Robert A. Gitzen, Stephen D. West, and **Brent E. Trim,**[1] Wildlife Science Group, College of Forest Resources, University of Washington, Box 352100, Seattle, Washington 98195-2100

Additional Information on the Distributions of Small Mammals at the Hanford Site, Washington

Abstract

The Hanford Site is a refuge for shrub-steppe organisms, including several small mammal species of concern in Washington. We inventoried species occurrence and relative abundance of small mammals in areas of Hanford that had not been surveyed extensively. During 1997 and 1998, we performed trapping surveys for shrews and small rodents; visual searches and trapping surveys for ground squirrels; and spotlight surveys for jackrabbits. We captured nine small mammal species during 21,743 trap days/nights with snap traps, Sherman traps, pitfall traps, Tomahawk traps, and rat traps. The Great Basin pocket mouse and deer mouse dominated captures. Total captures were highest in antelope bitterbrush/Indian ricegrass dune communities. Capture rates were lowest in cheatgrass fields. In contrast to most upland habitats at low elevation on Hanford, deer mice were captured in relatively high numbers near active dunes. Northern grasshopper mice were captured in low elevation sandy areas, with most captures in a large needle-and-thread patch. We observed and captured Washington ground squirrels within Hanford's northern boundary. Only six jackrabbits were seen during 118.5 km of spotlight surveys. We did not observe or capture Merriam's shrew, least chipmunk, Piute ground squirrel, or Ord's kangaroo rat. Low elevation areas of Hanford support a different small mammal fauna than higher elevation shrub-steppe areas on nearby lands of the Arid Lands Ecology Reserve and the Yakima Training Center.

Introduction

The Hanford Site in eastern Washington State contains areas of radioactive contamination resulting from plutonium production during 1943 to 1988 and ongoing nuclear waste processing (U.S. Department of Energy 1999). Most of the site, however, has been kept undeveloped and closed to the public as a security buffer since 1943, when the U.S. Government acquired the site (Rickard and Watson 1985). As a result, Hanford also contains the largest blocks of relatively undisturbed shrub-steppe habitat in the Columbia Basin (Hall 1998).

The role of Hanford as an ecological reserve is particularly important in light of the rapid loss of shrub-steppe communities in much of the Columbia Basin during the last century (Gray and Rickard 1989, Rickard and Poole 1989). Approximately 60% of Washington's shrub-steppe habitat has been converted to agriculture and other uses, and much of the remaining habitat is fragmented into small parcels (Dobler et al. 1996). Currently, the Washington Department of Fish and Wildlife lists several small mammals of Washington's shrub-steppe as candidates for state threatened or endangered status, including Merriam's shrew (*Sorex merriami*), black-tailed jackrabbit (*Lepus californicus*), white-tailed jackrabbit (*Lepus townsendii*), and Washington ground squirrel (*Spermophilus washingtoni*) (Washington Department of Fish and Wildlife 2000). The Washington ground squirrel also is a candidate for federal listing as threatened or endangered. The pygmy rabbit (*Brachylagus idahoensis*) is listed as a state endangered species. Land-use changes may have affected significantly the distributions of several other shrub-steppe rodents, including the least chipmunk (*Tamias minimus*), Ord's kangaroo rat (*Dipodomys ordii*), northern grasshopper mouse (*Onychomys leucogaster*), and sagebrush vole (*Lemmiscus curtatus*). In addition, shrub-steppe rodents and lagomorphs are primary or secondary prey for several raptor species of special concern found in the Columbia Basin (Fitzner et al. 1981).

Many of these shrub-steppe species occur on Hanford, although some have limited distributions on the site. The occurrence and population status of small mammals and other wildlife species on Hanford have been reviewed repeatedly (Rickard et al. 1974, Rickard and Poole 1989, Fitzner and Gray 1991, Downs et al. 1993, Fitzner et al. 1994), but most previous small mammal studies focused on the Fitzner/Eberhardt Arid Lands Ecology Reserve (ALE) or on areas near radiological sites and developments. In this study, we assessed small mammal occurrence and relative abundance across

[1]Current Address: 51 Cabin Lane, Selah, Washington 98942.

areas and plant communities that had not been surveyed extensively in previous work. We evaluated which areas and communities were of special importance for shrub-steppe small mammals, particularly for species and plant community types of special concern or limited distribution in Washington. We performed trapping and visual surveys for shrews, small rodents, ground squirrels, and jackrabbits. Our results emphasize the importance of low elevation sandy areas on Hanford. We also confirmed the presence of Washington ground squirrels inside the northern boundary of the site.

Study Area

The Hanford Site covers 1,517 km^2 (U.S. Department of Energy 1999) in Benton, Franklin, and Grant counties, Washington (Figure 1). During this study, the U.S. Department of Energy (DOE) administered Hanford, with some areas managed by the U.S. Fish and Wildlife Service and WDFW under permits from DOE. In June 2000, President Clinton designated portions of the site as the Hanford Reach National Monument. We refer to area designations that were relevant at the time

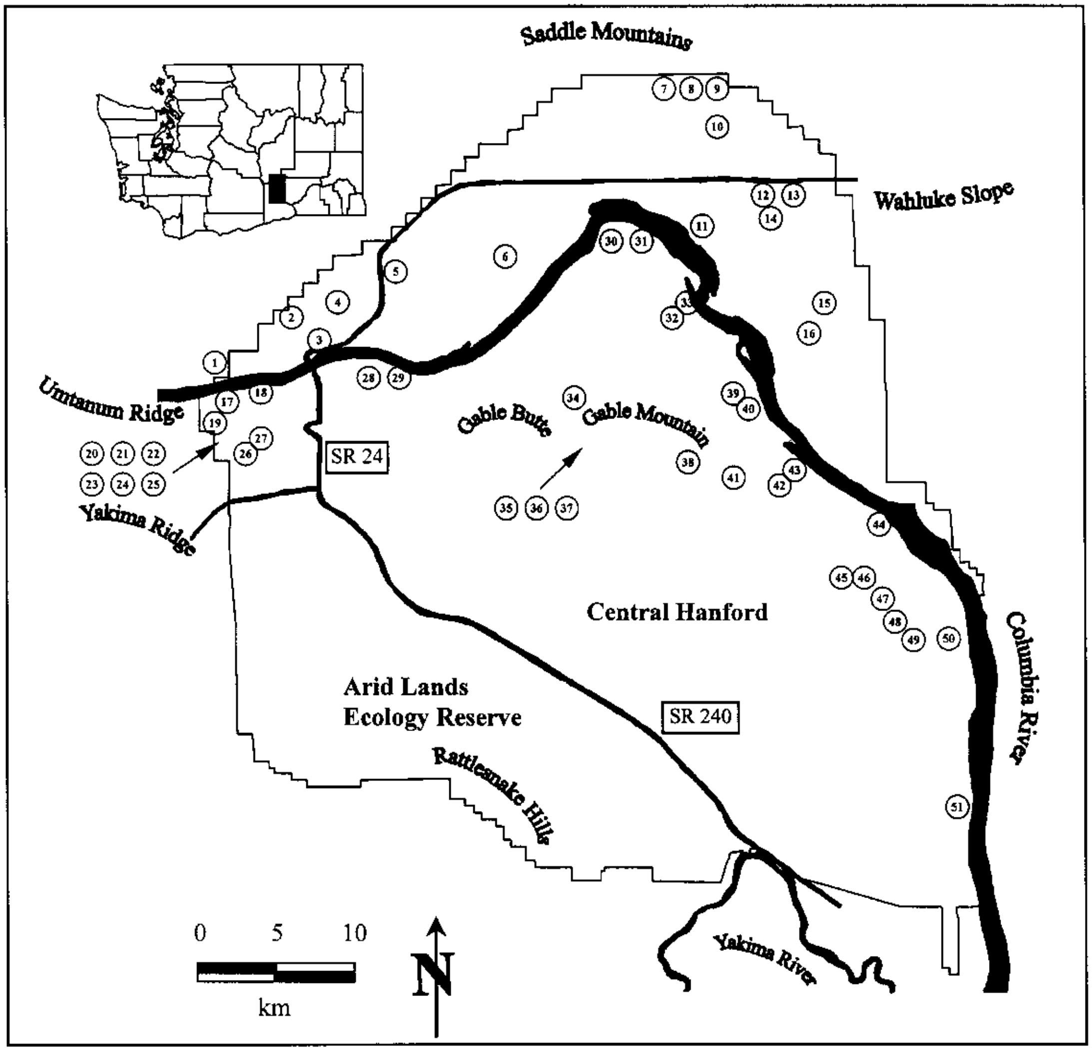

Figure 1. Map of the Hanford Site showing major features and sampling sites (numbered) for small mammal snap and Sherman trapping. Study site numbers are cross-referenced in Tables 2-4. The Wahluke Slope, the Arid Lands Ecology Reserve (ALE Reserve), Umtanum Ridge, and small portions of Central Hanford were designated as the Hanford Reach National Monument in June 2000.

of our work, including the Wahluke Slope on the east and north side of the Columbia River, and Central Hanford, Umtanum Ridge, and ALE on the west and south side of the river.

Hanford is in the Pasco Basin of the Columbia Plateau (Neitzel 1996), in the Columbia Basin province of Franklin and Dyrness (1988). The physiography of Hanford is characterized by anticlinal ridges that are partially or completely within the site boundaries and broad low-relief plains sloping down to the Columbia River (Neitzel 1996). Low elevation areas are bordered by the Saddle Mountains (480-580 m elevation), the Rattlesnake Hills (peak elevation 1,093 m on Rattlesnake Mountain), Yakima Ridge (507 m), and the eastern end of Umtanum Ridge (333-545 m). (Elevations listed are for the portions of each ridge on Hanford). Gable Mountain (182-273 m) and Gable Butte (237 m) are isolated ridges on Central Hanford. The low elevation plains (50-250 m) are among the hottest and driest locations in the Columbia Basin (Hall 1998), with average annual precipitation of 16 cm, mean July temperature of 24.6°C, and an average of 51 summer days with maximum temperatures of 32°C or greater (Neitzel 1996).

Most of Hanford is in shrub-steppe habitat. Big sagebrush (*Artemisia tridentata*)/cheatgrass (*Bromus tectorum*), big sagebrush/Sandberg's bluegrass (*Poa secunda*), and big sagebrush/needle-and-thread (*Stipa comata*) community types cover much of the site (Pabst 1995, Hall 1998). Central Hanford and the Wahluke Slope contain large patches of the antelope bitterbrush (*Purshia tridentata*)/Indian ricegrass (*Oryzopsis hymenoides*) dune complex type, including large blowout dunes in some areas. The big sagebrush/bluebunch wheatgrass (*Pseudoroegneria spicata*) type is a dominant plant community on the ALE reserve, but is limited to ridges and isolated low elevation areas on the rest of the site. Cheatgrass and other exotics dominate large fields that were cultivated prior to 1943, mainly near the Columbia River and on parts of ALE. Fire has impacted much of the site, often removing shrub cover across large areas. In 1984, a fire burned 81,000 ha across ALE, the southern portion of Central Hanford, and adjacent areas off the site. In June 2000, a 78,000 ha fire burned across nearly all of ALE and adjacent parts of Central Hanford (Gerber 2000).

Methods

Shrews and Small Rodents

In 1997, we compared species occurrence and relative abundance across a broad range of community types. In 1998, we shifted our focus to more intensive sampling of higher elevation areas most likely to support Merriam's shrews, sagebrush voles, and least chipmunks. We also attempted to estimate the abundance of northern grasshopper mice in low elevation sandy areas, and briefly examined mice occurrence near large active dunes.

In 1997, we used snaptrap transects to sample major plant community types and cover types of the site (Table 1). At least three replicates were sampled in all community types except for the spiny hopsage (*Grayia spinosa*)/Sandberg's bluegrass type. More widespread community types (especially big sagebrush-dominated sites) received more sampling effort. Each transect consisted of 50 trap stations spaced at 10-m intervals. Two Museum Special snap traps were baited with peanut butter and rolled oats and placed at each station. We trapped each transect for at least three nights. We added additional nights of sampling on a few sites when a high number of traps were sprung or cleaned of bait by insects. We checked traps in the morning, and reset sprung traps. For captured animals, we recorded species, body measurements (mass, total length, tail length and ear length) and reproductive data (size and state of reproductive organs and presence of embryos) in the field or during necropsy. Most transects were trapped during August and September, with a few sites sampled in late July or early October.

In 1998, we expanded our survey efforts in bunchgrass and big sagebrush/bunchgrass cover types (big sagebrush/bluebunch wheatgrass and needle-and-thread communities) in the Saddle Mountains and on Umtanum Ridge. We used Sherman live traps and pitfall traps to ensure that our conclusions about species occurrence did not reflect the sampling bias of any single trap type. At each site, two parallel lines of 25 trap stations (50 stations per site) were established, and two Sherman traps were placed at each station. The lines were 30 m apart, with 10 m between each station on a line. Thirty pitfall trap stations were installed around each Sherman transect pair in six lines of five traps, with 10 m between traps in a line. Pitfall lines were spaced 30 and 60 m outside

TABLE 1. Plant community types sampled with snaptrap transects at the Hanford Site in 1997.

Community type[1]	Cover description	Transects	Trap nights
Antelope bitterbrush/ Indian ricegrass	Sand areas with sparse cover of ricegrass and little shrub cover; 3-5 m tall active "blowout" dunes in some areas	6	2,000
Big sagebrush/ bluebunch wheatgrass	Bunchgrass areas with or without significant sagebrush cover	4	1,300
Big sagebrush/cheatgrass	Big sagebrush stands with light cheatgrass understory	4	1,300
Big sagebrush/ Sandberg's bluegrass	Big sagebrush stands with sparse understory or light grass layer	7	2,600
Cheatgrass	Cheatgrass fields without shrub cover	5	1,700
Low elevation bunchgrass	Bunchgrass without shrub cover: needle-and-thread, or mix of needle-and-thread and sand dropseed[2] or bluebunch wheatgrass	4	1,300
Riverine (Columbia River bank)	Dense grass and lightly vegetated cobble, small trees on some sites	6	1,800
Spiny hopsage/ Sandberg's bluegrass	Low shrubs with sparse grass cover	1	300
Stiff sagebrush[3]	Low shrubs in shallow rocky soil on ridge tops	3	900

[1]Based partially on Pabst (1995) and Hall (1998).
[2]*Sporobolus cryptandrus*.
[3]*Artemisia rigida*.

of the Sherman transect pair, parallel and perpendicular to the Sherman lines. At each pitfall station, a single number 10 can was placed flush with the ground surface adjacent to shrubs or bunchgrass clumps. Sherman traps were open for 5 nights at each site. Pitfall traps were open for 3 to 5 nights.

After two sagebrush voles were captured at one site on Umtanum Ridge, we established a single trapping grid bordering this site to determine if more sagebrush voles were present. A 12 x 12 grid of stations with 10 m between stations was established, using the transect where the sagebrush voles were captured as an end line. A single Sherman trap was placed at each station, and the grid was trapped for four nights.

To evaluate whether larger trapping grids would allow more rigorous comparison of northern grasshopper mouse abundance among plant community types, we installed 5.1 ha livetrapping grids at three low elevation sites (two in bunchgrass areas, one in a sagebrush/bitterbrush cover type). Each grid was a 16 x 16 array, with 15 m between grid points. A single Sherman trap was placed at each station. Traps were left open for five nights. We briefly trapped at four large dunes on Central Hanford to investigate patterns of species occurrence. Each dune was trapped with three transects of 10 trap stations each, with 15 m between stations. A single Sherman trap was placed at each station, and the transects were trapped for two nights.

All Sherman trapping surveys used large Sherman traps covered with a wooden board. With both Sherman and pitfall traps, rolled oats and polyester batting were placed inside the traps. During sampling at the 16 x 16 grids targeting grasshopper mice, Sherman traps also were baited with bacon bits. Traps were left open during the day and checked at dawn. Each animal was marked with a numbered metal ear tag. Some juvenile pocket mice instead were marked temporarily with a black marker. Species, sex, mass, and reproductive status were recorded for captured animals, and they were released at the point of capture. Pitfall and Sherman trapping occurred during July, August, and early September.

Catch-per-effort (CPUE) results are provided for 1997 snaptrap data, and are corrected for sprung, stuck, and missing traps. We used the Multi-response Permutation Procedure (MRPP) in program BLOSSOM (Slauson et al. 1994) to test whether 1997 snaptrap capture rates differed among eight habitat types for Great Basin pocket mice, deer mice and total captures. Significance level was set at $P = 0.05$ before the research began. The single sample from the hopsage type was omitted from this analysis. We used MRPP rather than ANOVA because of the low and unequal number of transects in each habitat, and the non-normality of the data. For Great Basin pocket mice and deer mice in 1997, we classified each animal as reproductively active (males with scrotal testes, females with embryos or enlarged nipples) or inactive. We summarized the number of reproductively active and inactive animals by habitat type.

We combined the 1997 and 1998 snaptrap and Sherman trap data sets to examine species richness and the relative proportion of pocket mice and deer mice. Sites for both years were assigned to general habitat types (low elevation bunchgrass, high elevation bunchgrass, dune/ricegrass, cheatgrass, sagebrush/cheatgrass, sagebrush/Sandberg's bluegrass, sagebrush/bitterbrush, riverine, and stiff sagebrush). These habitat categories only partially matched the 1997 plant community types because some 1998 sample units covered a mix of types. One 1997 big sagebrush/cheatgrass site was assigned to the sagebrush/bitterbrush habitat for the combined analyses. Species richness was summarized by habitat type. To investigate how the proportional abundances of the two most common mice varied across sites, we computed the proportion of deer mice in the combined catch of deer and pocket mice on each site. We used generalized linear models (McCullagh and Nelder 1989) with binomial error and logit link to examine proportional abundance of these mice. We included two categorical variables: elevation (low elevation vs. ridge areas) and habitat type. The habitat type categories were nested almost completely within the elevation categories; only the sagebrush/Sandberg's bluegrass type had sites in both elevation categories. We fit models incorporating the main effects of elevation and habitat type to determine whether the simpler "elevation only" model was adequate compared to the model incorporating habitat type. We used S-PLUS 4.5 (Mathsoft Inc., Seattle WA USA) for the logit analysis.

Ground Squirrels, Chipmunks, Woodrats, and Kangaroo Rats

We performed visual searches and livetrapping surveys for Piute (*Spermophilus mollis*) and Washington ground squirrels on Central Hanford, Umtanum Ridge, and the Wahluke Slope during 1997 and 1998. Ground squirrels on Hanford west of the Columbia River were formerly classified as Townsend's ground squirrels (*S. townsendii*) (Johnson 1975; O'Farrell 1975a, 1975b; Fitzner et al. 1979; Rogers and Gano 1980; Hedlund and Rickard 1981; Gano and Rickard 1982). Based on the work of Nadler et al. (1982), these appear to be a disjunct population of Piute ground squirrels (Wilson and Reeder 1993). We initially planned to compare numbers of squirrel observations across major cover types, particularly for Piute ground squirrels. Following the lack of ground squirrel observations in our 1997 surveys and in concurrent surveys by Marr (1997), our objective in 1998 was to determine whether either species occurred in the most suitable habitat patches on Hanford outside of ALE. In May and June 1997, we surveyed 1,000-m transects for ground squirrels and burrows. During each survey, a single observer walked slowly along a fixed bearing and scanned the transect area. Transect start locations were intentionally selected to cover patches targeted for surveys. In 1997, our surveys focused on the base of Gable Mountain and low elevation plains in the northern and eastern portions of Central Hanford. In March through May 1998, we focused our survey efforts on small portions of the Hanford Site that were judged as high priority survey areas based on Marr (1997) and our 1997 field work. We targeted mainly bunchgrass and sagebrush/bunchgrass areas in the Saddle Mountains and on Umtanum Ridge and Gable Mountain/Gable Butte. We delineated search polygons in these areas, and looked for potential burrows and squirrels while hiking a meandering route through each polygon.

When we observed burrows of unknown origin during the 1997 and 1998 surveys, we used Tomahawk live traps to help determine if squirrels were present. The number of traps was variable depending on the number of potential burrows. Traps were baited with apple chunks, left open at trap sites for one or more days, and checked several times during each trap day. Captured ground squirrels were given temporary marks with a black marker, weighed, sexed, photographed, and released.

We used Tomahawk live traps during 1997 and 1998 to determine if bushy-tailed woodrats (*Neotoma cinerea*) and least chipmunks were present in rock outcrops on Hanford. Survey lines of 5-10 Tomahawk live traps spaced at 10-15 m were placed at the base of several small cliffs on Central Hanford and Umtanum Ridge. Traps were baited with rolled oats, apple pieces, or a mixture of peanut butter, molasses, and rolled oats. Traps were left open for one to five nights at each site, checked each morning, and moved to a new site following the first capture of a bushy-tailed woodrat.

During ground squirrel searches and other fieldwork, we looked for Ord's kangaroo rat burrow mounds and tracks in sandy habitat, and for least chipmunks in all areas. We performed additional brief visual searches for kangaroo rat burrows on the Wahluke Slope. Several dune areas on the Wahluke Slope were sampled with either Tomahawk live traps or Victor rat traps during July through September 1997. These surveys were supplemental to ground squirrel and general small mammal trapping surveys, which would effectively sample least chipmunks and Ord's kangaroo rats if present.

Jackrabbits

We performed vehicle spotlight surveys (Smith and Nydegger 1985) to determine whether we could effectively use distance sampling methods (Buckland et al. 1993) to estimate the density of jackrabbits on Hanford. We surveyed five routes in 1997 (one on the Wahluke Slope, four on Central Hanford) and one route on Umtanum Ridge in 1998. We selected transect routes of variable length along dirt track, gravel, and secondary/primary paved roads. Transect routes passed through a mix of cover types, including areas dominated by big sagebrush, cheatgrass, and dune vegetation. Routes were surveyed one or two times. During each nighttime survey, a truck was driven at 8-16 km/hr along the route while a single observer used a 1-million candlepower spotlight to search perpendicular to the road along the passenger side of the vehicle. Observations of jackrabbits and other species were recorded. We also noted incidental observations of jackrabbits during other daytime and nighttime surveys.

Results

Shrews and Small Rodents

In 1997, we snaptrapped at 40 sites for a total of 13,200 trap nights of sampling. We captured 427 individuals of four small mammal species (Table 2). In 1998, we trapped at 11 sites with Sherman and pitfall traps for a total of 7,889 trap nights (839 pitfall and 7,050 Sherman trap nights). We captured 578 individuals of six rodent species with

TABLE 2. Number of small mammals captured (N) and mean (SE) catch per 100 trap nights by plant community type in 1997, corrected for sprung, stuck, and missing traps. Sampling transects in plant community types are cross referenced with Figure 1.

Community Type	Great Basin pocket mouse		Northern grasshopper mouse		Deer mouse		Western harvest mouse		Total captures	
	N	$\bar{x}$ (SE)	N	$\bar{x}$ (SE)	N	$\bar{x}$ (SE)	N	$\bar{x}$ (SE)	N	$\bar{x}$ (SE)
Antelope Bitterbrush/ricegrass (1, 6, 11, 46, 47, 49)	107	5.9 (0.91)	1	0.1 (0.06)	38	2.3 (1.12)	6	0.4 (0.25)	152	8.6 (1.83)
Big sagebrush/bluebunch wheatgrass (9, 27, 35, 37)	4	0.3 (0.20)	0	0	32	2.3 (1.19)	1	0.1 (0.09)	37	2.7 (1.09)
Big sagebrush/cheatgrass (4, 15, 17, 39)	22	1.9 (1.19)	1	0.1 (0.09)	13	1.1 (1.05)	0	0	36	3.1 (2.32)
Big sagebrush/bluegrass (5, 10, 16, 26, 34, 38, 41)	57	2.3 (0.61)	0	0	6	0.2 (0.11)	1	0.0 (0.04)	64	2.6 (0.60)
Cheatgrass (2, 28, 30, 32, 42)	10	0.6 (0.36)	0	0	1	0.1 (0.07)	0	0	11	0.6 (0.33)
Low elevation bunchgrass (12, 13, 48, 50)	48	4.2 (1.22)	5	0.4 (0.35)	2	0.2 (0.18)	0	0	55	4.8 (1.53)
Riverine (18, 29, 31, 33, 40, 43)	1	0.1 (0.06)	0	0	25	1.5 (0.47)	11	0.6 (0.21)	37	2.2 (0.52)
Spiny hopsage/bluegrass (3)	3	1.1	0	0	0	0	0	0	3	1.1
Stiff sagebrush (19, 20, 36)	11	1.3 (0.11)	0	0	20	2.3 (0.46)	1	0.1 (0.12)	32	3.7 (0.46)

TABLE 3. Total individuals captured in Sherman livetraps in 1998. See text for means and standard errors from Saddle Mountain and Umtanum Ridge transects. Sampling locations are cross referenced with Figure 1.

Area	Trap nights	Mountain cottontail	Great Basin pocket mouse	Northern grasshopper mouse	Deer mouse	Western harvest mouse	Sagebrush vole	Montane vole
Saddle Mountain[1] (7, 8)	798	1	4	0	17	0	0	0
Umtanum Ridge[1] (21-24)	1,596	0	169	0	52	1	2	1
Umtanum Ridge[2] (25)	576	0	57	0	67	1	0	0
Central Hanford[3] (51)	1,280	0	29	0	1	0	0	0
Central Hanford[4] (44)	1,280	0	35	0	0	0	0	0
Wahluke Slope[5] (14)	1,280	0	115	4	0	0	0	0
Hanford dunes (45)	240	0	15	1	14	0	0	0

[1]Transects in big sagebrush/bluebunch wheatgrass and needle-and-thread communities.

[2]Captures on grid in big sagebrush/bluebunch wheatgrass and needle-and-thread community included nine deer mice and six pocket mice captured previously on an Umtanum Ridge transect.

[3]Grid in antelope bitterbrush-big sagebrush/bluebunch wheatgrass – needle-and-thread communities.

[4]Grid in big sagebrush/needle-and-thread and sand dropseed/Sandberg's bluegrass communities.

[5]Grid in big sagebrush/needle-and-thread community.

1,057 total captures, and had one capture of a mountain cottontail (*Sylvilagus nuttallii*) (Table 3). Pitfall sampling captured eight juvenile pocket mice; these captures are excluded from subsequent summaries.

The distributions of 1997 capture rates (CPUE) were significantly different among eight habitat types for Great Basin pocket mice ($P < 0.001$), deer mice ($P = 0.028$), and total captures ($P = 0.004$). Overall capture rates in 1997 were highest in dune (bitterbrush/ricegrass) sites and big sagebrush/needle-and-thread transects; capture rates in these community types were approximately 8 to12 times greater than captures in cheatgrass-dominated sites. Bitterbrush/ricegrass sites with large dunes had the highest capture rates of pocket mice and relatively high capture rates of deer mice and western harvest mice (*Reithrodontomys megalotis*). Low elevation bunchgrass sites had high capture rates of pocket mice, but low capture rates of deer mice and western harvest mice. Northern grasshopper mouse captures were extremely low, averaging approximately one capture per 2,000 trap nights in 1997. Few pocket mice (13%, 35 of 263 mice), but the majority of deer mice (69%, 95 of 137 mice), were reproductively active. High numbers of reproductively active deer mice were present in higher elevation sites as well as riverine (88% reproductively active, 22 of 25) and dune areas (76% reproductively active, 29 of 38).

During 1998 Sherman trapping, pocket mice captures on Umtanum Ridge transects (mean 42.3 individuals per site, SE = 6.92) greatly exceeded captures on Saddle Mountain crest transects (mean 2 individuals per site, SE = 0). More deer mice were captured on Umtanum Ridge sites (mean 13.0 individuals per site, SE = 4.10) than the Saddle Mountain crest (mean 8.5, SE = 0.50). Sagebrush and montane voles were captured only on Umtanum Ridge Sherman transects. Two sagebrush voles, both scrotal males, were captured on one transect. One montane vole (male, non-scrotal) was captured at another transect. Both sites were near the top of the north slope of Umtanum Ridge, on steep slopes in dense bunchgrass (bluebunch wheatgrass/needle-and-thread) with loose soil and no shrub cover. Other 1997 and 1998 Umtanum Ridge transects were on the crest or on the gently sloping south side of the ridge. No sagebrush voles were captured at the 12 x 12 Sherman grid even though one grid edge overlapped the transect (and trap stations) where the two sagebrush voles were captured and released two weeks earlier. The Umtanum Ridge grid had high numbers of both pocket mice and deer mice. At the three low elevation grids, nearly all captures were of pocket mice. Northern grasshopper mice were captured at only one of these grids. Deer mice were captured frequently during 1998 trapping at four large active dunes on Central Hanford.

Species richness was low on the 51 sites sampled with snap traps or Sherman traps in 1997 and 1998, with zero (3 sites), one (16 sites), two (21 sites), three (9 sites) or four (2 sites) rodent species captured (Table 4). Cheatgrass, big sagebrush/cheatgrass, and hopsage areas averaged one or fewer species per site. Sites with large active dunes had the highest average species richness. In both years, the Great Basin pocket mouse was the most frequently captured species. Most (96%) individuals captured were pocket mice or deer mice. Captures of Great Basin pocket mice exceeded those of deer mice at all low elevation sites except for riverine transects and four sites (three cheatgrass, one sagebrush/cheatgrass) where no pocket mice and one or zero deer mice were captured. At low elevation upland areas, deer mice were captured in greatest numbers at bitterbrush/ricegrass sites with large active dunes, usually making up slightly less than 50% of the combined catch of pocket and deer mice. In bitterbrush/ricegrass sites without active dunes, deer mice were 0-3% of the combined catch. The relative abundance of deer mice and pocket mice at higher elevation areas varied. Deer mouse captures were greater than pocket mouse captures in bunchgrass patches in the Saddle Mountains and Gable Mountain, and at all stiff sagebrush patches trapped. Pocket mice captures were higher than deer mice captures in most bunchgrass and big sagebrush sites on Umtanum Ridge, although more deer mice than pocket mice were captured on the Umtanum trap grid. In the analysis of deer mouse proportional abundance, the logit model incorporating the main effects of habitat type and elevation (residual deviance 191.2, residual df = 36) was selected over the model including only elevation (residual deviance 371.5, residual df = 44).

During both years, the western harvest mouse was captured infrequently in upland habitats. Upland captures of this species were at trap stations near cover, particularly near dense patches of Russian thistle (*Salsola kali*) "tumbleweeds" at the base of large active dunes. Harvest mice were captured on most (five of six) riverine transects, generally at trap stations in or near dense grass cover or debris piles. The northern grasshopper mouse was captured only at low elevation, sandy-soiled areas. Nearly all captures of northern grasshopper mice occurred in a ~1,600-2,000 ha area of needle-and-thread bunchgrass on the Wahluke Slope. Of seven grasshopper mouse captures in 1997, five were from two transects in this patch. Four of the five grasshopper mice captured in 1998 were from the 5-ha grid in this patch. These sampling locations were separated by several hundred meters.

Ground Squirrels, Chipmunks, Woodrats, and Kangaroo Rats

In 1997 we did not see ground squirrels and or any holes likely to be ground squirrel burrows during 23 ground squirrel surveys along 22

TABLE 4. Species richness (mean (SE)) of rodents and proportion of deer mice[1] in general habitat categories sampled with Sherman and snap traps, 1997-1998. Sampling locations are cross referenced with Figure 1.

General Habitat	Species Richness	Proportion of of Deer Mice
Bitterbrush/sagebrush (15, 51)	2.5 (0.50)	0.24 (0.21)
Cheatgrass (2, 28, 30, 32, 42)	0.6 (0.24)	0.33 (0.33)
Bitterbrush/ricegrass dune (1, 6, 11, 45-47, 49)	2.3 (0.42)	0.24 (0.09)
Active dune sites[2] (11, 45, 46, 49)	3.0 (0.41)	0.42 (0.07)
High elevation bunchgrass (7-9, 21-25, 27, 35, 37)	2.3 (0.27)	0.57 (0.10)
Hopsage (3)	1.0	0
Low elevation bunchgrass (12-14, 44, 48, 50)	1.7 (0.21)	0.02 (0.02)
Riverine (18, 29, 31, 33, 40, 43)	1.8 (0.31)	0.98 (0.02)
Sagebrush/cheatgrass (4, 17, 39)	1.0 (0.58)	0.08 (0.08)
Sagebrush/Sandberg's bluegrass (5, 10, 16, 26, 34, 38, 41)	1.7 (0.29)	0.15 (0.07)
Stiff sagebrush (19, 20, 36)	2.3 (0.33)	0.63 (0.07)

[1]Proportion of deer mice individuals in combined deer mouse and Great Basin pocket mouse captures, excluding four sites where neither species was captured.
[2]Subset of bitterbrush/ricegrass dune sites.

transects (two on the Wahluke Slope, 20 on Central Hanford). No animals were captured during 106 trap days with Tomahawk traps at five sites during June 1997. In 1998, we performed visual searches in 17 survey patches. We did not observe ground squirrels or their burrows at Gable Mountain, Gable Butte, or low elevation survey patches. On Umtanum Ridge, large (10-cm diameter) holes dug into the side of cut banks were probably Piute ground squirrel burrows from a previous year. We did not observe squirrels at these holes in May or capture any animals during 30 trap days with Tomahawk traps in July.

In 1998, we observed at least nine Washington ground squirrels inside the northern border of the site along the Saddle Mountain crest. These observations were in a nearly continuous area of big sagebrush/bluebunch wheatgrass and big sagebrush/needle-and-thread community types. Active burrows were present in clusters throughout this area. We captured two Washington ground squirrels, including two captures of one pregnant or lactating female, during 156 trap days in this area, and observed young-of-the-year at one group of burrows. During some surveys, numerous high-pitched alarm calls indicated that many more squirrels were present than were seen. Washington ground squirrels were not seen in other Saddle Mountain survey patches within the site boundary, which were in rockier soils or disturbed areas.

We captured six bushy-tailed woodrats in 217 trapnights at cliff areas in 1997 and 1998. No other species were captured. Bushy-tailed woodrats were captured in all cliff areas sampled, including Gable Mountain, Gable Butte, and at Umtanum Ridge. Throughout both years of sampling, we did not capture or observe least chipmunks or Ord's kangaroo rats. We observed no obvious kangaroo rat burrow mounds on any part of the Hanford Site. In addition to trapping discussed previously, sampling for kangaroo rats included 145 trapnights at three sandy-soiled areas on the Wahluke Slope during July through September 1997.

Jackrabbits

We observed five black-tailed jackrabbits and one unidentified jackrabbit during spotlight surveys in 1997 and 1998. Total transect length was 100.7 km. Total survey distance was 118.5 km because two routes were visited twice. Three of the jackrabbits were observed during a single survey of the 4.5-km Umtanum Ridge route; the others were observed on Central Hanford routes. In addition to these spotlight survey observations, we observed repeatedly one to four black-tailed jackrabbits along a portion of the Umtanum Ridge route when we drove it during daylight hours for other surveys. Two dead white-tailed jackrabbits were observed on ALE during daytime driving. We also observed a road-killed white-tailed jackrabbit during daytime driving on Central Hanford, an area from which white-tailed jackrabbits have not been reported.

Discussion

Our data strongly support the conclusion that Merriam's shrews, least chipmunks, and sagebrush voles are rarely present in lower elevation areas of Hanford, as reported in previous reviews (e.g., Fitzner and Gray 1991, Downs et al. 1993). In addition, these species are absent or sparsely distributed in ridge areas that had received little or no sampling effort in previous studies. To our knowledge, the only other reported occurrence of these species on Hanford outside of ALE was of a single sagebrush vole captured on Central Hanford (Hedlund and Rogers 1976). In Washington, these species often have been noted as being found in higher elevation shrub-steppe areas, with sagebrush voles reaching lower elevations than Merriam's shrews and least chipmunks. Portions of Umtanum Ridge and the Saddle Mountains on Hanford are at the low end of the elevational range in which Merriam's shrew and the least chipmunk have been captured in Washington. Gable Mountain is below this range, lower than nearly all sagebrush vole capture locations on ALE, and isolated from larger areas of suitable habitat. Even on ALE, few captures or observations of least chipmunks have been reported. Johnson and Cassidy (1997) conclude that the least chipmunk probably does not occur below 300 m in Washington. On ALE, Merriam's shrews were captured in slight draws between 636-960 m (Corey A. Duberstein, Pacific Northwest National Lab, Richland, Washington, personal communication) and in old field and sagebrush/bunchgrass habitats at approximately 533 m (Gano et al. 1983). Wunder et al. (1994) captured these three species at the Yakima Training Center (YTC) on sites ranging from 512-1,097 m. Johnson and Clanton (1954) reported that Merriam's shrews had been captured only near sagebrush vole populations, and that sagebrush voles could tolerate more arid sites than the Merriam's shrew. Nearly all captures of sagebrush voles recorded by O'Farrell (1972) on ALE occurred above 300 m, with most captures on sites above 600 m. O'Farrell (1972) captured no sagebrush voles at two locations on Gable Mountain.

Although sagebrush voles occur most frequently in big sagebrush stands with an understory of bluebunch wheatgrass (O'Farrell 1972), our sagebrush vole captures on Umtanum Ridge were in a bunchgrass patch with almost no sagebrush cover. Fires prior to our study may have burned off the shrub cover in this patch. Throughout Hanford, continued loss of shrub cover from fires may have affected the distribution and densities of shrub-steppe mammals.

Our results and those of previous studies indicate that low elevation areas of Hanford complement, rather than duplicate, the role of higher elevation areas, such as on much of ALE and the YTC, in conserving Washington's shrub-steppe mammals. Several species of concern or of high importance as prey are uncommon or absent from much of Hanford, but are widespread at the YTC. Wunder et al. (1994) captured sagebrush voles at all sites and Merriam's shrews at most sites sampled at the YTC, and observed or captured least chipmunks in all big sagebrush/bluebunch wheatgrass sampling grids. Wunder et al. (1994) did not capture northern grasshopper mice, and captured few Great Basin pocket mice. Rogers et al. (1989) captured no Merriam's shrews at YTC, but the composition of their rodent captures was similar to that of Wunder et al. (1994). Piute ground squirrels and least chipmunks were widespread and easily observed at the YTC during the springs of 1993 and1994 (Mattias Leu, University of Washington, Seattle, personal communication).

At low elevations of Hanford, areas of sandy soils within a few kilometers of the Columbia River have been protected. Such habitats have been converted to agricultural use in most adjacent areas. Active dune areas were unique among low elevation areas in supporting high numbers of both pocket mice and deer mice. Although these species are among the most common mammals in the Columbia Basin, high populations of mice in dune areas (and of pocket mice in most sandy areas) provide an important prey base. In addition, pocket mice hibernate during much of the winter, potentially increasing the importance of low elevation areas supporting numerous deer mice.

Our results for deer mice in active dune fields contrast with patterns observed previously in other low elevation habitats. During the summer, deer mice are usually absent or uncommon in most low elevation habitats except riparian areas, and are reproductively active during the summer only at higher elevations (Kritzman 1974; Hedlund et al. 1975; O'Farrell 1975a, 1975b; Gano 1979). In this study, active dune areas supported a relatively high number of deer mice, most of which were reproductively active during the late summer (August to September). Dune and riverine areas were low elevation sites that supported moderate to high proportions of deer mice. Consequently, the logit model incorporating only elevation was inferior to the model incorporating habitat type in the analysis of deer mouse and pocket mouse proportional abundance. Although some reviews consider most of Hanford to be too hot and dry for western harvest mice (Johnson and Cassidy 1997), we captured six western harvest mice at two dune transects on Central Hanford and one harvest mouse at a low elevation sagebrush/Sandberg's bluegrass site on the Wahluke Slope. We also caught western harvest mice in ridge areas and along the Columbia River. Western harvest mice have been captured previously in low numbers on Central Hanford and ALE (e.g., O'Farrell et al. 1975, Fitzner et al. 1979, Gano 1979, Gano et al. 1983, Marr et al. 1988).

Low elevation sandy habitat such as the large needle-and-thread bunchgrass area on the Wahluke Slope may be important in providing suitable areas for the northern grasshopper mouse. Of the shrews and small rodents in Washington's shrub-steppe, the northern grasshopper mouse could be among the most vulnerable to extirpation, particularly in small fragments. It has low density even in good habitat, has a large home range, and occupies low elevation, sandy areas that are converted frequently to irrigated agriculture. Even in the area that supported our highest capture rates of grasshopper mice, our captures were too low to allow mark-recapture estimation of its abundance. In most Hanford studies, captures of northern grasshopper mice were limited to a few individuals per year, preventing detailed analysis (e.g., Gano and Rickard 1982). However, O'Farrell et al. (1975) captured 63 northern grasshopper mice during the first 21 months of sampling at a sagebrush/Sandberg's bluegrass plot on ALE. After a severe winter, the mice disappeared and were not captured during the remainder of the 5-yr study.

Previous reviews listed the Washington ground squirrel as being absent or unconfirmed on Hanford (Rickard and Poole 1989), but Booth (1947) mapped a record for White Bluffs that appears to be within the Wahluke Slope portion of Hanford. Although we observed Washington ground squirrels in only a small portion of the site, any existing population of this species is of significance given its status (Betts 1999). Patterns of occupancy we observed are consistent with Betts (1990), who found that Washington ground squirrels occupied sites with greater grass and forb cover and deeper soils than unoccupied sites. Based on the high number of alarm calls heard during some surveys, we suspect that several dozen Washington ground squirrels were present within the site boundary. The population may extend outside the site boundary on the north slope of the Saddle Mountains, where suitable bunchgrass habitat seemed abundant. The lack of observations of Piute ground squirrels in this study and Marr (1997) is somewhat unexpected, given that this species is reported to be widespread on Hanford (Fitzner and Gray 1991). Piute ground squirrels have been captured frequently on ALE, but only a few observations of this species have been documented on Central Hanford (Fitzner et al. 1979, Gano and Rickard 1982). As discussed by Marr (1997), the shallow soils and low precipitation found across low elevations of Hanford may provide unsuitable or low-quality habitat for ground squirrels.

Black-tailed jackrabbits are widespread on Hanford, but we observed too few during spotlight sampling to estimate density. Based on our observation rates, one would need to drive 1,100-1,600 km of transects on Hanford to obtain the minimum sample size of 60-80 observations recommended by Buckland et al. (1993) for density estimation with distance sampling methods. Using spotlight surveys with fixed width transects, Vaughan (1977) estimated black-tailed jackrabbit densities for the Hanford Site at 23.9 per km^2, but we were unable to determine his jackrabbit observation rate. We do not know whether seasonal changes, yearly fluctuations, or long-term trends contributed to our low detection rates.

We assume that our methods effectively sampled the targeted species. Although our 1997 ground squirrel surveys occurred when most adults and many juveniles may have entered dormancy (Scheffer 1941), we would have observed obvious burrows if ground squirrels were present earlier in the spring. Small shrews such as Merriam's shrew are sampled most effectively with pitfall traps (Hudson and Bacon 1956, Williams and Braun 1983). Our pitfall sampling targeted the areas outside of ALE most likely to support Merriam's shrew. The intensive Sherman and snap trapping of this and previous Hanford studies is likely to have captured Merriam's shrews if present. At the Yakima Training Center, capture rates of Merriam's shrews were not significantly different between pitfall and Sherman traps, although mean CPUE was much higher in pitfall traps (Wunder et al. 1994). Snap trapping underestimates the abundance and occurrence of small shrews (Brown 1967), but the method does capture them. On ALE, Gano et al. (1983) captured eight Merriam's shrews during 16,000 trap nights with snap traps and Sherman traps. Other studies also captured Merriam's shrews in snap traps (Hudson and Bacon 1956, Mullican 1986).

Several other areas of Hanford were of special interest in terms of their small mammal communities. Umtanum Ridge provides a high diversity of habitats, including bunchgrass patches, big sagebrush stands in loamy soils, stiff sagebrush stands in rocky soils, and the most extensive cliff areas on Hanford. These habitats support bushy-tailed woodrats, high numbers of pocket mice and deer mice, and possibly higher jackrabbit densities than much of the site. Sagebrush voles and perhaps Piute ground squirrels are present. Umtanum Ridge may be important from a landscape perspective because it extends through the Yakima Training Center up into the eastern Cascades, connecting Hanford with other large areas of shrub-steppe habitat (Hall 1998). In the Saddle Mountains, surveys are needed to determine if the Merriam's shrew, least chipmunk, and sagebrush vole occur outside of the site boundary. Johnson and Cassidy (1997) modeled this area as suitable habitat for these species, but listed no records. We also recommend additional inventories in the southeast part of the Wahluke Slope, which received little sampling effort in this or previous studies.

Current species occurrence in most shrub-steppe areas of Washington outside of Hanford and the YTC, and population trends for most species throughout the Columbia Basin, deserve further attention. Given the variation of small mammal community composition among management areas such as the YTC and much of Hanford, current patterns could best be studied with a regional approach that encompasses a wide gradient of habitat conditions, such as was done by Vander Haegen et al. (2000) for birds. Even in well-studied areas such as ALE, large-scale fires in 1984 and 2000 may have changed significantly patterns that were documented several decades ago.

Acknowledgements

The Nature Conservancy of Washington funded this work under contracts 106656 and 112914 to S.D. West. We thank Jonathan Soll of the Nature Conservancy for initiating this work and for his guidance regarding survey priorities. We thank J. Baumgardt, L. Dargis, and K. Kaczorowski for help with field data collection, and numerous people who provided information, suggestions, and relevant reports, including L. Cadwell, C. Duberstein, K. Gano, J. Hall, M. Leu, D. Major, M. Pounds, C. Quade, J. Rozdilsky, L. Rogers, B. Tiller, and L. Wunder. Bechtel Hanford, Inc. provided GIS maps. Hanford Patrol and other Hanford personnel facilitated our field activities.

Literature Cited

Betts, B.J. 1990. Geographic distribution and habitat preferences of Washington ground squirrels (*Spermophilus washingtoni*). Northwestern Naturalist 71:27-37.

Betts, B.J. 1999. Current status of Washington ground squirrels in Oregon and Washington. Northwestern Naturalist 80:35-38.

Booth, E.S. 1947. Systematic review of the land mammals of Washington. Ph.D. Dissertation, State College of Washington, Pullman, Washington.

Brown, L.N. 1967. Ecological distribution of six species of shrews and comparison of sampling methods in the central Rocky Mountains. Journal of Mammalogy 48:617-623.

Buckland, S.T., D.R. Anderson, K.P. Burnham, and J.L. Laake. 1993. Distance Sampling: Estimating Abundance of Biological Populations. Chapman and Hall, London, UK.

Dobler, F.C., J. Eby, C. Perry, S. Richardson, and M. Vander Haegen. 1996. Status of Washington's shrub-steppe ecosystem: extent, ownership, and wildlife/vegetation relationships. Washington Department of Fish and Wildlife, Olympia, Washington.

Downs, J.L., W.H. Rickard, C.A. Brandt, L.L. Cadwell, C.E. Cushing, D.R. Geist, R.M. Mazaika, D.A. Neitzel, L.E. Rogers, M.R. Sackschewsky, and J.J. Nugent. 1993. Habitat types on the Hanford Site: wildlife and plant species of concern. PNL-8942. Pacific Northwest Laboratory, Richland, Washington.

Fitzner, R.E., K.A. Gano, W.H. Rickard, and L.E. Rogers. 1979. Characterization of the Hanford 300 Area burial grounds: Task IV – Biological Transport. PNL-2774. Pacific Northwest Laboratory, Richland, Washington.

Fitzner, R.E., and R.H. Gray. 1991. The status, distribution and ecology of wildlife on the U.S. DOE Hanford Site: a historical overview of research activities. Environmental Monitoring and Assessment 18:173-202.

Fitzner, R.E., W.H. Rickard, L.L. Cadwell, and L.E. Rogers. 1981. Raptors of the Hanford Site and nearby areas of southcentral Washington. PNL-3212. Pacific Northwest Laboratory, Richland, Washington.

Fitzner, R.E., S.G. Weiss, and J.A. Stegen. 1994. Threatened and endangered wildlife species of the Hanford Site related to CERCLA characterization activities. WHC-EP-0513. Westinghouse Hanford Company, Richland, Washington.

Franklin, J. F., and C. T. Dyrness. 1988. Natural Vegetation of Oregon and Washington. Oregon State University Press, Corvallis, Oregon.

Gano, K.A. 1979. Analysis of small mammal populations inhabiting the environs of a low-level radioactive waste pond. PNL-2479. Pacific Northwest Laboratory, Richland, Washington.

Gano, K.A., and W.H. Rickard. 1982. Small mammals of a bitterbrush-cheatgrass community. Northwest Science 56:1-7.

Gano, K.A., J.R. Skalski, J.L. Badden, and L.E. Rogers. 1983. The effects of habitat on recapture probabilities of small mammals. PNL-SA-10159. Pacific Northwest Laboratory, Richland, Washington.

Gerber, M. 2000. 2000 Hanford fire most intense, not biggest. Hanford Reach 2000 July 17:3-5.

Gray, R.H., and W.H. Rickard. 1989. The protected area of Hanford as a refugium for native plants and animals. Environmental Conservation 16:251-260 and 215-216.

Hall, J. A. (editor). 1998. Biodiversity inventory and analysis of the Hanford Site: 1997 annual report. Report by the Nature Conservancy of Washington, Seattle, Washington.

Hedlund, J.D., D.T. McCullugh, and W.H. Rickard. 1975. Mouse populations on knob and kettle topography in south-central Washington. Northwest Science 49:253-260.

Hedlund, J.D., and W.H. Rickard. 1981. Wildfire and the short-term response of small mammals inhabiting a sagebrush-bunchgrass community. The Murrelet 62:10-14.

Hedlund, J.D., and L.E. Rogers. 1976. Characterization of small mammal populations inhabiting the B-C cribs environs. BNWL-2181. Battelle, Pacific Northwest Laboratory, Richland, Washington.

Hudson, G. E., and M. Bacon. 1956. New records of *Sorex merriami* for eastern Washington. Journal of Mammalogy 37:436-438.

Johnson, M.K. 1975. Interspecific associations of *Peromyscus maniculatus*, *Perognathus parvus*, and *Spermophilus townsendi* on the Arid Land Ecology Reserve examined by diet overlap and related data. BNWL-1929. Battelle, Pacific Northwest Laboratories, Richland, Washington.

Johnson, M. L., and C.W. Clanton. 1954. Natural history of *Sorex merriami* in Washington State. The Murrelet 35:1-4.

Johnson, R.E., and K.M. Cassidy. 1997. Terrestrial mammals of Washington State: Location data and predicted distributions. Volume 3 *In* K.M. Cassidy, C.E. Grue, M.R. Smith, and K.M. Dvornich (editors), Washington State Gap Analysis – Final Report. Washington State Cooperative Fish and Wildlife Research Unit, University of Washington, Seattle, Washington.

Kritzman, E.B. 1974. Ecological relationships of *Peromyscus maniculatus* and *Perognathus parvus* in eastern Washington. Journal of Mammalogy 55:172-188.

Marr, N.V., C.A. Brandt, R.E. Fitzner, and L.D. Poole. 1988. Habitat associations of vertebrate prey within the Controlled Area Study Zone. PNL-6495. Pacific Northwest Laboratory, Richland, Washington.

Marr, V. 1997. Washington ground squirrels and pygmy rabbit surveys, North Slope and Central Hanford, Hanford Nuclear Reservation, Washington 1997. Report for the Nature Conservancy of Washington, Seattle, Washington.

McCullagh, P., and J.A. Nelder. 1989. Generalized Linear Models. Chapman and Hall, London UK.

Mullican, T.R. 1986. Additional records of *Sorex merriami* from Idaho. The Murrelet 67:19-20.

Nadler, C.F., R.S. Hoffmann, N.N. Vorontsov, J.W. Koeppl, L. Deutsch, and R.I. Sukernik. 1982. Evolution in ground squirrels: II. Biochemical comparisons in Holarctic populations of *Spermophilus*. Zeitschrift für Säugetierkunde 47:198-215.

Neitzel, D.A. (editor). 1996. Hanford Site National Environmental Policy Act (NEPA) characterization. PNL-6415, Rev 8. Pacific Northwest Laboratory, Richland, Washington.

O'Farrell, T.P. 1972. Ecological distribution of sagebrush voles, *Lagurus curtatus*, in south-central Washington. Journal of Mammalogy 53:632-636.

O'Farrell, T.P. 1975a. Small mammals, their parasites and pathologic lesions on the Arid Lands Ecology Reserve, Benton County, Washington. American Midland Naturalist 93:377-387.

O'Farrell, T.P. 1975b. Seasonal and altitudinal variations in populations of small mammals on Rattlesnake Mountain, Washington. American Midland Naturalist 94:190-204.

O' Farrell, T.P., R.J. Olson, R.O. Gilbert, and J.D. Hedlund. 1975. A population of Great Basin pocket mice, *Perognathus parvus*, in the shrub-steppe of south-central Washington. Ecological Monographs 45:1-28.

Pabst, R.J. (editor). 1995. Biodiversity inventory and analysis of the Hanford Site: 1994 annual report. Report by the Nature Conservancy of Washington, Seattle, Washington.

Received 16 November 2000
Accepted for publication 7 May 2001

Rickard, W.H., J.D. Hedlund, and R.G. Schreckhise. 1974. Mammals of the Hanford Reservation in relation to management of radioactive waste. BNWL-1877. Battelle, Pacific Northwest Laboratories, Richland, Washington.

Rickard, W.H., and L.D. Poole. 1989. Terrestrial wildlife of the Hanford Site: past and future. Northwest Science 63:183-193.

Rickard, W.H., and D.G. Watson. 1985. Four decades of environmental change and their influence upon native wildlife and fish on the Mid-Columbia River, Washington, USA. Environmental Conservation 12:241-248.

Rogers, L.E., P.A. Beedlow, L.E. Eberhardt, D.D. Dauble, and R.E. Fitzner. 1989. Ecological baseline study of the Yakima Firing Center proposed land acquisition: a status report. PNL-6485 Rev.1. Pacific Northwest Laboratory, Richland, Washington.

Rogers, L.E., and K.A. Gano. 1980. Townsend ground squirrel diets in the shrub-steppe of southcentral Washington. Journal of Range Management 33:463-464.

Scheffer, T.H. 1941. Ground squirrel studies in the Four-Rivers Country, Washington. Journal of Mammalogy 22:270-279.

Slauson, W.L., B.S. Cade, and J.D. Richards. 1994. User's manual for BLOSSOM Statistical Software. Midcontinent Ecological Science Center, U.S. Geological Survey, Fort Collins, Colorado.

Smith, G.W., and N.C. Nydegger. 1985. A spotlight, line-transect method for surveying jack rabbits. Journal of Wildlife Management 49:699-702.

U.S. Department of Energy. 1999. Final Hanford comprehensive land-use plan environmental impact statement (HCP EIS), Hanford Site, Richland, Washington. DOE/EIS-0222-F. U.S. Department of Energy, Richland, Washington.

Vander Haegen, W.M., F.C. Dobler, and D.J. Pierce. 2000. Shrubsteppe bird response to habitat and landscape variables in eastern Washington, U.S.A. Conservation Biology 14:1145-1160.

Vaughan, B.E. 1977. Pacific Northwest Laboratory annual report for 1976 to the ERDA assistant administrator for environment and safety, Part 2: ecological sciences. BNWL-2100 PT2. Battelle, Pacific Northwest Laboratories, Richland, Washington.

Washington Department of Fish and Wildlife. 2000. Species of concern in Washington State. Washington Department of Fish and Wildlife Species of Concern. Available online at http://www.wa.gov/wdfw/wlm/diversty/soc/soc.htm.

Williams, D.F., and S.E. Braun. 1983. Comparison of pitfall and conventional traps for sampling small mammal populations. Journal of Wildlife Management 47:841-845.

Wilson, D.E., and D.M. Reeder (editors). 1993. Mammal Species of the World: a Taxonomic and Geographic Reference. Second edition. Smithsonian Institution Press, Washington, D.C.

Wunder, L., A. Young, A. Bidlack, and A.B. Carey. 1994. Establishment and final report: shrub steppe biodiversity studies, state candidate small mammal and passerine study. Part I. Distribution and relative abundance of Merriam's shrew on the Yakima Training Center, Yakima, Washington. Forestry Science Laboratory, Pacific Northwest Research Station, Olympia, Washington.