

THE STATUS, DISTRIBUTION AND ECOLOGY OF WILDLIFE ON THE U.S. DOE HANFORD SITE: A HISTORICAL OVERVIEW OF RESEARCH ACTIVITIES

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(Received March 1990)

Abstract. Since the inception of the U.S. DOE Hanford Site in 1943, numerous studies have been conducted on terrestrial wildlife. Onsite contractors have focused their attention on the role of wildlife in the uptake and transport of radionuclides. Graduate students from across the nation have also completed more than 15 theses on wildlife. This paper discusses the past history of wildlife research at Hanford and the individual species of wildlife that have been observed at Hanford. Forty species of mammals, 187 species of birds, 3 species of amphibians and 9 species of reptiles have been documented on the Hanford Site to date.

Introduction

The 1400 km² (560 mi²) U.S. Department of Energy (DOE) Hanford Site was established in 1943 to produce plutonium for the war effort. Nine reactors were constructed and public access to the Site and the Columbia River, which flows through it, was restricted for safety and security purposes. The human population residing at Hanford and White Bluffs on the Site prior to 1943 was relocated and their farmsteads and the villages were abandoned.

The plutonium production reactors operated through the 1960s; most were phased out by 1969. By 1970 only one reactor, the dual-purpose (plutonium production and steam for electricity) N Reactor was operational. In 1988, N Reactor ceased production.

In 1967, a 260 km² area of Hanford was designated as an environmental research area. This relatively undisturbed piece of land located in the southwestern sector of the Hanford Site (Figure 1) has been labeled as the Arid Land Ecology (ALE) Reserve. In 1977, the entire Hanford Site was designated a National Environmental Research Park (NERP) by the DOE for use as an outdoor laboratory for ecological research. In 1978, the Hanford reach of the Columbia River was re-opened to public access, 25 years after the imposition of restricted access. Although, today, site land lying west of the Columbia River is still restricted to public access, wildlife research by university personnel and Hanford Site contractors is encouraged.

This paper is an historical overview of wildlife research conducted since the early years of Hanford operations through 1989. We will synthesize the data (status, distribution, and seasonal use) collected on terrestrial vertebrates (mammals, birds, reptiles and amphibians) known to have existed at Hanford. We hope this review will aid state and federal agencies involved with regulatory compliance and the development of sound land management practices for the site.

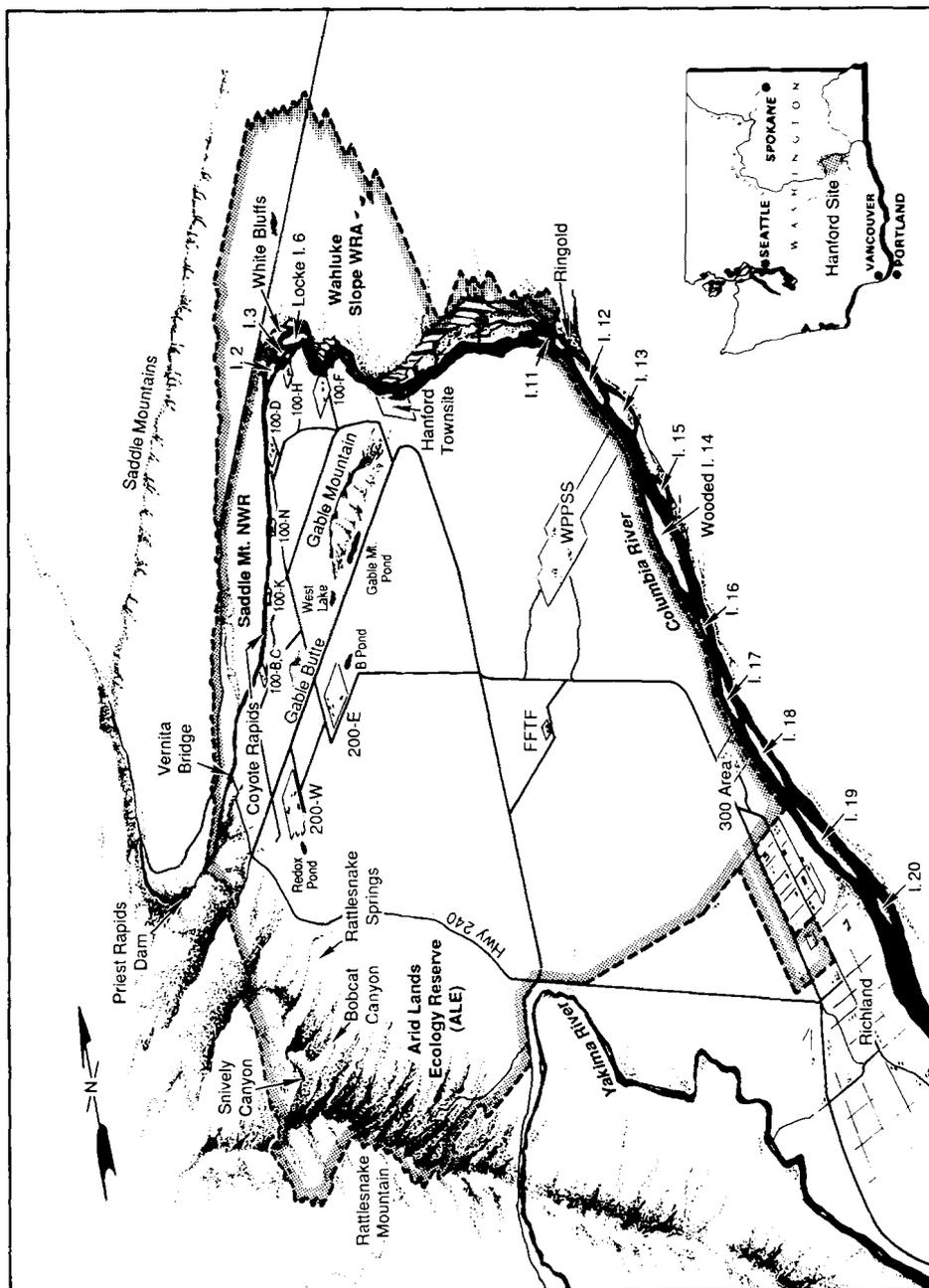


Fig. 1. The U.S. Department of Energy Hanford Site in southcentral Washington.

Historical Overview of Wildlife Studies

From 1943 to about 1970, most wildlife research at Hanford was conducted by onsite contractors. The research focused primarily on the role of wildlife in uptake and transport of radionuclides. Concentration factors, i.e. the ratio of radionuclides in organisms to that in the environment, were examined for numerous aquatic and terrestrial species (Hanson and Kornberg 1956). Environmentally available radioisotopes originated from activation (neutron capture) of Columbia River water as it passed through the reactors, from radioactive gases released into the air (mostly ^{131}I) and from liquid wastes containing fission products. Several wildlife species were sampled regularly for ^{131}I in thyroid tissues, ^{137}Cs in muscle, and ^{90}Sr in bone (Hanson and Kornberg 1956).

Routine wildlife monitoring occurred throughout the history of Hanford production reactors and continues today as part of the sitewide environmental monitoring and surveillance program (Jaquish and Mitchell 1988, Gray et al. 1989, Jaquish and Bryce 1989).

University research on wildlife began at Hanford in the early 1970s. Initially, graduate students focused on small mammals (Kritzman 1974, Schreiber 1973) but, by the end of the decade, they began to examine a wider array of wildlife species. Designation of the Site as a NERP in 1977 increased opportunities for graduate research. By 1989, approximately 15 graduate research projects had been conducted on wildlife; four are still in progress.

Wildlife research has been conducted on site by Pacific Northwest Laboratory (PNL)^a as part of the International Biological Program (IBP). The role of consumer organisms was studied to understand their role in energy and nutrient cycling in the shrub-steppe ecosystem. Emphasis was also placed on the role of wildlife in uptake and transport of buried radioactive waste and radionuclides contained in waste ponds. Studies conducted by PNL for Rockwell Hanford Operations and DOE resulted in numerous topical reports of birds and mammals. Wildlife research by Hanford contractors has continued through the 1980s as part of the site-wide monitoring program. Many studies on wildlife distribution, abundance, and behavior have been ongoing for over two decades. Studies on the Great Basin Canada goose (*Branta canadensis moffitti*) started in 1953 and continue today. Nearly four decades of continuous research have been conducted on the nesting ecology and behavior of this species, perhaps one of the longest running ecological studies in existence in the world.

A detailed description of wildlife research conducted at Hanford since 1943 follows. The discussion is divided into sections relating to major taxa, i.e., mammals, birds, reptiles, and amphibians. Special attention is paid to rare, threatened, and endangered species. Within each section, a checklist of species known to occur at Hanford is also provided. Similar information on fish was provided by Gray and Dauble (1977).

^a Pacific Northwest Laboratory is operated for the U.S. Department of Energy by Battelle Memorial Institute under Contract DE- AC06-76RLO 1830.

Mammals

Forty species of mammals have been documented as occurring on the Hanford Site since its inception. Table I lists the mammals of the Hanford Site, along with their status and distribution.

UNGULATES

Four species of large mammals – elk (*Cervus elaphus*), mule deer (*Odocoileus hemionus*), white-tailed deer (*O. virginianus*), and pronghorn antelope (*Antilocapra americana*) – have all been observed at Hanford.

Elk colonized the Hanford Site in 1972 (Rickard *et al.* 1977). McCorquodale *et al.* (1988a,b) estimated the rate of increase (r) for this self-colonizing population at 0.20 for 1975 to 1986 (2–13-yr post-colonization). Observations and simulation modeling suggest the high rate of increase was due to high first-year class survival and substantial reproductive output from 2-yr-old females. The elk population increased from about eight individuals in 1975 to about 90 individuals in 1986. The population has remained at this level through 1989. Annual and seasonal home ranges of elk at the Hanford Arid Lands Ecology (ALE) Reserve were about 3–10 times larger than those reported for elk in forested regions (McCorquodale 1985, McCorquodale *et al.* 1989). Minimum convex polygon annual home range estimates for elk at Hanford were estimated at 161 km² for females and 163 km² for males (McCorquodale *et al.* 1989). Elk preferred areas dominated by *Artemisia tridentata*/*Poa sandbergii* for bedding and areas dominated by *P. sandbergii*/*Bromus tectorum* without sagebrush for foraging (McCorquodale 1985, 1987). Foraging elk apparently selected areas without sagebrush because of higher availability of forage compared to sagebrush-dominated areas. Petron (1987) studied body temperatures of five Hanford elk using radio-telemetry and found that body temperatures were independent of environmental temperatures during both winter and summer, and that elk used sagebrush as cover during summer.

Mule deer occur throughout the Site but most commonly along the Columbia River. River islands provide important fawning habitat. Tagging studies of fawns were conducted from 1969 to 1976. Tag returns showed that mule deer fawns born at Hanford are killed offsite on public and private lands. Distances moved by deer from tag and release sites ranged from 0 to 113 km (Eberhardt *et al.* 1979, Hedlund 1975). The coyote (*Canis latrans*) is a major predator of fawns onsite (Steigers and Flinders 1980). Diets of mule deer inhabiting the 200 Area plateau were studied by Uresk and Uresk (1980); 44 food items were identified in fecal pellets. Common plant species in mule deer diets were bitterbrush (*Purshia tridentata*), Russian Thistle (*Salsola kali*), goldenrod (*Solidago spp.*), and willow (*Salix spp.*).

Because mule deer serve as a potential pathway for radionuclide movement to humans offsite, many studies have focused on determining radionuclide content of deer flesh and thyroids (Eberhardt *et al.* 1982, Eberhardt and Cadwell 1984). Price *et al.* (1981) provided a historical perspective of ¹³¹I in the Hanford environment and mule deer. Monitoring of deer tissue for radionuclides at Hanford has been ongoing for more than three decades

TABLE I
Mammals of the Hanford Reservation.

Family	Scientific Name	Common Name	Status	Distribution
Soricidae	<i>Sorex vagrans</i>	Vagrant shrew	UC	Ri
	<i>S. merriami</i>	Merriam's shrew	UC	UE, ALE
Vespertilionidae	<i>Lasionycteris noctivagans</i>	Silver-haired bat	C	Ri, ALE
	<i>Lasiurus cinereus</i>	Hoary bat	C	Ri, ALE
	<i>Antrozous pallidus</i>	Pallid bat	C	BC
	<i>Myotis lucifugus</i>	Little brown myotis	C	BC
	<i>M. yumanensis</i>	Yuma myotis	C	BC
	<i>M. californicus</i>	California myotis	C	BS, ALE
Leporidae	<i>Lepus townsendii</i>	White-tailed jack rabbit	UC	UE, ALE
	<i>L. californicus</i>	Black-tailed jack rabbit	C	E
	<i>Sylvilagus nuttallii</i>	Nuttall's cottontail	C	E
	<i>S. idahoensis</i>	Pygmy rabbit	EX	
Sciuridae	<i>Spermophilus townsendii</i>	Townsend ground squirrel	C	E
	<i>Marmota flaviventris</i>	Yellow-bellied marmot	R	UE, ALE
	<i>Eutamias minimus</i>	Least chipmunk	R	UE, ALE
Geomyidae	<i>Thomomys talpoides</i>	Northern pocket gopher	A	E
Heteromyidae	<i>Perognathus parvus</i>	Great Basin pocket mouse	A	E, LE
Castoridae	<i>Castor canadensis</i>	Beaver	C	CR
Cricetidae	<i>Reithrodontomys megalotis</i>	Western harvest mouse	R	E
	<i>Peromyscus maniculatus</i>	Deer mouse	A	E
	<i>Onychomys leucogaster</i>	Northern grasshopper mouse	C	ALE
	<i>Neotoma cinerea</i>	Bushy-tailed woodrat	C	E
	<i>Lagurus curtatus</i>	Sagebrush vole	UC	UE, Ri
	<i>Microtus montanus</i>	Montane meadow mouse	R	Ri
	<i>Ondatra zibethica</i>	Muskrat	R	CR
Muridae	<i>Rattus norvegicus</i>	Norway rat	C	B
	<i>Mus musculus</i>	House mouse	C	B
Erethizontidae	<i>Erethizon dorsatum</i>	Porcupine	C	E
Canidae	<i>Canis latrans</i>	Coyote	UC	E
Procyonidae	<i>Procyon lotor</i>	Raccoon	UC	Ri, CR
Mustelidae	<i>Mustela vison</i>	Mink	UC	Ri, CR
	<i>M. frenata</i>	Long-tailed weasel	UC	Ri, CR
	<i>M. erminea</i>	Short-tail weasel	R	Ri
	<i>Lutra canadensis</i>	Otter	R	CR
	<i>Taxidea taxus</i>	Badger	C	E
	<i>Mephitis mephitis</i>	Striped skunk	C	R
Felidae	<i>Lynx rufus</i>	Bobcat	UC	E
Cervidae	<i>Odocoileus hemionus</i>	Mule deer	C	E
	<i>O. virginianus</i>	White-tailed deer	R	CR
	<i>Cervus elaphus</i>	Elk	C	ALE
Antilocapridae	<i>Antilocapra americana</i>	Pronghorn	EX	

R=Rare

UC=Uncommon

C=Common

A=Abundant

EX=Extirpated

Ri=Riparian

BC=Buildings and Caves

BS=Basalt Outcropping and Cliffs

E=Entire site

CR=Columbia River

ALE=ALE Reserve

UE=Upper elevations

B=Buildings

(Jaquish and Mitchell 1988, Jaquish and Bryce 1989).

White-tailed deer were first reported onsite in 1970 (O'Farrell and Hedlund 1972). Since then, additional sightings have occurred in close association with riparian habitats along the Columbia River. Washington Department of Wildlife personnel have observed white-tailed deer at the Yakima River delta in Richland, and the Wallula River delta in Walla Walla county. Species distribution closely matches the distribution of wooded habitats and riparian vegetation.

The pronghorn antelope is uncommon in Washington. Small herds were established in about 1940 in eastern Washington through the transplants of Oregon stock (Larrison 1970). Nine pronghorns were observed on the Wahluke Slope Wildlife Recreation Area (WRA) and the Saddle Mountain National Wildlife Refuge (NWR) of the Hanford Site (Figure 1) in the winters 1978 and 1979 (personal observations of R. E. Fitzner). The pronghorns were also observed by T L. Fleming (1979) while conducting winter raptorial bird surveys in the winter of 1979–1980. Pronghorns have not been seen at Hanford since the winter of 1980–1981, probably reflecting conversion of their habitat to irrigated farmland, which forced them to move elsewhere.

CARNIVORES

Four families of carnivores are represented at Hanford; the *Felidae*, *Canidae*, *Mustelidae*, and *Procyonidae* (Table I). Within the *Felidae*, only one representative, the bobcat (*Lynx rufus*) has been documented onsite. This medium sized cat frequents Rattlesnake Mountain, Gable Butte, and Gable Mountain (Figure 1). Rock outcroppings and canyons provide denning sites. Rattlesnake Mountain, Gable Butte, and Gable Mountain also provide habitat for chukar (*Alectoris chukar*), Nuttall's cottontail (*Sylvilagus nuttalli*) and various small mammals that serve as prey for bobcat. There have been no detailed studies of the bobcat at Hanford.

The coyote is common at Hanford and has been studied since the mid-1970s. Springer (1977, 1980) evaluated movement patterns of 10 radiotagged coyotes and determined that average daily movements were 3.39 km and that home range size averages 87.91 km². Springer (1980) observed that coyotes residing near the Columbia River regularly fed on fish, primarily carp (*Cyprinus carpio*). Stoel (1976) examined 1143 coyote scats collected over 12 km along the Columbia River and found that small mammals, primarily the Great Basin pocket mouse (*Perognathus parvus*), northern pocket gopher (*Thomomys talpoides*), and the leporidae, Nuttall's cottontail and black-tailed jack rabbit (*Lepus californicus*) were chief components of the diet. Several graduate studies dealing with behavior and movement patterns of coyotes are currently being completed.

The mustelidae are represented by six species at Hanford; these include badger (*Taxidea taxus*), striped skunk (*Mephitis mephitis*), otter (*Lutra canadensis*), mink (*Mustela vison*), long-tailed weasel (*M. frenata*) and short-tailed weasel (*M. erminea*). Although none of these species has been studied on the Hanford Site, general observations have been made on their distributions and relative abundances over the years. The badger is the only mustelid at Hanford that occurs in dryland areas; it is very abundant, particularly in areas where Townsend's ground squirrels (*Spermophilus townsendii*) abound. Weasels and

skunks have been observed in riparian areas on the ALE Reserve and along the Columbia River. Although skunks are numerous along the Columbia River, they are rarely seen on ALE. Otter and mink have been observed along and in the Columbia River. Mink also frequent ponds on the Saddle Mountain NWR and on the Wahluke WRA. Otter and short-tailed weasel are uncommon inhabitants of the Hanford Site. Only two short-tailed weasels have been captured since 1970. Otters have been observed on one occasion and tracks have been found on several occasions.

Raccoons (*Procyon lotor*) occur throughout the Site, primarily around water. Prior to decommissioning of the 200 Area waste ponds (Figure 1), raccoons were frequently seen foraging around the 200 Areas. Today, this species occurs mostly along the Columbia River and near ponds on the Saddle Mountain NWR and Wahluke WRA. Raccoons have not been observed on ALE.

SHREWS

Two shrews, Merriam's shrew (*Sorex merriami*) and the vagrant shrew (*S. vagrans*) have been documented at Hanford. Merriam's shrew has only been captured above 330 m elevation on Rattlesnake Mountain. This small mammal prefers bunchgrass vegetation associations with thick ground litter and sagebrush overstory and has been collected in pit traps set to capture ground-dwelling insects. The vagrant shrew occurs more widely at lower elevations primarily in association with streamsides on the ALE Reserve and along the Columbia River.

BATS

Six species of bats frequent the Hanford environs (Table I). The largest, the hoary bat (*Lasiurus cinereus*), has been captured along streamsides on the ALE Reserve in August and September during their migration. The pallid bat (*Antrozous pallidus*) is common in summer and frequents deserted buildings associated with the 100 and 200 Areas (Figure 1). In July 1979, a colony of more than 100 female pallid bats with young, were found in 100-F Reactor Building. One male was found on Gable Mountain (Figure 1) in August 1979. The silver-haired bat (*Lasionycteris noctivagans*) is another fall migrant to the site; all records have been at Snively Canyon and Rattlesnake Springs (Figure 1) on the ALE Reserve. Three myotis bats have been observed on Site. The California myotis (*Myotis californicus*) is the smallest; specimens generally weigh less than 4.0 g. This bat frequents basalt outcroppings near water. All records are from Snively Canyon on the ALE Reserve. The little brown myotis (*M. lucifugus*) and the Yuma myotis (*M. yumanensis*) frequent similar habitats and are mostly found near buildings associated with the 100 and 200 Areas. These species can also be seen flying about lights at night, foraging for insects.

LEPORIDAE

Three leporidae are presently found at Hanford. Nuttall's cottontail is common across the Site often in association with buildings, particularly where grass and trees are planted for landscaping. No studies of this species have been conducted onsite. Undisturbed haunts include native grasslands with a dense overstory of shrubs and basalt outcroppings.

White-tailed jack rabbits (*Lepus townsendii*) are uncommon inhabitants of the upper elevations of Rattlesnake Mountain (above 400 m). All observations have occurred since 1980. No population estimates or ecological data exist for this species at Hanford.

The black-tailed jack rabbit is abundant at Hanford, particularly where a dense overstory of sagebrush exists. This species has been studied intensively, particularly in relation to radionuclides in tissues (Hanson and Kornberg 1956, Hanson 1963b, Houston and Blumer 1978, Price *et al.* 1985, Price 1988) and uptake and dispersal of radionuclides (O'Farrell *et al.* 1973, O'Farrell and Gilbert 1975, Rickard *et al.* 1974, Rogers and Rickard 1977). The diet of black-tailed jack rabbit was evaluated in sagebrush and bitterbrush habitats at Hanford (Uresk *et al.* 1975, Uresk 1978). Although the two plant communities were dissimilar in species frequency of occurrence and cover, jack rabbits diets were similar; jack rabbits actively sought turpentine cymopterus (*Cymopterus terebinthinus*), hoary aster (*Aster canescens*), needle and thread grass (*Stipa comata*), and Jim Hill mustard (*Sisymbrium altissimum*).

Although there is a wealth of information on the black-tailed jack rabbit at Hanford, there are no data on reproduction, longevity, habitat utilization, or dispersal. Data on these parameters would provide greater meaning to the radionuclide data.

The pygmy rabbit (*Sylvilagus idahoensis*) occurred on the Hanford Site prior to 1984 when a fire burned off much of the sagebrush. Before then, a small population of pygmy rabbits inhabited a dense stand of sagebrush (several hundred hectares) at the 800 m level on Rattlesnake Mountain, above Snively Springs. In 1985, after the fire, the rabbits were gone. There have been no other sightings of this small lagomorph on the Hanford Site.

RODENTS

Twelve species of small rodents inhabit the Hanford Site (Table I). Knowledge of their distribution, abundance, and ecology is extensive and encompasses several graduate student projects and Hanford contractor research. Kritzman (1970, 1974) studied the ecology of the deer mouse (*Peromyscus maniculatus*) and Great Basin pocket mouse (*Perognathus parvus*). The deer mouse was more abundant with increasing elevations while pocket mice decreased. This was correlated with a preference for loose, deep, sandy soils at low elevations by pocket mice. Stoney soils prevent burrowing by pocket mice and are a major factor affecting both density and distribution of this species at Hanford (Hedlund *et al.* 1975). The deer mouse was most successful in cooler, rocky soils and rock piles of upper elevations (Kritzman 1974). O'Farrell (1975) noted the same pattern. Schreiber (1973) studied the bioenergetics of deer mice, pocket mice, the western harvest mouse (*Reithrodontomys megalotis*), and grasshopper mouse (*Onychomys leucogaster*) at Hanford. The caloric value of natural diets of these species ranged from 4.2 to 6.2 kcal/g. Assimilation efficiency ranged from 77.8 to 98.4%; the grasshopper mouse showed greater assimilation than the other three species. O'Farrell *et al.* (1972) studied the dynamics of small mammal populations on grazed and ungrazed sites on ALE and recorded eight species: deer mouse, pocket mouse, Townsend's ground squirrel, grasshopper mouse, western harvest mouse, sagebrush vole, (*Lagurus curtatus*), Norway rat (*Rattus norvegicus*) and Northern pocket gopher (*Thomomys talpoides*). The first four species accounted for

98% of all captures. Pocket mice were most numerous (~20/hectare) with ground squirrels attaining the highest biomass. O'Farrell *et al.* (1975) provided an intensive ecological treatment of the pocket mouse and five other rodents that coinhabited the shrub steppe. During 41 130 trap nights, 15 386 mice were captured representing six species (*Perognathus parvus*, *Peromyscus maniculatus*, *Onychomys leucogaster*, *Reithrodontomys megalotis*, *Lagurus curtatus*, and *Microtus montanus*). Pocket mice accounted for 91% of the captures, deer mice 8%, and the remaining four species 1%.

O'Farrell *et al.* (1975) found that pocket mice were mostly inactive underground between December and February; adult males emerged in late March and females emerged in mid-April. Estrus began in April, first palpable pregnancies were in May and the last pregnant females were observed in July. Females bred twice in years of high availability. Average litter size was 3.7. Weanling survival to the following breeding season ranged from 56% to 80%. Pocket mice aestivate between late summer and autumn depending on environmental conditions, sex, and age. Population size on the 2.7-hectare study plot ranged from 206 in 1968 to 437 in 1969.

Population size from year to year was dependent on winter conditions the previous year. Pocket mouse populations in spring were higher when the previous winter precipitation was high, than in years when the previous winter was dry (Dunigan *et al.* 1980).

Diets of several rodents have been studied at Hanford (Johnson 1975, 1977). The pocket mouse feeds mostly on seeds, while ground squirrels eat mostly new plant growth, particularly Sandberg's bluegrass. The diet of the deer mouse varied, including insects and plant material. Summer wildfire did not destroy small mammal populations inhabiting a sagebrush-bunchgrass community on AIE (Hedlund and Rickard 1981) because of the subterranean behavior of most species.

Cheatgrass, an exotic European introduction, has invaded many low elevation sites at Hanford and often occurs in dense stands. Cheatgrass produces large numbers of seeds, and the density of cheatgrass groundcover is thought to hinder mobility of mice. Reduced mobility may reduce breeding success, thus reducing population size of small rodents on cheatgrass dominated habitats (Gano and Rickard 1982).

Small rodents have been studied at Hanford in relation to radioactive waste management. These small mammals can potentially burrow into shallow waste burial sites (Gano and States 1982) and take up and transport radioactive waste (Rickard *et al.* 1974, Rogers and Rickard 1977, Gano 1979, Fitzner *et al.* 1979a).

Although four species of medium-to large-sized rodents occur at Hanford, little is known of their ecology. The yellow-bellied marmot (*Marmota flaviventris*) is uncommon, occurring along the banks of the Columbia River and on basalt outcroppings at upper elevation of Rattlesnake Mountain. The beaver (*Castor canadensis*) is common along the Columbia River. Bank dens and stick lodges occur primarily from the Hanford townsite to Richland. Upper parts of the Hanford reach are less attractive to this species, probably because of the lack of willows and other forage plants. The porcupine (*Erethizon dorsatum*) is abundant across the entire Site occurring mostly around the Hanford townsite and other areas where trees were planted or occur naturally. Trees, however, do not limit the

distribution of porcupines, as they will feed on grasses, forbes, and shrubs. Although muskrats (*Ondatra zibethica*) are not common onsite, they occur along the Columbia River and have also been observed along waste ponds associated with the 200 Areas. Table I lists the mammals known to occur at Hanford with a notation on their status and distribution.

Birds

One hundred and eighty-seven bird species have been observed at Hanford. The status and distribution of bird species are shown in Table II. Species that are rare, new regional records, and those of ecological significance or found commonly are discussed below.

GAVIIFORMES

The common loon (*Gavia immer*) occurs throughout southcentral Washington throughout the year. Prior to 1978, no breeding records had been reported for southeastern Washington. During July 1978, William Radke of the Columbia National Wildlife Refuge, U.S. Fish and Wildlife Service observed an adult and one young loon at White Bluffs slough (Figure 1). This pair would have had to nest at Hanford because they were land locked from any other water bodies, and the young bird was downy, incapable of flight.

PODICIPEDIFORMES

Five species of grebes (Table II) are commonly observed in southcentral Washington. All of these species have been observed on the Hanford Site.

CICONIIFORMES

The great egret (*Casmerodius albus*) is not common in Washington. The first reported nesting in Washington occurred in 1978, at Potholes Reservoir, Grant Co. (Fitzner *et al.* 1979b). In 1986, two pairs were observed nesting at Hanford downstream from the 100-F Area.

The Great blue heron (*Ardea herodias*) has been the subject of much research at Hanford and serves as an indicator of radionuclide, heavy metal, and organic contaminants in the environment. Rickard *et al.* (1978) collected heron rejecta (feces, food scraps) on cheesecloth blankets spread on the ground under a rookery. Eight different radionuclides were measured, and the rejecta from Hanford herons contained more biologically available radionuclides than did rejecta collected offsite. This collection method appears to have considerable application to global monitoring of biologically transportable pollutants and in detecting trends in local environmental contamination of food chains. Fitzner *et al.* (1982) used cheesecloth blankets to sample heavy metals in heron rejecta and compared the Hanford findings with those from offsite colonies near Tacoma, Washington, and Lake Chatcolet, Idaho. Although the Hanford rookery had low levels of cadmium, mercury, and lead, colonies near the industrialized area of Tacoma and mining area of Chatcolet Lake were high in lead. Adult herons, their young, and eggs were also

TABLE II
Birds of the Hanford Site

Species	Status ¹	Season ²	Habitat ³
Order Gaviiformes			
Family Gaviidae			
Common Loon <i>Gavia immer</i>	C, B	yr	CR
Order Podicipediformes			
Family Podicipedidae			
Western Grebe <i>Aechmophorus occidentalis</i>	UC	W, Sp	CR
Horned Grebe <i>Podiceps auritus</i>	UC	W, Sp	CR
Eared Grebe <i>Podiceps nigricollis</i>	C, B	W, Sp, S	CR, P
Red-necked Grebe <i>Podiceps grisegna</i>	UC	W, Sp	CR
Pied-billed Grebe <i>Podilymbus podiceps</i>	C, B	yr	CR, P
Order Pelecaniformes			
Family Pelecanidae			
American White Pelican <i>Pelecanus erythrorhynchos</i>	C	W	CR
Family Phalacrocoracidae			
Double-crested Cormorant <i>Phalacrocorax auritus</i>	C	yr	CR
Order Anseriformes			
Family Anatidae			
Tundra Swan <i>Cygnus columbianus</i>	UC	F, Sp	CR
Canada Goose <i>Branta canadensis</i>	C, B	yr	CR, P
Brant <i>Branta bernicla</i>	R	F	CR
Snow Goose/Bue Goose <i>Chen caerulescens</i>	R	F, W, Sp	CR
Greater white-fronted Goose <i>Anser albifrons</i>	R	F, W, Sp	CR
Mallard <i>Anas platyrhynchos</i>	A, B	yr	CR, P
Gadwall <i>Anas strepera</i>	A	yr	CR, P
Pintail <i>Anas acuta</i>	A	yr	CR, P
Green-winged Teal <i>Anas crecca</i>	A	yr	CR, P
Blue-winged Teal <i>Anas discors</i>	C, B	F, S, Sp	CR, P
Cinnamon Teal <i>Anas cyanoptera</i>	C, B	F, S, Sp	CR, P
American Wigeon <i>Anas americana</i>	A	F, W, Sp	CR, P
Northern Shoveler <i>Anas clypeata</i>	C, B	Yr	CR, P
Redhead <i>Aythya americana</i>	A, B	F, W, Sp	CR, P
Ring-necked Duck <i>Aythya collaris</i>	A	F, W, Sp	CR, P
Canvasback <i>Aythya valisineria</i>	C	F, W, Sp	CR
Greater Scaup <i>Aythya marila</i>	C	F, W, Sp	CR, P
Lesser Scaup <i>Aythya affinis</i>	C, B	F, W, S	CR, P
Common Goldeneye <i>Bucephala clangula</i>	A	F, W, Sp	CR, P
Bufflehead <i>Bucephala albeola</i>	A	F, W, Sp	CR, P

Table II (continued)

Species	Status ¹	Season ²	Habitat ³
Family Anatidae (contd.)			
Old Squaw <i>Clangula hyemalis</i>	UC	W	CR
Ruddy Duck <i>Oxyura jamaicensis</i>	C, B	Yr	CR, P
Hooded Merganser <i>Lophodytes cucullatus</i>	UC	F, W, Sp	CR, P
Common Merganser <i>Mergus merganser</i>	A, B	Yr	CR, P
Order Falconiformes			
Family Cathartidae			
Turkey Vulture <i>Cathartes aura</i>	R	S	E
Family Accipitridae			
Sharp-shinned Hawk <i>Accipiter striatus</i>	C	F, W, Sp	E
Cooper's Hawk <i>Accipiter cooperii</i>	UC	F, W, Sp	E
Northern Goshawk <i>Accipiter gentilis</i>	UC	F, W, Sp	E
Northern Harrier <i>Circus cyaneus</i>	C, B	Yr	E
Rough-legged Hawk <i>Buteo lagopus</i>	C	F, W, Sp	E
Ferruginous Hawk <i>Buteo regalis</i>	C, B	Sp, S, F	E
Red-tailed Hawk <i>Buteo jamaicensis</i>	A, B	Yr	E
Swainson's Hawk <i>Buteo swainsoni</i>	A, B	Sp, S, F	E
Golden Eagle <i>Aguila chrysaetos</i>	C	Yr	E
Bald Eagle <i>Haliaeetus leucocephalus</i>	C	F, W	C
Osprey <i>Pandion haliaetus</i>	UC	Yr	C
Family Falconidae			
Gyr Falcon <i>Falco rusticolus</i>	UC	F, W	E
Prairie Falcon <i>Falco mexicanus</i>	C, B	Yr	E
Peregrine Falcon <i>Falco peregrinus</i>	R	Yr	E
Merlin <i>Falco columbarius</i>	R	F, W, Sp	E
American Kestrel <i>Falco sparverius</i>	A, B	Yr	E
Order Galliformes			
Sage Grouse <i>Centrocercus urophasianus</i>	R, B	Yr	E
Scaled Quail <i>Callipepla squamata</i>	Ex		
California Quail <i>Callipepla californica</i>	A, B	Yr	E, R
Ring-necked Pheasant <i>Phasianus colchicus</i>	A, B	Yr	E, R
Chukar <i>Alectoris chukar</i>	A, B	Yr	E, UE
Gray Partridge <i>Perdix perdix</i>	UC, B	Yr	ALE
Order Ciconiiformes			
Family Ardeidae			
Great Blue Heron <i>Ardea herodias</i>	A, B	Yr	CR, p
Black-crowned Night Heron <i>Nycticorax nycticorax</i>	UC, B	Yr	CR, P
American Bittern <i>Botaurus lentiginosus</i>	R	F, S, Sp	P

Table II (continued)

Species	Status ¹	Season ²	Habitat ³
Family Ardeidae (contd.)			
Great Egret <i>Casmerodius albus</i>	R, B	Sp	CR
Order Gruiformes			
Family Gruidae			
Sandhill Crane <i>Grus canadensis</i>	A	F, Sp	E
Family Rallidae			
Virginia Rail <i>Rallus limicola</i>	UC, B	S, F, Sp	P
Sora <i>Porzana carolina</i>	UC, B	S, F, Sp	P
American Coot <i>Fulica americana</i>	A, B	Yr	CR, P
Order Charadriiformes			
Family Charadriidae			
Killdeer <i>Charadrius vociferus</i>	A, B	Yr	E
Mountain Plover <i>Charadrius montanus</i>	R	F, Sp	CR
Black-bellied Plover <i>Phuvialis squatarola</i>	R	F, Sp	CR
Family Scolopacidae			
Common Snipe <i>Gallinago gallinago</i>	A, B	S, F, Sp	CR, P
Long-billed Curlew <i>Numenius americanus</i>	C, B	Sp, Su	E, LE
Spotted Sandpiper <i>Actitis macularia</i>	C, B	Sp, Su, F	CR, P
Greater Yellowlegs <i>Tringa melanoleuca</i>	C	Sp, E, F	Cr, P
Lesser Yellowlegs <i>Tringa flavipes</i>	C	Sp, F	Cr, P
Pectoral Sandpiper <i>Calidris melanotos</i>	R	Wp, F	Cr, P
Least Sandpiper <i>Calidris minutilla</i>	UC	Sp, F	CR, P
Dunlin <i>Calidris alpina</i>	C	Sp, F	CR, P
Long-billed Dowitcher <i>Limnodromus scolopaceus</i>	C	Sp, F	CR, p
Western Sandpiper <i>Calidris mauri</i>	C	Sp, F	CR, P
Sanderling <i>Crocethia alba</i>	R	Sp, F	CR, P
Family Recurvirostridae			
American Avocet <i>Recurvirostra americana</i>	C, B	Sp, S, F	CR, P
Family Phalaropodidae			
Wilson's Phalarope <i>Phalaropus tricolor</i>	UC	Sp, F	CR, P
Red-necked Phalarope <i>Phalaropus lobatus</i>	C	Sp, F	CR, P
Family Laridae			
Glaucous-winged Gull <i>Larus glaucescens</i>	C, B	Yr	CR
Herring Gull <i>Larus argentatus</i>	R	W	CR

Table II (continued)

Species	Status ¹	Season ²	Habitat ³
Family Laridae (contd.)			
California Gull <i>Larus californicus</i>	A, B	Sp, S, F	CR, E
Ring-billed Gull <i>Larus delawarensis</i>	A, B	Yr	CR, W
Bonaparte's Gull <i>Larus philadelphia</i>	R	Sp, S, F	CR
Franklin's Gull <i>Larus pipixcan</i>	R	Sp, S, F	CR
Sabine's Gull <i>Xema sabini</i>	R	Sp, S, F	CR
Arctic Tern <i>Sterna paradisaea</i>	R	Sp	CR
Forster's Tern <i>Sterna forsteri</i>	A, B	Sp, S, F	CR
Caspian Tern <i>Sterna caspia</i>	C	Sp, S, F	CR
Black Tern <i>Chlidonias niger</i>	UC	Sp, F	CR
Order Columbiformes			
Family Columbidae			
Rock Dove <i>Columa livia</i>	A, B	Yr	E
Mourning Dove <i>Zenaida macroura</i>	A, B	Yr	E
Band-tailed Pigeon <i>Columbia fasciata</i>	R	Sp	UE, ALE
Order Strigiformes			
Family Tytonidae			
Common Barn-Owl <i>Tyto alba</i>	C, B	Yr	E, R
Family Strigidae			
Great Horned Owl <i>Bubo virginianus</i>	C, B	Yr	E
Long-eared Owl <i>Asio otus</i>	C, B	Yr	E
Short-eared Owl <i>Asio flammeus</i>	UC, B	Yr	E
Snowy Owl <i>Nyctea scandiaca</i>	R	W	E
Barred Owl <i>Strix varia</i>	R	Yr	E, LE
Burrowing Owl <i>Athene cunicularia</i>	A, B	Yr	E
Northern Saw-whet Owl <i>Aegolius acadicus</i>	R	Sp, S, F	R, ALE
Flammulated Owl <i>Otus flammeolus</i>	R	Sp, F	ALE
Order Caprimulgiformes			
Family Caprimulgidae			
Common Nighthawk <i>Chordeiles minor</i>	A, B	S, F	E
Common Poorwill <i>Phalaenoptilus nuttallii</i>	UC, B	Sp, S, F	UE, ALE, R
Order Apodiformes			
Family Trochilidae			
Rufous Hummingbird <i>Selasphorus rufus</i>	UC	Sp, S	R, E
Order Coraciiformes			

Table II (continued)

Species	Status ¹	Season ²	Habitat ³
Family Alcedinidae			
Belted Kingfisher <i>Ceryle alcyon</i>	UC, B	Yr	CR
Order Piciformes			
Family Picidae			
Northern Shafter Flicker <i>Colaptes auratus</i>	C, B	Yr	E
Lewis' Woodpecker <i>Melanerpes lewis</i>	R	Sp, S, F	E
Hairy Woodpecker <i>Picoides villosus</i>	R	Sp, S, F	E, R
Downy Woodpecker <i>Picoides pubescens</i>	UC	Sp, S, F	E, R
Order Passeriformes			
Family Tyrannidae			
Eastern Kingbird <i>Tyrannus tyrannus</i>	A, B	Sp, S, F	E, R
Western Kingbird <i>Tyrannus verticalis</i>	A, B	Sp, S, F	E
Ash-throated Flycatcher <i>Myiarchus cinerascens</i>	R	Sp, F	E, R
Say's Phoebe <i>Sayornis saya</i>	UC, B	Sp, S, F	E
Western Wood-pewee <i>Contopus sordidulus</i>	UC	Sp, F	ALE, R
Willow Flycatcher <i>Empidonax traillii</i>	UC	Sp, F	ALE, R
Dusky Flycatcher <i>Empidonax oberholseri</i>	R	Sp, F	ALE, R
Family Alaudidae			
Horned Lark <i>Eremophila alpestris</i>	A, B	Yr	E
Family Hirundinidae			
Barn Swallow <i>Hirundo rustica</i>	A, B	Sp, S, F	E
Cliff Swallow <i>Hirundo pyrrhonota</i>	A, B	Sp, S, F	E, R
Bank Swallow <i>Riparia riparia</i>	A, B	Sp, S, F	CR
Violet-green Swallow <i>Tachycineta thalassina</i>	R	Sp, S, F	E, R
Tree Swallow <i>Tachycineta bicolor</i>	R	Sp, S, F	CR
Northern Rough-winged Swallow <i>Stelgidopteryx serripennis</i>	UC, B	Sp, S, F	CR
Family Corvidae			
Black-billed Magpie <i>Pica pica</i>	A, B	Yr	E
Comon Raven <i>Corvus corax</i>	A, B	Yr	E
American Crow <i>Corvus brachyrhynchos</i>	A, B	Yr	E, R
Family Sittidae			
Red-breasted Nuthatch <i>Sitta canadensis</i>	UC	Sp, F, W	E, R
Family Certhiidae			

Table II (continued)

Species	Status ¹	Season ²	Habitat ³
Brown Creeper <i>Certhia americana</i>	R	Sp, F	ALE
Family Troglodytidae			
Bewick's Wren <i>Thryomanes bewickii</i>	UC	Yr	E, R
Winter Wren <i>Troglodytes troglodytes</i>	R	Sp, F, W	E, R
Marsh Wren <i>Cistothorus palustris</i>	A, B	Yr	P
Rock Wren <i>Salpinctes obsoletus</i>	A, B	Sp, S, F	E, BS
Canyon Wren <i>Catherpes mexicanus</i>	UC, B	Sp, S, F	E, BS
Family Mimidae			
Mockingbird <i>Mimus polyglottos</i>	R	S	E
Sage Thrasher <i>Oreoscoptes montanus</i>	UC, B	Sp, S, F	E
Family Muscicapidae			
American Robin <i>Turdus migratorius</i>	A, B	Yr	E
Varied Thrush <i>Ixoreus naevius</i>	C	Sp, F, W	E
Hermit Thrush <i>Catharus guttatus</i>	R	F, Sp	E, R
Western Bluebird <i>Sialia mexicana</i>	R	F, Sp	E
Townsend's Solitaire <i>Myadestes townsendi</i>	R	F, Sp	E
Golden-crowned Kinglet <i>Regulus satrapa</i>	UC	F, Sp	E, R
Ruby-crowned Kinglet <i>Regulus calendula</i>	UC	F, Sp	E, R
Family Motacillidae			
American Pipit <i>Anthus rubescens</i>	R	F, Sp	CR
Family Bombycillidae			
Cedar waxwing <i>Bombycilla cedrorum</i>	UC	Yr	E, R
Family Laniidae			
Loggerhead Shrike <i>Lanius ludovicianus</i>	C, B	Yr	E
Family Sturnidae			
Starling <i>Sturnus vulgaris</i>	A, B	Yr	E
Family Vireonidae			
Hutton's Vireo <i>Vireo huttoni</i>	R	F, Sp	ALE, R
Red-eyed Vireo <i>Vireo olivaceus</i>	R	F, Sp	ALE, R
Warbling Vireo <i>Vireo gilvus</i>	C	F, Sp	E, R
Family Emberizidae			
Orange-crowned Warbler <i>Vermivora celata</i>	Uc	F, Sp	E, R
Nashville Warbler <i>Vermivora ruficapilla</i>	C	F, Sp	E, R

Table II (continued)

Species	Status ¹	Season ²	Habitat ³
Family Emberizidae (contd.)			
Yellow Warbler <i>Dendroica petechia</i>	UC	F, Sp	E, R
Yellow-rumped Warbler <i>Dendroica coronata</i>	A	F, Sp	E, R
Townsend's Warbler <i>Dendroica townsendi</i>	R	F, Sp	E, R
MacGillivry's Warbler <i>Oporornis tolmiei</i>	C, B	F, Sp, S	E, R
Wilson's Warbler <i>Wilsonia pusilla</i>	C, B	F, Sp	E, R
Western Meadowlark <i>Sturnella neglecta</i>	A, B	Yr	E
Yellow-headed Blackbird <i>Xanthocephalus xanthocephalus</i>	C, B	Sp, S, F	P, CR
Red-winged Blackbird <i>Agelaius phoeniceus</i>	A, B	Sp, S, F	R, E
Northern Oriole <i>Icterus glabula</i>	C, B	Sp, S, F	R, E
Brewer's Blackbird <i>Euphagus cyanocephalus</i>	C, B	Sp, S, F	R, E
Brown-headed Cowbird <i>Molothrus ater</i>	UC, B	Sp, S, F	R, E
Western Tanager <i>Piranga ludoviciana</i>	UC	Sp, S, F	R, E
Black-headed Grosbeak <i>Pheucticus melanocephalus</i>	UC	Sp, S, F	R, E
Lazuli Bunting <i>Passerina amoena</i>	UC, B	Sp, S, F	ALE, R
Rufous-sided Towhee <i>Pipilo erythrophthalmus</i>	UC, B	Sp, S, F	ALE, R
Savannah Sparrow <i>Passerculus sandwichensis</i>	C, B	Sp, S, F	E, R
Lark Sparrow <i>Chondestes grammacus</i>	C, B	Sp, S, F	E
Sage Sparrow <i>Amphispiza belli</i>	A, B	Sp, S, F	E
Dark-eyed Junco <i>Junco hyemalis</i>	A	F, W, Sp	E
American Tree Sparrow <i>Spizella arborea</i>	R	F, W, Sp	E
White-crowned Sparrow <i>Zonotrichia leucophrys</i>	A	F, W, Sp	E
Golden-crowned Sparrow <i>Zonotrichia atricapilla</i>	UC	F, W, Sp	E
Swamp Sparrow <i>Melospiza georgiana</i>	R	F, Sp	P
Song Sparrow <i>Melospiza melodia</i>	A, B	Yr	E, R
Vesper Sparrow <i>Pooecetes gramineus</i>	A, B	F, Sp, S	E
Brewer's Sparrow <i>Spizella breweri</i>	C, B	F, Sp, S	ALE, UE
Grasshopper Sparrow <i>Ammodramus savannarum</i>	UC, B	F, Sp, S	E
Lincoln's Sparrow <i>Melospiza lincolni</i>	UC, B	F, Sp, S	E
Family Fringillidae			
House Finch <i>Carpodacus mexicanus</i>	UC, B	Yr	E
American Goldfinch <i>Carduelis tristis</i>	UC	Yr	R, E
Rosy Finch <i>Leucosticte arctoa</i>	UC	Sp, F	UE, ALE
Cassin's Finch <i>Carpodacus cassinni</i>	UC	Sp, F	UE, ALE
Family Ploceidae			
House Sparrow <i>Passer domesticus</i>	A	Yr	E

R=Rare

UC=Uncommon

C=Common

A=Abundant

EX=Extirpated

B=Breeding

UE=Upper Elevations

LE=Lower Elevations

BS=Basalt Outcroppings

2. Yr=Resident all Year

Sp=Spring

S=Summer

F=Fall

3. E=Entire Site

R=Riparian Areas

CR=Columbia River

ALE=Arid Land Ecology

Reserve

P=Ponds

collected from Hanford in 1981 and 1982. Tissue samples were analyzed for heavy metals, and results were compared with those from samples collected near Tacoma and Lake Chatcolet (Blus *et al.* 1985). Levels of metals (Cu, Zn, Hg, Pb, Cd) were generally low and were all below concentrations known to induce mortality or adversely affect heron reproductive success. Organic contaminants (polychlorinated biphenyls, *p,p'*-DDE) were also measured in Hanford herons and eggs (Riley *et al.* 1986, Fitzner *et al.* 1988) and data were compared to those from herons and eggs from seven other rookeries in the Western United States (Fitzner *et al.* 1988).

PELECANIFORMES

The white pelican (*Pelecanus erythrorhynchos*) is a winter resident along the Hanford Reach of the Columbia River. For over two decades, a small flock of 10–12 birds have wintered between Ringold and Vernita bridge, foraging for scrap fish (carp, suckers). During the summer of 1989, nearly 300 pelicans frequented the Hanford reach. These birds are believed to have been part of a nesting colony that failed near Stillwater, Nevada. Currently, the U.S. Fish and Wildlife Service is experimenting with the reintroduction of nesting white pelicans to Washington State. Island 2 (Hanson and Eberhardt 1971b), on the Hanford reach has been selected for the placement of pelican decoys. These decoys may attract pelicans and induce them to nest in the vicinity.

Small numbers of double-crested cormorants (*Phalacrocorax auritus*) occur in the Hanford reach throughout the year where they forage on fish. There are no nesting records for the Site. The closest cormorant nesting occurs on the Umatilla National Wildlife Refuge near Umatilla, Oregon, and at Potholes Reservoir near Othello, Washington.

ANSERIFORMES

Many species of waterfowl frequent the Hanford Site because of the Columbia River and ponded habitats on the Saddle Mountain NWR, Wahluke Slope WRA and waste ponds onsite. Waste ponds were surveyed for waterfowl and other birds on a near weekly schedule from September 1971 through February 1974. Fitzner and Price (1973) and Fitzner and Rickard (1975) reported that 126 bird species used the waste ponds (Price and Fitzner 1979). Bio-uptake of radioactive substances from waste ponds and the Columbia River by waterfowl has been reported (Hanson and Kornberg 1956, Emery *et al.* 1978, Rickard *et al.* 1981). Since the shutdown of production reactors along the Hanford Reach (Cushing *et al.* 1981) and decommissioning of most of the waste ponds (Rickard and Watson 1985) opportunities for uptake and transport of radionuclides by waterfowl at Hanford have greatly diminished.

The Great Basin Canada Goose has also been studied at Hanford. Hanson and Eberhardt (1971a, 1971b) reported on the nesting ecology of geese utilizing the Hanford reach of the Columbia River. This early work was to determine if nuclear reactor operations at Hanford during the 1950s and 60s were having an impact on geese. The 97.4% fertility of Hanford geese over an 18-year study period demonstrated that the reactors had little effect on the goose population. Although most reactors were shut down

(Rickard and Watson 1985) by 1970, the goose nesting studies continued to evaluate potential delayed responses related to the nuclear industry and to determine if other onsite activities might impact the geese. Fitzner and Rickard (1983) again demonstrated reproductive rates as high or higher than those in areas not supporting nuclear operations. However, the coyote caused a decline in nesting attempts on Hanford islands.

Rickard and Fitzner (1985) examined the mineral content of goose eggs from Hanford. They established a baseline of element concentrations to compare with future levels. Two graduate theses were also written about Hanford geese. Dewaard (1981) found that proximity of islands to human activities correlated with nesting success. Eberhardt (1987) studied the ecology of goose broods at Hanford. He found the adult females and broods spent 50% of daylight hours foraging. However, activity budgets changed dramatically at fledging; time spent resting and preening increased, and foraging activities and movement decreased. Eberhardt *et al.* (1989b) also found that broods foraging in a fertilized pasture spent less time moving and more time resting than did broods using only native plant communities. However, time foraging and growth rates of broods in the two habitats were similar. Eberhardt *et al.* (1989a) also found that adult females used an average 8.8 km of Columbia River shoreline to raise their broods to fledging. Mean home range size was 983 ha. Broods preferred riparian habitats within 5 km of the shoreline over aquatic habitats. Eberhardt *et al.* (1989c) estimated a 70-day survival rate for goslings or 0.491 which was lower than that usually recorded for the species. Reasons for the apparent low survival were unknown.

FALCONIFORMES

Olendorff (1973) surveyed nesting raptors at Hanford in 1973 to evaluate their potential for future onsite research. These studies laid the groundwork for several research projects on raptors. Fitzner (1980) and Fitzner *et al.* (1981) reported on year round raptor populations at Hanford from 1973 through 1978. Reproductive chronology, productivity and diets of the northern harrier (*Circus cyaneus*), red-tailed hawk (*Buteo jamaicensis*), Swainson's hawk (*B. swainsoni*), ferruginous hawk (*B. regalis*), prairie falcon (*Falco mexicanus*), and American kestrel (*F. sparverius*) were presented. A history of Hanford birds of prey research through 1984 was described by Fitzner (1985), who discussed productivity, nest site selection, and impacts of the Hanford facilities on raptors. The red-tailed hawk, Swainson's hawk, and common raven (*Corvus corax*) have apparently benefitted from Hanford activities. Swainson's hawk ecology and behavior at Hanford was the subject of graduate student research by Fitzner (1978a, 1980), who found a maximum of 17 pairs of Hanford in 1975. Productivity (1.6 young fledged per adult pair) was as high or higher than that reported in other North American studies. Fitzner (1978a) documented numerous aspects of the biology and behavior of the Swainson's hawk at Hanford and throughout the birds range in North and South America. The 'candidate species' federal status of Swainson's hawk indicates concern for this species in the Americas.

The ferruginous hawk, a state-listed 'threatened species' in Washington was uncommon at Hanford prior to 1988. In 1988, surveys showed an increase in nesting

attempts by this species (Fitzner and Newell 1989). Eight nests were located that year and seven occurred in transmission towers. Five nests were found in 1989 and four were situated in transmission towers. Transmission towers were previously not reported as nesting substrate for ferruginous hawks in Washington (Fitzner and Newell 1989).

Thompson-Hanson (1984) studied the nesting ecology of northern harriers at Hanford in 1981 and 1982. She compared nesting success between dry upland sites and pond sites. Pond sites contained the largest number of successful nests (75%) and dry sites the lowest (25%). Forty percent of 15 nests found in 1981 fledged at least one young. Forty-seven percent of 15 confirmed nests in 1982 were successful. The number of young fledged per successful nests in 1981 averaged 4.5. In 1982, fledging success dropped to 2.6 per successful nest. Home ranges for male harriers ranged between 72.1 km² to 366.4 km².

The bald eagle (*Haliaeetus leucocephalus*), a wintering raptor at Hanford has been the subject of much study. Fitzner and Hanson (1979) compared 12 years (1961–1979) of bald eagle winter survey data from Hanford with waterfowl numbers and chinook salmon (*Oncorhynchus tshawytscha*) redd counts and provided statistical evidence that eagle numbers in winter varied dependently with salmon redd counts but not with waterfowl numbers. Eagle numbers increased from a low of 4–6 eagles wintering at Hanford in the 1960s to 25 birds in 1979 (Fitzner *et al.* 1980b). Eagle numbers have continued to rise in the 1980s with a maximum count of 55 birds being made in the winter of 1987–1988 (Gray and Rickard 1989).

Table II lists falconiformes species that have been observed on Hanford. Sightings of several of these are few and deserve special mention. The peregrine falcon (*Falco peregrinus*) is rarely seen in southcentral Washington. The only confirmed sightings at Hanford were on May 2, 1988, one immature, near Coyote Rapids, Saddle Mountains, NWR – (Pers. communication, W. H. Radke, Columbia NWR); November 3, 1987, one subadult male, ALE Reserve (observation by R. E. Fitzner).

Although the gyrfalcon (*Falco rusticolus*) is also rarely seen in southcentral Washington, two observations have been made at Hanford Site (observation by R. E. Fitzner); January 10, 1985, and March 4, 1985. Both sightings were made on ALE; the January observation was near the south end, the March observation was at Rattlesnake Springs.

Merlins (*Falco columbarius suckleyi*, *F.c. richardsonii* *F.c. columbarius*) occur in southcentral Washington. Several observations of all three races have been made at Hanford from October through December (Fitzner *et al.* 1981).

Ospreys (*Pandion haliaetus*) frequent the Columbia River at Hanford and are occasionally seen during spring and summer. No breeding records have been reported for Hanford. Lisa Fitzner, Washington Department of Wildlife, erected a nesting platform at McNary Dam 50 km south of Hanford in 1988 and had occupancy by a nesting pair that same year. This is the closest nesting record to Hanford and the only nesting record in southcentral Washington.

The turkey vulture (*Cathartes aura*) is a rare visitor to southcentral Washington, but is a common summer resident in the foothills of the Cascade Mountains near Ellensburg and Yakima. Observations of this species at Hanford occur mostly in spring and early summer (Fitzner *et al.* 1981).

GALLIFORMES

Six species of gallinaceous birds have been reported at Hanford (Table II). All but one, the sage grouse (*Centrocercus urophasianus*), are not native to the area. Because gamebirds are eaten by humans, they serve as a potential pathway for radionuclide transport to people. Thus, chukar (*Alectoris chukar*), ring-necked pheasant (*Phasianus colchicus*), and California quail (*Lophortyx californicus*) have been routinely sampled by Hanford radiation monitors as part of their environmental monitoring program (Price *et al.* 1985, Houston and Blumer 1978, Hanson 1963b, Hanson and Kornberg 1956). There has been no attempt to relate body burdens of radionuclides recorded in gamebirds to offsite movements of these birds, nor have there been any studies on the ecology of Hanford gamebirds. Thus, there are no data on diets or habitat utilization necessary to determine routes of exposure to radionuclides and other hazardous waste. These data are needed to formulate predictive models on radionuclide transport.

General distribution and status of gallinaceous birds is shown in Table II. Although Hungarian partridge (*Perdix perdix*) is rare at Hanford, a few observations of individuals, pairs, and broods occur during most years. These are restricted to upper elevations of Rattlesnake Mountain. The scaled quail (*Callipepla squamata*) has been observed only once at Hanford. A single brood was noted on the Wahluke WRA in 1956 (Rickard *et al.* 1982).

The sage grouse once occupied the southern and western parts of the Hanford Site, but disappeared by mid-1960. W. H. Radke, Columbia NWR reported observing a small lek on the Saddle Mountain NWR in 1985. Only a few birds were observed at that time. Today, sage grouse are found only at upper elevations of Rattlesnake Mountain. Their numbers are low, with only one or two birds observed annually. A female and brood were recorded in Snively Canyon (Rotenberry *et al.* 1979) in spring 1976. No broods have been seen since.

GRUIFORMES

Sandhill cranes (*Grus canadensis*) are common migrants over the Site. Numerous observations have been made of flocks passing over the Site from late September through early October and again in mid-March through April. Few observations have been made of birds landing on the Site. Fitzner and Rickard (1975) sighted six individuals at Redox Pond (decommissioned in 1973) on October 5, 1972. These birds were believed to be greater sandhill cranes (*G. c. tabida*).

Nesting and feeding ecology of American coots (*Fulica americana*) on Hanford waste ponds are well documented (Fitzner *et al.* 1980a, Fitzner and Schreckhise 1979). Nests with eggs were observed from mid-April to mid-June. Average clutch size of 11 nests on Gable Mountain Pond was 6.45. This number was not significantly different from clutch sizes reported for 30 nests on a control site at Columbia NWR, 50 km north of the Hanford Site. Diets of coots from Hanford waste ponds consisted mostly of vegetation, primarily pond weeds (*Potamogeton spp.*), watermilfoil (*Myriophyllum sp.*) and filamentous algae.

The American coot is perhaps the most important bird in the biological dispersal of radionuclides from Hanford waste ponds (Fitzner and Rickard 1975). Total ^{137}Cs export from Gable Mountain Pond via coots, having an average body burden of $0.092\ \mu\text{Ci}$, was estimated to be $46\ \mu\text{Ci}$ per year (Cadwell *et al.* 1979).

CHARADRIIFORMES

Seasonal movements of shorebirds on Hanford waste ponds were reported by Fitzner and Rickard (1975). Fifteen species of shorebirds, excluding gulls and terns, were observed on waste ponds (Table II). Books (1984, 1985) sighted two additional species in studies of Columbia River shoreline use at Hanford. Three mountain plovers (*Charadrius montanus*) and nine black-bellied plovers (*Phivialis squatarola*) were observed on the Hanford reach of the Columbia River in September 1982.

Long-billed curlews (*Numenius americanus*) are an uncommon nesting species in shortgrass and sagebrush habitats on Hanford. They were studied intensively by Fitzner (1978b) and Allen (1980). Curlews breed at Hanford but winter south from southern California through Mexico. In 1977, Allen (1980) estimated that the Hanford Site supported nearly 300 curlews. The Site lying west of the Columbia River was believed to support 60 pairs of curlews, 20 unpaired males, and 20 unemployed individuals. The coyote and raven were found to be major predators of the nests. Island 3, located in the Columbia River between the 100-H and 100-D areas (Figure 1) was found to be a major loafing and staging area for curlews from the Hanford Site and the Wahluke WRA. Allen (1980) also reported on a variety of curlew behaviors.

Seven species of gulls and four species of terns have been observed at Hanford (Table II). Hanson (1963a) reported two mixed-species (ring-billed gull, *Larus delawarensis*; California gull, *L. californicus*) colonies on the Hanford reach of the Columbia River. One was located at Coyote Rapids and another at Ringold. The Ringold colony had 2,072 breeding adults; the Coyote Rapids colony contained 2310 breeding adults. The Ringold and Coyote Rapids colonies were deserted in 1971 and 1975, respectively. New ring-billed and California gull colonies were established on Island 18 and Island 20 (Hanson and Eberhardt 1971b) in 1971 and 1970, respectively (Conover *et al.* 1979). The Island 18 colony included 4491 ring-billed gulls and 5910 California gulls. The Island 20 colony included 4710 ring-billed gulls and 3600 California gulls. Both colonies are active today. In 1981 and again in 1982, Weber and Fitzner (1986) reported a single pair of glaucous-winged gulls (*Larus glaucescens*) nesting on Island 18. This species is a common winter visitor to Hanford. Previous to 1981, the species had not been found nesting in eastern Washington.

Other gull species reported for the Hanford Site include Bonaparte's gull (*Larus philadelphia*) (Fitzner and Rickard 1975) and Franklin's (*L. pipixcan*), Sabine's (*Xenna sabini*), and herring gulls (*Larus argentatus*) (Books 1984). Sabine's gull is rare in eastern Washington and there are few records.

Four species of terns have been observed at Hanford. These include the black (*Chlidonias niger*), Arctic (*Sterna paradisaea*), Forster's (*S. forsteri*), and Caspian (*S. caspia*) terns. Hanson (1958) collected a single Arctic tern near Ringold on May 21, 1957.

Since then, Arctic terns have been observed on several other occasions, mostly in late April. Although black terns breed in eastern Washington near Spokane, no breeding records exist for the Hanford Site. Migrants are often observed flying along the Columbia River. The Caspian tern is a common migrant and summer resident on the Site though no nesting has been reported. Nesting has been observed on Cabin Island, immediately above Priest Rapids Dam in Grant County Washington. Forster's tern is a fairly common breeding species at Hanford. Hall (1985, 1989) studied nesting on Cobblestone Islands in the Columbia River near Richland, Washington. He found 179 active nests in 1985. The same islands (18, 19, 20) supported about 400 nests in both 1977 and 1978. Hall (1985) hypothesized that the declining tern population reflected increasing ring-billed and California gull populations and possibly human disturbance.

COLUMBIFORMES

Three species of doves and pigeons have been reported at Hanford. The band-tailed pigeon (*Columba fasciata*) is a rare visitor, with two being observed on May 25, 1973, in Snively Canyon. No other records exist for Hanford or southcentral Washington. The mourning dove (*Zenaida macroura*) is common onsite, nesting in trees and shrubs and on the ground. A large number of birds nest on the ground on Cobblestone Islands in the Columbia River. Doves also utilized radioactive waste ponds (Fitzner and Rickard 1975) for nesting, feeding, and drinking water. Because doves are a migratory game bird eaten by humans, they are important to consider in developing transport models for radionuclides (Emery *et al.* 1978). The rock dove (common pigeon) is a common inhabitant of Hanford. Interest in this species reflects its recent involvement in the uptake and spread of radioactivity onsite (Conklin *et al.* 1985). Because of its ability to fly long distances for food and water, and its potential for uptake of Hanford waste, this species is important when considering biotic transport of radionuclides.

STRIGIFORMES

Nine species of owls have been observed at Hanford (Table II). Four species (barred, *Strix varia*; flammulated, *Otus flammeolus*; saw-whet, *Aegolius acadicus*; and snowy owls, *Nyctea scandiaca*) are relatively uncommon in southcentral Washington. There has only been one observation of the barred owl at Hanford (Personal communication Kelly McAllister, Washington Department of Wildlife). The bird was seen at the Fast Flux Test Facility (Figure 1) on February 15, 1978. A lone flammulated owl was observed in Bobcat Canyon on the ALE reserve on March 5, 1972. A single saw-whet owl was also observed on the ALE reserve in Snively Canyon on August 10, 1982.

Snowy owls are infrequently sighted in southcentral Washington (Fitzner *et al.* 1981). The largest documented incursion of snowy owls into southcentral Washington was in winter 1966-1967 when 20-27 birds were observed wintering near the confluence of the Columbia, Snake and Yakima Rivers (Hanson 1971). Observations were also made on the Hanford Site during this same period.

CAPRIMULGIFORMES

The common nighthawk (*Chordeiles minor*) occurs throughout the Hanford Site, nesting in all habitat types. They generally arrive the end of May and migrate south in mid to late September. Common poorwills (*Phalaenoptilus nuttallii*) have more restricted habitat affinities and prefer riparian streamsides and seeps at the upper elevations of Rattlesnake Mountain. Lundstrom (1988) studied the feeding ecology and nesting biology of both the nighthawk and poorwill. Both species ate similar prey (mostly moths) and used riparian streamsides for foraging. The poorwill was a passive forager, feeding much like a flycatcher. The nighthawk was an active flier much like a swallow. Poorwills were highly dependent on native bluebunch wheatgrass for nesting habitat, and riparian areas for feeding.

CORACIIFORMES

The belted kingfisher (*Ceryle alcyon*) occurs at Hanford, both on waste ponds (Fitzner and Rickard 1975) and along the Columbia River (Books 1984, 1985). Nesting has been observed in sand banks at Locke Island and Wooded Island (Figure 1).

PICIFORMES

Four woodpecker species have been reported at Hanford. Lewis' (*Melanerpes lewis*) and hairy (*Picoides villosus*) woodpeckers are uncommon visitors. Lewis' woodpecker has been observed on the ALE Reserve only, while the hairy woodpecker has only been observed at waste ponds (Fitzner and Rickard 1975).

PASSERIFORMES

Numerous species of passerines commonly occur throughout southcentral Washington and on the Hanford Site (Table II). Only those species for which little is known and historical accounts are absent are discussed below. We will also discuss revisions since Fitzner and Rickard (1975) and Rotenberry *et al.* (1979) published checklists of Hanford birds.

Three species of swallows, the violet green (*Tachycineta thalassina*), rough-winged (*Stelgidopteryx serripennis*), and tree swallow (*Tachycineta bicolor*) are uncommon at Hanford. Books (1984, 1985) observed all three along the Hanford reach of the Columbia River. Exact dates were not provided.

Mockingbirds (*Mimus polyglottos*) historically were rare in southcentral Washington (Jewett *et al.* 1953). Since 1973, at least one bird has used Rattlesnake Springs repeatedly during the spring and summer each year. A singing male was observed, but no nests were found.

Sage thrashers (*Oreoscoptes montanus*) are a common nesting bird throughout upper elevations of eastern Washington, particularly in Kittitas, Grant, Douglas, and Lincoln counties (Jewett *et al.* 1953). Prior to 1989, there were no nesting records for Hanford. On May 4, 1989, a territorial pair was observed in a dense stand of sagebrush near Rattlesnake Springs. After several hours a thrasher was observed on a nest in sagebrush by R.E.

Fitzner. The bird was incubating three eggs.

The vesper sparrow (*Poocetes gramineus*) nests in large numbers at upper elevations on Rattlesnake Mountain in April and May. Nests are usually situated at the base of bunchgrass clumps and are shaded from direct sunlight. Brewer's sparrows (*Spizella breweri*) are also common nesters mostly at upper elevations of Rattlesnake Mountain on the ALE reserve, occurring in dense stands of sagebrush. They tend to select stands of sage growing as dense pockets. Grasshopper (*Ammodramus savannarum*) and Lincoln's sparrows (*Melospiza lincolni*) have been reported along the Hanford Reach of the Columbia River (Books 1984) though exact dates are lacking. Sage sparrows (*Amphispiza belli*) occur abundantly wherever big sagebrush (*Artemisia tridentata*), hopsage (*Grayia spinosa*) or bitterbrush (*Purshia tridentata*) occur. They nest in bushes, above ground. Since a large fire in 1984, much of the sagebrush at Hanford was lost. Today, the range of sage sparrow at Hanford is restricted to the remaining patches of shrubs.

Reptiles and Amphibians

There are no comprehensive accounts of reptiles and amphibians at Hanford. Distribution and abundance of these cold-blooded vertebrates is poorly understood. Rickard (1967) studied temperature tolerance of the side-blotched lizard (*Uta stansburiana*) and found

TABLE III
Reptiles and Amphibians of the Hanford Site

Species	Scientific name	Status ¹	Habitat ²
Amphibians			
Pacific Treefrog	<i>Hyla regilla</i>	C	R
Great Basin Spadfoot	<i>Scaphiopus intermontana</i>	C	R
Woodhouse's Toad	<i>Bufo woodhousei</i>	C	R
Reptiles			
Painted Turtle	<i>Chrysemys picta</i>	C	P
Short-horned Lizard	<i>Phrynosoma douglassi</i>	UC	E
Sagebrush Lizard	<i>Sceloporus graciosus</i>	C	S, LE
Side-blotched Lizard	<i>Uta stansburiana</i>	A	LE
Western Rattlesnake	<i>Crotalus viridis</i>	C	E, BS
Gopher Snake	<i>Pituophis melanoleucus</i>	A	E
Night Snake	<i>Hypsiglena torquata</i>	UC	BS, E
Striped Whipsnake	<i>Masticophis taeniatus</i>	R	LE
Racer	<i>Coluber constrictor</i>	A	E

R=Rare

C=Common

UC=Uncommon

A=Abundant

R=Riparian

S=Sandy Areas

P=Pond

LE=Low Elevation

E=Entire Site

BS=Basalt Outcroppings

that when daily maximum temperatures were below 60°F, the lizards were dormant. Rickard (1968) also studied the altitudinal distribution of the side-blotched lizard on ALE and did not find this species above the 1200-ft elevation. Table III lists the reptiles and amphibians known to inhabit the Hanford Site; their status and habitat affinities are also provided.

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