USA: CA Mexico		G5		LR(lc)
<i>C. c. femoralis</i>	USA: CA Mexico	CA: S?	G5T3	C2	DD
<i>Chaetodipus fallax</i>	USA: CA Mexico		G5		LR(lc)
<i>C. f. fallax</i>	USA: CA Mexico	CA: S?	G5T3	C2	DD
<i>C. f. pallidus</i>	USA: CA	CA: S?	G5T3	C2	DD
<i>Dipodomys elator</i>	USA: OK,TX	OK: S1 TX: S2	G2	C2	VU:B1;B2c
<i>Dipodomys heermanni</i>	USA: CA		G5		LR(lc)
<i>D. h. berkeleyensis</i>	USA: CA	CA: SH	G5TH	C2	VU:B1;B2c
<i>D. h. dixoni</i>	USA: CA	CA: SH	G5TH	C2	LR(nt)
<i>D. h. morroensis</i>	USA: CA	CA: S1	G5T1	E	CR:B1;B2c;D
<i>Dipodomys ingens</i>	USA: CA	CA: S1	G2	E	CR:A1a;B2c
<i>Dipodomys merriami</i>	USA Mexico		G5		LR(lc)
<i>D. m. collinus</i>	USA: CA	-	-	C2	DD
<i>D. m. parvus</i>	USA: CA	CA: S?	G5T2T3	C1	DD
<i>Dipodomys microps</i>	USA		G5		LR(lc)
<i>D. m. alfredi</i>	USA: UT	UT: S1	G5T1	C2	DD
<i>D. m. leucotis</i>	USA: AZ	AZ: S1	G5T1	C2	VU:B1;B2c
<i>Dipodomys nitratooides</i>	USA: CA	CA: S?	G3	-	LR(nt)
<i>D. n. brevinasus</i>	USA: CA	CA: S?	G3T1T2	C2	LR(nt)
<i>D. n. exilis</i>	USA: CA	CA: S1	G3T1	E	CR:B1;B2c
<i>D. n. nitratooides</i>	USA: CA	CA: S1	G3T1	E	CR:A1c
<i>Dipodomys stephensi</i>	USA: CA	CA: S2	G2	E	LR(cd)
<i>Microdipodops megacephalus</i>	USA: CA,ID,NV,OR,UT		G5		LR(lc)
<i>M. m. atrelictus</i>	USA: ID	-	-	-	VU:D2
<i>M. m. nexus</i>	USA: NV	-	-	-	DD
<i>Microdipodops pallidus</i>	USA: CA, NV		G5		LR(lc)
<i>M. p. restrictus</i>	USA: NV	-	-	-	VU:D2
<i>Perognathus alticola</i>	USA: CA	CA: S?	G1G2	-	LR(nt)
<i>P. a. alticola</i>	USA: CA	CA: S1S2	G2TH	C2	CR:B1;B2b
<i>P. a. inexpectatus</i>	USA: CA	CA: S2S3	G2T2	C2	LR(nt)
<i>Perognathus flavus</i>	USA Mexico		G5		LR(lc)
<i>P. f. goodpasteri</i>	USA: AZ	AZ: S3	G5T3	C2	LR(nt)
<i>Perognathus inornatus</i>	USA: CA	CA: S?	G4Q	-	LR(lc)
<i>P. i. neglectus</i>	USA: CA	CA: S?	G4QT1T2	C2	LR(nt)
<i>P. i. psammophilus</i>	USA: CA	CA: S?	G4QT2?	C2	LR(nt)
<i>Perognathus longimembris</i>	USA Mexico		G5		LR(lc)
<i>P. l. bangsi</i>	USA: CA	CA: S?	G5T3?	C2	DD
<i>P. l. brevinasus</i>	USA: CA	CA: S?	G5T1T2	C2	VU:B1;B2c
<i>P. l. internationalis</i>	USA: CA Mexico	CA: S?	G5T2T3	C2	DD
<i>P. l. pacificus</i>	USA: CA	CA: S1S2	G5T1	E	CR:B1;B2c;C1;C2a;C2b

Table 5.1 ... continued					
	Historical distribution	The Nature Conservancy State	Global	Federal status	Red List Category
MURIDAE					
<i>Arborimus albipes</i>	USA: CA,OR	OR: S3 CA: S?	G4	C2	DD
<i>Arborimus pomo</i>	USA: CA,OR?	CA,OR: S?	G3	C2	DD
<i>Clethrionomys gapperi</i>	USA Canada		G5		LR(lc)
<i>C. g. maurus</i>	USA: KY	KY: S3S4	G5T3T4	C2	LR(nt)
<i>C. g. solus</i>	USA: AK	AK: S3	G5T3	-	DD
<i>Dicrostonyx exsul</i>	USA: AK	AK: S4	G4	-	DD
<i>Dicrostonyx nunatakensis</i>	Canada: YT	-	-	-	DD
<i>Dicrostonyx unalascensis</i>	USA: AK	AK: S?	G3	-	DD
<i>D. u. stevensoni</i>	USA: AK	-	-	-	DD
<i>D. u. unalascensis</i>	USA: AK	-	-	-	DD
<i>Microtus abbreviatus</i>	USA: AK	AK: S3	G3Q	-	DD
<i>M. a. abbreviatus</i>	USA: AK	AK: S2	G3QT2	-	DD
<i>M. a. fisheri</i>	USA: AK	AK: S3	G3QT3	-	DD
<i>Microtus breweri</i>	USA: MA	MA: S1	G1Q	C2	LR(nt)
<i>Microtus californicus</i>	USA: CA,OR Mexico		G5		LR(lc)
<i>M. c. mohavensis</i>	USA: CA	CA: S1	G5T1	C2	VU:A1d;A2d;D2
<i>M. c. scirpensis</i>	USA: CA	CA: S1	G5T1	E	VU:B1;B3c;B3d
<i>M. c. stephensi</i>	USA: CA	CA: S?	G5T2T3	C2	DD
<i>M. c. vallicola</i>	USA: CA	CA: S1	G5T1	C2	LR(nt)
<i>Microtus chrotorrhinus</i>	USA Canada	MD,VA: S1 NC,PA,VT: S2 ME,MN,WV: S3 NH,NY: S4 NJ: SU SC,TN: S?	G4		LR(lc)
<i>M. c. carolinensis</i>	USA: MD?,NC,TN,VA,WV	MD,VA: S1 NC,TN: S2 WV: S3	G4T3	C2	LR(nt)
<i>M. c. ravus</i>	Canada: LB	-	-	-	DD
<i>Microtus longicaudus</i>	USA Canada		G5		LR(lc)
<i>M. l. bernardinus</i>	USA: CA	-	-	-	DD
<i>M. l. coronarius</i>	USA: AK	AK: S3	G5T3Q	-	DD
<i>M. l. leucophaeus</i>	USA: AZ	AZ: S3	G5T3	-	DD
<i>Microtus mogollonensis</i>	USA: AZ,CO,NM,TX,UT		G5		LR(lc)
<i>M. m. hualpaiensis</i>	USA: AZ	AZ: S1	G5T1	E	VU:B1;B2c;D2
<i>Microtus montanus</i>	USA Canada		G5		LR(lc)
<i>M. m. arizonensis</i>	USA: AZ,NM	NM: S1 AZ: S3S4	G5T3	-	LR(nt)
<i>M. m. codiensis</i>	USA: MT,WY	-	-	-	DD
<i>M. m. fucosus</i>	USA: NV	NV: S1	G5T1	C2	VU:D2
<i>M. m. nevadensis</i>	USA: NV	NV: SH	G5TH	C2	VU:D2
<i>M. m. rivularis</i>	USA: UT	UT: S2	G5T2	C2	LR(nt)
<i>M. m. zygomaticus</i>	USA: WY	-	-	-	DD
<i>Microtus oeconomus</i>	USA Canada		G5		LR(lc)
<i>M. o. amakensis</i>	USA: AK	AK: S2	G5T2Q	C2	DD
<i>M. o. elymocetes</i>	USA: AK	AK: S2	G5T2	C2	DD
<i>M. o. innuitus</i>	USA: AK	AK: S3	G5T3	-	DD
<i>M. o. popofensis</i>	USA: AK	AK: S3	G5T3	-	DD
<i>M. o. punukensis</i>	USA: AK	AK: S1	G5T1	-	DD
<i>M. o. sitkensis</i>	USA: AK	AK: S3	G5T3	-	DD

Table 5.1 ... continued

	Historical distribution	The Nature Conservancy		Federal status	Red List Category
		State	Global		
<i>Microtus pennsylvanicus</i>	USA Canada		G5		LR(lc)
<i>M. p. admiraltiae</i>	USA: AK	AK: S3	G5T3	-	LR(nt)
<i>M. p. dukecampbelli</i>	USA: FL	FL: S1	G5T1	E	VU:D2
<i>M. p. kincaidi</i>	USA: WA	WA: S3	G5T3	C2	LR(nt)
<i>M. p. provectus</i>	USA: RI	RI: S2	G5T3	C2	LR(nt)
<i>M. p. shattucki</i>	USA: ME	ME: S?	G5T3Q	C2	LR(nt)
<i>Microtus townsendii</i>	USA: CA,OR,WA Canada: BC	OR: S4 CA,WA: S?	G5	-	LR(nt)
<i>M. t. cowani</i>	Canada: BC	-	-	-	LR(cd)
<i>M. t. pugeti</i>	USA: WA	WA: S?	G5T1T2	C3C	LR(nt)
<i>Neofiber alleni</i>	USA: FL,GA	FL: S3 GA: S3S4	G3	C2	LR(nt)
<i>Neotoma floridana</i>	USA		G5		LR(lc)
<i>N. f. baileyi</i>	USA: NE,SD?	NE: S2 SD: SU	G5T3	-	LR(nt)
<i>N. f. haematoreia</i>	USA: GA,NC,SC,TN?	TN: S1 NC: S2 GA: S3 SC: S3S4	G5T5	C2	LR(nt)
<i>N. f. smalli</i>	USA: FL	FL: S1	G5T1	E	EN:B2c;C2b
<i>Neotoma fuscipes</i>	USA: CA,OR Mexico		G5		LR(lc)
<i>N. f. annectens</i>	USA: CA	-	-	C2	DD
<i>N. f. luciana</i>	USA: CA	-	-	C2	DD
<i>N. f. riparia</i>	USA: CA	CA: S?	G5TH	C1	CR:B1;B2c
<i>Neotoma lepida</i>	USA Mexico	-	G5	-	LR(lc)
<i>N. l. intermedia</i>	USA: CA Mexico	CA: S?	G5T3?	C2	DD
<i>Neotoma magister</i>	USA: AL,CT,GA,IL, IN,KY,MD,NC,NY,OH, PA,TN,VA,WV	NY: SH MD,NJ: S1 NC: S1S2 IN,OH: S2 PA,VA,WV: S3 KY,TN: S3S4 AL: S4 CT,GA: S?	G3G4	C2	LR(nt)
<i>Ondatra zibethicus</i>	USA Canada Mexico		G5		LR(lc)
<i>O. z. ripensis</i>	USA: NM,TX Mexico	TX: S2S3	G5T?	C2	DD
<i>Onychomys leucogaster</i>	USA Canada Mexico		G5		LR(lc)
<i>O. l. durranti</i>	USA: OR,WA	-	-	-	DD
<i>Onychomys torridus</i>	USA Mexico		G5		LR(lc)
<i>O. t. ramona</i>	USA: CA	CA: S?	G5T3?	C2	DD
<i>O. t. tularensis</i>	USA: CA	CA: S1S2	G5T1T2	C2	DD
<i>Oryzomys palustris</i>	USA Mexico		G5		LR(lc)
<i>O. p. natator</i>	USA: FL	FL: S1	G5T1Q	E	DD
<i>Peromyscus gossypinus</i>	USA		G5		LR(lc)
<i>P. g. allapaticola</i>	USA: FL	FL: S1	G5T1Q	E	VU:D2
<i>P. g. restrictus</i>	USA: FL	FL: SX	G5TX	C3A	EX

Table 5.1 ... continued						
	Historical distribution	The Nature Conservancy			Red List Category	
		State	Global	Federal status		
<i>Peromyscus leucopus</i>	USA Canada Mexico		G5		LR(lc)	
<i>P. l. ammodytes</i>	USA: MA	MA: S?	G5T1	C2	DD	
<i>Peromyscus maniculatus</i>	USA Canada Mexico		G5		LR(lc)	
<i>P. m. anacapae</i>	USA: CA	CA: S?	G5T2?	C2	LR(nt)	
<i>P. m. clementis</i>	USA: CA	CA: S?	G5T1T3	C2	LR(nt)	
<i>Peromyscus polionotus</i>	USA: AL,FL,GA,MS,SC		G5		LR(lc)	
<i>P. p. allophrys</i>	USA: FL	FL: S1	G5T1	E	EN:B1;B2c	
<i>P. p. ammobates</i>	USA: AL	AL: S1	G5T1	E	EN:B1;B2c	
<i>P. p. decoloratus</i>	USA: FL	FL: SX	G5TX	C3A	EX	
<i>P. p. leucocephalus</i>	USA: FL	FL: S1	G5T1	C2	LR(nt)	
<i>P. p. niveiventris</i>	USA: FL	FL: S1	G5T1	T	LR(nt)	
<i>P. p. peninsularis</i>	USA: FL	FL: S1	G5T1	C1	EN:B1;B2c	
<i>P. p. phasma</i>	USA: FL	FL: S1	G5T1	E	EN:B1;B2c	
<i>P. p. trissyllepsis</i>	USA: AL,FL	AL,FL: S1	G5T1	E	CR:B1;B2c	
<i>Peromyscus truei</i>	USA Mexico		G5		LR(lc)	
<i>P. t. comanche</i>	USA: TX	TX: S2	G5T3Q	C2	LR(nt)	
<i>Podomys floridanus</i>	USA: FL	FL: S3	G3	C2	VU:A1a;A2d	
<i>Reithrodontomys raviventris</i>	USA: CA	CA: S1	G1G2	E	VU:A1c;A2c;B2c	
<i>R. r. halicoetes</i>	USA: CA	-	-	E	LR(cd)	
<i>R. r. raviventris</i>	USA: CA	-	-	E	EN:A2c;B1;B2c	
<i>Sigmodon arizonae</i>	USA: AZ,CA,NV		G5		LR(lc)	
<i>S. a. arizonae</i>	USA: AZ	AZ: SX	G5TX	C3A	EX	
<i>S. a. plenus</i>	USA: AZ,CA,NV	NV: SX CA: SH	G5T1	C2	LR(nt)	
<i>Sigmodon fulviventor</i>	USA: AZ, NM		G5		LR(lc)	
<i>S. f. goldmani</i>	USA: NM	NM: S1	G5T1	C2	EX	
<i>Sigmodon hispidus</i>	USA Mexico		G5		LR(lc)	
<i>S. h. eremicus</i>	USA: AZ,CA	CA: SH	G5T3	C2	LR(nt)	
<i>S. h. insulicola</i>	Mexico USA: FL	AZ: S3? FL: S1S2	G5T1T2	C2	LR(nt)	
<i>Synaptomys borealis</i>	USA Canada	NH: SH ID,ME: S1 MT: S2 MN,WA: S3 AK: S5?	G4		LR(lc)	
<i>S. b. artemisiae</i>	USA: WA Canada: BC	-	-	-	LR(nt)	
<i>S. b. sphagnicola</i>	USA: ME,NH Canada: NB,PQ	NH: SH ME: S1	G5T3Q	C2	LR(nt)	
<i>Synaptomys cooperi</i>	USA Canada		G5		LR(lc)	
<i>S. c. paludis</i>	USA: KS	KS: SH	G5T1	C3A	EX	
<i>S. c. relictus</i>	USA: NE	NE: S1	G5T?	C3A	EX	
DIPODIDAE						
<i>Zapus hudsonius</i>	USA Canada		G5		LR(lc)	
<i>Z. h. campestris</i>	USA: MT,SD,WY	WY: S2	G5T3	-	VU:B1;B2c	
<i>Z. h. luteus</i>	USA: AZ,NM	AZ,NM: S2	G5T3	C2	LR(nt)	
<i>Z. h. preblei</i>	USA: CO,WY	WY: S1 CO: S2	G5T2	C2	EN:B1;B2c	
<i>Zapus trinotatus</i>	USA: CA,OR,WA Canada: BC	OR: S4 CA,WA: S?	G5	-	LR(nt)	
<i>Z. t. orarius</i>	USA: CA	CA: S?	G4QT3	C2	LR(cd)	

Table 5.2. Number of North American rodent species of conservation concern by Red List Category and by IUCN region; several taxa occur in more than one region.

Each species is listed only once: at its highest level of threat at the species level or, if the species is at Lower Risk (least concern), then at the highest level of threat to a subspecies.

	Northwestern Region	Southwestern Region	Eastern Region	North America (north of Mexico)
Total number of species:	109	165	44	206
Total number of species listed:	35 (32.1%)	54 (32.7%)	17 (38.6%)	86 (41.7%)
Listed at the species level:				
Extinct	-	-	-	0
Critically Endangered	-	1	-	1
Endangered	2	1	-	3
Vulnerable	1	4	1	6
Lower Risk:				
Conservation Dependent	-	2	-	2
Near Threatened	6	10	3	15 ¹
Data Deficient	6	2	-	7
Total:	15	20	4	34
Listed at the subspecies level²:				
Extinct	1	3	3	6
Critically Endangered	-	6	-	6
Endangered	2	1	1	3
Vulnerable	3	6	2	9
Lower Risk:				
Conservation Dependent	-	-	1	1
Near Threatened	3	6	4	9
Data Deficient	11	12	2	18
Total:	20	34	13	52

¹ Five species listed as LR(nt) have threatened subspecies (VU, CR, or EX)

² Species is of Lower Risk (least concern); where multiple subspecies of a species are listed, only the single most-threatened subspecies is included.

We consider 86 of the 206 species (41.7%) of North American rodents to warrant inclusion in this Action Plan (Table 5.2). Nearly one in five (39 of 206) species is threatened (Vulnerable, Endangered, Critically Endangered, or Extinct) at the species or subspecies level. Ten species are currently threatened, five other species listed as Lower Risk (near threatened) have threatened subspecies, and 24 species of least concern have subspecies that are threatened. Another 28 species have at least one subspecies that is dependent on ongoing conservation efforts, near-threatened, or suspected of being threatened but for which data are lacking.

A breakdown of taxa of conservation concern, listed by Red List Category and by region (Table 5.2), reflects the history and species richness of each region. The highest proportion of species and subspecies of conservation concern are found in the Southwestern Region, the most speciose region. Nearly one-half (11 of 26) of the species of the Southwestern Region that are either threatened or have threatened subspecies are threatened in California, which has suffered extensive agricultural and urban development. Nine of these 11 species occur in just three habitats: the San Joaquin Desert, Coastal Sage Scrub, or the Mojave Desert. The Eastern Region, which has experienced human impact for the longest period, has the largest percentage of species with threatened subspecies (15.9% of the 44 species in the region; six listed at the subspecies level, one at the species

level). Six of these seven species are from Florida, which, like California, has been heavily impacted. Over one-half (18 of 35) of the Northwestern species of conservation concern are listed as Data Deficient, and over one-half (10 of 17) of these are from Alaska, which has not been well surveyed.

Family APLODONTIDAE

Aplodontia rufa (Rafinesque 1817) Mountain beaver or sewellel

Dale T. Steele

7 subspecies, 2 of conservation concern:

A. r. nigra Point Arena mountain beaver

A. r. phaea Point Reyes mountain beaver

IUCN Red List Category

Aplodontia rufa – Lower Risk, near threatened (LR,nt)

A. r. nigra – Vulnerable (VU): B1;B2d;B2e

A. r. phaea – Vulnerable (VU): B1;B2e

Assignment of the species is based on its restricted distribution (156,000km²) and Vulnerable status of two of the seven recognized subspecies. Assignment of subspecies is based on small geographic ranges (62km² and 175km²)

and limited numbers of known populations, but no immediate threats to populations in those limited areas are known.

Taxonomy

Aplodontia has been the subject of repeated taxonomic revisions (Taylor 1918, Finley 1941, Dalquest and Scheffer 1945, Miller and Kellogg 1955, Hall and Kelson, 1959). Hall (1981) considered aplodontids as the only living Protrogomorpha, the group to which the earliest known rodents belong. The masseter muscles of *A. rufa* are usually considered representative of the primitive condition for rodents (Simpson 1945) suggesting that the family may represent a lineage ancestral to sciurid rodents (McGrew 1941). Recent electromyographic studies of the masseter muscles of the mountain beaver revealed that they are strikingly similar to those of the woodchuck (*Marmota monax*) and may not represent the primitive condition for rodents (Druzinsky 1983, 1984). Although the mountain beaver is the sole living species of the family Aplodontidae, this and several related families once occurred over an extensive area of North America, Asia, and Europe (McLaughlin 1984).

Taylor (1918) felt that the geographical isolation of *A. r. nigra* was argument for full species status. However, the lack of representative specimens, combined with the wide range of individual variation and overlapping cranial characteristics among other California coastal mountain beavers (Steele pers. obs.) do not support this assessment.

Distribution

Mountain beavers are restricted to a small area (156,000km²; Herlocker 1950) extending from southern British Columbia to northern California along the Pacific Coast, and in the Sierra Nevada of California. Within this geographically diverse area, mountain beavers are further limited to a cool, moist environment. Inland subspecies appear dependent upon an insulating snow pack that moderates surface and burrow temperatures.

The Point Arena mountain beaver (*A. r. nigra*) is known only from 62km² surrounding its type locality in coastal Mendocino County, California. The land rises to about 2700m elevation within 32km of the shore in a series of parallel ranges with interspersed narrow, irregular valleys. Camp (1918) originally collected and identified populations between the town of Point Arena and Alder Creek, a distance of about 11km. Later work by Pfeiffer (1954) added the Christiansen Ranch area and increased the known range northward another 8km. Steele (1982) attempted to relocate previous collection areas and survey additional areas of suitable habitat. Only one of four previously known sites (Alder Creek) was relocated, but three new populations were discovered, all within the previously described geographic range of the subspecies. Additional studies by Steele (unpubl.) have revealed a

total of ten small, fragmented populations, all within a portion of the previously described range. Populations of *A. r. nigra* have been discovered in sheltered gulches, steep north-facing slopes, and in several old dune systems (Steele 1986). Burrow systems are under dense stands of perennial vegetation where soil conditions allow for easy excavation. An abundant supply of food plants, sometimes forming an impenetrable thicket, and moderately deep and firm soil with good drainage are consistent features of the habitat of the Point Arena mountain beaver. Populations found on coastal strand/coastal scrub habitat are less sheltered but effectively buffered from temperature extremes produced by high winds and a strong marine influence. This is the only subspecies of mountain beaver that inhabits sand dunes.

The Point Reyes mountain beaver (*A. r. phaea*), the southernmost coastal subspecies of mountain beaver, is known from only about 175km² within Point Reyes National Seashore, north of San Francisco Bay in Marin County, California. It is found in sheltered gulches and steep, north-facing slopes of coastal scrub habitat dominated by coyote bush and salmon berry, or dense understory within Bishop pine forest habitat. In all known cases, the populations are closely associated with riparian habitat including red alder, willow, and nettle.

Remarks

The most primitive of all living rodents, mountain beavers are relicts of a formerly widespread family that now survives as a single genus and species in the Pacific Northwest and Sierra Nevada. *Aplodontia r. nigra* and *A. r. phaea* have suffered habitat loss due to past logging and conversion of forests for grazing. *Aplodontia r. nigra* continues to be subjected to these impacts to a reduced degree, whereas *A. r. phaea* is now restricted to the Point Reyes National Seashore where such impacts are avoided. Both subspecies are subjected to threats from feral cats and dogs, and increasing urbanization of surrounding areas tends to increase this threat. On private and open public lands, *A. r. nigra* faces habitat loss from continued conversion of brush areas to grazing pastures for dairy use, as well as urbanization (highway and communications-line construction, and housing development).

Laboratory studies of mountain beavers have explored various aspects of their physiology and anatomy (see Steele 1986 for review), and have documented physiological limitations in water balance and thermoregulatory abilities (relative to other rodents) that appear to be directly related to the habitat restrictions of the species.

Like other burrowing rodents, the mountain beaver can be a nuisance due to its habit of extensive digging and foraging in gardens, cropland, and forests. In some districts of coastal Oregon and Washington, for example, it may be considered a pest (Scheffer 1929, Phillips 1982). However, the Point Arena mountain beaver is not known to cause

any significant economic damage and is largely unknown by local residents. There is a considerable gap between the ranges of the Point Reyes and Point Arena subspecies of mountain beaver, although the intervening area appears to provide potential habitat. The most recent reviews of these subspecies are by Steele (1986, 1989). Carraway and Verts (1993) reviewed the general biology of this species.

Conservation status

The Point Arena mountain beaver was listed as an Endangered species by the United States Fish and Wildlife Service in 1991. The California Department of Fish and Game considers the animal to be a Species of Special Concern. The California Department of Fish and Game and the United States Fish and Wildlife Service both recognize the Point Reyes mountain beaver as a state Species of Special Concern and a federal C2 candidate for endangered species status. According to the staff of these agencies, if a petition for listing were developed it is likely that the animal would be listed. A draft recovery plan (Steele *in litt.*) has been accepted by the United States Fish and Wildlife Service, and is currently under internal review. A single population (at Mono Basin) of the relatively widespread Sierra Nevada subspecies, *A. r. californica*, was listed as a federal PE taxon (“already proposed to be listed as Endangered”) in 1991, and as a C2 candidate taxon in 1994. The earlier listing appears to have been an error; no additional information is available about the status of this population.

Occurrence in captivity and protected areas

Aplodontia r. phaea has been maintained in captivity for extended periods. Other subspecies have reproduced in captivity. Mountain beaver are known to die suddenly when in captivity for unexplained reasons, possibly stress. Live trapping may cause mortality unless traps are checked frequently, sharp edges of traps are padded, and traps are covered to provide shelter from the elements.

Approximately half of the known populations of Point Arena mountain beaver are located on California Department of Parks and Recreation State Park property. The Point Reyes mountain beaver is currently known only from within the Point Reyes National Seashore although previous records have included areas beyond its boundaries. The National Park Service recognizes the animal as a Species of Special Concern and controls collection or study activities.

Recommended action

- Determine source and severity of specific current threats to populations of *A. r. nigra*.
- Increase current protection to include all known populations of *A. r. nigra*.
- Expand long-term monitoring of all populations of *A. r. nigra* and consider additional research, including

telemetry studies, on its ecology. Monitoring should initially focus on extant population sites and remaining adjacent suitable habitats. Assessment of population status, changes in on-site or adjacent land management practices, and contacts with local Mendocino County government authorities should be integral components of the program to ensure enforcement of protective zoning or other measures. Later management actions may require artificial movement of individual *Aplodontia* between populations to maintain these sites, or development of a captive breeding program to boost extant populations or introduce captive raised specimens into currently unoccupied habitats within historic range.

- Bring populations of *A. r. nigra* on private land under governmental protection by land acquisition or conservation easement. Placing additional population sites in public ownership with management to enhance coastal scrub/riparian habitat may make formal designation of critical habitat unnecessary. All of the known population sites may provide critically important habitat for the animal. The Mallo Pass Creek and Irish Gulch population sites may represent the northernmost populations and could play a critical role in maintenance of genetic diversity.
- Establish protective buffers around all known populations of *A. r. nigra* and exclude further housing or other developments. The width of the buffer should be sufficient to reduce opportunity for disturbance or mortality of *Aplodontia* by domestic cats and dogs. A buffer width of at least 0.5km is recommended unless protective fencing or cooperative management agreements can be reached with adjacent property owners. Other actions should include: 1) reduction or scheduling of mowing to minimize disturbance during key periods of the rodent’s life cycle, 2) reduction of grazing pressure, and 3) restrictions in use of herbicides and rodenticides.
- Minimize identification of *A. r. nigra* locations to decrease human visitation, foot traffic, and vandalism on public land population sites.
- Conduct comparative biochemical analysis of coastal subspecies of mountain beaver to determine nature and degree of genetic differentiation among populations and coastal subspecies.
- Continue long-term monitoring of all known populations of *A. r. nigra*. A population at the AT&T communications facility has been monitored quarterly for the last two years. This work was funded by AT&T as mitigation for construction impacts resulting from a fiber optic cable project. No current scheduled monitoring is underway. Additional communications projects have either occurred or are planned in the near future. It is necessary that a qualified biologist provide on-site monitoring during any projects in the vicinity of *A. r. nigra* populations and that adequate mitigation be

included to preserve and enhance population sites. Additional work to restore habitat associated with each site should also receive adequate funding. It has been estimated that approximately \$10,000 per year for the next five years would be needed to carry out the necessary projects.

- Provide formal endangered species status for *A. r. phaea* by the California Fish and Game Commission and the United States Fish and Wildlife Service. In addition, the National Park Service should work with other agencies and interested parties to develop a comprehensive management and recovery plan for populations within its jurisdiction.
- Carry out additional survey work to search for populations of *A. r. phaea* beyond National Seashore boundaries.
- Establish long-term monitoring transects for *A. r. phaea*.

Family SCIURIDAE

***Ammospermophilus nelsoni* (Merriam 1893)**
Nelson's antelope squirrel;
San Joaquin antelope squirrel;
San Joaquin antelope ground squirrel

John H. Harris

IUCN Red List Category

Ammospermophilus nelsoni—Endangered (EN): A1a; B1; B2c

Assignment is based on the extensive loss (80%) of the original occupied habitat and restricted area of known occupancy (<3900km²).

Taxonomy

Taylor (1916a) recognized two allopatric subspecies within *A. nelsoni*: a larger, yellower northern form (*A. n. amplus*) and a smaller, somewhat grayer southern form (*A. n. nelsoni*). Subsequent collecting between the two forms revealed morphologically intermediate populations, and the two were synonymized by Howell (1938). Morphometric analysis by Hafner (1981) supported Howell's (1938) arrangement. Phyletic analysis (Hafner 1981) documents that *A. nelsoni* is most closely related to the widespread species, *A. leucurus*. However, it is unclear whether *A. nelsoni* was isolated from *A. leucurus* recently (post-Xerothermic, <6,000 years ago; Hafner 1981) or earlier, during a middle Pleistocene vicariance of the San Joaquin desert fauna (Friesen 1979).

Distribution

The San Joaquin antelope squirrel is endemic to the San Joaquin Valley of California, but formerly occurred from the vicinity of Los Banos (Merced County) south to the Cuyama Valley (Santa Barbara and San Luis Obispo

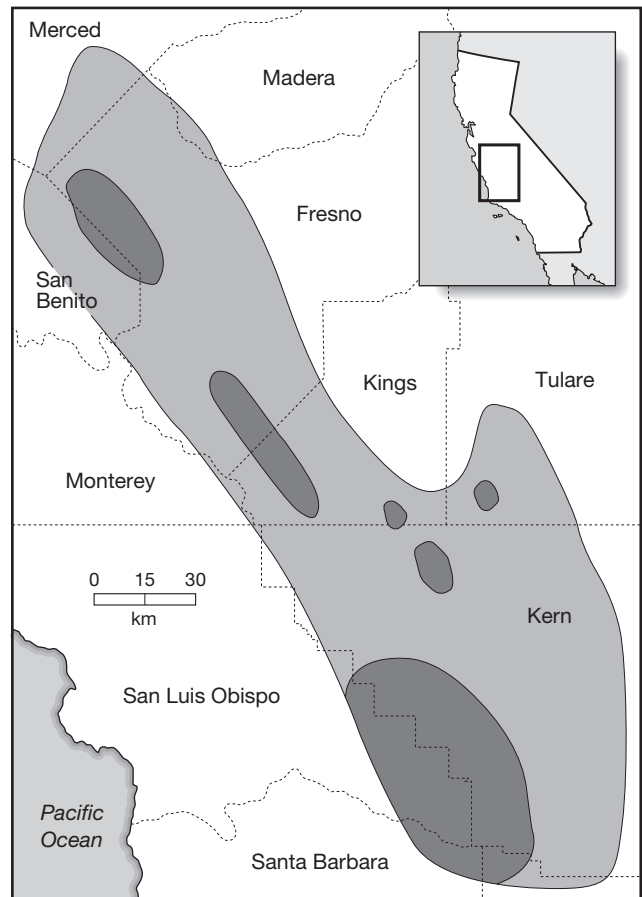


Figure 5.1. Historical (light shading) and current (dark) distribution of Nelson's antelope squirrel, *Ammospermophilus nelsoni*, in California's San Joaquin Desert (counties indicated).

counties) (Fig. 5.1). Within this area it occurred on the west side of the San Joaquin Valley and adjacent uplands, the Tulare and Buena Vista lake basins, and the southeastern portion of the San Joaquin Valley north to the vicinity of Tipton (Tulare County) (Grinnell and Dixon 1918, Hawbecker 1953). About 80% of this species' habitat had been eliminated by 1979, and most of the remaining habitat is marginal (Williams 1981). Currently, these antelope squirrels are found primarily in the southwestern portion of the historical distribution, including the Elk Hills and Buena Vista Valley, Elkhorn Plain, Carrizo Plain, and Cuyama Valley. Small, isolated populations are found scattered on the floor of the San Joaquin Valley and in the Panoche and Kettleman Hills, San Benito and Fresno counties (Harris and Stearns 1991).

Remarks

The San Joaquin antelope squirrel is a small, diurnal rodent found in the arid San Joaquin Valley of California. Its elevational distribution spans a range from about 50 to 1,100m and it may be found on open terrain and gently sloping hills (Best *et al.* 1990). Habitats include open

perennial bunchgrass, annual grasslands, *Atriplex* scrub, *Ephedra* scrub and other open shrublands on sandy loam and alluvial soils. Cultivated croplands are avoided (Grinnell and Dixon 1918, Hawbecker 1953, Williams 1981). Although shrubs may provide significant shelter from heat (Hawbecker 1953, Heller and Henderson 1976), these squirrels are also found in areas devoid of shrubs (Best *et al.* 1990, Harris and Stearns 1991). San Joaquin antelope squirrels are omnivorous, eating green vegetation, insects and seeds (Hawbecker 1947). Average home range size for the species was reported to be 10–14ha (Harris and Stearns 1991). Existing populations of the species are potentially threatened by cultivation, oil and gas development, residential development, rodent poisoning, and possibly cattle grazing (Schlorff 1987).

Hawbecker (1947, 1953) suggested that San Joaquin antelope squirrels were dependent on the burrowing activities of other rodents, specifically kangaroo rats (*Dipodomys* spp.). Harris and Stearns (1991) found them in moderate densities in areas devoid of shrubs but occupied by giant kangaroo rats (*Dipodomys ingens*). Burrowing of other rodents may promote movement of *A. nelsoni* into unoccupied habitat. California ground squirrels (*Spermophilus beecheyi*) have been reported to displace antelope ground squirrels and other rodents from burrow systems (Harris and Stearns 1991). This would be especially likely where a small population is surrounded by disturbed habitat occupied by California ground squirrels. Best *et al.* (1990) reviewed the general biology of this species.

The core of the San Joaquin antelope squirrel's current distribution is the southwestern margin of the San Joaquin Valley and adjacent upland habitats, specifically the Elk

Hills, upper Buena Vista Valley, the Elkhorn Plain, and Carrizo Plain. Within this core of the species' range, it may be locally common. Recent studies (Harris and Stearns 1991) suggest that the highest densities (2–5 per ha) within this range are within the limits (2–11 per ha) reported for good habitat historically (Grinnell and Dixon 1918) but lower than the maximum densities suggested by these authors. The areas considered to be the best sites (based on population density) by Grinnell and Dixon (1918) no longer exist as suitable habitat (Williams 1981).

On the floor of the San Joaquin Valley and the northern part of the species' range, populations are isolated, small, and have low densities (Williams 1981, Harris and Stearns 1991). All of these populations should be considered at risk due to potential random population fluctuations, habitat loss and degradation due to proximity to developed lands. Some of the populations on the floor of the San Joaquin Valley occupy marginal alkaline sink habitat, restricted to low hummocks above the level of periodic floods (Williams 1981, Harris and Stearns 1991).

Conservation status

Currently, this species is listed as Threatened by the California Fish and Game Commission and is a federal C2 candidate species.

Occurrence in captivity and protected areas

Significant populations of San Joaquin antelope squirrels are found on the Carrizo Plain Natural Heritage Reserve. This reserve is a recently established, large (>600km²) preserve jointly managed by the Bureau of Land Management, The Nature Conservancy, and the California



Nelson's antelope squirrel,
Ammospermophilus nelsoni.

John H. Harris

Department of Fish and Game. Each of these agencies owns parcels of land which make up the preserve. Small populations are found on two preserves in Kern County that are owned by The Nature Conservancy: the Semitropic Ridge Preserve (about 10km²) and the Lokern Preserve (about 8km² of Nature Conservancy lands plus additional Bureau of Land Management and Chevron USA holdings totalling about 120km²). The California Department of Fish and Game owns two reserves with small populations of this squirrel: the Buttonwillow Ecological Reserve (about 5.5km² in Kern County) and the Allensworth Ecological Reserve (about 10km², Tulare County). Although small, the Semitropic Ridge Preserve is critical because of its location on the floor of the San Joaquin Valley, where few viable populations of this species are found.

Populations of this rodent are also found on Federal lands managed for multiple uses. The species is fairly common on the Elk Hills Naval Petroleum Reserve. The few squirrels found in the Panoche Hills include populations on Bureau of Land Management (BLM) holdings that also are used for grazing and hunting. They are also found on other BLM lands on small parcels intermingled with private land in the Buena Vista Valley and on parcels surrounding the Carrizo Plain Natural Heritage Reserve. A small population is found in Ballinger Canyon, Los Padres National Forest, adjacent to a campground in an area intensively used by off-road vehicles.

Recommended action

- Monitor populations closely in the northern part of the range and on the floor of the San Joaquin Valley. Previous surveys (Williams 1981, Harris and Stearns 1991) along with those being conducted by the California Energy Commission (R. Anderson pers. comm.) can serve as a basis for identifying areas in need of monitoring and targeting lands for acquisition or protection.
- Acquire and protect lands supporting San Joaquin antelope squirrel populations in the northern part of its range (Panoche and Kettleman Hills region) and on the floor of the San Joaquin Valley. Consolidate suitable habitat and maintain corridors between occupied sites.
- Restore habitat of *A. nelsoni* on the Carrizo Plain Natural Heritage Reserve; this is an excellent opportunity for promoting significant growth of squirrel populations in the southwestern part of the species' range. Habitat restoration also may provide opportunities for furthering understanding of habitat relationships by experimenting with such variables as the presence or density of shrubs and presence of other rodent species.
- Locate sites suitable for reintroduction where this species is most vulnerable in the northern part of its range and on the floor of the San Joaquin Valley to increase the number of viable populations and the overall species population. Some potential sites are identified by Harris

and Stearns (1991). Reintroduction of fossorial rodents has been successfully conducted with the giant kangaroo rat (D. F. Williams pers. comm.).

- Conduct research on techniques for reintroduction, perhaps using previously employed methods developed for the giant kangaroo rat. Employ these techniques as needed.
- Conduct research on the effects of grazing and fire for managing lands inhabited by the species (e.g., the Carrizo Plain Natural Heritage Reserve and BLM lands in the Panoche Hills).
- Obtain more information on interspecific relationships, particularly on the possible positive influence of the presence of other burrowing rodents and the possible negative influence of California ground squirrels.

***Cynomys ludovicianus* (Ord 1815)** **Black-tailed prairie dog**

David J. Hafner

IUCN Red List Category

Cynomys ludovicianus – Lower Risk, near threatened (LR,nt)

Assignment is based on extensive loss of habitat suffered during this century: e.g., from 1 million ha to 15,000ha in Kansas, and from 750,000ha to 24,000ha in South Dakota (Linder and Hillman 1973).

Taxonomy and distribution

Prior to 1975, two subspecies were recognized: the widespread *C. l. ludovicianus* and *C. l. arizonensis*, which was historically found in relatively arid desert-grasslands of southeastern Arizona, southwestern New Mexico, west Texas, and northern Mexico, but has been extirpated from most of this range. Based on morphometric analyses, Pizzimenti (1975) concluded that “there is no reason to support subspecific designation” of *C. l. arizonensis*, and Hoffmeister (1986) followed that recommendation in regarding the species as monotypic.

Cynomys ludovicianus occupies short-grass prairie along the western margin of the Great Plains, from southern Canada to northern Mexico. Compared to other species of prairie dogs, *C. ludovicianus* inhabits lower-elevation, relatively mesic environments with milder winters and longer growing seasons (Goodwin, 1995). Fossil evidence (Goodwin, 1995) indicates that *C. ludovicianus* occurred widely across Mexico during the latter pluvial intervals, consistent with the hypothesis that *C. mexicanus* is a relictual species recently derived by isolation of a Mexican population of *C. ludovicianus*.

Remarks

The highly social prairie dogs occur in large colonies, or ‘towns,’ usually of about 100ha in the open plains.

Populations increased dramatically in the late nineteenth century during the westward expansion of European people, possibly due to elimination of predators and forage competitors (Banfield 1974), or introduction of domestic livestock (Nowak 1991). Soon regarded as an economic menace, prairie dogs were subjected to intensive public and private poisoning programs.

The species has been extirpated from most of its historical distribution in Arizona, New Mexico, Texas, and Mexico (Arizona Game and Fish 1988, Hoffmeister 1986, Findley *et al.* 1975, Anderson 1972, Cockrum 1960). *Cynomys ludovicianus* was probably extirpated from Arizona and southwestern New Mexico by 1940 as a result of poisoning campaigns (Arizona Game and Fish 1988, Findley *et al.* 1975). Northern portions of its previous range in central New Mexico are now occupied by *C. gunnisoni* (Findley *et al.* 1975). The subspecies may persist along the eastern edge of its former distribution in southeastern New Mexico, northern Mexico, and western Texas. Brown *et al.* (1974) reported a failed attempt to reintroduce prairie dogs near Elgin, Arizona, in 1972, and recommended further reintroduction efforts in the San Rafael Valley, Santa Cruz County, Arizona. Hoffmeister (1986) reported that as of 1977, ranchers in the San Rafael Valley were still opposed to such reintroduction efforts. Cheateam (1977) estimated that populations of *C. ludovicianus* in Texas had been reduced from ca. 800 million in 1905 to 2.25 million as a result of poisoning and range development.

Conservation status and occurrence in captivity and protected areas

Cynomys ludovicianus arizonensis (no longer considered to be a valid subspecies) is listed as a federal C2 candidate taxon (United States Fish and Wildlife Service 1994a), as Extinct in Arizona, and as Rare or Uncommon in Texas. A closely related species occurring in Mexico, *C. mexicanus*, is a federal Endangered species. No populations of either subspecies are known to occur in protected areas, and no captive populations of either subspecies are known.

Recommended action

- Compare remaining populations that were previously assigned to *C. l. arizonensis* in New Mexico, Texas, and Mexico to adjacent populations to evaluate subspecific validity using molecular genetic data.
- Provide formal protection for peripheral populations of *C. ludovicianus* in New Mexico and Mexico.
- Conduct survey and inventory of remaining populations of *C. ludovicianus* to determine extent of loss of occupied area.
- Study potential reintroduction of populations to protected semi-desert grassland areas in southwestern New Mexico and southeastern Arizona (e.g., areas surrounding Animas Mountains, New Mexico, and Chiricahua Mountains, Arizona).

***Cynomys parvidens* J. Allen 1905** **Utah prairie dog**

Richard A. Fridell and Kenneth P. McDonald

IUCN Red List Category

Cynomys parvidens – Lower Risk, conservation dependent (LR,cd)

Assignment is based on substantial loss of occupied habitat (50%), low numbers of remaining individuals (3,529), and the need for continuation of the existing management program.

Taxonomy

Cynomys parvidens is in the white-tailed subgenus *Leucocrossuromys*, distinguished by a relatively short, white-tipped tail, as opposed to members of the subgenus *Cynomys*, distinguished by a black-tipped tail. Chromosomal and biochemical data suggest that the Utah Prairie dog and the white-tailed prairie dog (*C. leucurus*) are closely related and may have once belonged to a single, interbreeding species (Pizzimenti 1975). Utah prairie dogs are also distinguished by the cinnamon to clay coloration of the dorsum and proximal half of the tail and by sharply outlined dark eyebrows, which are lacking in other species (Pizzimenti and Collier 1975).

Utah prairie dog, *Cynomys parvidens*.



Richard A. Fridell

Distribution

The Utah prairie dog occurs only in grassland areas of southwestern Utah at elevations ranging from 1500 to 2700m. This species has the most limited distribution of any prairie dog species in the United States. Colonial like other prairie dogs, they feed primarily on grasses and forbs, inhabit only short-grass habitat where the height of the vegetation allows them to see over it when standing, and avoid areas dominated by tall, woody shrub vegetation (Collier 1975).

Remarks

Pizzimenti and Collier (1975) reviewed the general biology of *Cynomys parvidens*. This species hibernates during winter and breeds shortly after emergence from hibernation in March. Litter size averages 4.1 per female (Pizzimenti and Collier 1975, Wright-Smith 1978, Mackley *et al.* 1988). Sex ratio of juveniles at birth is 1:1, but adult sex ratio is skewed towards females, with an adult female: adult male ratio of 2:1 (Wright-Smith 1978, Mackley *et al.* 1988).

The total number of Utah prairie dogs was estimated at 95,000 individuals in 1920, prior to control programs. During the following 50 years, their range was reduced by approximately 50% (Collier and Spillett 1975). By 1972 an estimated 3,300 prairie dogs remained in 37 separate colonies. The decline has been attributed to poisoning, disease, drought, and alteration and loss of habitat resulting from long-term overgrazing and cultivation. Urban development has encroached on prairie dog habitat and is currently a major threat on private property.

As amplification hosts of plague (from the bacterium *Yersinia pseudotuberculosis* var. *pestis*), prairie dogs periodically suffer epizootic infection. Epizootic infections can lead to rapid devastation of entire colonies (e.g., Eskey and Hass, 1940).

Conservation status

Due to dramatic declines in abundance and distribution, the Utah prairie dog is a federal Endangered species. Large increases in populations on private land led to reclassification as Threatened in 1984. A formal recovery plan for Utah prairie dogs was approved in 1991 (United States Fish and Wildlife Service 1991a). The objective of the plan is to maintain the species as a self-sustaining, viable population with retention of 90% of its genetic diversity for 200 years. For delisting, the recovery plan calls for establishing a minimum of 813 adults on public lands in each of three recovery areas, and maintaining those population levels for five consecutive years.

Occurrence in captivity and protected areas

The primary emphasis of recovery efforts has been to establish additional colonies on public lands by transplanting them from private lands within their historical range. Between 1972–1993, 16,740 prairie dogs have been

transplanted to 38 sites, following guidelines that have been developed during the past 20 years (Jacquart *et al.* 1986, Coffeen and Pederson 1989). Transplant colonies now include 29% of all *Cynomys parvidens*, and colonies persist on 17 of the 38 transplant sites. Most (74%) of the transplant colonies are on public land and account for 44% of the total number of colonies located on public lands. However, many of the colonies on public lands are small and are isolated from other colonies.

Following protective measures implemented with listing, prairie dog numbers increased from 2,975 to 7,422 in 1989. They have since declined to 3,529 in 1993. The recovery goal of 813 adults on public lands was reached in two of the three recovery areas in 1989, but populations later dropped well below the target levels. The decline of prairie dogs on public lands in the Awapa Plateau recovery area is of critical concern; numbers on public lands there have fallen from 1,013 in 1989 to only 44 in 1993, probably the result of disease and changes in range conditions resulting from drought and overgrazing by livestock.

Recommended action

- Continue to monitor present populations and distributions.
- Continue attempts to establish colonies on public lands through translocation from private lands.
- Develop long-term (i.e. 100-year) management plans for all public land colonies to ensure that the habitat remains suitable for prairie dogs.
- Locate transplant sites to allow dispersal between populations.
- Re-evaluate the recovery goal of 813 adults on public lands in each of the three recovery areas to take into account that colonies are not all interconnected and are subject to rapid declines.
- Determine the causes of failure to reach the initial recovery goals.
- Develop models to predict the expected effects of plague on long-term survival of isolated colonies.

***Glaucomys sabrinus* (Shaw 1801) Northern flying squirrel**

John R. Demboski, Joseph A. Cook,
and Gordon L. Kirkland, Jr.

25 subspecies, 4 of conservation concern:

G. s. californicus San Bernardino flying squirrel

G. s. coloratus Carolina flying squirrel

G. s. fuscus Virginia flying squirrel

G. s. griseifrons Prince of Wales Island flying squirrel

IUCN Red List Category

Glaucomys sabrinus – Lower Risk, least concern (LR,lc)

G. s. californicus – Data Deficient (DD)

G. s. coloratus – Vulnerable (VU): A2c;B1;B2c
G. s. fuscus – Vulnerable (VU): A2c;B1;B2c
G. s. griseifrons – Endangered (EN): A1c;A2c;B1;B2c

Assignment of four subspecies of conservation concern is based on the highly restricted distribution of all four subspecies, the immediate and specific threats (habitat destruction) directed at the eastern and Alaskan subspecies, and need for data on the population status and current distribution of the southern California subspecies.

Taxonomy

Analysis of mitochondrial DNA indicates the existence of two major lineages within *G. sabrinus*: a western form occurring in the Cascade, Coast, Sierra Nevada, and Transverse ranges of Washington, Oregon, California, and Nevada, and a northern and eastern form that occupies the rest of the range, including the Rocky Mountains (B. S. Arbogast pers. comm.). These two forms may be nearly as distinct from one another as they are from the other species of *Glaucomys*, *G. volans*. Howell (1934) described *G. s. griseifrons* based on three specimens collected by E.P. Walker in 1927. The dorsum, tail, sides of the head, and flying membrane were described as darker than specimens of the Alaska coast flying squirrel, *G. s. zaphaeus*, from the mainland (Cleveland Peninsula; Osgood 1905). No additional specimens were collected until 1992 and 1993, when 11 specimens were collected from Prince of Wales Island and deposited in the University of Alaska Museum. These specimens display the same pelage characteristics described by Howell (1934) for *G. s. griseifrons*. Howell (1934) noted no differences in size between the two subspecies, although he examined only three specimens of *G. s. griseifrons*. Flying squirrels were trapped in 1956 and from 1977–1979, but these were not retained for museum collections (McGregor 1958, Van Horne 1981, 1982).

The taxonomic status and biogeography of flying squirrels in Southeastern Alaska and the surrounding region is currently under review (J. Demboski and J. A. Cook unpubl. data). The taxonomic status of flying squirrels from the coastal islands of British Columbia has not been investigated.

Distribution

The northern flying squirrel has a broad distribution across most of Canada and extending down the major mountain ranges of western and eastern North America. Four subspecies are considered to be of conservation concern. Three of these are found on the southern periphery of the species' distribution: *Glaucomys s. californicus* is known from the San Bernardino and San Jacinto Mountains of southern California, and may occur in the San Gabriel Mountains (Vaughan, 1954); and two subspecies, *G. s. coloratus* and *G. s. fuscus*, occur in the Appalachian Mountains. A fourth subspecies (*G. s.*

griseifrons) is known only from Prince of Wales Island, the largest island in Southeastern Alaska (Howell 1934, Fay and Sease 1985). Specimens of the latter have been collected from the central and northern parts of the island, near Lake Bay, Thorne Bay, Nossuk Bay, and Stoney Creek. *Glaucomys s. coloratus* is limited in distribution to North Carolina, Tennessee, and Virginia, while *G. s. fuscus* occurs further north in Virginia and West Virginia.

Remarks

The southern flying squirrel, *G. volans*, is more adaptable and aggressive than *G. sabrinus* and may be displacing northern flying squirrels in the southern Appalachian Mountains. *Glaucomys volans* also carries a parasite (*Strongyloides*) that is benign to *G. volans* but adversely affects *G. s. coloratus* and *G. s. fuscus* (Lowe *et al.* 1990). Both eastern subspecies of *G. sabrinus* are limited to higher elevations (above 1,525m) where they inhabit remnant boreal spruce-fir forests and mixed forests of conifers and hardwoods (Webster *et al.* 1985). Lowe *et al.* (1990) note that the Appalachian subspecies are found primarily at the ecotone between spruce-fir and northern hardwood forests, and that they occur at progressively higher elevations towards the southern limits of their distribution. Because of the greater frequency of tree cavities in hardwood forests, southern Appalachian populations of northern flying squirrels generally nest in hardwood forests (Lowe *et al.* 1990).

Specific habitat use by *G. s. griseifrons* on Prince of Wales Island is not known. Habitat use by other subspecies of northern flying squirrels has been well documented and was summarized by Wells-Gosling and Heaney (1984). Those studies indicated that northern flying squirrels require old-growth forest for nesting sites (Weigl 1978, Mowrey and Zasada 1985). Carey (1995) concluded that *G. sabrinus* was more abundant in old-growth forests than in younger, managed forests on the Olympic Peninsula, Washington. The diet of flying squirrels in the Pacific Northwest consists primarily of fungi and lichens, which are intimately tied to old-growth forests (C. Maser *et al.* 1986). Population estimates for *G. s. griseifrons* have not been made, although the taxon has been considered scarce (Howell 1934, McGregor 1958, Van Horne 1981, 1982).

Species introduced to Prince of Wales Island include marten (*Martes americana*), raccoon (*Procyon lotor*), and red squirrel (*Tamiasciurus hudsonicus*; Anonymous 1985). The marten is apparently the only survivor of these introductions and probably preys upon *G. s. griseifrons*. Other potential predators are owls and domestic cats and dogs.

Approximately 40% of the Prince of Wales planning area has been logged under provisions of 50-year timber sale contracts. An additional 4000ha of old-growth timber is scheduled to be cut in the next five years. Prince of Wales Island also has the most extensive road network of any

island in Southeastern Alaska. No significant old growth habitat is protected on the island.

The two Appalachian subspecies face a growing threat of habitat loss and degradation owing to clearcutting and other development. As a result, they are being restricted to increasingly isolated habitats at higher elevations of the southern Appalachians. These small, isolated populations are subject to a higher probability of chance extinction. Protection of old growth ecotones is important to the survival of these two forms (Lowe *et al.* 1990). Appalachian populations of the northern flying squirrels eat fungi, lichens, buds, some seeds, and insects. Females usually have one litter of 2–4 young each year (Lowe *et al.* 1990). Wells-Gosling and Heaney (1984) reviewed the general biology of this species.

Conservation status and occurrence in captivity and protected areas

Glaucomys sabrinus is listed as protected in Nevada, presumably because of its limited distribution in that state rather than due to any valid biological threat. The California subspecies, *G. s. californicus*, is a federal C2 candidate taxon, and a Species of Special Concern in California, due to its limited distribution and proximity to the rapidly growing Los Angeles metropolitan area. The Carolina northern flying squirrel (*G. s. coloratus*) is considered Endangered in Tennessee and Virginia, is Critically Imperiled in North Carolina, and is a federal Endangered taxon. The Virginia northern flying squirrel (*G. s. fuscus*) is Critically Imperiled in West Virginia and Endangered in Virginia, and is a federal Endangered taxon. *Glaucomys s. griseifrons* was listed as a federal C2 candidate taxon in 1974. However, the United States Fish and Wildlife Service delisted this subspecies in 1986 without additional biological study.

Prince of Wales Island is the largest island in the Alexander Archipelago. Approximately 90% of the island is under the jurisdiction of the United States Forest Service. The remaining 10% of the island consists of land owned by the State of Alaska (small communities) and Alaskan native corporations, particularly in the vicinity of Craig and Klawock.

Recommended action

- Protect old growth forest habitat on Prince of Wales Island; immediate action is required.
- Protect old growth ecotones, critical to the survival of *G. s. coloratus* and *G. s. fuscus*.
- Conduct survey to determine population status and distribution of *G. s. coloratus* and *G. s. fuscus*.
- Conduct taxonomic study of *G. s. griseifrons* relative to *G. s. zaphaeus* and *G. sabrinus* specimens from other islands (e.g., Mitkof and Revillagigedo) throughout Southeastern Alaska and the northern British Columbia coast.

- Survey Prince of Wales Island and neighboring islands to determine the distribution and population levels of this subspecies.
- Survey historical distribution of *G. s. californicus* and appropriate habitat in the San Gabriel Mountains to determine population status, distribution, and potential threats to survival of the subspecies.

***Marmota caligata* (Eschscholtz 1829) Hoary marmot**

Joseph A. Cook

9 subspecies, 2 of conservation concern:

M. c. sheldoni Montague Island hoary marmot

M. c. vigilis Glacier Bay hoary marmot

IUCN Red List Category

Marmota caligata – Lower Risk, least concern (LR,lc)

M. c. sheldoni – Data Deficient (DD)

M. c. vigilis – Data Deficient (DD)

Assignment is based on the need for information on the full distribution and taxonomic validity of both subspecies of conservation concern, and possible adverse effects of development of Montague Island on *M. c. sheldoni*.

Taxonomy

Howell (1914a, 1915) designated marmots of Montague Island, Alaska, as a separate subspecies (*M. c. sheldoni*) on the basis of smaller size and skull characteristics, including narrower premaxillae and shorter nasals. Hoffmann *et al.* (1979) concluded that *M. c. sheldoni* was smaller than mainland subspecies, but they examined only two specimens from the type locality. The taxonomic status of this insular form needs further study.

Heller (1909) described *M. c. vigilis* as a species distinct from *M. caligata* based upon its “larger, more rounded auditory bullae and shallowness of the basioccipital trough” (Heller 1909:249). Howell (1915) reduced this form to subspecies rank. This subspecies was not treated by Hoffmann *et al.* (1979) and its taxonomic distinctiveness has not been re-evaluated.

Distribution

The hoary marmot occurs throughout much of Alaska southward along the Coastal and Rocky Mountain ranges of western Canada and into high elevations of northwestern United States. Isolated populations of *Marmota caligata* are known from two islands at the entrance to Prince William Sound, Alaska (60°10'N, 147°15'W): Hinchinbrook Island (*M. c. caligata*) and Montague Island (*M. c. sheldoni*). A steep mountain range extending the length of Montague Island reaches elevations of over 900m; alpine habitat is found above about 300m elevation (Heller 1910; J. A. Cook

pers. obs.). Heller (1910) reported *M. c. sheldoni* in alpine habitat near the timberline of Hanning and Ziekof bays. The Glacier Bay hoary marmot (*M. c. vigilis*) is known only from the type locality on the “West shore, Glacier Bay, Alaska” (Heller 1909:248), and also may be of conservation concern.

Remarks

Neither specimens nor sight records of *M. c. sheldoni* have been reported since the original collections in 1905 and 1908, although only cursory searches of the alpine habitat have been made (Fay and Sease 1985, J. A. Cook pers. obs., D. Youkey pers. comm.). Montague Island (850km²) is the largest in Prince William Sound. Some 63km² are privately owned by the Chugach Alaska Native Corporation and are currently undergoing clearcut logging. Habitat modification has occurred at lower elevations; logging occurred along the west coast in the 1960s and early 1970s. A new road links the deep water port at McLeod Harbor to the logging sites north of the Nellie Martin River. The impact of these earlier activities and the current logging operations upon populations of *M. c. sheldoni* is unknown. The remaining 787km² is managed by the United States Forest Service (Chugach National Forest Management of Resource Information Group 1993). Logging may have little or no direct impact upon the marmots unless it involves road construction or increased human contact. Possible indirect effects may involve creation of dispersal sinks (see *Marmota vancouverensis* account). Sitka black-tailed deer (*Odocoileus hemionus sitkensis*) and mink (*Mustela vison*) were successfully introduced to the island in the early 1950s. Other species, including mountain goat (*Oreamnos americanus*), recently have been proposed for introduction and the impact of these species on populations of *M. c. sheldoni* is unknown. Marmots are preyed upon by brown bears (*Ursus arctos*).

Heller (1909) noted that *M. c. vigilis* was abundant on the west shore of Glacier Bay near a copper mine. The current status of *M. c. vigilis* is unknown: it has not been documented since the type specimen was collected, although marmots have been observed recently on the west side of Glacier Bay (M. Schroeder pers. comm.).

Conservation status and occurrence in captivity and protected areas

Neither subspecies is provided any current protective status. Most of Montague Island is managed by the Chugach National Forest. *Marmota c. vigilis* is known to occur only in Glacier Bay National Park.

Recommended action

- Clarify the taxonomic status of *M. c. sheldoni* and *M. c. vigilis* using increased sample sizes, molecular data, and more intensive morphometric analyses.

- Survey alpine areas of Montague Island to determine the distribution and relative abundance of these marmots.
- Survey the Glacier Bay area, particularly the western shore, to determine the distribution and relative abundance of *M. c. vigilis*.

***Marmota vancouverensis* Swarth 1911 Vancouver Island marmot; Vancouver marmot**

David W. Nagorsen

IUCN Red List Category

Marmota vancouverensis – Endangered (EN): C2b;D

Assignment is based on the small number of individuals (200–400) in a single population within a restricted area that has been subjected to extensive human modification.

Taxonomy and distribution

This melanistic species is karyotypically (genetically) and morphologically a member of the *Marmota caligata* group (Hoffmann *et al.* 1979), from which it was probably isolated on Vancouver Island, British Columbia in the late Pleistocene. However, it is more similar in skull morphology to *M. c. nivaria* from which it is geographically distant (Idaho, Montana, Alberta) than the adjacent *M. c. raceyi* or *M. c. cascadenis*. Hoffmann *et al.* (1979) treated it as a full species in the superspecies *caligata*.

Marmota vancouverensis is endemic to Vancouver Island, where it is confined to a small area of about 80km² on the southeastern part of the island (Nagorsen 1987). Prehistoric (2500–700 years ago) records from archeological sites, historical museum specimens, and anecdotal observations compiled by the Ministry of Environment indicate that it had a much larger distribution in the past.

Remarks

This species is associated with subalpine herbaceous communities (1100–1450m elevation) with steep slopes where avalanches and snow creep inhibit the growth of trees. Ideal conditions are south-facing slopes where there is early spring snowmelt.

The population was estimated at 200–400 individuals that comprise a single ‘metapopulation’ (Bryant 1990, Janz *et al.* 1994). Specific threats and reasons for the range decrease are not well understood and more research is needed. Reduction in range may relate to climatic changes and even prehistoric hunting that extirpated local colonies. The most contentious issue is the impact of high elevation logging that began on Vancouver Island 10–15 years ago. Virtually all known colonies are now surrounded by clear cuts. However, marmots have colonized clear cuts and are breeding in logged habitats.

Winter survival in clearcuts and the effects of logged habitats on dispersal are unknown at present. Because these logged habitats are at lower elevations, they have less winter snow accumulations than traditional subalpine colonies. A. Bryant (pers. comm.) hypothesized that winter survival was lower in clearcuts because of a lack of insulating snow cover, and that clearcuts act as a dispersal sink impeding dispersal among alpine colonies. At present, data are lacking to evaluate these hypotheses. Alternatively, clearcuts may be beneficial because of the early appearance of spring forage and the open habitats associated with logged areas could promote dispersal among colonies and facilitate predator detection.

This is a secretive species that is difficult to inventory. Many of the inaccessible mountains on Vancouver Island have not been inventoried and more surveys are needed. However, many of these areas have deep snow accumulations with a short growing season and support barren alpine vegetation. There are probably no large undiscovered colonies. Nagorsen (1987) reviewed the general biology of this species.

Conservation status and occurrence in captivity and protected areas

Although there is no clear evidence for anthropogenic threats, the species' numbers and distribution make it vulnerable. *Marmota vancouverensis* is classified nationally (COSEWIC), by British Columbia, and is a U.S. federal Endangered species. It is the only rodent species endemic to Canada that is considered endangered. About 40% of the known colonies are in the 120ha Haley Lake Ecological Reserve. Additional colonies are protected in an adjacent 300ha Critical Wildlife Management Area.

Recommended action

- A national recovery team was established and the final draft of a recovery plan (Janz *et al.* 1994) has been approved. The recovery plan recommends:
- Continue inventories to determine number of extant colonies and their distribution.
- Develop habitat models, continue monitoring of known colonies, and study winter survival and dispersal, especially in relation to effects of logging.

***Sciurus niger* Linnaeus 1758 Fox squirrel; eastern fox squirrel**

Gordon L. Kirkland, Jr.

10 subspecies, 4 of conservation concern in North America (north of Mexico):

S. n. avicennia Big Cypress fox squirrel

S. n. cinereus Delmarva fox squirrel

S. n. shermani Sherman's fox squirrel

S. n. vulpinus Eastern fox squirrel

IUCN Red List Category

Sciurus niger – Lower Risk, least concern (LR,lc)

S. n. avicennia – Lower Risk, conservation dependent (LR,cd)

S. n. cinereus – Lower Risk, conservation dependent (LR,cd)

S. n. shermani – Lower Risk, near threatened (LR,nt)

S. n. vulpinus – Data Deficient (DD)

Assignment of subspecies of conservation concern is based on the historical loss of habitat and restricted number and distribution of populations of *S. n. avicennia*, probably including Big Cypress National Preserve; the extensive habitat loss suffered by *S. n. cinereus*, mitigated by success of the ongoing translocation program; extensive loss of the habitat of *S. n. shermani*, which could be mitigated by establishment of preserves of adequate size; and severe habitat loss experienced by *S. n. vulpinus*, coupled with the effects of introduction of *S. n. rufiventer* and subsequent introgression between the two forms.

Taxonomy and distribution

The fox squirrel naturally occurs over the eastern half of the United States, extending slightly into Canada (Manitoba) and Mexico (Coahuila). The species has also been introduced successfully into urban parks in the western United States, where it has spread into riparian areas (D. J. Hafner pers. obs.). Historically, *S. n. avicennia* (variously known as the Big Cypress fox squirrel, mangrove fox squirrel, Everglades fox squirrel, or south Florida fox squirrel) occurred across southern Florida south of Lake Okeechobee and in the Everglades. Preferred habitats of the Big Cypress fox squirrel include open pinelands, dry cypress stands, and coastal broadleaf evergreen hammocks. The Delmarva fox squirrel (*S. n. cinereus*) originally occurred in southeastern Pennsylvania, Delaware, and the Eastern Shore regions of Maryland and Virginia. The Delmarva fox squirrel inhabits mature stands of hardwoods and pines, especially loblolly pine (*Pinus taeda*) and is restricted to larger stands adjacent to water (bays, streams or saltmarshes; Lowe *et al.* 1990). In all cases the understory must be open. Sherman's fox squirrel (*S. n. shermani*) inhabits longleaf pine (*Pinus palustris*) sandhills and flatwoods from central Georgia to central Florida (Kantola and Humphrey 1990). The original distribution of the eastern fox squirrel (*S. c. vulpinus*) encompassed parts of Pennsylvania, Maryland, Virginia, and West Virginia, and extended northward through New Jersey, southeastern New York, and much of Connecticut (Flyger and Lustig 1976). As depicted by Hall (1981), its range lay between that of *S. n. cinereus* to the east and *S. n. rufiventer* to the west, and to the north of *S. n. niger*.

Remarks

Heavy logging of the pine and cypress forests in southern Florida at the turn of the century contributed to massive habitat loss of *S. n. avicennia* (Humphrey and Jodice

1992). This was followed by rapid development and urbanization of coastal areas and a high influx of humans. Fire prevention has contributed to an increase in understory growth which makes forests unsuitable for fox squirrel habitation (Brown 1978a, Gurnell 1987). Today, *S. n. avicennia* is limited in distribution to the Big Cypress Swamp and the pinelands adjacent to the swamp in southwestern Florida (Brown 1978a). No recent sightings have been made in the Everglades (Brown 1978a). An open understory, free of shrubs and undergrowth is conducive to the success of this squirrel (Brown 1978a).

The Delmarva fox squirrel (*S. n. cinereus*) has experienced a decline in numbers due to habitat loss caused by logging, conversion to agriculture, residential development, exploitation through hunting, and competition from gray squirrels (Kirkland 1986, Lowe *et al.* 1990, Nowak 1991). By the 1920s *S. n. cinereus* was extirpated except in Maryland. Currently, this subspecies occurs in portions of Kent, Queen Anne's, Talbot, and Dorchester Counties, Maryland. It has been introduced into Caroline, Cecil, Kent, Somerset, Wicomico, and Worcester counties, Maryland (1979 to 1991); Sussex County (Assawoman Wildlife Management Area and Prime Hook National Wildlife Refuge), Delaware (1984 to 1987); Chester County, Pennsylvania (1987 to 1988); and Accomack (Chincoteague National Wildlife Refuge, 1968 to 1971) and Northampton counties (1982 to 1983), Virginia (United States Fish and Wildlife Service 1993b, Lowe *et al.* 1990). Translocation at the majority of these sites has been successful, with at least one population persisting in all counties except Cecil County, Maryland and in Pennsylvania (Chester County; United States Fish and Wildlife Service 1993b, J. Hassinger pers. comm.).

Sciurus n. shermani has experienced extensive habitat loss: between 1936 and 1980, longleaf pine forest in Florida diminished by 90%, and loss is expected to accelerate with continued human population growth. Specific impacts to the longleaf pine forests include logging, tapping for turpentine, and suppression of the natural fire cycle. Hunting of the squirrel is still permitted, however, because the practice is traditional and is not considered to be a major threat (Kantola and Humphrey 1990). Conservation of Sherman's fox squirrel requires establishment and proper management of large preserves: the inherently low density of the squirrels and the variation of their food resources in time and space dictate that suitable reserves be several km² (Kantola and Humphrey 1990). Populations of this squirrel on smaller parcels of land may not be viable in the long term, because they are vulnerable to overhunting and plant succession.

During the past 50 years, populations of *S. n. vulpinus* have declined, particularly in Pennsylvania, where this form and *S. n. rufiventer* are considered to be Rare (Kirkland and Krim 1990). Factors contributing to the

decline of *S. n. vulpinus* include loss of habitat and overharvesting. The much larger size of *S. niger* compared to the more common gray squirrel (*S. carolinensis*) makes it an appealing target for hunters, who seem to target fox squirrels whenever small populations are discovered. In Pennsylvania, this subspecies apparently persists in small, scattered populations in mature riparian forests associated with the Susquehanna River and its major tributaries. Riparian forests with adjacent agricultural fields are considered to be preferred habitats (M. Steele *in litt.*). The current distribution of this species would appear to fit the metapopulation model. A major threat to the survival of *S. n. vulpinus* as a distinct taxon stems from efforts of the Pennsylvania Game Commission to augment populations of fox squirrels in south-central Pennsylvania, within the original range of *S. n. vulpinus*, by releasing 1,212 *S. n. rufiventer* in an 11-county area between 1923 and 1936 (Gifford and Whitebread 1951).

Conservation status

Sciurus n. cinereus is a federal Endangered taxon, and is Critically Imperiled in Delaware, Endangered in Maryland, and apparently Extinct in Pennsylvania. *Sciurus n. avicennia* and *S. n. shermani* are federal C2 candidate taxa; the Florida Game and Fresh Water Fish Commission considers *S. n. avicennia* to be Threatened and *S. n. shermani* to be a Species of Special Concern. *Sciurus n. vulpinus* currently has no protective status.

Occurrence in captivity and protected areas

Populations of *S. n. avicennia* probably occur within Big Cypress National Preserve. Translocated populations of *S. n. cinereus* occur in Assawoman Wildlife Management Area and Prime Hook National Wildlife Refuge), Sussex County, Delaware, and in Chincoteague National Wildlife Refuge, Accomack County, Virginia.

Recommended action

- Conduct studies to determine the optimum habitat requirements of *S. n. avicennia*, and survey for presence of populations in Big Cypress National Preserve.
- Conduct controlled burns to open up the understory for better foraging areas for *S. n. avicennia*
- Set aside remaining occupied habitat as refuges for *S. n. avicennia* (Brown 1978a) and *S. n. cinereus*.
- Consider reintroduction of *S. n. cinereus* into unoccupied areas of preferred habitat.
- Establish large (several km²) preserves of longleaf pine habitat for *S. n. shermani*; management should include a natural fire-cycle of burning at 3 to 5-year intervals.
- Initiate studies to determine the distribution, abundance, and genetic identity of populations of *S. niger* within the historical range of *S. n. vulpinus*; in particular, evaluate the genetic impact of introgression with *S. n. rufiventer*.

- Initiate studies on the ecology of *S. n. vulpinus* in order to assess its habitat requirements and ecological relationships with potential predators and competitors.
- Establish sanctuaries within the historic range of *S. n. vulpinus* in which it is protected from habitat loss and hunting.

***Spermophilus brunneus* (A. H. Howell 1928) Idaho ground squirrel**

Eric Yensen

2 subspecies, both of conservation concern:

S. b. brunneus Northern Idaho ground squirrel

S. b. endemicus Southern Idaho ground squirrel

IUCN Red List Category

Spermophilus brunneus – Endangered (EN): B2d;B3d

S. b. brunneus – Critically Endangered (CR): B1;B2d

S. b. endemicus – Vulnerable (VU): B1;B3d

Assignment of the species and subspecies is based on the restricted distributions, small population sizes, and adverse human impacts to the highly fragmented populations.

Taxonomy

Originally described as a subspecies of *S. townsendii* (Howell 1928), *S. brunneus* was elevated to species status by Howell (1938) and this has not been challenged. There are two subspecies of *S. brunneus*, but these may be distinct at the species level, based upon bacula and other differences (Yensen 1991), further increasing the conservation importance of this taxon. *Spermophilus b. endemicus* was recognized as distinct from *S. b. brunneus* based upon size, cranial morphometrics, bacular differences, pelage length and texture, and lighter coloration (Yensen 1991). Yensen (1991) considered species status for the form but was uncertain how to evaluate bacular variation in *Spermophilus*. Current work indicates that the bacular differences between these two forms exceed normal intraspecific variation, further suggesting that these ground squirrels are specifically distinct (E. Yensen unpublished data). Gill and Yensen (1992), using starch-gel electrophoresis, found gene frequency differences between *S. b. brunneus* and *S. b. endemicus*, but no fixed differences.

Distribution

The Idaho ground squirrel is restricted to a small area of west-central Idaho (Fig. 5.2). Within this small area, two subspecies have been recognized: a northern subspecies, *S. b. brunneus*, and a southern subspecies, *S. b. endemicus*. The northern subspecies is endemic to Adams and Valley counties of west-central Idaho. It is known from 28 sites, but in 1995 was extant at only 18 of these. The geographic range is about 2,000km². However, all but one of the

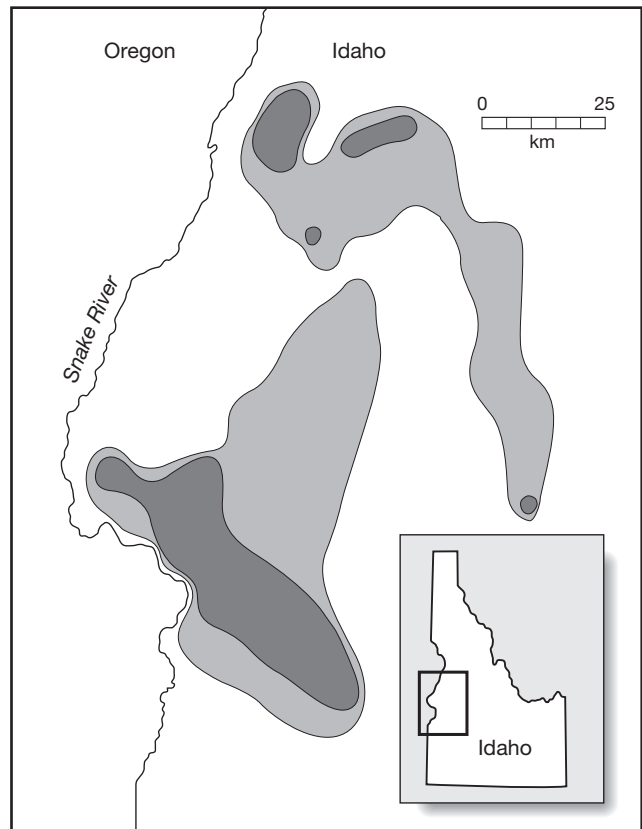


Figure 5.2. Historical (light shading) and current (dark) distribution of the Idaho ground squirrel, *Spermophilus brunneus*, in western Idaho.

remaining localities are within an area of 250km², and the squirrels actually occupy <1.5km² within that range (Yensen 1991; unpublished data). The southern subspecies is endemic to an area of <1,000km² in the low, rolling hills of Gem, Payette, and Washington counties, southwestern Idaho. The squirrel is distributed intermittently across this area (Yensen 1991), and occurs at lower elevations (670–975 m) than the northern Idaho ground squirrel. The closest approach of the two subspecies is within 19km and 250m elevation. A change in soils, vegetation, and topography, but no apparent biogeographic barrier, separates the two taxa (Yensen 1991).

Remarks

Spermophilus b. brunneus occurs in xeric montane meadows usually surrounded by ponderosa pine (*Pinus ponderosa*) or Douglas fir (*Pseudotsuga menziesii*) forests at about 1,150–1,550m elevation. One population is of 200–300 individuals, five of 50–100 individuals, 12 of 10–50 individuals, and several of <10 individuals, and there are probably 600–800 individuals total (Yensen 1991, T. Gavin, P. W. Sherman, and E. Yensen unpublished data). Thus, the situation for the subspecies is critical. Idaho ground squirrels are outcompeted by the larger sympatric Columbian ground squirrels (*S. columbianus*), and the

subspecies is restricted to ‘refugia’ of shallow soils with pockets of deep soil not utilized by Columbian ground squirrels (Yensen *et al.* 1991, E. Yensen and P. W. Sherman unpublished data).

Conifers invade deeper soils more readily than shallow ones. Because of extensive fire control (110 years since the last fire), most of the deeper soil pockets now have trees or are overgrown with shrubs, forcing the squirrels into areas of shallower soils. These areas may be ‘sink areas’, and remaining populations may be doomed unless changes can be effected in forest management policies.

In Adams County, Idaho, as well as throughout the western United States, during the past century there have been changes in forest structure (Truksa and Yensen 1990; Agee 1993) due to timber harvest and fire suppression. Originally, wildfires killed the small trees, but larger trees survived, maintaining the open stands. Regrowth after logging and fire suppression have converted these open stands of ponderosa pine and Douglas fir to dense, closed stands of young trees with little or no understory to provide food for ground squirrels. Further, these conifers are invading meadows. Thus, Idaho ground squirrels have lost habitat and dispersal corridors, and only remain in a handful of isolated meadows within their small range (E. Yensen and P.W. Sherman unpublished data).

Shooting of ground squirrels as “vermin” is traditional in Idaho, and is a popular springtime recreation. With northern Idaho ground squirrel populations so reduced,

this practice is of potential concern at some sites. However, with or without recreational shooting, for all but one population with less than 50 adults and yearlings, the situation for the species is grim. Normal mortality factors, such as hard winters or predation, could now become critical.

The habitat of *S. b. endemicus* was originally sagebrush (*Artemisia tridentata*) and bitterbrush (*Purshia tridentata*) with perennial bunchgrasses and forbs. The area has been invaded by annual grasses, such as cheatgrass (*Bromus tectorum*) and medusahead rye (*Taeniatherium asperum*). After invasion by these exotic grasses, subsequent wildfires are much more severe, and have killed the shrubs and replaced the native habitat with rangeland dominated by annual grasses. When perennial species are replaced by annuals, primary productivity can fluctuate wildly from one year to the next due to the region’s highly variable annual precipitation. Exotic annual-dominated rangeland in the nearby Snake River Birds of Prey Area had a destabilizing effect on Paiute ground squirrel (*Spermophilus mollis*) populations, leading to local extinctions (Yensen *et al.* 1992).

There have been no studies of southern Idaho ground squirrel demography, but their populations have been observed to fluctuate (E. Yensen unpublished data). The long-term effects of conversion of native habitat to exotic annuals are unknown, although ground squirrels are known to use them for food (Yensen and Quinney



Idaho ground squirrel,
Spermophilus brunneus.

Eric Yensen

1992). There do not appear to be any imminent threats, but because of the small distribution, any major land use change could threaten the taxon (E. Yensen pers. obs.).

Conservation status and occurrence in captivity and protected areas

Spermophilus b. brunneus is classified as a federal C2 candidate taxon and is listed as a Species of Special Concern by the Idaho Department of Fish and Game. The southern Idaho ground squirrel is a federal C2 candidate taxon.

The largest population of *S. b. brunneus* exists on the OX Ranch, Adams County, Idaho. A conservation easement exists between the OX Ranch and The Nature Conservancy to protect part of this population. Six of the remaining populations occur in the Payette National Forest.

As a result of the Spotted Owl controversy, legal protection through listing as a federal Endangered species may be counterproductive. There is passionate local opposition to the Endangered Species Act and fear of economic losses in the timber industry. Also, the local people are fiercely independent and deeply resent what would be perceived as government interference. If the species were listed, local residents have threatened to poison the remaining squirrels.

The United States Fish and Wildlife Service, United States Forest Service, and Boise-Cascade Corporation are attempting to negotiate a conservation agreement as an alternative to formally listing the species under the United States Endangered Species Act. A conservation easement of 120ha has been negotiated with the OX Ranch, which has the largest known population. The United States Forest Service has moved a road and expressed interest in thinning young trees in meadow habitats. The latter is of critical importance. A conservation assessment and conservation strategy have been written for the United States Fish and Wildlife Service (Boise Field Office) as part of the process of establishing a conservation agreement.

Recommended action

- Survey range of both subspecies of *S. brunneus* for additional extant populations.
- Monitor the southern Idaho ground squirrel with periodic surveys.
- Rehabilitate range in vicinity of both subspecies with native perennial grasses and shrubs.
- Carefully evaluate major land use changes in the area for possible impact on both subspecies.
- Employ controlled burns or thinning to remove young trees and shrubs from meadows inhabited by surviving populations of both subspecies, and to open corridors to connect inhabited meadows.
- Implement the conservation strategy of the United States Fish and Wildlife Service (Boise Field Office).

***Spermophilus elegans* Kennicott 1863 Wyoming ground squirrel**

Eric Yensen

3 subspecies, one of conservation concern:

S. e. nevadensis Nevada ground squirrel

IUCN Red List Category

Spermophilus elegans – Lower Risk, least concern (LR,lc)

S. e. nevadensis – Data Deficient (DD)

Assignment of the subspecies is based on the need for specific information on the current distribution of populations of *S. e. nevadensis*, particularly in Nevada and relative to populations of *S. beldingi*. If widespread replacement of *S. e. nevadensis* by *S. beldingi* is occurring, the causes for such a replacement should be investigated.

Taxonomy

Spermophilus elegans, originally described as a distinct species by Kennicott (1863), was considered a subspecies of *S. richardsonii* by Allen (1874). Howell (1938:76–77) supported Allen's arrangement, noting that intergradation between the two forms (*elegans* and *richardsonii*) occurred in Gallatin County, Montana. Although Hall (1981) included *elegans* under *richardsonii*, he noted the evidence for specific distinction based on cranial morphology (Robinson and Hoffmann 1975) and chromosomal complements (Nadler *et al.* 1971). Koepl *et al.* (1978) and Fagerstone (1982) provided additional evidence for specific recognition of *S. elegans*. *Spermophilus e. nevadensis* is distinguished from other subspecies of *S. elegans* by its larger size, grayish coloration, and minor skull differences (Howell 1938, Davis 1939). The subspecific taxonomy has not been challenged.

Distribution

The subspecies of the Wyoming ground squirrel occupy three separate areas: Wyoming and adjacent Colorado, Utah, and Nebraska (*S. e. elegans*); east-central Idaho and adjacent Montana (*S. e. aureus*); and northern Nevada, southeastern Oregon, and southwestern Idaho (*S. e. nevadensis*). *Spermophilus e. nevadensis* is known from 11 localities in Nevada, two in Oregon, and one in Idaho (Howell 1938, Hall 1946, 1981). In addition, there are specimens of *S. e. nevadensis* in the Albertson College Museum of Natural History from Rogerson, Twin Falls County, Idaho. This is a previously unpublished record which extends the subspecies' distribution 128km to the east in Idaho. The geographic range of *S. e. nevadensis* shown in Hall (1981) is approximately 90,000km², three-quarters of which is in the higher elevation portion of the Great Basin in northern Nevada.

Remarks

Davis (1939) believed that *S. elegans* formerly occupied a wide and virtually continuous geographic range in southern Idaho, northern Nevada, eastern Montana, and northern Utah, and that *S. armatus* and *S. beldingi* were recent immigrants to the areas between the ranges of the subspecies of *S. elegans*. Hall (1946:303) thus considered *S. e. nevadensis* to be “an isolated race of a species that in a sense is relict.”

Durrant and Hansen (1954:85) further suggested that *S. e. nevadensis* “is a relict and is on the way out. Its range is sympatric with both *C. [=S.] beldingi* and *C. [=S.] townsendii*. The former outcompetes it for the wet situations while the latter does the same with reference to the dry ecological situations.”

Spermophilus e. nevadensis is apparently extirpated in Oregon. A search by Larry Turner in 1971 (Olterman and Verts 1972) failed to find them, but Belding’s ground squirrels were abundant in the area formerly occupied by Wyoming ground squirrels. There are no records since 1927 in Oregon (Zegers 1984). The subspecies no longer occurs at the one published locality in Idaho (Riddle, Owyhee County), although Belding’s ground squirrels were common there in 1983 (E. Yensen pers. obs.). *Spermophilus e. nevadensis* is known to occur in Idaho only at the new locality (Rogerson). The current status of the subspecies in Nevada is unknown. However, in one area where they were extremely abundant in 1982, there were no surviving squirrels in 1992 (B.J. Verts pers. comm.). Thus, the subspecies appears to have lost over one-quarter of its range in this century, and has been replaced, at least in some areas, by Belding’s ground squirrels.

Although competition with *S. beldingi*, *S. armatus*, and *S. mollis* [=townsendii] has been suggested as the reason for the decline in *S. e. nevadensis* (Howell 1938, Davis 1939, Durrant and Hansen 1954), it is possible that grazing practices (B.J. Verts pers. comm.), poisoning campaigns, or other factors may be responsible for extirpation of *S. elegans*, and the other species may be moving into unoccupied habitat. Passive replacement may be more probable, considering that these species have coexisted elsewhere for millennia. Zegers (1984) reviewed the general biology of this species.

Conservation status and occurrence in captivity and protected areas

Spermophilus e. nevadensis is on the Oregon Conservation Data Center Monitor list, although Olterman and Verts (1972) considered it Endangered in the state. It has no protected status in Idaho or Nevada, and no federal protected status. No populations are known to occur in captivity or in protected areas.

Recommended action

- Survey the range of *S. e. nevadensis* to document its current distribution and abundance.

- Determine population trends of *S. e. nevadensis* from interviews and any historical records, especially relative to the historical and current distribution of *S. beldingi*.
- Survey the range of *S. e. nevadensis* to document its current distribution and abundance.
- Study the population dynamics, competition, and habitat associations of *S. e. nevadensis* and other ground squirrel species in its range.
- Investigate the role of grazing practices, range management, and possible ground squirrel control campaigns on population trends in *S. e. nevadensis*.

Spermophilus lateralis (Say 1823) Golden-mantled ground squirrel

Eric Yensen

13 subspecies, 1 of conservation concern:

S. l. wortmanni Green River Basin golden-mantled ground squirrel

IUCN Red List Category

Spermophilus lateralis – Lower Risk, least concern (LR,lc)
S. l. wortmanni – Data Deficient (DD)

Assignment of *S. l. wortmanni* is based on the need for specific data on the status and distribution of its populations.

Taxonomy

Howell (1938) examined 50 specimens of *S. l. wortmanni* from five localities. *Spermophilus l. wortmanni* is paler and buffier in color, is slightly larger, and has shorter nasal bones than *S. l. lateralis* (Howell 1938, Long 1965). The lateral stripes differ from all other subspecies of *S. lateralis* (except *S. l. lateralis*) in lacking dark inner stripes; the stripes are brownish rather than blackish (Howell 1938, Long 1965). Armstrong (1972) regarded only one Colorado specimen (from the north side of Little Snake River 20mi [32km] below Bagg’s Crossing, Carbon County, Wyoming) as belonging to this subspecies. He found intergrades with *S. l. lateralis* further south in Moffat County, Colorado.

Distribution

The golden-mantled ground squirrel is widely distributed over the mountainous areas of western North America from British Columbia to southern New Mexico. In the more arid regions of its range, it tends to occur in more isolated patches of montane habitat surrounded by deserts. One subspecies, *S. l. wortmanni*, is considered to be of conservation concern. This subspecies is endemic to the Green River Basin of southwestern Wyoming and one locality in adjacent Colorado, where it is “confined to a rather restricted area of desert country” (Howell 1938:195). It occurs in isolated conifer stands in the deserts and badlands (C. Garber pers. comm.).

Remarks

Long (1965) reported 49 specimens from six localities; 42 were from the type locality. However, E.R. Hall could not find them at the type locality in 1945 (Long 1965). According to C. Garber (pers. comm.) there are no recent records of *S. l. wortmanni*, although there have been no recent efforts to ascertain the status of this subspecies. Bartels and Thompson (1993) reviewed the general biology of this species.

Conservation status and occurrence in protected areas

Spermophilus l. wortmanni has no current state or federal protective status. No populations of *S. l. wortmanni* are known to occur in protected areas.

Recommended action

- Survey to determine the range and abundance of mantled ground squirrels in the Green River Basin.

***Spermophilus mohavensis* Merriam 1889** **Mohave ground squirrel**

David J. Hafner

IUCN Red List Category

Spermophilus mohavensis – Vulnerable (VU): B1;B3d

Assignment is based on the extremely fragmented distribution and fluctuating nature of populations of *S. mohavensis* on an estimated 20,000km² area.

Taxonomy

The Mohave ground squirrel (*Spermophilus mohavensis*) is one of two species of xeric-adapted ground squirrels of the subgenus *Xerospermophilus*. Hafner and Yates (1983) documented limited hybridization between *S. mohavensis* and its parapatric sister taxon, *S. tereticaudus*, at a single, ecologically disturbed site, but corroborated the species-level distinctiveness of the two forms. The two species have different diploid chromosomal numbers but exhibit a moderate level of genic similarity. Speciation of the two taxa probably resulted from isolation by river and lakes systems during pluvial maxima (Hafner 1992).

Distribution

The Mohave ground squirrel has a restricted distribution of less than 20,000km² tucked into the extreme northwestern corner of the Mojave Desert adjoining the Sierra Nevada and Transverse mountain ranges (Hoyt 1972, Wessman 1977). Historical records indicate that the species previously occurred in the Antelope Valley, on the southwestern corner of its range (Gustafson 1993), and across the Mojave River wash on the southeastern portion of its range (Hafner 1992).

Remarks

The boundary between *S. mohavensis* and its more widespread relative, *S. tereticaudus*, coincides with the Wisconsinan system of pluvial lakes and river systems that isolated a cooler, more mesic refugium of Mojave Desert flora and fauna during pluvial maxima (Hafner 1992). A continuous barrier was last present 10,000 years ago, but disappeared at least 6,000 years ago. Subsequent range expansion of either species across this previous barrier has been limited to 30km, or an average of $\leq 5\text{m/year}$. Certainly, the ecology of these desert squirrels contributes to this remarkably low range expansion: their vagility is limited by the short period of aboveground activity (3 to 4 months), during which individuals must reproduce and develop fat reserves in order to estivate and avoid both intense summer heat and harsh winters. Colonies of the Mohave ground squirrel are small and widely scattered, although populations may become locally abundant during early summer. Thus, it appears that the species is distributed in isolated inbreeding units, or metapopulations.

During drought years, when winter precipitation is $< 7.6\text{cm}$, herbaceous plant growth is severely reduced, and *S. mohavensis* responds by failing to reproduce (Leitner and Leitner 1990, 1992; P. Leitner pers. comm.). Adults appear to depend on two perennial species, spiny hopsage (*Grayia spinosa*) and winter fat (*Eurotia lanata*) for summer fat accumulation during drought years, and avoid reproduction rather than risk delay in accumulating fat prior to estivation. It may be noteworthy that the eastern margin of the species' range is coincidental with a marked reduction in winter precipitation: drought periods with annual winter precipitation $< 7.6\text{cm}$ of more than two years are rare within the species' range, and fairly common east of that range (P. Leitner pers. comm.). Prolonged years of drought may result in extinction of local populations as adults die from old age and predation and are not replaced (Best 1995). Recruitment of immigrants from neighboring colonies or recolonization of extirpated sites is probably rare due to the apparent low vagility of the species. Ongoing studies of radio-tagged juvenile *S. mohavensis* (P. Leitner pers. comm.) should provide important information on the dispersal capabilities and tendencies of the species.

The small (20,000km²) geographic range of *S. mohavensis* borders the populous and rapidly expanding Los Angeles metropolitan area. Agricultural development of the Antelope Valley during the 1940s and 1950s displaced Mojave Desert flora and fauna, including *S. mohavensis*, and habitat disturbance may have aided the displacement of *S. mohavensis* by its parapatric relative (*S. tereticaudus*) in a southeastern portion of its range. Heavy recreational use (such as off-road vehicles), grazing pressures, and development for urban, suburban, agricultural, and military purposes has resulted in decline or loss of many of the isolated populations (Best 1995). The scattered

distribution of isolated colonies, low vagility of the species, and potential for extirpation of colonies from natural causes (e.g., prolonged drought), in conjunction with continued habitat destruction, fragmentation, and degradation due to adverse human impact jeopardize the species' survival. Currently, nearly 700km² (3%) of the range of *S. mohavensis* are urbanized. Population growth in cities of the western Mojave Desert has averaged nearly 100% in the last decade (ranging from 30–460%; Gustafson 1993). Another 870km² (4%) have been disturbed by agricultural or other rural development. In total, at least 15% of the estimated 20,000km² distribution of *S. mohavensis* is not available habitat, either as dry lake beds, developed areas, or heavily damaged areas (Gustafson 1993).

The Coso Mitigation Program, which addresses impacts to the species resulting from geothermal development of the Coso Known Geothermal Resource Area, indicated promise for habitat rehabilitation, particularly the elimination of grazing pressures (Leitner and Leitner 1992). The status review conducted by the California Department of Game and Fish (Gustafson 1993) developed specific recommended actions for recovery and management of Mohave ground squirrel habitat.

Conservation status

In 1971, the California Fish and Game Commission listed the Mohave ground squirrel as Rare, indicating that the species “although not threatened with extinction, is in such small numbers throughout its range that it may be endangered if its environment worsens.” With passage of the new California Endangered Species Act in 1984, all Rare species became classified as Threatened, including the Mohave ground squirrel.

In 1991, the Commission received a petition from the Kern County Department of Planning and Development Services requesting delisting of *S. mohavensis* as a Threatened species. Despite recommendations from the California Department of Fish and Game (CDFG) and numerous biologists to reject the petition, the Commission accepted the petition in 1992. As a result of a careful and comprehensive status review (Gustafson, 1993), the CDFG recommended that the Commission should find that the petition to delist was not warranted at that time. However, the Commission voted in favor of delisting in 1993, prompting legal action by a consortium of environmental groups. In June of 1994, the case was decided in favor of the squirrel, and the petition to delist the Mohave ground squirrel has been rejected. It is unclear whether this is a temporary or permanent action. If the petition is eventually accepted, and the species is delisted by the state, it will lose protection currently afforded through the California Endangered Species Act, the California Environmental Quality Act, and the California Desert Conservation Area Plan (administered by the United States Bureau of Land

Management or BLM). The Mohave ground squirrel is currently considered a federal C2 candidate taxon based on “decreasing numbers and/or increasing threat.”

In December 1993, Dr. Glenn Stewart of California State Polytechnic University, Pomona, California, petitioned the United States Fish and Wildlife Service to list *S. mohavensis* as a federally Threatened species. The Service did not respond to the petition in the legally-mandated twelve-month period after submission. The status of the federal review of the petition is unknown.

Occurrence in captivity and protected areas

Of the 20,000km² of *S. mohavensis* distribution, 36% is private land, 34% is military land, and the rest is mostly public land, 2% of which is designated for off-road vehicle use by the BLM. Under the California Desert Conservation Area Plan, the Mohave ground squirrel would receive full protection only if it is listed as a federal or state Threatened or Endangered species. The multi-agency West Mojave Coordinated Management Plan may provide protection of habitat throughout much of the squirrel's range, but the plan is currently in the formative stages, and must have the participation of military and private landowners to ensure preservation of habitat on those significant holdings.

Recommended action

- Retain Threatened status (California) and gain federal listing as Threatened.
- Adopt the West Mojave Coordinated Management Plan to aid in the design of management areas for the squirrel and to develop a list of compatible land uses in these areas.
- Encourage participation by the United States Navy, United States Army, United States Air Force, and all appropriate State and Federal agencies, counties, cities, and special districts in the West Mojave Coordinated Management Plan.
- Identify (BLM, in cooperation with the CDFG) existing large areas of desert scrub vegetation under its control that can have land-use restrictions put in place for protection of the squirrel and other animals and plants, and formal establishment of these protected areas.
- Identify (Navy at China Lake Naval Air Weapons Center, the Army at the National Training Center and Fort Irwin, and the Air Force at Edwards Air Force Base, in cooperation with the BLM and CDFG) existing large areas of desert scrub vegetation on each base that can be set aside for the squirrel and other animals and plants while meeting the mission of the base, and formal establishment of these protected areas.
- Establish which of the proposed troop-training areas have populations of *S. mohavensis* and encourage the BLM to deny proposals to expand troop-training to those areas.

- Manage the squirrel and co-existing animals and plants by the BLM on lands that it receives in fee-title as mitigation for non-government projects on public lands.
- Establish (CDFG) a recovery team and preparation of a recovery/management plan for the squirrel.
- Modify livestock grazing practices in essential habitat within the geographic range of the squirrel on public lands managed by the BLM, on military land managed by the Navy, and on State lands managed by the State Lands Commission, to eliminate the grazing of sheep where now permitted and reduce the level of cattle grazing if it is found to negatively affect squirrel habitat in the studies at the Coso Known Geothermal Area.
- Eliminate off-road-vehicle activities in undesignated areas on public and State lands within the range and in habitat of the squirrel.
- Restore disturbed native vegetation on the periphery of each new project site within the range and in the habitat of the squirrel on public and State lands as a condition of the permit for the project, and follow-up inspection by the permitting agency to determine compliance; if not a condition of the permit, then the permitting agency has the responsibility of restoration.
- Continue field studies throughout the range of the squirrel to determine preferred habitats (plant species, soils, slopes, aspect), size and distribution of populations, genetic variation between and within colonies, and life history elements such as juvenile dispersal and colony demography.
- Determine minimum population size necessary for self-sustaining populations and, therefore, minimum size of habitat areas.
- Restrict use of rodenticides within the range of the squirrel to areas not adjacent to, or within 1mi [1.6km] of, desert scrub vegetation.

***Spermophilus parryii* (Richardson 1825)** **Arctic ground squirrel**

Joseph A. Cook

8 subspecies, 3 of conservation concern:

S. p. kodiacensis Kodiak ground squirrel

S. p. lyratus St. Lawrence Island ground squirrel

S. p. nebulicola Shumagin ground squirrel

IUCN Red List Category

Spermophilus parryii – Lower Risk, least concern (LR,lc)

S. p. kodiacensis – Data Deficient (DD)

S. p. lyratus – Data Deficient (DD)

S. p. nebulicola – Data Deficient (DD)

Assignment of the three subspecies is based on the need for additional information regarding their distribution, population status, and immediate threats to their survival.

Taxonomy

The Kodiak ground squirrel (*S. p. kodiacensis*) was described as a subspecies of *S. parryii* (Allen 1874), considered to be a distinct species by Howell (1938), and again treated as a subspecies of *S. parryii* by Murie (1959), Hall (1981), and Wilson and Reeder (1993). Hall and Gilmore (1932) described *S. p. lyratus* as a species based on seven specimens; Howell (1938) examined 41 specimens and reduced it to subspecies rank. Rausch (1953a) later reviewed the taxonomy of this form. Multivariate morphological analysis (Pearson 1981) indicated that *S. p. kodiacensis* and *S. p. lyratus* are both strongly differentiated from other *S. parryii* and from each other. *Spermophilus p. nebulicola* was first described from Nagai Island in the Shumagin Island group by Osgood (1903). Howell (1938) examined 15 specimens from three islands in the Shumagin group and found them geographically and physically closest to *S. p. ablusus* and *S. p. kodiacensis* but separated by skull and pelage differences. Pearson's (1981) morphometric analysis found the taxonomic distinctiveness of this form was questionable.

Distribution

Spermophilus parryii is Holarctic in distribution, and has a wide distribution across northern North America, from Alaska to Keewatin. The three subspecies of conservation concern (*S. p. kodiacensis*, *S. p. lyratus*, and *S. p. nebulicola*) are restricted to islands offshore Alaska. *Spermophilus p. kodiacensis* is known only from Kodiak Island and nearby Woody Island, Alaska (Hall 1981, V. Barnes pers. comm., D. Zwiefelhofer pers. comm.). *Spermophilus p. lyratus* is restricted to St. Lawrence Island (63°30'N, 170°30'W), an island in the Bering Sea that is approximately 170km from the Alaska coast and 60km from Siberia. The island is about 155km long and 40km wide (Orth 1971) and is some 4,500km² in area (Fay and Sease 1985). Specimens of *S. p. nebulicola* are known from the type locality on Nagai Island (55°05'N, 160°00'W), as well as Koniuji and Simeonof islands in the Shumagin Island group off of the southeastern coast of the Alaska Peninsula (Howell 1938).

Remarks

There are no available estimates of population size of *S. p. kodiacensis* on Kodiak and Woody islands. The only recently documented population on Kodiak Island occurs near the airport. Woody Island is also inhabited by humans, and ground squirrels may be affected by increasing human use of the island.

Petroff (1884) stated that ground squirrels did not occur on Kodiak Island, but were found on the smaller surrounding islands. Howell (1938) cites Osgood (1903), "on the authority of a native, that the spermophiles on Kodiak Island were introduced from North Semidi Island" but further states that "no specimens from the latter island have been seen." Murie (1959) reported *S. p. kodiacensis* only from Kodiak Island, noting that he found none on

Kodiak Island in 1936 or 1937, but that Scheffer collected two specimens from Kodiak Island in 1938. The University of Alaska Museum obtained six specimens from the Kodiak Airport in 1992.

Rausch (1953b) collected 85 specimens of *S. p. lyratus* from St. Lawrence Island in 1950 and noted that this subspecies was “rather common” from 1950 to 1952. Fay (1973) and Fay and Sease (1985) later reported this species to be found in suitable habitats, particularly mesic tundra, at all times from 1952 to 1979. No estimates of population numbers have been made. Rausch (1953b) noted that other terrestrial mammals on the island include a shrew (*Sorex jacksoni*), tundra vole (*Microtus oeconomus*), northern red-backed vole (*Clethrionomys rutilus*), varying lemming (*Dicrostonyx exsul*), arctic fox (*Alopex lagopus*), and the introduced reindeer (*Rangifer tarandus*). Ground squirrels apparently are not preyed upon by arctic foxes (Fay and Stephenson 1989). Geist (1933) and Cade (1951) reported on the carnivorous food habits of *S. p. lyratus*.

Murie (1959) observed *S. p. nebulicola* on islands in the Shumagin group, including Koniuji and Simeonof islands. The current status of this subspecies is unknown. Little is known of its distribution, taxonomy, or ecology. It is unclear whether the Koniuji Island referred to by Murie (1959) and listed in Hall (1981) was Big Koniuji or Little Koniuji Island. Red fox (*Vulpes vulpes*) are endemic to Nagai Island, and apparently introduced on Big Koniuji, Little Koniuji, and Simeonof islands (Bailey 1993). Other land mammals have not been documented from these islands.

Conservation status and occurrence in captivity and protected areas

No subspecies of *S. parryii* currently has protected status. *Spermophilus p. kodiacensis* has not been reported from, but may occur within, Kodiak National Wildlife Refuge. St. Lawrence Island (to which *S. p. lyratus* is restricted) is a National Reindeer Range that is managed by the Gambell and Savoonga Native Corporations. *Spermophilus p. nebulicola* does not occur in any protected areas.

Recommended action

- Survey Kodiak Island and surrounding islands to determine the distribution and relative abundance of ground squirrels.
- Determine if *S. p. kodiacensis* is a valid species or an insular subspecies of *S. parryii* using molecular data and more extensive morphometric analyses.
- Monitor populations of *S. p. lyratus* at regular intervals.
- Include *S. p. lyratus* in a molecular taxonomic investigation of geographic variation throughout the range of *S. parryii*; the potential for evolutionary divergence is enhanced in island populations.
- Survey the Shumagin Islands to determine the current distribution and abundance of *S. p. nebulicola*.

- Include specimens from the Shumagin Island populations in a modern systematic revision of *S. parryii* to confirm or refute Howell’s (1938) taxonomic treatment.
- Determine the existence and nature of any immediate threats to each of the subspecies.

***Spermophilus tereticaudus* Baird 1858 Round-tailed ground squirrel**

David J. Hafner

4 subspecies, 1 of conservation concern in North America (north of Mexico):

S. t. chlorus Palm Springs round-tailed ground squirrel

IUCN Red List Category

Spermophilus tereticaudus – Lower Risk, least concern (LR,lc)

S. t. chlorus – Data Deficient (DD)

Assignment of *S. t. chlorus* is based on the need for specific information on its subspecific validity, population status, and remaining distribution.

Taxonomy and distribution

Spermophilus tereticaudus is one of two species in the subgenus *Xerospermophilus*. Hafner and Yates (1983) described genetic variation throughout the range of this species and genetic interactions of this species with its closely related sister-taxon, *S. mohavensis* (see account of that species). Only slight differences in pelage coloration appear to distinguish *S. t. chlorus* from the widespread and neighboring subspecies, *S. t. tereticaudus* (Howell 1938).

The round-tailed ground squirrel is broadly distributed in the Sonoran and Mojave deserts around the eastern and northern margins of the Gulf of California. A northern Baja California subspecies (*S. t. apricus*) depicted as disjunct by Hall (1981) is instead continuously distributed with its neighboring subspecies, *S. t. tereticaudus* (D. J. Hafner pers. obs.). One of two subspecies in the deserts of southern California, *S. t. chlorus* has a restricted distribution of about 1,400km² in the Coachella Valley above the Salton Sea.

Remarks

The Coachella Valley has experienced extensive urban development, specifically around Palm Springs and numerous country clubs, golf courses, and resorts. *Spermophilus t. chlorus* has undoubtedly lost habitat, but the exact amount of loss and extent of remaining habitat is not known. Ernest and Mares (1987) reviewed the general biology of this species.

Conservation status and occurrence in captivity and protected areas

Spermophilus t. chlorus is listed as a Species of Special Concern in California, and a federal C2 candidate taxon.

No populations of *S. t. chlorus* are known to occur in protected areas.

Recommended action

- Compare populations of *S. t. chlorus* to *S. t. tereticaudus* to document level of evolutionary differentiation and subspecific validity.
- Survey historic range of *S. t. chlorus* to determine current distribution and status of populations.

***Spermophilus townsendii* Bachman 1839** **Townsend's ground squirrel**

Eric Yensen

IUCN Red List Category

Spermophilus townsendii – Data Deficient (DD)

Assignment of *S. townsendii* is based on the need for specific information on the status and distribution of extant populations. Further investigation of the systematic relationships between *S. townsendii*, *S. canus*, and *S. mollis*, based on other genetic (particularly molecular) data, is warranted.

Taxonomy

Howell (1938) and Hall and Kelson (1959) considered all *S. townsendii* west of the Columbia River in Washington to be of a single subspecies, *S. t. townsendii*. Nadler (1968) found that Townsend's ground squirrels west of the Yakima River had a unique diploid chromosome number ($2n=36$) compared to that of populations between the Columbia and Yakima Rivers ($2n=38$), and he recognized the latter as a distinct subspecies, *S. t. nancyae*. Based on these and more striking karyotypic differences, *S. t. nancyae* and other similar ground squirrels in Oregon, Idaho, Utah, and Nevada formerly placed in *S. townsendii* are now referred to *S. canus* and *S. mollis* (Hoffmann *et al.* 1993). Thus, *S. townsendii* is monotypic. No hybridization has been reported between *S. townsendii* and adjacent *S. canus* or *S. mollis* (Rickart *et al.* 1985).

Distribution

Spermophilus townsendii is restricted to the Yakima River Valley west of the Yakima River and in the Horse Heaven Hills to the south of the valley. There are specimens from about 15 localities in Yakima, Klickitat, and Benton counties, Washington (Howell 1938, Nadler 1966, 1968, R.E. Johnson pers. comm.). However, the squirrel probably was, and still is, found in more localities within the 4300km² range than specimen records indicate (E. Yensen pers. obs.). The Yakima River apparently serves as a barrier to dispersal, and *S. townsendii* is replaced by *S. m. nancyae* to the east of the river. According to the current taxonomy, *S. townsendii* is found between

two similar-appearing species: *S. mollis* and *Spermophilus canus*; the latter species occurs across the Columbia River in Oregon.

Remarks

Extensive agricultural development has occurred in the Yakima River Valley and the Horse Heaven Hills, and less than 10% of the original habitat remains (E. Yensen pers. obs., R. Leach pers. comm.). Remaining ground squirrel populations are fragmented and isolated, precluding recolonization after local extirpation occurs. The deepest, well-drained, and most fertile soils, which were preferred by the squirrels, have been converted to agriculture, and squirrels remain in only a few such areas (e.g., an orchard near Selah, some pastures on Wenas Creek, and a pasture on Umptanum Creek; E. Yensen pers. obs.).

This squirrel has not appeared previously on any list, and this constitutes the first suggestion that it is of conservation concern. Rickart (1987) reviewed the general biology of this species.

Conservation status and occurrence in captivity and protected areas

Spermophilus townsendii has no current protected status. Most of the geographic range is now private agricultural land. Some squirrels occur on a wildlife management area on Umptanum Creek west of Ellensburg. The extent of its distribution on the Yakama Indian Reservation is not known, but it would have more protection within the administratively closed area (R. Leach pers. comm.).

Recommended action

- Survey historical range to determine distribution, number, and densities of squirrels at extant sites.
- Explore mechanisms (e.g., conservation easements or Nature Conservancy-style land purchases) for protection of the squirrel in areas of deeper soils, which are now agricultural land. This might be accomplished through establishment of wildlife management areas, which would protect multiple species in this disappearing palouse prairie ecosystem.

Spermophilus tridecemlineatus **(Mitchill 1821)**

Thirteen-lined ground squirrel

Eric Yensen

10 subspecies, 1 of conservation concern:

S. t. alleni Big Horn thirteen-lined ground squirrel

IUCN Red List Category

Spermophilus tridecemlineatus – Lower Risk, least concern (LR,lc)

S. t. alleni – Data Deficient (DD)

Assignment of *S. t. alleni* is based on the need for specific information on the status and distribution of the subspecies' populations and an assessment of its taxonomic relationships to neighboring subspecies.

Taxonomy

Spermophilus tridecemlineatus is a member of the subgenus *Ictidomys*. It has been shown to hybridize with one of its sympatric sister-taxa, *S. mexicanus* (Cothran and Honeycutt 1984, Cothran *et al.* 1977). Wyoming biologists are skeptical about the validity of *S. t. alleni* (B. Luce pers. comm., S. Brockman pers. comm., C. Garber pers. comm.). The absence of a geographic discontinuity between the ranges of *S. t. alleni* and *S. t. parvus* appears to be the main point of concern, rather than specimen-based criticism. Howell (1938) described *S. t. alleni* from six specimens. It is about the same size as *S. t. parvus*, but with longer nasals and smaller auditory bullae, and can be distinguished from the adjacent *S. t. pallidus* by its much darker pelage and smaller size.

Distribution

The thirteen-lined ground squirrel is widely distributed throughout the Great Plains and midwestern United States. Disjunct (presumably Wisconsin-relict) populations are known from meadows in the higher elevations of east-central Arizona and west-central New Mexico, and the species has been sighted on Mt. Taylor in western New Mexico (T.L. Best pers. comm.). *Spermophilus t. alleni* is endemic to the Big Horn Basin, western foothills, and the adjacent Big Horn Mountains of northwest central Wyoming (Clark and Stromberg 1987). It is known from only four localities (Long 1965).

Remarks

Long (1965:579) knew only of the six specimens of *S. t. alleni* from the four localities mentioned by Howell (1938), despite "intensive collecting of vertebrates within the geographic range of this subspecies by field parties from the Museum of Natural History of the University of Kansas." The subspecies was considered "rare, if not extirpated, because of repeated, widespread distribution of poisoned grain by humans" (Clark and Stromberg 1987:103). The poisoning occurred during campaigns to exterminate prairie dogs (C. Garber pers. comm.). Wyoming Game and Fish personnel have trapped thirteen-lined ground squirrels within the range of *S. t. alleni* in recent years (B. Luce pers. comm.), but apparently no specimens have been deposited in museum collections. The Nature Conservancy has not been successful in trapping them (C. Garber pers. comm.). Streubel and Fitzgerald (1978) reviewed the general biology of this species.

Conservation status and occurrence in captivity and protected areas

Spermophilus t. alleni is a federal C2 candidate taxon.

Wyoming Game and Fish personnel have not added it to the state list because of doubts about the validity of the taxonomy and lack of information about the population status. No populations of *S. t. alleni* are known to occur in protected areas.

Recommended action

- Survey the Big Horn Basin of Wyoming to determine the distribution and population status of *S. t. alleni*.
- Evaluate the taxonomic validity of *S. t. alleni* relative to neighboring subspecies using larger sample sizes and modern morphometric and molecular techniques.

Spermophilus washingtoni (A. H. Howell 1938) Washington ground squirrel

Eric Yensen

IUCN Red List Category

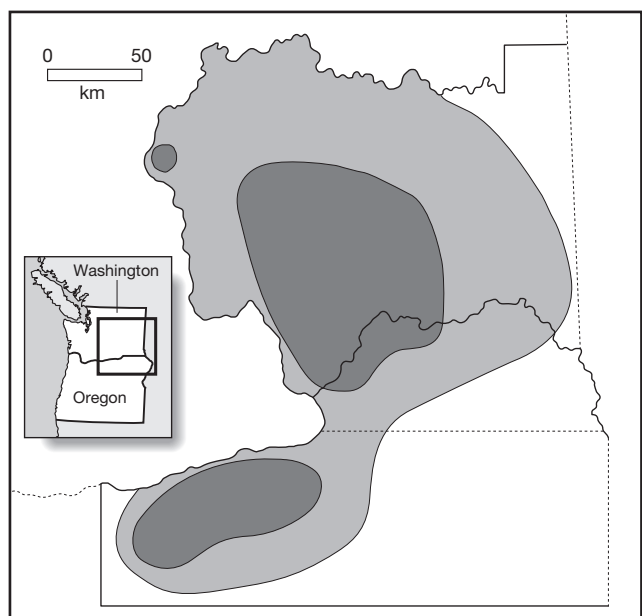
Spermophilus washingtoni – Vulnerable (VU): A1a;B1; B2d;C2a

Assignment is based on the extensive fragmentation and loss of habitat of *S. washingtoni*, particularly within the last decade, the vulnerable status of most isolated populations, and the continuation of threats to remaining populations.

Taxonomy and distribution

Due to an imprecise type locality and poor type specimen, the spotted ground squirrels east and south of the Columbia River were confused by early authors with the unspotted

Figure 5.3. Historical (light shading) and current (dark) distribution of the Washington ground squirrel, *Spermophilus washingtoni*, in Oregon and Washington.





Washington ground squirrel,
Spermophilus washingtoni.

Eric Yensen

ground squirrels west and north of the Columbia River. Howell (1938) named the spotted species *S. washingtoni* and its taxonomic status has not been challenged (Rickart and Yensen 1991). Howell (1938) designated two subspecies, *S. w. washingtoni* and *S. w. loringi*, but the validity of *S. w. loringi* has not been accepted by later authors (Dalquest 1948, Hall 1981). Hill (1978) compared populations of *S. washingtoni* north and south of the Snake River (a natural barrier) and found no taxonomic differences. However, Hill did not sample populations considered by Howell (1938) to be *S. w. loringi*, and the status of *S. w. loringi* may merit further evaluation.

The Washington ground squirrel is restricted to an area of <20,000km² within the Columbia Plateau south and east of the Columbia River in Washington and Oregon (Fig. 5.3). It lives in sagebrush or grassland habitats and selects areas with deep, soft, sandy soils with high grass cover (Betts 1990, Rickart and Yensen 1991).

Remarks

The range of *S. washingtoni* has been greatly reduced in recent years (Betts 1990, Marshall 1992). Betts (1990) surveyed 179 known locations in Washington and Oregon. He confirmed Washington ground squirrels at 80 sites, and they possibly were present at seven others; they no longer occurred at the remaining 92 sites, and had been extirpated at 35 sites during the 1980s. The formerly continuous range is now much reduced and fragmented into three clusters of isolated sites, one in Oregon and two in Washington.

Betts (1990) further evaluated the threat to the species at each site. At 52 of 87 sites, the squirrels were thought to be of medium to high vulnerability; and 40 populations were “small.” In Oregon, the species occurs at the United States Naval Weapons Systems Test Facility (Boardman Bombing Range) and at 35 sites on private land. The

Boardman population was the largest with an estimated 90 individuals in 1979 (Marshall 1992) and probably the most secure, if the area is maintained as a government facility.

Threats to the species include habitat loss related to conversion of rangeland to agriculture in the most productive portions of the range. Center-pivot sprinkler irrigation has converted vast areas of habitat to continuous farmland. Other threats include poisoning and shooting. Badger predation is a natural factor, but could be critical for very small populations (Betts 1990). Rickart and Yensen (1991) reviewed the general biology of this species.

Conservation status and occurrence in captivity and protected areas

The Washington ground squirrel is on the Washington state Monitor list, but no actual monitoring is being conducted. In Oregon, the species is tracked in the Oregon Natural Heritage Program Sensitive Species database, but official listing is pending. The squirrels occur at The Nature Conservancy’s Boardman Research Natural Area in Oregon, and probably receive some incidental protection on the United States Naval Weapons Systems Test Facility (Boardman Bombing Range).

Recommended action

- Evaluate the taxonomic status of *S. w. loringi*. This is of immediate concern, because populations remain at only a few of the historical sites within the range of *S. w. loringi*.
- Add protected areas by preserving remnants of native shrub steppe-vegetation and encouraging conservation agreements with private landowners.
- Augment population sizes at existing smaller sites, possibly by purchasing adjacent land to increase the area of the sites.

***Tamias canipes* (V. Bailey 1902)**
Gray-footed chipmunk

David J. Hafner

IUCN Red List Category

Tamias canipes – Lower Risk, near threatened (LR,nt)

Assignment is based on the limited, patchy distribution of the species; there is no evidence of any specific or immediate threat to the species' survival.

Taxonomy and distribution

Tamias canipes (subgenus *Neotamias*) was originally described as a subspecies of *T. cinereicollis* (Bailey 1902), but recognized as a separate species by Fleharty (1960) based on pelage coloration and shape of the baculum. Findley *et al.* (1975) cited evidence indicating a close relationship between these two and two other allopatric species, *T. quadrivittatus* and *T. bulleri*, and expressed suspicion that all four taxa are "postpluvial differentiates of a formerly widespread forest chipmunk stock," although Sullivan (1985) questioned those relationships.

Tamias canipes is restricted to the Gallina, Jicarilla, Capitan, and Sacramento mountains of southeastern New Mexico, the Guadalupe Mountains of New Mexico and adjacent western Texas, and the isolated Sierra Diablo in Texas. The species is most common in forests, ranging from spruce-fir forest down to pinyon-juniper woodland, but descend out into lava flows of the Carrizozo Malpais in the Tularosa Valley.

Remarks

Tamias canipes does not appear to be currently threatened in any portion of its somewhat limited and patchy distribution; listing as a federal C2 candidate species appears to reflect this distribution. Best *et al.* (1992) reviewed the general biology of this species.

Conservation status and occurrence in captivity and protected areas

Tamias canipes is a federal C2 candidate species. Both Texas populations of *T. canipes* occur in managed areas: the Guadalupe Mountains National Park and Sierra Diablo Wildlife Management Area. Populations in New Mexico occur in either national forests or the Mescalero Apache Indian Reservation in the Sacramento Mountains, and receive no specific protection.

Recommended action

- Monitor status of populations periodically, particularly those in smaller and more isolated ranges (Gallinas and Jicarilla mountains of New Mexico, Sierra Diablo in Texas).
- Conduct genetic comparison to determine levels of genetic variation and differentiation within and among isolated populations.

***Tamias minimus* Bachman 1839**
Least chipmunk

Robert M. Sullivan and David W. Nagorsen

18 subspecies, 2 of conservation concern:

T. m. atristriatus Peñasco least chipmunk

T. m. selkirki Selkirk least chipmunk

IUCN Red List Category

Tamias minimus – Lower Risk, least concern (LR,lc)

T. m. atristriatus – Critically Endangered (CR): A1a;B1;D

T. m. selkirki – Vulnerable (VU): D2

Assignment of subspecies of conservation concern is based on what is currently known of the population and distribution of both subspecies: only 15–20 individuals of *T. m. atristriatus* are known to exist at a single locality; and *T. m. selkirki* is known only from the type locality. No specific and immediate threats are known for either population, and both subspecies may enjoy a broader range than is currently known.

Taxonomy

Tamias minimus is a member of the subgenus *Neotamias*; specific relationships within the subgenus *Neotamias* are unclear (Patterson and Heaney 1987). *Tamias m. selkirki* was described from a small number of specimens (Cowan 1946) and its validity has not been re-evaluated since the original description.

Distribution

The least chipmunk has a broad distribution across most of Canada and western United States, and is found in habitats ranging from tundra (in Canada), shrub-steppes and sand dunes (in the Great Basin), through pinyon-juniper woodland and ponderosa pine forest, to spruce-fir forest. Five disjunct populations are currently known: one in British Columbia (*T. m. selkirki*), two in Arizona (*T. m. consobrinus* and *T. m. operarius*) and two in New Mexico (*T. m. operarius* and *T. m. atristriatus*). *Tamias m. atristriatus* (Peñasco or black-striped least chipmunk) and *T. m. selkirki* (Selkirk least chipmunk) are of conservation concern.

Tamias minimus atristriatus is probably a Pleistocene relict population that is currently restricted to the Sacramento Mountains, Otero County, New Mexico (Hall 1981, Sullivan and Petersen 1988). The single known population of the Peñasco subspecies is restricted to a small glacial cirque surrounded by Engelmann spruce (*Picea engelmanni*), aspen (*Populus tremuloides*), corkbark fir (*Abies lasiocarpa* var. *arizonica*), limber pine (*Pinus flexilis*), and Douglas-fir (*Pseudotsuga menziesii*) forest on top of Sierra Blanca Peak (3,900m). In this habitat Peñasco chipmunks occur on talus and along the steep rocky ridges north of the peak (Conley 1970, Sullivan 1985, Sullivan

and Petersen 1988). Bailey (1931) described *T. m. atristriatus* as numerous and widespread in the Sacramento Mountains, particularly in more open habitats, including along fence rows bordering agricultural fields and in less dense stands of ponderosa pine down to the upper edge of the pinyon pine (*Pinus edulis*) and juniper (*Juniperus monosperma*) woodland. Specimens were again collected in 1958 and 1969 (Conley 1970, Sullivan and Petersen 1988), but the subspecies was not found during intensive surveys in 1981–1982 (Hubbard *et al.* 1985), and likely has been extirpated from most of its original range. Where chipmunks persist, they are of the gray-footed species, *T. canipes*. The old-growth ponderosa pine parkland that was apparently typical habitat of the Peñasco chipmunk (Bailey 1931, Brown 1982) is characteristic of sites on the Mescalero Apache Indian Reservation and near the towns of Cloudcroft, Mescalero, and Ruidoso (Lincoln and Otero Counties). Although this area of the Mescalero Apache Indian Reservation has not been sampled, chipmunks other than *T. canipes*, but similar in appearance to the Peñasco chipmunk, were observed feeding on seed-heads of grass species that grew along fence rows adjacent to Highway 24 (R. M. Sullivan and J. A. Cook pers. obs.).

Tamias minimus selkirki is known only from the type locality of Paradise Mine near Toby Creek, 19mi [30km] W Invermere, Purcell Mountains, British Columbia. The collecting sites were near the tree line at 2380m elevation (Carl and Hardy 1945). In southern British Columbia, *T. minimus* appears to be restricted to high elevations. Although populations of *T. minimus oreocetes* occur in the Rocky Mountains of British Columbia, they are probably isolated from the Purcell Mountains by the Rocky Mountain Trench and the Columbia River Valley. No specimens of *T. minimus* have been taken from this valley and Cowan and Guiguet (1965) considered the range of *T. m. selkirki* to be disjunct. Further evidence for the localized distribution of this taxon is that it has not been found in Mount Revelstoke or Glacier National Parks that lie to the north in the Purcell and Selkirk Mountains, despite intensive inventories in both parks.

Remarks

The single known population of *T. m. atristriatus* was estimated at 15–20 individuals in 1981–1982 (R. M. Sullivan and J. A. Cook pers. obs.). No population estimates are available for *T. m. selkirki*, and there is no new information on this subspecies since the type series was collected in the 1940s.

Conservation status and occurrence in protected areas

Tamias minimus atristriatus is listed as Endangered by New Mexico. The British Columbia Ministry of Environment has placed *T. m. selkirki* on its Red List (potentially threatened or endangered). No threats to this

population are known, although it is presumably vulnerable because of its localized distribution. The type locality of *T. m. selkirki* is not protected but is about 20km east of the Purcell Wilderness Conservancy, a large (131,523ha) protected area with substantial alpine habitat.

Recommended action

- Maintain critical habitat and enact full protection to sustain the single known population of *T. m. atristriatus* on Sierra Blanca.
- Continue strict control over collecting of the Sierra Blanca population of *T. m. atristriatus*, including those taken for scientific purposes.
- Conduct surveys to document the contemporary range, population size, and habitat requirements of extant populations of *T. m. atristriatus*. Particular effort should focus on areas typical of the historical habitat and range of the chipmunk, such as along Highway 24 between Cloudcroft and Mescalero, New Mexico.
- Adopt a coordinated multi-agency management plan for *T. m. atristriatus*, because it is highly probable that its distribution encompasses the Mescalero Apache Indian Reservation as well as United States Forest Service land in both Lincoln and Otero Counties. The New Mexico Department of Game and Fish and the United States Fish and Wildlife Service should also be included.
- Census population of *T. m. selkirki* at type locality.
- Conduct a comprehensive survey in the Purcell Mountains, especially the Purcell Wilderness Conservancy, to determine the distribution, elevational range, and relative abundance of *T. m. selkirki*. Its taxonomic validity should be confirmed using modern morphometric and molecular techniques.

Tamias palmeri (Merriam 1897) Palmer's chipmunk

Michael J. O'Farrell

IUCN Red List Category

Tamias palmeri – Vulnerable (VU): A2c

Assignment is based on the restricted range of the species and the immediate threat of urban expansion and development.

Taxonomy and distribution

Tamias palmeri is a member of the subgenus *Neotamias*; specific relationships within the subgenus *Neotamias* are unclear (Patterson and Heaney 1987). *Tamias palmeri* occurs entirely on a single mountain range (Spring Mountains) in Clark County, Nevada. The Spring Mountains are located immediately west of the fast-growing city of Las Vegas, Nevada.

Remarks

Palmer's chipmunk occupies a relatively narrow belt from the upper end of pinyon-juniper association to timberline (2,100–3,600m elevation; Best 1993a). Although a variety of habitats are utilized (white fir-Ponderosa pine, mountain mahogany-manzanita, bristlecone pine), the greatest concentration of animals appears to be within the deeper, mesic canyon bottoms (2,400–2,550m elevation), which provide an abundance of fallen logs, large rocks, and cliffs. The more widespread Panamint chipmunk (*T. panamintinus*) occupies the pinyon-juniper habitat at lower elevations on the Spring Mountains, although overlap has been reported at some localities (Best 1993a).

The species appears to be more abundant on the east-facing slopes of the Spring Mountains, and associated with deeper, more mesic canyons on that side of the range. The eastern foothills grade into the Las Vegas Valley, currently the fastest growing community in the United States with a metropolitan population of over 1 million people. Housing developments under construction on the west side of the valley are expected to add another 300,000 people. Kyle and Lee Canyons represent the two best-known population centers for the species. Kyle Canyon contains a community of private homes, a resort, and various campgrounds. The resort is under expansion with a proposal for a golf course. Lee Canyon contains a ski resort and nearby campgrounds. Both canyons are within a one-hour drive of Las Vegas. Of secondary but increasing importance is the intensification of development of the Pahrump Valley on the west side of the Spring Mountains. The higher elevations of the Spring Mountains have been designated a National Recreational Area. Although this designation might invite an increase in recreational activities destructive to the existing habitat (e.g., off-road vehicle use), it might also afford an opportunity to pursue management plans to preserve that habitat. Best (1993a) reviewed the general biology of this species.

Conservation status and occurrence in captivity and protected areas

Tamias palmeri is a federal C2 candidate species but carries no state protection. The species has been held in captivity for growth and development studies (Hirshfeld 1975, Hirshfeld and Bradley 1977). Currently, there are no protected areas in the range of the species.

Recommended action

- Conduct a comprehensive survey of the Spring Mountains to determine the extent of habitat occupied by *T. palmeri*.
- Select replicate sites within each habitat type occupied by the species for detailed studies of population dynamics and habitat affinities.

- Formulate and enact a habitat conservation and management plan for *T. palmeri*, particularly within the Spring Mountains National Recreational Area.

Tamias quadrivittatus (Say 1823) Colorado chipmunk

Robert M. Sullivan

3 subspecies, 1 of conservation concern:

T. q. australis Organ Mountains chipmunk

IUCN Red List Category

Tamias quadrivittatus – Lower Risk, least concern (LR,lc)

T. q. australis – Vulnerable (VU): C2a;D2

Assignment of the subspecies of conservation concern is based on its extremely restricted distribution; specific and immediate threats are not known.

Taxonomy

Tamias from the Organ Mountains of New Mexico were originally described as *T. cinereicollis cinereus* (Howell 1929). Patterson (1980) instead assigned the population to *T. quadrivittatus*, and named the new subspecies, *T. q. australis*. Patterson (1980) also reported *T. quadrivittatus* from the Oscura Mountains (first collected in 1977). Sullivan (*in litt.*) has proposed a new subspecies for the Oscura Mountains population, which is currently included within *T. q. australis*.

Distribution

The Colorado chipmunk occurs in the 'Four Corners' states of Utah, Colorado, New Mexico, and Arizona, and extends into the western edge of the Oklahoma panhandle. Two isolated populations are known from southern New Mexico, from the Oscura Mountains and from the Organ Mountains. The Oscura Mountains form part of the northern margin of the Tularosa Basin, which is centered on alkaline Lake Lucero. This region is arid and consists of rugged terrain with frequent limestone outcrops, particularly along the western escarpment of the mountain range. Slopes are moderate to extreme, and the general area lies within pinyon-juniper woodland. The Organ Mountains lie along the western margin of the Tularosa Basin. Together with the southernmost San Andres Range in south-central New Mexico, they are part of a west-tilted fault block which is 240km long, extending from El Paso, Texas, north to central New Mexico. This region lies within the Great Basin conifer-woodland biotic community (Brown 1982; Brown and Lowe 1983). At its northern limit, the San Andres Range is a high-elevation (>1,730m), arid corridor that terminates in a series of small stepping-stone mountains. The geographic discontinuity separating the northern extension of the Organ-San Andres corridor

from the Oscura Mountains at Mockingbird Gap (1,800m elevation) is only 2.5km wide and lies within semidesert grassland habitat (Brown and Lowe 1983).

Remarks

The population in the Organ Mountains has been estimated at 1,000–2,000 individuals (Patterson 1979, 1980); no estimate is currently available for the Oscura Mountain subspecies. The Oscura Mountains were used for ranching prior to creation of White Sands Missile Range in 1945. North Oscura Peak currently is used for military test operations, and construction of new buildings and roads has been proposed for both the northern and southern ends of the mountain range. Most of the mountain peaks in the San Andres Range are on the White Sands Missile Range, as is the northeast flank of the Organ Mountains. The west-central and southeastern part of the Organ Mountains are administered by the Fort Bliss Military Reservation, United States Army, part of which is used as a target range for heavy artillery. Thus, the catastrophic extinction potential is real for relict populations of *T. quadrivittatus* and other endemic wildlife in both the Oscura and Organ mountains through the simultaneous effects of fire, habitat destruction, human disturbance, and demographic or environmental stochasticity. In the Organ Mountains, the population of this chipmunk is centered in the Aguirre Springs basin, including an area bordered by Baylor, Baldy, and Sugarloaf Peaks (Patterson 1979, 1980; Sullivan *in litt.*). It has been collected in seven 1mi² sections (a maximum of 18km²) in this region (Patterson 1979, 1980).

Conservation status and occurrence in captivity and protected areas

Tamias q. australis (including both the Organ and Oscura mountains populations) is listed as Endangered by New Mexico and is a federal C2 candidate taxon. The Organ Mountains population is most abundant on the Aguirre Springs National Recreation Area, which borders the Organ Mountain Wilderness Study Area (Bureau of Land Management). The southern half of the Organ Mountains and the Oscura Range are both on military land. Although this land is not currently managed for protection of wildlife, appropriate protection would be facilitated by the regulated access already in existence.

Recommended action

- Conduct surveys to document the contemporary range, population size, and habitat requirements of *Tamias q. australis* in both the Organ and Oscura mountains.
- Prohibit activities likely to cause disturbance to these relict populations, including construction activities and public use in the vicinity of potential or critical habitat for the subspecies in order to avoid habitat degradation. In addition, strict control over collecting these chipmunks, including those taken for scientific purposes,

should continue at least until population sizes are estimated.

- Adopt a coordinated and multi-agency management and monitoring plan for these populations, to include natural resource divisions of both White Sands Missile Range and Fort Bliss Military Reservation, the New Mexico Department of Game and Fish, and the United States Fish and Wildlife Service.

***Tamias umbrinus* J. A. Allen 1890** **Uinta chipmunk**

David J. Hafner

7 subspecies, 2 of conservation concern:

T. u. nevadensis Hidden Forest chipmunk

T. u. sedulus Henry Mountains chipmunk

IUCN Red List Category

Tamias umbrinus – Lower Risk, least concern (LR,lc)

T. u. nevadensis – Critically Endangered (CR): A1a

T. u. sedulus – Data Deficient (DD)

Assignment of subspecies of conservation concern is based on the possible extinct status of *T. u. nevadensis* and the restricted distribution of both subspecies.

Taxonomy and distribution

The Uinta chipmunk was formerly included within *T. quadrivittatus*, which it closely resembles. It is possible that specimens referred to *T. quadrivittatus* are actually *T. umbrinus*, and that the species is more widely distributed than is thought (Hall 1981, White 1953).

The Uinta chipmunk has a highly fragmented distribution that includes the Rocky Mountains of Montana and Wyoming, the Wasatch and Uinta Ranges of Utah, and higher elevations in and around the Great Basin. Two isolated subspecies are of conservation concern: *T. u. nevadensis*, known only from the Sheep Mountains of Nevada, and *T. u. sedulus*, known only from Mt. Ellen in the Henry Mountains of Utah.

Remarks

Tamias umbrinus nevadensis was originally reported above 2,500m in the Sheep Mountains (Burt 1931), with *T. dorsalis* reported as occurring at lower elevations. At least four attempts have been made since 1960 to collect *T. u. nevadensis* at or above the type locality (T. E. Lawlor pers. comm.). No individuals of this species have been detected, but the lower-elevation species, *T. dorsalis*, has been found up to the highest point in the Sheep Mountains, suggesting that *T. u. nevadensis* may be extinct, and may have been replaced by *T. dorsalis*. Much of the Sheep Mountains has been a wildlife refuge (Desert National Wildlife Refuge for mountain sheep, *Ovis canadensis*)

since the 1930s, and has been protected from grazing. Thus, if *T. u. nevadensis* is extinct, it may have been the victim of natural climatic change rather than human-related impact. The status of *T. u. sedulus* is not known.

Conservation status and occurrence in captivity and protected areas

Both *T. u. nevadensis* and *T. u. sedulus* are listed as federal C2 candidate taxa. If populations of *T. u. nevadensis* survive, they would be found on the Desert National Wildlife Refuge. No protected areas occur in the range of *T. u. sedulus*.

Recommended action

- Conduct immediate and intensive survey of sites above 2,500m in the Sheep Mountains for presence of *T. u. nevadensis*.
- Conduct surveys to determine the distribution and population status of *T. u. sedulus* at the type locality and the extent of its distribution within the Henry Mountains.

***Tamiasciurus hudsonicus* (Erxleben 1777) Red squirrel, chickaree, spruce squirrel, or pine squirrel**

David Belitsky

25 subspecies, 1 of conservation concern:

T. h. grahamensis Mount Graham red squirrel

IUCN Red List Category

Tamiasciurus hudsonicus – Lower Risk, least concern (LR,lc)
T. h. grahamensis – Critically Endangered (CR): B1;C2b

Assignment of the subspecies of conservation concern is based on the small population size (200 to 300) and restricted area of occupancy (100km²) of this isolated subspecies, which is currently subjected to impact from construction of an observatory.

Taxonomy

The Mount Graham red squirrel, *Tamiasciurus hudsonicus grahamensis*, exhibits a low level of distinctiveness relative to neighboring populations (based on morphology and ecology, as well as analysis of allozymes and mitochondrial DNA; R. M. Sullivan and T. L. Yates pers. comm, B. R. Riddle pers. comm.). This level of differentiation is consistent with either a late Pleistocene or early Holocene isolation of the population and subsequent evolutionary divergence, or recent colonization of the Pinaleño Mountains by a small founding population, resulting in founder effect and genetic drift.

Distribution

Chickarees are widely distributed across northern North America from the Pacific to Atlantic oceans, and extend down montane corridors of the western (Rocky Mountains) and eastern (Appalachians) United States. In the southwestern periphery of its range, the species has a



Mount Graham red squirrel,
Tamiasciurus hudsonicus
grahamensis.

Bob Miles

fragmented distribution on cool, mesic mountaintops surrounded by semiarid grassland and desert. One such isolated subspecies, the Mount Graham red squirrel (*T. h. grahamensis*), is restricted to Mt. Graham in the Pinaleño (= Graham) Mountains of southeastern Arizona (Spicer *et al.* 1985a). This population is isolated from its nearest conspecific, *T. h. mogollonensis*, by 60km of semiarid grassland (Hoffmeister 1986).

Remarks

Tamiasciurus h. grahamensis currently occupies an area of approximately 100km² that is characterized by Engelmann spruce and corkbark fir at elevations above 2590m. Clearing for timber harvest, development of recreation facilities, summer homes, and roads have fragmented the habitat. Construction of a major astrophysical facility is underway within the red squirrel's habitat. This facility is a cooperative venture between the University of Arizona, the Steward Observatory, the Max Planck Institute, the Smithsonian Institution, and the Vatican. Although site construction involves clearing only a few hectares of habitat, the associated road construction and projected additional sites may lead to the urbanization of Mt. Graham. Further reduction of forested areas may increase the potential for competition between *T. h. grahamensis* and the introduced Abert's squirrel (*Sciurus aberti*), although little is known about the interaction of the two species (Brown 1984).

Populations of *T. h. grahamensis* may be estimated based on the number of active middens, which are heaps of cone refuse and buried food caches that are at the center of each squirrel's territory. Estimates derived from midden survey data since 1986 have ranged between 200 and 300 red squirrels. Midden surveys are conducted semi-annually by the United States Forest Service, United States Fish and Wildlife Service, and the Arizona Game and Fish Department. These agencies have established a study committee that reviews research directed at the subspecies and, in some cases, channels funding to investigators. Little is known about life history parameters and population ecology of the Mount Graham red squirrel (Froelich and Smith 1990). Ongoing research includes studies of foraging ecology of red squirrels, habitat characteristics of middens, evaluation of red squirrel trapping and marking techniques, fire history of the forest, and cone production of Engelmann spruce. Funding from the observatory consortium is \$50,000/year for a ten-year period. The Arizona Game and Fish Department has funded management and research activities through fiscal year 1993 at approximately \$50,000/yr.

Conservation status and occurrence in captivity and protected areas

Tamiasciurus h. grahamensis is a federal Endangered species and is also considered by the Arizona Game and Fish to be Endangered. A refuge has been established in

the highest quality red squirrel habitat that is closed to camping, hiking, or other recreational activities.

Recommended action

- Vigorous protection of existing habitat from further loss or fragmentation, and rehabilitation of disturbed habitat. The United States Forest Service has stopped all harvesting of timber, fuelwood, and Christmas trees.
- Provide sufficient habitat for a population that does not drop below 300 adults even during periods of low cone production.
- Continue funding research directed at life history information, including current and minimum viable population levels, critical habitat characteristics, and dispersal patterns.
- Continue interagency midden census used to derive population estimates.

Family CASTORIDAE

Castor canadensis Kuhl 1820 Beaver; American beaver

Stephen O. MacDonald and Joseph A. Cook

24 subspecies, 1 of conservation concern in North America (north of Mexico):

C. c. phaeus Admiralty Island beaver

IUCN Red List Category

Castor canadensis Lower Risk, least concern (LR,lc)

C. c. phaeus Data Deficient (DD)

Assignment of *C. c. phaeus* is based on the need for specific information on the systematic relationship of the subspecies to surrounding populations and the need for information on the status and distribution of beavers on islands in the Alexander Archipelago.

Taxonomy

Lavrov and Orlov (1973) considered *Castor canadensis* to be distinct from the Old World species, *C. fiber*. Heller (1909) described *C. c. phaeus* as endemic from Admiralty Island, Southeastern Alaska. A total of six specimens, only three of them adults, were used in his analysis. No analyses using additional materials have been conducted since (Hall 1981, Taylor 1916b).

Distribution

Castor canadensis is widely distributed across North America except for most of the southwestern deserts, the Florida peninsula, and the extreme northern regions, and has been introduced in Europe and Asia. *Castor canadensis phaeus* is known only from Admiralty Island, Southeastern Alaska. Beavers from the adjacent Chichagof and Baranof islands

were presumed to be the same taxon (Hall 1981, Allen 1942, Heller 1909). However, no materials were preserved for comparison before the beaver's extirpation on those islands prior to 1907. All other beavers in Alaska, including the rest of the Alexander Archipelago, and throughout most of Yukon and western British Columbia, Canada, are included under the subspecies *C. c. belugae* (Hall 1981).

Remarks

The current distribution and abundance of *C. c. phaeus* is unknown. Beavers from Prince of Wales Island (presumably *C. c. belugae*) were successfully re-introduced to Baranof Island in 1927 (Burris and McKnight 1973). Jenkins and Busher (1979) reviewed the general biology of this species.

Conservation status and occurrence in protected areas

Castor c. phaeus has no current protected status. Most of Admiralty Island, except the northern point that includes Mansfield Peninsula, is within the Admiralty Island National Monument and the Kootznoowoo Wilderness.

Recommended action

- Evaluate taxonomic relationships of *C. c. phaeus* relative to surrounding populations using additional specimens and modern biochemical and molecular techniques.
- Survey the Alexander Archipelago to document the extant distribution of *C. canadensis*

Family GEOMYIDAE

Geomys arenarius Merriam 1895

Desert pocket gopher

David J. Hafner

IUCN Red List Category

Geomys arenarius – Lower Risk, near threatened (LR,nt)

Assignment is based on the restricted distribution of this species. Specific information is needed on the distribution, status, and population dynamics of possibly ephemeral populations that may connect the secure, isolated populations along the Rio Grande and at the two national monuments.

Taxonomy and distribution

The desert pocket gopher occurs in the arid basins and valleys of southern New Mexico, western Texas, and northern Chihuahua, Mexico. *Geomys arenarius* was described as a full species by Merriam (1895) and was so treated by Hall (1981). Hafner and Geluso (1983) relegated it to two subspecies of *G. bursarius*, *G. b. arenarius*, and *G. b. brevirostris*, based on analysis of clinal variation of fundamental chromosomal number and allozyme

complements between the disjunct populations of the two taxa. Jones *et al.* (1992) stated that submergence of *G. arenarius* under *G. bursarius* was “premature (see especially Qumsiyeh *et al.* 1988)” and readmitted *G. arenarius* to their checklist of North American mammals, although Qumsiyeh *et al.* (1988) did not include *G. arenarius* in their study, but merely stated that “karyotypic diversity of *G. b. lutescens*, *G. arenarius*, and *G. tropicalis* would require extensive chromosomal evolution” and did not cite Hafner and Geluso (1983). Patton (1993) retained the more traditional species (including *G. arenarius*) “due to lack of a thorough geographic analysis throughout the range of the genus and a consensus among workers.” The taxon is listed as *G. b. arenarius* in its federal listing, presumably including both *G. b. arenarius* and *G. b. brevirostris*.

Remarks

Regardless of whether the desert pocket gopher is considered as a distinct species or as one or two subspecies of *G. bursarius*, it clearly represents a relict of a previous western expansion of the latter species into the interior valleys of New Mexico (Hafner and Geluso 1983), rather than from *G. personatus* from the southeast (as proposed by Alvarez 1963). These valleys have experienced extensive desertification and increase in shrub cover during this century due to overgrazing and fire suppression, perhaps accelerated by a warming and drying trend (Sallach 1986). Reduction in quality and expanse of grassland has apparently resulted in increased fragmentation and isolation of pocket gophers, which already have a patchy distribution dictated by the availability of appropriate friable soil. Populations of *G. arenarius* were found to be locally abundant in pinyon-juniper habitat at and near Gran Quivera National Monument, along the margins and interior basins of White Sands National Monument in the Tularosa Valley, and along the banks of the Rio Grande near Las Cruces in 1981 (D. J. Hafner pers. obs.). In contrast to Williams and Genoways (1978) and Williams and Baker (1974) who speculated that *Cratogeomys castanops* may be replacing *Geomys arenarius* in many areas of White Sands, Hafner and Geluso (1983) found *Geomys* to be abundant within and immediately adjacent to the gypsum sand dunes there (as described by Blair 1941, 1943a), while they caught relatively few *Cratogeomys* in the same habitat, and never within the margins of the dunes. However, no pocket gophers of either genus were found at White Sands in 1982, after a summer of prolonged drought; a mummified *Geomys* was found in a burrow beneath a dirt mound that appeared moderately fresh (D. J. Hafner pers. obs.). Similarly, only old mounds could be located at a site in the Jornada del Muerto from which *Geomys* had previously been collected, indicating that this population was perhaps ephemeral (Hafner and Geluso 1983). Continued grazing and fire suppression, coupled with warming and drying trends, may further isolate the Rio Grande and Tularosa Valley

populations by extirpating intermediate, ephemeral populations. Populations are dense along the Rio Grande in areas where the river has been channelized and natural bosque has been eradicated, as well as in adjacent fields used for agriculture and livestock. Apparently secure but isolated populations thus persist along the Rio Grande, at White Sands National Monument, and at Gran Quivera National Monument. The distribution, status, and population dynamics of intermediate populations remain to be determined, as well as the nature of any threats to these intermediate populations. Williams and Baker (1974) reviewed the general biology of this species.

Conservation status and occurrence in captivity and protected areas

Geomys arenarius is a federal C2 candidate taxon (as *G. b. arenarius*, presumably including *G. b. brevirostris*). Large populations of *G. arenarius* occur on Gran Quivera and White Sands National Monuments.

Recommended action

- Determine distribution and long-term population dynamics of isolated populations between the three established populations (Rio Grande, White Sands, and Gran Quivera).
- Evaluate the effect of grazing and fire suppression on intermediate populations.
- Monitor established populations periodically to determine population dynamics.

***Geomys personatus* True 1889 Texas pocket gopher**

David J. Hafner

6 subspecies, 3 of conservation concern in North America (north of Mexico):

- G. p. fuscus* Rio Grande pocket gopher
- G. p. maritimus* Maritime pocket gopher
- G. p. streckeri* Carrizo Springs pocket gopher

IUCN Red List Category

- Geomys personatus* – Lower Risk, near threatened (LR,nt)
- G. p. fuscus* – Lower Risk, near threatened (LR,nt)
- G. p. maritimus* – Vulnerable (VU): D2
- G. p. streckeri* – Vulnerable (VU): D2

Assignment of the species is based on its restricted distribution in southern Texas and adjacent Tamaulipas, Mexico, and the highly restricted distributions of the three subspecies of conservation concern.

Taxonomy and distribution

The Texas pocket gopher has a patchy distribution in southern Texas and coastal Tamaulipas, Mexico. Three

subspecies with limited distributions in Texas are considered to be of conservation concern: *G. p. fuscus* occurs along a short reach of the Rio Grande (<1,000km²) south of the junction of the Pecos River, *G. p. maritimus* is known only from the type locality south of Corpus Cristi, and *G. p. streckeri* is known only from the type locality at Carrizo Springs, Dimmit County, Texas.

Remarks

No immediate threats to any of the subspecies of *G. personatus* are known, but their restricted distributions may leave them vulnerable to adverse human impacts. Williams (1982) reviewed the general biology of this species.

Conservation status and occurrence in captivity or protected areas

Geomys personatus streckeri is considered by Texas to be Critically Imperiled. The other two subspecies of concern (*G. p. fuscus* and *G. p. maritimus*) are considered by Texas to be Imperiled. *Geomys p. streckeri* and *G. p. maritimus* are federal C2 candidate taxa. No populations of any of the subspecies are known to occur in captivity or protected areas.

Recommended action

- Evaluate the taxonomic relationships among the six subspecies of *G. personatus*.
- Conduct a field survey to determine the population status and distribution of *G. p. fuscus*, *G. p. maritimus*, and *G. p. streckeri*.
- If *G. p. maritimus* and *G. p. streckeri* are each found to occur only at a single locality, those localities should be managed as protected preserves.

***Geomys pinetis* Rafinesque 1817 Southeastern pocket gopher**

Gordon L. Kirkland, Jr.

8 subspecies, 4 of conservation concern:

- G. p. colonus* Colonial pocket gopher
- G. p. cumberlandius* Cumberland Island pocket gopher
- G. p. fontanelus* Sherman's pocket gopher
- G. p. goffi* Goff's southeastern pocket gopher

IUCN Red List Category

- Geomys pinetis* – Lower Risk, least concern (LR,lc)
- G. p. colonus* – Lower Risk, near threatened (LR,nt)
- G. p. cumberlandius* – Vulnerable (VU): D2
- G. p. fontanelus* – Vulnerable (VU): D2
- G. p. goffi* – Extinct (EX)

Assignment of subspecies of conservation concern is based on the presumed extinction of *G. p. goffi* and the restricted distribution of *G. p. cumberlandius*, *G. p. colonus*, and *G. p. fontanelus*.

Taxonomy and distribution

Hall (1981) listed *G. colonus*, *G. fontanelus*, and *G. cumberlandius* as distinct species, but these forms are now regarded as subspecies of *G. pinetis* (Laerm 1981, Williams and Genoways 1980). The range of the southeastern pocket gopher includes southern Georgia and Alabama, and northern and central Florida (Hall 1981). *Geomys pinetis* is associated with loose sandy soils in open or thinly wooded areas (Pembleton and Williams 1978). Four subspecies are considered to be of conservation concern: *G. p. colonus*, *G. p. cumberlandius*, *G. p. fontanelus*, and *G. p. goffi*. *Geomys p. colonus* is limited in distribution to extreme southeastern Georgia between Crooked River on the north, Dark Entry Creek on the east, St. Mary's River on the south, and Miller's Branch on the west (Golley 1962, Morgan 1980). *Geomys p. cumberlandius* is restricted in distribution to Cumberland Island (80km²) in extreme southeast Georgia. Only one colony of *G. p. fontanelus* is known to exist, and it is located approximately 7mi [11.3km] northwest of Savannah, Georgia, in Chatham County (Golley 1962, Morgan 1980). *Geomys p. goffi* was endemic to the Pineda Ridge, which borders the Indian River in Brevard County, Florida. It was found in habitat consisting of sand pine scrub, a mixture of scrub and flatwoods, and coastal dune scrub (Ehrhart 1978a).

Remarks

All three Georgia subspecies of *G. pinetis* have experienced a significant decline in numbers presumably due to human encroachment upon their habitat. The last colony of *G. p. goffi* known to exist was documented in 1955. Since then, no sightings of *G. p. goffi* have been made. Conversion of the single known site near Eau Gallie to human use apparently resulted in extirpation of this subspecies (Humphrey 1992b).

Conservation status and occurrence in captivity and protected areas

Geomys p. colonus and *G. p. cumberlandius* are considered to be Endangered by the Georgia Department of Natural Resources; *G. p. cumberlandius* is a federal C2 candidate taxon; *G. p. fontanelus* is considered to be Endangered and possibly extinct by the Georgia Department of Natural Resources; *G. p. goffi* is regarded as Extinct by the Florida Committee on Rare and Endangered Plants and Animals and on federal listings (C3A) and as Endangered by the Florida Game and Fresh Water Fish Commission. No populations of the subspecies of conservation concern are known to occur in captivity or protected areas.

Recommended action

- Set aside occupied habitat of *G. p. colonus*, *G. p. fontanelus*, and *G. p. cumberlandius* in Georgia as wildlife sanctuaries and prohibit further development of these areas.

- Conduct an intensive survey to determine the status and distribution of any remaining populations of *G. p. fontanelus*.
- Conduct surveys to determine the status and distribution of populations of *G. p. cumberlandius* and *G. p. colonus*.

Geomys texensis Merriam 1895 **Llano pocket gopher; Texas pocket gopher** David J. Hafner

3 subspecies, 1 of conservation concern:
G. t. bakeri Baker's pocket gopher

IUCN Red List Category

Geomys texensis – Lower Risk, near threatened (LR,nt)
G. t. bakeri – Lower Risk, near threatened (LR,nt)

Assignment of the species is based on its restricted distribution in central Texas. Assignment of the subspecies of conservation concern is based on its highly restricted distribution, although no immediate threats to its continued survival are known.

Taxonomy and distribution

Baker (1950) included *texensis* as a subspecies of *G. bursarius*, but Block and Zimmerman (1991) recognized *G. texensis* as specifically distinct from *G. bursarius*, and included two former subspecies of *G. bursarius*: *G. b. texensis* and *G. b. llanensis*. They indicated that “there is little justification in retaining the subspecific status of *G. t. llanensis*.” Demastes and Hafner (1993) documented that *G. b. texensis* and *G. b. llanensis* are genetically differentiated and that populations of their lice (*Geomydoecus heaneyi*) are also genetically differentiated, supporting continued recognition of *G. b. llanensis* (Demastes pers. comm.). Smolen *et al.* (1993) named a third subspecies, *G. t. bakeri*, from a restricted area south of the Edwards Plateau.

Geomys texensis is restricted to small regions of suitable soils on and near the Edwards Plateau of south-central Texas (Block and Zimmerman 1991, Smolen *et al.* 1993). Of three named subspecies, *G. t. bakeri* has the most restricted distribution, occurring only around Hondo, west of San Antonio and immediately south of the Edwards Plateau (Smolen *et al.* 1993).

Remarks

Block and Zimmerman (1991) suggested that *G. texensis* was isolated from *G. bursarius* 10,000 years ago during the warming and drying trend that followed the latest pluvial interval. Continued warming and drying could further reduce the already restricted geographic range of *G. texensis*. We know of no human-related threat or immediate

biological threat to the species. Smolen (pers. comm.) knows of only two small populations of *G. t. bakeri*: one is adjacent to a trailer park, and the other is in a more rural location in which gophers may be more abundant.

Conservation status and occurrence in captivity and protected areas

Geomys t. bakeri is a federal C2 candidate species, presumably due to its restricted distribution. No populations are known to occur in captivity or in protected areas.

Recommended action

- Conduct surveys to determine the status and distribution of populations of *G. texensis*, and assess any current or potential threats, with particular focus on *G. t. bakeri*.

***Thomomys idahoensis* Merriam 1901 Idaho pocket gopher**

Eric Yensen

3 subspecies, 1 of conservation concern:

T. i. confinus Hamilton pocket gopher

IUCN Red List Category

Thomomys idahoensis – Lower Risk, near threatened (LR,nt)

T. i. confinus – Lower Risk, near threatened (LR,nt)

Assignment of the species is based on its limited distribution in the central Rocky Mountains. Assignment of the subspecies of conservation concern is based on its highly restricted distribution; no immediate threats to its continued survival are known.

Taxonomy

Davis (1937) described *T. i. confinus* as *Thomomys talpoides confinus* from 13 specimens from Hamilton and nearby Gird Creek, Ravalli County, Montana. He noted they were closest to *Thomomys idahoensis* (later reduced to subspecific rank as *Thomomys talpoides idahoensis*). Thaeler (1972) subsequently re-elevated *T. t. idahoensis* to specific status, and chromosomal analysis confirmed that *T. t. confinus* (as well as *T. t. pygmaeus*) should be transferred to *T. idahoensis* (Thaeler 1977). Hall (1981) did not recognize *T. idahoensis* as a distinct species, but did so in the addenda (Hall 1981:1179). Patton (1993) also recognized *T. idahoensis* as distinct, and the taxonomy of *T. i. confinus* has not been challenged.

Thomomys idahoensis is found in the central Rocky Mountains of western Montana, eastern Idaho, western Wyoming, and northern Utah. *Thomomys i. confinus* is limited to the southern end of the Bitterroot Valley, Ravalli County, Montana, from Corvallis to about 30–35km S of

Hamilton, a geographic range approximately 40km long (Thaeler 1977) of about 200km².

Remarks

The most recent specimens in the University of Montana mammal collection are a series collected in 1981 (K. Foresman pers. comm.). There is no recent information on the subspecies, or known threats at the moment (K. Foresman pers. comm.).

Conservation status and occurrence in captivity and protected areas

This taxon is classified as Sensitive by the Montana Natural Heritage Program. No populations are known to occur in captivity or in protected areas.

Recommended action

- Survey the Bitterroot Valley and the Big Hole Valley to the southeast (which would connect *T. i. confinus* to *T. i. idahoensis* populations further south) to determine the distribution and abundance of this subspecies.

***Thomomys mazama* Merriam 1897 Mazama pocket gopher; western pocket gopher**

Eric Yensen

15 subspecies, 9 of conservation concern:

T. m. couchi Puget Sound pocket gopher

T. m. glacialis Roy Prairie pocket gopher

T. m. helleri Rogue River pocket gopher

T. m. louiei Cathlamet pocket gopher

T. m. melanops Olympic Mountains pocket gopher

T. m. pugetensis Olympia pocket gopher

T. m. tacomensis Tacoma pocket gopher

T. m. tumuli Rocky Prairie pocket gopher

T. m. yelmensis Yelm Prairie pocket gopher

IUCN Red List Category

Thomomys mazama – Lower Risk, near threatened (LR,nt)

T. m. couchi – Vulnerable (VU): B1;B2c

T. m. glacialis – Vulnerable (VU): B1;B2c

T. m. helleri – Lower Risk, near threatened (LR,nt)

T. m. louiei – Critically Endangered (CR): A1c;C2b

T. m. melanops – Lower Risk, near threatened (LR,nt)

T. m. pugetensis – Vulnerable (VU):B1;B2c

T. m. tacomensis – Extinct (EX)

T. m. tumuli – Vulnerable (VU): B1;B2c

T. m. yelmensis – Vulnerable (VU): B1;B2c

Assignment of the species is based on its restricted distribution and the threatened status of seven of 15 recognized subspecies. Assignment of *T. m. helleri* and *T. m. melanops* is based on their restricted distribution and

the lack of any known immediate threats to their continued survival; assignment of *T. m. couchi*, *T. m. glacialis*, *T. m. pugetensis*, *T. m. tumuli*, and *T. m. yelmensis* is based on their severely fragmented distribution at few localities, and an observed and projected decline in the extent and quality of its habitat; assignment of *T. m. louiei* is based on the observed reduction in its population and distribution, and the single known population; assignment of *T. m. tacomensis* is based on persuasive evidence that the subspecies, if ever valid, is extinct.

Taxonomy

The taxonomic status of the Washington subspecies of *T. mazama* is currently under study using molecular techniques (E. Steinberg pers. comm., J. Kenagy pers. comm.). Some subspecies may be separated by as little as 8km (E. Steinberg pers. comm.). According to J. L. Patton (pers. comm.), all of the subspecies currently recognized from around the southern arm of Puget Sound (*couchi*, *glacialis*, *pugetensis*, *tacomensis*, *tumuli*, and *yelmensis*) are probably better considered as a single subspecies, *T. m. yelmensis*. However, Witmer *et al.* (1996) reported a significant difference in baculum, tail, and hind-foot lengths and body weights between populations at Lacey and the Olympia airport, two sites that are about 15km apart. This report further documented the considerable morphological variability within Mazama pocket gophers in the Puget Sound area. Elliot (1903) described *T. m. helleri* as a full species. Bailey (1936) treated it as a subspecies of *T. monticola*. Johnson and Benson (1960) examined the bacula of pocket gophers of the *T. mazama-talpoides* complex and found that *T. mazama* has a baculum roughly twice as long as *T. monticola*, and concluded that

T. m. helleri was a subspecies of *T. mazama*. B. J. Verts (pers. comm.) has compared specimens of *T. m. helleri* with *T. m. niger*, *T. m. hesperus*, and *T. m. mazama* and found no consistent morphological differences among these subspecies. However, Thaeler (1980) found that *T. m. helleri* has a different chromosome number (2N=42) than either *T. m. niger* (2N=44) or *T. m. mazama* (2N=58). Thus, *T. m. helleri* may be a valid taxon.

Distribution

The Mazama pocket gopher has a relatively limited distribution along the Pacific coast of the United States from Washington's Olympic Peninsula to northern California. Nine of the 15 described subspecies may be of conservation concern. One well-isolated subspecies (*T. m. helleri*) has a restricted distribution along the southern coast of Oregon near the mouth of the Rogue River, Curry County, Oregon. The only published records are Gold Beach and near Wedderburn on opposite sides of the mouth of the Rogue River (Thaeler 1980, Hall 1981). Bailey (1936:258) reported that this subspecies was "common on both sides of the Rogue River, at Gold Beach and Wedderburn, and their hills [= mounds] were seen a couple of miles from the coast along the river bottoms ... They occupy sandy bottoms and grassy ridge tops only in the openings, which are scarce and isolated along this coast section."

Eight other subspecies of concern occur in western Washington. Two of these subspecies have isolated distributions. *Thomomys m. melanops* is restricted to the higher Olympic Mountains, Washington (Dalquest 1948). The habitat of this subspecies is subalpine meadows (E. Steinberg pers. comm.). *Thomomys m. louiei* is known



Mazama pocket gopher,
Thomomys mazama.

W.P. Leonard

only from the type locality of Crown-Zellerbach's Cathlamet Tree Farm 12mi [19km] NNE Cathlamet, Wahkiakum County, Washington (Hall 1981). This population is near the Columbia River and separated from the Puget Sound populations.

The remaining six western Washington subspecies are clustered around the southern margin of Puget Sound. *Thomomys m. couchi* is known from two localities on the southwestern side of Puget Sound, Washington: 2–4mi [3–6km] N Shelton and about 40km SW at Lost Lake Prairie near Satsop (Dalquest 1948, Hall 1981). *Thomomys m. glacialis* is known from the type locality of Roy Prairie, 2mi [3km] S Roy, Pierce County, Washington (Dalquest 1948, Hall 1981). However, there are also specimens in the University of Puget Sound collection that apparently belong to this subspecies from 0.5 and 0.6mi [1km] S Roy (R. E. Johnson pers. comm.). *Thomomys m. pugetensis* was known from 3–5mi [5–8km] S of Olympia, Washington (Dalquest 1948, Hall 1981). However, there are also records from 0.6mi [1km] NE Lacey (R. E. Johnson pers. comm.) and another nearby locality. The latter is significant in that the gophers did not previously occur there (E. Steinberg pers. comm.). *Thomomys m. tacomensis*, or was, endemic to the Tacoma-Steilacoom area, Pierce County, Washington (Dalquest 1948). There are specimen records for Tacoma and 6mi [10km] S Tacoma (R.E. Johnson pers. comm.). *Thomomys m. tumuli* is another subspecies of Mazama pocket gopher with a very restricted distribution, known only from Rocky Prairie, 5 and 7mi [8 and 11km] N Tenino, Thurston County, Washington (Dalquest 1948, Hall 1981). These localities are about 8–10km south of Olympia, and approximately 5–8km SE of the range of *T. m. pugetensis*. The type of *T. m. yelmensis* was collected from Tenino, Yelm Prairie, Thurston County, Washington. The other localities are 2mi [3km] N Rochester and 1mi [1.6km] W Vail (Hall 1981). The known range is thus <35km across. New pocket gopher populations have been recently discovered on the Fort Lewis Military Reservation, between the ranges of *T. m. glacialis*, *T. m. yelmensis*, and *T. m. tumuli*.

Remarks

The most recent specimens of the restricted coastal subspecies, *T. m. helleri*, were collected in 1986 (Museum of Vertebrate Zoology #176428 and 176429; B. J. Verts pers. comm.). Additional records of *T. mazama*, presumably *T. m. helleri*, extend from Gold Beach and Wedderburn south to the Oregon-California state boundary (B. J. Verts pers. comm.).

The range of the Olympic Mountains subspecies, *T. m. melanops*, is fully within the Olympic National Park. R.E. Johnson (pers. comm.) has records of 23 specimens of *T. m. melanops* from four localities. Hall (1981) lists two additional localities. The most recent specimen was collected in 1976.

R. E. Johnson (pers. comm.) has records of 11 specimens of *T. m. louiei* from the type locality trapped in 1956. The subspecies was collected several times between 1950 and 1960 (United States Fish and Wildlife Service unpublished) and was last trapped in the 1970s (E. Steinberg pers. comm.). Unfortunately, the forest at the type locality has been clearcut logged. D. Taylor and E. Steinberg recently searched for *T. m. louiei* without success, and M. Johnson was also unsuccessful in locating them (J. Kenagy pers. comm.).

The limited prairie habitat in the Puget Sound region has been modified by urban expansion and gravel mining operations (Washington Department of Wildlife, unpublished memo, 31 January 1994). R. E. Johnson (pers. comm.) has records of about 40 specimens of *T. m. couchi*, the most recent of which was collected in 1962. E. Steinberg (pers. comm.) has recently observed mounds of *T. m. couchi*, so the subspecies is still in existence, but she has not done enough work to be able to comment upon their population status. R.E. Johnson (pers. comm.) has records of 29 specimens of *T. m. glacialis* from two localities; the most recent was collected in 1967. There are few gophers left at the type locality (E. Steinberg pers. comm.). R.E. Johnson (pers. comm.) has records of 51 specimens of *T. m. pugetensis*; the most recent was collected in 1993. R.E. Johnson (pers. comm.) has records of 141 specimens of *T. m. tacomensis* from 10–15 localities (some only marginally distinct) in the Tacoma area. Most were collected in 1947; the most recent on 4 January 1962. This restricted range has been completely enveloped by the Tacoma urban area. The habitat has been dramatically altered by residential development and gravel mining (Washington Department of Wildlife, unpublished memo, 31 January 1994). M. Johnson has searched for *T. m. tacomensis* without success, it has not been reported in the area since 1962, and it is probably extinct (M. Johnson pers. comm., D. Taylor pers. comm., E. Steinberg pers. comms.). Dalquest (1948) lists 25 specimens of *T. m. tumuli* in the National Museum of Natural History; R.E. Johnson (pers. comm.) has records of 3 additional specimens. All of these specimens were collected in the early 1940s. R.E. Johnson (pers. comm.) has records of 81 specimens of *T. m. yelmensis* from 10 localities. The most recent was collected in 1976. E. Steinberg (pers. comm.) has not been able to find pocket gophers at Tenino or other areas where they used to occur. However, there are large populations on the nearby Fort Lewis Military Reservation.

Thomomys mazama couchi, *T. m. glacialis*, *T. m. pugetensis*, *T. m. tacomensis*, *T. m. tumuli*, and *T. m. yelmensis* constitute a currently unknown number of valid subspecies. Even if these all comprise only a single subspecies, the aggregate would still be of conservation concern. If all are valid, then correspondingly more biological diversity is threatened. Pocket gophers play an

important ecological role in soil aeration, soil fertility, and in water percolation into the soil that may exceed the economic value of crop losses (Dalquest 1948, Ingles 1949, 1952) and if that role is to be maintained in those ecosystems, this genetic diversity should be retained. With the exception of the Fort Lewis Military Reservation, most of the small native prairies are being rapidly replaced by urban sprawl. Witmer *et al.* (1996) suggest that extensive deforestation in the southern Puget Sound area may be beneficial to *Thomomys mazama*, which will invade newly created meadows.

Conservation status

Thomomys m. couchi is a state of Washington candidate species under review for possible listing. *Thomomys m. glacialis* is a state of Washington candidate now under review for possible listing and a federal C2 candidate taxon. *Thomomys m. helleri* is on the Oregon Natural Heritage Program Monitor list and is a federal C2 candidate taxon. *Thomomys m. louiei* is a state of Washington candidate species under review for possible listing as Endangered, Threatened, or Sensitive, and is a federal C2 candidate taxon. *Thomomys m. melanops* is on the state of Washington Monitor list. It is probably not threatened at the moment, but neither is it thought to be very abundant (D. Taylor pers. comm.). The known populations are in the Olympic National Park, and thus have some degree of protection. For this reason it may be delisted (E. Steinberg pers. comm.). *Thomomys m. pugetensis* has not been given an official conservation status by the state of Washington, but also seems to have a very restricted range. *Thomomys m. tacomensis* is a federal C2 candidate taxon, but a recent biennial review of the United States Fish and Wildlife Service list of federal candidate species recommends relegating the subspecies to C3A (extinct). The state of Washington does not formally list the subspecies, apparently because it is believed extinct. Because of its very restricted distribution, *T. m. tumuli* is a candidate species in the state of Washington, but it is not federally listed. *Thomomys m. yelmensis* is not currently listed by the state of Washington or the United States Fish and Wildlife Service. Although it may be less vulnerable than some *T. mazama* subspecies, it is nevertheless vulnerable due to its very restricted range and continuing control efforts (Witmer *et al.* 1996).

Occurrence in protected areas

All known populations of *T. m. melanops* are in Olympic National Park. The Nature Conservancy has resource natural areas on the Fort Lewis Military Reservation, where *T. m. yelmensis* occurs. Pocket gophers on the Reservation are protected, and there are efforts to restore native prairies there. No populations of other subspecies of conservation concern are known to occur in captivity or protected areas.

Recommended action

- Complete taxonomic survey to determine genetic relationships of extant populations.
- Preserve existing patches of meadow (prairie) habitat within distribution of *T. mazama*, particularly those occupied by pocket gophers.
- Survey the area from the mouth of the Rogue River to the California border to determine whether *T. m. helleri* still exists in this area, the size of populations, and the nature of the threats to their survival.
- Determine status and distribution of *T. m. louiei*, and develop management strategies to preserve any existing population(s).
- Determine population status, distribution, and taxonomic relationships among populations of *T. mazama* on the southern margin of Puget Sound.

***Thomomys talpoides* (Richardson 1828) Northern pocket gopher**

Eric Yensen and David W. Nagorsen

58 subspecies, 3 of conservation concern:

- T. t. douglasi* Vancouver pocket gopher
- T. t. limosus* Columbia River pocket gopher
- T. t. segregatus* Goat Mountain pocket gopher

IUCN Red List Category

- Thomomys talpoides* – Lower Risk, least concern (LR,lc)
- T. t. douglasi* – Vulnerable (VU): B1;B2c
- T. t. limosus* – Lower Risk, near threatened (LR,nt)
- T. t. segregatus* – Lower Risk, near threatened (LR,nt)

Assignment of *T. t. douglasi* is based on the fragmented distribution of the few known populations, and projected decline in the extent and quality of its habitat; assignment of *T. t. limosus* and *T. t. segregatus* is based on their restricted distribution; no immediate threat to their continued survival is known.

Taxonomy and distribution

The taxonomy of *T. talpoides* is still unresolved. The revision of subspecies by Johnstone (1954) was based upon color and cranial size, traits known to be extremely plastic in pocket gophers (Smith and Patton 1980). Chromosomal studies (Thaeler 1985) suggest that several sibling species inhabit the Pacific Northwest.

The northern pocket gopher is widely distributed across the central plains of Canada and northern United States and the higher elevations of western United States. Along its southern periphery, it is often found in isolated patches on mountaintops surrounded by semiarid grassland or desert. Although many of these southern peripheral populations may be somewhat vulnerable to extirpation due to climatic warming or drying (reducing

the habitat area) or stochastic processes associated with reduced population size, the three subspecies that have been considered to be of conservation concern are all in the northwestern periphery of the species' range. *Thomomys t. douglasi* has been collected only at localities in the vicinity of Vancouver and nearby (15km NE) Brush Prairie, Clark County, Washington. *Thomomys t. limosus* is endemic to the north side of the Columbia River in south-central Washington. Its range extends from Paterson west to 8km W of White Salmon, a distance of approximately 160km (Hall 1981). The localities are at low elevations along the Columbia River. *Thomomys t. segregatus* is known only from the type locality on the benchlands of Goat Mountain near Wyndel, above the Kootenay River, British Columbia. This subspecies is completely isolated from adjacent subspecies (Johnstone 1954, Cowan and Guiguet 1965).

Remarks

The meadow (prairie) habitat of *T. t. douglasi* is being encroached upon by the growth of Vancouver, Washington (D. Taylor, pers. comm.). Its restricted range and the expansion of the Vancouver urban area make the form vulnerable. R.E. Johnson (pers. comm.) knew of about 70 specimens of *T. t. limosus*; the most recent were collected in 1956. No population estimates are available, and no specimens of *T. t. segregatus* have been collected since Johnstone's work in the early 1950s. No information is available on habitat. It is presumably vulnerable due to its localized distribution. Agricultural development in the lower Columbia River valley could be a threat to this subspecies.

Conservation status and occurrence in protected areas

Thomomys t. douglasi is a state of Washington candidate species under review for possible listing. *Thomomys t. limosus* is on the state of Washington Monitor list, although we know of no current monitoring activities. *Thomomys t. segregatus* is on the British Columbia Red List (potentially threatened or endangered). No populations are known to occur in captivity or in protected areas.

Recommended action

- Survey the current distribution and identify more precisely present and potential threats to *T. t. douglasi*.
- Consider establishment of a protected area for remaining populations of *T. t. douglasi*.
- Evaluate taxonomic validity of these subspecies of *T. talpoides* using modern techniques.
- Survey for presence of *T. t. limosus* in Klickitat County, Washington.
- Determine range and habitat requirements of *T. t. segregatus*.

***Thomomys umbrinus* (Richardson 1829) Southern pocket gopher**

Charles S. Thaeler, Jr.

33 subspecies, 1 of conservation concern in North America (north of Mexico):

T. u. emotis Animas Mountains pocket gopher

IUCN Red List Category

Thomomys umbrinus – Lower Risk, least concern (LR,lc)

T. u. emotus – Lower Risk, near threatened (LR,nt)

Assignment of the subspecies of conservation concern is based on its restricted distribution; no immediate threats to its continued survival are known.

Taxonomy

Populations of *T. umbrinus* north of Mexico previously were considered to be of three subspecies: *T. u. intermedius* and *T. u. quercinus* in southern Arizona, and *T. u. emotus* in southwestern New Mexico. Hoffmeister (1986) included *T. u. quercinus* in *T. u. intermedius* without comment. Hafner *et al.* (1987) combined both Arizona and New Mexico populations with other populations from northern Sonora and northern Chihuahua into a 'northern desert' genetic group, based on analysis of allozyme complements. Hoffmeister (1986), Patton and Dingman (1968), and Patton (1973) reported hybridization between *T. umbrinus* and *T. bottae* in southern Arizona, although introgressive hybridization was not found. Thaeler (*in litt.*) reported possible hybridization between the two species in southwestern New Mexico, based on 13% morphologically intermediate gophers of 106 examined.

Distribution

Like its close relative, *Thomomys bottae*, the southern pocket gopher has a wide distribution and a large number of formally recognized subspecies, most of which were described based on pelage coloration and size. The species enters the United States only in southern Arizona and southwestern New Mexico, with its Mexican range extending south to Puebla and Veracruz. North of Mexico, *T. umbrinus* is found at higher elevations in arid mountains that are surrounded by *T. bottae*, which occurs at lower elevations. In the Animas Mountains of southwestern New Mexico, *T. u. emotus* occurs as low as 1680m (Hinesley and Thaeler 1977, Thaeler *et al.* 1977, Thaeler and Hinesley 1978, Cook 1986). Based on 78 museum specimens, *T. u. emotus* occurs at four scattered areas throughout the Animas Mountains: 1) openings in the high conifer forest at and near Aspen Spring; 2) Indian Creek between 1,770 and 2,000m on the north flank of these mountains; 3) about 8km south and 2 to 5km east of Animas Peak between 1,770 and 2,000m; and 4) an area

along Lower Deer Creek south of Birch Spring between 1,680 and 1,830m. Most specimens (57 of 78) come from the last area.

Remarks

Although limited in distribution, *T. umbrinus* in New Mexico appears to be under no immediate threat (D. J. Hafner pers. obs. 1993). The introduction of feral pigs (*Sus scrofa*) into the range of *T. u. emotus* potentially could lower carrying capacity due to habitat degradation, but such degradation or lowered populations has not been noted.

Conservation status and occurrence in captivity and protected areas

Thomomys u. emotus is considered an Endangered species by the state of New Mexico. Prior to 1952, the Animas Mountains, including the range of *T. u. emotus*, were part of the Coronado National Forest. In 1952, it became part of a land exchange and was incorporated into a private holding known as the Gray Ranch. As part of the Gray Ranch at least some of this area was subjected to moderate levels of cattle grazing that have not appeared to have led to serious degradation. In 1989 the Gray Ranch was purchased by The Nature Conservancy. Future disposition of this land is not known but for the present, appropriate stewardship of the land by The Nature Conservancy seems assured.

Recommended action

- Analyze hybridization between *T. umbrinus* and *T. bottae* to determine the degree of introgression of *T. bottae* genetic material into the *T. u. emotus* gene pool, using modern molecular techniques.
- Document the extent of habitat degradation in the Animas Mountains by *Sus scrofa*, and its possible effect on *T. u. emotus*.

Family HETEROMYIDAE

Chaetodipus californicus Merriam 1889 California pocket mouse

David J. Hafner

8 subspecies, 1 of conservation concern in North America (north of Mexico):

C. c. femoralis Dalzura pocket mouse

IUCN Red List Category

Chaetodipus californicus – Lower Risk, least concern (LR,lc)
C. c. femoralis – Data Deficient (DD)

Assignment of *C. c. femoralis* is based on the need for information on its population status, current distribution,

extent of habitat loss, and nature of continued threats (if any) to its continued survival.

Taxonomy and distribution

While recognition of *Chaetodipus* apart from *Perognathus* (Hafner and Hafner 1983) appears well supported, relationships within *Chaetodipus* are poorly understood, and close similarity among cranial and pelage characters evidently results in common misidentification of specimens. However, genetic studies (e.g., Patton *et al.* 1981, Riddle 1995) indicate that many of the species of *Chaetodipus* are old and well differentiated. *Chaetodipus californicus* has never been reviewed systematically.

The California pocket mouse occurs in chaparral (and occasionally desert grassland) communities in the Sierra Nevada, Coast, Transverse, and Peninsular ranges of southern California and northern Baja California, Mexico. The distribution of *C. c. femoralis* spans the United States-Mexico border.

Remarks

Chaetodipus c. femoralis may be suffering habitat reduction due to the continued expansion of the San Diego metropolitan area. The extent of any such threat, however, is not known.

Conservation status and occurrence in captivity and protected areas

Chaetodipus c. femoralis is a federal C2 candidate taxon and is a Species of Special Concern in California. No populations are known to occur in captivity or in protected areas.

Recommended action

- Survey the range of *C. c. femoralis* to determine its population status, current distribution, extent of habitat loss, and effect of urban development on this taxon.

California pocket mouse, *Chaetodipus californicus*.



J. Harris

***Chaetodipus fallax* Merriam 1889**
San Diego pocket mouse

David J. Hafner

6 subspecies, 2 of conservation concern in North America (north of Mexico):

C. f. fallax San Diego pocket mouse

C. f. pallidus Mountain Springs pocket mouse

IUCN Red List Category

Chaetodipus fallax – Lower Risk, least concern (LR,lc)

C. f. fallax – Data Deficient (DD)

C. f. pallidus – Data Deficient (DD)

Assignment of the subspecies of concern is based on the need for information on the population status, current distribution, and nature and extent of any existing threats to their continued survival.

Taxonomy and distribution

Chaetodipus fallax occurs in chaparral habitat along the coast and mountain ranges of southern California and Baja California, and on Isla Cedros off the Pacific coast of Baja California (*C. anthonyi* on Isla Cedros was considered a subspecies of *C. fallax*, *C. f. anthonyi*, by Williams *et al.* 1993a). Although *C. fallax* is externally most similar to *C. californicus*, genetic studies do not support a close relationship (Patton *et al.* 1981, Riddle 1995). The species is represented in the United States by two subspecies: *C. f. fallax* occupies the basins and slopes on the Pacific side of the mountains of southern California and northern Baja California, Mexico; *C. f. pallidus* is found more inland, along the southern margins of the Mojave Desert, California, and along the northern slopes of the San Bernardino Mountains and the western edge of the Colorado Desert, south to the Mexican boundary.

Remarks

Chaetodipus fallax may be suffering habitat reduction due to the continued expansion of the San Diego metropolitan area. The extent of any such threat, however, is not known.

Conservation status and occurrence in captivity and protected areas

Chaetodipus f. fallax and *C. f. pallidus* are federal C2 candidate taxa and Species of Special Concern in California. No populations are known to occur in captivity or in protected areas.

Recommended action

- Survey historical sites within range of *C. fallax* in southern California (which includes only the two subspecies of conservation concern) to determine population status, current distribution, and effect of urban development on this species.

***Dipodomys elator* Merriam 1894**
Texas kangaroo rat

Robert E. Martin and Kenneth G. Matocha

IUCN Red List Category

Dipodomys elator – Vulnerable (VU): B1;B2c

Assignment is based on the restricted distribution and observed decline in extent and quality of the habitat of this species.

Taxonomy and distribution

Dipodomys elator is considered to be closely related to *D. phillipsii*, although its specific relationships are not clear (Jannett 1976). The distribution of the Texas kangaroo rat is not well defined and it probably does not occur in all of the historic range of the species. Jones *et al.* (1988) provided detailed accounts of known records of occurrence in ten Texas and two Oklahoma counties, but confirmed the species in only four Texas counties (Cottle, Hardeman, Wilbarger, and Wichita). Martin and Matocha (1991) reported on a 1989 record of the species from Motley County, Texas. The area of available habitat for the species has not been determined, although it is not likely to exceed the area of rangeland (6520km²) in the five counties where it is presently known to occur. Ground checks in Hardeman County reveal that the above estimate of available rangeland may exceed by several factors the actual habitat available to the species (Martin and Matocha *in litt.*). The species occurs primarily in areas with short grasses and open patches of bare ground with high clay content (Dahlquest and Collier 1964, Dahlquest and Horner 1984, Roberts and Packard 1973, Martin and Matocha 1972, 1991, Stangl *et al.* 1992). Patches of mesquite (*Prosopis glandulosa*) are often closely associated with *D. elator*, (Martin and Matocha 1972, 1991) but may not be required (Stangl *et al.* 1992).

Remarks

Populations of *Dipodomys elator* have declined in certain areas of its north Texas distribution in the last decade (Dahlquest and Horner 1984; Jones *et al.* 1988; Stangl *et al.* 1992), and no extant populations are known in Oklahoma (Moss and Mehlop-Cifelli 1990). Reasons for the decline appear to be lack of suitable open, short-grass habitat (Stangl *et al.* 1992) and general clearing of mesquite brushlands for agricultural fields (Dahlquest and Horner 1984). Present population levels for the geographic range of the species are unknown but it can be locally abundant in suitable habitat (Dahlquest and Horner 1984; Stangl *et al.* 1992). Roberts and Packard (1973) reported densities of 2.0 to 5.7 animals per ha, based on four live-trapping grids of small size (0.55 to 0.63ha). The mean home range size is reported by Roberts and Packard (1973) to be 0.08ha (male maximum was 0.18ha; female maximum was



Texas kangaroo rat,
Dipodomys elator.

R.E. Martin

0.20ha). Carter *et al.* (1985) reviewed the general biology of this species.

Conservation status

The Texas kangaroo rat is protected as a Threatened nongame species by the state of Texas, and is a federal C2 candidate taxon (Jones *et al.* 1988, Hall 1989, Martin and Matocha 1991).

Occurrence in captivity and protected areas

Captive breeding populations of this kangaroo rat are not known. The species may have the potential to be bred in captivity utilizing the protocols developed by Daly *et al.* (1984) for *D. merriami* and *D. microps* and by Roest (1991) for *D. heermanni*. Almost all of the range of the Texas kangaroo rat is on private lands. The species is known to occur in low numbers, however, in Copper Breaks State Park, Hardeman County, Texas (R.E. Martin and K.G. Matocha pers. obs.). Little of the habitat in this park is currently suitable for this species, although the Texas Parks and Wildlife Department has expressed interest in management efforts to ensure its survival (L. Pace pers. comm.).

Recommended action

- Develop detailed habitat and distribution maps for the known range of the species. A geographic information system (GIS) model developed by Shaw (1989) or the method used by Price and Endo (1989) would be useful.
- Conduct experiments to measure the effect of grass and forb densities on subsequent population levels of the species; an increase in grass cover may be detrimental to this rodent.
- Conduct controlled experiments to measure the role of

potential competitors (e.g., *Chaetodipus hispidus*) on densities of *D. elator*.

- Identify protected areas, including Copper Breaks State Park, Hardeman County, that could be managed to increase the densities of this species. A long-term goal would be to have a mean viable population size of 1,000 individuals or more in the reserves. These reserves would have to be managed to create and maintain conditions (short grasses and bare ground) that are favored by this species.

Dipodomys heermanni Le Conte 1853 Heermann's kangaroo rat

Aryan I. Roest

9 subspecies, 3 of conservation concern:

D. h. berkeleyensis Berkeley Hills kangaroo rat

D. h. dixonii Merced kangaroo rat

D. h. morroensis Morro Bay kangaroo rat

IUCN Red List Category

Dipodomys heermanni – Lower Risk, least concern (LR,lc)

D. h. berkeleyensis – Vulnerable (VU): B1;B2c

D. h. dixonii – Lower Risk, near threatened (LR,nt)

D. h. morroensis – Critically Endangered (CR): B1;B2c;D

Assignment of *D. h. berkeleyensis* is based on its very restricted distribution and observed decline in both extent and quality of its habitat; assignment of *D. h. dixonii* is based on its restricted distribution and absence of known immediate threats to its continued survival; assignment of *D. h. morroensis* is based on its severely restricted distribution, observed loss of habitat, and low number of known individuals.

Taxonomy and distribution

Dipodomys heermanni was last revised by Grinnell (1922). Patton *et al.* (1976) demonstrated that *D. californicus* is a species distinct from *D. heermanni*. Heermann's kangaroo rat is found primarily in the San Joaquin Valley of California, but also extends through interior valleys and mountains to the Pacific coast. *Dipodomys h. berkeleyensis* is known from the hills and valleys east of San Francisco Bay. *Dipodomys h. dixonii* is a small-bodied subspecies from grassland and savanna communities on the eastern margin of the San Joaquin Valley. *Dipodomys h. morroensis* is limited to disturbed areas (i.e. early successional stages) of coastal plant communities along the shore of Morro Bay. Morro Bay kangaroo rats are known only from a 10km² area centered around the community of Los Osos, at the south end of Morro Bay, in San Luis Obispo County, California. The animals are restricted to the sandy soil of ancient dune deposits which accumulated thousands of years ago (Roest 1982).

Remarks

Western peripheral populations of *D. heermanni* appear to be most severely impacted by urbanization and agricultural conversion of the species' native range. *Dipodomys h. berkeleyensis* has not been seen in the Berkeley Hills since the 1930s, and is almost certainly extinct there (J. L. Patton pers. comm.); surviving populations of these kangaroo rats may exist in hills further inland, although taxonomic studies are necessary to document their assignment to this subspecies.

The Morro Bay kangaroo rat has lost appropriate habitat as the city of Los Osos grew from a population of about 1,500 to over 14,000 during the past 30 years. The animals were last censused by live-trapping in 1986, at which time it was estimated that only 50 still existed, all on a privately owned parcel of about 13ha. None are now known to occur on nearby state park land and other protected areas, including a 20ha tract purchased several years ago as the Morro Bay Kangaroo Rat Ecological Reserve (Roest 1982, Gambs 1986). The surviving animals

are found only on private land, and the current landowner will not grant permission for government agents or biologists to live-trap on the property. Thus there is no current information available about the wild population. A recovery plan for the Morro Bay kangaroo rat prepared in 1982 (Roest 1982) recommended land acquisition and protection, vegetation management, and captive propagation as measures necessary to ensure survival. In 1992 a meeting of representatives from five groups with an interest in Morro Bay kangaroo rats was held in San Luis Obispo, at which time it was decided to actively consider acquisition of the property that still supports animals. Due to the high cost of local land near a seaside community, the cost may reach several million dollars. It appears to be the only approach which may still save the Morro Bay kangaroo rat from extinction.

Populations of *D. heermanni* in the San Joaquin Valley, although subject to extensive displacement by cultivation of the valley floor, are able to inhabit a wide variety of marginal and remnant habitat, and currently are not in jeopardy (Williams and Kilburn 1992). The Merced kangaroo rat (*D. h. dixonii*) is locally abundant but has a limited distribution.

In view of the precarious status of two coastal subspecies with limited ranges (*D. h. berkeleyensis* and *D. h. morroensis*), investigation of the status of a third coastal form with a limited distribution (*D. h. arenae*) appears warranted. Kelt (1988) reviewed the general biology of this species.

Conservation status and occurrence in captivity and protected areas

Dipodomys h. morroensis is a federal and state Endangered taxon. *Dipodomys h. berkeleyensis* and *D. h. dixonii* are both federal C2 candidate taxa. Populations of *D. h. berkeleyensis* may persist in the regional and state parks within its historic range. No populations of *D. h. dixonii* are known to be in protected areas. A captive breeding colony of *D. h. morroensis* was established at California Polytechnic State University in San Luis Obispo, California with 10



Morro Bay kangaroo rat,
Dipodomys heermanni
morroensis.

Aryan I. Roest

founder animals, captured between 1984 and 1986. At one time the colony included 29 animals (Roest 1991, Roberts and Rall 1991). Four were released into a semi-protected 4,000m² enclosure in 1988, but one burrowed out and the others also disappeared (Gambis and Nelson 1990). Mortality further reduced the colony, and the remaining animals (all captive-born in 1986 and 1987) first were transferred to a United States Fish and Wildlife Service facility in California, then to a research program at the National Zoo in Washington, D.C. The last of these animals died in captivity in 1991 (M. D. Matocq pers. comm.).

In May 1993 the California Department of Fish and Game, using funds obtained from the United States Fish and Wildlife Service through the Section 6 grant-in-aid program, contracted with the Museum of Vertebrate Zoology at the University of California, Berkeley, to develop methods for captive-breeding of *D. h. morroensis*. The University, using as a surrogate the closely related and geographically nearest subspecies, *D. h. arenae*, has successfully bred both wild-caught and captive-born kangaroo rats. A live-trapping program within the known range of *D. h. morroensis* was scheduled to begin in the fall of 1995 under the auspices of the Department of Fish and Game. If it is successful in finding the endangered subspecies, captured individuals will be taken to Berkeley for captive-breeding.

Recommended action

- Survey potential habitat in historical distribution of *D. h. berkeleyensis* and *D. h. arenae* to determine population and taxonomic status of these subspecies relative to adjacent subspecies of *D. heermanni*.
- Monitor populations of *D. h. dixonii* to detect and mitigate any serious threat due to habitat loss.
- Acquire the property that supports the last known colony of wild *D. h. morroensis*. Subsequent vegetation management of that site could increase the wild population to the point where transplants could be made to other protected areas (state park, ecological reserve, etc.), and could provide animals to begin a new captive colony at the University of California, Berkeley.
- Conduct intensive live-trapping surveys to determine whether *D. h. morroensis* persists at other sites.

Dipodomys ingens (Merriam 1904)

Giant kangaroo rat

David J. Hafner

IUCN Red List Category

Dipodomys ingens – Critically Endangered (CR): A1a;B2c

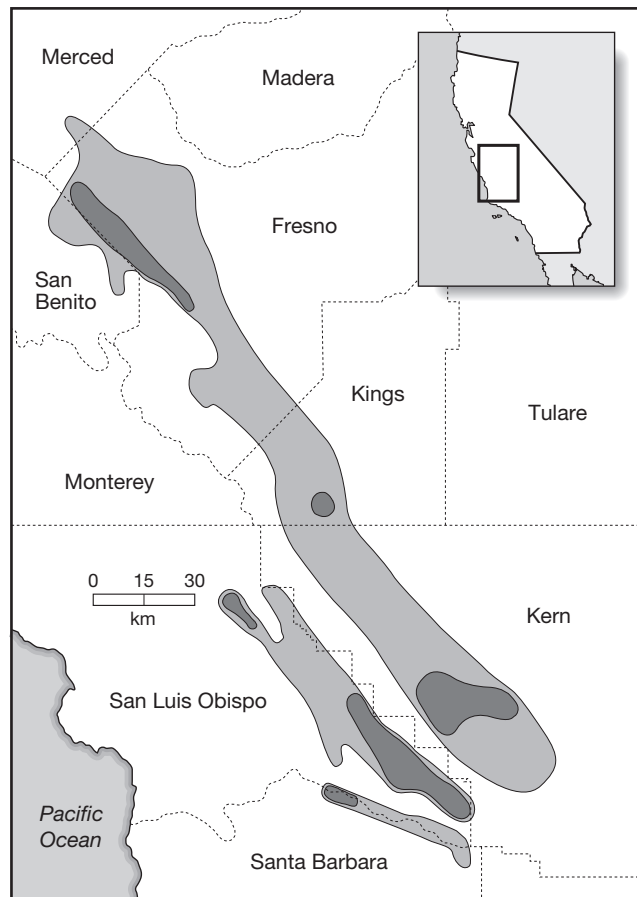
Assignment is based on the extreme loss of habitat observed and the observed and projected decline in both extent and quality of habitat of *D. ingens*.

Taxonomy and distribution

The giant kangaroo rat is the largest of more than 20 species in the genus *Dipodomys* (Best 1993b). Like most kangaroo rats, the giant kangaroo rat is primarily granivorous, but it also eats green vegetation. *Dipodomys ingens* appears to be closely related to the sympatric species, *D. heermanni* (Williams *et al.* 1993a).

Dipodomys ingens is endemic to the San Joaquin Valley of California, where it was formerly the dominant rodent of much of the annual desert-grassland on the southwestern margin of the valley (Grinnell 1932, Williams 1992) (Fig. 5.4). Historically, this kangaroo rat occupied a narrow band of gently sloping ground along the southern and western edge of the San Joaquin Valley (Williams and Kilburn 1992). According to Williams (1992), based on historical descriptions, the species was narrowly restricted to the more arid, sparsely vegetated communities on level or gently sloping ground and sandy-loam soils. Grinnell (1932), Shaw (1934), and Hawbecker (1951) all commented on the unique character of the fine sandy-loam soil to which *D. ingens* were restricted, noting that it was quite friable, yet firm and not subject to wind drifting. The historical

Figure 5.4. Historical (light shading) and current (dark) distribution of the giant kangaroo rat, *Dipodomys ingens*, in California's San Joaquin Valley (counties indicated).





Giant kangaroo rat,
Dipodomys ingens.

S.E. Braun

distribution nearly coincided with the distribution of marine sediment-derived soils on the southwestern margin of the valley (Williams 1992), and included the Tulare Basin, adjacent Carrizo Basin, and Cuyama and Panoche valleys.

Remarks

Much of the historical habitat of *D. ingens* has been destroyed by overgrazing, introduction of exotic plants, cultivation, and (to a lesser degree) oil and gas development and mineral mining operations. According to Williams (1992), much of the remaining habitat of the species was cultivated during the 1970s, with concomitant widespread application of rodenticides. Williams (1992) estimates that of the original 701,916ha of historical area, only 11,145ha were occupied by *D. ingens* in 1987, largely in marginal-quality, heavily grazed habitat. Fully 98.5% of the historical geographic range of the species has been developed or at least now does not support the species. Few of the extant habitats conform to the historical characteristics of preferred habitat, indicating their marginal quality (Williams 1992). Further, only 3460ha in six areas supported population densities described as typical by Grinnell (1932). Within these remaining six areas of higher density, all in the southeastern portion of the range, Williams (1992) noted further population decrease during 1982–1985, when the entire colony in the Cuyama Valley (Santa Barbara County) was apparently extirpated. Thus, of the extant range, populations of appreciable density may persist only in the Carrizo and Elkhorn Plains of southeastern San Luis Obispo County and near the Elk Hills in Kern County. Williams (1992) stressed the need to identify and protect those small core areas where colonies are more likely to survive natural stochastic events such as torrential rains and subsequent sheet flow from rapid runoff.

Williams *et al.* (1993b) report success of one translocated colony of *D. ingens* to formerly occupied habitat, while another colony translocated to a fallow grain field failed within one year, probably due to heavy predation. Williams (1992) and Williams and Kilburn (1991) had previously noted natural colonization of a fallow field from colonies in adjacent natural habitat, which indicated promise for this type of translocation. Williams *et al.* (1993b) listed specific recommendations for projects involving southern populations (included below). Williams and Kilburn (1991) reviewed the general biology of this species.

Conservation status and occurrence in captivity and protected areas

Because of extensive habitat loss, *D. ingens* was listed as Endangered by both the California Fish and Game Commission (in 1980) and the United States Fish and Wildlife Service (in 1987). Significant populations of the giant kangaroo rat occur on the Carrizo Plain Natural Heritage Reserve (San Luis Obispo County). Colonies are also known from Federal lands managed for multiple use. O'Farrell *et al.* (1987) reported extant colonies on the Elk Hills Naval Petroleum Reserve (Kern County), while colonies in the Panoche Hills of San Benito and Fresno Counties are found on Bureau of Land Management holdings used for grazing and hunting.

Recommended action

- Continue long-term population studies on populations in the Elkhorn Plains, including biannual censuses on grazed and nongrazed plots, measurement of seed caches, and differences in plant species composition and productivity on and around colonies.
- Establish a cooperative research program between the California Department of Fish and Game, United States

Fish and Wildlife Service, and United States Bureau of Land Management (and other entities) to assess no grazing, 3-year rest-rotation grazing, annual grazing, and controlled burns as management tools to maintain and enhance habitat for threatened and endangered species (including *D. ingens*) in the San Joaquin Valley.

- Establish small, temporary colonies of giant kangaroo rats to study reproduction, growth, and development.
- Relocate colonies of giant kangaroo rats to fallow fields where microrelief and plant cover have been modified to mimic conditions in natural colonies, and to vacant, formerly occupied habitat in Fresno, San Benito, Kings, Kern, San Luis Obispo, and Santa Barbara counties. Potential sites have been identified by Williams (1992).
- Conduct follow-up census of colonies verified by Williams (1992), and provide increased protection for isolated populations in San Benito-Fresno, Kings, and northern San Luis Obispo counties, which may harbor genetic variation critical to survival of the species.
- Conduct molecular genetic assay of the surviving metapopulations of giant kangaroo rat, and determine the degree of genetic variation between these metapopulations, between isolated colonies within each metapopulation, and within representative colonies.

***Dipodomys merriami* Mearns 1890 Merriam's kangaroo rat**

David J. Hafner

19 subspecies, 2 of conservation concern in North America (north of Mexico):

D. m. collinus Earthquake Valley kangaroo rat

D. m. parvus San Bernardino kangaroo rat

IUCN Red List Category

Dipodomys merriami – Lower Risk, least concern (LR,lc)

D. m. collinus – Data Deficient (DD)

D. m. parvus – Data Deficient (DD)

Assignment of the subspecies of conservation concern is based on the need for specific information on their population status, distribution, magnitude of habitat loss, and nature of any existing threats.

Taxonomy and distribution

Lidicker (1960) reviewed the taxonomy of this widespread species. Merriam's kangaroo rat has a very broad distribution throughout the western deserts, from northern Nevada to central Mexico, and from the Pacific coast to western Texas. *Dipodomys m. collinus* and *D. m. parvus* each have limited distributions adjacent to the Los Angeles-San Diego metropolitan areas. Lidicker (1960) remarked that *D. m. parvus* was one of the most highly differentiated

subspecies of *D. merriami*, and that it had nearly achieved species rank.

Remarks

The two California subspecies are unquestionably subjected to extensive (*D. m. parvus*) or potential (*D. m. collinus*) habitat loss due to rapid expansion of coastal metropolitan areas. The magnitude of this habitat loss has not been measured.

Conservation status and occurrence in captivity and protected areas

Dipodomys m. parvus is a federal C1 candidate taxon and a California Species of Special Concern; *D. m. collinus* is a federal C2 candidate taxon. No populations of either subspecies are known to occur in protected areas.

Recommended action

- Survey extant populations of *D. m. parvus* and *D. m. collinus* to determine population and distributional status and to quantify the nature and extent of habitat loss (if any).
- Depending on the extent of habitat loss in these subspecies, it may be necessary to take mitigative actions to preserve extant populations on their western margins. At the least, these populations should be monitored for further habitat loss.

***Dipodomys microps* (Merriam 1904) Chisel-toothed kangaroo rat; Great Basin kangaroo rat**

Blair Csuti

13 subspecies, 2 of conservation concern:

D. m. alfredi Gunnison Island kangaroo rat

D. m. leucotis House Rock Valley kangaroo rat

IUCN Red List Category

Dipodomys microps – Lower Risk, least concern (LR,lc)

D. m. alfredi – Data Deficient (DD)

D. m. leucotis – Vulnerable (VU): B1;B2c

Assignment of *D. m. alfredi* is based on the need for specific information on its population status; assignment of *D. m. leucotis* is based on its restricted distribution and inferred decline in both extent and quality of its habitat.

Taxonomy and distribution

Hall and Dale (1939) reviewed the taxonomy of *D. microps*. Csuti (1979) evaluated geographic patterns in ecology, genetics, and morphology in the species, but provided no taxonomic review. Durrant (1952) remarked on the high degree of morphological differentiation evident in *D. m. alfredi* on Gunnison Island, a small island (about

1km²) and one of the few in the Great Salt Lake that has not been connected to the mainland in historic times.

The chisel-toothed kangaroo rat has a broad distribution in and around the Great Basin, with narrow extensions into the Mojave Desert of California, southeastern Oregon, southwestern Idaho, and northern Arizona. Disjunct populations occur in southern California (Joshua Tree National Monument) and in southwestern Utah and adjacent northwestern Arizona (Csuti 1979). *Dipodomys m. alfredi* is restricted to Gunnison Island in the Great Salt Lake, Utah. *Dipodomys m. leucotis* is found in the House Rock Valley of northern Arizona. This peripheral population appears to be separated from other *D. microps* populations by unsuitable habitat (Spicer and Johnson 1988). *Dipodomys m. leucotis* occurs only along a 40km stretch of the Marble Canyon platform on the west side of the Colorado River in Coconino County, northern Arizona.

Remarks

No information is currently available regarding the status of the Great Salt Lake insular subspecies, *D. m. alfredi*. The House Rock Valley form (*D. m. leucotis*) has rarely been collected and occurs at low density where it is present. Only 62 animals have been captured since 1929, all from eight sites (Spicer and Johnson 1988, SWCA Inc. 1990). Forty-one of the 62 specimens were taken prior to 1938; only 11 specimens or observations are recorded since 1986. These figures may suggest a decline over the last 50 years, although no factors leading to general decline can be identified (Spicer and Johnson 1988), and they may instead reflect a decline in collecting effort. Hardy (1949) captured one specimen 0.8km east of the Navajo Bridge over the Colorado river and speculated that construction of the bridge in 1929 allowed the subspecies to cross the river. Spicer and Johnson (1988) found no sign of the subspecies east of the Colorado River, and concluded that heavy livestock trampling and browsing rendered the vegetation too degraded to be suitable habitat for *D. m. leucotis*.

This kangaroo rat occurs in Great Basin desert shrub communities dominated by shadscale (*Atriplex confertifolia*) or blackbrush (*Coleogyne ramosissima*) with sparse grass cover. Spicer and Johnson (1988) estimate that 182km², or 30% of the 607km² Houserock Valley area, is suitable habitat for *D. m. leucotis*. They found an average of 6.05 (±1.84) occupied burrow complexes per ha. Without further study of the distribution and density of the subspecies' populations, the current population size cannot be estimated, although, if most apparently suitable habitat is occupied, it would not appear to be in immediate danger of extinction. For a related species (*Dipodomys stephensi*), Burke *et al.* (1991) calculated that a population of 13, 210 individuals would have a 95% chance of persisting for 100 years. They recommended a minimum of three such viable populations be maintained for long-term persistence of the taxon.

Most of the suitable habitat for *D. m. leucotis* occurs on federal land managed by the Bureau of Land Management. These lands are leased for cattle grazing; grazing pressure is not currently intensive enough to damage habitat for the kangaroo rat. Intensive browsing and trampling of shrubs by cattle would represent a threat to it. Although Spicer and Johnson (1988) knew of no plans for changes in grazing practices or 'range improvement', eliminating shrub cover from large areas by bulldozing or chaining could render most if not all of Houserock Valley unsuitable for this rodent. Predation by free-ranging or feral house cats could be a local threat to populations of the subspecies living near settlements around Glen Canyon National Recreation Area. Hayssen (1991) reviewed the general biology of this species.

Conservation status and occurrence in captivity and protected areas

Dipodomys m. alfredi and *D. m. leucotis* are federal C2 candidate taxa; *D. m. leucotis* is also a candidate taxon for listing in Arizona. The majority of records for *D. m. leucotis* occur in that portion of Bureau of Land Management land between U. S. Alternate Highway 89 and the Vermilion Cliffs. Most of this area has been designated the Vermilion Cliffs Wilderness by the Bureau of Land Management (Spicer and Johnson 1988). Grazing is permitted in the wilderness area, and some springs along the base of the Vermilion Cliffs have been developed for domestic water supplies. No populations of *D. m. alfredi* are known to occur in captivity or protected areas.

Recommended action

- Conduct a field survey to determine the status of *D. m. alfredi* on Gunnison Island.
- Compare Great Salt Lake insular subspecies (*D. m. alfredi*) to populations of *D. microps* on the adjacent mainland using modern genetic techniques to evaluate the degree and nature of differentiation.
- Protect Great Salt Lake insular forms from human disturbance, regardless of their degree of differentiation from mainland forms; no attempt should be made to prevent natural contact with mainland populations.
- Conduct field surveys to determine distribution, density, population size, and metapopulation structure of *D. m. leucotis*.
- Establish at least three areas of optimal *D. m. leucotis* habitat on public land to be managed primarily for the maintenance of viable populations of this rodent, other native species, and natural ecosystems.
- Monitor private and public land use management plans that could result in immediate or cumulative degradation of large areas of suitable habitat within the distribution of *D. m. leucotis*.
- Establish experimental exclosures to document the effects of various levels of livestock grazing on habitat quality for *D. m. leucotis*.

Dipodomys nitratoides Merriam 1894
San Joaquin kangaroo rat
Bernard Peyton

3 subspecies, all of conservation concern:
D. n. brevinasus short-nosed kangaroo rat
D. n. exilis Fresno kangaroo rat
D. n. nitratoides Tipton kangaroo rat

IUCN Red List Category

Dipodomys nitratoides – Lower Risk, near threatened (LR,nt)
D. n. brevinasus – Lower Risk, near threatened (LR,nt)
D. n. exilis – Critically Endangered (CR): B1;B2c
D. n. nitratoides – Critically Endangered (CR): A1c

Assignment of the species is based on the threatened status of two of the three recognized subspecies. Assignment of *D. n. brevinasus* is based on its restricted distribution and apparent absence of any immediate threat to its continued survival; assignment of *D. n. exilis* is based on its severely restricted distribution, and observed and projected loss of habitat extent and quality; assignment of *D. n. nitratoides* is based on the extensive loss of habitat that it has experienced.

Taxonomy

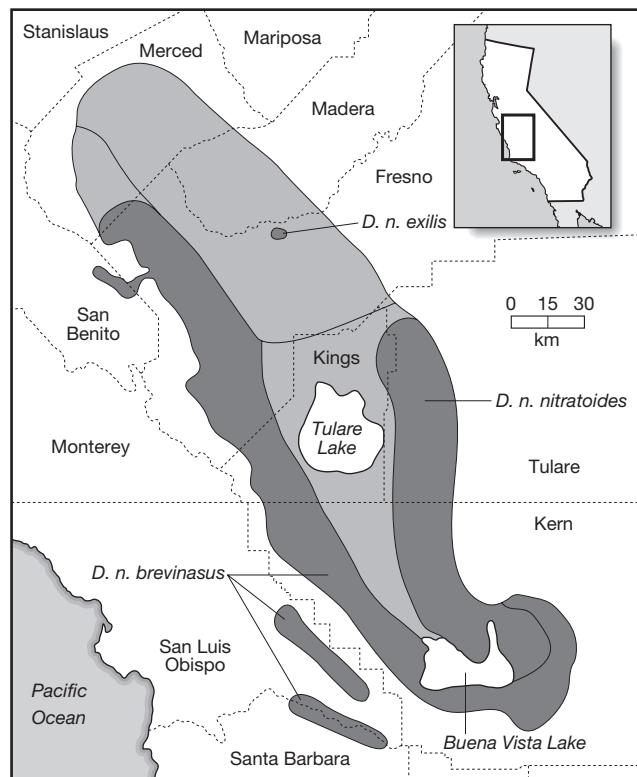
Hoffman (1975) refuted Booloottian’s (1954) claim that *D. n. nitratoides* and *D. n. exilis* were synonymous, and noted that specimens of *D. n. brevinasus* from the iodine bush communities in Livingston, Merced County, and Firebaugh, Madera County, were intermediate between *D. n. brevinasus* and *D. n. exilis* but seemed closest to the latter. Williams *et al.* (1993a) considered the area north of the former Tulare Lake in southern Fresno and northern Kings counties to be a probable area of intergradation between populations of *D. n. exilis* and *D. n. nitratoides*. (Pluvial Tulare Lake reached a maximum size of 4,100km² during the last glacial interval; only the lake bed remains today; Smith and Street-Perrott 1983.) In Merced County, Williams (unpubl. data) reported specimens of *D. nitratoides* from the valley floor iodine bush community (*Allenrolfea* sp.) that appeared intermediate between *D. n. brevinasus* and *D. n. exilis*. Along the western edge of Kern County, populations of *D. n. brevinasus* in the foothills of the Temblor Range and Elk Hills are contiguous with populations of *D. n. nitratoides* on the valley floor. The California Aqueduct defines the boundary between these subspecies and constitutes at least a partial barrier to dispersal. San Joaquin kangaroo rats in western Kern County appear to be part of an interbreeding population that extends from the foothills to the valley floor.

Distribution

The smallest of the 20 species of kangaroo rats, *Dipodomys nitratoides* is endemic to the San Joaquin Valley of

California (Fig. 5.5) and is geographically isolated from its nearest relative, *D. merriami*, by the Sierra Nevada and Transverse ranges. Two subspecies, *D. n. exilis* and *D. n. nitratoides*, are restricted to the valley floor of the San Joaquin Valley. The historic range of *D. n. exilis* included alkaline sink grassland and saltbush communities of the floor of the San Joaquin Valley from Kings River in the south to Merced River in the north, from Fresno Slough in the west, and east to the city of Fresno (Culbertson 1934, San Joaquin Valley Drainage Program 1990). Today the subspecies is restricted to approximately 160ha west of the town of Kerman in Fresno County (Hoffman and Chesemore 1982, Chesemore and Rhodehamel 1992). At one time *D. n. nitratoides* occupied most of the alkaline shrub and annual grassland habitat on the valley floor of the Tulare Basin from approximately Lemoore and Hanford in the north, to Visalia, Tipton, and Delano in the east, to Bakersfield and the shores of Buena Vista Lake in the south; and to the western quarter of Tulare County and the northwestern quarter of Kern County (San Joaquin Valley Drainage Program 1990). The current range is restricted to remnant patches surrounded by agriculture from approximately the foothills of the Tehachapi Mountains in southern Kern County to the northern boundaries of Kings County, east of the Kettleman and

Figure 5.5. Historical (light shading) and current (dark) distribution of three subspecies of the San Joaquin kangaroo rat, *Dipodomys nitratoides*, in California’s San Joaquin Valley (counties indicated). Tulare and Buena Vista Lakes are now dry.



Lost Hills. The southeast range limit is near Bakersfield, and on the southwest is the old shore line of Lake Buena Vista (Williams *et al.* 1993a). The most widespread subspecies, *D. n. brevinasus*, inhabits annual grasslands and shrub communities above the valley floor along the western side of the San Joaquin Valley from Merced County (in the north) south to the mouth of San Emigdio Creek, Kern County. The range then extends in a narrow band above the valley floor to the eastern side of the San Joaquin Valley and north to Poso Creek, east of Bakersfield. *Dipodomys n. brevinasus* also occurs in the Panoche Valley in eastern San Benito County, on the Carrizo Plain, San Luis Obispo County, and in the upper Cuyama Valley in San Luis Obispo and Santa Barbara counties (Williams *et al.* 1993a).

Remarks

The major threat to both *D. n. nitratoides* and *D. n. exilis* is loss and degradation of both the occupied range and the potential range they could colonize, either naturally or by reintroduction. Populations of both valley subspecies are small, isolated, and surrounded by inhospitable agricultural land, which leaves them highly vulnerable to local extinctions. In the case of *D. n. nitratoides*, populations often number as few as 10–50 individuals and occur in such restricted areas as the median strips of highways. The threats from close proximity to agriculture include rodenticide poisoning, increased road mortalities, and overgrazing by sheep. Grazing is often preceded by burning of the sparse shrub cover, which provides preferred sites for foraging and burrowing of *D. nitratoides*. The effects of overgrazing by livestock on the food supply of *D. nitratoides* are not known, but the soil impaction and puncturing of burrow systems by livestock increase mortalities during floods. In the absence of overgrazing, the loose friable soils on slightly elevated hummocks that are the preferred environment for burrows resist flood damage. Additional threats include the loss of remaining habitat due to construction of drainage evaporation ponds and the potential damage to kangaroo rat populations and their insect food supplies from pesticide overdrift (Williams 1985). Some level of grazing is known to be important to maintain favorable habitat conditions for *D. n. nitratoides* (Williams and Germano 1991) and probably for *D. n. brevinasus*, but the long-term effects of livestock grazing, fire, oil development, and pesticide application are not known.

Habitat conversion has had a less severe impact on the range of *D. n. brevinasus* than on that of the other two subspecies. Agricultural impact is less severe in the foothills (habitat of *D. m. brevinasus*) than on the valley floor, and sizeable areas owned by the energy industry, such as the 17,375ha Naval Petroleum Reserve in western Kern County, have not been disc-plowed and consequently contain large populations of *D. n. brevinasus*. Population



T.L. Best

San Joaquin kangaroo rat, *Dipodomys nitratoides*.

densities of 60 to 80 short-nosed kangaroo rats per ha can be found in shrubless grasslands as well as drainages with sparse grass cover and with over 25% shrub cover; the other subspecies are most often found in areas with some shrub cover. Soil in the foothills is not as friable and powdery as that of the valley floor, and burrow systems in the foothills thus withstand grazing impact better than burrows on the valley floor. Flooding is not nearly as severe a problem in the foothills as on the valley floor.

Dipodomys n. brevinasus populations did well relative to the larger kangaroo rat species (*D. ingens* and *D. heermanni*) populations during the 5–6 year drought that ended in 1991 in both the Carrizo Plain, San Luis Obispo County, and western Kern County. Populations of *D. n. brevinasus* dropped to 8–20 individuals per ha, approximately 25% of the density found during the middle (1988) and end of the drought (1991). Populations of the larger-bodied kangaroo rat species declined during the same period to a few individuals per ha or were not found. Although female *D. n. brevinasus* were estrous during the latter drought years of 1989–1990, males became inactive with recrudescing testes, thereby possibly reserving energy for individuals of both sexes for maintenance (Peyton unpubl. data). No information is available on potential competitive interactions between *D. nitratoides* and sympatric congeneric species, *D. ingens* and *D. heermanni*. Best (1991) reviewed the general biology of this species.

Conservation status

Both *D. n. exilis* and *D. n. nitratoides* are listed as Endangered by the State of California and by the United States Fish and Wildlife Service. *Dipodomys n. exilis* was considered extinct prior to its rediscovery in 1934 near the town of Kerman (Culbertson 1934). During the five years prior to its being listed as Endangered by the State of California in 1980, the range of *D. n. exilis* had declined from roughly 6,070ha to less than 2,025ha (San Joaquin Valley Drainage Program 1990), and it was listed as a federal Endangered taxon in 1985 due to rapid conversion of the remaining saltbush community to agriculture and

urban uses. By 1985, agriculture and urban use had occupied roughly 96% of the historic range of *D. n. nitratoides*, and it was listed as a federal Endangered taxon in 1988 and by the State of California in 1989. *Dipodomys n. brevinasus* is a federal C2 candidate taxon.

Occurrence in captivity and protected areas

Dipodomys nitratoides has been bred in captivity (Eisenberg 1967) and one population has been transplanted with unknown results. The entire known range of *D. n. exilis* is currently included in 350ha of federally designated critical habitat in two State of California-owned parcels: the Alkaline Sink Ecological Reserve, and a portion of the Mendota Wildlife Area (San Joaquin Valley Drainage Program 1990). Roughly 10% of the present range of *D. n. nitratoides* is managed by the State (Allensworth Ecological Reserve), or Federal governments (Pixley National Wildlife Refuge), and The Nature Conservancy (Paine Preserve). Currently, *D. n. brevinasus* is protected on a 60,500ha reserve in the Carrizo Plain, San Luis Obispo County, managed jointly by State (California Department of Fish and Game), Federal (Bureau of Land Management), and non-governmental agencies (The Nature Conservancy). The subspecies also occurs on the Elkhorn Ecological Reserve in the adjacent Elkhorn Plain, San Luis Obispo County, a 65ha parcel owned by the State of California and managed by the California Department of Fish and Game. *Dipodomys n. brevinasus* shares protection with *D. n. nitratoides* on the Lokern Reserve, an 800ha reserve established by The Nature Conservancy that straddles Lokern Road near the town of McKittrick, and in Cole's Levy Ecosystem Preserve, a 2,585ha parcel owned by ARCO that extends from the southern end of Buena Vista Lake to the Elk Hills, both on the western edge of Kern County. ARCO plans to add at least 250ha to each of these protected areas in the near future.

Recommended action

- The future status of the San Joaquin kangaroo rat is dependent on the establishment of reserves encompassing the largest populations and protecting corridors between them. Representatives from the seven federal agencies, five state agencies, The Nature Conservancy, and the energy industries that share management and regulatory responsibilities for the San Joaquin kangaroo rat met with biological consultants to promote a coordinated effort. A San Joaquin Valley Biological Technical Committee was formed and plans for a reserve system have been drafted, based on extensive surveys of threatened and endangered taxa in the southern half of the San Joaquin Valley. Conservation of *D. n. brevinasus* is dependent on the future land use policies of the energy companies who own roughly half the land where the subspecies occurs. Specific recommendations are:

- Survey the remaining populations of the San Joaquin kangaroo rat, particularly in the northern half of the San Joaquin Valley where development pressures are greatest. Efforts should focus on determining the metapopulation structure of the species and could be coupled with surveys of other threatened and endangered taxa such as the San Joaquin kit fox (*Vulpes macrotis mutica*).
- Develop reliable methods of distinguishing the presence of San Joaquin kangaroo rats (scats, burrows) from sympatric congeners without the use of live traps.
- Determine the level of genetic differentiation within and among the three subspecies.
- Initiate long-range studies on the natural history and demographics of the San Joaquin kangaroo rat as a basis for the intensive management needed to maintain valley floor populations. Information is needed to permit production of a life table and population modeling, especially for *D. n. exilis* and *D. n. nitratoides*.
- Expand studies of microhabitat use, predator avoidance behavior, population structure, survivorship, mating behavior, and dispersal of the three subspecies of *D. nitratoides*. Studies should include monitoring populations in different microhabitats and under different intensities of human use, and evaluate the long-term effects of livestock grazing, fire, oil development, and pesticide application.
- Study relationships between community members, particularly competition between *D. nitratoides*, *D. ingens*, and *D. heermanni*.

***Dipodomys stephensi* (Merriam 1907) Stephens' kangaroo rat**

Michael J. O'Farrell

IUCN Red List Category

Dipodomys stephensi—Lower Risk, conservation dependent (LR,cd)

Assignment is based on the assumption that the Habitat Conservation Plan, prepared by Riverside County and targeting *D. stephensi*, has provided sufficient preserve sites and will be fully implemented.

Taxonomy and distribution

Stephens' kangaroo rat is generally considered to be related to *D. heermanni* (Bleich 1977), and is most similar morphologically to the southern subspecies of *D. heermanni* (Lackey 1967, O'Farrell 1992a). Lackey (1967) stated that one of two allopatric populations in San Diego County that was referred by Huey (1962) to *D. cascus* was similar to, but recognizably distinct from the larger northern population in Riverside County, but did not recommend subspecific recognition of the populations.

Dipodomys stephensi is restricted to western Riverside County, portions of northern San Diego County, and extreme southwestern San Bernardino County, California. The species is adapted for open grassland habitats dominated by annual forbs and avoids shrublands with greater than 32% aerial cover (M. J. O'Farrell *in litt.*). Preferred habitat comprises intermediate seral associations that become unsuitable as climax shrublands develop (O'Farrell 1992b).

Remarks

Stephens' kangaroo rats inhabit areas with soils and topography most suited for agriculture and building development, and its known range is centered in the fastest growing area of southern California. Although a significant portion of the species' range has been permanently destroyed, several major remaining populations have been located (O'Farrell and Uptain 1989, O'Farrell 1992b). Several new locations have been discovered outside the current range (S.J. Montgomery pers. comm.), but distribution maps are not yet available. All unpublished technical reports on the distribution of *D. stephensi* are on deposit at the United States Fish and Wildlife Service Field Office, 2730 Loker Avenue West, Carlsbad, CA 92008. The species currently inhabits non-native grassland, but certain components, such as brome grasses, are detrimental to prolonged occupation. Bleich (1977) reviewed the general biology of this species.

Conservation status

Dipodomys stephensi was listed as Rare by the California Fish and Game Commission in 1971. This status was changed in 1984 with the passage of the California Endangered Species Act, when all Rare species became classified as Threatened. The species was federally listed as Endangered in 1988 (United States Fish and Wildlife Service 1988), prompting Riverside County to begin preparation of a Habitat Conservation Plan that targets *D. stephensi*. Six major areas have been designated for study as potential preserve sites, and some land has been purchased within these areas for preserve use. This effort is being coordinated within a county-wide, multi-species reserve system.

Occurrence in captivity and protected areas

The species has been held temporarily in captivity for the purpose of relocation studies (O'Farrell pers. obs.). Most of the major *D. stephensi* populations occur within the boundaries of existing park or preserve lands, including Lake Perris State Park, San Jacinto Wildlife Area, Sycamore Canyon Park, Lake Mathews Ecological Reserve, and the newly formed Roy E. Shipley Reserve.

Recommended action

- Conduct field studies to determine the number and size of preserves and optimal habitat necessary for the long-term survival of the species.

- Complete and initiate the Habitat Conservation Plan for Riverside County, which should include plans for dispersal corridors between established preserves. The present trend to incorporate *D. stephensi* preserve lands within multi-species, multi-habitat reserves should be encouraged.
- Establish a long-term monitoring program within each preserve location to assess habitat and population trends.
- Establish a management program to maintain habitat within optimal conditions.

Microdipodops megacephalus

Merriam 1891

Dark kangaroo mouse

David J. Hafner and John C. Hafner

13 subspecies, 2 of conservation concern:

M. m. atrirelictus Owyhee River kangaroo mouse

M. m. nexus Izenhood kangaroo mouse

IUCN Red List Category

Microdipodops megacephalus – Lower Risk, least concern (LR,lc)

M. m. atrirelictus – Vulnerable (VU): D2

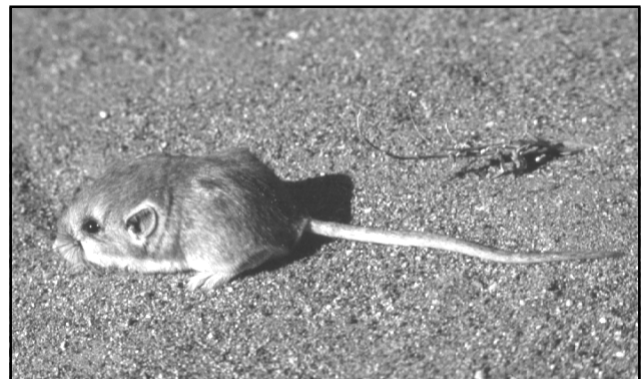
M. m. nexus – Data Deficient (DD)

Assignment of *M. m. atrirelictus* is based on its occurrence at a single site. Subspecific validity of *M. m. nexus* remains to be confirmed based on genetic comparison with neighboring populations of *M. megacephalus*.

Taxonomy and distribution

Hafner *et al.* (1979) evaluated genetic interactions of the two species of *Microdipodops* in sympatry, and demonstrated that they behaved as distinct species at a purported zone of hybridization. Hafner (1981) revised the taxonomy of the species and evaluated evolutionary relationships and biogeography of the genus. He questioned the subspecific validity of *M. m. nexus*, but retained it as

Dark kangaroo mouse, *Microdipodops megacephalus*.



J. Harris

a subspecies pending investigation of genetic relationships with neighboring subspecies. Hafner (1985) named a new subspecies, *M. m. atrirelictus*, for a highly distinctive, disjunct population in southern Idaho.

Kangaroo mice (*Microdipodops*) are confined to the Great Basin of Nevada and parts of surrounding California, Oregon, Idaho, and Utah. Within the Great Basin, they are further restricted to xeric, sandy habitats, often bordering alkaline dry lakes and sinks. Of the two species, the dark kangaroo mouse (*M. megacephalus*) occupies higher elevations and is more widespread, occurring in all five states (above). Hafner *et al.* (1996) studied ecological interactions of *M. pallidus* and *M. megacephalus* in sympatry. *Microdipodops m. atrirelictus* is known only from one locality, 11mi [17.7km] S and 44.2mi [71.1km] W Riddle, 5,000ft [1,524m], Owyhee County, Idaho (Hafner 1985). *Microdipodops m. nexus* has an extremely limited distribution in north-central Nevada, and may already be extirpated from its type locality (Hafner 1981).

Remarks

Although no current threats to either *M. m. atrirelictus* or *M. m. nexus* are known, their restricted and isolated distributions leave both subspecies particularly vulnerable to habitat alteration. Throughout the remainder of the range of the genus, other populations have suffered from introduction of weedy grasses and cultivation of dry sinks by irrigation from limited pockets of water that collect under the pans (J.C. Hafner pers. obs.). Although the supply of water may be limited, habitat alteration at these cultivated sites is extreme, resulting in wholesale displacement of *Microdipodops*. In addition to these human-related habitat changes, apparently natural shifts in vegetative zones have resulted in the replacement of rodent communities including *Microdipodops* by those including *Dipodomys deserti*, and vice versa (J. C. Hafner pers. obs.). Natural and human-related habitat modifications may have amplified effects on the already fragmented, patchy distribution of *Microdipodops*. O'Farrell and Blaustein (1974a) reviewed the general biology of this species.

Conservation status and occurrence in captivity and protected areas

Neither subspecies currently has any protected status. Breeding populations of *Microdipodops megacephalus* have been maintained with limited success for several generations (D.J. Hafner pers. obs., J.C. Hafner pers. obs., W.L. McNeil pers. comm.). No populations of either subspecies are known to occur in protected areas.

Recommended action

- Initiate a survey and monitoring program to detect major human-induced and natural habitat alterations that affect the distribution of *Microdipodops*, specifically to include *M. m. atrirelictus* and *M. m. nexus*.

- Compare *M. m. nexus* to neighboring populations of *M. megacephalus* in order to evaluate validity of its subspecific distinction.
- Survey appropriate habitat in the vicinity of the type locality of *M. m. atrirelictus* to determine its population status and distributional limits, and consider potential protected area(s) for conservation of this isolated subspecies.

***Microdipodops pallidus* Merriam 1901** **Pale kangaroo mouse**

David J. Hafner and John C. Hafner

5 subspecies, 1 of conservation concern:

M. p. restrictus Soda Spring Valley kangaroo mouse

IUCN Red List Category

Microdipodops pallidus – Lower Risk, least concern (LR,lc)

M. p. restrictus – Vulnerable (VU): D2

Assignment of the subspecies of conservation concern is based on its occurrence at a single known locality.

Taxonomy and distribution

Hafner *et al.* (1979) evaluated genetic interactions of the two species of *Microdipodops* in sympatry, and demonstrated that they behaved as distinct species at a purported zone of hybridization. Hafner (1981) revised the taxonomy of the species and evaluated evolutionary relationships and biogeography of the genus. Hafner (1985) named a new subspecies, *M. p. restrictus*, from Soda Spring Valley at the southern end of Rhodes Salt Marsh in Mineral County, Nevada.

Kangaroo mice (*Microdipodops*) are confined to the Great Basin of Nevada and parts of surrounding California, Oregon, Idaho, and Utah. Within the Great Basin, they are restricted to xeric, sandy habitats, often bordering alkaline dry lakes and sinks. Of the two species, the pale kangaroo mouse (*M. pallidus*) has a more restricted distribution at lower elevations of Nevada and California in the immediate rain-shadow of the Sierra Nevada. Hafner *et al.* (1996) studied ecological interactions of *M. pallidus* and *M. megacephalus* in sympatry. *Microdipodops p. restrictus* is known only from the type locality, 8.9mi [14.3km] S, 1.2mi [1.9km] E Mina, 4,400ft [1,341m], Mineral County, Nevada.

Remarks

Although no current threats to *Microdipodops p. restrictus* are known, its restricted and isolated distribution leaves it particularly vulnerable to habitat alteration. Throughout the remainder of the range of the genus, other populations have suffered from introduction of weedy grasses and cultivation of dry sinks by irrigation from limited pockets

of water that collect under the pans (J.C. Hafner pers. obs.). Although the supply of water may be limited, habitat alteration at these cultivated sites is extreme, resulting in wholesale displacement of *Microdipodops*. In addition to these human-related habitat changes, apparently natural shifts in vegetative zones have resulted in the replacement of rodent communities including *Microdipodops* by those including *Dipodomys deserti*, and vice versa (J. C. Hafner pers. obs.). Natural and human-related habitat modifications may have amplified effects on the already fragmented, patchy distribution of *Microdipodops*. O'Farrell and Blaustein (1974b) reviewed the general biology of this species.

Conservation status and occurrence in captivity and protected areas

This subspecies currently has no protected status. Breeding populations of *Microdipodops pallidus* have been maintained with limited success for several generations (D.J. Hafner pers. obs., J.C. Hafner pers. obs., W.L. McNeil pers. comm.). No populations are known to occur in protected areas.

Recommended action

- Initiate survey and monitoring program to detect major human-induced and natural habitat alterations that affect the distribution of *M. p. restrictus*.
- Survey appropriate habitat in the vicinity of the type locality of *M. p. restrictus* to determine its population status and distributional limits, and consider potential protected area(s) for conservation of this isolated subspecies.

***Perognathus alticola* Rhoads 1894 White-eared pocket mouse**

James M. Sulentic

2 subspecies, both of conservation concern:

P. a. alticola White-eared pocket mouse

P. a. inexpectatus Tehachapi white-eared pocket mouse

IUCN Red List Category

Perognathus alticola – Lower Risk, near threatened (LR,nt)

P. a. alticola – Critically Endangered (CR): B1;B2b

P. a. inexpectatus – Lower Risk, near threatened (LR,nt)

Assignment of the species is based on its restricted distribution and threatened status of one of two recognized subspecies. Assignment of *P. a. alticola* is based on its severely restricted and fragmented distribution and observed decline in area of occupancy; assignment of *P. a. inexpectatus* is based on its restricted distribution and apparent absence of any immediate threat to its continued survival.

Taxonomy and distribution

Perognathus alticola is clearly a disjunct relict of *P. parvus*, the nearest population of which (*P. p. xanthonotus*) is found in the Tehachapi Mountains immediately east of the range of *P. a. inexpectatus*. Sulentic (1983) argued for full specific recognition of *P. a. inexpectatus*, but Williams *et al.* (1993a) recommended retention of the current taxonomy until further *P. a. alticola* could be collected. Some still use the original but incorrect specific epithet, *alticolus*, the spelling of which was amended without comment by Osgood (1900).

The white-eared pocket mouse is known from two disjunct mountain ranges in southern California. Populations in yellow pine forest and bracken fern habitat in the western San Bernardino Mountains (1,615 to 1,830m elevation) are referred to *P. a. alticola*. The entire known range of *P. a. alticola* is in the San Bernardino National Forest and within a 4km radius of its type locality, and is a private inholding. Populations from scattered localities along the San Andreas Fault from the Tehachapi Mountains to Mt. Pinos (1,030 to 1,830m elevation) are referred to *P. a. inexpectatus*. The type locality of *P. a. inexpectatus* is within the Los Padres National Forest. More recently, specimens have been collected on private ranch land within the Tehachapi Mountains (J.M. Sulentic pers. obs.). *Perognathus a. inexpectatus* occurs in yellow pine forest and pinyon-juniper woodland at higher elevations, and chaparral and coastal sage scrub communities at lower elevations. The species is not known from the San Gabriel Mountains, located between the two subspecies.

Remarks

At best, the two subspecies of *P. alticola* are rare throughout their range; *P. a. alticola* may be extinct. From June 1979 through June 1982, nearly 18,000 trap-nights at historic collecting localities and other suitable areas within the potential range of both taxa yielded 11 specimens of *P. a. inexpectatus*, while no specimens of *P. a. alticola* were found (Sulentic 1983).

Conservation status and occurrence in captivity and protected areas

Both subspecies are federal C2 candidate taxa and California Species of Special Concern. No populations of either subspecies are known to occur in protected areas, and no individuals of either subspecies are currently known to be held in captivity. However, specimens have been maintained in the laboratory for short periods (Williams 1978, Sulentic 1983).

Recommended action

- Conduct additional surveys to document surviving populations of both subspecies, particularly *P. a. alticola*.

- If one or more populations of *P. a. alticola* survive, it may be necessary to initiate emergency protective measures of that habitat area to ensure the subspecies' survival.
- Determine the specific habitat needs of the species, and adjust resource management practices within the national forests in which *P. alticola* occurs to ensure they are compatible with those needs.
- Identify private landowners whose properties support the species and work with them on land management strategies of benefit to both.

***Perognathus flavus* Baird 1855** **Silky pocket mouse**

David J. Hafner

14 subspecies, 1 of conservation concern in North America (north of Mexico):

P. f. goodpasteri Goodpaster's silky pocket mouse

IUCN Red List Category

Perognathus flavus – Lower Risk, least concern (LR,lc)

P. f. goodpasteri – Lower Risk, near threatened (LR,nt)

Assignment of the subspecies of conservation concern is based on its restricted distribution; there are no known threats to its continued survival.

Taxonomy and distribution

Wilson (1973), based on morphological data, considered *P. flavus* to include *P. merriami* of southeastern New Mexico, Texas, and northeastern Mexico, but Lee and Engstrom (1991) considered *P. merriami* to be a distinct species based on biochemical data. The two species are very similar morphologically. The silky pocket mouse, *P. flavus*, is broadly distributed over the arid grasslands and deserts of the southwestern Great Plains, Chihuahuan Desert, and limited portions of the Sonoran Desert. *Perognathus f. goodpasteri* has a restricted distribution on grasslands of the Mogollon Plateau of eastern Arizona.

Remarks

Hoffmeister (1986) reported localities for *P. f. goodpasteri* that substantially increased the range of the subspecies, although its distribution is still quite restricted. There are no known threats to the survival of this subspecies.

Conservation status and occurrence in captivity and protected areas

Perognathus f. goodpasteri is a federal C2 candidate taxon. No populations are known to occur in captivity or in protected areas.

Recommended action

- Conduct additional surveys to document extant distribution and status of *P. f. goodpasteri*.
- Determine nature and severity of any threats to habitat of *P. f. goodpasteri*.

***Perognathus inornatus* Merriam 1889** **San Joaquin pocket mouse**

David J. Hafner

3 subspecies, 2 of conservation concern:

P. i. neglectus McKittrick pocket mouse

P. i. psammophilus Salinas pocket mouse

IUCN Red List Category

Perognathus inornatus – Lower Risk, least concern (LR,lc)

P. i. neglectus – Lower Risk, near threatened (LR,nt)

P. i. psammophilus – Lower Risk, near threatened (LR,nt)

Assignment of both subspecies of conservation concern is based on their restricted distribution and the apparent absence of immediate threats to their continued survival.

Taxonomy and distribution

There is extensive confusion regarding the relationships within the *longimembris* group of pocket mice (*P. longimembris*, *P. inornatus*, and *P. amplus*) and within subspecies of *P. inornatus*. According to Williams *et al.* (1993a), *P. inornatus* may include two or three species. Misidentification of pocket mice has added to the existing confusion. Specimens of *P. l. longimembris* from the Central Valley of California represent misidentified *P. inornatus*, and specimens of *P. l. psammophilus* from the interior valleys and foothills of California's Coast Range appear to be juvenile and subadult *P. inornatus*. Williams *et al.* (1993a) referred *P. l. psammophilus* to *P. inornatus* and restricted its distribution to the Salinas Valley, referred pocket mice from the Carrizo Plain (formerly *P. l. psammophilus* and *P. i. sillimani*) to *P. i. neglectus*, and considered it likely that *psammophilus* will prove to be a synonym of *neglectus*. As currently recognized, the San Joaquin pocket mouse occupies the Central Valley (Sacramento and San Joaquin valleys), surrounding foothills, and extreme western Mojave Desert of California (Williams *et al.* 1993a).

Remarks

Williams and Kilburn (1992) reported that *P. i. psammophilus* has not been located in recent years, and that most natural communities in its range have been subjected to cultivation or urban development. However, little field work has been conducted on this subspecies and most areas where the subspecies may still occur are on private land or military bases, making survey difficult.

Williams and Kilburn (1992) did not consider *P. i. inornatus* or *P. i. neglectus* to be currently jeopardized, but recommended that they be considered sensitive (due to habitat loss) until their population and taxonomic status can be determined. Best (1993c) reviewed the general biology of this species.

Conservation status and occurrence in captivity and protected areas

Perognathus inornatus is a federal C2 candidate species, while *P. i. psammophilus* is a California Species of Special Concern. No populations are known to occur in captivity or in protected areas.

Recommended action

- Survey for extant populations of *P. i. psammophilus* in the vicinities of Camp Roberts, Fort Hunter Liggett, and Fort Ord military reservations.
- Preserve suitable habitat around all extant populations of *P. i. psammophilus* in the Salinas Valley.
- Monitor habitat of *P. i. neglectus* to assess current or potential threats, particularly rate of habitat loss.
- Evaluate systematic relationships within *P. inornatus* and relative to *P. longimembris* and *P. amplus*.

***Perognathus longimembris* (Coues 1875) Little pocket mouse**

Michael A. Patten, Stephen J. Myers, Chet McGaugh, John R. Easton, and Richard A. Erickson

16 subspecies, 4 of conservation concern in North America (north of Mexico):

- P. l. bangsi* Palm Springs pocket mouse
- P. l. brevinasus* Los Angeles pocket mouse
- P. l. internationalis* Jacumba pocket mouse
- P. l. pacificus* Pacific pocket mouse

IUCN Red List Category

Perognathus longimembris – Lower Risk, least concern (LR,lc)

P. l. bangsi – Data Deficient (DD)

P. l. brevinasus – Vulnerable (VU): B1;B2c

P. l. internationalis – Data Deficient (DD)

P. l. pacificus – Critically Endangered (CR): B1;B2c;C1;C2a;C2b

Assignment of *P. l. bangsi* and *P. l. internationalis* is based on the need for information on their population status, current distribution, and the nature and severity of any existing threats to their continued survival; assignment of *P. l. brevinasus* is based on its restricted distribution and inferred decline in both extent and quality of its habitat; assignment of *P. l. pacificus* is based on its extremely restricted distribution, observed and projected decline in

both extent and quality of its habitat, the severely fragmented nature of any surviving populations, and the certain existence of only one population.

Taxonomy

Williams (1986) found the subspecies *P. l. pacificus* and *P. l. brevinasus* to be very similar and suspected that they, along with the other southernmost recognized races of *P. longimembris* in southern California and Baja California, may represent a species separate from *P. longimembris*. Williams *et al.* (1993a) considered subspecific recognition of *P. l. internationalis* to be equivocal, as this form may represent an intergrade between the coastal (*brevinasus* and *pacificus*) and inland (*bangsi* and *aestivus*) subspecies.

Distribution

The little pocket mouse is broadly distributed throughout the Great Basin and Mojave deserts, with peripheral and disjunct populations around the northern margin of the Gulf of California. Specimens of *P. longimembris* from the Central Valley and Coast Range of California have been referred to *P. inornatus* (Williams *et al.* 1993a). The four subspecies of conservation concern all occur in extreme southwestern California and adjacent Baja California, Mexico.

Perognathus l. brevinasus is restricted to lower elevation grassland, alluvial sage scrub, and coastal sage scrub in southern California. A purported specimen of *P. l. brevinasus* from El Segundo, Los Angeles County (Williams 1986), is instead *P. l. pacificus* (R.A. Erickson pers. obs.). Grinnell (1933) reported *P. l. brevinasus* as occurring from 167m at Burbank, Los Angeles County, to 945m at Jacumba, San Diego County. The latter population, however, is *P. l. internationalis*, which was described by Huey (1939) as occurring through east-central San Diego County south to Baja California. Thus, *P. l. brevinasus* has been found at a maximum elevation of 808m at Oak Grove on the north side of Mount Palomar, San Diego County (Santa Barbara Museum of Natural History no. 65-6).

Records of *P. l. pacificus* extend from the vicinity of Marina del Rey, in Los Angeles, south along the immediate coast to the Mexican border. Occupied habitats included coastal strand and sand dunes, ruderal vegetation on river alluvium, and open coastal sage scrub (Grinnell 1933, Meserve 1972). Telegraph weed (*Heterotheca grandiflora*) was “the principal associational plant” at each of three capture sites in San Diego County (von Bloeker 1931a). Except for one caught on a “gravelly slope” on San Onofre Bluff in September 1903 (dictation of Frank Stephens in Joseph Grinnell’s field notes dated 8 August 1916, Museum of Vertebrate Zoology), apparently all captures have been on sandy substrates. Only nine definite localities are known, all within 4km of the ocean and at elevations of 200m or less: the Marina del Rey-El Segundo area, Clifton, and

Wilmington in Los Angeles County; Newport Beach and Dana Point in Orange County; and San Onofre Bluff, Santa Margarita River mouth and vicinity, Los Penasquitos Lagoon, and lower Tijuana River Valley in San Diego County. The remaining California subspecies of conservation concern, *P. l. bangsi*, occurs west of the Imperial Valley, from north of Palm Springs, Riverside County, southward to near the Mexican boundary in western Imperial County (Williams *et al.* 1993a).

Remarks

Little is known about the current status of *P. l. brevinasus*. As noted by Williams (1986), “urbanization and cultivation of the majority of the land within the interior valleys of the Los Angeles Basin have made a large percentage of its historic range uninhabitable.” The subspecies is seldom detected during trapping surveys and Stephens (1906) considered it “rare.” Nevertheless, it is occasionally common or even abundant in some areas (usually within small colonies), perhaps more so after years of greater than average precipitation (Williams 1986). Because *P. l. brevinasus* inhabits annual grassland, alluvial sage scrub, and coastal sage scrub (Williams 1986), three rapidly disappearing plant communities in southern California, its population size in recent years has almost certainly dropped dramatically. Many records of this mouse are specimens collected prior to 1940, and fewer were collected from 1940 into the mid-1960s. There have been few recent specimens or reported captures, with apparently none from Los Angeles County. Four trapped in Day Canyon Wash, San Bernardino County (R.L. McKernan pers. comm.) are the westernmost recent records. The northernmost recent trappings have been in the lower Cajon Pass, San Bernardino County (S.J. Myers pers. obs.). Three 1984 specimens from the Temecula, Riverside County, area (Los Angeles County Mus. nos. 89249, 89250, and 89251), “several” trapped west of Vail Lake, Riverside County (S.J. Montgomery pers. comm.), and the aforementioned Oak Grove specimen are the southernmost. These recent records suggest that the inland valleys from San Bernardino south to the vicinity of Temecula might be the best (or only) remaining habitat for this subspecies. The California Department of Fish and Game planned a field survey for *P. l. brevinasus* in 1996, using funds obtained from the United States Fish and Wildlife Service through the Section 6 program (J.R. Gustafson pers. comm.).

Perognathus l. pacificus has been found on remarkably few occasions. Their known distribution has always been patchy, and they have gone unrecorded for decades at a time: over 97% of all records (specimens and live captures) are from only five localities and approximately 77% are from the years 1931 and 1932. The only known extant population of *P. l. pacificus* is on Dana Point Headlands, Orange County, where Brylski (1993) documented 25–36

individuals occupying approximately 1.5ha of coastal sage scrub on a 50ha parcel proposed for development. A small population occupying a limited habitat patch such as this is subject to a number of negative influences, among them demographic and genetic factors (Lande 1988), habitat degradation, and a documented cat (*Felis catus*) problem (United States Fish and Wildlife Service 1994b).

Other areas such as Orange County beaches, San Diego County coastal lagoons, La Jolla headlands, and Mission Bay probably once provided suitable habitat for *P. longimembris*, but are now mostly developed or disturbed. Whatever habitat may have been available on the northernmost coast of Baja California is now largely disturbed (E. Mellink pers. comm.). Focused trapping efforts in 1993 and 1994 in the vicinity of the eight other historic sites were unsuccessful, as was trapping at several of these sites from 1980 to 1992; numerous other sites were trapped from 1990 to 1994 (United States Fish and Wildlife Service unpubl. data, R.A. Erickson unpubl. data).

The only other *P. l. pacificus* populations found in the last 50 years were also in Orange County. M'Closkey (1970, 1972) and Meserve (1972, 1976a,b) studied a rodent community, including this species, from 1968 to 1971, at a location that was subsequently graded for residential development (Spyglass Hill) in Newport Beach. There has been no record for Los Angeles County since 1938. The small amount of remaining dune habitat in the El Segundo area, where non-native red fox (*Vulpes fulva*) may have hastened the demise of *P. l. pacificus*, has been trapped extensively without success (United States Fish and Wildlife Service 1994b, R.H.T. Mattoni pers. comm.). In San Diego County, the two northern sites are now within the Camp Pendleton Marine Corps Base, where approximately 25km of relatively undisturbed coastline offers the best hope of finding additional populations. Extensive recent trapping on the base has been unsuccessful, however, (Ogden Environmental and Energy Services 1994, United States Fish and Wildlife Service 1994b, S.J. Montgomery pers. comm. 1994, United States Fish and Wildlife Service unpubl. data) and the last record there was in 1936. The only record at Los Penasquitos Lagoon is of one or two caught by P. H. Krutzsch (pers. comm. 1994) sometime during 1933–1935. The lower Tijuana River Valley is the type locality for this mouse, but remaining habitat is heavily disturbed and may be insufficient to support it. The last record was in the mid-1930s, and extensive recent trapping efforts have failed to locate this species (Davenport 1994, Taylor and Tizler 1991, R.T. Miller pers. comm.).

Recent reports of *P. l. pacificus* from three additional sites are considered inconclusive. Williams (1986) included a report from Starr Ranch, Orange County, where a female, live-trapped on a study grid 15 November 1975, was identified as *P. longimembris* (C.T. Collins pers. comm.). No specimen or detailed field notes were taken, the location is outside the known range and elevational

limits of the species, the capture was later in the season than all but one specimen date, and Bontrager (1975) did not find this species in his extensive survey of the ranch. Another animal live-trapped on 13 June 1989 in suitable habitat in Lux Canyon, Encinitas, San Diego County was identified as this species, but the observer now considers the record only probable (E.R. Lichtwardt pers. comm.). San Dieguito Lagoon, Del Mar, San Diego County has been the source of three reports of *P. l. pacificus*: documentation for the report of this species by Mudie *et al.* (1976) is unavailable (P.J. Mudie pers. comm.); the report of this species by the Pacific Southwest Biological Service (1979) is apparently a typographical error (S.J. Montgomery pers. comm. 1994), and one reported in April 1994 (S. Tremor pers. comm. 1994) was inadequately documented (United States Fish and Wildlife Service 1994b). The area is deserving of further attention, especially because of its proximity to Los Penasquitos Lagoon, although recent walk-over surveys and trapping efforts have been unsuccessful (United States Fish and Wildlife Service 1994b, L.R. Hays pers. comm.).

Williams (1986) listed habitat loss due to highways, urbanization, and off-road vehicle activities as factors contributing to the decline of *P. l. pacificus*. Likely additional factors include habitat loss from industrial and agricultural development, habitat fragmentation, and depredation by non-native red foxes (Jurek 1992, Lewis *et al.* 1993) and feral cats (Jurek 1994). Defining the range of *P. l. pacificus* as the area within 3km of the coast, the United States Fish and Wildlife Service (1994b) estimated that 99% of the range in Los Angeles County and 81% in Orange County has been developed. Oberbauer and Vanderwier (1991) estimated that 100% of coastal strand, 92% of maritime scrub, and 72% of coastal sage scrub of San Diego County had been converted to urban and agricultural uses by 1988. The impact of habitat loss and fragmentation caused by construction of Interstate 5 through coastal San Diego County alone may have been enormous. Flood control measures (stream channelization and flow restrictions altering alluvium deposition) may also have been influential. A more insidious impact may have been the spread of non-native annual grasses in California over the past 150 years, reducing the amount of relatively open ground available. Periodic events serving to reduce plant cover, such as fire, may have benefited a species such as this. Lande (1988) suggested that for populations maintained by local extinctions and colonization, the proportion of suitable habitat that is occupied decreases as the overall amount of suitable habitat in the region decreases. Bolger *et al.* (1994) maintained that decreased density is an accurate predictor of vulnerability to extinction of San Diego County rodents. Neither observation is encouraging for *P. l. pacificus*.

The geographic distributions of *P. l. bangsi* and *P. l. internationalis* are somewhat more removed from the rapid

urbanization of coastal California. However, agricultural conversion, urbanization, and spread of non-native grasses continues to advance east into the inland deserts, and the northern one-half of the distribution of *P. l. bangsi*, in the Coachella Valley, is already heavily developed. The degree and nature of adverse human-related impacts to either of these subspecies are not known.

Conservation status and occurrence in captivity and protected areas

Perognathus l. pacificus is a federal Endangered taxon and California Species of Special Concern; *P. l. bangsi*, *P. l. brevinasus*, and *P. l. internationalis* are federal C2 candidate taxa and California Species of Special Concern. Even though the little pocket mouse apparently survives well under captive conditions (Edmonds and Fertig 1972, Hayden *et al.* 1966), there are no published accounts of *P. l. brevinasus* or *P. l. pacificus* being kept in captivity for any appreciable length of time. Bailey (1939) discussed his experience with two adult Pacific pocket mice and mentioned the incompatibility of the male and the female. Meserve (1976b) reported a similar experience with *P. l. pacificus* involving a fatal encounter between a pair placed in the same enclosure. No populations of any of the subspecies of conservation concern are known to occur in captivity or protected areas.

Recommended action

- Document current distribution, population status, and extent of habitat loss of *P. l. pacificus*, *P. l. bangsi*, and *P. l. internationalis* within known historical ranges.
- Consider potential protected area(s) based on the 1996 survey of *P. l. brevinasus* conducted by the California Department of Fish and Game.
- Clarify taxonomic status of subspecies of *P. longimembris* in southern California and northern Baja California.
- Initiate strict conservation of the Dana Point population of *P. l. pacificus*, including cat control measures and vegetation management.
- Consider a captive breeding program to augment on-site conservation at Dana Point and to prepare for eventual release elsewhere.
- Continue systematic live-trapping in potential habitat in search of additional *P. l. pacificus*, particularly in undeveloped areas of Huntington Beach, Irvine, Newport Beach and vicinity, coastal Camp Pendleton, the San Diego County coastal lagoons, Silver Strand, and the lower Tijuana River Valley. Trapping efforts should not be cursory, as populations of this mouse are known to fluctuate widely. The species has been described as “exceedingly difficult to catch” (von Bloeker 1931b), and may spend an extensive amount of time underground, especially when resources are abundant (French 1993).

Family MURIDAE

***Arborimus albipes* (Merriam 1901) White-footed vole**

Eric Yensen

IUCN Red List Category

Arborimus albipes – Data Deficient (DD)

Assignment is based on the need for information on the population status, current distribution, and nature and extent of threats (if any) to the continued survival of this species.

Taxonomy and distribution

Merriam (1901) described this species from a single specimen. The species was originally placed in *Phenacomys*, and was so treated by Hall (1981), but was transferred to *Arborimus* by Johnson and Maser (1982). Repenning and Grady (1988) returned the species to *Phenacomys* based upon fossil evidence; Musser and Carleton (1993) used the name *Arborimus* in their checklist, whereas Verts and Carraway (1995) use *Phenacomys*.

This species occurs in western Oregon from the Columbia River south along the Pacific coast into Humboldt County, northwestern California. All records are from the Coast Range, except for five specimens from the foothills of the Cascade Mountains (Maser *et al.* 1981), one of them at about 1000m elevation (B. J. Verts pers. comm.).

Remarks

This was considered the rarest North American vole species; only 72 had been collected as of 1981 (Maser *et al.* 1981). However, it is uncertain if the lack of specimens reflects real rarity or inappropriate collecting techniques. Additional specimens have been captured in recent years. For example, one study collected 59 in pitfall traps during 100,800 trap-nights (Verts and Carraway 1995).

Maser *et al.* (1981) suggested white-footed voles are associated with the riparian zones of small streams, especially those with alders (*Alnus* sp.). They have been found mostly in deciduous forests, but also occur in a variety of other forest types and in stands of various ages (Verts and Carraway 1995). They feed on leaves of alders (*Alnus rubra*), willows (*Salix lasiandra*), and other shrubs, plus grasses and ferns (Verts and Carraway 1995), indicating that they are at least partially arboreal. *Arborimus albipes* may be highly sensitive to logging and other modifications of its habitat (Olterman and Verts 1972, Williams 1986).

Conservation status and occurrence in captivity and protected areas

The Oregon Natural Heritage Database ranks this species as naturally rare and it is tracked in their database. The

Oregon Department of Fish and Wildlife ranks it as a Sensitive species, it is a Species of Special Concern for the California Department of Fish and Game (Verts and Carraway 1995), and is a federal C2 candidate species. However, it is not clear to us that this species is in fact threatened, and may be either naturally rare or simply not vulnerable to ordinary trapping methods. No populations are known to occur in captivity or in protected areas.

Recommended action

- Conduct studies on general ecology of this species to determine if it is truly rare and threatened, or only is collected uncommonly and is in no danger.

***Arborimus pomo* Johnson and George 1991 California red tree mouse; California red tree vole**

David J. Hafner

IUCN Red List Category

Arborimus pomo – Data Deficient (DD)

Assignment is based on the need for information on the population status, current distribution, and nature and extent of threats (if any) to the continued survival of this species.

Taxonomy and distribution

Arborimus pomo was formerly included within *A. longicaudus longicaudus*, but was regarded as a distinct species by Johnson and George (1991). The California red tree mouse occurs in coniferous forests along the Pacific coast of California from the Klamath Mountains south to Sonoma County.

Remarks

As is the case with *A. albipes*, it is uncertain if the lack of specimens of *A. pomo* reflects real rarity or inappropriate collecting techniques. Existing records indicate that populations are small, restricted, and fragmented. Populations may have declined in response to logging of old-growth forests (Corn and Bury 1988, Williams 1986).

Conservation status and occurrence in captivity and protected areas

Arborimus pomo is a federal C2 candidate species and a Species of Special Concern in California; it is incorrectly listed as occurring in Oregon as well as California by the United States Fish and Wildlife Service (1994a). Laboratory colonies have been maintained for many generations (e.g., 1955 to 1986: Johnson and George 1991). No populations are known to occur in protected areas.

Recommended action

- Conduct studies on general ecology of this species to determine if it is truly rare and threatened, or only is collected uncommonly and is in no danger.

***Clethrionomys gapperi* (Vigors 1830) Southern red-backed vole; Gapper's red-backed mouse**

Joseph A. Cook and Gordon L. Kirkland, Jr.

29 subspecies, 2 of conservation concern:

C. g. maurus Kentucky red-backed vole

C. g. solus Revillagigedo Island red-backed vole

IUCN Red List Category

Clethrionomys gapperi – Lower Risk, least concern (LR,lc)

C. g. maurus – Lower Risk, near threatened (LR,nt)

C. g. solus – Data Deficient (DD)

Assignment of *C. g. maurus* is based on its limited distribution and the apparent absence of any immediate threats to its survival. Assignment of *C. g. solus* is based on the need for specific information on its population status and the nature and extent of any threats to its continued survival.

Taxonomy and distribution

The southern red-backed vole is broadly distributed across northern North America, with extensions south along the major western (Rocky Mountains) and eastern (Appalachians) mountain ranges. *Clethrionomys g. maurus* is limited in distribution to Black Mountain, Harland County, Kentucky (Barbour and Davis 1974), and southwestern Virginia, where it has been collected at Big Stone Gap, Cumberland Mountains, Wise County, and northward along the Walker Mountains to Mountain Lake, Giles County (Hamilton 1943). Preferred habitat on Black Mountain includes cool, damp forests, especially those with logs and rock piles. However, this vole has also been taken in dry, brushy areas dominated by hawthorne and rhododendron, in oak-hickory forests, and among tulip poplars in dry, rocky sites. *Clethrionomys g. maurus* is distinguished from the neighboring subspecies, *C. g. carolinensis*, by its noticeably darker dorsal pelage, which is overlain by black-tipped hairs (Hamilton 1943).

Hall and Cockrum (1952) described *Clethrionomys g. solus* from 13 specimens from 2 localities on Revillagigedo Island, Alaska, and included this subspecies in their revision of microtine rodents (Hall and Cockrum 1953). *Clethrionomys g. solus* is known only from Revillagigedo Island (55°35'N, 131°20'W), an area approximately 90km long by 55km wide (approximately 4,000km²). The taxonomy of this subspecies has not been re-examined using larger samples or modern techniques.

Remarks

The population status of *Clethrionomys g. solus* is unknown. A total of 18 specimens were collected in 1993 at 10 localities across Revillagigedo Island (J.A. Cook unpubl. data.). Other insular populations of *C. gapperi* from Southeastern Alaska and the northern coast of British Columbia, particularly Princess Royal Island, have not been evaluated taxonomically (D. Nagorsen and J. A. Cook unpubl. data). Conservation concern for *C. g. maurus* appears due to its limited distribution, rather than to any known immediate threats. Merritt (1981) reviewed the general biology of this species.

Conservation status and occurrence in captivity and protected areas

Clethrionomys g. maurus is a federal C2 candidate taxon and is listed as a Species of Special Concern by the Kentucky State Nature Preserves Commission, but was not included as a taxon of special concern in Virginia by Handley (1991). *Clethrionomys g. solus* has no current protected status. Most of Revillagigedo Island, to which *C. g. solus* is confined, is managed by the Tongass National Forest. Private holdings occur throughout the island, although they are concentrated primarily in the west near the city of Ketchikan (population about 15,000) and surrounding George Inlet. No captive populations of either subspecies are known.

Recommended action

- Survey Revillagigedo Island and surrounding islands to determine the distribution, relative abundance, and nature and extent of any threats to the continued survival of *C. g. solus*.
- Clarify the taxonomic status of *C. g. solus* using molecular data and more intensive morphometric analyses in a modern taxonomic review of the red-backed voles of Southeastern Alaska and the northern coast of British Columbia (e.g., Princess Royal Island population).
- Survey the known range of *C. g. maurus* to determine its distribution and relative abundance, and nature and extent of any threats to its continued survival

***Dicrostonyx exsul* G.M. Allen 1919 St. Lawrence Island collared lemming**

Joseph A. Cook

IUCN Red List Category

Dicrostonyx exsul – Data Deficient (DD)

Assignment is based on the need to establish the validity of species-level recognition of *D. exsul* apart from *D. groenlandicus*, and gather specific information on the population status and nature and extent of any threat to the species' continued survival.

Taxonomy and distribution

The taxonomic status of this form is unclear. While considered a valid species by some (Hall 1981, Jones *et al.* 1992, Musser and Carleton 1993), others (Jarrell and Fredga 1993) consider it conspecific with *D. groenlandicus*. Rausch and Rausch (1972) reported fertile progeny from crosses of Seward Peninsula *D. groenlandicus* and St. Lawrence Island lemmings. This species is known only from St. Lawrence Island (63°30'N, 170°30'W) in the Bering Sea, Alaska. The island is about 155km long and 40km wide (Orth 1971) and is some 4,500km² in area (Fay and Sease 1985).

Remarks

The current status of *D. exsul* is not known. Rausch (1953b) noted that other terrestrial mammals on the island include a shrew (*Sorex jacksoni*), ground squirrel (*Spermophilus parryii lyratus*), northern red-backed vole (*Clethrionomys rutilus*), tundra vole (*Microtus oeconomus inuitus*), arctic fox (*Alopex lagopus*), and the introduced reindeer (*Rangifer tarandus*).

Conservation status and occurrence in protected areas

This species has no current protective status. St. Lawrence Island is a National Reindeer Range that is managed by the Gambell and Savoonga Native Corporations. The island has been part of the Alaska Maritime National Wildlife Refuge since 1980.

Recommended action

- Include *D. exsul* in a molecular systematic study of several species of *Dicrostonyx* to determine validity of species-level separation from *D. groenlandicus*.
- Conduct survey to determine the population status and nature and extent of any threat to the species' continued survival.
- Consider the establishment of protected areas on St. Lawrence Island specifically for habitat of *D. exsul* if the species-level status is validated and the species is found to be under threat.

Dicrostonyx nunatakensis Youngman 1967 Ogilvie Mountains collared lemming

David W. Nagorsen

IUCN Red List Category

Dicrostonyx nunatakensis – Data Deficient (DD)

Assignment is based on the need for specific information on the distribution, population status, and nature and extent of any threats to the continued survival of this species.

Taxonomy

The *Dicrostonyx torquatus* group in North America is now

considered to consist of a number of allospecies as a result of chromosomal and molecular studies (Engstrom *et al.* 1993; Musser and Carleton 1993). Youngman (1967) described the Ogilvie Mountains population of *Dicrostonyx* as a subspecies of *D. torquatus*; Musser and Carleton (1993) tentatively treated this taxon as a full species. According to Youngman (1967), it is distinguished from other *Dicrostonyx* (*D. kilangmiutak*, *D. richardsoni*, *D. rubricatus*) by its gray-brown pelage color and small cranial size, although statistical comparisons could not be made because of the small sample sizes. Chromosomal and molecular data, such as mitochondrial DNA sequences, are unavailable for *D. nunatakensis*.

Distribution

This species is known only from 11 specimens, 9 from the type locality (20mi [32km] S Chapman Lake) and two specimens from an adjacent peak (14mi [22km] S Lomand Lake) in the Ogilvie Mountains of the Yukon Territory. The specimens were taken in rocky alpine tundra at 1,650–1,675m elevation. The Ogilvie Mountains population of *Dicrostonyx* is about 400km from the nearest other *Dicrostonyx* populations, *D. kilangmiutak* in northern Yukon and *D. rubricatus* in Alaska. Youngman (1975) speculated that this taxon could also occur to the east in the Wernecke Mountains and to the southeast in the Selwyn Mountains in Yukon Territory.

Remarks

The current population status of this species is unknown, but it could be vulnerable because of its localized distribution. *Dicrostonyx nunatakensis* appears to be isolated from *Dicrostonyx* populations in the Brooks Range of northern Alaska and the British Mountains of northern Yukon by low elevation taiga forest in the Eagle Plain and Porcupine River drainage. Youngman (1967) speculated that *D. nunatakensis* represents a relict population that was isolated on nunataks at the southern periphery of the range in the early post-glacial.

Conservation status and occurrence in captivity and protected areas

This taxon currently has no protected status. No protected areas occur within the known range.

Recommended action

- Survey intensively the Ogilvie Mountains and adjacent Selwyn Mountains to determine the distribution and population status of *D. nunatakensis*.
- Obtain specimens for molecular studies to evaluate species-level status of *D. nunatakensis*.
- Consider the establishment of protected areas if the species-level status is validated and the species is found to be under threat.

***Dicrostonyx unalascensis* Merriam 1900** **Unalaska collared lemming**

Joseph A. Cook

2 subspecies, both of conservation concern:

D. u. stevensoni Umnak Island collared lemming

D. u. unalascensis Unalaska Island collared lemming

IUCN Red List Category

Dicrostonyx unalascensis – Data Deficient (DD)

D. u. stevensoni – Data Deficient (DD)

D. u. unalascensis – Data Deficient (DD)

Assignment of both subspecies of conservation concern is based on the need for specific information on their population status and the nature and extent of any threats to their continued survival.

Taxonomy and distribution

Hall and Cockrum (1953) considered both subspecies of *D. unalascensis* to be subspecies of *D. groenlandicus*. Musser and Carleton (1993) examined museum specimens, which led them to “readily appreciate the specific distinctiveness of *groenlandicus* ... and *unalascensis*”. This is the only species of *Dicrostonyx* that does not turn white or develop snow claws in the winter (Gilmore 1933, Rausch and Rausch 1972). The subspecies of *D. unalascensis* are very similar morphologically (Nelson 1929, Gilmore 1933, Rausch and Rausch 1972). The two subspecies of *D. unalascensis* occur on two different islands: *Dicrostonyx u. stevensoni* is found only on Umnak Island (53°15'N, 168°20'W; 1,850km²), while *Dicrostonyx u. unalascensis* is known only from Unalaska Island (53°35'N, 166°50'W) in the Aleutian Islands, Alaska.

Remarks

The current status of *D. unalascensis* on Umnak and Unalaska islands is unknown. Murie (1959) noted that lemmings were scarce on Unalaska Island in 1936 and 1937, but lemmings on Umnak Island occasionally become very numerous (Murie 1959). Introductions to Umnak and Unalaska islands include reindeer (*Rangifer tarandus*) and domestic sheep (*Ovis aries*), although it is not known whether they may impact lemming populations (Fay and Sease 1985). Arctic ground squirrels (*Spermophilus parryii*) were introduced to Unalaska Island about 1895 (Peterson 1967). Nikolski, a community of about 50 people, is located on the southwest end of Umnak Island. There is also an abandoned United States military base (Fort Glenn) on Umnak Island that was closed shortly after World War II. Dutch Harbor is a busy fishing port on the northeast end of Unalaska Island, and two small villages (Kashega and Makushin) are also found on the island.

Conservation status and occurrence in captivity and protected areas

Neither subspecies currently has protected status. Umnak Island is in the Alaska Maritime National Wildlife Refuge. The remaining land is owned by native corporations or the state of Alaska.

Recommended action

- Conduct a molecular systematic investigation of the species of *Dicrostonyx*, including both subspecies of *D. unalascensis*.
- Survey to determine the status of populations of lemmings on both islands.
- Monitor regularly the potential impact of development on populations of lemmings on both islands.
- Consider the establishment of protected areas if the species-level status is validated and the species is found to be under threat.

***Microtus abbreviatus* Miller 1899** **Insular vole**

Joseph A. Cook

2 subspecies, both of conservation concern:

M. a. abbreviatus Hall Island vole

M. a. fisheri St. Matthew Island vole

IUCN Red List Category

Microtus abbreviatus – Data Deficient (DD)

M. a. abbreviatus – Data Deficient (DD)

M. a. fisheri – Data Deficient (DD)

Assignment is based on the need for specific information on the distribution, population status, and nature and extent of immediate threats to the continued survival of the species and either of the subspecies.

Taxonomy and distribution

A single specimen collected in 1885 provided the material for the original description of this species by Miller (1899). More specimens were collected by the Alaska Harriman Expedition and provided the basis for Merriam's (1900) separation of the species into two subspecies; Hall and Cockrum (1952) and Musser and Carleton (1993) agreed with his assessment. Rausch and Rausch (1968) reviewed the taxonomy and systematic relationships of the insular vole and noted its close association with *M. miurus* of the Alaska mainland. Fedyk (1970) discussed chromosomal affinities within the subgenus *Stenocranius*.

The two subspecies occur on two of the three islands in the St. Matthew's Islands group in the Bering Sea, Alaska. *Microtus a. abbreviatus* is known only from the type locality on Hall Island in the St. Matthews Islands group, whereas *M. a. fisheri* is known only from the type locality

on St. Matthew Island (Klein 1959, Hall 1981). Hall Island (60°40'N, 173°06'W) is about 9km long by a maximum width of 4km (<30km²). St. Matthew Island (60°24'N, 172°42'W) is some 52km long by about 10km at its maximum width (<500km²).

Remarks

The current status of this species is unknown. However, populations appear to fluctuate considerably. Rausch and Rausch (1968) found them abundant in 1954 and collected 250 specimens. Klein (1959) reported that numbers were very low in 1957. Two other terrestrial mammals, the polar bear (*Ursus maritimus*) and arctic fox (*Alopex lagopus*) are known from these islands, but the former species was not present in 1954 (Rausch and Rausch 1968). Reindeer (*Rangifer tarandus*) were introduced to St. Matthew Island by the United States Coast Guard in 1944. The herd grew to approximately 1,350 individuals by 1957 (Klein 1959), and 6,000 by 1963, before declining to 42 by 1966 due to deterioration of the vegetation (Rausch and Rausch 1968). No reindeer have been seen on St. Matthew since 1982 (Klein 1987). The island has been uninhabited since World War II.

Conservation status and occurrence in protected areas

Neither subspecies currently has protected status. St. Matthew Island and Hall Island were designated the St. Matthew National Wildlife Refuge in 1909.

Recommended action

- Survey to determine the population status and nature and extent of any immediate threats to the survival of these insular voles.
- Monitor populations of *M. abbreviatus* on Hall and St. Matthew islands periodically.
- Include specimens of both subspecies in a molecular analysis to determine their taxonomic status because both were originally based on few specimens (Merriam 1900).
- Consider the establishment of protected areas if the subspecies-level status is validated and the species is found to be under threat.

***Microtus breweri* (Baird 1858)**

Beach vole

Gordon L. Kirkland, Jr.

IUCN Red List Category

Microtus breweri Lower Risk, near threatened (LR,nt)

Assignment is based on the restricted distribution and apparent absence of immediate threats to the continued survival of *M. breweri*.

Taxonomy and distribution

Microtus breweri is an insular variant of *M. pennsylvanicus* (Musser and Carleton 1993): the two are inseparable karyotypically (Fivush *et al.* 1975, Modi 1986), marginally distinct electrophoretically (Kohn and Tamarin 1978), but morphologically sharply discrete (Bailey 1900, Miller 1896, Moyer *et al.* 1988). Corbet and Hill (1991), Jones *et al.* (1986) and Modi (1986) considered *M. breweri* to be a subspecies of *M. pennsylvanicus*, but Moyer *et al.* (1988) provided evidence for retention of specific status of *M. breweri*. The beach vole is restricted to Muskeget Island, off the west coast of Nantucket Island, Massachusetts. Principal habitat of *M. breweri* on this small (2.6km²; Tamarin 1977), sandy island is meadows dominated by beach grass (*Ammophila breviligulata*) and poison ivy (*Rhus radicans*).

Remarks

No specific threats to *M. breweri* are known, other than those common to any insular population with a highly restricted geographic range: particular vulnerability to loss of habitat and stochastic catastrophic events. This vulnerability is exacerbated by the potential for dramatic population fluctuations in microtine rodents. Muskeget Island is apparently unstable: it has moved eastward about 1.6km during the past 200 years due to tidal buildup and erosion. However, there do not appear to be any direct threats to *M. breweri* from human development. Tamarin and Kunz (1974) reviewed the general biology of this species.

Conservation status and occurrence in captivity and protected areas

Microtus breweri is a federal C2 candidate species, but is not listed among the taxa of special concern in Massachusetts (T. French in litt.). No populations are known to occur in captivity or in protected areas.

Recommended action

- Survey extant populations and estimate density of *M. breweri*.
- Re-evaluate systematic position of *M. breweri* relative to *M. pennsylvanicus*.
- Consider the establishment of protected areas if the species-level status is validated and the species is found to be under threat.

***Microtus californicus* (Peale 1848)**

California vole

Vernon C. Bleich

17 subspecies, 4 of conservation concern in North America (north of Mexico):

M. c. mohavensis Mojave River vole



Vernon Bleich

Amargosa River vole, *Microtus californicus scirpensis*.

- M. c. scirpensis* Amargosa River vole
- M. c. stephensi* Stephen's California vole
- M. c. vallicola* Owens Valley California vole

IUCN Red List Category

- Microtus californicus* – Lower Risk, least concern (LR,lc)
- M. c. mohavensis* – Vulnerable (VU): A1d;A2d;D2
- M. c. scirpensis* – Vulnerable (VU): B1;B3c;B3d
- M. c. stephensi* – Data Deficient (DD)
- M. c. vallicola* – Lower Risk, near threatened (LR,nt)

Assignment of *M. c. mohavensis* is based on its highly restricted distribution and probable past and projected habitat loss; surveys may reveal that its status is far more perilous. Assignment of *M. c. scirpensis* is based on its severely restricted distribution and number of populations, and the extreme fluctuations in both number of subpopulations and number of individuals within each population. Assignment of *M. c. stephensi* is based on the need for specific information on its population status, distribution, and extent of loss of beach habitat. Assignment of *M. c. vallicola* is based on its restricted distribution and apparent absence of any immediate threat to its continued survival.

Taxonomy

The uncertain relationships of *M. californicus* within *Microtus* led Zagorodnyuk (1990) to recognize this species as the sole member of the *californicus* species group, subgenus *Mynomes*. Gill (1980) reported instances of sterility of hybrids between *M. c. californicus* and *M. c. stephensi*, indicating that they may be distinct species. The distribution of *M. c. stephensi* is surrounded by that of *M. c. sanctidiégi*, and that subspecies' distribution abuts that of *M. c. californicus*; all three should be included in a systematic study to determine their level of differentiation.

Distribution

The California vole is broadly distributed throughout much of California and into south-central Oregon, with

disjunct populations occurring on the eastern side of the southern Sierra Nevada (*M. c. vallicola*), in desert riparian areas along the Amargosa River (*M. c. scirpensis*) and Mojave River (*M. c. mohavensis*) in the Mojave Desert, and in the Peninsular mountains and Pacific coast of northern Baja California, Mexico. *Microtus c. stephensi* occurs along Pacific coastal beaches in the Los Angeles area.

Microtus c. scirpensis originally was described from the vicinity of Shoshone, Inyo County, California (Bailey 1900). Currently, the Amargosa vole occurs in disjunct populations that may be temporary in nature along the Amargosa River near the hamlets of Tecopa Hot Springs and Tecopa, Inyo County. It is possible that some disjunct populations exist in suitable habitat along the Amargosa River in extreme northern San Bernardino County. It is no longer extant at the type locality, and occurs only in association with Olney bulrush (*Scirpus olneyi*) marshes along the Amargosa River. Other species of vegetation common in vole habitat include southern reed (*Phragmites australis*), salt grass (*Distichlis spicata*), cattail (*Typha domingensis*), rushes (*Juncus* sp.) and yerba mansa (*Anemopsis californica*).

Remarks

Microtus c. scirpensis was described by Vernon Bailey in 1900 and presumed extinct in 1918 by Kellogg (1918). The Amargosa vole was thought to exemplify the recent extinction of a North American mammal until its rediscovery (Bleich 1979). Extensive live-trapping has revealed extant populations at eight sites along the Amargosa River (Bleich 1980, Rado and Rowlands 1984, K.E. Freas and D.D. Murphy unpubl. data). However, the ephemeral nature of some of these populations is confirmed by the fact that one location, at which 14 voles were captured in 1977 (Bleich 1980), has failed to yield a single vole during substantial trapping efforts in March, 1988, 1990, and 1992 (K.E. Freas and D.D. Murphy unpubl. data, V.C. Bleich unpubl. data). Rado and Rowlands (1984) failed to capture voles at other locations in which they had been previously reported (Gould and Bleich 1977). Rado and Rowlands (1984) speculated that flooding along the Amargosa River could result in local extirpations of populations occupying low-lying areas of apparently suitable habitat. Thus, populations of this vole may be subjected to catastrophic extirpation and, subsequently, periodic recolonization (K.E. Freas and D.D. Murphy unpubl. data, Rado and Rowlands 1984): populations occupying high-elevation ground may serve as sources for recolonization of lower-lying habitats from which voles are extirpated during extreme flooding. It is possible that additional populations of this animal exist in the Amargosa Canyon, south of Tecopa. However, any such populations certainly would be subject to periodic extirpation and recolonization because of the steep-walled nature of the canyon and impacts of heavy storm flows. House mice

(*Mus musculus*) recently have been confirmed in two areas where they previously had not been detected (V.C. Bleich unpubl. data); these areas also harbor populations of voles. The role of house mice as competitors with the Amargosa vole is speculative, but warrants investigation.

No information is available on the current status of or existing threats to the other three subspecies of conservation concern. Populations of *M. c. mohavensis* are likely subject to the same natural climatic perturbations and adverse human impacts as *M. c. scirpensis*, and may be more subject to human impact due to the increasing urbanization and agricultural conversion of the Mojave River in its known range of <50km² near the type locality (Victorville) and nearby Oro Grande (the only two known localities). *Microtus c. stephensi*, which occurs along Pacific coastal beaches in the Los Angeles area, is probably suffering from urban development of beach areas. *Microtus c. vallicola* is probably the least impacted of the four subspecies. However, it occurs in small, isolated patches of moist habitat in the rain-shadow of the Sierra Nevada, and these populations are probably highly vulnerable to natural periods of drought or human-related impacts (e.g., overgrazing), and likelihood of recolonization in many cases would be remote.

Conservation status

Microtus c. scirpensis is listed as an Endangered species by the California Fish and Game Commission as well as by the United States Fish and Wildlife Service (1994a). A draft recovery plan has been prepared by the United States Fish and Wildlife Service; recommended actions listed below are, in part, taken from that draft plan. *Microtus c. mohavensis*, *M. c. stephensi*, and *M. c. vallicola* are federal C2 candidate taxa and California Species of Special Concern; an additional subspecies (not considered here), *M. c. sanpabloensis*, is federal C3C taxon (“more abundant or widespread than previously believed and/or not subject to any identifiable threat”), although it remains a California Species of Special Concern.

Occurrence in captivity and protected areas

Of seven localities known to harbor Amargosa vole populations during 1977, six were in private ownership. Acquisition of several privately-owned parcels has been completed by The Nature Conservancy, and the Bureau of Land Management has prepared site-specific management plans for the Grimshaw Lake Natural Area and the Amargosa Canyon Natural Area, both to be managed as “areas of critical environmental concern.” The acquisition of private lands and preparation of management plans for federal lands supporting populations of the vole will enhance the probability of protection from site-specific development. Off-site developments, including ground water pumping and geothermal development, could, however, impact vole habitat. No populations of the other

subspecies of conservation concern are known to occur in captivity or protected areas.

Recommended action

- Monitor the status of habitats that are known to support, or to have recently supported, populations of *M. c. scirpensis*, *M. c. mohavensis*, and *M. c. stephensi*.
- Survey in the vicinity of the known range of *M. c. scirpensis*, *M. c. mohavensis*, *M. c. stephensi*, and *M. c. vallicola* to determine densities of voles in these areas.
- Acquire additional, privately owned, parcels that may be critical to the continued viability of *M. c. scirpensis* and *M. c. mohavensis*.
- Collect information on the population ecology and life history of *M. c. scirpensis* and *M. c. mohavensis* to determine minimum viable population size and number of populations necessary for recovery.
- Undertake a hydrological study to determine the importance of specific spring and subterranean water flows for perpetuating habitat of *M. c. scirpensis* and *M. c. mohavensis*.
- Analyze natural and human-caused impacts to *M. c. scirpensis* and *M. c. mohavensis* to ensure that populations are managed at optimum densities and associated habitats receive a high level of protection.
- Determine genetic relationships between *M. c. stephensi*, *M. c. sanctidiegi*, and *M. c. californicus*.

Microtus chrotorrhinus (Miller 1894) Rock vole

Gordon L. Kirkland, Jr.

3 subspecies, 2 of conservation concern:

- M. c. carolinensis* Southern rock vole
- M. c. ravus* Labrador rock vole

IUCN Red List Category

- Microtus chrotorrhinus* – Lower Risk, least concern (LR,lc)
- M. c. carolinensis* – Lower Risk, near threatened (LR,nt)
- M. c. ravus* – Data Deficient (DD)

Assignment of *M. c. carolinensis* is based on its restricted distribution and continued loss and degradation of its habitat, which pose increasing threats to its continued survival. Assignment of *M. c. ravus* is based on the need for specific information on its population status, distribution, and nature and extent of any immediate threats to its survival.

Taxonomy

This species has been conventionally viewed as closely related to (Anderson 1960), if not conspecific with (Hall and Kelson 1959) *M. xanthognathus*, but morphological and chromosomal traits indicate its distinct nature (Bailey

1900, Guilday 1982, Martin 1973, 1979, Rausch and Rausch 1974). It is the sole member of the *chrotorrhinus* species group, subgenus *Aulacomys* (Zagorodnyuk 1990). The five earliest specimens collected at Black Bay, Labrador, were given subspecific status (*M. c. ravidus*) by Bangs (1899) on the basis of gray pelage and a smaller, more slender skull with lighter dentition than *M. c. chrotorrhinus* (Peterson 1966). The gray pelage is also characteristic of at least one other Labrador rodent (*Clethrionomys gapperi proteus*).

Distribution

The rock vole occupies moist areas of rock or talus in wooded areas (Banfield 1974, Kirkland and Jannett 1982) of eastern United States and Canada from North Carolina to Labrador, and west in Canada to Ontario and adjacent Minnesota. The rock vole generally is considered to be a species of boreal habitats, but it often inhabits transition zone forests with admixtures of coniferous and deciduous tree species (Kirkland and Knipe 1979). The range of *M. chrotorrhinus carolinensis* includes the higher Appalachian Mountains of western Virginia, eastern Tennessee, West Virginia, and western North Carolina (Hall 1981, Webster *et al.* 1985). The range of this Appalachian subspecies is separated from that of *M. c. chrotorrhinus* to the northeast by a hiatus of approximately 400km (Kirkland and Jannett 1982). *Microtus c. carolinensis* occupies a spectrum of forests including remnant boreal coniferous (red spruce, *Picea rubens*), mixed coniferous-northern hardwoods, and mixed deciduous, as well as recent clearcuts (Kirkland 1977). Sites where this species occurs often are characterized by an abundance of mosses and forbs (Kirkland and Jannett 1982). *Microtus c. ravidus* is restricted to a small distribution in southeastern Labrador.

Remarks

Microtus c. carolinensis is an isolated subspecies, and is probably a relict of a broader and more continuous Pleistocene distribution. The spectrum of habitats in which this species has been taken in West Virginia (Kirkland 1977) mirrors that in which northern populations of *M. chrotorrhinus* occur. However, this subspecies seems to occur in small, discrete populations in patches of appropriate habitat. These patches of cool, moist, rocky forested sites become more widely dispersed further south in the Appalachian Mountains. Loss and degradation of habitat in the southern Appalachians probably pose a serious threat to this subspecies, as fragmentation of forests results in increased isolation of small populations, which are subject to higher extinction rates.

Little is known of the taxonomic status, patterns of habitat use, and distribution of *M. c. ravidus*. Few rodent censuses have been conducted in the interior of Labrador, and fewer still within the interior range of *M. chrotorrhinus*. Coastal small mammal censuses conducted in the general

area of the type locality by Pruitt (1972) from 1966–1971, by D.W. Morris (pers. comm.) in 1983, and by Newfoundland Wildlife Division in 1985, 1989, and 1991, have all failed to capture any rock voles. The status and biology of *M. c. ravidus* is thus enigmatic. Human activity within its purported range is generally restricted to small coastal settlements. Future hydro-electric power developments and associated transmission corridors pose the greatest foreseeable threat to this taxon. Kirkland and Jannett (1982) reviewed the general biology of this species.

Conservation status and occurrence in captivity and protected areas

Microtus c. carolinensis is a federal C2 candidate taxon and is proposed as an Endangered taxon in Virginia. No populations of either taxon are known to occur in captivity or in protected areas.

Recommended action

- Identify and preserve critical localities at which *M. c. carolinensis* occurs.
- Conduct survey of suitable habitat in Labrador to determine the population status and distribution of *M. c. ravidus*, and determine nature and extent of any immediate threats to its continued survival.
- Determine systematic status of *M. c. ravidus* relative to *M. c. chrotorrhinus* using modern biochemical and molecular techniques.

Microtus longicaudus (Merriam 1888) Long-tailed vole

Christopher J. Conroy and Joseph A. Cook

15 subspecies, 3 of conservation concern:

- M. l. bernardinus* San Bernardino long-tailed vole
- M. l. coronarius* Coronation Island long-tailed vole
- M. l. leucophaeus* Mount Graham long-tailed vole

IUCN Red List Category

- Microtus longicaudus* – Lower Risk, least concern (LR,lc)
- M. l. bernardinus* – Data Deficient (DD)
- M. l. coronarius* – Data Deficient (DD)
- M. l. leucophaeus* – Data Deficient (DD)

Assignment of these three isolated subspecies of conservation concern is based on the need for specific information on their population status, distribution, and nature and extent of any immediate threats to their continued survival.

Taxonomy

The systematic status of *M. l. coronarius* has not been resolved. It was described as a distinct species, *M. coronarius*, from specimens collected on Coronation, Forrester, and

Warren islands, Alaska, based upon its large body size. Swarth (1911:131–132) noted that this vole is “similar to *Microtus macrurus* [=longicaudus] in coloration and proportions but size much greater throughout ... It appears to be a gigantic insular development of *M. macrurus* [=longicaudus], but none of the specimens secured show intergradation with that species.” The close relationship of specimens from these islands to *M. longicaudus* was pointed out by Hall (1981:809) and needs to be examined further. Howell (1923) suggested a positive correlation between size of long-tailed voles on Coronation Island and “favorable conditions,” and recommended more collecting for a thorough analysis. Goldman (1938:491) lumped most long-tailed vole taxa in North America under *M. longicaudus*, avoiding a change in *M. coronarius* by stating that “I have seen no specimens.” Large-bodied voles are not restricted to these islands; other sizable long-tailed vole specimens are available from the mainland and other islands of Southeastern Alaska. Some authors (e.g., Hall 1981) have treated the Coronation Island vole as a distinct species, while others (e.g., Musser and Carleton 1993) treated it as a subspecies of *M. longicaudus*.

Microtus l. leucophaeus was described from only four specimens as differing from other subspecies of long-tailed vole by degrees of color and shape, rather than discrete characters (Allen 1894). Hoffmeister (1986) confirmed subspecific status of *M. l. leucophaeus* based on 130 specimens examined, stating that it is “one of the larger subspecies in Arizona.” The taxonomic status of *M. l. bernardinus* has not been examined since its initial description.

Distribution

The long-tailed vole is widely distributed over western North America from northeastern Alaska to southern New Mexico. Isolated populations occur on islands of Alaska and in mesic areas of mountains in the arid southwestern United States. *Microtus l. coronarius* was reported as limited to Coronation (55°53'N, 134°14'W), Warren (55°33'N, 133°53'W), and Forrester (54°48'N, 133°31'W) islands in the southern Alexander Archipelago, Southeastern Alaska (Swarth 1933). The overall distribution of this vole on Coronation and Warren islands and the collecting locality on Forrester Island are unknown. Since Swarth's (1933) study, long-tailed voles have been caught on nearby islands, but taxonomic comparisons have not been conducted to determine possible range extensions. Distribution beyond these areas is unknown due to few surveys and relatively undocumented faunas on nearby islands.

Isolated populations of *M. longicaudus* occur throughout the mountains of the southwestern deserts; two have been described as distinct subspecies of restricted distribution. *Microtus l. bernardinus* occurs in the San Bernardino Mountains on the eastern margin of the Los

Angeles metropolitan area. *Microtus l. leucophaeus* is known only from Mt. Graham in southeastern Arizona.

Remarks

Microtus l. bernardinus is apparently rare, and Kellogg (1922) suggested that it might be competitively excluded from surrounding areas by *M. californicus*. Relatively few specimens exist, and its continued existence has been questioned (Williams 1986). However, the subspecies has been listed as extant in recent publications (Brylski and Harris 1990, Jameson and Peeters 1988), and was reported as recently as 1991 (Butler and Schiffer 1992). Meadow habitat for this subspecies may be endangered by invasion of forests due to 60 years of fire suppression and by ongoing development in the San Bernardino Mountains (Minnich *et al.* 1995, S. Loe pers. comm.).

Mt. Graham, the only known locality for *M. l. leucophaeus*, is currently the site of construction of an observatory (see account of *Tamiasciurus hudsonicus grahamensis*). The impact of construction on the habitat of this subspecies is unknown, and must be determined.

No estimates of population numbers of *M. l. coronarius* have been made. The habitat affinities of the Coronation Island vole have not been studied in detail, but Swarth (1933) and others note vole runways at Egg Harbor on Coronation Island “are all in the woods, in the deep moss, and are very broad,” and “the forest is quite open and easy to get around in ... with the ground carpeted deep with moss, and in places with hardly any underbrush. It is here that we have been trapping the *Microtus*” (Swarth field notes 1909). Swarth (field notes 1909) trapped “probably two or three miles [3–5km] north of Warren Cove” (=False Cove) on Warren Island and states that “there are no meadows at all but many grassy patches scattered through the woods especially along the edge, and there is considerable *Microtus* sign in such places.” Changes in forest structure induced by logging could adversely affect this species. The few specimens of *M. l. coronarius* that have been collected are housed at the University of Alaska Museum, Museum of Vertebrate Zoology, and the Bird and Mammal Collection of the Department of Zoology at the University of California, Los Angeles. Smolen and Keller (1987) reviewed the general biology of this species.

Conservation status and occurrence in captivity and protected areas

None of these subspecies currently have protected status. *Microtus l. coronarius* occurs in the Coronation Island and Warren Island Wilderness Areas managed by the United States Forest Service and Forrester Island in the Alaska Maritime National Wildlife Refuge. *Microtus l. leucophaeus* may benefit from a refuge that has been established for *Tamiasciurus hudsonicus grahamensis* in the highest quality red squirrel habitat; this area is closed to camping, hiking, or other recreational activities.

Recommended action

- Evaluate systematic relationships among isolated populations of *M. longicaudus* in the southwestern portion of the species' distribution to delineate genetic units.
- Compare specimens from Coronation, Warren, and Forrester and surrounding islands to mainland populations of *M. longicaudus*, using morphological, biochemical, and molecular data.
- Conduct ecological studies to determine habitat requirements of *M. l. coronarius*.
- Survey islands of Southeastern Alaska and the adjacent mainland to determine the distribution of *M. l. coronarius*.
- Survey appropriate habitat in the San Bernardino Mountains to determine the current distribution and population status of *M. l. bernardinus*.
- Preserve meadow habitat surrounding large populations of *M. l. bernardinus*, and prohibit development, grazing, or other activities detrimental to preservation of meadows.
- Survey appropriate habitat on Mt. Graham to determine the current distribution and population status of *M. l. leucophaeus*.
- Include habitat needs of *M. l. leucophaeus* in management plans for red squirrel refuge on Mt. Graham.

***Microtus mogollonensis* (Mearns 1890)** **Mogollon vole**

Robert B. Spicer and Kimberly A. Kime

4 subspecies, 1 of conservation concern:

M. m. hualpaiensis Hualapai vole

IUCN Red List Category

Microtus mogollonensis – Lower Risk, least concern (LR,lc)

M. m. hualpaiensis – Vulnerable (VU): B1;B2c;D2

Assignment of *M. m. hualpaiensis* is based on its severely restricted and fragmented distribution, projected decline in both extent and quality of its habitat, and the small size and restricted distribution of the two known populations.

Taxonomy

Frey and LaRue (1993) recognized populations of *M. mexicanus* in the United States as *M. mogollonensis*, based on studies by Judd (1980), Modi (1987), and Frey (1989). Biochemical and mtDNA analyses support specific recognition of *M. mogollonensis* (Frey and Zalles *in litt.*). Populations of *M. m. hualpaiensis* are geographically, ecologically, and genetically isolated from other vole populations and each other. The distribution and taxonomy of the species in much of Arizona, and in particular this subspecies in northwestern Arizona, is still somewhat

unclear. Field investigations of its distribution and genetic studies have been initiated by state and federal agencies and several academic institutions to clarify questions about gaps in distribution, habitat preferences, and taxonomic relationships. The subspecies was originally described from the Hualapai Mountains in 1938. Hoffmeister (1986) considered it to be a poorly characterized subspecies but felt that more material was needed for an adequate review. Hoffmeister (1986) reassigned specimens from Prospect Valley taken in 1913 to the subspecies *M. m. hualpaiensis*, and reassigned populations along the South Rim of the Grand Canyon and the western end of the Mogollon Plateau from *M. m. mogollonensis* to *M. m. navaho*, thereby expanding the range of *M. m. navaho* considerably. The discovery of previously unknown populations of *M. mogollonensis* in three places in northern Arizona together with the collection of additional specimens and the rediscovery of several populations has provided new material for taxonomic and biogeographic analyses, which are currently underway (J. K. Frey pers. comm.).

Distribution

The Mogollon vole has a fragmented distribution on mountainous regions of Arizona, New Mexico, and adjacent Utah, Colorado, and Texas, and is a close relative of the Mexican vole (*M. mexicanus*) of the Sierra Madre Occidental and Mexican Plateau of Mexico. *Microtus mogollonensis hualpaiensis* is found at the extreme northwestern margin of the species' range and is presently known only from two isolated localities in northwestern Arizona: the Hualapai Mountains, which contain the type locality, and the lower end of Prospect Valley (a tributary of the Colorado River and about 110mi [177km] to the northeast of the Hualapai Mountains). Specimens of *Microtus mogollonensis* taken in 1981 and 1991 from the Music Mountains (about 50mi [80km] north of the Hualapais) may well belong to this subspecies but have not yet been critically examined to determine their subspecific affinities. *Microtus m. hualpaiensis* is an uncommon and local occupant in very restricted areas of grass/sedge/forb ground cover along watercourses or open areas in scattered ponderosa pine communities. It is less frequently found in similar restricted areas of ground cover in adjacent mixed conifer forest, pinyon-juniper woodland, and interior chaparral communities.

Remarks

Although the ancestral species, *M. mexicanus*, is one of the more xeric-adapted of the genus, populations of *M. mogollonensis hualpaiensis* are believed to be relicts from wetter and cooler Pleistocene times when suitable habitat was more widespread (Frey and Zalles *in litt.*). Habitat restrictions probably resulted from regional trends toward increased summer temperatures and precipitation, decreased winter precipitation, and a lower overall annual

precipitation related to the retreat of continental glaciation as described by Van Devender *et al.* (1987). During the last century and continuing to the present in some areas, human-related activities (grazing, mining, and road building) in combination with an arid climate, highly variable annual precipitation, and steep slopes of highly erodible granitic soils have reduced and degraded suitable ground vegetation. During the last decade, recreational activities (e.g., off-road-vehicles, trampling) have become problems in several areas, resulting in scattered, small populations and probably greatly reduced densities in those areas of intervening marginal habitat that may exist (Spicer *et al.* 1985b).

Conservation status and occurrence in captivity and protected areas

The Hualapai Mexican vole is listed as Endangered by both the Arizona Game and Fish Department and the United States Fish and Wildlife Service. A recovery plan was completed by the United States Fish and Wildlife Service in 1991 (United States Fish and Wildlife Service 1991b). No populations of the subspecies of conservation concern are known to occur in captivity or protected areas.

Recommended action

- The Hualapai Mexican vole recovery plan estimates that recovery for this vole will take at least 25 years. Costs for implementing the following recommendations are estimated at \$816,000 for the first three years.
- Protect existing habitat through activities such as fencing, livestock control, signing, flood control, and erosion control.
- Encourage cooperation among agencies, institutions, and private entities and form a multi-agency management team.
- Designate special management areas and implement range management plans and probably fire suppression until the role of fire is clarified.
- Initiate research for defining optimum habitat and restoring degraded habitat.
- Develop a long-term monitoring program for populations of *M. m. hualpaiensis*.

***Microtus montanus* (Peale 1848)** **Montane vole**

David J. Hafner

15 subspecies, 6 of conservation concern:

- M. m. arizonensis* Arizona montane vole
- M. m. codiensis* Cody montane vole
- M. m. fucosus* Pahrnagat Valley montane vole
- M. m. nevadensis* Ash Meadows montane vole
- M. m. rivularis* Virgin River montane vole
- M. m. zygomaticus* Big Horn montane vole

IUCN Red List Category

- Microtus montanus* – Lower Risk, least concern (LR,lc)
- M. m. arizonensis* – Lower Risk, near threatened (LR,nt)
- M. m. codiensis* – Data Deficient (DD)
- M. m. fucosus* – Vulnerable (VU): D2
- M. m. nevadensis* – Vulnerable (VU): D2
- M. m. rivularis* – Lower Risk, near threatened (LR,nt)
- M. m. zygomaticus* – Data Deficient (DD)

Assignment of *M. m. arizonensis* and *M. m. rivularis* is based on their restricted distributions and apparent absence of any immediate threat to their continued survival. Assignment of *M. m. fucosus* and *M. m. nevadensis* is based on their severely restricted distributions. Assignment of the Wyoming subspecies (*M. m. codiensis* and *M. m. zygomaticus*) is based on the need for specific information on their current status, particularly the extent of any threat posed by grazing.

Taxonomy and distribution

Although Anderson (1959) considered *M. montanus* to be a sister-taxon to *M. oeconomus*, genetic (karyotypic and allozyme) analyses (Modi 1987, Moore and Janecek 1990) instead support a closer relationship between *M. montanus*, *M. pennsylvanicus*, and *M. townsendii*, as advocated by Hooper and Hart (1962). Anderson (1954) evaluated subspecies of *M. montanus* in Wyoming and Colorado, and Anderson (1959) reviewed the distribution, geographic variation, and systematic relationships of the entire species.

The montane vole is widely distributed over western North America from the central Rocky Mountains to the Sierra Nevada, and from British Columbia to central Arizona. Populations in the arid American Southwest are restricted to mesic montane sites or desert riparian patches, and thus have a highly fragmented distribution. Three disjunct southern subspecies and one southern peripheral subspecies are considered to be of conservation concern: *M. m. arizonensis* of the Mogollon Plateau of eastern Arizona and western New Mexico (Hubbard *et al.* 1983); *M. m. fucosus* from springs in the Pahrnagat Valley of southern Nevada (Hall 1946); *M. m. nevadensis*, reported from the vicinity of Ash Meadows in southern Nevada (Hall 1946); and *M. m. rivularis*, at the southern periphery of the species' Utah distribution (Hall 1981).

Two subspecies are considered to be of conservation concern in Wyoming. *Microtus montanus zygomaticus* is endemic to Wyoming, where it is restricted to the higher elevations of the Big Horn Mountains. Anderson (1954) considered this subspecies to be the most divergent within *M. montanus*. *Microtus montanus codiensis* is nearly endemic to northwestern Wyoming, with populations also occurring in the Bear Tooth Mountains of southern Montana.

Remarks

Populations of *M. montanus* in the Great Basin (*M. m. fucosus* and *M. m. nevadensis*) have highly restricted distributions, as they are dependent on marshy places in the vicinity of springs or meadows or irrigated fields. Thus they are particularly vulnerable to grazing or other practices that may degrade their habitat. *Microtus m. arizonensis*, while more geographically isolated than other subspecies, occurs over a larger area in high meadows of the Mogollon Plateau. Most of the range of this subspecies is in Arizona, with only two sites known in New Mexico (Hubbard *et al.* 1983). The Utah subspecies, *M. m. rivularis*, is not as isolated as the other subspecies, and represents the southernmost populations of *M. montanus* that range throughout the Wasatch Range of that state. No specific threats to any of these subspecies are known.

Concern for the Wyoming subspecies (*M. m. codiensis* and *M. m. zygomaticus*) is based on the history of extensive grazing within the range of both subspecies.

Conservation status and occurrence in captivity and protected areas

Microtus m. fucosus, *M. m. nevadensis*, and *M. m. rivularis* are federal C2 candidate taxa, presumably due to their limited distribution; *M. m. rivularis* is also regarded as a Sensitive taxon in Utah, although we know of no evidence for decline in this population. Prospects for survival or recruitment of *M. m. arizonensis* in New Mexico are considered to be in jeopardy by the New Mexico Department of Game and Fish. The Wyoming Conservation Data Center formerly listed the entire species *M. montanus* as Sensitive, without consideration for subspecies. They have recently reclassified *M. montanus* as Secure, but without specific information on the two endemic subspecies. The third subspecies in the state, *M. m. nanus*, is widespread and abundant in western and southern Wyoming. *Microtus m. codiensis* and *M. m. zygomaticus* have thus not been evaluated by Wyoming as to conservation status. No populations of any of the subspecies are known to occur in captivity or in protected areas.

Recommended action

- Evaluate level of genetic differentiation among *M. m. arizonensis*, *M. m. fucosus*, and *M. m. nevadensis* relative to neighboring populations of *M. montanus* using biochemical and molecular techniques.
- Survey historical sites of *M. m. fucosus* and *M. m. nevadensis* to determine current population status, and protect remaining habitat if necessary.
- Survey the known distribution of *M. m. codiensis* and *M. m. zygomaticus* to determine current population status and the extent (if any) of habitat degradation or loss due to grazing.

Microtus oeconomus (Pallas 1776) Tundra vole

Ellen Weintraub Lance and Joseph A. Cook

10 subspecies, 6 of conservation concern:

- M. o. amakensis* Amak Island tundra vole
- M. o. elymocetes* Montague Island tundra vole
- M. o. innuitus* St. Lawrence Island tundra vole
- M. o. popofensis* Shumagin Islands tundra vole
- M. o. punukensis* Punuk Islands tundra vole
- M. o. sitkensis* Alexander Archipelago tundra vole

IUCN Red List Category

- Microtus oeconomus* – Lower Risk, least concern (LR,lc)
- M. o. amakensis* – Data Deficient (DD)
- M. o. elymocetes* – Data Deficient (DD)
- M. o. innuitus* – Data Deficient (DD)
- M. o. popofensis* – Data Deficient (DD)
- M. o. punukensis* – Data Deficient (DD)
- M. o. sitkensis* – Data Deficient (DD)

Assignment of the six subspecies is based on the need for specific information on the current status of known insular populations and their distribution on the various islands.

Taxonomy

Microtus o. amakensis was first described as a full species on the basis of 28 specimens (Murie 1930). Hall and Cockrum (1952) and Paradiso and Manville (1961) subsequently suggested that this was a subspecies of the tundra vole. Fay and Sease (1985) noted that there are an additional 12 specimens in Fay's personal collection. *Microtus o. elymocetes* was originally considered a distinct species, based on seven specimens with distinctly larger size and darker pelage than adjacent tundra voles (Osgood 1906). Heller (1910), examined a series of thirty specimens, and concurred with Osgood's (1906) original species-level designation. However, Zimmermann (1942) and Paradiso and Manville (1961) subsequently concluded that this vole was a subspecies of *M. oeconomus*. Merriam (1900) described *M. o. innuitus* as a distinct species based on its darker coloration, and larger size, including a more massive, angular skull with inflated bullae. However, Hall and Gilmore (1932) and Zimmermann (1942) concluded that it was a subspecies of *M. oeconomus*. *Microtus o. popofensis* was first described by Merriam (1900) as a subspecies of *M. unalascensis* based on an unreported number of specimens (possibly seven, Bailey 1900). Zimmermann (1942) suggested that this was a subspecies of *M. oeconomus*. Murie (1959:322) noted that *M. o. popofensis* can be distinguished from the mainland *M. o. operarius* by skull characters, including "a more slender rostrum, with a little longer and definitely wider incisive foramen." Hall and Gilmore (1932) described *M. o. punukensis* as a subspecies of *M. innuitus* based on 21

specimens. Subsequent revisions placed it under *M. oeconomus* (Zimmermann 1942, Paradiso and Manville 1961). This taxon is similar to *M. o. innuitus* on nearby St. Lawrence Island, but differs in that the supraoccipital is flat and vertical instead of convex and sloping (Hall and Gilmore 1932, Fay and Sease 1985). *Microtus o. sitkensis* was first described as a distinct species from specimens taken near Sitka, Baranof Island, Southeastern Alaska (Merriam 1897). Later collecting in 1907 extended the range of this vole to nearby Chichagof Island (Heller 1909). The most recent published revision of this taxon was by Paradiso and Manville (1961). A recent unpublished revision of tundra voles from Southeastern Alaska (Antell 1987) used morphometric data from skulls and pelage comparisons, but did not include this subspecies.

Distribution

The tundra vole has a large Holarctic distribution, occurring in North America in Alaska through Yukon Territory to western Northwest Territories and northwestern British Columbia. Seven subspecies are found on islands of the Bering Sea or Gulf of Alaska. One of these (*M. o. unalascensis*) occurs on several Aleutian Islands and the tip of the adjacent Alaska Peninsula; the other six, all considered to be of conservation concern, are restricted to islands. *Microtus o. amakensis* is known to occur only on Amak Island (55°25'N, 163°08'W), a low island of about 40km² (Orth 1971) that is about 20km north of the Alaska Peninsula. *Microtus o. elymocetes* is known only from Montague Island (60°10'N, 147°15'W; 850km²) in Prince William Sound, Alaska. *Microtus o. innuitus* occurs only on St. Lawrence Island (63°30'N, 170°30'W; 4,500km²) in the Bering Sea, Alaska. *Microtus o. popofensis* is known from two small islands, Popof (55°9'N, 160°24'W) and Unga (55°11'N, 160°30'W) in the Shumagin Island group, Alaska, although E. Bailey (pers. comm.) reports voles on other islands in this group. *Microtus o. punukensis* is known only from Big Pujuk and Center Pujuk islands (63°05'N, 168°49'W) southeast of St. Lawrence Island, Bering Sea, Alaska (Hall and Gilmore 1932, Paradiso and Manville 1961). *Microtus o. sitkensis* is presumably restricted to Baranof and Chichagof islands, Alexander Archipelago, Southeastern Alaska.

Remarks

Murie (1930) and Fay and Sease (1985) reported that *M. o. amakensis* had been collected in beach rye (*Elymus mollis*), wild celery (*Angelica lucida*), ferns (*Dryopteris dilatata*), and lupine (*Lupinus nootkatensis*) on the lower elevations of the southeastern plain of Amak Island. However, a few were collected in crowberry (*Empetrum nigrum*) at mid-elevations on the volcano. There have been no estimates of population size of *M. o. amakensis*, although Murie (1959) noted that these voles were “extremely abundant” in 1925 when he trapped on the island.

Microtus o. elymocetes may have dispersed over-water to Montague Island less than 12,000 years ago. The island is isolated in Prince William Sound by deep ocean trenches. The most recent glacial maximum in the region occurred during the Wisconsin, at which time Montague Island was covered by a piedmont glacier, with the possible exception of small nunatacs (Molina 1986, Mobley 1990). Heller (1910) described Montague Island voles as abundant at several locations he visited on the island. Habitat descriptions from the early 1900s indicate the Montague Island vole was abundant from the shoreline to the alpine zone, with especially high concentrations among the rye grass (*Elymus mollis*) and in the coniferous forest (Osgood 1906). Seventy *M. o. elymocetes* were trapped using Sherman live traps and museum special snap traps in 7,314 trap nights in 1991 (Weintraub and Cook 1991). Trap effort in 1991 occurred in several habitat types. However, 51 of the voles were trapped in 304 trap nights in *Elymus*/Beach Fringe habitat. That recent inventory corroborates the association between voles and rye grass, although seasonal influence on habitat use has not been examined (Weintraub and Cook 1992). Effects of tundra vole population fluctuations and seasonal movements on habitat use are unknown. Sitka black-tailed deer (*Odocoileus hemionus sitkensis*) and mink (*Mustela vison*) were successfully introduced to islands in the Prince William Sound in the early 1950s. Logging occurred along the west coast of Montague in the 1960s and early 1970s, and along the east coast in the 1990s. The effects of logging and species introductions on the voles is not known.

Microtus o. innuitus was abundant in 1949–1951: Rausch (1953b) reported collecting about 600 specimens during this time. This subspecies may exhibit weak population cycles of three to four years duration (Rausch and Schiller 1956, Fay 1973). No estimation of total population size has been reported. Rausch (1953b) noted that other terrestrial mammals on St. Lawrence Island include a shrew (*Sorex jacksoni*), arctic ground squirrel (*Spermophilus parryii*), northern red-backed vole (*Clethrionomys rutilus*), varying lemming (*Dicrostonyx exsul*), arctic fox (*Alopex lagopus*), and the introduced reindeer (*Rangifer tarandus*).

Allen (1902:223) noted that Figgins reported “Popof Island was literally overrun with these mice [*M. o. popofensis*]” and Murie (1959:322) reported them as “extremely abundant at one place on Unga Island” in 1936 and “the ground was honeycombed with burrows.” However, Fay (pers. comm., cited in Fay and Sease 1985) noted little sign of the voles in the Sand Point area in 1981. The current status is unknown. Red foxes (*Vulpes vulpes*), bison (*Bison bison*), dogs (*Canis familiaris*), and cats (*Felis catus*) have all been introduced on Popof Island and the effect of these introductions on the vole populations has not been monitored.

Microtus o. punukensis is the only small mammal on the Pujuk Islands. Fay and Sease (1985) reported *M. o.*

punukensis as common in 1962 when Fay collected about 100 additional specimens. Fay and Kelly (1980) noted that voles were absent from Center Punuk Island in 1979 when they searched for them. Fay and Sease (1985) noted that walruses (*Odobenus rosmarus*) have impacted some of the vole habitat.

The current status of *M. o. sitkensis* is unknown. We know of only two tundra vole specimens taken on Chichagof Island after 1907 (Carnegie Museum #62297 and University of Alaska Museum #14610), despite intensive trapping by the University of Alaska Museum and others (R. Flynn pers. comm.) in recent years. Specimens of this subspecies were collected from Lake Plotnikof in 1994.

Conservation status and occurrence in captivity and protected areas

Microtus o. amakensis and *M. o. elymocetes* are federal C2 candidate taxa. Amak Island is part of the Alaska Maritime Refuge and is managed by the United States Fish and Wildlife Service. There are no humans living on the island. Montague Island is the largest island in Prince William Sound at about 850km². Some 63km² is privately owned by the Chugach Alaska Native Corporation and is currently undergoing clearcut logging. A new road links the deep water port at McLeod Harbor to the logging sites north of the Nellie Martin River. The remaining 787km² is managed by the United States Forest Service (Chugach National Forest Management of Resource Information Group 1993). St. Lawrence Island is a National Reindeer Range that is managed by the Gambell and Savoonga Native Corporations. The island is about 155km long and 40km wide (Orth 1971) and is some 4,500km² in area (Fay and Sease 1985). Popof Island is almost entirely owned by the Shumagin Native Corporation while Unga is owned by the Unga Corporation. The Alaska Maritime Refuge (United States Fish and Wildlife Service) manages Bay Point on the western side of Unga because of the existence of sea bird colonies (E. Bailey pers. comm.). Sand Point on Popof is a village of 625 people (Fay and Sease 1985) and Squaw Harbor on Unga is reported to have less than 100 people (E. Bailey pers. comms.). The ownership of the Punuk Islands is unclear (Fay and Sease 1985), but they may be part of the St. Lawrence Island National Reindeer Range. Both Baranof and Chichagof islands are being extensively logged. This activity is currently exempt only in the West Chichagof-Yakobi Wilderness and South Baranof Wilderness. The effects of logging on tundra vole populations is unknown.

Recommended action

- Conduct a morphological and molecular taxonomic study to determine relationships of insular subspecies to each other and to populations on the adjacent mainland.

- Conduct a survey to determine distribution and population status of all insular forms of *M. oeconomus*.
- Monitor insular populations of *M. oeconomus* regularly to detect incipient threats to populations.
- Investigate possible seasonal shifts in habitat use by *M. o. elymocetes*: the *Elymus*/Beach Fringe habitat may not be occupied in the wet winter months.

***Microtus pennsylvanicus* (Ord 1815)** **Meadow vole**

Stephen O. MacDonald, Joseph A. Cook,
Gordon L. Kirkland, Jr., and Eric Yensen

26 subspecies, 5 of conservation concern in North America (north of Mexico):

- M. p. admiraltiae* Admiralty Island meadow vole
- M. p. dukecampbelli* Florida saltmarsh vole
- M. p. kincaidi* Potholes meadow vole
- M. p. provectus* Block Island meadow vole
- M. p. shattucki* Penobscot meadow vole

IUCN Red List Category

- Microtus pennsylvanicus* – Lower Risk, least concern (LR,lc)
- M. p. admiraltiae* – Lower Risk, near threatened (LR,nt)
- M. p. dukecampbelli* – Vulnerable (VU): D2
- M. p. kincaidi* – Lower Risk, near threatened (LR,nt)
- M. p. provectus* – Lower Risk, near threatened (LR,nt)
- M. p. shattucki* – Lower Risk, near threatened (LR,nt)

Assignment of the three insular subspecies, *M. p. admiraltiae*, *M. p. provectus*, and *M. p. shattucki*, is based on their restricted distribution and the apparent absence of any immediate threat to their continued survival. Assignment of *M. p. kincaidi* is based on its highly restricted distribution, low number of known populations, degree of population fluctuation, and loss of prairie habitat in its region of occurrence. Assignment of *M. p. dukecampbelli* is based on its severely restricted distribution.

Taxonomy

Microtus p. admiraltiae was described as a distinct species by Heller (1909) from a series collected in 1907 from three localities on Admiralty Island, Southeastern Alaska. Swarth (1933, 1936) gave it subspecific ranking under *Microtus pennsylvanicus*. *Microtus p. admiraltiae* is a poorly-defined taxon in need of revision using materials from the mainland and the newly-discovered island localities. Compared to other subspecies, *M. p. dukecampbelli* is larger and darker (Woods *et al.* 1982); ‘saltmarsh melanism’ is exhibited by a number of other saltmarsh-dwelling small mammals. Dalquest (1948:347) distinguished *M. p. kincaidi* by its “large size; dark blackish color; long fur; wide, angular skull.” The geographically closest *M. p. funebris* is “size medium; color reddish

brown; fur short, harsh; skull small and narrow.” There are specimens of *M. pennsylvanicus* from Adams, Lincoln, and extreme northern Grant Counties that either extend the range of *M. p. kincaidi*, or belong to *M. p. funebris* or possibly an undescribed subspecies, but the taxonomic affinities of these specimens have not been examined in detail (R.E. Johnson pers. comm.). The taxonomic status of *M. p. provectus* and *M. p. shattucki* has not been re-examined since their description by Youngman (1967).

Distribution

The meadow vole has a very extensive distribution across North America, ranging continuously from the Atlantic to the Pacific coasts, south along the eastern seaboard to Georgia, and south along the Rocky Mountains into New Mexico. Disjunct, relictual populations are known from Washington (*M. p. kincaidi*), Florida (*M. p. dukecampbelli*), New Mexico (*M. p. modestus*), and Chihuahua, Mexico (*M. p. chihuahuensis*; Anderson 1972). Restricted subspecies have been described from islands in the Gulf of St. Lawrence, Quebec (*M. p. magdalenensis*), and nearshore islands adjacent to New Brunswick (*M. p. copelandi*), Maine (*M. p. shattucki*), Rhode Island (*M. p. provectus*), and Alaska (*M. p. admiraltiae*). Peripheral populations of *M. pennsylvanicus* in New Mexico are known from around the Sangre de Cristo Mountains, along the San Juan River, and from relict marsh communities in the northern part of the state, and from remote, isolated sites in west-central New Mexico (Findley *et al.* 1975, R. A. Smartt pers. comm.).

Microtus p. admiraltiae was thought to be restricted to Admiralty Island in the Alexander Archipelago of Southeastern Alaska. However, collectors for the University of Alaska Museum have recently found meadow voles on Mitkof and Vank islands in the Alexander Archipelago (MacDonald and Cook 1994). These islands are close to the mainland and the Stikine River, where the subspecies *M. p. rubidus* is said to occur (Dale 1940, Hall 1981). *Microtus p. dukecampbelli* is endemic to Central Florida’s Gulf Coast and is known only from the shore of Waccasassa Bay near Cedar Key. All records of *M. p. kincaidi* are from the vicinity of Moses Lake and Grand Coulee, Grant County, Washington. R. E. Johnson (pers. comm.) knew of 26 specimens from eight localities, all in Grant County; the most recent specimen was collected in 1977. *Microtus p. provectus* is known only from Block Island (<30km²), Newport Co., Rhode Island (Chamberlain 1954), while *M. p. shattucki* is known from three islands in Penobscot Bay, Maine: Islesboro (= Long), North Haven, and Tumble Down Dick islands, with a total area of <100km².

Remarks

Microtus p. dukecampbelli is believed to have separated from *M. p. pennsylvanicus* 5,000 or more years ago as grasslands in Florida disappeared and saltmarsh habitats

became isolated (Woods *et al.* 1982). According to Woods (1992), *M. p. dukecampbelli* favors seashore saltgrass (*Distichlis spicata*) and black rush (*Juncus roemerianus*) and avoids smooth cordgrass (*Spartina alterniflora*). The small range of *M. p. dukecampbelli*, coupled with the short- and long-term disturbances characteristic of its saltmarsh habitat, make the Florida saltmarsh vole highly susceptible to extirpation from flooding of its habitat. Predicted increases in mean sea level also threaten this form (Woods 1992). *Microtus p. dukecampbelli* appears to be reproductively active all year long, with breeding being most intense in February and March (Woods 1992). High reproductive potential may be a key to the survival of this subspecies. Because it inhabits an environment that is subject to periodic catastrophic disturbances from severe storms, including hurricanes, the ability to rapidly increase in numbers may be essential to its survival. Maximum known density was recorded in 1980 when five males and nine females were trapped in a 3.75ha sampling grid (Woods *et al.* 1982). The population was severely reduced in 1987 and 1988.

The status of *M. p. admiraltiae* is unknown. Recently, the University of Alaska Museum has collected specimens of this vole from localities at the head of Seymour Canal, Hood Bay, and Pybus Bay on Admiralty Island. *Microtus p. kincaidi* inhabits marshy areas around lakes and potholes, and is cyclically abundant (Dalquest 1948). An attempt several years ago by students from Washington State University to trap this subspecies was unsuccessful (M. O’Connell pers. comm.). Chamberlain (1954) noted that pronounced ecological change had occurred on Block Island since the original description of *M. p. provectus* by Bangs (1908). In 1908, the island was under intensive cultivation and trees were virtually nonexistent. In the 1950s, the island was dominated by abandoned fields. If natural succession has continued since the 1950s, the amount of suitable habitat for *M. p. provectus* may have been substantially reduced. No information is available on the current status of *M. p. shattucki*, which has a broader distribution on several larger islands. Reich (1981) reviewed the general biology of this species.

Conservation status and occurrence in captivity and protected areas

Microtus p. dukecampbelli is a federal and Florida Endangered taxon. *Microtus p. kincaidi* is on the State of Washington Monitor list and is a federal C2 candidate taxon. *Microtus p. provectus* and *M. p. shattucki* are federal C2 candidate taxa. Most of Admiralty Island, except the northern point that includes Mansfield Peninsula, is within Admiralty Island National Monument and the Kootznookoo Wilderness, providing a measure of protection for populations of *M. p. admiraltiae*. No populations of the other subspecies are known to occur in captivity or protected areas.

Recommended action

- Collect additional specimens from Admiralty Island and surrounding localities to document current distribution of *M. p. admiraltiae* and for a taxonomic revision using modern techniques.
- Consider establishing a captive-breeding program for *M. p. dukecampbelli* and reintroducing surplus individuals to suitable habitat.
- Sample other saltmarshes along the west coast of Florida between Suwannee and Withlacoochee rivers in order to locate additional populations of *M. p. dukecampbelli*.
- Protect saltmarsh and adjacent upland habitat in the vicinity of *M. p. dukecampbelli* (Woods 1992).
- Conduct survey to document current distribution, population status, and nature and extent of any threats to the continued survival of *M. p. kincaidi*.
- Conduct survey to document current distribution, population status, and nature and extent of any threats to the continued survival of *M. p. provectus*.
- Conduct survey to document current distribution, population status, and nature and extent of any threats to the continued survival of *M. p. shattucki*.
- Investigate taxonomic identity of peripheral records of voles near *M. p. kincaidi* to determine the taxonomic distinctiveness of this population and the limits of the subspecies.

Microtus townsendii (Bachman 1839) Townsend's vole

David W. Nagorsen and Eric Yensen

6 subspecies, 2 of conservation concern:

M. t. cowani Triangle Island vole

M. t. pugeti Shaw Island vole

IUCN Red List Category

Microtus townsendii—Lower Risk, near threatened (LR,nt)

M. t. cowani—Lower Risk, conservation dependent (LR,cd)

M. t. pugeti—Lower Risk, near threatened (LR,nt)

Assignment of the species is based on its restricted distribution in the Pacific Northwest. Assignment of *M. t. cowani* is based on the highly restricted distribution of the subspecies within an ecological reserve; assignment of *M. t. pugeti* is based on its restricted distribution and the apparent absence of any immediate threats to its continued survival.

Taxonomy

Microtus t. cowani is a strongly differentiated subspecies that exhibits gigantism and an unusual pale, grizzled pelage (Guiguet 1955). There have been no genetic studies, but this taxon could be differentiated at the species level.

It demonstrates some remarkable parallels to *M. breweri*, an insular species from Muskeget Island, off Nantucket, Massachusetts in the eastern United States. *Microtus t. pugeti* is distinguished from mainland subspecies by its small size and the wide interorbital region of the skull (Dalquest 1948). The original taxonomy has not been re-examined.

Distribution

Townsend's vole occurs along the Pacific coast and nearshore islands from British Columbia to northern California. *Microtus t. cowani* is known only from Triangle Island (1.07km²), the outermost island of the Scott Islands off the northwest coast of Vancouver Island, British Columbia (Carl *et al.* 1951). *Microtus townsendii* is absent from the other Scott Islands. This isolated island population is 12km from the nearest island in the archipelago, and 46km from Vancouver Island where the nearest population of *M. townsendii* is found. *Microtus t. pugeti* is restricted to several islands in the Puget Sound, Washington (Schoen 1972). R. E. Johnson (pers. comm.) has records of 75 total specimens, collected from Allen, Cypress, Deception, Dot, Frost, Guemes, Lopez, Orcas, Saddlebag, San Juan, Shaw, Sucia, and Turn Islands. There are additional records (apparently without specimens) from Henry and McConnel islands.

Remarks

Triangle Island is treeless and supports hundreds of thousands of nesting seabirds. The greatest potential threat would be the introduction of predators (e.g., mink, *Mustela vison*) or rats (*Rattus* sp). European rabbits (*Oryctolagus cuniculatus*) were introduced in the early 1900s when the island had a lighthouse. A feral population is established, but its impact on *M. t. cowani* is unknown. *Microtus t. pugeti* occurs in meadows, saltmarshes, beach driftwood, sparse grass, and rock piles, but it may be more limited in the range of habitats it uses than the deer mice (*Peromyscus maniculatus*) that also inhabit these islands (Dalquest 1948, Schoen 1972). There seems to be little primary information on this subspecies (R.E. Johnson pers. comm.). The San Juan Islands are experiencing habitat changes from an increasing human population. Potential threats to the vole would include habitat loss and increased numbers of domestic dogs and cats (D. Taylor pers. comm.). Cornely and Verts (1988) reviewed the general biology of this species.

Conservation status and occurrence in captivity and protected areas

Microtus t. cowani is on the Red List of the British Columbia Ministry of Environment. *Microtus t. pugeti* is on the state of Washington Monitor list but is a federal C3C taxon ("more abundant or widespread than previously believed... or not subject to any identifiable threat"). Triangle Island

is an ecological reserve. Visitors (in theory) require permits. No populations of *M. t. pugeti* are known to occur in captivity or protected areas.

Recommended action

- Resolve the taxonomic level (species or subspecies?) of *M. t. cowani* through genetic comparison with mainland and other insular subspecies.
- Assess habitat affinities, population vulnerability, and possible impacts of introduced rabbits on populations of *M. t. cowani*.
- Determine the current distribution, abundance, and threats to *M. t. pugeti* by field survey.
- Monitor populations of *M. townsendii* to assess any current or potential threats, particularly habitat reduction.

***Neofiber alleni* True 1884** **Round-tailed muskrat**

Gordon L. Kirkland, Jr.

IUCN Red List Category

Neofiber alleni Lower Risk, near threatened (LR,nt)

Assignment of *N. alleni* is based on the restricted distribution and absence of any immediate threats to its continued survival.

Taxonomy and distribution

Neofiber alleni, a monotypic genus, is sometimes placed within the genus *Ondatra*, but morphological and fossil evidence indicates a very distant relationship (summarized in Musser and Carleton 1993). The round-tailed muskrat is restricted to the Florida peninsula and adjacent Georgia. The modern distribution of the genus is but a small relict of a widespread Pleistocene range (Frazier 1977). Birkenholz (1972) questioned the utility of the slightly differentiated subspecies of *N. alleni*, and Burt (1954) used subspecies of *N. alleni* in his criticism of the use of subspecies in mammalogy. Burt felt that subspecies boundaries in *N. alleni* did not correspond to observed geographic variation in pelage coloration, although this was supposedly the principal character upon which the subspecies were based. Burt documented a north-to-south cline of increasing intensity of melanism with decreasing latitude on the Florida peninsula, and felt that there was no evidence to support subspecific differentiation in *N. alleni*. There have been no taxonomic revisions of *N. alleni* since Schwartz (1953).

Remarks

The species inhabits heavily vegetated freshwater habitats, and is restricted to permanent bodies of freshwater free of freezing; Birkenholz (1972) reviewed the general biology

of this species. Population trends appear to be related to water-level fluctuations and changes in habitat conditions. According to Humphrey (1992a), draining, filling, or mining of wetlands threatens existing and potential habitat of this species. Further, populations isolated by urbanization would be extremely vulnerable to destruction by natural fluctuations in water levels.

Conservation status and occurrence in captivity and protected areas

Neofiber alleni is a federal C2 candidate species and is considered by the Florida Committee on Rare and Endangered Plants and Animals to be a Species of Special Concern. No immediate threats to its populations are known. No populations are known to occur in captivity or in protected areas.

Recommended action

- Conduct a field survey to determine the current distribution, abundance, and nature and extent of any threats to the continued survival of *Neofiber alleni*.
- Consider the establishment of protected areas if surveys indicate a restricted distribution and the existence of serious threats to the survival of the species.

***Neotoma floridana* (Ord 1818)** **Eastern woodrat**

Eric Yensen and Gordon L Kirkland, Jr.

9 subspecies, 3 of conservation concern:

N. f. baileyi Bailey's eastern woodrat

N. f. haematoreia Southern Appalachian eastern woodrat

N. f. smalli Key Largo woodrat

IUCN Red List Category

Neotoma floridana – Lower Risk, least concern (LR,lc)

N. f. baileyi – Lower Risk, near threatened (LR,nt)

N. f. haematoreia – Lower Risk, near threatened (LR,nt)

N. f. smalli – Endangered (EN): B2c;C2b

Assignments of *N. f. baileyi* and *N. f. haematoreia* are based on their restricted distribution and apparent lack of any immediate threats to their continued survival. Assignment of *N. f. smalli* is based on the past and projected decline in both extent and quality of its restricted habitat, and the fact that all individuals of the subspecies are in a single population.

Taxonomy and distribution

The eastern woodrat formerly was distributed widely over most of eastern United States. *Neotoma f. baileyi* is a relict population that may have been isolated from other populations of *N. floridana* after the warmer, wetter Climatic Optimum of 9,000 to 4,000 years ago (Jones *et al.*

1983). A disjunct subspecies, *N. f. baileyi* is found along the Niobrara River in north-central Nebraska from Valentine east to near Nebraska Highway 137, a distance of about 110km (M. Clausen pers. comm.). Records of this subspecies from adjacent South Dakota in Hall (1981) have been rejected (Jones 1964, Birney 1973, Jones *et al.* 1983) as a misidentification of *Neotoma cinerea rupicola*, and there are no confirmed records of the species from that state. Birney (1973) was unable to locate it in South Dakota, and it is doubtful that the species occurs there (D. Blacklund pers. comm.). *Neotoma f. baileyi* differs from the adjacent subspecies, *N. f. campestris*, which occurs further south on the Great Plains, by its darker pelage, smaller size, and shorter incisive foramina in the skull (Jones *et al.* 1983). Birney (1973) concluded on the basis of cranial morphometrics that it was a valid subspecies.

An insular subspecies (*N. f. smalli*) is restricted to the northern half of Key Largo, Monroe County, off the southern tip of Florida. This subspecies occupies a narrow range of habitats, occurring principally in dry tropical forests (Humphrey 1992c), specifically mature tropical hammock type forest (Brown 1978b). *Neotoma f. smalli* is smaller than its conspecifics in Florida.

In addition to these two disjunct subspecies, a geographically restricted subspecies is considered to be of conservation concern: *N. f. haematoreia* is found in a limited area of the southern Appalachian Mountains. *Neotoma magister*, formerly considered and listed as a federal C2 candidate taxon as a subspecies of *N. floridana*, is herein treated as a distinct species (see account of *N. magister*).

Remarks

Neotoma f. baileyi is very localized in distribution (M. Clausen pers. comm.), occurring in eastern red cedar (*Juniperus virginiana*) and cottonwoods (*Populus deltoides*), abandoned buildings, and dense plum thickets in the sand hills. The subspecies tends to occur in colonies of clusters of individuals separated from other such clusters, seems tolerant of human activities, and adapts to a variety of habitats. Pastureland, the current land use, appears compatible with the woodrats; wooded areas along the Niobrara River inhabited by woodrats are not threatened (M. Clausen pers. comm.).

Humphrey (1992c) estimated the undeveloped upland forest habitat remaining for *N. f. smalli* on Key Largo as 851ha. There is no remaining mature dry tropical forest habitat on the southern two-thirds of Key Largo. A distinctive feature of the Key Largo woodrat (*N. f. smalli*) is its habit of constructing large and conspicuous stick houses on the ground; these sometimes approach the size and configuration of small beaver lodges (Brown 1978b). Associated with stick houses is a burrow system that includes a nest chamber and one or more entrances (Humphrey 1992c). The principal threat to *N. f. smalli* is

the conversion of its habitat to residential and other human uses; the introduced black rat (*Rattus rattus*) is a potential competitor (Humphrey 1992c).

We know of no threats to *N. f. haematoreia*. Wiley (1980) reviewed the general biology of this species.

Conservation status and occurrence in captivity and protected areas

Neotoma f. baileyi was once proposed for listing because of a projected dam on the Niobrara River, which would have flooded much of its range. However, plans for the dam have been withdrawn, and pending a major change in land use, the population appears secure (M. Clausen pers. comm.). *Neotoma f. baileyi* occurs in Niobrara National Park, which should provide long-term protection. *Neotoma f. haematoreia* is a federal C2 candidate taxon, presumably due to its restricted distribution; the status of the subspecies varies from Imperiled in North Carolina, to Undetermined in South Carolina, to Demonstrably Secure in Georgia. *Neotoma f. smalli* is a federal and Florida Endangered taxon. No populations of *N. f. haematoreia* or *N. f. smalli* are known to occur in captivity or protected areas.

Recommended action

- *Neotoma f. baileyi* is currently being monitored by the Nebraska Natural Heritage Database, and this should continue; no new action is required.
- Preserve forest habitat critical to *N. f. smalli* on Key Largo.
- Survey population and distributional status of *N. f. haematoreia*, and determine nature and extent of any immediate threats to its continued survival.

Neotoma fuscipes Baird 1858 Dusky-footed woodrat

David J. Hafner

11 subspecies, 3 of conservation concern in North America (north of Mexico):

N. f. annectens San Francisco dusky-footed woodrat

N. f. luciana Monterey dusky-footed woodrat

N. f. riparia San Joaquin Valley woodrat

IUCN Red List Category

Neotoma fuscipes – Lower Risk, least concern (LR,lc)

N. f. annectens – Data Deficient (DD)

N. f. luciana – Data Deficient (DD)

N. f. riparia – Critically Endangered (CR): B1;B2c

Assignment of *N. f. annectens* and *N. f. luciana* is based on the need for specific information on their population status, current distribution, and nature and extent of any threats to their continued survival. Assignment of *N. f.*

riparia is based on the extensive loss of habitat experienced by the subspecies, which is now restricted to a single known population.

Taxonomy and distribution

Neotoma fuscipes is a member of the subgenus *Teonoma*, along with *N. cinerea* (Carleton 1980, Koop *et al.* 1985). The dusky-footed woodrat occurs in brushy habitat in chaparral and foothills woodlands along the Coast Range and Sierra Nevada of California, extending north into the Cascade Range of Oregon and south into the Peninsular Range of Baja California. *Neotoma f. riparia* occurs in riparian communities in the northern San Joaquin Valley; *N. f. annectens* is found around the southern San Francisco Bay and adjacent coastal ranges; and *N. f. luciana* occurs south of that subspecies to Morro Bay.

Remarks

Williams and Kilburn (1992) consider *N. f. riparia* to be a taxon “facing proximate threats to extinction” due to “loss of habitat to cultivation, lack of appropriate refuge from annual flooding, ... regulation of stream flow, stream channelization, and removal of brush, trees, and snags from riverside habitat.” The subspecies historically was known from along the San Joaquin, Stanislaus, and Tuolumne rivers in Stanislaus and San Joaquin counties, but is currently known only from Caswell Memorial State Park in San Joaquin County. Other populations may be extant, but there are no records since the 1970s (Williams and Kilburn 1992). No specific threats to *N. f. annectens* or *N. f. luciana* are known, but a large part of their combined range has been subjected to extensive development by the expanding metropolitan areas surrounding San Francisco Bay and along the coast. Carraway and Verts (1991) reviewed the general biology of this species.

Conservation status and occurrence in captivity and protected areas

Neotoma f. riparia is a federal C1 candidate taxon; *N. f. annectens* and *N. f. luciana* are federal C2 candidate taxa. All three are California Species of Special Concern. State parks may be important refugia for these subspecies that are subjected to extensive development of their limited ranges, particularly Caswell Memorial State Park (*N. f. riparia*), and Mount Diablo and Big Basin Redwoods State Parks (*N. f. annectens*). The Ventana Wilderness of Los Padres National Forest encloses a large portion of the range of *N. f. luciana* in the Santa Lucia Range.

Recommended action

- Immediate in-depth survey of the distribution, extent of suitable habitat, population structure, precise habitat requirements, and threats to remaining populations of *N. f. riparia*.

- Survey to determine status of populations of *N. f. annectens* and *N. f. luciana* in protected areas (e.g., state parks and wilderness areas), and in undeveloped sites within their ranges.

***Neotoma lepida* Thomas 1893**

Desert woodrat

David J. Hafner

23 subspecies, 1 of conservation concern in North America (north of Mexico):

N. l. intermedia (*sensu* Planz 1992) San Diego desert woodrat

IUCN Red List Category

Neotoma lepida – Lower Risk, least concern (LR,lc)

N. l. intermedia – Data Deficient (DD)

Assignment is based on the need for specific information on the population status, distribution, and nature and extent of any threats to the continued survival of *N. l. intermedia*.

Taxonomy and distribution

Neotoma lepida formerly included woodrats of the arid regions of the Great Basin, Mojave Desert, western Sonoran desert, Baja California peninsula (and offshore islands), southern San Joaquin Valley, and California coastal chaparral from south of San Francisco Bay, California, into Baja California, Mexico. Most of the populations on Baja California offshore islands were originally described as distinct species, although they are likely conspecific with populations on the peninsular mainland (Mascarello 1978). However, Mascarello (1978) argued that populations south and east of the Colorado River in Arizona and Sonora (Mexico) should be recognized as a distinct species (*N. devia*), and that populations of the Baja California peninsula and coastal California east to the Salton Sea are as distinct from *N. lepida* as is *N. devia*. Planz (1992) proposed a distinct species, *N. intermedia*, of Baja California, the California coast, and San Joaquin Valley. This new species would include all former *N. lepida* of the Baja California peninsula and offshore islands, and the following subspecies of *N. lepida* in California: *californica*, *gilva*, *intermedia*, part of *lepida* (in southeastern California), and *petricola*. *Neotoma intermedia* may be more divergent than the other two species of the *Neotoma lepida* species-group (Planz 1992). Pending a formal taxonomic revision of the species-group, we retain *N. intermedia* (as geographically defined by Planz 1992) as a subspecies of *N. lepida*.

Evidence from bacular (Burt and Barkalow 1942) and cranial (Carleton 1980) morphology, chromosomal studies (Mascarello and Hsu 1976), and allozyme and mtDNA data (Planz 1992) indicate that the *Neotoma lepida* species-



Desert woodrat,
Neotoma lepida.

D.G. Huckaby

group is a distinct lineage that warrants at least subgeneric status (the species-group is currently included in the subgenus *Neotoma*). Taxonomic revision of the *Neotoma lepida* species-group is in preparation (Planz pers. comm.).

Remarks

No specific threats to *N. l. intermedia* are known. However, the geographic range of this form of *N. lepida* includes those arid regions most subjected to habitat loss and degradation in California: the southern San Joaquin Valley and the coastal deserts of southern California.

Conservation status and occurrence in captivity and protected areas

Neotoma l. intermedia is a federal C2 candidate taxon and a California Species of Special Concern. No populations are known to occur in captivity or in protected areas.

Recommended action

- Specify exact distribution and current status of populations of *N. l. intermedia* in the southern San Joaquin Valley and coastal deserts of southern California through a general trapping survey.
- Conduct genetic and morphological survey of populations within the taxon *intermedia* to determine the nature of geographic variation in the taxon and relative to populations on islands surrounding the Baja California peninsula.

***Neotoma magister* Baird 1858** **Allegheny woodrat**

Gordon L. Kirkland, Jr.

IUCN Red List Category

Neotoma magister Lower Risk, near threatened (LR,nt)

Assignment is based on the past decline, from unknown causes, in extent of the species' distribution. Although its

range is still quite extensive, further range reduction and fragmentation could make the species Vulnerable or Endangered.

Taxonomy and distribution

The Allegheny woodrat was considered to be a subspecies of *N. floridana*, but Hayes and coworkers (Hayes 1990, Hayes and Harrison 1992, Hayes and Richmond 1993) have provided convincing evidence of the specific integrity of *N. magister*.

The Allegheny woodrat historically was found from Connecticut and New York southward through the Appalachian Mountains to extreme northern Alabama. It also occurred westward along the Ohio and Mississippi River drainages in southern Ohio, Indiana, and Illinois (Hall 1981). It is now extirpated in Connecticut and New York, and it is greatly reduced in abundance and distribution in New Jersey, Pennsylvania, Ohio, Indiana, and Illinois. The species occupies rocky habitats, including caves, deep crevices, talus slopes with large boulders and adjacent woodlands. Populations appear to be small and localized in distribution in many areas.

Remarks

Specific causes of the decline of *N. magister*, especially in the northern regions of its distribution, are not known. Suspected agents include climate change, decline in food supply resulting from gypsy moth defoliation of mast trees or stress from acid precipitation, increased predation from Great Horned Owls (*Bubo virginianus*) owing to habitat fragmentation, and mortality from a raccoon nematode (*Baylisascaris procyonis*).

Conservation status and occurrence in captivity and protected areas

Neotoma magister is a federal C2 candidate taxon (listed as *Neotoma floridana magister*). Its status in the states varies from Historically Known in New York, In Need

of Conservation in Maryland, and Threatened in Pennsylvania and Indiana, to Endangered in New Jersey, Ohio, and Illinois. The Baltimore Zoo maintains a captive colony of *N. magister*. No populations are known to occur in protected areas.

Recommended action

- Survey remaining populations in northern reaches of the distribution of *N. magister* to document current population status.
- Determine specific nature and extent of threats to continued survival, and whether these threats are human-related or due to climatic change.
- Consider the establishment of protected areas if the species is found to be very restricted and its survival under serious threat.

***Ondatra zibethicus* (Linnaeus 1766) Muskrat; common muskrat**

David J. Hafner

16 subspecies, 1 of conservation concern in North America (north of Mexico):

O. z. ripensis Rio Grande muskrat

IUCN Red List Category

Ondatra zibethicus – Lower Risk, least concern (LR,lc)

O. z. ripensis – Data Deficient (DD)

Assignment of *O. z. ripensis* is based on the need for specific information on its current distribution, population status, and genetic integrity.

Taxonomy and distribution

The muskrat is broadly distributed over most of North America from the Arctic Ocean to northern Mexico. Following introduction in Czechoslovakia in 1905, it spread throughout the Palearctic as well. Another introduction into Argentina resulted in established colonies there. The southernmost subspecies, *O. z. ripensis*, occurs along the Rio Grande and Pecos Rivers of New Mexico, Texas, and adjacent Mexico, and is considered to be of conservation concern.

Remarks

The habitat of *O. z. ripensis* has undoubtedly suffered extensive modification ranging from channelization of rivers and eradication of riparian habitat to disappearance of river flow from El Paso to Presidio, Texas. Introduction of other subspecies of muskrats in the remaining portions of its range may have diluted the genetic distinction of any surviving populations. Willner *et al.* (1980) reviewed the general biology of this species.

Conservation status and occurrence in captivity and protected areas

Ondatra z. ripensis is a federal C2 candidate taxon. Wildlife refuges are found along both the Rio Grande (Bosque del Apache NWR, New Mexico; Black Gap Wildlife Area, Texas) and Pecos River (Bitter Lakes NWR, New Mexico); populations may occur in Big Bend National Park, Texas.

Recommended action

- Survey historic range of *O. z. ripensis* to determine distribution and status of surviving populations, particularly in Texas portion of Rio Grande and Pecos River.
- Investigate documented history of introductions of other *O. zibethicus* to any portions of the range of *O. z. ripensis*.
- Conduct genetic study to evaluate extent and nature of variation within surviving populations of *O. z. ripensis* and nature and extent of genetic distinction from adjacent subspecies.

***Onychomys leucogaster* (Wied-Neuwied 1841) Northern grasshopper mouse**

Eric Yensen

13 subspecies, 1 of conservation concern in North America (north of Mexico):

O. l. durranti Durrant's northern grasshopper mouse

IUCN Red List Category

Onychomys leucogaster – Lower Risk, least concern (LR,lc)

O. l. durranti – Data Deficient (DD)

Assignment of *O. l. durranti* is based on the need for specific information on its population status, current distribution, and response to agricultural development.

Taxonomy and distribution

Onychomys leucogaster durranti was described from 91 specimens and 35 localities as part of a revision of *O. leucogaster* using multivariate morphometric, karyotypic, and fossil data (Riddle and Choate 1986). Populations of *Onychomys leucogaster* from the Columbia Basin were formerly placed in *O. l. fuscogriseus*. The northern grasshopper mouse is broadly distributed in shrub steppe, desert shrub, and grassland habitats of the Great Plains, Great Basin, and Chihuahuan Desert. One subspecies, *O. l. durranti* from the Columbia Basin and adjacent extensions of the palouse prairie of eastern Washington and north-central Oregon, has been considered to be of conservation concern.

Remarks

Bailey (1936) noted that this mouse never was common. However, the Oregon Natural Heritage Database suggests that the subspecies may be reduced or eliminated from much of the Columbia Basin by agricultural conversion. The Columbia Basin has been subject to widespread agricultural conversion, especially for wheat fields and center-pivot irrigation systems. The responses of grasshopper mice to agricultural conversion in this area are unknown, but populations may be declining. B.J. Verts (pers. comm.) caught them regularly in the Boardman Bombing Range at densities of 2 per 3ha in the early to mid-1980s. They were found in early seral communities of rabbitbrush (*Chrysothamnus* sp.) and cheatgrass (*Bromus tectorum*). McCarty (1978) reviewed the general biology of this species.

Conservation status and occurrence in captivity and protected areas

The Columbia Basin subspecies of the northern grasshopper mouse is on the State of Washington Monitor list. The Oregon Natural Heritage Program (E. Gaines, pers. comm.) is not tracking this subspecies. No populations are known to occur in captivity. *Onychomys l. durranti* probably occurs at the N.C. Boardman Research Natural Area and the U.S. Naval Weapons System Test Facility (Boardman Bombing Range) in Oregon. Limitations on access to and development of such bombing ranges often provide effective (albeit unintentional) wildlife refuges.

Recommended action

- Conduct field survey to determine the population status of grasshopper mice in the Columbia Basin. Because these mice have large home ranges, probably as a reflection of their predatory habits (estimated average 2.3ha; McCarty 1978), special survey methods may be required.
- Determine the distributional and population response of *O. leucogaster* in areas of its historical range that have been subjected to agricultural conversion.

Onychomys torridus (Coues 1874) Southern grasshopper mouse

David J. Hafner

7 subspecies, 2 of conservation concern in North America (north of Mexico):

O. t. ramona Southern grasshopper mouse

O. t. tularensis Tulare grasshopper mouse

IUCN Red List Category

Onychomys torridus – Lower Risk, least concern (LR,lc)

O. t. ramona – Data Deficient (DD)

O. t. tularensis – Data Deficient (DD)

Assignment of the two subspecies is based on the need for specific information on their population status, current distributions, and nature and extent of any current threats to their survival.

Taxonomy and distribution

Populations of small-bodied grasshopper mice from the Chihuahuan Desert that were formerly included within *O. torridus* were elevated to full-species status (*O. arenicola*) by Hinesley (1979). Although Sullivan *et al.* (1986) and Riddle and Honeycutt (1990) viewed *O. arenicola* and *O. leucogaster* as sister taxa, neither indicated a “close relationship” between the latter taxa, nor intended to “cast doubt on the specific validity” of *O. arenicola*, as stated by Jones *et al.* (1992). The southern grasshopper mouse inhabits the Mojave, San Joaquin, Sonoran, and southern Great Basin deserts of western North America. Both subspecies of conservation concern occur in California: *O. t. tularensis* of the San Joaquin Valley, and *O. t. ramona* of the southern California-northern Baja California coastal chaparral. The subspecific taxonomy of *O. torridus* has not been re-examined.

Remarks

Williams and Kilburn (1992) considered *O. t. tularensis* to be “facing proximate threats, immediacy uncertain.” Although apparently widespread, it is nowhere locally abundant, is poorly represented in research collections, and is the rarest species of rodent in the San Joaquin Mammalian Faunal Region. Williams and Kilburn (1992) cited two lines of evidence indicating that this poorly known taxon faces threat of extinction: the species with which it is commonly associated are all jeopardized to some extent, and the low fecundity, low population density, and large home range characteristic of the species (McCarty 1975) make this subspecies particularly vulnerable to loss and fragmentation of habitat. Habitat loss to cultivation is the most serious threat to *O. t. tularensis*. *Onychomys t. ramona* may suffer similar habitat loss due to development of coastal chaparral communities, but specific threats and status of these populations are not known. The insectivorous habits of this species may make it particularly vulnerable to pesticides related to agricultural development. McCarty (1975) reviewed the general biology of this species.

Conservation status and occurrence in captivity and protected areas

Onychomys t. tularensis and *O. t. ramona* are federal C2 candidate taxa and California Species of Special Concern. Records for *O. t. tularensis* are known from ecological preserves recently established in the southern San Joaquin Valley, but the status of those populations is not known. No populations of *O. t. ramona* are known to occur in protected areas.

Recommended action

- Document the current distribution and abundance of *O. t. tularensis* and *O. t. ramona*, determine the basic habitat requirements of both forms, and identify the nature and extent of any threats to their continued survival.

***Oryzomys palustris* (Harlan 1837)**

Marsh rice rat

Gordon L. Kirkland, Jr.

23 subspecies, 1 of conservation concern:

O. p. natator Marsh rice rat

IUCN Red List Category

Oryzomys palustris – Lower Risk, least concern (LR,lc)

O. p. natator – Data Deficient (DD)

Assignment of *O. p. natator* is based on the need for specific information on the possible subspecific distinction of populations on the Lower Keys and the unknown level of dispersal between mainland and insular forms.

Taxonomy

Prior to the taxonomic revision by Humphrey and Setzer (1989), populations now included under *O. p. natator* were separated into four subspecies of *O. palustris* and a distinct species, *O. argentatus*. Three of these taxa, all island forms from Florida, were considered for possible federal protection: *O. p. planirostris* from Little Pine Island, *O. p. sanibeli* from Sanibel Island, and *O. argentatus* from Cudjoe Key. Humphrey and Setzer (1989) presented convincing evidence for the genetic continuity of all of these forms; all are included here within *O. p. natator*.

The marsh rice rat is widely distributed across the east coast and southeastern states of the United States, from Pennsylvania and Florida to Kansas and southern Texas. *Oryzomys p. natator* occupies most of the Florida peninsula and Little Pine Island, Sanibel Island, and the Lower Keys (Humphrey and Setzer 1989).

Remarks

According to Humphrey and Setzer (1989), “ecological and zoogeographic uniqueness of the Lower Keys population of rice rats has been exaggerated,” and “interchange among populations of rice rats separated by water barriers may be the rule rather than the exception.” Although Barbour and Humphrey (1982) failed to locate rice rats on Cudjoe and nearby keys and mistakenly concluded that the population might be extirpated, Goodyear (1987) subsequently found extant populations on nine of the Lower Keys. Thus, rice rats on the Lower Keys do not appear subjected to any immediate threats, and may experience occasional or even frequent genetic

interchange with mainland populations. Wolfe (1982) reviewed the general biology of this species.

Humphrey and Setzer (1989) did not fully dismiss the possibility that rice rats on the Lower Keys may represent a distinct subspecies, and recommended further collection of these populations to increase the sample size for morphometric and genetic comparison with the mainland forms. Evaluation of genetic relationships between Lower Keys and mainland populations would reveal the extent of differentiation or introgression between the forms, clarify their taxonomic relationship, and provide important data as to dispersal between mainland and insular populations. Until such studies are conducted, populations of *O. p. natator* on the Lower Keys should retain some minimal level of protected status.

Conservation status and occurrence in captivity and protected areas

Populations of *O. p. natator* on the Lower Keys (west of Seven Mile Bridge) constitute a federal Endangered taxon and a Florida Rare taxon. Goodyear and Lazell (1986) examined specimens of *O. argentatus* (= *O. p. natator*) from a laboratory colony, which may still exist. Portions of Cudjoe Key and adjacent islands west of Seven Mile Bridge are included in the Great White Heron National Wildlife Refuge.

Recommended action

- Conduct genetic and morphological evaluation of increased sample of *O. p. natator* from the Lower Keys relative to mainland populations to determine level and extent of differentiation.
- Monitor populations on Lower Keys to determine natural population fluctuations and levels of dispersal and genetic introgression among island populations.

***Peromyscus gossypinus* (Le Conte 1853)**

Cotton mouse

Gordon L. Kirkland, Jr.

7 subspecies, 2 of conservation concern:

P. g. allapaticola Key Largo cotton mouse

P. g. restrictus Chadwick Beach cotton mouse

IUCN Red List Category

Peromyscus gossypinus – Lower Risk, least concern (LR,lc)

P. g. allapaticola – Vulnerable (VU): D2

P. g. restrictus – Extinct (EX)

Assignment of *P. g. allapaticola* is based on its extremely restricted distribution; *P. g. restrictus* is apparently extinct.

Taxonomy and distribution

Peromyscus gossypinus is broadly distributed over the southeastern United States from the Atlantic coast as far

north as Virginia and west to eastern Texas and Oklahoma. Although this species hybridizes in the laboratory with its close relative, *P. leucopus* (Bradshaw 1968), differentiation in the field is well documented (Engstrom *et al.* 1982, Price and Kennedy 1980, Robbins *et al.* 1985). An insular subspecies, *P. g. allapaticola*, is known from Key Largo, Florida (also introduced on Lignum Vitae Key). The Key Largo cotton mouse previously was considered to be restricted in distribution to mature dry tropical hammock-type forests (Brown 1978c), but recent studies indicate that this species may inhabit the entire successional sere from recently burned forests to mature forests (Humphrey 1992d). Another subspecies, *P. g. restrictus*, is known only from Chadwick Beach near Englewood, Florida. The Chadwick Beach cotton mouse is listed as extirpated in the state of Florida (Humphrey 1992e). This mouse appears to have lived near the southern end of Manasota Key, in present-day Englewood Beach and, if still extant, would currently be restricted in distribution to a narrow coastal forest on one peninsula. The Anastasia Island cotton mouse was formerly recognized as a distinct and endangered subspecies, *P. g. anastasae*, but was considered synonymous with *P. g. gossypinus* by Humphrey (1992a).

Remarks

The Key Largo cotton mouse, *P. g. allapaticola*, is threatened by the development of its habitat into residential areas. It can be preserved by maintaining tropical hammock forests in north Key Largo. The fact that this species is not dependent on mature forests means that maintaining habitat will be easier than for species dependent on mature forest, such as the Key Largo woodrat.

A principal reason for the decrease in numbers of *P. g. restrictus* appears to be development of coastal areas for human uses. Predation by house cats associated with human habitation may have played a role. A 1985 survey of its historical range yielded no evidence that the Chadwick Beach mouse is still extant. However, remnant populations may exist in the Manasota Key area (Humphrey 1992e). Wolfe and Linzey (1977) reviewed the general biology of this species.

Cotton mouse, *Peromyscus gossypinus*.



R. W. Van Devender

Conservation status and occurrence in captivity and protected areas

Peromyscus g. allapaticola is a federal and Florida Endangered taxon; *P. g. restrictus* is a federal C3A taxon (“persuasive evidence of extinction”), a Florida Endangered taxon, and is considered to be Extinct by the Florida Committee on Rare and Endangered Plants and Animals. No populations of either subspecies are known to occur in captivity or in protected areas.

Recommended action

- Preserve remaining tropical hammock forests in north Key Largo as critical habitat for *P. g. allapaticola*.
- Determine the number and size of remaining populations of *P. g. allapaticola*.
- Survey Manasota Key area for possible extant populations of *P. g. restrictus*.

Peromyscus leucopus (Rafinesque 1818) White-footed mouse

Gordon L. Kirkland, Jr.

17 subspecies, 1 of conservation concern in North America (north of Mexico):

P. l. ammodytes Monomoy white-footed mouse

IUCN Red List Category

Peromyscus leucopus – Lower Risk, least concern (LR,lc)

P. l. ammodytes – Data Deficient (DD)

Assignment of *P. l. ammodytes* is based on the need for specific information on the taxonomic validity of the subspecies relative to *P. l. noveboracensis*.

Taxonomy and distribution

The white-footed mouse is broadly distributed over most of eastern and central United States, extending north into south-central Canada and Nova Scotia, west into arid regions of Arizona and New Mexico, and south into the Chihuahuan Desert and Caribbean coast of Mexico. Two distinctive cytotypes of *P. leucopus* are known, with introgression across a hybrid zone in central Oklahoma (Nelson *et al.* 1987). *Peromyscus. l. ammodytes* is confined to Monomoy Island in the Nantucket Sound offshore from Chatham, Barnstable Co., Massachusetts. It differs from the mainland subspecies (*P. l. noveboracensis*) in having a smaller body size and shorter tail (Hamilton 1943). Allan (1939) described Monomoy Island as being of post-glacial origin and extending for 16km south of Chatham, with intermittent connections to the mainland. Monomoy Island varies in width from 0.8 to 1.2km (i.e. about 16km²); vegetation on the island is predominately grassy with patches of shrubs and stunted trees.

Remarks

If *P. l. ammodytes* still exists as a distinct subspecies, it should be reasonably secure: as part of the National Wildlife Refuge System, Monomoy Island appears safe from development. The major threat to the continuation of the subspecies is introgression with the mainland subspecies that disperses to the island when it is occasionally connected to the mainland. As long ago as 1943, Hamilton (1943) concurred with Allan (1939) that *P. l. ammodytes* was probably extinct as a subspecies, due to the influx of mainland *P. l. noveboracensis* onto the island. Hamilton (1943) noted that a specimen collected on Monomoy Island in 1939 was a typical mainland form (i.e. *P. l. noveboracensis*). Lackey *et al.* (1985) reviewed the general biology of this species.

Conservation status and occurrence in captivity and protected areas

Peromyscus l. ammodytes is a federal C2 candidate taxon, but is not included among the legally recognized Rare taxa in Massachusetts (T. French *in litt.*). All of Monomoy Island is included in the Monomoy Island National Wildlife Refuge.

Recommended action

- Conduct genetic studies to determine the extent and nature of differentiation between *P. l. ammodytes* and the mainland subspecies, *P. l. noveboracensis*.

Peromyscus maniculatus (Wagner 1845) Deer mouse

David J. Hafner

65 subspecies, 2 of conservation concern in North America (north of Mexico):

P. m. anacapae Anacapa deer mouse

P. m. clementis San Clemente deer mouse

IUCN Red List Category

Peromyscus maniculatus – Lower Risk, least concern (LR,lc)

P. m. anacapae – Lower Risk, near threatened (LR,nt)

P. m. clementis – Lower Risk, near threatened (LR,nt)

Assignment of subspecies of conservation concern is based on their restricted distributions and apparent absence of any immediate threats to the continued survival of either subspecies.

Taxonomy and distribution

According to Musser and Carleton (1993), the “specific homogeneity of [the] included taxa [of *P. maniculatus*] is doubtful.” For accounts of relationships of *P. maniculatus* to related species, see citations in Musser and Carleton (1993). Evidence from mtDNA indicated that deer mice

on Anacapa Islands may have been established by more than one colonization from the mainland, while divergence of San Clemente Island deer mice may have occurred after a single colonization (Ashley and Wills 1987).

The deer mouse has an extensive North American distribution in a wide variety of habitats from the Atlantic to Pacific coasts, and from northern Canada to southern Mexico. Isolated populations are known from islands off both Atlantic and Pacific coasts and in the Gulf of California. Two insular populations from southern California have been considered to be of conservation concern: *P. m. anacapae* from West, Middle, and East Anacapa islands, and *P. m. clementis* from San Clemente Island.

Remarks

Peromyscus maniculatus is known from numerous islands, including both landbridge and oceanic islands (e.g., in the Gulf of California). Thus, isolation of populations on landbridge islands (e.g., San Clemente and Anacapa islands) does not necessarily date to disruption of connections with the adjacent mainland, and may be of either ancient or very recent dispersal via rafting.

Conservation status and occurrence in captivity and protected areas

Peromyscus m. anacapae and *P. m. clementis* are federal C2 candidate taxa and California Species of Special Concern. We know of no specific threats to either insular form. The Anacapa Islands are in the Channel Island National Park; San Clemente Island is a United States Military Reservation.

Recommended action

- Conduct survey to determine status of populations of *P. m. anacapae* and *P. m. clementis*.

Peromyscus polionotus (Wagner 1843) Oldfield mouse; beach mouse

Gordon L. Kirkland, Jr.

16 subspecies, 8 of conservation concern:

P. p. allophrys Choctawhatchee beach mouse

P. p. ammobates Alabama beach mouse

P. p. decoloratus Ponce de Leon beach mouse

P. p. leucocephalus Santa Rosa beach mouse

P. p. niveiventris Southeastern beach mouse

P. p. peninsularis St. Andrews beach mouse

P. p. phasma Anastasia Island beach mouse

P. p. trissyllepsis Perdido Key beach mouse

IUCN Red List Category

Peromyscus polionotus – Lower Risk, least concern (LR,lc)

P. p. allophrys – Endangered (EN): B1;B2c

P. p. ammobates – Endangered (EN): B1;B2c

P. p. decoloratus – Extinct (EX)

P. p. leucocephalus – Lower Risk, near threatened (LR,nt)
P. p. niveiventris – Lower Risk, near threatened (LR,nt)
P. p. peninsularis – Endangered (EN): B1;B2c
P. p. phasma – Endangered (EN): B1;B2c
P. p. trissyllepsis – Critically Endangered (CR): B1;B2c

Assignment of *P. p. allophrys* is based on its highly restricted distribution at only two known localities and the threat of continued loss in both extent and quality of its habitat. Assignment of *P. p. ammobates* is based on its restricted distribution and the threat of continued loss in both extent and quality of its habitat. *Peromyscus p. decoloratus* is believed to be extinct. Assignments of *P. p. leucocephalus* and *P. p. peninsularis* are based on their restricted known distribution and probability of continued loss in extent and quality of their habitat. Assignment of *P. p. niveiventris* is based on its restricted distribution and the possibility of loss in extent and quality of its habitat. Assignment of *P. p. phasma* is based on its restricted distribution of two known sites, and the probability of continued loss in extent and quality of its habitat. Assignment of *P. p. trissyllepsis* is based on its highly restricted distribution of two small sites, past habitat loss, and the high probability of continued habitat loss.

Taxonomy and distribution

Selander *et al.* (1971) surveyed intraspecific genetic differentiation in the species. *Peromyscus polionotus* occurs in the southeastern United States, in the states of Florida, South Carolina, Georgia, Alabama, and eastern Mississippi. This species is largely restricted to sandy substrates, including coastal beaches, sandy floodplains, and the herbaceous stage of old-field succession in sandy old-fields. Coastal forms typically are referred to as beach mice, whereas inland populations are referred to as oldfield mice. Eight subspecies of *P. polionotus* occur (or occurred) on isolated barrier islands or sandbars of southeastern Alabama and the Florida panhandle; all are considered to be of conservation concern.

Peromyscus p. allophrys is limited in distribution to <20km² of coastal dunes on barrier islands of Florida's western gulf coast between Choctawhatchee Bay, Okaloosa County, on the west and St. Andrew's Bay in Bay County, to the east (Ehrhart 1978b). Only two disjunct populations are known to exist, one occupying 6.5km² of Topsail Hill and the other limited to 9.4km² on Shell Island (United States Fish and Wildlife Service 1987). Principal habitat consists of high primary and secondary dunes of the Gulf Coast. These are vegetated by sea oats (*Uniola paniculata*), beach grass (*Panicum amarum*), and bluestem (*Andropogon maritimus*). Populations are also found on the series of smaller, older interior dunes. The inland dunes are vegetated by scrubby oaks (*Quercus myrtifolia* and *Q. virginiana*), dwarfed magnolia (*Magnolia grandifolia*), and rosemary (*Ceratiola ericoides*) (Holler 1992a).

Historically, *P. p. ammobates* occurred on Ono Island, Alabama, and along the gulf coast from Perdido Pass west to Fort Morgan State Park. Currently, it is limited in distribution to undeveloped beach dune habitats from Bon Secour National Wildlife Refuge westward to Fort Morgan State Park (Holler and Rave 1991), an area of 80km². The sand dune habitat in which *P. p. ammobates* is found includes both primary and secondary dunes, which are vegetated by preferred food species (sea oats and beach grass), along with other plants. Habitats also includes older scrub dunes that occur immediately inland (Holler and Rave 1991).

Populations of *P. p. niveiventris* occur in the Canaveral Peninsula of Merritt Island, Brevard County and Hillsboro Inlet, Palm Beach County. The northern limit is New Smyrna Beach at Ponce (Mosquito) Inlet, Volusia County. The southern limit of distribution appears to be Ft. Pierce, St. Lucie County (Stout 1992). This subspecies occurs principally in the sea oats zone of primary dunes. In some instances grassland and open sandy areas with scattered shrubs located behind the primary dunes may be occupied. On the Cape Canaveral peninsula this form also occupies shrubby habitats dominated by oaks, rosemary and saw palmetto (*Serenoa repens*) (Stout 1992).

Peromyscus p. phasma is endemic to a small geographic area and a single habitat. It is restricted in distribution to two sites in northeastern Florida: Point Romo, Anastasia Island, St. Johns County, and on the coastal dunes of the peninsular barrier beach from St. Augustine Inlet to the border between Duval and St. Johns Counties (Humphrey and Frank 1992). There has been a substantial reduction in the population of this form in recent years. It is restricted to sand dunes vegetated by sea oats, panic grass, and scrub with oaks, sand pine, or palmetto.

Peromyscus p. trissyllepsis is limited in distribution to coastal dunes between Perdido Bay, Alabama and Pensicola Bay, Florida (United States Fish and Wildlife Service 1987). The subspecies is currently restricted to 1.9km (<2km²) of habitat in Gulf State Park, Alabama, and 11km (<10km²) of the Gulf Islands National Seashore, Florida (Holler 1992b). These mice inhabit dry, sandy, whitish, sparsely-vegetated coastal dune habitat. Plants of areas inhabited by these mice include sea oats, bluestem, panic grass, sedges (*Cyperus*), rushes (*Juncus*), yaupon (*Ilex vomitoria*), marsh-elder (*Iva* sp.), oaks, and pines (Linzey 1978).

Peromyscus p. decoloratus was endemic to the barrier beach between Matanzas and Ponce de Leon inlets. *Peromyscus p. leucocephalus* is known only from Santa Rosa Island, Florida, a barrier island of about 600km² that is between the ranges of the subspecies *P. p. trissyllepsis* and *P. p. allophrys*. *Peromyscus p. peninsularis* occurs on the coast and sandy peninsulas between Panama City and Cape San Blas, Florida.

Remarks

All coastal or insular subspecies of *Peromyscus polionotus* in Alabama and Florida are vulnerable to habitat loss from real estate development, direct mortality from tropical storms, genetic isolation of small populations, predation by house cats, and competition with house mice (*Mus musculus*; Holler 1992a, Stout 1992). Beach erosion also may pose a problem if sea level rises. *Peromyscus p. decoloratus* suffered extensive habitat loss, and was evidently “more vulnerable than its habitat” (Humphrey 1992a): it has not been found since 1946 despite intensive surveys, and is considered to be extinct.

The recovery plan developed by the United States Fish and Wildlife Service (1987) for *P. p. allophrys*, *P. p. ammobates*, and *P. p. trissyllepsis* emphasizes three initiatives: maintenance and restoration of habitat, re-establishment of populations, and education of the general public regarding the requirements of these races. For subspecies with extremely limited extant populations, re-establishment programs will be dependent on a successful captive breeding program (Holler 1992a).

Stout (1992) noted the close association of *P. p. niveiventris* with primary dunes, which are threatened by development and wave action. Further, development near refugial habitats increases the occurrence of human commensals such as house mice and cats, which threaten these mice directly through competition and predation. This subspecies reoccupied dune habitats after houses were removed following purchase of land for NASA facilities on Merritt Island (Stout 1992).

Humphrey and Frank (1992) stressed the importance of competition from house mice as a potential threat to the continued survival of *P. p. phasma*. They noted that Florida’s Coastal Setback Law has served to preserve the primary habitat of this beach mouse from development, but has not prevented the invasion of house mice into that habitat.

James (1992) noted that the principal threats to *P. p. peninsularis* are habitat loss, direct mortality from storms, predation (particularly from house cats), genetic isolation of small populations, and competition from house mice.

The restricted range of *P. p. trissyllepsis* makes it particularly vulnerable: in addition to the other threats, it is subjected to predation by red foxes (*Vulpes vulpes*), and its once-contiguous population has been fragmented, although all critical habitat is in public ownership. This subspecies is considered to be the most endangered of the extant subspecies of *P. polionotus* (Holler 1992b). The only known populations are restricted to 1.9km of habitat in Gulf State Park, Alabama, and 11km of habitat at Gulf Islands National Seashore, Florida. The latter population represents a recently re-established population, and this subspecies apparently has been through several severe genetic bottlenecks (Holler 1992b).

Conservation status

Peromyscus p. decoloratus is considered to be Extinct by the Florida Committee on Rare and Endangered Plants and Animals and on previous federal listing (C3A), and is regarded as Endangered by the Florida Game and Fresh Water Fish Commission. *Peromyscus p. allophrys*, *P. p. ammobates*, *P. p. phasma*, and *P. p. trissyllepsis* are all federal and Florida Endangered taxa; *P. p. niveiventris* is a federal and Florida Threatened taxon; *P. p. peninsularis* is a federal C1 candidate taxon and Florida Endangered taxon; and *P. p. leucocephalus* is a federal C2 candidate taxon.

Occurrence in captivity and protected areas

Grayton Beach State Recreation Areas and Shell Island, where populations of *P. p. allophrys* still occur, are in public ownership. Extant populations of *P. p. ammobates* occur in Bon Secour National Wildlife Refuge, Fort Morgan State Park, and Gulf State Park. The range of *P. p. peninsularis* is virtually restricted to St. Joseph Peninsula State Park in Gulf County, Florida. Protected areas of the distribution of *P. p. phasma* include Fort Matanzas National Monument and the Anastasia State Recreation Area. Extant populations of *P. p. niveiventris* occur in the Canaveral National Seashore, Cape Canaveral Air Force Station, Sebastiani Inlet State Recreation Area, Turtle Trail Public Beach Access, and Pepper Park. The current distribution of *P. p. trissyllepsis* is limited to Gulf State Park (Alabama) and Gulf Islands National Seashore (Florida). No populations of *P. p. leucocephalus* are known to occur in captivity or protected areas.

Recommended action

- Conduct inventory of extant populations and appropriate unoccupied habitat within historical range of each subspecies.
- Identify major populations of each subspecies, particularly those on protected lands, that can be preserved from development of habitat, and explore methods to control predation by house cats and invasion by house mice.
- For those subspecies with extremely low extant populations for which appropriate unoccupied habitat in their historical range is available, establish captive breeding colonies as source for reintroduction.
- Reintroduce populations to appropriate unoccupied habitat (e.g., introduction of *P. p. phasma* to Guana River State Park, as recommended by Humphrey and Frank 1992) from captive colonies or large extant populations.
- Initiate educational program through regional state parks, national wildlife refuges, and national seashores to inform the public of the importance of preserving biodiversity and the particular habitat needs of these subspecies.
- Maintain and restore areas identified as critical habitat for each of the subspecies of concern.

***Peromyscus truei* (Shufeldt 1885)**

Pinyon mouse

David J. Hafner

15 subspecies, 1 of conservation concern in North America (north of Mexico):

P. t. comanche Palo Duro mouse

IUCN Red List Category

Peromyscus truei – Lower Risk, least concern (LR,lc)

P. t. comanche – Lower Risk, near threatened (LR,nt)

Assignment of *P. t. comanche* is based on its somewhat restricted distribution and the apparent absence of any immediate threat to its continued survival.

Taxonomy and distribution

Blair (1943b) described *P. comanche* as a full species closely related to *P. nasutus*; Hoffmeister (1951) regarded *comanche* as a subspecies of *nasutus*. Schmidly (1973) subsequently demonstrated that *comanche* was closely related to *P. truei*, not *P. nasutus*, and reallocated *comanche* as a subspecies of *P. truei*.

The pinyon mouse occurs at moderate to higher elevation, usually in pinyon-juniper woodland, throughout much of western North America from Oregon south to Oaxaca, Mexico. Disjunct subspecies occur in a three-county area along the eastern margin of the Llano Estacado of northwestern Texas (*P. t. comanche*) and in the Sierra Laguna in the Cape Region of Baja California Sur, Mexico (*P. t. lagunae*).

Remarks

The nearest known relative (*P. t. truei*) of *P. t. comanche* is found in Deaf Smith County, Texas, along the western margin of the Llano Estacado (Choate *et al.* 1991). Records of *P. t. comanche* south of Briscoe County have subsequently proven to be *P. attwateri* (Jones *et al. in litt.*). Competition with congeneric species, particularly *P. attwateri*, may be limiting the distribution of *P. t. comanche*. The subspecies does not appear to be subjected to any immediate threat. Hoffmeister (1981) reviewed the general biology of this species.

Conservation status and occurrence in captivity and protected areas

Peromyscus t. comanche is a federal C2 candidate taxon and a Texas Threatened taxon. According to Jones *et al. (in litt.)*, highest densities of *P. t. comanche* are found in “prime habitat” in Palo Duro Canyon State Park (60km²) and Caprock Canyons State Park (5km²).

Recommended action

- Maintain the integrity of Palo Duro Canyon and Caprock Canyons state parks, which include prime habitat for *P. t. comanche*.

- Conduct periodic monitoring to detect any changes in status of *P. t. comanche*.

***Podomys floridanus* (Chapman 1889)**

Florida mouse

Gordon L. Kirkland, Jr.

IUCN Red List Category

Podomys floridanus – Vulnerable (VU): A1a;A2d

Assignment of *P. floridanus* is based on the extensive loss of habitat already suffered by the species in the last 50 years, the accelerated loss of habitat observed since 1981, and the projected continuation of habitat loss through real estate and agricultural development.

Taxonomy and distribution

Originally described in the genus *Hesperomys*, this species was named as a separate subgenus of *Peromyscus* by Osgood (1909) and maintained as such by Hooper (1968). Carleton (1980, 1989) argued for generic recognition, a ranking disputed by Rogers *et al.* (1984) and Stangl and Baker (1984) but followed by Musser and Carleton (1993). The Florida mouse is endemic to the Florida peninsula, where it is restricted to “high well-drained sandy ridges covered with pines and/or palmetto” (Hall 1981:720). It is limited in geographic distribution to the northern two-thirds of the Florida peninsula, with the exception of an apparently isolated population in the western panhandle near Carabelle, Franklin County, Florida (Layne 1992). Within its limited geographic range, *P. floridanus* is largely restricted to fire-maintained, xeric, upland vegetation. Vegetational communities in which *P. floridanus* typically occurs include sand pine scrub, coastal scrub, scrubby flatwoods, longleaf pine-turkey oak, south Florida slash pine-turkey oak, upland hammock, live oak hammock, and drier pine flatwoods (Layne 1992). The occurrence of *P. floridanus* in other habitats (e.g., mesic hammock, shorelines of ponds, freshwater marshes, and old fields) is attributed to transient individuals (Layne 1992).

Remarks

This species is considered threatened with extirpation due to disappearance of the scrub habitat on which it depends (Layne 1990). Layne (1978) suggested that a considerable portion of the suitable habitat within the original range of *P. floridanus* had already been lost. As an example, Layne (1992) reported that 64% of the species’ habitat in Highlands County had been destroyed between 1940 and 1980, an additional 10% was disturbed, and the rate of clearing for real estate and agricultural development had increased since 1981. The preferred habitat of *P. floridanus* is in heavy demand for real estate development because of its

well-drained soils (Layne 1978). Extensive areas have been destroyed for agricultural development, particularly citrus groves and pine plantations. Because its preferred habitat is now distributed in small, isolated patches, so are populations of *P. floridanus*. Further, the species prefers early successional habitats, which are in turn dependent on natural fire cycles. Thus, fire suppression has further decreased the availability of preferred habitats. The major threat is loss of habitat to urban development and agriculture (Layne 1992). Unlike wetlands, which have been accorded considerable legal protection, drier upland habitats in Florida have very limited legal protection (Layne 1992). Jones and Layne (1993) reviewed the general biology of this species.

Conservation status and occurrence in captivity and protected areas

Podomys floridanus is a federal C2 candidate taxon and is considered Threatened by the Florida Committee on Rare and Endangered Plants and Animals and a Species of Special Concern by the Florida Game and Fresh Water Fish Commission. No populations are known to occur in captivity or in protected areas.

Recommended action

- Conduct survey to document distribution and status of extant populations of *P. floridanus*.
- Identify and preserve large populations at sites with the highest potential for protection from development and subsequent habitat loss.

***Reithrodontomys raviventris* Dixon 1908** Saltmarsh harvest mouse

Howard S. Shellhammer

2 subspecies, both of conservation concern:

R. r. halicoetes Saltmarsh harvest mouse

R. r. raviventris Red-bellied harvest mouse

IUCN Red List Category

Reithrodontomys raviventris – Vulnerable (VU): A1c; A2c; B2c

R. r. halicoetes – Lower Risk, conservation dependent (LR,cd)

R. r. raviventris – Endangered (EN): A2; B1; B2c

Assignment of the species is based on the threatened status of both of its subspecies, and the overall extensive loss of habitat. Assignment of *R. r. halicoetes* is based on its restricted occurrence in protected areas, without which it would be vulnerable to threat of extinction. Assignment of *R. r. raviventris* is based on its extensive past and projected loss of habitat, and its severely fragmented current distribution.

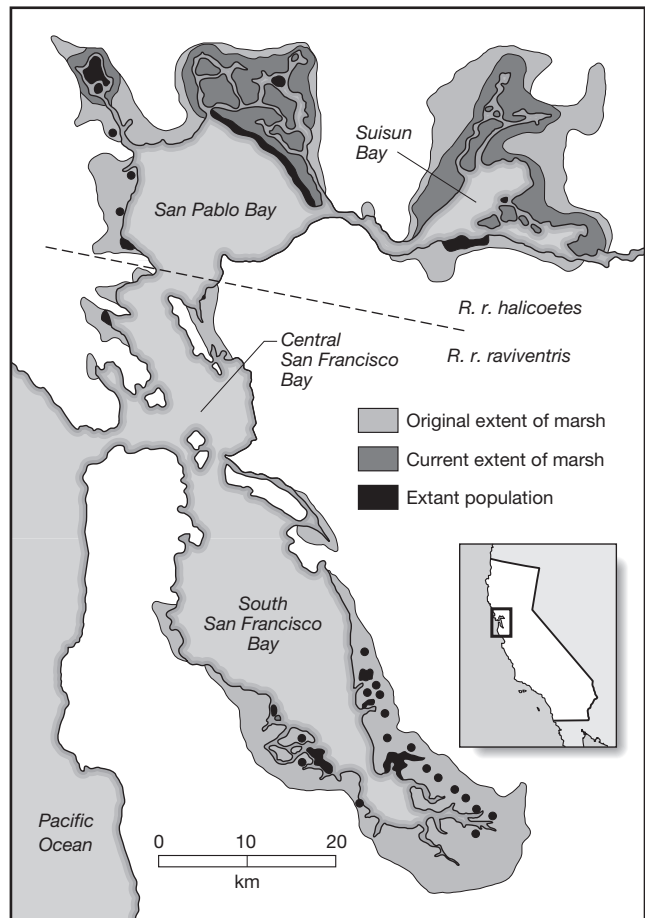


Figure 5.6. Original (pre-1800) and current extent of marsh, and distribution of extant populations of the two subspecies of saltmarsh harvest mouse, *Reithrodontomys raviventris*, in California's San Francisco Bay area. Most extant populations persist only in remnant patches of marsh habitat.

Taxonomy and distribution

The saltmarsh harvest mouse (*Reithrodontomys raviventris*) is restricted to brackish marshes and saltmarshes adjoining San Francisco Bay, California. *Reithrodontomys r. raviventris* is found in the southern and central portions of San Francisco Bay, while *R. r. halicoetes* inhabits marshes around San Pablo and Suisun bays (Fig. 5.6).

The species *R. raviventris* was divided into the present two subspecies by Howell (1914b). Fisler (1965) substantiated the status of the two subspecies and suggested that both subspecies were derived from *Reithrodontomys megalotis*, a widespread species that occurs throughout western North America. Nelson *et al.* (1984) and Hood *et al.* (1984), however, presented genetic evidence that *R. raviventris* and *R. montanus* share a closer common ancestor than do *R. raviventris* and *R. megalotis*. The population of *R. montanus* geographically closest to *R. raviventris* occurs in southeastern Arizona, approximately 1,100km from San Francisco Bay.

Remarks

Over 80% of the tidal marshes of the San Francisco Bay has been filled or diked-off and converted into salt ponds, agricultural fields, or pastures. Most of the marshes bordering the southern San Francisco Bay have subsided and consequently undergone increased tidal inundation and vegetation change. Escape cover for mice from high tides is missing in many of the latter marshes, many of which have been reduced to narrow strips along outboard dikes, and most of such marshes have few to no mice. Most urbanization has taken place around the southern and central portions of San Francisco Bay (the range of the southern subspecies of the mouse, *R. r. raviventris*); more open space, and hence more potential refuge areas, adjoin the marshes in the San Pablo and Suisun Bays (the range of the northern subspecies, *R. r. halicoetes*). Middle portions of the marshes in the more saline parts of the bay are dominated by pickleweed (*Salicornia virginica*) while cordgrass (*Spartina foliosa*) covers the deep marsh (which is not used by the mouse). A variety of other halophytes (Australian saltbush, *Atriplex semibaccata*; salt grass, *Distichlis spicata*; and fathen, *A. patula*) inhabit the upper and sometimes ruderal edges of the marshes. Marshes in the Suisun Bay and some parts of the Petaluma and Napa Marshes off the San Pablo Bay are more brackish and are covered by a mixture of pickleweed, bulrushes (*Scirpus* spp.), cattails (*Typha* spp.) and rushes (*Juncus* spp.) as well as *Atriplex* spp. and *Distichlis*.

Four potential large refuges exist within the range of the northern subspecies; they include the Petaluma Marsh and adjacent wetlands in the northwest corner of San Pablo Bay, the Napa Marsh off the central portion of San Pablo Bay, the Suisun Marsh (including the potential Montezuma Marsh development), and the northern Contra Costa County coast (especially the marshes of the

Concord Naval Weapons Station and the Point Edith Unit of the California Department of Fish and Game.) Each of these areas is large enough to support several populations of saltmarsh harvest mice and hence achieve Level 9 protection as suggested in Schonewald-Cox *et al.* (1983).

In the range of the southern subspecies, most of the tidal marshes are narrow strips along outboard dikes and, as noted above, have few mice, although some of the remaining, deeper tidal marshes have sizable populations, at least in summer (H.T. Harvey Associates 1990). Both subsidence and decreased salinities caused by sewage effluents have greatly reduced populations of these mice in brackish portions of the southern San Francisco Bay (H. T. Harvey Associates 1990). Small populations persist in many of the diked wetlands in the southern and southeastern portions of southernmost San Francisco Bay (Shellhammer *et al.* 1988). These diked wetlands will constitute the refugia of last resort should development continue and sea rise take place at a faster rate than at present (Shellhammer 1989).

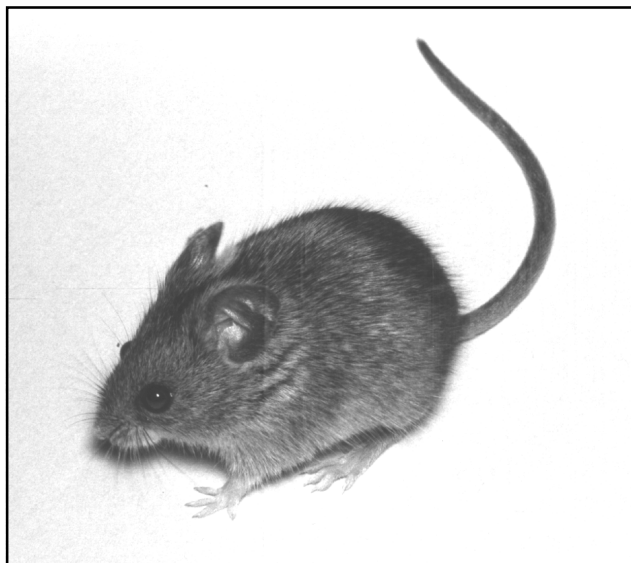
The protection of diked wetlands during the last decade has been through the efforts of the United States Fish and Wildlife Service responding to potential developers on a parcel-by-parcel basis. There has been no coordinated action to create a recovery team or to implement a recovery plan (United States Fish and Wildlife Service 1984), and no funds have been available. The situation in the southern San Francisco Bay is critical: the costs of buying and protecting land are astronomical, and overall planning is needed.

The northern subspecies (*R. r. halicoetes*) is close to downlisting and, with a few but costly projects, it could be delisted. The more endangered southern subspecies (*R. r. raviventris*) has little chance of ever being delisted, as most of its critical habitat has probably been irretrievably lost. Shellhammer (1982) reviewed the general biology of this species.

Conservation status and occurrence in captivity and protected areas

Reithrodontomys raviventris is a federal and California Endangered species. Populations of *R. raviventris* are found in a number of protected areas including the San Francisco Bay National Wildlife Refuge, San Pablo Bay National Refuge, Concord Naval Weapons Station, China Camp State Park, Mare Island Naval Shipyards, Grizzly Island State Game Refuge, Petaluma Marsh State Wildlife Area, Coon Island State Ecological Reserve, Fagan Marsh State Ecological Reserve and Pt. Edith State Ecological Reserve. Most of these sites are within the range of the northern subspecies, and many of them probably are not large enough to have the appropriate borders or corridors at the present time to ensure protection in the long term of the populations they contain.

Saltmarsh harvest mouse, *Reithrodontomys raviventris*.



Tom Tutt and Howard Shellhammer

Recommended action

- Define brackish marsh or saltmarsh to include a band of peripheral halophytes and a band of upland vegetation; all governmental units should employ this definition, particularly the California Department of Fish and Game (CDFG), which purchases much of the wetlands in the area.
- Create a task-force of interagency, nonprofit, and community representatives to accomplish the goals of the recovery plan and the recommendations of this Action Plan. The State of California, and many citizen groups within it, is experimenting with “regional biodiversity task-forces”; local task-forces that are somewhat similar to Habitat Conservation Planning units used in the Endangered Species Act are needed. These should be oriented towards communication and facilitation on a voluntary basis. Such task forces could help identify parcels of marsh and upland edge to purchase and identify units and groups to buy or otherwise acquire them, thus aiding the recovery process.
- Acquire a band of both peripheral halophytes and upland vegetation along the western edge of the Petaluma Marsh Unit of the CDFG. The unit now includes only flooded wetlands and no uplands. Estimated cost is \$5–10 million unless land trades or other creative deals can be made.
- The San Francisco Bay National Wildlife Refuge (SFBNWR) should establish an overlay refuge on the United States Navy lands on Skaggs Island to facilitate the conversion of much of the grazing lands on that unit to tidal marshes.
- Acquire, protect, and manage marsh-bordered islands in the Napa Marsh between Skaggs Island, the new Napa Marsh Unit of the SFBNWR, the northern San Pablo Bay units of the SFBNWR and the Coon Island and Fagan Slough units of the CDFG. It is important to protect a series of strip marshes around islands in this area, as most of the upland edge to the west and north of Napa Marsh has been converted to vineyards. Estimated costs are unknown as they depend on a blend of purchases, mitigation activities, land swaps, and the establishment of overlay refuges.
- Establish a realistic buffer zone between recreated marshes and industrial park development if the Montezuma Marsh development takes place. This subsided diked area, on the extreme eastern edge of the Suisun Marsh, may be used as a disposal site for mildly to quite toxic dredge material from the San Francisco Bay, covered with a cap of uncontaminated mud, and turned into a series of large tidal marshes. The concept that an upland edge is part of a tidal marsh should be implemented in this case. Cost should be borne by developer.

- Purchase duck club marshes as they become available in the Suisun Bay marshes, especially on Hammond, Wheeler, Van Sickle, and Chipps Islands. Much of the Suisun Marsh is presently protected from development by the Suisun Bay Conservation Plan, developed to serve the interests of duck hunters. With a decrease both in duck populations and duck hunters, it is possible that the Conservation Plan will be weakened in the future. Hence it is advisable to checkerboard and then connect enough parcels to prevent most of the Suisun Bay from becoming developed for industrial or housing purposes. Some parcels, or portions of parcels, of new acquisitions should be set aside and managed for harvest mouse habitat. Estimated costs are unknown.

***Sigmodon arizonae* Mearns 1890** **Arizona cotton rat**

Brad R. Blood

5 subspecies, 2 of conservation concern in North America (north of Mexico):

S. a. arizonae Arizona cotton rat

S. a. plenus Colorado River cotton rat

IUCN Red List Category

Sigmodon arizonae – Lower Risk, least concern (LR,lc)

S. a. arizonae – Extinct (EX)

S. a. plenus – Lower Risk, near threatened (LR,nt)

Sigmodon a. arizonae is considered to be extinct. Assignment of *S. a. plenus* is based on its restricted distribution, which may have expanded with agricultural development along some parts of the Colorado River and been reduced along other portions, and the apparent absence of any immediate threat to its continued survival.

Taxonomy and distribution

Sigmodon arizonae resembles *S. hispidus*, to which the five subspecies of *S. arizonae* were originally assigned. Zimmerman and Lee (1968) found the two taxa to be chromosomally distinct: *S. hispidus* possesses 52 chromosomes, compared to a diploid number of 22 in *S. arizonae*. Zimmerman (1970) elevated *S. arizonae* to full species status, including the subspecies *arizonae*, *cienegae*, *jacksoni*, *major*, and *plenus*. Severinghaus and Hoffmeister (1978) described morphological differences between *S. arizonae* and *S. hispidus*. Hoffmeister (1986) restricted *S. a. arizonae* to the type locality at Camp Verde, reassigning other populations to *S. a. cienegae* and noting that the Camp Verde population was significantly larger than its conspecifics, and may have been specifically distinct.

The Arizona cotton rat ranges from along the Colorado River of California and Arizona south through Arizona and along the eastern coast of the Gulf of California to

Nayarit, Mexico. In Arizona, the species is broadly distributed south of the Mogollon Plateau, with disjunct populations reported from the southern slopes of the northwestern section of the Plateau (*S. a. arizonae*), and from the Colorado River banks of Nevada, California, and Arizona (*S. a. plenus*). The distributional limits of *S. a. plenus* along the Colorado River have not been established, and the southern limits of its range are not known. The subspecies is currently known to occupy a narrow band of mesic habitat along the banks of the Colorado River. Its known range extends from the vicinity of Parker, Arizona, southward to the Palo Verde Valley of California (Blood 1990, Hoffmeister 1986). Populations once occurring in Nevada are now thought to be extinct (Hall 1946, Bradley 1966). *Sigmodon a. plenus* is restricted to the mesic habitats of the lower Colorado River Valley, avoiding the surrounding true desert habitats (Hoffmeister 1986, Goldman 1928, Grinnell 1914).

Remarks

Sigmodon a. arizonae (as restricted by Hoffmeister 1986) may be extinct as a result of predation by house cats; no specimens have been taken since 1932 (Hoffmeister 1986). Populations of cotton rats along the Colorado River (*S. a. plenus*) may have expanded their range by occupying disturbed habitat of agricultural fields.

Cotton rats are usually associated with grassland habitats, preferring dense overgrowth (Goertz 1964, Odum 1955). Blood (1990) reported no captures of cotton rats (*S. a. plenus*) in typical grassy habitat along the Colorado River, but only in disturbed and open areas. Within the current range of *S. a. plenus*, cultivated fields provide available habitat suitable for cotton rats. Zimmerman (1970) captured *S. a. plenus* near Parker, Arizona in stands of the common reed (*Phragmites communis*). Grinnell (1914) noted that cotton rats were common in irrigated fields. The hispid cotton rat (*S. hispidus eremicus*), which occurs further south along the Colorado River, is also associated with irrigated fields (Blood 1990, McClenaghan 1980). Grinnell (1914) reported *Sigmodon* occupying the willow-cottonwood plant association along the Colorado River. The dominant plants of this association are willow (*Salix* sp.), Fremont cottonwood (*Populus fremontii*), guatemote (*Baccharis glutinosa*), and common reed (*Phragmites communis*). This plant association occurs along the river's edge and was subject to seasonal flooding (Grinnell 1914). The only true desert plant to occur there is the screwbean (*Prosopis pubescens*). The screwbean is only found in areas in which flooding has not occurred for several years. Dam construction and flood control have stopped flooding along the lower Colorado River. Elsewhere in Arizona, *S. arizonae* occupies a variety of habitats, ranging from desert-like areas of mesquite and tumbleweeds to areas of heavy weeds and brush. This species demonstrates a strong distributional association

with the pattern of irrigation canals in Arizona (Hoffmeister 1986).

Conservation status and occurrence in captivity and protected areas

Sigmodon a. plenus is a federal C2 candidate taxa; *S. a. plenus* is also a California Species of Special Concern. *Sigmodon a. arizonae* (as restricted by Hoffmeister 1986) is considered to be Extinct by the Arizona Department of Game and Fish and is a federal C3A (extinct) taxon. No populations of either subspecies are known to occur in captivity or in protected areas.

Recommended action

- Initiate survey to document whether *S. a. arizonae* is extinct at Camp Verde and vicinity.
- Investigate distribution and population density of *S. a. plenus* in Arizona and California. Populations are known to cycle, therefore a minimum period of three years will be required.
- Determine the extent of suitable habitat available for *S. a. plenus*.

***Sigmodon fulviventer* J.A. Allen 1889 Zacatecan cotton rat; tawny-bellied cotton rat**

David J. Hafner

4 subspecies, 1 of conservation concern in North America (north of Mexico):

S. f. goldmani Hot Springs cotton rat

IUCN Red List Category

Sigmodon fulviventer – Lower Risk, least concern (LR,lc)
S. f. goldmani – Extinct (EX)

Sigmodon fulviventer goldmani is considered to be extinct.

Taxonomy and distribution

Baker (1969) included *S. fulviventer* with *S. ochrognathus*, *S. alleni*, and *S. leucotis* in the *fulviventer* species group. *Sigmodon fulviventer* occurs primarily in Mexico from Michoacan north to southeastern Arizona, southwestern New Mexico, and along the Rio Grande Valley to northern New Mexico. *Sigmodon fulviventer goldmani* was known only from its type locality along the Rio Grande in central New Mexico.

Remarks

Sigmodon fulviventer occurs in well-developed grasslands, which historically were found along the Rio Grande Valley of New Mexico. This grassland has degraded markedly during this century into desert, and suitable remaining habitat along the southern Rio Grande has been occupied

by *S. hispidus*. Whether due to habitat degradation, competitive displacement, or a combination thereof, *S. fulviventris* is no longer found at the type locality (and single site) of *S. f. goldmani*, and the population in the northern Rio Grande Valley is isolated from southern populations by about 150km of habitat occupied only by *S. hispidus* (Findley *et al.* 1975). If *S. f. goldmani* was ever a valid subspecies, it is now extinct. Baker and Shump (1978) reviewed the general biology of this species.

Conservation status and occurrence in captivity and protected areas

Sigmodon f. goldmani is a federal C2 candidate taxon; no extant populations are known to exist.

Recommended action

- *Sigmodon fulviventris goldmani* should be delisted, as it is extinct and may never have been a valid taxon.

***Sigmodon hispidus* Say and Ord 1825 Hispid cotton rat**

David J. Hafner and Gordon L. Kirkland, Jr.

25 subspecies, 2 of conservation concern in North America (north of Mexico):

S. h. eremicus Yuma hispid cotton rat

S. h. insulicola Insular hispid cotton rat

IUCN Red List Category

Sigmodon hispidus – Lower Risk, least concern (LR,lc)

S. h. eremicus – Lower Risk, near threatened (LR,nt)

S. h. insulicola – Lower Risk, near threatened (LR,nt)

Assignment of both subspecies of conservation concern is based on their restricted distributions and apparent lack of immediate threats to their continued survival.

Taxonomy and distribution

The hispid cotton rat is broadly distributed over most of southern North America from the Atlantic coast to southeastern Arizona and south to eastern Panama. Musser and Carleton (1993) expressed doubts about the homogeneity of taxa included within *S. hispidus*. Four species have already been recognized from within *S. hispidus*: *S. arizonae*, *S. inopinatus*, *S. mascotensis*, and *S. peruanus*. A disjunct subspecies (*S. h. eremicus*) is found near the mouth of the Colorado River in California, Arizona, and Sonora, Mexico. Island populations are known from Florida (*S. h. exsputus* and *S. h. insulicola*) and the Caribbean coast of Mexico (*S. h. solus*). *Sigmodon h. insulicola* is largely confined to islands off the west coast of Florida. Layne (1978) reported this subspecies from Captiva Island (the type locality), Sanibel Island, Pine Island, and Chadwick Beach near Englewood. Cotton rats

on Little Pine Island are probably referable to *S. h. insulicola* as well (Layne 1978).

Remarks

The distribution of *S. h. eremicus* doubtlessly has been profoundly altered by the agricultural development of the lower Colorado River Valley and the Imperial Valley of southern California. The lower Colorado River Valley and Colorado River delta have undergone dramatic change during this century, as river water was diverted west to irrigate the Imperial Valley, and a combination of dams and irrigation channels greatly expanded agricultural areas along the Colorado River (Smith and Patton 1980). For a period of two years between 1905 and 1907, the entire flow of the Colorado River was accidentally diverted into the Salton Sea (Sykes 1937). Even without this catastrophic diversion, irrigation probably would have eventually eliminated much or all of the habitat appropriate for *Sigmodon* in the Colorado River delta, as the river rarely reaches the delta today. At the same time, cotton rats expanded along with agricultural development in the lower Colorado River Valley. According to Hoffmeister (1986), *S. h. eremicus* may have once occurred in the western part of the Gila River Valley, east of Yuma; they are currently locally numerous around irrigated fields in Yuma.

According to Layne (1978), *S. h. insulicola* occurs in a variety of habitats including pine-palmetto stands, dense cordgrass (*Spartina patens*), dry open grassy fields, mixed grass and brushlands, the drier areas of freshwater marshes, and in garbage dumps in wet areas. This subspecies was listed as “status undetermined” by Layne (1978); subsequent surveys have revealed that it is more abundant and less vulnerable than was previously thought (Humphrey 1992a). Cameron and Spencer (1981) reviewed the general biology of this species.

Conservation status and occurrence in captivity and protected areas

Sigmodon h. eremicus and *S. h. insulicola* are both federal C2 candidate taxa; *S. h. eremicus* is also a California taxon of concern, whereas *S. h. insulicola* has no official conservation status in Florida (Humphrey 1992a). No populations of either subspecies are known to occur in captivity or in protected areas.

Recommended action

- Conduct survey to determine the population status and distribution of *S. h. insulicola*, and the nature and extent of any immediate or anticipated threats to its continued survival.
- Conduct survey to determine the population status and distribution of *S. h. eremicus*, particularly the extent of loss of habitat in the Colorado River delta and the extent of range expansion associated with agricultural development of the lower Colorado River Valley.

- Evaluate the systematic relationships of these isolated subspecies of *S. hispidus* to neighboring conspecifics using modern biochemical and genetic techniques.

***Synaptomys borealis* (Richardson 1828) Northern bog lemming**

Eric Yensen and Gordon L. Kirkland, Jr.

9 subspecies, 2 of conservation concern:

S. b. artemisiae Okanogan bog lemming

S. b. sphagnicola Northern bog lemming

IUCN Red List Category

Synaptomys borealis – Lower Risk, least concern (LR,lc)

S. b. artemisiae – Lower Risk, near threatened (LR,nt)

S. b. sphagnicola – Lower Risk, near threatened (LR,nt)

Assignment of both subspecies of conservation concern is based on their restricted distributions and the apparent lack of immediate threats to their continued survival.

Taxonomy and distribution

The northern bog lemming is broadly distributed across northern North America from the Atlantic to the Pacific coasts of Canada, extending into the United States in the New England states (*S. b. sphagnicola*), Minnesota (*S. b. smithi*), and the Pacific Northwest (*S. b. truei* along the coastal forests, *S. b. chapmani* in the Rocky Mountains, and *S. b. artemisiae* in between). *Synaptomys b. sphagnicola* is the only subspecies that occurs south of the St. Lawrence River. Its range includes the Gaspé Peninsula of Quebec, New Brunswick, Maine, and New Hampshire, where it inhabits bogs dominated by sphagnum moss (*Sphagnum* sp.), Labrador tea (*Ledum groenlandicum*) and black spruce (*Picea mariana*); marginal habitats include mossy spruce woods, alpine tundra, and wet alpine meadows (Banfield 1974).

Synaptomys b. artemisiae is known only from three localities in British Columbia and three in Washington. R.E. Johnson (pers. comm.) examined many of the known specimens of northwestern bog lemmings. The few known specimens exhibited considerable variation in molt, pelage wear, age class, and seasonal variation, and he concluded that there was not enough material to judge the subspecific validity of *S. b. artemisiae*. The British Columbia localities are Stevenson Creek (type locality, 5 specimens), Whipsaw Creek (4 specimens) in the Similkameen Valley on the east slope of the Cascade Range (Anderson 1932), and Frenchy Creek (1 specimen, Royal British Columbia Museum 19033, collected in 1994; D. W. Nagorsen pers. comm.). The Stevenson Creek site (elevation 730m) is characterized by arid sagebrush (*Artemisia tridentata*) habitat with no standing water; the Whipsaw Creek site (1700m) is in willow (*Salix* sp.) thickets associated with Engelmann spruce (*Picea engelmannii*) in the subalpine zone; and the

Frenchy Creek site (1650m elevation) is a willow thicket association with a clearcut in Engelmann spruce forest.

Wilson *et al.* (1980) reported the first Washington specimens of *S. b. artemisiae* about 80km south of the British Columbia localities in Okanogan County. The Washington localities are at the southern edge of the species' range. Both records (Thirtymile Meadows and Long Swamp) were from wet sedge meadows in Englemann spruce or lodgepole pine (*Pinus contorta*) forests at 1650–1860m elevation. There is an additional unpublished Washington record of *S. b. artemisiae* in the Washington State University collection (#81-398) collected by Jim Reichel on 21 August 1979 in “wet meadow-marginal alpine” habitat in the east cirque of Slate Peak at 6,700ft [2,040m] elevation, Okanogan County, Washington. This locality is less than 1mi [1km] from the Pacific Crest and the Whatcom County line (R.E. Johnson pers. comm.).

Remarks

If *S. borealis* is similar in its biology to *S. cooperi*, then it may be more wary of capture than other small rodents, and its apparent rarity may reflect in part its avoidance of standard live and snap traps. With only 13 known specimens of *S. b. artemisiae* (for example), it is difficult to conclude whether it is genuinely rare, or only difficult to trap. No specific threats to this population are known.

The disjunct population of *S. borealis* south of the St. Lawrence River may prove to be the most sensitive of all Quebec rodents. Although spruce bogs are not a disappearing habitat, as relicts of the last glaciation they are extremely patchy and frequently very isolated. *Synaptomys b. sphagnicola* may thus be represented by a series of more or less isolated populations of extremely small size. If this is indeed the case, then many may be below a minimum viable population size and subject to a high risk of extinction. *Synaptomys borealis* is rare throughout its range. In an internal report to the Ministère des Loisirs, Chasses et Pêches du Québec, Breton and Gauthier (1989) indicated that none of the small-mammal biologists they contacted at nine Quebec universities and colleges had ever trapped *S. borealis* in that province.

Conservation status and occurrence in captivity and protected areas

The British Columbia Ministry of Environment placed *S. b. artemisiae* on its Red List (potentially endangered or threatened), presumably because of its localized distribution; in Washington, the taxon is on the state Monitor list. *Synaptomys b. sphagnicola* is a federal C2 candidate taxon and is considered Threatened in Maine. None of the records of *S. b. artemisiae* are from protected areas. Parks and ecological reserves in this region of British Columbia are small and highly fragmented. No populations of *S. b. sphagnicola* are known to occur in captivity or protected areas.

Recommended action

- Survey historical range of *S. b. artemisiae*, including low elevation wetland and riparian habitats associated with the Okanagan River system, to determine distribution and status of the subspecies.
- Compare *S. b. artemisiae* with adjacent subspecies based on increased sample sizes to assess validity of subspecific status.
- Document the current distribution and abundance of *S. b. sphagnicola* within its distribution.

***Synaptomys cooperi* Baird 1858** **Southern bog lemming**

David J. Hafner

7 subspecies, 2 of conservation concern:

S. c. paludis Kansas bog lemming

S. c. relictus Nebraska bog lemming

IUCN Red List Category

Synaptomys cooperi – Lower Risk, least concern (LR,lc)

S. c. paludis – Extinct (EX)

S. c. relictus – Extinct (EX)

Both subspecies of conservation concern are considered to be extinct.

Taxonomy and distribution

The southern bog lemming has a broad distribution centered on the Great Lakes, from the Atlantic coast to the Great Plains of western Nebraska and Kansas. Disjunct, peripheral subspecies occur in Virginia and North Carolina (*S. c. helaletes*), western Nebraska (*S. c. relictus*), and western Kansas (*S. c. paludis*). The latter two subspecies, each known from only a single locality, are of conservation concern.

Wilson and Choate (*in litt.*) surveyed geographic variation in *S. cooperi* on the Great Plains based on cranial morphology, and found that size varied clinally with an increase in size from east to west and north to south (in the reverse of Bergman's Rule). Due to a paucity of specimens from the Great Plains, they recommended tentative retention of the current taxonomy.

Remarks

No individuals of *S. c. paludis* and *S. c. relictus* have been collected since 1946 and 1968, respectively, and these subspecies may be extinct (Wilson and Choate *in litt.*). The single population of *S. c. relictus* was restricted to suitable habitat "approximately 100 yards [91m] wide and one mile [1.6km] long" near the Rock Creek Fish Hatchery (Jones 1964). According to R.M. Timm (*pers. comm.*), *S. c. paludis* should be considered extinct. This subspecies was found around a single natural spring, and probably was a relict of a more extensive late Pleistocene distribution. The

spring was surrounded by arid habitat, unsuitable for *Synaptomys*, but is in a state park and thus protected. *Synaptomys* apparently suffered extinction from competition with *Sigmodon*, rather than habitat change (R.M. Timm *pers. comm.*). The species appears to be vulnerable to competition, such that the common characteristic of its habitat is that it is marginal for *Microtus*, which otherwise excludes this species (Linzey 1983). Detection of extant populations may be difficult: another restricted subspecies, *S. c. helaletes*, was rediscovered after a hiatus of 83 years between collections (Linzey 1983). Linzey (1983) reviewed the general biology of this species.

Conservation status and occurrence in captivity and protected areas

Both western peripheral isolates of *S. cooperi* (*S. c. paludis* and *S. c. relictus*) are federal C3A taxa, indicating that there is persuasive evidence that both are extinct. If individuals of *S. c. paludis* survive, they most likely would be located in Meade County State Park.

Recommended action

- It may be useful to conduct intensive surveys of the historical sites of both subspecies in the unlikely event that populations survive.

Family DIPODIDAE

***Zapus hudsonius* (Zimmermann 1780)** **Meadow jumping mouse**

David J. Hafner and Eric Yensen

11 subspecies, 3 of conservation concern:

Z. h. campestris Black Hills meadow jumping mouse

Z. h. luteus New Mexico meadow jumping mouse

Z. h. preblei Preble's meadow jumping mouse

IUCN Red List Category

Zapus hudsonius – Lower Risk, least concern (LR,lc)

Z. h. campestris – Vulnerable (VU): B1;B2c

Z. h. luteus – Lower Risk, near threatened (LR,nt)

Z. h. preblei – Endangered (EN): B1;B2c

Assignment of *Z. h. campestris* is based on its highly restricted and fragmented distribution and the projected continuation in the decline in both extent and quality of its habitat. Assignment of *Z. h. luteus* is based on its restricted distribution and apparent absence of immediate threats to its continued survival: populations have persisted at agriculturally developed sites throughout its geographic range. Assignment of *Z. h. preblei* is based on its severely restricted and fragmented distribution and the projected continuation in the decline in both extent and quality of its habitat.

Taxonomy and distribution

Krutzsch (1954) described *Z. h. preblei* as a distinct, isolated subspecies most similar to *Z. h. campestris* based on 11 specimens (4 adults, 7 non-adults). *Zapus h. preblei* has fewer black tipped dorsal hairs and a less distinct dorsal band; smaller cranial measurements; a narrower interorbital constriction; smaller, less-inflated auditory bullae; narrower incisive foramina; and a more inflated frontal region. The two subspecies are separated by about 125–150km of unsuitable habitat. One intergrade between *Zapus h. campestris* and *Z. h. pallidus* is known from South Dakota (Krutzsch 1954).

Zapus luteus was described by Miller (1911); Bailey (1913) later recognized two subspecies, *Z. l. australis* from the southern Rio Grande, and *Z. l. luteus* from the northern Rio Grande and Sacramento Mountains of New Mexico. Krutzsch (1954) combined these subspecies and new records from the White Mountains of Arizona under *Z. princeps luteus*. Hafner *et al.* (1981) demonstrated that populations assigned to *luteus* formed a natural group, but are relictual isolates of *Z. hudsonius* rather than *Z. princeps*.

The meadow jumping mouse is broadly distributed across northern North America from the Atlantic to Pacific coasts, extending south into the United States to Alabama and Georgia and west across the Great Plains to the base of the Rocky Mountains, and is a common inhabitant of moist, grassy, and herbaceous fields. Frey (1992) reported a rapid distributional shift of this species (and other members of a boreal faunal element) in response to an onset of cool, mesic conditions in the central plains since the 1960s. Fossil records document a more widespread Wisconsinan distribution in the arid American Southwest (Dalquest *et al.* 1969, Hafner *et al.* 1981, Scarbrough 1986, Hafner 1993a). Currently, the main distribution of central plains boreal mammal species reaches northeastern Wyoming and south-central Nebraska. However, isolated populations of *Zapus hudsonius* (presumably relicts of Wisconsinan times) persisted historically along the species' southwestern margin from Montana to Arizona.

Zapus hudsonius campestris is found in the Black Hills of southeastern Montana, northeastern Wyoming, and western South Dakota (Hall 1981). It is known from seven localities in Crook and Weston Counties, Wyoming (Long 1965). *Zapus hudsonius preblei* historically occurred on the eastern foothill marshes of the Laramie Range along the upper drainages of the North Platte River in southeastern Wyoming (Clark and Stromberg 1987) and on the western edge of the Colorado piedmont along the South Platte River drainage south to the vicinity of Denver (Armstrong 1972). Long (1965) reported three localities in Wyoming, and Armstrong (1972) listed 15 localities for Colorado. Compton and Hugie (1993) added eight Colorado localities. Isolated populations of *Z. h. luteus* are known from the Sacramento Mountains, Jemez Mountains, and Rio

Grande Valley of New Mexico, and the White Mountains of Arizona, where they are restricted to mesic grass/forb riparian habitat along permanent waterways. Jones (1996) reported three localities in Las Animas County, southeastern Colorado; preliminary genetic evidence (Riggs *et al.* 1997) supports identification of this isolated population as *Z. h. luteus*.

Remarks

Zapus hudsonius is a species of marshy areas, wet meadows, and riparian areas (Krutzsch 1954, Whitaker 1972, Clark and Stromberg 1987). Referring to both subspecies of *Zapus hudsonius* in Wyoming, Clark and Stromberg (1987:185) state that, "overgrazing of domestic animals, which consistently removes all dense vegetation along the eastern creeks of Wyoming, has no doubt contributed to the scarcity of these mice in Wyoming." In South Dakota, *Z. h. campestris* has lost habitat in the Black Hills, and "there is not a lot of good habitat left" (D. Blacklund pers. comm.), although there have been no recent sampling efforts. In Montana, *Z. h. campestris* occurs only in a limited range and has not been searched for extensively; overgrazing of riparian areas is considered the primary threat (J. Reichel pers. comm.).

Zapus h. preblei may have been extirpated from its Wyoming range due to extensive overgrazing and pesticide spraying. During extensive survey trapping at previous and potential sites during 1993 (Compton and Hugie 1994), no specimens were captured anywhere in its historical Wyoming range. Long (1965) considered the subspecies rare in Wyoming, and only seven specimens exist, all collected prior to 1954. The Colorado Natural Heritage Program (J. Sheppard pers. comm. 1997) lists two sites "where Preble's [meadow jumping mouse] has been captured since 1990." Preliminary genetic analysis (Riggs *et al.* 1997) indicates that specimens from one of these sites (in Albany Co.) may in fact be *Z. h. preblei*, while those from the other (from Warren Air Force Base in Laramie Co.) may instead be *Z. princeps*. Due to its probable past low density and rarity, and the difficulties in trapping the species, it is possible that isolated populations remain in the region.

Compton and Hugie (1993) reported that populations of *Z. h. preblei* had been detected at only four sites in Colorado since 1972: Fort St. Vrain Nuclear Generating Station near Greely, Weld County; Rocky Flats Power Plant north of Golden, Jefferson County; and two parcels of City of Boulder Open Space south of Boulder, Boulder County. No captures have been reported from the Fort St. Vrain site since 1977, and that population may have been extirpated (Compton and Hugie 1993; Ryon 1996). Subsequent trapping efforts have revealed six extant populations of *Z. h. preblei* in six counties of Colorado (Armstrong *et al.* 1997; Meaney *et al.* 1997): northern Larimer Co., northern Boulder Co., southern Boulder

and northern Jefferson counties, Douglas Co., northwestern El Paso Co., and northwestern Elbert Co. Preliminary genetic analysis (Riggs *et al.* 1997) indicates that there may be a disjunct population of *Z. h. preblei* in western Las Animas Co., near the New Mexico border. A population reported from Weld Co. appears to represent *Z. princeps* based on preliminary genetic analysis (Riggs *et al.* 1997). Populations in Boulder and Jefferson counties are within the rapidly expanding Colorado Piedmont development area that includes Denver, Boulder, Fort Collins, and Greeley. It is likely that agricultural, residential, and commercial development will continue to accelerate in this region, increasing existing impacts and introducing new negative pressures (e.g., predation by house cats from residential areas and feral populations). Although survey of appropriate habitat has revealed new populations of *Z. h. preblei* in Colorado, none were found at any of the seven historical sites surveyed by Ryon (1996), indicating that the subspecies “has suffered a decline within its historic range in Colorado” (Armstrong *et al.* 1997). On a more positive note, new populations are being found in a wider variety of habitats, including such disturbed areas as irrigation ditches, areas that have been subjected to some grazing, and areas adjacent to hayfields (C. A. Meaney pers. comm. 1997). Meaney *et al.* (1997) stress that the species favors high plant species richness with well-developed cover, which is found along natural riparian areas as well as irrigation ditches, and that these habitats also serve as dispersal corridors between isolated populations.

Extensive agricultural development of the Rio Grande Valley of New Mexico has destroyed or severely altered natural riparian bosque and marsh associations, and it was feared that *Z. h. luteus* was in danger of extirpation along the Rio Grande (Findley *et al.* 1975, Hafner *et al.* 1981). However, extant populations have been found at virtually all previous localities (Morrison 1990, 1992), persisting in patches of natural riparian habitat and similar man-made mesic habitat along agricultural fields. In the Sacramento Mountains, known populations are restricted to small patches of meadow that have escaped extensive livestock grazing. These patches may be adversely affected by continued recreational use and development of the region (e.g., ski resorts). Populations in the White Mountains of Arizona appear to be least affected by adverse human impacts, although intensive grazing pressures could destroy streamside grass and forb vegetation on which the species depends. Identification of a population of *Z. h. preblei* reported from the Raton Mesa of Las Animas Co. (Jones 1996) has been verified by preliminary genetic analysis. It is possible that other, as yet undiscovered populations of *Zapus hudsonius* survive along the western edge of the Rocky Mountains of Colorado and New Mexico.

Survey and monitoring of populations of *Zapus* may be complicated by their avoidance of the most typically used

live trap, the Sherman live trap, and by the species' lengthy period of hibernation: from October to April or May in most of its range. *Zapus* are more readily trapped in snap traps (D.J. Hafner pers. obs.) or in open wire-mesh Havahart traps (Najera 1994) than in Sherman traps. Further, the species appears to be more readily trapped in late summer, perhaps related to increased foraging activity preceding hibernation. Thus, surveys conducted earlier in the summer with Sherman traps may be far less likely to detect existing populations. Whereas lack of capture certainly indicates very low density of the population (at best), previous and potential sites should continue to be monitored for persisting populations. It is recommended that trapping be conducted in late summer using snap traps (if population density is high and detection is the goal) or Havahart traps (for small, sensitive populations or for mark-recapture efforts). Additional cryptic populations of *Z. h. luteus* may persist in the American Southwest, as presence of meadow jumping mice is often difficult to detect. For example, no specimens were reported from the Rio Grande Valley between 1930 and 1976, despite frequent survey trapping and persistence of essentially all valley populations. Intensive survey of suitable habitat has revealed additional populations (Ohmart and Hink 1984, Morrison 1992). Whitaker (1972) reviewed the general biology of this species.

Conservation status

Zapus h. campestris is classified as Critically Rare with habitat decreasing (Houtcooper *et al.* 1985) in South Dakota. The Wyoming Natural Diversity Database ranks *Z. h. campestris* as Imperiled in the state. The Wyoming Department of Game and Fish, ranks it as a Priority II, that is, “species which are in need of additional study to determine whether intensive management is warranted or whether low level management will suffice.”

Zapus h. preblei is a federal C2 candidate taxon. The Wyoming Natural Diversity Database ranks *Z. h. preblei* as Imperiled in the state. The Wyoming Department of Game and Fish ranks *Z. h. preblei* as a Priority II taxon. The subspecies was designated a Colorado nongame species, which provides legal protection against taking. It is also a Colorado Division of Wildlife Species of Special Concern, which is an administrative classification rather than a legal one (Compton and Hugie 1993). Compton and Hugie (1993) originally recommended that the subspecies be listed by the United States Fish and Wildlife Service as threatened in Colorado and Wyoming, but amended that recommendation (Compton and Hugie 1994) to Endangered status based on lack of captures in the Wyoming portion of its range.

Zapus h. luteus is currently listed as Endangered by the New Mexico Department of Game and Fish and Threatened by the Arizona Game and Fish Commission. The United States Fish and Wildlife Service is requesting

reduced status of the species on its endangered species list from C2 to C3C status (“more abundant than previously thought”); it was initially listed as C1 status.

Occurrence in captivity and protected areas

Populations of *Z. h. luteus* exist on several state and federal refuges along the Rio Grande, but management practices have not yet included habitat of this species as a priority. Studies are being conducted to determine the specific habitat requirements and distribution on the largest refuge, Bosque del Apache National Wildlife Refuge (Najera 1992, 1994). City of Boulder Open Space Department parcels may provide some *de facto* protection of *Z. h. preblei* from urban development, but not from grazing (Compton and Hugie 1993); both parcels are managed for multiple use, including recreational use and leasing for grazing and agricultural purposes. Rocky Flats Plant was established by the United States Department of Atomic Energy to produce plutonium for nuclear weaponry, and so was surrounded by a 2400ha buffer zone surrounded by a security fence. The current administrators, the United States Department of Energy, have maintained the secure buffer zone, which has functioned as a nature preserve. However, no proactive wildlife or habitat management has occurred on the site. No populations of *Z. h. campestris* are known to occur in captivity or protected areas.

Recommended action

- Survey suitable habitat within historical range of *Z. h. preblei* to determine the amount and quality of remaining meadow mouse habitat, localities of extant populations, and population trends.
- Survey suitable habitat within historical range of *Z. h. campestris* to determine the amount and quality of remaining meadow mouse habitat, localities of extant populations, and population trends.
- Study the specific habitat requirements of *Z. h. preblei* at remaining sites and apply these results to preservation and enhancement of necessary habitat at these sites.
- Study the specific habitat requirements at both low elevation (Rio Grande) and montane sites occupied by *Z. h. luteus* and apply these results to preservation and enhancement of necessary habitat, particularly on state and federal game refuges and other protected lands.
- Cease immediately all grazing and pesticide application on all current and historical sites of *Z. h. preblei* in Wyoming, and development at and around remaining sites of the subspecies in Colorado. Particular care must be taken to preserve upland sites critical for winter hibernation.
- Identify and establish appropriate protected areas for remaining populations of *Z. h. campestris*.
- Monitor extant populations of *Z. h. preblei* to determine critical summer and hibernacula habitat and critical forage species.

- Conduct further molecular genetic analyses of extant populations to determine genetic variation within and between surviving populations of *Z. h. campestris*, *Z. h. preblei*, and *Z. h. luteus*.

***Zapus trinotatus* Rhoads 1895** **Pacific jumping mouse**

William Z. Lidicker, Jr.

4 subspecies, 1 of conservation concern:

Z. t. orarius Point Reyes jumping mouse

IUCN Red List Category

Zapus trinotatus – Lower Risk, near threatened (LR,nt)

Z. t. orarius – Lower Risk, conservation dependent (LR,cd)

Assignment of the species is based on its restricted distribution in the Pacific Northwest. Assignment of *Z. t. orarius* is based on its restricted distribution within Point Reyes National Seashore and Golden Gate Recreational Area, where populations receive necessary protection from development of their critical habitat.

Taxonomy

Zapus t. orarius is the smallest subspecies in size within its species, has the most intense ochraceous or buffy wash on its venter, a relatively shortened tail, and differs in other minor cranial and dental features. The name *orarius* originated with Preble (1899), who assigned it to a “very well-marked species requiring close comparison with no other known form.” He viewed its distribution as being from Pt. Reyes north to Humboldt County, California. Subsequently, Howell (1920) described *Z. t. eureka*, applying this name to the jumping mice of the coast from the extreme northwest of California south to Mendocino City (Mendocino County). In doing this, he restricted the range of *orarius* to the Pt. Reyes Peninsula, but continued to recognize it as “a well defined species ... [that] apparently intergrades with no other form.” Hooper (1944) was the first to arrange *orarius* as a subspecies of *trinotatus*. This suggestion was supported by Krutzsch (1954) in his major revision of the entire genus *Zapus* on the basis of bacular morphology, diameter and pigment pattern of the hair, and general configuration of the skull. Both he and Hooper, however, affirmed that *orarius* was isolated from other jumping mice because of intervening unsuitable terrain (the so-called Sonoma-Marín Gap or Petaluma Gap).

Distribution

The Pacific jumping mouse ranges along the Pacific Coast of North America from the Golden Gate of California (San Francisco Bay) to southern British Columbia (Krutzsch 1954). The southernmost subspecies, *Z. t. orarius*, is restricted to the ocean side of Marin County,

just north of San Francisco Bay, and is completely isolated from other populations of *Zapus*. The southernmost record of its nearest conspecific, *Z. t. eureka*, seems to be Albion River, 0.5km E of MacDonald's Ranch, Mendocino County. Albion River is 115km from the northernmost record for *Z. t. orarius*. This river heads in the vicinity of Comptche and enters the ocean only 8km south of Mendocino (City). Both Krutzsch (1954) and Hall (1981:847) show on their distribution maps a southernmost locality for *eureka* approximately in the southeast corner of Mendocino County, but this location is not matched by any of the specimen localities. *Zapus t. orarius* is known from seven locations (an additional location is unplotable: 6mi [9.7km] SSE Tomales Bay) extending from near the Golden Gate (southernmost Marin County) to the Point Reyes Peninsula (Williams 1986). These mice live in moist meadows, marshlands, open shrubby grasslands, and streambanks. Such areas are characterized by generally moist soil but without danger of inundation.

Remarks

Except for two specimens collected in 1967 on the Point Reyes Peninsula, all distribution records predate mid-1945. Although recent data are lacking, it seems likely that this subspecies persists over most of its ancestral range. The taxon remains at risk, however, because of its extremely limited distribution and presumably fragmented population structure. Except on the Point Reyes Peninsula, suitable habitat exists only in very localized and disjunct patches. It is possible that the range of this mouse extends, or did so in the recent past, along the northeast side of Tomales Bay. If this were the case, it may have extended up the drainages of several creeks draining into Tomales and Bodega bays. Two of these, Stemple and Americano creeks, have headwaters in southernmost Sonoma County, and could bring the range of *orarius* to the southern edge of the Petaluma biogeographic gap. Even if this were the case, *Z. t. orarius* remains a distinct taxon isolated by at least 100km from its nearest known relative to the north.

As with other species of *Zapus*, *Z. trinotatus* hibernates for most of the year. Collection dates from the 32 specimens of *orarius* in the Museum of Vertebrate Zoology (University of California, Berkeley) range from 30 April to 9 August. Reproduction seems to be in spring with the latest recorded embryos being on 6 June. Survey efforts must consider both the period of activity and changing activity patterns and movements associated with preparation for hibernation. Gannon (1988) reviewed the general biology of this species.

Conservation status and occurrence in captivity and protected areas

Zapus t. orarius is a federal C2 candidate taxon and a California Species of Special Concern. All localities of known occurrences are now within protected areas: Point Reyes National Seashore and Golden Gate National Recreation Area. Additional populations may be located in Mount Tamalpais State Park.

Recommended action

- Survey and determine the current distribution of *Z. t. orarius*, including explorations beyond its known range, especially to the northeast.
- Establish a system of monitoring populations, once their locations are determined. This phase may be facilitated if such procedures could be incorporated into the management plans of the relevant reserves.
- Conduct a study of the dispersal behavior of this subspecies. Knowledge of this aspect of the animals' life history would better provide for its conservation. The predilection of this species to disperse and its ability to traverse marginal habitats is critically important to an understanding of its metapopulation structure.
- Monitor populations of *Z. trinotatus* throughout its distribution to assess current or potential threats to the species, including habitat loss.

Conservation Priorities, Action Plans, and Conservation Strategies for North American Rodents

Eric Yensen, David J. Hafner, and Joseph A. Cook

Conservation measures such as those recommended in this Action Plan will always be limited by logistic and economic considerations. Therefore, it is necessary to establish priorities for those rodent taxa and habitats in greatest need of project funding and implementation. As noted by Mace *et al.* (1992:19), priority for conservation action does not depend solely upon the category of threat, but includes “numerous other factors, such as the likelihood that restorative action will be successful; political, economic, and logistical considerations; and perhaps the taxonomic distinctiveness of the taxon in question.”

Today, conservation efforts are shifting away from saving single species on a crisis basis and toward protection of habitats and ecosystems. The hope is that saving habitats will frequently protect the species contained therein, including more cryptic species whose threatened status has not yet been revealed. However, conservation agencies will still need to assimilate recommendations from diverse taxon-directed groups such as the IUCN Specialist Groups. Thus, we offer here our suggestions regarding important habitats for conservation action, rodent species deserving conservation priority, and some thoughts on appropriate strategies for rodent conservation.

In order to better focus on those taxa truly in need of conservation efforts, we have examined all taxa currently listed by state, provincial, federal, or private agencies as threatened, and recommend that a number of these be excluded from such listing. We understand that we may not have had full access to all information regarding the status of these taxa, and that some may in fact require conservation measures. For those taxa, we hope that the critical information will be made available for future action plans.

Patterns of vulnerability

Nature of threats

The most pervasive threat to North American rodents of global conservation concern is conversion of critical habitat. Habitat conversion has been effected through agricultural development, urban expansion, grazing, fire suppression,

logging of old-growth forest, and recreational activities. Of the 86 species included in this Action Plan, nearly one-half (35) are threatened by conversion of their preferred habitat; 15 of those are threatened at the specific or generic level. Of 12 species and 63 subspecies listed as Conservation Dependent or at higher levels of threat, fully 10 species and 39 subspecies have suffered from habitat conversion. Agricultural conversion of natural habitats has spread for centuries in an east-to-west wave that has fragmented tracts of continuous habitat and reduced or eliminated pockets of others. Elimination of habitat for urban or industrial development has been a more recent phenomenon of this century. In many cases, agricultural conversion preceded urban or industrial development. Specific effects of agricultural conversion on endemic rodents are variable, but would include radical changes in food availability, food types, and dietary diversity; mechanical disruption of burrow systems; flooding of burrows by irrigation; toxic effects of pesticides; intentional poisoning and trapping of rodents; and predation by domestic and feral dogs and cats associated with urban areas.

Introduced exotic species pose a more insidious threat to native rodent species, resulting in habitat conversion, increased predation, and direct competition. Although the adverse effects of introduced exotic species on oceanic islands have long been appreciated, it is now apparent that invasive species are affecting the structure of ecosystems and native biological diversity on continents as well (Vitousek *et al.* 1996). These exotics are widespread, ranging from escaped cultivated plant species and feral domesticated animals (particularly domestic cats) to accidentally introduced insects that serve as vectors of disease or are direct pest species. Probably no region in the North American continent is unaffected by introduced species, but they are particularly prevalent in certain areas. Of the estimated 2,000 species of invasive non-native plants that now occur in the continental United States (United States Congress, Office of Technology Assessment 1993), California and Florida each have nearly 1,000 of these introduced exotics; five of the six most threatened biotic communities included in our Priority 1 are in California and Florida. Vitousek *et al.* (1996) note that the eastern deciduous forests have recovered

substantially from extensive clearing that occurred during the 1800s, but have suffered this century from repeated invasion of non-native species (particularly insect pests and pathogens). Moreover, they predict that invasive species “will continue to be the greatest threat to the diversity of these forests in the foreseeable future.”

Direct extermination by humans has been implicated in dramatic declines in several species. Broadcast of poisoned grain resulted in widespread extirpation of two species of prairie dogs and a ground squirrel. The fur trade may have been responsible for decline in one subspecies of beaver.

For 77 taxa (nearly one-half of the total included in this Action Plan), the nature of threat, if any, is unknown. These taxa are considered to be of conservation concern based on evidence of declining populations or highly restricted or declining distributions. Clearly, conservation actions depend on the prompt identification of the nature and extent of threat to these populations.

Geographic patterns

Threatened rodents are not randomly or evenly distributed across North America, but instead are concentrated in areas of high biological diversity that are subject to intense habitat alteration. Eight geographic regions contain 50% (84 of 168) of the threatened taxa included in this Action Plan. These areas are: 1) the San Joaquin Valley, California (a restricted regional desert that has been largely converted to agriculture); 2) coastal and barrier-island habitat of Florida (largely converted for urban development); 3) Pacific Coast Douglas Fir and Redwood forests along the coast from northern California to southern British Columbia (which have suffered from urban expansion, logging, agricultural development, and introduction of exotic species); 4) Coastal Chaparral communities of southern California (subjected to agricultural and urban development, as well as introduction of exotic species); 5) the Mojave Desert of southern California (severely impacted along its western margin by agricultural and urban development); 6) the Columbia Basin of Washington and Oregon (a restricted desert-grassland that has been subjected to agricultural conversion); 7) deciduous and remnant boreal forests of the Appalachian Mountains (a formerly widespread and continuous forest system that has been severely reduced and dissected through deforestation, agricultural development, and urban expansion); and 8) the Transverse Ranges bordering the Los Angeles Metropolitan Area of southern California (subjected to grazing and urban development).

Island endemics are susceptible to extinction due to small population sizes and limited habitat, and are particularly vulnerable to introduction of exotic species. At least 39 species have representative populations of concern that are restricted to either actual islands (oceanic,

landbridge, or in lakes), ecological islands of critical habitat, or both; at least five of these species are threatened. Drastic effects of exotic species on insular faunas have been well documented throughout the world (e.g., Savidge 1987; Freed *et al.* 1988; Schofield 1989). In Alaska alone, Bailey (1993) reported introduction of arctic fox (*Alopex lagopus*) or red fox (*Vulpes vulpes*) on at least 455 islands. Many of these introductions probably have resulted in the decline of seabird colonies (Murie 1959). Their effects upon endemic rodents are unknown. However, introduced exotics have been implicated in the extinction of native rodents in other island systems (Konecny 1987a, 1987b; Owen 1977; Smith *et al.* 1993).

Populations restricted to ecological islands may be subject to the same threats as those on actual islands. These include forest or boreal taxa isolated on cool, mesic mountaintops in the arid Southwest, as well as rodents dependent on mesic conditions that persist in isolated riparian or montane environments.

Taxa in need of basic survey to determine the nature and extent of any threat (Data Deficient) are of potential conservation concern due to restricted geographic range. Of seven species and 49 subspecies listed as Data Deficient, two species and 25 subspecies occur on either actual or ecological islands, and three species and 18 subspecies have restricted ranges within habitat that appears to be more widespread. The single Data Deficient species known to have been subjected to habitat conversion (*Spermophilus townsendii*) also has a highly restricted range. Further investigation may reveal that some of these Data Deficient taxa are not valid, and are instead members of widespread, secure taxa; that others, although distinct taxa, are in fact secure and not immediately threatened within their restricted range; and that others will require immediate action to mitigate threats to their continued survival.

Twenty-one species have limited species ranges (10 species) or highly restricted subspecies ranges (40 subspecies of 11 species), and so are considered as vulnerable or potentially vulnerable to adverse human impact. Most of these taxa historically had small geographic ranges, with two exceptions: the black-tailed prairie dog (*Cynomys ludovicianus*) and Allegheny woodrat (*Neotoma magister*) formerly were widespread, but poisoning campaigns and conversion of prairie habitat, and clearing of eastern forests (respectively) have greatly reduced and fragmented these formerly widespread distributions.

Taxonomic vulnerability

The majority of North American rodents of conservation concern belong to the four most common of the eight families of rodents that occur north of Mexico: Muridae (rats and mice), Sciuridae (squirrels and chipmunks), Heteromyidae (desert rodents), and Geomyidae (pocket

gophers; Table 6.1). These four families account for 96.6% of the North American species, and 95.2% of the North American subspecies. In Table 6.1, the proportion of species and subspecies within each family are shown as: total composition of the North American rodent fauna; those included in this Action Plan that are threatened above the level of Lower Risk (least concern); those that are at least Vulnerable or Conservation Dependent (excluding LR[least concern] and LR[near threatened]); and Data Deficient taxa. The number of subspecies within the major four families that are threatened is roughly in proportion to their contribution to the total subspecies of North American rodents. However, there are proportionately fewer species of rats and mice (Muridae) that are threatened, while there are more species of squirrels (Sciuridae) and pocket gophers (Geomyidae) that are of conservation concern. This probably is a direct reflection of the smaller average distribution of species of squirrels and pocket gophers relative to that of rats and mice. Thus, it appears that although families of North American rodents are affected by adverse impact in proportion to their relative diversity, murids tend to be more secure at the species level due to generally broader distributions, while the more limited average geographic range of sciurids and geomyids leaves them particularly vulnerable at the species level.

Both ground squirrels (Sciuridae) and pocket gophers (Geomyidae) are sedentary rodents that form numerous geographic races, often with limited distributions. Further, they prefer deep, well-drained, fertile soils that are often converted to agriculture and other types of development. Ground squirrels usually have spotty distributions, but in favorable years populations expand and occupy marginal areas. In unfavorable years, populations survive only in better sites, which serve as temporal refugia. The impact of conversion of these refugia during favorable years may not be evident until an unfavorable period, when populations disappear from marginal sites and have no refugia to which they can retreat. Currently, some threatened species of

ground squirrels persist only as fragmented populations in marginal localities, with interconnecting dispersal corridors cut off. At these marginal sites, ground squirrels may be abundant for a time, then become extinct locally during a series of years with unfavorable climate. Without interconnecting dispersal corridors, there is little possibility of recolonizing sites. This may explain the recent loss of many populations of Washington ground squirrel, *Spermophilus washingtoni* (Betts 1990), and Townsend's ground squirrel, *Spermophilus townsendii*. Difficulties in recolonizing extirpated sites may be compounded by an already low ability to disperse. In the Mohave ground squirrel, *Spermophilus mohavensis*, average effective dispersal rate over the last 6000 years has been estimated at $\leq 5\text{m}$ per year (Hafner 1992).

Rats and mice (Muridae) are proportionately overrepresented in the Data Deficient category (both species and subspecies). This is less likely due to taxonomy than it is to geography: four of seven DD species and 20 of 53 DD subspecies occur in Alaska, the rodent fauna of which has a high proportion of murids and has been historically underexplored (MacDonald and Cook 1996). Although murids make up the highest proportion of North American species (39.3%), they are even more dominant in Alaska, where they compose fully 58.3% of the state's rodent species. All four of the DD species and 14 of 20 DD subspecies from Alaska are murid rodents.

The most important overall pattern of vulnerability of North American rodents is the pervasiveness of threat. Although some regions have experienced greater adverse impact, and some families are perhaps more vulnerable to such impact, rodents of conservation concern are found in virtually every state and province, and only one of eight families of North American rodents (porcupines, family Erethizontidae) is not represented in this Action Plan. Of the 206 species in North America north of Mexico, 86 (41.7%) are included in this Action Plan; 27 (13.1%) are threatened or near threatened at the species level.

Table 6.1. Taxonomic composition of rodents of conservation concern relative to their proportional occurrence in the rodent fauna of North America (north of Mexico; "Total").

Figures are percent contribution of each family to the total; subspecies counts include monotypic species; status codes are defined in Appendix 2. Figures indicated by boldface are departures from expected proportions that are referred to in text.

Family	Total <i>n</i> =	Species:			Subspecies:				
		Total	>LR(lc)	>LR(nt)	DD	Total	>LR(lc)	>LR(nt)	DD
	206		27	12	7	1426	117	73	53
Muridae	39.3	22.2	16.7	85.7	35.3	41.9	32.9	58.5	
Sciuridae	32.5	33.3	58.3	14.3	20.4	17.1	24.7	22.6	
Heteromyidae	18.0	18.5	24.0	0.0	14.9	16.2	17.8	17.0	
Geomyidae	6.8	18.5	0.0	0.0	24.6	19.7	17.8	0.0	
Dipodidae	1.9	3.7	0.0	0.0	2.2	3.4	4.1	0.0	
Aplodontidae	0.5	3.7	0.0	0.0	0.5	1.7	2.7	0.0	
Castoridae	0.5	0.0	0.0	0.0	1.7	0.0	0.0	1.9	
Erethizontidae	0.5	0.0	0.0	0.0	0.4	0.0	0.0	0.0	

Conservation priorities and recommended actions

The following factors were included in determining our list of priorities:

- It is most cost-effective to direct conservation efforts and funds to those regions that include concentrations of endangered taxa. Although specific conservation measures depend on details of each taxon's ecological needs and threats, it is probable that closely-related taxa of a particular region (e.g., San Joaquin Valley desert rodents) will share many needs and threats. Thus, we have attempted to identify endangered communities or ecosystems containing several species of rodents of conservation concern.
- No ongoing conservation effort should be jeopardized because of a lower priority ranking, which indeed may result from success of that effort. Administrative costs involved in planning and implementing any new effort prohibit constant shifting of funds as priorities change, and instead underscore the need to complete ongoing programs.
- Taxa of greater taxonomic distinctiveness should be accorded higher priority, but the geographic range of related taxa must also be considered. Although taxonomic treatment is notoriously uneven, particularly of allopatric populations, we have assumed (in the absence of more detailed genetic data) that the current taxonomy is the single best indicator of the evolutionary distinctiveness of the taxon.
- Some peripheral populations of widespread species, particularly in the Southwestern Region, may be of conservation concern due to natural climatic changes. Because natural changes are beyond human control, we give much higher priority to taxa that are threatened by human activities. Indeed, there is a growing conviction that taxa that suffer habitat restriction or are otherwise imperiled due to natural climate change should be monitored and studied without interference in the process of decline (even to the point of extirpation or extinction). It is imperative, however, that these populations be noted as susceptible to adverse human activities, and often it will be necessary to investigate possible human-induced threats. Because of the pervasiveness of human-induced habitat changes (e.g., due to grazing, fire control, or alteration of ground water regimes), it may be difficult to determine if declines in some populations are natural, human-induced, or both.
- In all cases, the degree of threat, especially if well-documented, is always a primary consideration.

We have classified the threatened taxa into six categories, according to priority for conservation action (Table 6.2).

These categories correspond to the urgency with which the action should be taken, and more or less parallel the IUCN Red List categories. However, the first priority, endangered communities, necessarily includes taxa assigned to a wide variety of threat categories, and some Data Deficient taxa are included at higher priority levels because it is possible that they are at risk now and could be lost before we have sufficient information.

Priority 1: Endangered Communities

We have identified eight geographic areas or biotic communities (in a broad sense) of critical concern for rodent conservation in North America; we encourage others to identify additional areas of high concentration of taxa of conservation concern.

The single most-impacted biotic region is the **San Joaquin Valley desert of central California**. The San Joaquin Mammalian Faunal Region (as defined by Williams and Kilburn 1992) includes 22 endemic species and subspecies of mammals, fully one-half of which “face proximate threats of extinction due to anthropogenic causes, primarily loss of habitat” (Williams and Kilburn 1992). Eleven taxa of eight species of rodents in the San Joaquin Valley are of conservation concern (see Fig. 6.1): San Joaquin antelope ground squirrel (*Ammospermophilus nelsoni*, EN); giant kangaroo rat (*Dipodomys ingens*, CR); Merced kangaroo rat (*Dipodomys heermanni dixonii*, LR[nt]); San Joaquin kangaroo rat (*Dipodomys nitratoides*, LR[nt]; *D. n. brevinasus*, LR[nt]; *D. n. exilis*, CR; and *D. n. nitratoides*, CR); San Joaquin pocket mouse (*Perognathus inornatus neglectus*, LR[nt]; and *P. i. psammophilus*, LR[nt]); San Joaquin Valley woodrat (*Neotoma fuscipes riparia*, CR); San Diego desert woodrat (*Neotoma lepida intermedia*, DD), and Tulare grasshopper mouse (*Onychomys torridus tularensis*, DD).

Florida coastal and island habitats have suffered from extensive development, leaving surviving patches of habitat extremely susceptible to further development or natural disasters (e.g., hurricanes). Sixteen taxa of eight species are of conservation concern (see Fig. 6.2): Big Cypress fox squirrel (*Sciurus niger avicennia*, LR[cd]); Goff's southeastern pocket gopher (*Geomys pinetis goffi*, EX); Florida saltmarsh vole (*Microtus pennsylvanicus dukecampbelli*, VU); Key Largo woodrat (*Neotoma floridana smalli*, EN); Marsh rice rat (*Oryzomys palustris natator*, DD); Cotton mouse (*Peromyscus gossypinus allapaticola*, VU; and *P. g. restrictus*, EX); beach mouse (*Peromyscus polionotus allophrys*, EN; *P. p. decoloratus*, EX; *P. p. leucocephalus*, LR[nt]; *P. p. niveiventris*, LR[nt]; *P. p. peninsularis*, EN; *P. p. phasma*, EN; and *P. p. trissyllepsis*, CR; another subspecies of beach mouse, *P. p. ammobates* [EN], is restricted to barrier islands of adjacent Alabama); and insular hispid cotton rat (*Sigmodon hispidus*

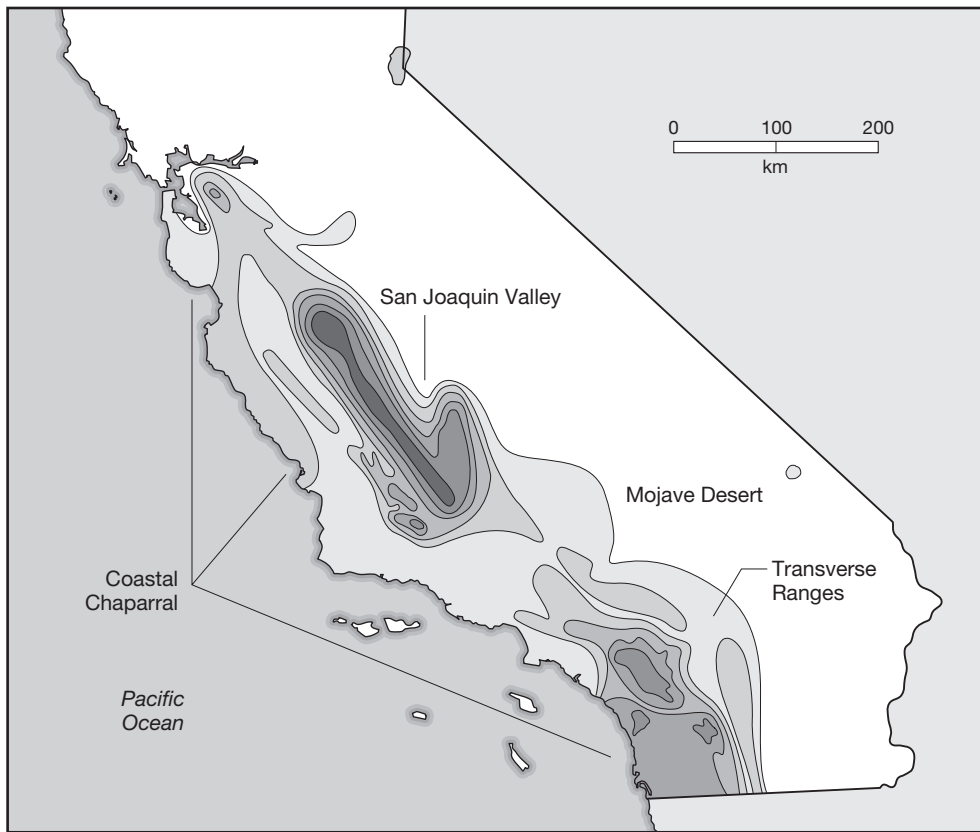


Figure 6.1. Distribution of rodent taxa of conservation concern (34 taxa of 19 species) in four Endangered Communities (Priority 1) in central and southern California: San Joaquin Valley Desert (11 taxa, 8 species), Coastal Chaparral (14 taxa, 8 species), Mojave Desert (7 taxa, 5 species), and Transverse Ranges (4 taxa, 3 species); several taxa occur in more than one of the communities. Lightest shading represents a single species, darker shadings represent higher density of species (up to six species).

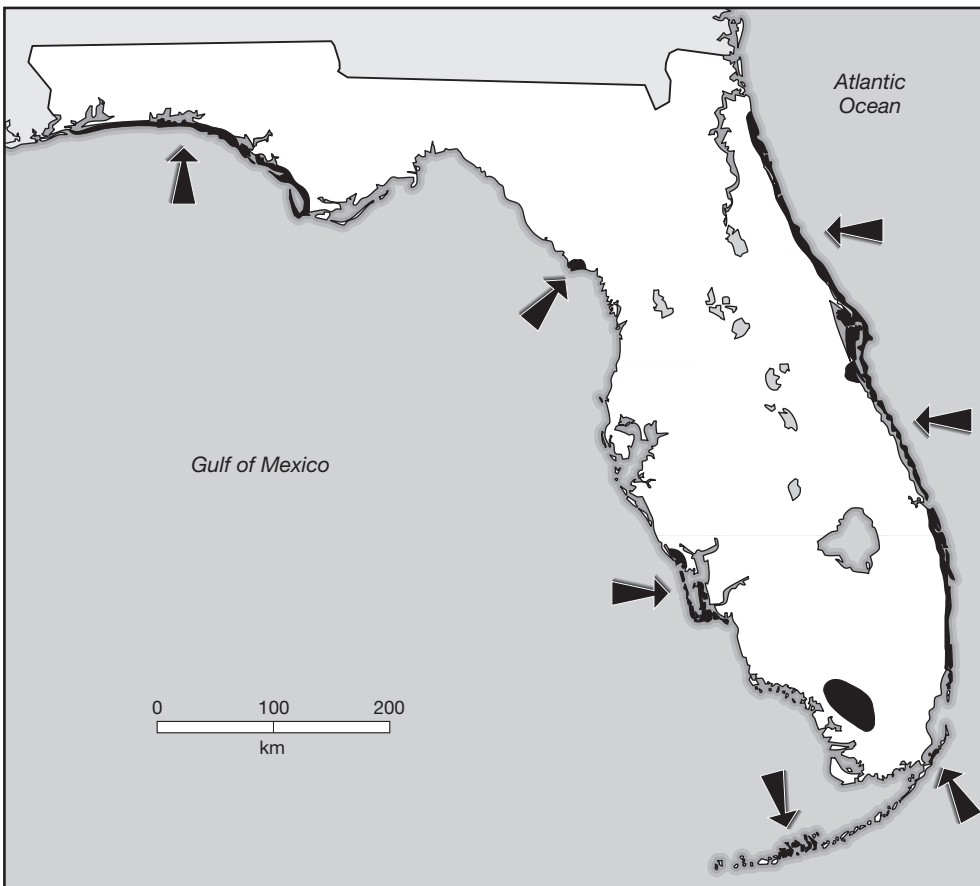


Figure 6.2. Distribution of rodent taxa of conservation concern in the Florida Coastal and Island Habitats (a Priority 1 Endangered Community; 16 taxa of 8 species).

Table 6.2. Priority listing of North American rodents of conservation concern.

Status codes are defined in Appendix 2.

	Species	Red List Category	Subspecies
PRIORITY 1: ENDANGERED COMMUNITIES			
1.1 San Joaquin Valley Desert (California)			
Species:			
<i>Ammospermophilus nelsoni</i>		EN:A1a;B1;B2c	
<i>Dipodomys ingens</i>		CR:A1a;B2c	
<i>Dipodomys nitratoides</i>		LR(nt)	
Subspecies:			
<i>Dipodomys heermanni dixonii</i>			LR(nt)
<i>Dipodomys nitratoides brevinasus</i>			LR(nt)
<i>Dipodomys nitratoides exilis</i>			CR:B1;B2c
<i>Dipodomys nitratoides nitratoides</i>			CR:A1c
<i>Perognathus inornatus neglectus</i>			LR(nt)
<i>Perognathus inornatus psammophilus</i>			LR(nt)
<i>Neotoma fuscipes riparia</i>			CR:B1;B2c
<i>Neotoma lepida intermedia</i>			DD
<i>Onychomys torridus tularensis</i>			DD
1.2 Florida Coastal and Island Habitats			
Subspecies:			
<i>Sciurus niger avicennia</i>			LR(cd)
<i>Geomys pinetis goffi</i>			EX
<i>Microtus pennsylvanicus dukecampbelli</i>			VU:D2
<i>Neotoma floridana smalli</i>			EN:B2c;C2b
<i>Oryzomys palustris natator</i>			DD
<i>Peromyscus gossypinus allapaticola</i>			VU:D2
<i>Peromyscus gossypinus restrictus</i>			EX
<i>Peromyscus polionotus allophrys</i>			EN:B1;B2c
<i>Peromyscus polionotus ammobates</i>			EN:B1;B2c
<i>Peromyscus polionotus decoloratus</i>			EX
<i>Peromyscus polionotus leucocephalus</i>			LR(nt)
<i>Peromyscus polionotus niveiventris</i>			LR(nt)
<i>Peromyscus polionotus peninsularis</i>			EN:B1;B2c
<i>Peromyscus polionotus phasma</i>			EN:B1;B2c
<i>Peromyscus polionotus trissyllepsis</i>			CR:B1;B2c
<i>Sigmodon hispidus insulicola</i>			LR(nt)
1.3 Pacific Coast Douglas Fir and Redwood Forests (British Columbia, Washington, Oregon, California)			
Species:			
<i>Aplodontia rufa</i>		LR(nt)	
<i>Marmota vancouverensis</i>		EN:C2b;D	
<i>Thomomys mazama</i>		LR(nt)	
<i>Arborimus albipes</i>		DD	
<i>Arborimus pomo</i>		DD	
<i>Microtus townsendii</i>		LR(nt)	
<i>Zapus trinotatus</i>		LR(nt)	
Subspecies:			
<i>Aplodontia rufa nigra</i>			VU:B1;B2d;B2e
<i>Aplodontia rufa phaea</i>			VU:B1;B2e
<i>Thomomys mazama couchi</i>			VU:B1;B2c
<i>Thomomys mazama glacialis</i>			VU:B1;B2c
<i>Thomomys mazama helleri</i>			LR(nt)
<i>Thomomys mazama louiei</i>			CR:A1c;C2b
<i>Thomomys mazama melanops</i>			LR(nt)
<i>Thomomys mazama pugetensis</i>			VU:B1;B2c
<i>Thomomys mazama tacomensis</i>			EX
<i>Thomomys mazama tumuli</i>			VU:B1;B2c
<i>Thomomys mazama yelmensis</i>			VU:B1;B2c
<i>Microtus townsendii cowani</i>			LR(cd)
<i>Microtus townsendii pugeti</i>			LR(nt)
<i>Zapus trinotatus orarius</i>			LR(cd)

Table 6.2 ... continued		Red List Category	
	Species		Subspecies
1.4 Coastal Chaparral Communities (California)			
Species:			
<i>Dipodomys stephensi</i>	LR(cd)		
Subspecies:			
<i>Chaetodipus californicus femoralis</i>			DD
<i>Chaetodipus fallax fallax</i>			DD
<i>Chaetodipus fallax pallidus</i>			DD
<i>Dipodomys heermanni berkeleyensis</i>			VU:B1;B2c
<i>Dipodomys heermanni morroensis</i>			CR:B1;B2c;D
<i>Perognathus longimembris bangsi</i>			DD
<i>Perognathus longimembris brevinasus</i>			VU:B1;B2c
<i>Perognathus longimembris internationalis</i>			DD
<i>Perognathus longimembris pacificus</i>			CR:B1;B2c;C1;C2a;C2b
<i>Neotoma fuscipes annectens</i>			DD
<i>Neotoma fuscipes luciana</i>			DD
<i>Neotoma lepida intermedia</i>			DD
<i>Onychomys torridus ramona</i>			DD
1.5 Mojave Desert (California)			
Species:			
<i>Spermophilus mohavensis</i>	VU:B1;B3d		
Subspecies:			
<i>Spermophilus tereticaudus chlorus</i>			DD
<i>Dipodomys merriami collinus</i>			DD
<i>Dipodomys merriami parvus</i>			DD
<i>Microtus californicus mohavensis</i>			VU:A1d;A2d;D2
<i>Microtus californicus scirpensis</i>			VU:B1;B3c;B3d
<i>Neotoma lepida intermedia</i>			DD
1.6 Columbia Basin (Washington and Oregon)			
Species:			
<i>Spermophilus townsendii</i>	DD		
<i>Spermophilus washingtoni</i>	VU:A1a;B1;B2d;C2a		
Subspecies:			
<i>Microtus pennsylvanicus kincaidi</i>			LR(nt)
<i>Onychomys leucogaster durranti</i>			DD
1.7 Appalachian Mountains			
Species:			
<i>Neotoma magister</i>	LR(nt)		
Subspecies:			
<i>Glaucomyssabrinus coloratus</i>			VU:A2c;B1;B2c
<i>Glaucomyssabrinus fuscus</i>			VU:A2c;B1;B2c
<i>Sciurus niger vulpinus</i>			DD
<i>Clethrionomys gapperi maurus</i>			LR(nt)
<i>Microtus chrotorrhinus carolinensis</i>			LR(nt)
<i>Neotoma floridana haematoreaia</i>			LR(nt)
1.8 Transverse Ranges (southern California)			
Species:			
<i>Perognathus alticola</i>	LR(nt)		
Subspecies:			
<i>Glaucomyssabrinus californicus</i>			DD
<i>Perognathus alticola alticola</i>			CR:B1;B2b
<i>Perognathus alticola inexpectatus</i>			LR(nt)
<i>Microtus longicaudus bernardinus</i>			DD
PRIORITY 2: IMMEDIATE CONSERVATION ACTION NEEDED			
<i>Glaucomyssabrinus griseifrons</i>			EN:A1c;A2c;B1;B2c
<i>Spermophilus brunneus</i>	EN:B2d;B3d		
<i>Spermophilus brunneus brunneus</i>			CR:B1;B2d
<i>Spermophilus brunneus endemicus</i>			VU:B1;B3d

Table 6.2 ... continued		
	Species	Red List Category Subspecies
	<i>Tamias minimus atristriatus</i>	CR:A1a;B1;D
	<i>Tamias umbrinus nevadensis</i>	CR:A1a
	<i>Tamiasciurus hudsonicus grahamensis</i>	CR:B1;C2b
	<i>Reithrodontomys raviventris</i>	VU:A1c;A2c;B2c
	<i>Reithrodontomys raviventris halicoetes</i>	LR(cd)
	<i>Reithrodontomys raviventris raviventris</i>	EN:A2c;B1;B2c
	<i>Zapus hudsonius preblei</i>	EN:B1;B2c
PRIORITY 3: VULNERABLE SPECIES		
	<i>Cynomys parvidens</i>	LR(cd)
	<i>Tamias palmeri</i>	VU:A2c
	<i>Dipodomys elator</i>	VU:B1;B2c
	<i>Podomys floridanus</i>	VU:A1a;A2d
PRIORITY 4: NEAR-THREATENED SPECIES		
	<i>Cynomys ludovicianus</i>	LR(nt)
	<i>Tamias canipes</i>	LR(nt)
	<i>Geomys arenarius</i>	LR(nt)
	<i>Geomys personatus</i>	LR(nt)
	<i>Geomys personatus fuscus</i>	LR(nt)
	<i>Geomys personatus maritimus</i>	VU:D2
	<i>Geomys personatus streckeri</i>	VU:D2
	<i>Geomys texensis</i>	LR(nt)
	<i>Geomys texensis bakeri</i>	LR(nt)
	<i>Thomomys idahoensis</i>	LR(nt)
	<i>Thomomys idahoensis confinus</i>	LR(nt)
	<i>Microtus breweri</i>	LR(nt)
	<i>Neofiber alleni</i>	LR(nt)
PRIORITY 5: VULNERABLE (OR SUSPECTED VULNERABLE) SUBSPECIES		
	<i>Marmota caligata sheldoni</i>	DD
	<i>Marmota caligata vigilis</i>	DD
	<i>Spermophilus tridecemlineatus alleni</i>	DD
	<i>Tamias minimus selkirki</i>	VU:D2
	<i>Tamias quadrivittatus australis</i>	VU:C2a;D2
	<i>Tamias umbrinus sedulus</i>	DD
	<i>Geomys pinetis cumberlandius</i>	VU:D2
	<i>Geomys pinetis fontanelus</i>	VU:D2
	<i>Thomomys talpoides douglasi</i>	VU:B1;B2c
	<i>Dipodomys microps alfredi</i>	DD
	<i>Dipodomys microps leucotis</i>	VU:B1;B2c
	<i>Microdipodops megacephalus atrelictus</i>	VU:D2
	<i>Microdipodops megacephalus nexus</i>	DD
	<i>Microdipodops pallidus restrictus</i>	VU:D2
	<i>Microtus abbreviatus abbreviatus</i>	DD
	<i>Microtus abbreviatus fisheri</i>	DD
	<i>Microtus californicus stephensi</i>	DD
	<i>Microtus longicaudus coronarius</i>	DD
	<i>Microtus longicaudus leucophaeus</i>	DD
	<i>Microtus mogollonensis hualpaiensis</i>	VU:B1;B2c;D2
	<i>Microtus montanus codiensis</i>	DD
	<i>Microtus montanus fuscus</i>	VU:D2
	<i>Microtus montanus nevadensis</i>	VU:D2
	<i>Microtus montanus zygomatiscus</i>	DD
	<i>Microtus oeconomus amakensis</i>	DD
	<i>Microtus oeconomus elymocetes</i>	DD
	<i>Microtus oeconomus innuitus</i>	DD
	<i>Microtus oeconomus popofensis</i>	DD
	<i>Microtus oeconomus punukensis</i>	DD
	<i>Microtus oeconomus sitkensis</i>	DD
	<i>Zapus hudsonius campestris</i>	VU:B1;B2c

Table 6.2 ... continued		
	Species	Red List Category Subspecies
PRIORITY 6: EXTINCT, LOWER PRIORITY, OR UNKNOWN THREAT		
Extinct Subspecies:		
	<i>Sigmodon arizonae arizonae</i>	EX
	<i>Sigmodon fulviventor goldmani</i>	EX
	<i>Synaptomys cooperi paludis</i>	EX
	<i>Synaptomys cooperi relictus</i>	EX
Lower Risk (near threatened) Subspecies:		
	<i>Sciurus niger shermani</i>	LR(nt)
	<i>Geomys pinetis colonus</i>	LR(nt)
	<i>Thomomys talpoides limosus</i>	LR(nt)
	<i>Thomomys talpoides segregatus</i>	LR(nt)
	<i>Thomomys umbrinus emotus</i>	LR(nt)
	<i>Perognathus flavus goodpasteri</i>	LR(nt)
	<i>Microtus californicus vallicola</i>	LR(nt)
	<i>Microtus montanus arizonensis</i>	LR(nt)
	<i>Microtus montanus rivularis</i>	LR(nt)
	<i>Microtus pennsylvanicus admiraltiae</i>	LR(nt)
	<i>Microtus pennsylvanicus provectus</i>	LR(nt)
	<i>Microtus pennsylvanicus shattucki</i>	LR(nt)
	<i>Neotoma floridana baileyi</i>	LR(nt)
	<i>Peromyscus maniculatus anacapae</i>	LR(nt)
	<i>Peromyscus maniculatus clementis</i>	LR(nt)
	<i>Peromyscus truei comanche</i>	LR(nt)
	<i>Sigmodon arizonae plenus</i>	LR(nt)
	<i>Sigmodon hispidus eremicus</i>	LR(nt)
	<i>Synaptomys borealis artemisiae</i>	LR(nt)
	<i>Synaptomys borealis sphagnicola</i>	LR(nt)
	<i>Zapus hudsonius luteus</i>	LR(nt)
Lower Risk (conservation dependent) Subspecies:		
	<i>Sciurus niger cinereus</i>	LR(cd)
Data Deficient Species:		
	<i>Dicrostonyx exsul</i>	DD
	<i>Dicrostonyx nunatakensis</i>	DD
	<i>Dicrostonyx unalascensis</i>	DD
	<i>Dicrostonyx unalascensis stevensoni</i>	DD
	<i>Dicrostonyx unalascensis unalascensis</i>	DD
	<i>Microtus abbreviatus</i>	DD
Data Deficient Subspecies:		
	<i>Spermophilus elegans nevadensis</i>	DD
	<i>Spermophilus lateralis wortmanni</i>	DD
	<i>Spermophilus parryii kodiacensis</i>	DD
	<i>Spermophilus parryii lyratus</i>	DD
	<i>Spermophilus parryii nebulicola</i>	DD
	<i>Castor canadensis phaeus</i>	DD
	<i>Clethrionomys gapperi solus</i>	DD
	<i>Microtus chrotorrhinus ravus</i>	DD
	<i>Ondatra zibethicus ripensis</i>	DD
	<i>Peromyscus leucopus ammodytes</i>	DD

insulicola, LR[nt]). Unfortunately, the barrier islands and sandbars to which these species are restricted are dispersed and cannot be effectively conserved in a single area reserve. Two other species of conservation concern in Florida are not restricted to coastal areas or barrier islands, but could benefit peripherally from preservation of these habitats: Florida mouse (*Podomys floridanus*, VU) and round-tailed muskrat (*Neofiber alleni*, LR[nt]).

Pacific Coast Douglas Fir and Redwood Forests (northern California to British Columbia), including coastal islands, continue to suffer reduction from logging, agricultural conversion, and urban development. Seventeen taxa of seven species of rodents in these coastal forests are of conservation concern (see Fig. 6.3): mountain beaver, the only living representative of the family Aplodontidae (*Aplodontia rufa*, LR[nt]; *A. r. nigra*, VU; *A. r. phaea*, VU),

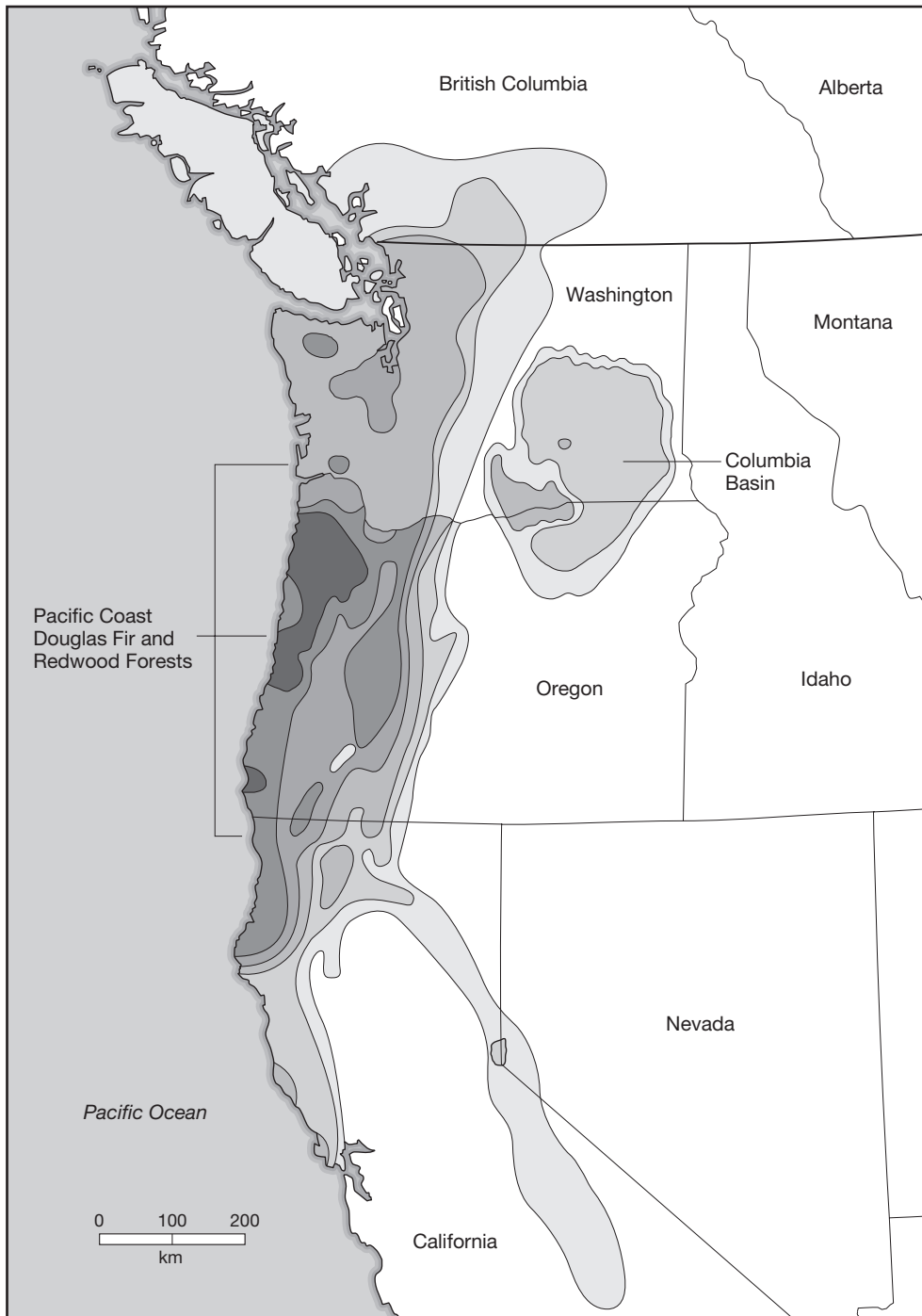


Figure 6.3. Distribution of rodent taxa of conservation concern (21 taxa of 11 species) in two Endangered Communities (Priority 1) in northern California, Oregon, Washington, and British Columbia: Pacific Coast Douglas Fir and Redwood Forests (17 taxa, 7 species), and Columbia Basin (4 taxa, 4 species). Lightest shading represents a single species, darker shadings represent higher density of species (up to six species).

Vancouver marmot (*Marmota vancouverensis*, EN); western pocket gopher (*Thomomys mazama*, LR[nt]; *T. m. couchi*, VU; *T. m. glacialis*, VU; *T. m. helleri*, LR[nt]; *T. m. louiei*, CR; *T. m. melanops*, LR[nt]; *T. m. pugetensis*, VU; *T. m. tacomensis*, EX; *T. m. tumuli*, VU; *T. m. yelmensis*, VU); white-footed vole (*Arborimus albipes*, DD); red tree vole (*Arborimus pomo*, DD), Townsend's vole (*Microtus townsendii*, LR[nt]; *M. t. cowani*, LR[cd]; *M. t. pugeti*, LR[nt]); and Pacific jumping mouse (*Zapus trinotatus*, LR[nt]; *Z. t. orarius*, LR[cd]).

Coastal chaparral communities of California are rapidly disappearing in the face of urban development. Fourteen taxa of eight species of rodents are of conservation concern in these coastal regions (see Fig. 6.1): California pocket mouse (*Chaetodipus californicus femoralis*, DD); San Diego pocket mouse (*Chaetodipus fallax fallax*, DD; and *C. f. pallidus*, DD); Stephens' kangaroo rat (*Dipodomys stephensi*, LR[cd]); Heermann's kangaroo rat (*Dipodomys heermanni berkeleyensis*, VU; and *D. h. morroensis*, CR); little pocket mouse (*Perognathus longimembris bangsi*,

DD; *P. l. brevinasus*, VU; *P. l. internationalis*, DD; and *P. l. pacificus*, CR); dusky footed woodrat (*Neotoma fuscipes annectens*, DD; and *N. f. luciana*, DD); San Diego desert woodrat (*Neotoma lepida intermedia*, DD); and southern grasshopper mouse (*Onychomys torridus ramona*, DD).

The **Mojave Desert** of southern California faces increasing threat from the continued expansion of the Los Angeles and San Diego metropolitan areas. Seven taxa of five species are of conservation concern (see Fig. 6.1): Mohave ground squirrel (*Spermophilus mohavensis*, VU); Palm Springs round-tailed ground squirrel (*Spermophilus tereticaudus chlorus*, DD); two subspecies of Merriam's kangaroo rat (*Dipodomys merriami collinus*, DD; and *D. m. parvus*, DD); two subspecies of California vole (*Microtus californicus mohavensis*, VU; and *M. c. scirpensis*, VU); and San Diego desert woodrat (*Neotoma lepida intermedia*, DD).

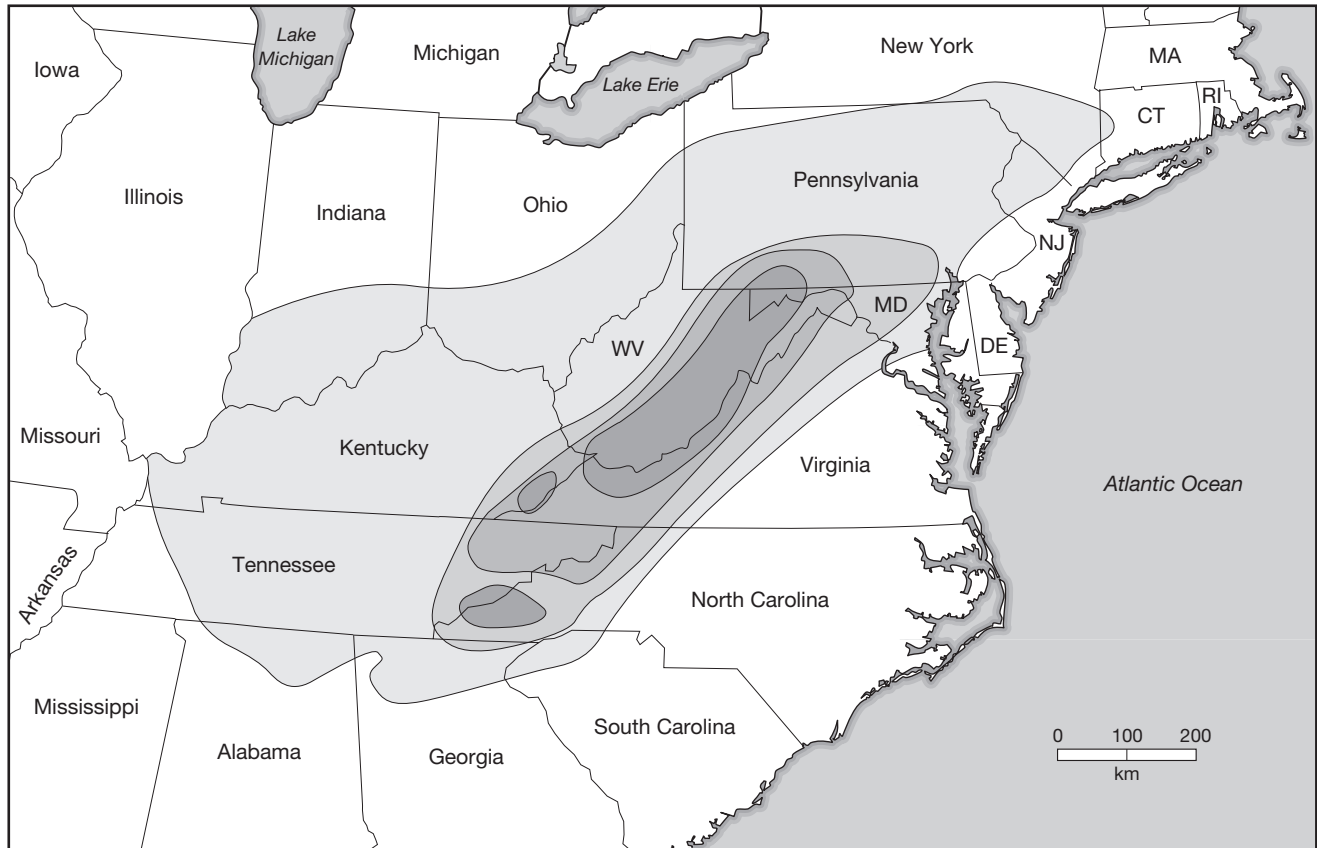
The **Columbia Basin in eastern Washington and adjacent Oregon** has been almost completely converted to agriculture. All taxa that are endemic or largely restricted to the basin are affected. Four taxa of four species of rodents are of conservation concern in the Columbia Basin (IUCN Red List categories indicated): Washington ground squirrel (*Spermophilus washingtoni*, VU), Townsend's ground squirrel (*Spermophilus townsendii*, DD); potholes meadow

vole (*Microtus pennsylvanicus kincaidi*, LR[nt]); and northern grasshopper mouse (*Onychomys leucogaster durranti*, DD).

Deciduous and remnant boreal forests of the Appalachian Mountains have a long history of fragmentation (from clearcutting), agricultural conversion, suburban sprawl, pollution (particularly acid rain), and fire suppression. Taxa that previously enjoyed a relatively large, continuous distribution now survive in disjunct patches of habitat, where they are susceptible to local extirpation from a variety of causes. Seven taxa of six species are of conservation concern (see Fig. 6.4): Allegheny woodrat (*Neotoma magister*, LR[nt]); northern flying squirrel (*Glaucomys sabrinus coloratus*, VU; *G. s. fuscus*, VU), fox squirrel (*Sciurus niger vulpinus*, DD); southern red-backed vole (*Clethrionomys gapperi maurus*, LR[nt]); rock vole (*Microtus chrotorrhinus carolinensis*, LR[nt]); and eastern woodrat (*Neotoma floridana haematoreia*, LR[nt]).

The **Transverse Ranges of southern California** contain ecological islands of montane habitat that have historically been isolated by surrounding deserts, and have been subjected to increasing habitat degradation by expansion of the Los Angeles Metropolitan Area. Five taxa of three species are of conservation concern (see Fig. 6.1): white-

Figure 6.4. Distribution of rodent taxa of conservation concern in the Appalachian Mountains (a Priority 1 Endangered Community; 7 taxa of 6 species). Lightest shading represents a single species, darker shadings represent higher density of species (up to four species).



eared pocket mouse (*Perognathus alticola*, LR[nt]; *P. a. alticola*, CR; *P. a. inexpectatus*, LR[nt]); northern flying squirrel (*Glaucomys sabrinus californicus*, DD); and long-tailed vole (*Microtus longicaudus bernardinus*, DD). The flying squirrel is known from the San Bernardino and San Jacinto Mountains, and may occur in the San Gabriel Mountains (Vaughan 1954); the pocket mouse is known from the San Bernardino Mountains (*P. a. alticola*) and Tehachapi Mountains (*P. a. inexpectatus*); the vole is known only from the San Bernardino Mountains.

Endangered communities can be conserved most effectively by establishment of reserves or interconnected systems of reserves in each of the priority areas. Each of the endangered communities identified herein includes rodent taxa that are seriously threatened, as well as taxa whose survival is not currently in jeopardy (Lower Risk) or for which information is lacking (Data Deficient). Preserves would mitigate impact on those taxa currently threatened, and hopefully prevent other endemic taxa from becoming threatened. A system of preserves is already being established in the San Joaquin Valley, and some of the critical habitat in the other regions has gained a measure of protection. However, sufficient continuous habitat must be set aside in order to successfully preserve these communities, and a coordinated management plan must be developed. As noted by Williams (1992), "habitat acquisition is not habitat protection." Without a comprehensive management plan in each of the four regions that uses adequate "information on species geographic distributions, habitat requirements, population statuses, demographics, population genetics, and requirements for dispersal," an uncoordinated system of splintered and competing conservation plans "limits options for recovering species from endangerment and risks jeopardizing others." We advocate a community approach to conservation, but it is critical that a community-wide management plan consider specific requirements of as many component species as possible.

Priority 2: Taxa needing immediate conservation action

Taxa from seven species of rodents (including all populations of two species) are in need of immediate conservation action, but are not found in the endangered communities listing in Priority 1 (three additional species and 14 additional subspecies needing immediate conservation action are included in Priority 1 listing). These taxa could be lost in the next few years if immediate action is not taken. The Idaho ground squirrel (*Spermophilus brunneus*, EN; *S. b. brunneus*, CR; *S. b. endemicus*, VU), and saltmarsh harvest mouse (*Reithrodontomys raviventris*, VU; *R. r. raviventris*, EN; and *R. r. halicoetes*, LR[cd]) each have highly restricted distributions. The Prince of Wales

Island flying squirrel (*Glaucomys sabrinus griseifrons*, EN) is restricted to forested areas that have been heavily logged. Three Priority 2 subspecies are restricted to cool, forested habitat on the tops of mountains ('sky islands') in the arid Southwest, all of which have been or are being subjected to extensive human impact: Peñasco least chipmunk (*Tamias minimus atristriatus*, CR) in southern New Mexico, Hidden Forest chipmunk (*Tamias umbrinus nevadensis*, CR) in southern Nevada, and Mt. Graham red squirrel (*Tamiasciurus hudsonicus grahamensis*, CR) in southern Arizona. Preble's meadow jumping mouse (*Zapus hudsonius preblei*, EN) no longer occurs at historical sites, and is limited to decreasing patches of appropriate habitat in eastern Colorado; appropriate habitat has been destroyed by encroaching agricultural or urban development.

Whereas the success of community-level (Priority 1) conservation plans will often depend on the cooperation of private landowners and businesses, and so will require extensive public education programs, we urge state and federal conservation agencies to take a more unilateral and aggressive approach to halt immediately clear threats to the continued existence of Priority 2 taxa. These actions are likely to be unpopular with the public, and extreme care must be taken to avoid unnecessary obstruction of private interests. Ideally, a brief moratorium on development of critical habitat will allow private interests and government agencies sufficient time to develop a plan that permits continued, controlled development while mitigating or reversing environmental threats. Amendments to the Endangered Species Act (ESA) of the United States that were proposed in 1996 would have greatly reduced federal powers on private lands, in some cases eliminating the option of preserving critical habitat for high-priority species. We urge the U.S. Congress to strengthen, or at least not weaken, legal powers of the ESA, and at the same time streamline bureaucratic processes that would delay nonintrusive developments and thereby place unnecessary and unpopular financial burden on private interests.

Priority 3: Vulnerable species

Unless conservation action plans are developed and implemented soon, four species (one of which is the sole representative of the genus) could become Endangered, Critically Endangered, or Extinct in the near future. These include one monotypic genus (Florida mouse, *Podomys floridanus*, VU) and three monotypic species (Utah prairie dog, *Cynomys parvidens*, LR[cd]; Palmer's chipmunk, *Tamias palmeri*, VU, of southern Nevada; and Texas kangaroo rat, *Dipodomys elator*, VU). A conservation action plan is already in effect only for the Utah prairie dog; without it, this species would be listed as Vulnerable or Endangered. Similarly, Stephens' kangaroo rat (*Dipodomys stephensi*, included in Priority 1) would be

listed as Vulnerable without the conservation action plan already in place. Two additional monotypic species listed as Vulnerable (*Spermophilus washingtoni* and *Spermophilus mohavensis*) are included among Priority 1 communities.

Threats to Vulnerable species are of two sorts: a long history of agricultural, mining, or urban development that has resulted in extensive loss and fragmentation of appropriate habitat (*Podomys floridanus*, *Cynomys parvidens*, *Dipodomys elator*); or more recent threat of urban expansion (*Tamias palmeri*), agricultural conversion (*Spermophilus washingtoni*), or both (*Spermophilus mohavensis*) on a restricted distribution.

It is probably not necessary to risk adverse public opinion by taking an aggressive approach for Vulnerable (Priority 3) or Near Threatened (Priority 4) species. However, conservation efforts must begin at once in order to prevent situations where emergency actions are necessary. Where conservation plans exist, they should be implemented immediately with public and private cooperation. Where sufficient natural history information is lacking to develop action plans, gathering of these data should be a high priority. We urge federal and state conservation agencies to take advantage of graduate programs in biology at regional universities, where adequate expertise can be obtained with limited budgets in order to collect the necessary information. In this regard, we recommend programs such as the Share with Wildlife tax check-off fund administered by the Endangered Species Program of the New Mexico Department of Game and Fish. This program has funded a large variety of research projects conducted by graduate students, targeting 'low-profile' species that are less familiar to the public.

Priority 4: Near Threatened species

Eight species considered as Near Threatened, LR(nt), but not included among Priority 1 listing are of next highest priority. The black-tailed prairie dog (*Cynomys ludovicianus*) and round-tailed muskrat (*Neofiber alleni*), like the Allegheny woodrat (*Neotoma magister*; included in Priority 1) are monotypic species that have suffered extensive fragmentation of appropriate habitat over a historically large geographic range. Three other monotypic species have highly restricted distributions, but no known immediate threat to their continued existence: gray-footed chipmunk (*Tamias canipes*), desert pocket gopher (*Geomys arenarius*), and beach vole (*Microtus breweri*). Three other species have relatively restricted distributions and immediate threats to a significant proportion of their subspecies (as is the case with six other Near Threatened species included in Priority 1 communities): Idaho pocket gopher (*Thomomys idahoensis*; 1 of 3), Texas pocket gopher (*Geomys personatus*; 3 of 6), and llano pocket gopher (*Geomys texensis*; 1 of 3).

Priority 5: Vulnerable (or suspected Vulnerable) subspecies

One to six subspecies each of 17 wide-ranging species are considered Vulnerable (VU), or are Data Deficient but suspected of being Vulnerable. These 31 subspecies are all peripheral to the main distribution of their respective species, are usually of very restricted distribution, and generally represent a small proportion of the species' diversity (as measured by numbers of recognized subspecies). There is persuasive evidence of existing threat and a high probability of continued threat to the survival of 12 of the subspecies. Fifteen additional Vulnerable subspecies are included in Priority 1 communities.

Six of the 17 species involved are widespread boreal mammals, as is the northern flying squirrel (*Glaucomys sabrinus*, Vulnerable subspecies of which are included in Priority 1 communities). Their Vulnerable subspecies are relicts of full-glacial expansions that have persisted in peripheral montane or wetland areas: hoary marmot (*Marmota caligata*); least chipmunk (*Tamias minimus*); Colorado chipmunk (*Tamias quadrivittatus*); Uinta chipmunk (*Tamias umbrinus*); northern pocket gopher (*Thomomys talpoides*); and meadow jumping mouse (*Zapus hudsonius*). Six of the 17 species are voles (*Microtus*), Vulnerable subspecies of which are peripheral relicts of full-glacial distributions that have persisted on landbridge islands, in wet areas in desert mountains, or along ephemeral desert springs: insular vole (*Microtus abbreviatus*); California vole (*Microtus californicus*); long-tail vole (*Microtus longicaudus*); Mogollon vole (*Microtus mogollonensis*); montane vole (*Microtus montanus*), and tundra vole (*Microtus oeconomus*). Five of the 17 species are desert species, peripheral subspecies of which are vulnerable to agricultural or urban development: round-tailed ground squirrel (*Spermophilus tereticaudus*); Merriam's kangaroo rat (*Dipodomys merriami*); chisel-toothed kangaroo rat (*Dipodomys microps*); dark kangaroo mouse (*Microdipodops megacephalus*); and pale kangaroo mouse (*Microdipodops pallidus*). Two Vulnerable subspecies of the southeastern pocket gopher (*Geomys pinetis*), restricted to a small island and to a single colony along the Atlantic coast, respectively, are suffering human encroachment.

Single subspecies of three species may already be extinct. Although listed as Data Deficient (DD), their precarious position necessitates more immediate evaluation of their conservation status. Allen's thirteen-lined ground squirrel (*Spermophilus tridecemlineatus alleni*) may be extinct or only exist in small, isolated populations. The Puncuk Island tundra vole (*Microtus oeconomus punicus*) was not found in 1979 on one of the two small islands where it has historically occurred. The Montague Island hoary marmot (*Marmota caligata sheldoni*) has not been reported since 1908.

Seven other subspecies that are Data Deficient are included in this section. Of the seven subspecies that are considered Imperiled by The Nature Conservancy (Table 5.1), six are included here as higher priority for basic status survey. Four occur on small islands: two subspecies of *Microtus oeconomus* from Alaska (*M. o. amakensis* and *M. o. elymocetes*), *Microtus abbreviatus abbreviatus* from Hall Island in Alaska, and *Dipodomys microps alfredi* from Gunnison Island in the Great Salt Lake, Utah. *Tamias umbrinus edulus* is known only from Mt. Ellen in the Henry Mountains of Utah, a 'sky island' in an arid region. *Microtus californicus stephensi* occurs along coastal beaches of the Los Angeles metropolitan area. Each of these six subspecies may be in a particularly vulnerable or critical condition due to a combination of restricted distribution and human impact. The seventh subspecies considered by The Nature Conservancy as Imperiled is *Peromyscus leucopus ammodytes* of Monomoy Island, Massachusetts. The threat posed to this subspecies is natural introgressive hybridization with the mainland subspecies during intermittent connections with the mainland. The subspecies may no longer exist, and does not merit a high priority for immediate study. In the spirit of efficiency of field survey and a community approach to conservation, one other Data Deficient subspecies is included here: *Microtus longicaudus leucophaeus* should be studied during survey of the Mt. Graham red squirrel, *Tamiasciurus hudsonicus grahamensis*, which is a Priority 2 species.

Priority 5 Vulnerable subspecies present an interesting set of possibilities and opportunities for the species as well as for conservation and evolutionary biologists. As genetically differentiated populations isolated on the periphery of the species' distribution, they may represent new evolutionary trajectories for the species. Alternatively, they may represent failed lineages, doomed to extirpation by natural climatic change. It is critical that we attempt to differentiate between adverse human impact on such isolated populations and the results of natural climatic change. By attempting to resist normal biological change (which includes extinction of failed lineages), we would be further interfering with the environment: effecting adverse human impact under the guise of conservation. Further, such victims of climatic change may provide natural laboratories in which to monitor the extent and pace of environmental change, and study the processes of extinction and replacement.

For peripheral, isolated subspecies that are judged to be Vulnerable, the most important first step is to identify the probable nature of threat as due to either human impact or climatic change. In either case, the limited habitat for these isolated populations will render them particularly susceptible to human impact. If the threat does not involve adverse human impact, however, we recommend continued monitoring to observe changes in

the genetics, population structure, or ecology of the population during reduction (even to the point of extinction), and changes in community structure following extinction.

Priority 6: Taxa with Lower or unknown level of threat; Extinct subspecies

Recognizing that some form of conservation action or exploratory survey is justified for every rodent listed in this Action Plan above the category of Lower Risk (least concern), the rodents in less-immediate jeopardy are included in this final category. These are of three sorts: 1) Extinct subspecies (four), for which there exists persuasive evidence of extinction (four other Extinct subspecies are included in Priority 1 communities); 2) Near Threatened (21) or Conservation Dependent (one) subspecies, the extinction of which would not elevate the threat category of the respective species, because they do not constitute a large percentage of the species' subspecific diversity or geographic distribution; and 3) Data Deficient species (four) and subspecies (12), for which there is probably no immediate cause for concern, but which merit detailed survey to determine their conservation status. In order to be successful, a long-range, proactive conservation program must consider the Data Deficient taxa, and hopefully avoid the possibility of their becoming of conservation concern.

Recommendations for delisting of taxa previously considered to be threatened

Three groups of taxa of North American rodents of conservation concern can be identified:

- those known to be subjected to some degree of threat or potential threat, including those that may be extinct;
- those whose distribution, location, or ecology indicates that they may be threatened or potentially threatened, but for which sufficient information is not currently available (Data Deficient); and
- those taxa that have been considered by state or federal agencies to be in need of protection, but that are not globally threatened.

Taxa may be included in this third category because studies conducted subsequent to listing may have documented their more secure status (Table 6.3). Alternatively, many taxa have been included on state federal lists simply because of a restricted distribution in that state or country, although these populations are merely at the margins of widespread ranges of taxa that are not threatened elsewhere (Table 6.4). We judge these

'peripheral taxa' to be of less concern than subspecies or species whose existence is globally threatened. Finally, some taxa have been found to be indistinct from another form that is widespread and not currently of conservation concern (Table 6.5).

We recommend the 115 taxa in these three tables for removal (delisting) from state, provincial, or federal lists of threatened wildlife. Although we understand that human-mitigated detrimental impact to any natural population is regrettable and should be avoided, limited funds and practical considerations force us to focus on those populations that are most at risk. Retention of secure, widespread taxa on state and federal lists would serve only to dilute the effort that should be directed at globally threatened taxa. Similarly, widespread taxa that are on state, provincial, and federal lists only because of their peripheral distribution in that region (peripheral taxa; Table 6.4) should be of far lower priority in management decisions. Because a taxon's distribution would be expected to contract or expand due to natural climatic change, these peripheral populations might often be ephemeral, and their loss would not necessarily signal any threat to the taxon's survival. Finally, taxa that have been found to be indistinct from another,

widespread taxon (Table 6.5) should not be considered to be of any conservation concern. We have elected to include here taxa that are considered by experts in the field to be synonymous with widespread taxa, rather than wait for publication of a formal taxonomic synonymy. We recommend retention of taxa on state and federal lists that are believed to have suffered extinction during this century, as it is possible that surviving populations may have been overlooked (as was the case with a jumping mouse, *Zapus hudsonius luteus*, in New Mexico), or that systematic study may reveal their synonymy with extant populations and reintroduction may be considered.

As we have stressed elsewhere in this report, these recommendations are based on the best information currently available. We hope that circulation of this report will bring to our attention more information about these rodents, and this new information may result in reassignment of taxa. Certainly, 'current status' of any species, particularly one subjected to an immediate threat, can change rapidly; we can only hope that such change will be an improvement in that status, but expect that at least some taxa now judged to be at low risk of extinction will require conservation action in the future.

Table 6.3. Rodent taxa previously listed as threatened or endangered, whose status now appears to be of no immediate conservation concern.			
	Historical distribution	State/Province listed	Federal status
APLODONTIDAE			
<i>Apodontia rufa californica</i>	CA,NV	CA,NV	C2C
SCIURIDAE			
<i>Marmota flaviventris notioros</i>	CO		C2
<i>Sciurus arizonensis catalinae</i>	AZ		C2
<i>Sciurus nayaritensis chiricahuae</i>	AZ		C2
<i>Spermophilus elegans</i>	CO,NE,UT,WY	WY	
<i>Tamias speciosus speciosus</i>	CA		C2
GEOMYIDAE			
<i>Geomys bursarius breviceps</i>	LA		C3C
<i>Thomomys bottae guadalupensis</i>	NM,TX	TX	C2
<i>Thomomys bottae limpiae</i>	TX	TX	C2
<i>Thomomys bottae mearnsi</i>	NM		C2
<i>Thomomys bottae paguatae</i>	NM		C2
<i>Thomomys bottae texensis</i>	TX	TX	C2
HETEROMYIDAE			
<i>Microdipodops megacephalus albiventer</i>	NV		C2
<i>Perognathus amplus amplus</i>	AZ		C2
<i>Perognathus amplus cineris</i>	AZ		C2
MURIDAE			
<i>Clethrionomys gapperi breviceaudus</i>	WY,SD	WY	
<i>Microtus californicus sanpabloensis</i>	CA	CA	C3C
<i>Microtus mogollonensis navaho</i>	AZ,UT	AZ,UT	C2
<i>Microtus townsendii pugeti</i>	WA	WA	C3C
<i>Peromyscus leucopus easti</i>	VA	VA	C3C
<i>Peromyscus leucopus fusus</i>	MA		C3C

Table 6.4. North American rodent taxa previously listed as threatened or endangered due to peripheral distribution in a particular state or country, but that are wide-ranging and not considered to be of conservation concern elsewhere.

	Historical distribution	State/Province listed
SCIURIDAE		
<i>Cynomys leucurus</i>	MT,WY,UT,CO	MT,WY
<i>Glaucomys sabrinus</i>	widespread	ID,ND,NV,WA,
<i>Glaucomys volans volans</i>	widespread	NS
<i>Marmota monax</i>	widespread	MT
<i>Sciurus aberti</i>	widespread	UT,WY
<i>Sciurus carolinensis</i>	widespread	SD
<i>Sciurus griseus</i>	WA,OR,CA,NV	NV,WA
<i>Spermophilus beldingi</i>	widespread	UT
<i>Spermophilus elegans elegans</i>	CO,NE,UT,WY	UT
<i>Spermophilus lateralis lateralis</i>	widespread	WY
<i>Spermophilus spilosoma</i>	widespread	SD,UT,WY
<i>Spermophilus tridecemlineatus</i>	widespread	UT
<i>Spermophilus variegatus</i>	widespread	ID
<i>Tamias amoenus</i>	widespread	UT
<i>Tamias dorsalis</i>	widespread	ID,WY
<i>Tamias ruficaudus</i>	widespread	WA
<i>Tamias striatus</i>	widespread	FL,SD
<i>Tamias umbrinus</i>	widespread	ID,MT
<i>Tamiasciurus douglasii</i>	widespread	NV
GEOMYIDAE		
<i>Thomomys talpoides</i>	widespread	MN,UT
HETEROMYIDAE		
<i>Chaetodipus hispidus</i>	widespread	LA,MT,ND,WY
<i>Chaetodipus intermedius</i>	widespread	UT
<i>Dipodomys deserti</i>	widespread	UT
<i>Dipodomys ordii</i>	widespread	ND,WA
<i>Dipodomys spectabilis baileyi</i>	AZ,NM	AZ
<i>Perognathus fasciatus</i>	widespread	UT,WY
<i>Perognathus flavescens</i>	widespread	IA,MO,WY
<i>Perognathus flavescens perniger</i>	ND	ND
<i>Perognathus flavus</i>	widespread	WY
<i>Perognathus longimembris gulosus</i>	ID,UT,NV	ID
<i>Perognathus parvus</i>	widespread	WY
MURIDAE		
<i>Clethrionomys gapperi</i>	widespread	IA
<i>Lemmyscus curtatus levidensis</i>	widespread	WY
<i>Lemmyscus curtatus pallidus</i>	widespread	SD
<i>Lemmyscus curtatus pauperrimus</i>	OR,WA	WA
<i>Microtus canicaudus</i>	OR,WA	WA
<i>Microtus chrotorrhinus chrotorrhinus</i>	widespread	MN
<i>Microtus longicaudus</i>	widespread	SD,WY
<i>Microtus ochrogaster</i>	widespread	MN
<i>Microtus pinetorum</i>	widespread	MN
<i>Microtus richardsoni</i>	widespread	WY
<i>Neotoma stephensi</i>	UT,AZ,NM	UT
<i>Onychomys torridus</i>	widespread	UT
<i>Oryzomys couesi aquaticus</i> ¹	TX,MX	TX
<i>Peromyscus crinitus</i>	widespread	WY
<i>Peromyscus eremicus</i>	widespread	UT
<i>Peromyscus gossypinus</i>	widespread	KY,MO
<i>Peromyscus leucopus</i>	widespread	WY
<i>Peromyscus nasutus</i>	widespread	UT
<i>Peromyscus truei</i>	widespread	WY
<i>Phenacomys intermedius</i>	widespread	MN,WY
<i>Reithrodontomys humulis</i>	widespread	AR,LA
<i>Reithrodontomys montanus</i>	widespread	AR,MO,WY
<i>Sigmodon ochrognathus</i> ¹	AZ,NM,TX,MX	TX
<i>Synaptomys borealis</i>	widespread	MN
<i>Synaptomys borealis chapmani</i>	widespread	ID,MT
<i>Synaptomys cooperi</i>	widespread	IA

¹ Federal C2 candidate taxon

Table 6.5. North American rodent taxa previously listed as threatened or endangered, but that probably are not distinct from wide-ranging taxa of secure status according to the cited authority.

	Historical distribution	USA status	State listed	Reference
SCIURIDAE				
<i>Cynomys ludovicianus arizonensis</i>	USA: AZ,NM,TX Mexico	-	AZ, TX	Pizzimenti (1975)
GEOMYIDAE				
<i>Thomomys bottae abstrusus</i>	NV	C2	-	J. L. Patton (pers. comm.)
<i>Thomomys bottae amargosae</i>	CA	C3B	-	J. L. Patton (pers. comm.)
<i>Thomomys bottae bonnevilliei</i>	UT	C2	UT	J. L. Patton (pers. comm.)
<i>Thomomys bottae convexus</i>	UT	C2	UT	J. L. Patton (pers. comm.)
<i>Thomomys bottae curtatus</i>	NV	C2	-	J. L. Patton (pers. comm.)
<i>Thomomys bottae detumidus</i>	OR	C2	-	J. L. Patton (pers. comm.)
<i>Thomomys bottae dissimilis</i>	UT	C2	UT	J. L. Patton (pers. comm.)
<i>Thomomys bottae hualpaiensis</i>	AZ	C2	-	Hoffmeister (1986)
<i>Thomomys bottae minimus</i>	UT	C2	UT	J. L. Patton (pers. comm.)
<i>Thomomys bottae muralis</i>	AZ	C2	-	Hoffmeister (1986)
<i>Thomomys bottae nesophilus</i>	UT	C2	UT	J. L. Patton (pers. comm.)
<i>Thomomys bottae powelli</i>	UT	C2	UT	J. L. Patton (pers. comm.)
<i>Thomomys bottae robustus</i>	UT	C2	UT	J. L. Patton (pers. comm.)
<i>Thomomys bottae sevieri</i>	UT	C2	UT	J. L. Patton (pers. comm.)
<i>Thomomys bottae suboles</i>	AZ	C2	-	Hoffmeister (1986)
<i>Thomomys bottae subsimilis</i>	AZ	C2	-	Hoffmeister (1986)
<i>Thomomys umbrinus quercinus</i>	AZ	C2	-	Hoffmeister (1986)
HETEROMYIDAE				
<i>Chaetodipus intermedius nigrimontis</i>	AZ	C2	-	Hoffmeister (1986)
<i>Dipodomys californicus eximius</i>	CA	C2	CA	Williams (1986)
<i>Dipodomys elephantinus</i>	CA	C3B	CA	Best (1986)
<i>Dipodomys merriami frenatus</i>	UT	C2	UT	Durrant and Setzer (1945)
<i>Dipodomys microps russeolus</i>	UT	C2	-	Durrant (1952)
<i>Dipodomys ordii cineraceus</i>	UT	C2	-	Durrant (1952)
<i>Microdipodops megacephalus nasutus</i>	NV	C2	-	Hafner (1981)
<i>Perognathus amplus ammodytes</i>	AZ	C2	-	Hoffmeister (1986)
MURIDAE				
<i>Neotoma mexicana bullata</i>	AZ	C2	-	Hoffmeister (1986)
<i>Neotoma micropus leucophaea</i>	NM	C2	-	Birney (1973)
<i>Oryzomys palustris planirostris</i>	FL	C2	FL	Humphrey and Setzer (1989)
<i>Oryzomys palustris sanibeli</i>	FL	C2	FL	Humphrey and Setzer (1989)
<i>Peromyscus eremicus papagensis</i>	USA: AZ Mexico	C2	-	Hoffmeister (1986)
<i>Peromyscus eremicus pullus</i>	AZ	C2	-	Hoffmeister (1986)
<i>Reithrodontomys megalotis arizonensis</i>	AZ	C2	-	Hoffmeister (1986)
<i>Reithrodontomys megalotis limicola</i>	CA	C3B	-	Collins and George (1990)
<i>Reithrodontomys megalotis ravus</i>	UT	C2	-	Durrant (1952)
<i>Reithrodontomys megalotis santacruzae</i>	CA	C3B	-	Collins and George (1990)
<i>Sigmodon arizonae jacksoni</i>	AZ	C2	-	Hoffmeister (1986)

Recommended conservation strategies

In order to be effective, conservation strategies for rodents should be proactive and should include sustained, multidisciplinary, and collaborative approaches. These will necessarily require public education and involvement of governmental and private conservation agencies, research institutions, and private landowners. Conservation strategies will be more successful if they

are based upon sound and adequate information about the rodents involved, which will require renewed efforts at gaining basic data. The polemicism, hyperbole, and rhetoric that has characterized over two decades of environmental debate since the passage of the U.S. Endangered Species Act must be replaced by fair and honest consideration of all facets of environmental issues. Conflicts must be resolved in a manner that includes both protection and rational use of natural resources, and avoids alienation of the public.

A proactive, habitat-based approach

Traditional tactics of rallying support for conservation of a particular species may be less productive for rodents than for more charismatic species. In the past, conservation action normally has been taken only after a species' survival has become imperiled. In the United States, action typically involves listing of a particular species under the Endangered Species Act, followed by design and eventual implementation of a recovery plan. Due to the substantial investment of funds and labor in this process, it has been employed primarily to the benefit of more charismatic species such as bald eagles, peregrine falcons, and wolves. Action for other species (e.g., snail darters, spotted owls), or action involving fundamental social or economic change (e.g., patterns of timber harvest, construction projects) has been controversial. Few rodents will be considered charismatic by the public, and consequently they are rather poor candidates for species-focused conservation efforts.

The large number of rodent taxa of conservation concern would also render species-by-species approaches ineffective. Extensive human impact on North American ecosystems, coupled with the diversity, habitat specificity, and low dispersal capabilities of most rodents, have placed one-half of the monotypic species of rodents in North America in some level of jeopardy, while nearly one-half of the total species have at least one subspecies of conservation concern.

We recommend a shift in emphasis from conservation of individual (often charismatic) species to the conservation of functional ecosystems. Preservation of larger areas of natural habitat is usually necessary to ensure the long-term survival of individual species. Moreover, habitat preservation will incidentally conserve co-occurring species, protecting species whose threatened status may be unknown to biologists and preventing others from becoming imperiled. Thus, this habitat approach is more proactive, more effective, and more cost-efficient. At the same time, we caution that the needs of individual threatened taxa, when known, must be considered in the overall management plan, and that establishment of larger habitat preserves is not a substitute for continued study of the interactions and dynamics of component species.

An ecosystem approach should emphasize the important ecological roles occupied by rodents. Rodents are important in soil aeration, soil fertility, and penetration of ground water into the soil (pocket gophers; Dalquest 1948; Ingles 1949, 1952); as prey for furbearers (Magoun and Johnson 1991) and predatory birds, and as keystone species supporting entire carnivore food webs (ground squirrels; Yensen *et al.* 1992); as keystone species supporting up to 170 associated species (prairie dogs; Miller *et al.* 1994); and play an integral role in forest health

through their relationships with mycorrhizal fungi (chipmunks, voles, flying squirrels; Maser *et al.* 1978, C. Maser *et al.* 1986, Z. Maser *et al.* 1986).

The black-tailed prairie dog (*Cynomys ludovicianus*) provides a particularly cogent example of the enormous impact of rodents on ecosystems. This species merits our conservation concern even though it is not globally threatened. Secure populations exist in a number of states, and they are often locally abundant. However, black-tailed prairie dogs now occupy less than two percent of their former distribution, and surviving populations are fragmented and isolated (Miller *et al.* 1994). At the same time, an estimated 170 other species are associated with the black-tailed prairie dog, and several, including black-footed ferrets (*Mustela nigripes*) and swift foxes (*Vulpes velox*), are closely dependent upon *C. ludovicianus* (Miller *et al.* 1994, B. Ruediger pers. comm.). Thus, the distribution of this species tightly restricts the distribution and security of a wide variety of associated and dependent species. Ironically, the economic arguments used to justify eradication of prairie dogs now appear to be specious (Miller *et al.* 1994).

Sustainable strategy

In 1980, The World Conservation Union, United Nations Environment Programme, and World Wide Fund for Nature sought to end counterproductive battles between developers and environmentalists by declaring that "conservation is *not* the opposite of development" (IUCN/UNEP/WWF 1980). In the ongoing and accelerating conflicts between these two camps, mistakes have been made on both sides, including deliberate misrepresentation of biological data, political stacking of appointed review boards, and public name-calling. Clearly, a new strategy is needed, as outlined in *Caring for the Earth: A Strategy for Sustainable Living* (IUCN/UNEP/WWF 1991). In this sense, we particularly endorse principles and actions directed at changing personal attitudes and practices, enabling communities to care for their own environments, and providing a national framework for integrating development and conservation. Without a substantial shift in strategy, we can expect current patterns of adverse impact and extinction to accelerate.

Collaborative efforts

While we remain cautiously optimistic that a framework can be developed in which development and conservation can be integrated in a sustainable conservation strategy, we are discouraged at the lack of cooperation and collaboration among the diverse government and private conservation agencies. Conservation efforts of state and

provincial agencies are notoriously uneven, and the diversity of criteria and codes for recognition of threatened species is truly bewildering. In our survey of state conservation agencies, we found that many states lack non-game conservation departments, or existing departments often have no contact with similar agencies in neighboring states. This uncoordinated approach results in redundant, inefficient, and misdirected conservation efforts. It is truly a rare species that has a geographic limit coincident with a political border, yet state conservation efforts rarely look beyond the state's borders or consider the global status of species.

Conservation agencies, whether federal, state, provincial, or private, must develop more innovative ways to gather the necessary natural history information for Data Deficient taxa; to gain a sharper appreciation of the specific threats to Lower Risk (Near Threatened) taxa; and to monitor the status of Lower Risk (Conservation Dependent) taxa. In order to avoid duplication of effort, rapidly determine the appropriate action plan for a given taxon, and promote efficient use of limited funds, conservation agencies must develop cooperative efforts among themselves and with academic institutions. One particularly successful model appears to be the growing network of state and provincial Heritage Programs that are set up by The Nature Conservancy (TNC) and, in many cases, adopted by state and provincial governments. Many state conservation agencies are already working closely with the local Heritage Program. We strongly recommend that more states and provinces follow this example, and that federal conservation agencies become active partners in cooperative efforts. We recognize that this will involve dropping territorial attitudes, and in some cases redundant agencies will have to be relocated, merged, or dissolved. Such changes would certainly be justified and rewarded if the result is a coordinated, cost-efficient, and proactive network of conservation agencies that works with the public and private interests to conserve biodiversity.

There exists an unfortunate variety of threat categories to which species of conservation concern are assigned. Often, state regulatory agencies have developed their own criteria, which bear little resemblance to those of even neighboring states. A noteworthy exception to this pattern involves TNC's scheme, which is used by all Heritage Programs. These criteria are very similar to Red List criteria employed by the IUCN, except that TNC has both state and global status assignments. Red List and TNC assignments of species included in this Action Plan are both listed in Table 5.1, and global rankings are compared in Table 6.6. In general, there is a rough correspondence between Red List and TNC rankings at the species level, but subspecies are assigned to ranks of higher threat by TNC than to Red List categories in this Action Plan. A number of species and subspecies of rodents not included in this Action Plan have been assigned global ranks of G3 (species) or T3 (subspecies) or higher threat by TNC (Table 6.7). Although these may include invalid taxa, we include them here as possible candidates for consideration in future action plans.

In order to enact a more proactive approach to conservation issues, regulatory agencies must gain knowledge of Data Deficient taxa and devise means to avoid costly future mitigation. Certainly, higher-priority taxa necessarily demand the greater proportion of limited federal and state funding. However, our experience has been that cooperative efforts between regulatory agencies and academic institutions has been inadequately exploited in most regions. By forging stronger ties with regional universities and natural history museums, conservation agencies can have increased access to studies currently underway, and increase opportunities for graduate or undergraduate study with little expenditure of limited funds. Most of the Data Deficient taxa are in need of basic natural history information that could be obtained through field work conducted by undergraduate students supervised by appropriate mentors. Funding for such work is readily available through federal programs such

Table 6.6. Comparison of global-status rankings for taxa ranked by both IUCN (this Action Plan) and The Nature Conservancy (TNC).

Number of taxa not ranked by TNC shown in parentheses. Status codes are defined in Appendix 2.

<i>n</i> (species)	<i>n</i> (subspecies)	IUCN Category	TNC status (species)		TNC status (subspecies)	
			Mean rank	Range	Mean rank	Range
0	7 (1)	EX	(GX)	-	TX	TX-T1
1	12	CR	G2	-	T1	TX-T2
2 (1)	7 (1)	EN	G2G3	G2-G3	T1T2	T1-T2
6	25 (5)	VU	G2	G1G2-G3	T1	TX-T3
2	2 (2)	LR(cd)	G2	G1G2-G2	T2T3	T2-T3
15	35 (5)	LR(nt)	G3G4	G1-G5	T2T3	TH-T5
52	-	LR(lc)	G5	G4-G5	(T5)	-
5 (2)	36 (13)	DD	G3G4	G3-G4	T2T3	T1-T4T5

Table 6.7. Rodent species listed at a threat category of G3 or higher, and subspecies listed at a threat category of T3 or higher by The Nature Conservancy, not included in Tables 6.3-6.5, and not included in this Action Plan. This list may include invalid taxa.

	Historical distribution	Global status	State status
SCIURIDAE			
<i>Marmota olympus</i>	WA	G3	S?
<i>Sciurus aberti kaibabensis</i>	AZ	G5T3	S3
<i>Spermophilus parryii osgoodi</i>	AK	G5T3?	S3?
<i>Spermophilus tridecemlineatus monticola</i>	AZ	G5T3	S3
<i>Tamias amoenus celeris</i>	NV	G5TH	SH
<i>Tamias panamintinus acrus</i>	CA	G5T1T2	S1S2
<i>Tamias speciosus callipeplus</i>	CA	G5T1T3	S?
<i>Tamiasciurus hudsonicus picatus</i>	AK	G5T3?	S3?
GEOMYIDAE			
<i>Geomys knoxjonesi</i>	NM,TX	G3	TX: S2
<i>Geomys personatus davisi</i>	TX	G4T2	S2
<i>Geomys texensis texensis</i>	TX	G3T2	S2
<i>Thomomys bottae pervagus</i>	CO,NM	G5T3	CO: S2
<i>Thomomys talpoides clusius</i>	WY	G5T2	S2
<i>Thomomys mazama hesperus</i>	OR	G4G5T2T3?	SU
<i>Thomomys mazama niger</i>	OR	G4G5T2T3?	SU
HETEROMYIDAE			
<i>Dipodomys compactus compactus</i>	TX	G4T3	S3
<i>Dipodomys ordii cineraceus</i>	UT	G5T1	S1
<i>Dipodomys panamintinus argusensis</i>	CA	G5T1T3	S?
<i>Dipodomys panamintinus panamintinus</i>	CA	G5T3	S3
<i>Perognathus flavescens relictus</i>	CO	G5TH	SH
<i>Perognathus inornatus inornatus</i>	CA	G4QT2T3	S2S3
<i>Perognathus parvus xanthonotus</i>	CA	G5T3	S3
MURIDAE			
<i>Arborimus longicaudus longicaudus</i>	OR	G4T3	S3
<i>Arborimus longicaudus silvicola</i>	OR	G4T3	S3
<i>Clethrionomys gapperi rupicola</i>	PA	G5T3Q	S3
<i>Clethrionomys gapperi stikinensis</i>	USA: AK Canada: BC	G5T2T3	AK: S?
<i>Clethrionomys gapperi wrangeli</i>	AK	G5T2T3	S2S3
<i>Clethrionomys rutilus albiventer</i>	AK	G5T3	S3
<i>Clethrionomys rutilus glacialis</i>	AK	G5T3	S3
<i>Clethrionomys rutilus insularis</i>	AK	G5T3	S3
<i>Clethrionomys rutilus orca</i>	AK	G5T3	S?
<i>Lemmus sibiricus nigripes</i>	AK	G5T3	S3
<i>Microtus ochrogaster ludovicianus</i>	LA	G5TX	SX
	TX		SX
<i>Microtus oeconomus unalascensis</i>	AK	G5T3	S3
<i>Microtus pennsylvanicus nesophilus</i>	NY	G5TX	SX
<i>Peromyscus maniculatus algidus</i>	USA: AK Canada: BC,YT	G5T3	AK: S?
<i>Peromyscus sitkensis oceanicus</i>	AK	G5T3Q	S3
<i>Peromyscus sitkensis sitkensis</i>	AK	G5T3?	S3?
<i>Reithrodontomys megalotis distichlis</i>	CA	G5TH	SH
<i>Sigmodon hispidus exsputus</i>	FL	G5T2	S2
<i>Synaptomys cooperi helaletes</i>	NC	G5T3	S2?
	VA		S3

as the Research Experience for Undergraduates program of the National Science Foundation. In many cases, the necessary information is already available, having been gathered incidentally during other studies (e.g., observations noted during studies directed at evolutionary relationships of a taxon) but has not been included in a publication.

Public involvement

Recently, the U.S. Fish and Wildlife Service has been using “conservation agreements” as alternatives or supplements to the Endangered Species Act, sometimes in lieu of listing. Conservation agreements are fixed-term agreements between land owners, land managers, governmental

agencies, or other interested parties that specify actions that will be taken on behalf of a species of conservation concern. Conservation agreements have the advantage of being much less expensive, more rapid, and more flexible than formal listing, and involve the people directly impacted by conservation efforts of the species in question. Another approach that is proving to be successful is the use of conservation easements, in which land owners receive something of value (e.g., money or tax credits) in exchange for restrictions on the use of their property that help ensure the survival of a species. We feel that such direct involvement of all parties with interests in the area and the animal in question is highly preferable to the all-too-common confrontational politics of conservation.

Need for basic research

The role of taxonomy and systematics in conservation biology and wildlife management cannot be overstated (Vane-Wright *et al.* 1991; Rojas 1992). Failure to recognize the limitations of existing taxonomies has resulted in serious management mistakes (Daughtery *et al.* 1990; May 1990). The major problem in rodent conservation is lack of solid information. The subspecies-level (and in some cases, species-level) taxonomy of most groups is outdated and often based upon few specimens.

Recall that for 77 taxa (nearly one-half of the total included in this Action Plan), the nature of threat, if any, is unknown. The need for basic survey and taxonomic study is perhaps most obvious in southeastern Alaska and adjoining British Columbia, which together include the most extensive temperate rain forest in the world (Alaback 1991). The fauna and flora of the area are characterized by a high rate of endemism stemming from the large number of islands and complex topography of the region. Most of southeastern Alaska is under federal jurisdiction in Glacier Bay National Park or Tongass National Forest, the largest national forest in the United States that covers some 80% of southeastern Alaska. Federal legislation (National Environmental Policy Act of 1969, Endangered Species Act of 1973, National Forest Management Act of 1976) has mandated the conservation of biological diversity as a national goal in forests, yet surprisingly little has been done to rigorously inventory the biotic diversity of the coastal forest ecosystem of southeastern Alaska, a significant portion of which has been clearcut logged (Kiester and Eckhardt 1994). Much of our knowledge of rodent distributions in this region derives from biological surveys conducted at the beginning of this century. In Alaska, two of these, the Alexander Expeditions of 1907 and 1909 (Heller 1909; Swarth 1911) remain our best sources of information. Unfortunately both were limited in geographic scope and in time spent at collecting localities. Despite the restricted coverage of these early studies (24 islands sampled

out of more than 1000), three new species and 23 subspecies of small mammals were described as endemic to this region of North America (Hall 1981). Since that time, technological and theoretical advances have greatly enhanced our ability to describe genetic variation and species boundaries (Hillis and Moritz 1990; Avise 1994).

Rodent conservation cannot take place in an information vacuum, and the need for basic taxonomic studies and modern inventories must be addressed immediately. Museum collections play an important role in this basic research, housing the most complete documentation of species and habitats that are disappearing at an accelerating rate. Museum specimens provide physical documentation for species identifications and associated data on reproduction, habitat, and parasites (Yates 1987). Expansion of museum collections should include biological inventories of threatened and disappearing habitats and species, voucher specimens from biological surveys, and diversified samples including frozen tissue collections (Miller 1993).

Concluding remarks

Lidicker (1989) asked if rodent conservation was a viable issue. We feel the question can be answered in the affirmative. Despite the large number of taxa for which we have insufficient information, documented conservation problems do indeed exist for a substantial proportion of North American rodents. The geographic and ecological diversity of rodents, combined with their value as biological indicators of specific habitats, should promote their inclusion in conservation programs directed at ecosystems. Similarly, their abundance and ubiquity should encourage cooperation among government and private conservation agencies. In effect, rodents deserve a central role in conservation programs.

In addition to specific actions directed at individual species, we have suggested or endorsed newer approaches to conservation: protecting entire ecosystems, involving the public through conservation agreements and easements, increasing cooperation among conservation agencies, and developing innovative means to gather needed data. In the final analysis, success of these conservation efforts will depend on a major shift in public attitudes towards our environment. Unless we voluntarily adopt actions that limit human population growth, decrease environmental pollution, and integrate development and conservation into a strategy for sustainable living, conservation efforts will be fighting a continual retreating action. Rodents have not enjoyed a favored place in human appreciation; if considered at all, it is usually in a negative context. If the public can learn to appreciate the value of rodents to the survival of our environment and to human welfare, then there is certainly cause for hope of success in our conservation efforts.

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Definition of Categories of Threatened Status

[As employed by the IUCN Red List (IUCN 1994), The Nature Conservancy (TNC, *in litt.* August, 1996), and the United States federal government (Federal Register, 50 CFR 17.11 & 17.12, August 20, 1994). Both the Red List and TNC definitions include very specific and measurable attributes of the population and habitat sizes which are not specified here].

Code Definition

IUCN RED LIST:

- EX Extinct: no reasonable doubt that the last individual has died.
- EW Extinct in the Wild: known only to survive in cultivation, in captivity, or as a naturalized population (or populations) well outside the past range.
- CR Critically Endangered: facing an extremely high risk of extinction in the wild in the immediate future (based on criteria specified in IUCN 1994).
- EN Endangered: not Critically Endangered, but facing a very high risk of extinction in the wild in the near future (based on criteria specified in IUCN 1994).
- VU Vulnerable: not Critically Endangered or Endangered but facing a high risk of extinction in the wild in the medium-term future (based on criteria specified in IUCN 1994).
- LR Lower Risk: taxon has been evaluated, and does not satisfy criteria for any of the categories Critically Endangered, Endangered, or Vulnerable. Taxa included in the Lower Risk category can be separated into three subcategories:
- LR(cd) Lower Risk, Conservation Dependent: the focus of a continuing taxon-specific or habitat-specific conservation program targeted towards the taxon in question, the cessation of which would result in the taxon qualifying for one of the threatened categories above within a period of five years.
- LR(nt) Lower Risk, Near Threatened: does not qualify for Conservation Dependent, but is close to qualifying for Vulnerable.
- LR(lc) Lower Risk, Least Concern: does not qualify for Conservation Dependent or Near Threatened.
- DD Data Deficient: there is inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and/or population status.

NATURE CONSERVANCY:

- GX Presumed Extinct: believed to be extinct throughout its range.
- GH Possibly Extinct: known from only historical occurrences.
- GI Critically Imperiled: critically imperiled globally because of extreme rarity or of some factor(s) making it especially vulnerable to extinction.
- G2 Imperiled: imperiled globally because of rarity or because of some factor(s) making it very vulnerable to extinction.
- G3 Vulnerable: vulnerable globally either because very rare and local throughout its range, found only in a restricted range (even if abundant at some locations), or because of other factors making it vulnerable to extinction.
- G4 Apparently Secure: uncommon but not rare, and usually widespread. Possibly cause for long-term concern.
- G5 Secure: Common, typically widespread and abundant.
- G#G# Range Rank: a numeric range rank (e.g., G2G3) is used to indicate uncertainty about the exact status of a taxon.
- GU Unrankable: currently unrankable due to lack of information or due to substantially conflicting information about status or trends.
- G? Unranked: global rank not yet assessed.
- HYB Hybrid: element represents an interspecific hybrid.
- ? Denotes inexact numeric rank.
- Q taxonomic status is questionable; numeric rank may change with taxonomy.
- C Captive or Cultivated only: taxon at present is extant only in captivity or cultivation, or as a reintroduced population not yet established.

Code	Definition
T	Infraspecific Taxon (trinomial): the status of infraspecific taxa (subspecies or varieties) are indicated by a “T-rank” following the species’ global rank. For example, the global rank of a critically imperiled subspecies of an otherwise widespread and common species would be G5T1.
SX	Extirpated: believed to be extirpated from the state, province, or other subnational unit.
SH	Historical: occurred historically in the state (with expectation that it may be rediscovered), perhaps having not been verified in the past 20 years, and suspected to be still extant.
SI	Critically Imperiled: critically imperiled in the state because of extreme rarity or of some factor(s) making it especially vulnerable to extirpation from the state.
S2	Imperiled: imperiled in the state because of rarity or because of some factor(s) making it very vulnerable to extirpation from the state.
S3	Vulnerable: vulnerable in the state either because very rare and local throughout its range, found only in a restricted range (even if abundant at some locations), or because of other factors making it vulnerable to extirpation from the state.
S4	Apparently Secure: uncommon but not rare, and usually widespread in the state.
S5	Secure: demonstrably widespread, abundant, and secure in the state, and essentially ineradicable under present conditions.
S?	Unranked: state not yet assessed.
SU	Unrankable: currently unrankable due to lack of information or due to substantially conflicting information about status or trends.
S#S#	Range Rank: a numeric range rank (e.g., S2S3) is used to indicate uncertainty about the exact status of a taxon.
HYB	Hybrid: element represents an interspecific hybrid.
SE	Exotic: an exotic established in the state; may be native in nearby regions.
S#	Exotic numeric: an exotic established in the state that has been assigned a numeric rank to indicate its status.
B	Breeding: basic rank refers to the breeding population of the taxon in the state.
N	Non-breeding: basic rank refers to the non-breeding population of the taxon in the state.
SA	Accidental: accidental or casual in the state.
SZ	Zero Occurrences: not of practical conservation concern in the state because there are no definable occurrences, although the taxon is native and appears regularly in the state (e.g., long-distance migrants regularly passing through state).
SP	Potential: potential that element occurs in the state but no extant or historical occurrences reported.
SR	Reported: taxon reported in state but without a basis for either accepting or rejecting the report.
SRF	Reported Falsely: erroneously reported in the state and the error has persisted in the literature.
SSYN	Synonym: reported as occurring in the state, but state does not recognize the taxon; therefore the element is not ranked by the state.

UNITED STATES:

E	Endangered
T	Threatened
C1	Category 1 candidate: sufficient information exists to support proposals to list as endangered or threatened
C2	Category 2 candidate: information indicates that proposing to list as endangered or threatened is possibly appropriate, but conclusive data are not currently available
C3A	Persuasive evidence of extinction exists
C3B	Taxonomically invalid name
C3C	More abundant or widespread than previously believed; not subject to any identifiable threat
XE	Essential experimental population
XN	Nonessential experimental population

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