

## Terrestrial Wildlife of the Hanford Site: Past and Future

### Abstract

The undeveloped land of the U.S. Department of Energy's Hanford Site provides habitat suitable for a few shrubsteppe animal species whose populations are diminishing elsewhere in eastern Washington, primarily due to the conversion of native stands of vegetation to crop plants. To sustain isolated remnant populations in the future requires information on the habitat requirements of each species. The balance between the extent of natural perturbations, such as wildfire, and the human-induced vegetational changes, such as conversion of stands of native vegetation to crop plants or maintenance of grasses instead of shrubs and grasses to provide more livestock forage, has long-term implications for sustaining threatened and endangered species as well as other native wild animals in semiarid eastern Washington and the shrubsteppe region in general. The Hanford Site, by virtue of its large size (1400 km<sup>2</sup>) and its conservative use of land, provides a refugium for native wildlife populations in the absence of farming and/or livestock grazing.

### Introduction

Wildlife populations inhabiting the 1400 km<sup>2</sup> of mostly undeveloped land that the Hanford Site now occupies received little or no scientific attention during the years following the advent of regional livestock grazing (circa 1850) and crop cultivation (circa 1880).

In 1943, the land was acquired by the federal government as a site for the production of nuclear materials (Figure 1). The sparse resident human population was relocated, livestock grazing and farming ceased, and the general public was excluded from using the land. The impact of a century of livestock grazing, irrigated and dryland agriculture, and urbanization (two small towns, Hanford and White Bluffs) upon native wildlife populations was not scientifically documented.

Following the relocation of the human population from the Hanford Site, abandoned agricultural fields became self-colonized by a few species of weedy annual plants. These plants, all Eurasian introductions, are now persistent members of the flora. Cheatgrass, *Bromus tectorum*, tumble mustard, *Sisymbrium altissimum*, jagged chickweed, *Holosteum umbellatum*, yellow salsify, *Tragopogon dubius*, and wild lettuce, *Lactuca serriola*, are especially abundant. Re-invasion of the abandoned fields by native plants has been a slow process, mostly because of the intense competition for soil water and nutrients provided by the aliens (Daubenmire 1970, 1975; Rickard and Sauer 1982; Rickard and Rogers 1983).

For the purpose of this review, shrubsteppe habitat consists of stands of desert shrubs with an understory consisting mostly of grasses. Shrubsteppe wildlife species are those that can successfully breed and reproduce using the resources provided mostly by shrubsteppe plant communities.

Mature shrubsteppe plant communities on the Hanford Site are usually dominated by big sagebrush, *Artemisia tridentata*, with scattered stands of antelope bitterbrush, *Purshia tridentata*, rabbitbrush, *Chrysothamnus nauseosus*, spiny hopsage, *Grayia sponosa*, or greasewood, *Sarcobatus vermiculatus*. The most abundant native grasses are bluebunch wheatgrass, *Agropyron spicatum*, Sandberg's bluegrass, *Poa sandbergii*, needle-and-thread, *Stipa comata*, Indian ricegrass, *Oryzopsis hymenoides*, and prairie junegrass *Koeleria cristata*. Native forb species include balsamroot, *Balsamorhiza careyana*, lupine, *Lupinus* spp., long-leaved phlox, *Phlox longifolia*, hawksbeard, *Crepis atribarba*, scarlet globemallow, *Sphaeralcea munroana*, and evening primrose, *Oenothera pallida*, among others. The few native trees, cottonwoods, *Populus* spp., and willows, *Salix* spp., are restricted to the wet shoreline of the Columbia River and the few spring streams in the Rattlesnake Hills.

Before 1960, cattle had grazed the land adjacent to these spring streams for many years, suppressing the growth of the woody plants. When cattle grazing was terminated by fencing, the streamside vegetation recovered quickly (Rickard and Cushing 1982).

Exotic deciduous trees were planted and irrigated around farm houses for shade and as

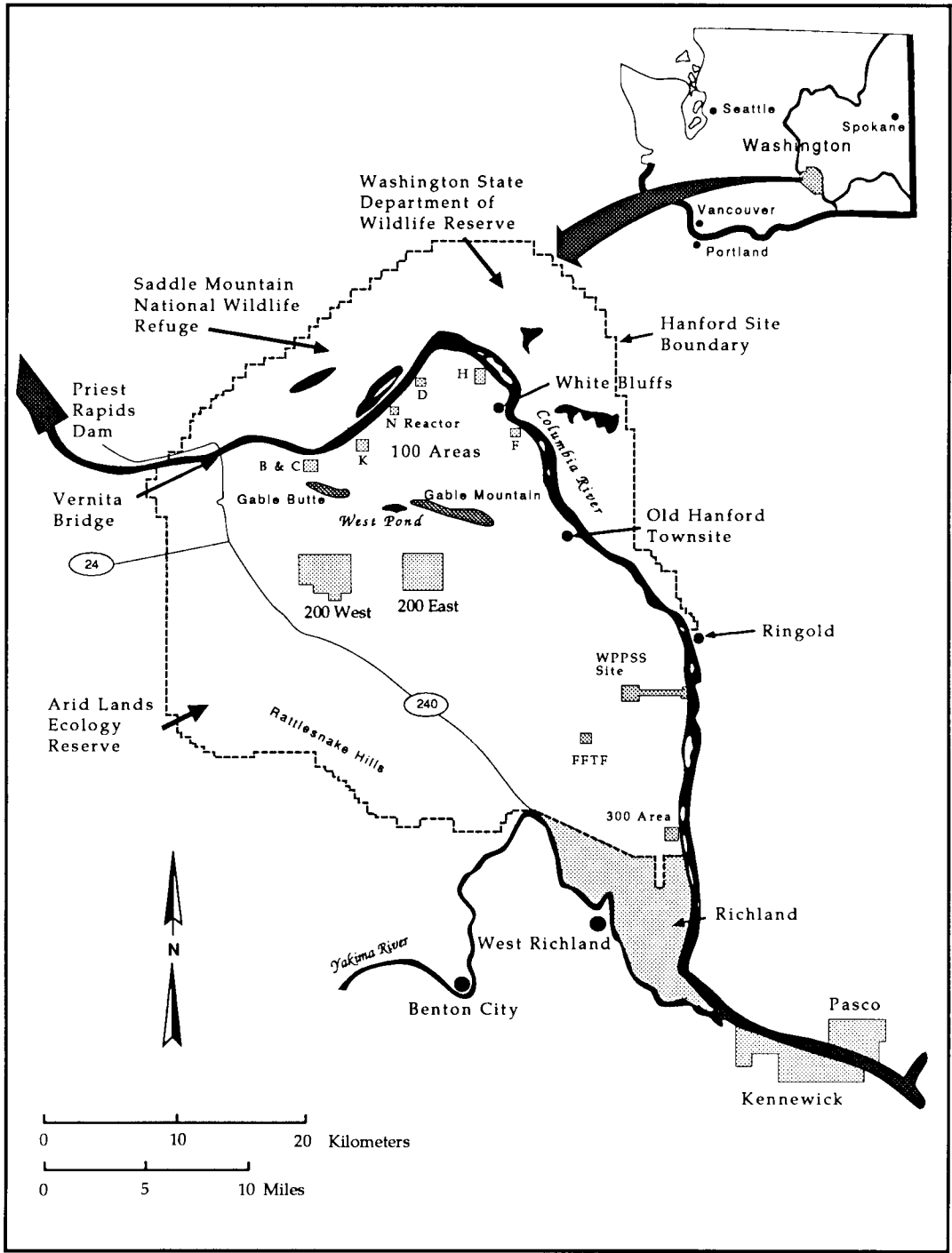


Figure 1. Outline Map of the U.S. Department of Energy's Hanford Site.

windbreaks by residents in the decades before 1943. These trees, mostly black locusts, *Robinia pseudoacacia*, and Siberian elms, *Ulmus pumila*, have not been artificially irrigated since the residents were relocated. Many trees have died, but others are still alive, although they do not reproduce by seedlings.

The large buildings associated with nuclear materials production are clustered at widely spaced locations on the Hanford Site. The reactor buildings (100 Areas) are all situated on the western shoreline of the Columbia River (Figure 1). The chemical separation buildings are located in the 200 East and 200 West Areas near the center of the Hanford Site. The 300 Area, located in the extreme southeastern corner, contains the uranium fuel fabrication facilities as well as numerous other buildings associated with laboratory research. Other building clusters include the Fast Flux Test Facility (FFTF) and the commercial nuclear power stations, WNP-1, 2 and 4, owned by the Washington Public Power Supply System (WPPSS). All building clusters are connected by roadways, railroad tracks, and electrical transmission lines. However, most of the land between the clusters is undeveloped and provides stands suitable for sustaining populations of shrubsteppe birds, mammals, reptiles, and amphibians.

The Arid Land Ecology (ALE) Reserve is a special area of relatively undisturbed land (260 km<sup>2</sup>) located in the southwestern sector of the Hanford Site (Figure 1 and Figure 2). There are no industrial buildings on the reserve. The ALE reserve was designated as an environmental research area in 1967.

### Land Use and Shrubsteppe Wildlife

Land use on the Hanford Site over the last 45 years has not been changed as much as has the surrounding land. In 1952, irrigation water was delivered to the Columbia Irrigation Project, and irrigated crops today occupy thousands of hectares of formerly shrubsteppe habitat (Figure 3). Although the many lakes and seeps formed by irrigation waters have benefited wildlife, such as waterfowl, it has been detrimental to local populations of most native terrestrial species by destroying their habitats.

The shrubsteppe birds, mammals, and reptiles that have been most adversely affected by

agricultural land use have been identified by the Washington Department of Wildlife (1987) and the U.S. Fish and Wildlife Service (1985). Those species thought to be in most need of protection, and that are known or thought to inhabit the Hanford Site, are listed below:

#### Birds

Sage grouse, *Centrocercus urophasianus*  
Sage sparrow, *Amphispiza belli*  
Sage thrasher, *Oreoscoptes montanus*  
Loggerhead shrike, *Lanius ludovicianus*  
Long-billed curlew, *Numenius americanus*  
Swainson's hawk, *Buteo swainsoni*  
Ferruginous hawk, *Buteo regalis*  
Burrowing owl, *Athene cunicularia*

#### Mammals

Merriam's shrew, *Sorex merriami*  
Pygmy rabbit, *Sylvilagus idahoensis* (?)

#### Reptiles

Striped whipsnake, *Masticophis taeniatus*

The Hanford Site provides habitat suitable for wide-ranging species, including elk, *Cervus elaphus*; mule deer, *Odocoileus hemionus*; coyote, *Canis latrans*; and black-tailed jackrabbits, *Lepus californicus*. These wild animals are usually not tolerated at all, or their populations are artificially suppressed to low-levels, if they inhabit or intrude upon farmlands because of the damage they can do to crops, in the case of the herbivores, and to livestock, in the case of coyotes.

### Habitat Conservation and Breeding Shrubsteppe Birds

Habitat conservation is believed to be the key to maintaining breeding populations of shrubsteppe birds. Plants provide nesting sites, perches, and shelter from weather as well as herbage, seeds, insects, and other foods. Sage grouse, *Centrocercus urophasianus*, are rarely seen on the Hanford Site today. In recent years, a few widely separated groups of two to three birds have been seen in the Rattlesnake Hills on the ALE Reserve. Even in the long-time absence of livestock grazing, a purposeful sagebrush eradication program, and recreational hunting, the future of sage grouse on the Hanford Site does not appear promising. Extensive wildfires on the Hanford Site since 1980 have destroyed thousands of hectares of sagebrush stands, and sagebrush itself is believed to be a critical



Figure 2. Rattlesnake Hills on the Arid Lands Ecology (ALE) Reserve; Long-billed Curlew and Badger.

element in sage grouse habitat (McAdoo and Klebenow 1979).

Chukar, *Alectoris chukar*, populations are centered around permanent springs, especially those located in the rough topography of the Rattlesnake Hills on the ALE reserve. At present, the chukar, an alien introduction, is more abundant than the native sage grouse. Chukars forage upon the green shoots and seeds of cheatgrass. The great abundance of cheatgrass on the Hanford Site provides food for chukars during most of the year. However, in the occasional years of deep, persistent snow cover there may be short-term food shortages, as deep snow covers the short-statured cheatgrass plants and especially seeds dropped on the ground.

Long-billed curlews select sparse, mixed stands of Sandberg's bluegrass and cheatgrass for nesting (Allen 1980). Such stands occur in places where fire has destroyed the shrubs or on

some of the abandoned cultivated fields that support sparse stands of cheatgrass.

Historically, nest sites for tree-nesting raptorial birds have been limited on the Hanford Site. Before human settlement, trees were probably scarce and restricted to very narrow zones along the Columbia River and the spring streams on the ALE Reserve. Farmers had planted shade and fruit trees, mostly within a few kilometers of the Columbia River, in the years before 1943. In later years, trees were planted around the few military installations and industrial facilities located in the interior of the Hanford Site. These artificially established trees now provide most of the nest sites for common ravens, *Corvus corax*, black-billed magpies, *Pica pica*, Swainson's hawks, *Buteo swainsoni*, red-tailed hawks, *Buteo jamaciensis*, and American kestrels, *Falco sparverius* (Olendorff 1975, Fitzner 1980a). The number of trees that are suitable for nesting appears to be important in determining Swainson's

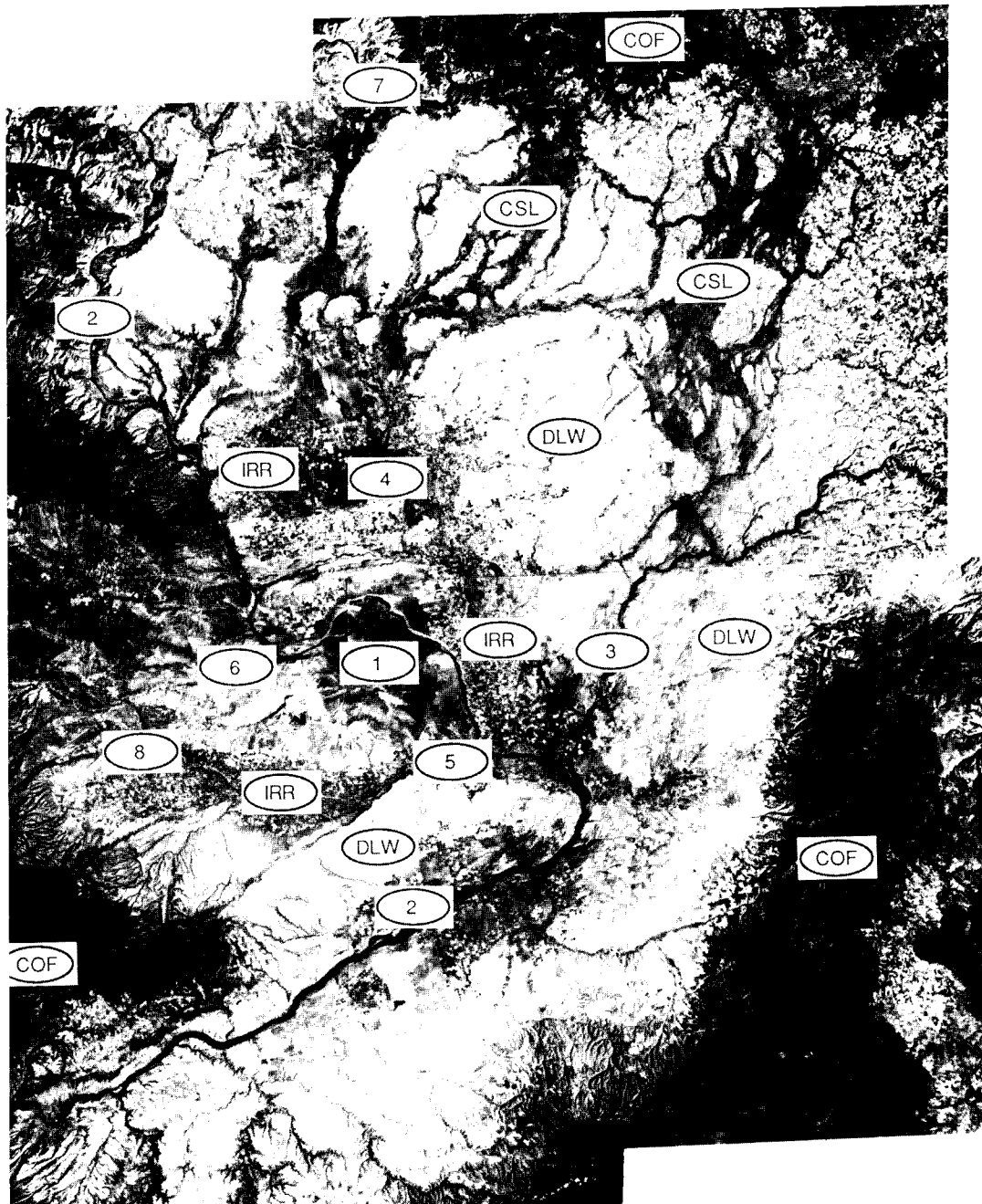


Figure 3. Satellite Image of Southeastern Washington and Adjacent Oregon Showing the Extent of Cultivated Land Surrounding the U.S. Department of Energy's Hanford Site. IRR = Irrigated Land, DLW = Dryland Wheat, COF = Conifer Forest, RRL = Rangeland, and CSL = Channeled Scabland. 1 = Hanford Site Rangeland, 2 = Columbia River, 3 = Snake River, 4 = Potholes Reservoir, 5 = Richland, 6 = Priest Rapids Dam, 7 = Grand Coulee Dam, and 8 = Yakima.

hawk distribution and abundance throughout semi-arid eastern Washington (Tank 1985, Poole *et al.* 1988).

Although cliffs that are suitable for raptor nesting are scarce on the Hanford Site, they do provide nesting locations for prairie falcons, *Falco mexicanus*, red-tailed hawks, and ravens. Electrical transmission towers and utility poles located on the Hanford Site have created artificial nesting platforms for ravens, red-tailed hawks, and ferruginous hawks (Olendorff 1975, Fitzner 1980a). Nesting populations of red-tailed hawks, ferruginous hawks, and common ravens have expanded greatly since 1978, largely through the use of powerline transmission towers as nest sites (Fitzner 1980b).

Western meadowlarks, *Sturnella neglecta*, sage sparrows, and horned larks, *Eremophila alpestris*, are the most abundant of the breeding shrubsteppe passerine birds on the Hanford Site. The most comprehensive study of passerine birds is that of Rotenberry and Wiens (1978), conducted in a sagebrush-bluebunch wheatgrass stand on the ALE Reserve. Total density ranged between 206 and 291 birds per km<sup>2</sup> over a four-year period.

Although burrowing owls, sage thrashers, and loggerhead shrikes are also present as breeding shrubsteppe birds, studies have not been made to determine their nesting abundance and distribution.

### Shrubsteppe Mammals

Elk were not resident on the Hanford Site or elsewhere in the shrubsteppe region of eastern Washington until the early 1970s when a small, self-established herd took up residence on the ALE Reserve (Rickard *et al.* 1977). The herd today numbers about 90 individuals, and the breeding and foraging activities have been mostly confined to the ALE Reserve (McCorquodale *et al.* 1986). The increase of the elk herd from only a few animals in 1972 is attributed to lack of predator mortalities to calves, the absence of shooting, the lack of livestock as competitors for the available forage plants, and the virtual absence of threatening human disturbance during the spring calving period. Although elk, like cattle, depend on only a few spring streams on the ALE Reserve as permanent sources of drinking water, they tend not to congregate and

linger in herds near drinking water sources as cattle do. In summer, elk seek water mostly at night and bed during midday hours, usually at locations more than 2 km from water sources (McCorquodale *et al.* 1986). Elk are also more conservative of water use than cattle, and they tend to forage over much wider areas (Petron 1987).

In recent months elk have strayed from the ALE Reserve and have damaged newly planted fruit trees on adjacent private lands. The damage done to fruit trees by elk has created a need to determine the capacity of the ALE Reserve to provide enough forage to sustain an elk herd of 100 or so animals without permanently damaging the vegetative cover and also to remove excess animals.

No quantitative estimates have been made of the size of the mule deer population on the Hanford Site, but the population is several times greater than the elk population. Deer that are born on the Hanford Site travel off site and are sometimes killed by hunters on adjacent properties (Hedlund 1975). The deer population has not increased to the point where they have damaged crops as has been the case with elk. Coyote predation on new-born fawns is thought to be an important factor in suppressing the mule deer population on the Hanford Site (Steigers and Flinders 1980).

The coyote is the largest mammalian predator inhabiting the Hanford Site. Information on the seasonal movements of radio-collared coyotes has been obtained by Springer (1982) and Crabtree (doctoral dissertation in preparation). Mated coyotes have relatively small activity ranges, but transients are highly mobile, often travelling beyond the boundaries of the Hanford Site.

No population data exists concerning bobcats, *Lynx rufus*, but they are thought to be much less abundant than coyotes. Badgers, *Taxidea taxus*, are also present, but in small numbers. Badgers are of special concern to maintaining the integrity of low-level radioactive waste burial trenches because of their inherent capacity for deep burrowing with possible exhumation of buried waste materials.

Black-tailed jackrabbits on the Hanford Site are generally more abundant at elevations less than 290 m above mean sea level. They also tend to avoid areas that are devoid of sagebrush from

burning or past agricultural practices. Cyclic fluctuations in jackrabbits during the 45-year existence of the Hanford Site are not apparent. This contrasts with the shrubsteppe lands of Idaho National Engineering Laboratory in southeastern Idaho, which periodically experiences marked cyclic fluctuations (Stoddart 1983). The factors responsible for the absence of marked cyclic population fluctuations on the Hanford Site are unknown. There is some evidence suggesting that cheatgrass is not palatable to jackrabbits; thus, an abundant forage plant may not be available to them (Uresk 1978).

White-tailed jackrabbits, *Lepus townsendi*, are rarely seen on the Hanford Site, and the few sightings that have been made are all near the summit of the Rattlesnake Hills (1000 m above sea level) on the ALE Reserve (Fitzner pers. comm.).

The Great Basin pocket mouse, *Perognathus parvus*, is by far the most numerous mammal on the Hanford Site, occurring in all dryland habitats ranging from near the Columbia River to the crest of the Rattlesnake Hills (Hedlund *et al.* 1975, O'Farrell *et al.* 1975, Rogers and Hedlund 1980, Gano and Rickard 1982, Marr *et al.* 1988). At higher elevations in the Rattlesnake Hills the pocket mouse is generally less abundant in trap catches than the deer mouse, *Peromyscus maniculatus*. At low elevations pocket mice usually comprise more than 80 percent of the small mammal trap catches. Northern grasshopper mice, *Onychomys leucogaster*, are widespread, but their numbers are very low in comparison to deer mice and pocket mice. In addition to mice, Townsend's ground squirrels, *Spermophilus townsendi*, can be locally abundant in certain stands of shrubsteppe vegetation (Hedlund and Rickard 1981). Small mammals provide the food base for badgers, coyotes, and nesting hawks.

Three relatively rare, sagebrush-dependent species of small mammals are known or thought to inhabit shrubsteppe habitats on the Hanford Site. These are Merriam's shrew, the sagebrush vole, *Lagurus curtatus*, and the pygmy rabbit. Little is known about the distribution of shrews, but sagebrush voles were most often trapped at elevations above 400 m (O'Farrell 1975). Pygmy rabbits were present in a sagebrush stand on the ALE Reserve in the years before 1979 (Fitzner pers. comm.). Since then, several large wildfires have destroyed many square kilometers of sage-

brush and the rabbits have not been seen since. Patches of sagebrush habitat, superficially similar to the site that burned, did not burn, but these patches have not yet been thoroughly searched for the presence of pygmy rabbits.

Ord's kangaroo rats, *Dipodomys ordii*, and Washington ground squirrels, *Spermophilus washingtonii*, may occur on the Hanford Site, but there are no validated sightings.

## Reptiles and Amphibians

The abundance and distribution of reptiles and amphibians on the Hanford Site have received little scientific investigation. Side-blotched lizards, *Uta stansburiana*, occur in sagebrush-dominated as well as shrub-free burned areas and are by far the most abundant of the Hanford Site lizards (Marr *et al.* 1988). Northern sagebrush lizards, *Sceloporus graciosus*, have been collected from sand dune habitats, dominated by bitterbrush (Marr *et al.* 1988). Short-horned lizards, *Phrynosoma douglassi*, occur all across the Hanford Site (Marr *et al.* 1988, Fitzner pers. comm.), but in small numbers.

Great Basin gopher snakes, *Pituophis melanoleucus*, western yellow-bellied racers, *Coluber constrictor*, and northern Pacific rattlesnakes, *Crotalus viridis*, are the most abundant snakes on the Hanford Site (Marr *et al.* 1988). Striped whipsnakes rarely have been sighted (Fitzner pers. comm.). The presence of the desert night snake, *Hypsiglena torquata*, has not been confirmed.

The abundance and distribution of amphibians on the Hanford Site has not yet been determined. However, Great Basin spadefoot toads, *Spea intermontana*, occur near Rattlesnake Springs on the ALE Reserve (Marr *et al.* 1988).

## Wildfire

Wildfire destroys shrubs, especially sagebrush, bitterbrush, and spiny hopsage. Many years may be required for the self-restoration of shrub stands. However, greasewood shrubs are not easily killed by burning, and the stands essentially can be self-restored within a few years (Rickard and McShane 1984). A lightning-caused fire destroyed almost all the sagebrush in a sagebrush-bluebunch wheatgrass stand on the ALE Reserve, resulting in a reduction in the number of sage sparrows in succeeding years. Densities of horned

larks on the burned area initially increased, then declined (Rotenberry and Wiens 1978).

Little is known about the size of sagebrush stands that are acceptable as nesting habitats for sage sparrows. Sullivan (1987) investigated passerine species' richness in sagebrush patches of various sizes in the Columbia Basin north of the Hanford Site, finding higher densities of sage sparrows in large contiguous sagebrush stands than in stands of less than 615 ha. However, passerine species' richness was more highly correlated with the number of shrub species present than with stand size.

Some evidence exists that natural burning of sagebrush-bunchgrass stands has little immediate impact on pocket mouse and ground squirrel populations (Hedlund and Rickard 1981). Most Hanford Site wildfires occur in July and August when the vegetation is at seasonal dryness. Ground squirrels remain below ground in burrows in summer, and they do not re-emerge until late winter. When they do become surface active, in later winter or early spring, there is an abundance of fresh green grass, especially Sandberg's bluegrass. The perennial grasses associated with sagebrush stands are usually capable of restoring shoot productivity in the first growing season after burning (Uresk *et al.* 1976). Pocket mice are active above ground in the summer fire season (O'Farrell *et al.* 1975), but they can escape direct burn and heat mortality by remaining in their burrows. Summer wildfires probably do not destroy all the seeds that are stored in the litter and surface soil, and at least some seeds are probably available to pocket mice even in the first few days and weeks after summer burning. Following summer burning, a new seed crop of Sandberg's bluegrass is ripe by mid-April, and cheatgrass seeds are ripe by mid-May, thereby providing an abundant food source for pocket mice throughout summer and autumn months.

Non-burrowing animals are probably more vulnerable to direct fire mortality than are the burrowing animals. Adult deer, elk, coyotes, and bobcats are usually mobile enough to avoid most wildfires, but jackrabbits may be killed. The long-term damage of burning to jackrabbit populations is perceived as the loss of mature sagebrush shrubs, which provide forage, concealment from predators (golden eagles, bobcats, and coyotes), and shade from the hot summer sun. Deer populations can also be indirectly affected by wildfires

over the long term because burning kills bitterbrush shrubs that provide browse. The self-recovery of bitterbrush stands following summer burning appears to be a slow process, especially if the burned areas are extensive (Rickard and Rogers 1983).

### Human-Imposed Habitat Changes

Shrubsteppe habitats in eastern Washington are under continuous assault from a multitude of human activities that result in the continuing diminishment or even extirpation of local populations of some native avian and mammalian shrubsteppe species. Some large-scale, human-induced landscape alterations (e.g., shrub removal by mechanical means and herbicide applications) are designed to economically eliminate shrubs and improve the site for livestock-palatable grasses. The resulting grass-dominated habitats are not acceptable to some nesting birds (Wiens and Rotenberry 1985, Wiens *et al.* 1986).

In shrubsteppe areas of southern Idaho, crested wheatgrass, an alien perennial bunchgrass, has been artificially established on vast acreages of land to produce forage for livestock. These stands provide only marginal habitat for native shrubsteppe wildlife (Reynolds 1978). Springtime livestock grazing can also be harmful to ground nesting birds through trampling of nests (Reynolds and Trost 1981).

The exotic trees artificially planted on the Hanford Site do not re-establish themselves through seedlings. Unless some effort is made to artificially replace these trees, the number of acceptable nesting places for tree-nesting birds such as Swainson's hawks will slowly diminish as the trees age and eventually die. Artificial nest structures could provide acceptable nesting sites for some tree-nesting birds. One advantage of artificial structures is that they can be located at strategic locations appropriately spaced to accommodate home ranges and territory requirements, if these are known from previous research.

### Shrubsteppe Wildlife in Relation to Radionuclide Contamination on the Hanford Site

From 1943 to the early-1960s, little attention was paid to terrestrial wildlife on the Hanford Site except as biological indicators of airborne releases of radionuclides from the operating

industrial buildings. The radionuclide of most concern to non-occupational human health was iodine-131 released into the air during the operation of the chemical separation buildings in the 200 Areas. Some of the radioactive iodine was deposited on the leaves of plants, which in turn were eaten by black-tailed jackrabbits. Jackrabbits were routinely collected from various locations on the Hanford Site to determine the pattern of dispersion of iodine-131 because it was assimilated in the thyroid glands and could be detected and measured by the instruments available at that time (Hanson 1960, 1962).

Today, the terrestrial environmental monitoring conducted for the Hanford Site includes collecting chukars, California quail, *Callipepla californica*, ring-necked pheasants, *Phasianus colchicus*, and Nuttall's cottontails, *Sylvilagus nuttalli*, to obtain flesh and bone samples for cesium-137 and strontium-90 analyses (Price *et al.* 1985). Tissues of road-killed mule deer are also included in the environmental sampling protocol.

As an adjunct to the routine monitoring programs, Eberhardt and Cadwell (1984) recorded the daily and seasonal movements of radio-collared mule deer. Deer that habitually drank from and foraged around ponds that had received controlled releases of radionuclides in aqueous streams had slightly higher concentrations of radiocesium in their flesh than did deer that drank from and foraged along the Columbia River.

The regurgitated castings of hawks and owls that roost on the Hanford Site had measurable concentrations of radionuclides of Hanford Site origin, indicating that the prey items (mostly rodents) eaten by the hawks and owls had access to arrays of radionuclides indicative of the different chemical processes used in the nuclear fuel industry (Cadwell and Fitzner 1984).

The most unusual case of terrestrial wildlife and radionuclide dispersal involved a burrowing mammal in conjunction with black-tailed jackrabbits (O'Farrell and Gilbert 1975). A burrowing mammal dug into a shallow land burial trench and brought radioactive material to the soil surface. The exhumed materials were then ingested by jackrabbits, and radionuclides became dispersed in the rabbits' feces and urine during the normal movements of free-roaming individuals.

Today, engineering designs for low-level

radioactive waste burial trenches incorporate "biological barriers" constructed to deter burrowing mammals and deep-rooting plants from contacting buried wastes. Layers of loose rock (to deter animal burrowing) and the downward moisture percolation are capped with fine-textured soil to encourage shallow root penetration. Rainwater stored in the surface soil is returned to the atmosphere via evaporation and plant transpiration processes during the growing season, thereby restricting the amount of downward percolation of moisture through the soil cap and possible transport beyond the Hanford Site boundaries by groundwater.

### Future

The long-term land use of the Hanford Site has a somewhat uncertain future. However, it does not appear likely that the undeveloped land surrounding the industrial buildings will be used for livestock grazing or agricultural crops, at least until the existing inventory of high-level radioactive waste stored in underground tanks during the years of nuclear materials production is permanently isolated from the biological environment. This will probably require many years of effort. Environmental monitoring will be continued and can be expected to include sampling of wildlife populations and documentation of the status of ever-changing wildlife populations, especially rare, threatened or endangered species, and those species of great aesthetic or recreational importance.

The lands surrounding the Hanford Site are expected to continue to be intensively cultivated, with irrigated acreages continuing to expand at the expense of the remnant stands of native vegetation. Stands of native vegetation will become increasingly restricted to thin, rocky soils and steep hillsides that cannot be plowed. However, even these places will probably be grazed by livestock. The Hanford Site will serve as a future refuge for remnant populations of native wildlife species in eastern Washington as the surrounding land becomes more intensively used for crop plants, for livestock grazing, and for urban developments.

Wildfires will continue to be an important factor in determining the pattern of distribution of mature shrubs on the Hanford Site. Burning has implications for the long-term conservation

and management of shrub-dependent species of animals such as sage sparrows, sage thrashers, and sage grouse (McAdoo and Klebenow 1979, Castrale 1982) as well as for mule deer and jackrabbit populations. Burning of sagebrush stands appears to provide habitat for nesting long-billed curlews (Figure 2), western meadowlarks, and horned larks, birds that usually select sparse stands of herbaceous plants as nesting

habitat. However, burning is deleterious to nesting sage sparrows, loggerhead shrikes, and sage thrashers, birds that characteristically place their nests in the branches of sagebrush shrubs.

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