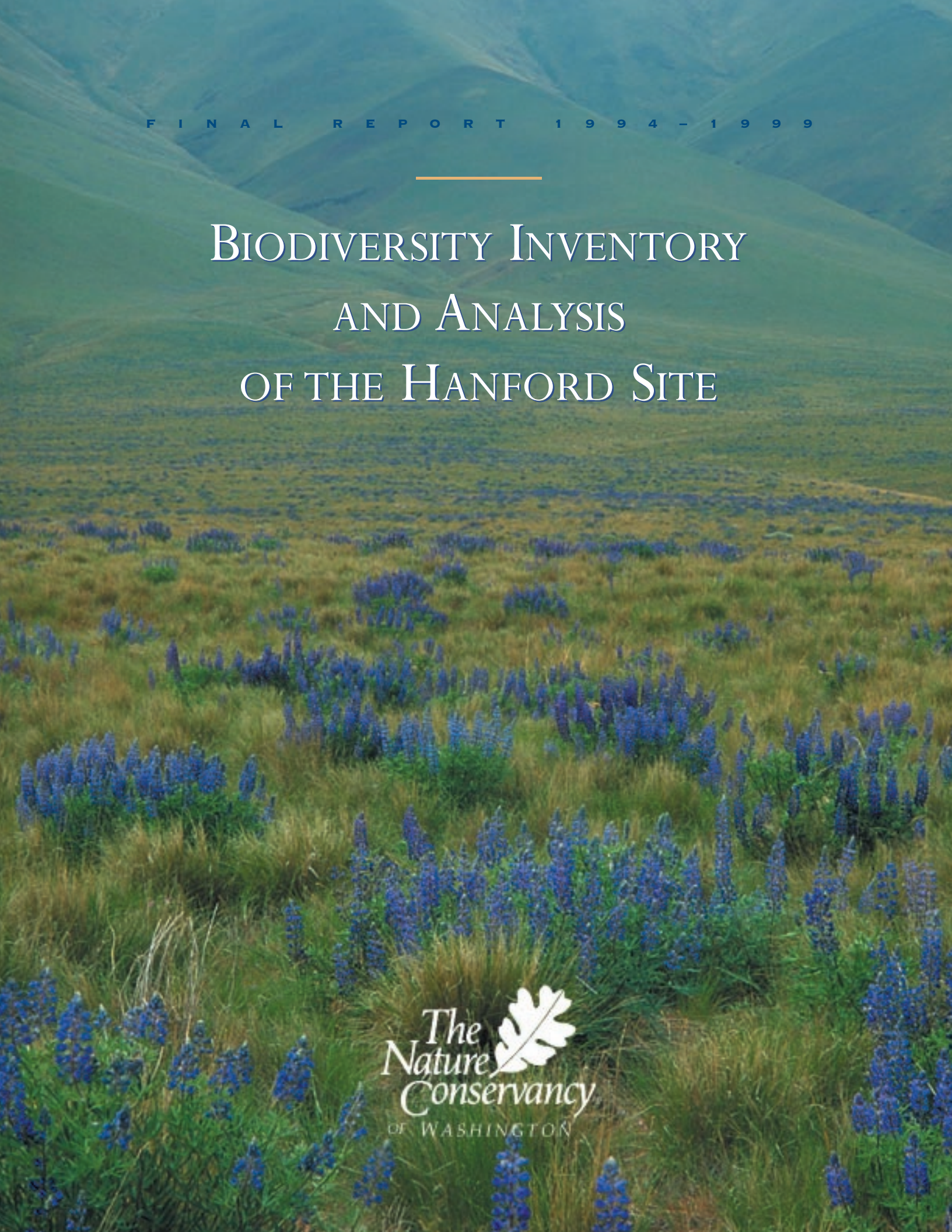
FINAL REPORT 1994–1999

Biodiversity Inventory and Analysis of the Hanford Site



The Nature Conservancy of Washington

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Final Report: 1994–1999

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EXECUTIVE SUMMARY

Background

In 1992 the U.S. Department of Energy (DOE) and The Nature Conservancy of Washington (TNC) entered into a Memorandum of Understanding that called for a cooperative and coordinated inventory of plants, animals and ecologically significant areas at the Hanford Site. In October 1993 DOE awarded TNC a grant to conduct the inventory. The Nature Conservancy also raised private funds to support the project, now titled the Biodiversity Inventory and Analysis of the Hanford Site. Although initially conceived as a comprehensive three-year project, budget cuts and their effect on grant funding levels led to adjustments in the inventory scope and schedule.

The goal of the inventory was to identify and map occurrences of native plant communities, rare plant populations, and important animal taxa over large areas of the Hanford Site, in order to provide DOE with information useful for making resource management and land-use decisions. Relevant findings from the 1994, 1995 and 1997 inventory efforts are provided in previous annual reports (Pabst 1995, Soll and Soper 1996, Hall 1998). The inventory was inactive in 1996. This report presents a comprehensive summary of all findings to date including results of field activities during 1998, and serves as the final report for the project.

Hanford Site History and Management Areas

The 560 mi^2 (1450 km^2) Hanford Site (Hanford, the Site) has been administered by DOE, or its predecessors, since it was first acquired in 1943 by the U.S. Government as a national security area for the production of weapons-grade plutonium. With the end of the Cold War and associated weapons production, the site's mission has changed to nuclear waste clean-up, environmental restoration, and research and development. Most of the Hanford Site has been closed to the public since 1943.

In addition to its significance in nuclear weapons development, energy technology advancement, and scientific research, Hanford supports the economy of the Tri-Cities region. The site also has important cultural significance to the local Native American Nations: Confederated Tribes of the Umatilla Indian Reservation, Nez Perce Tribe, Wanapum, and Yakama Indian Nation. From an ecological perspective, placing such a large tract of land virtually off-limits to public access and development for over 50 years has preserved Hanford's shrub-steppe ecosystem in a condition and to an extent that exists nowhere else.

The Hanford Site, in its entirety, is one of 7 DOE National Environmental Research Parks (NERP) nationwide. The NERP program was established by the DOE in the 1970s to provide for ecosystem preservation and study, and environmental education (DOE 1994). The Hanford Site can be divided into five management areas: Fitzner / Eberhardt Arid Lands Ecology (ALE) Reserve, Saddle Mountain National Wildlife Refuge, Wahluke Unit Columbia Basin Wildlife Area (also known as the Wahluke State Wildlife Recreation Area), Hanford Reach, and what is referred to in this report as Central Hanford. The Saddle Mountain National Wildlife Refuge and Wahluke Wildlife Area are known, and will be referred to collectively in this report, as the North (or Wahluke) Slope.

Natural History of the Hanford Site

The Hanford Site is located within the Columbia Basin Ecoregion (DOE-RL 1996), an area that historically included over 14.8 million acres (6 million ha) of steppe and shrub-steppe vegetation across most of central and southeastern Washington State (Franklin and Dyrness 1973), as well as portions of north-central Oregon. The pre-settlement vegetation consisted primarily of shrubs, perennial bunchgrasses, and a variety of forbs. An estimated 60% of shrub-steppe in Washington has been converted to agriculture or other uses. Much of what remains is in small parcels, in shallow rocky soils or has been degraded by historic land uses (mostly livestock grazing).

The Hanford Site, along with the Department of Defense Yakima Training Center, retains the largest remaining blocks of relatively undisturbed shrub-steppe in the Columbia Basin Ecoregion (Smith 1994, Soll 1999). Hanford's importance as a refuge for the shrub-steppe ecosystem is not solely size-related, however. The presence of a high diversity of physical features and examples of rare, undeveloped deep and sandy soil has led to a corresponding diversity of plant and animal communities (Pabst 1995, Soll and Soper 1996, Hall 1998). Many places on Hanford are relatively free of non-native species and are extensive enough to retain characteristic populations of shrub-steppe plants and animals that are absent or scarce in other areas. Because it is located within the hottest and driest part of the ecoregion, Hanford also retains some of its own uniqueness and fragility. Finally, because of its location, Hanford provides important connectivity with other undeveloped portions of the ecoregion.

The Columbia River within the Hanford Site is unique within the post-dam Columbia River system in the United States. Here, the river runs essentially free-flowing through an approximately 47-mile (76 km) segment—the so-called Hanford Reach. The Hanford Reach extends from the upper end of McNary Dam Reservoir to Priest Rapids Dam, and contains significant riparian habitat which is otherwise rare within the Columbia River system (USFWS 1980, NPS 1994). As a result, the Hanford Reach provides remnant habitat for aquatic organisms that were widespread before the remainder of the Columbia River system was converted to reservoirs. Recent surveys also have identified several rare plant associations along the shoreline and islands of the Reach (Salstrom and Easterly 1995, Soll and Soper 1996).

The Need for a Biodiversity Inventory

The Department of Energy needs an accurate accounting of the species, communities and ecosystems present on the Hanford Site to make informed decisions about land use and resource management. Because the primary mission at Hanford has changed from plutonium production to environmental restoration, ground-disturbing activities and transfer of land ownership or management are likely. The biodiversity inventory can help determine where potentially destructive activities might be best located, timed, or otherwise modified to avoid or minimize impacts to significant natural resources. Information obtained from the inventory also will assist DOE in biological resource management planning and implementation in the context of regional and statewide conservation values. Indeed, DOE already has used the inventory information obtained by TNC in 1994 and 1995 (Pabst 1995 and Soll and Soper 1996, respectively) during its preparation of the Draft Hanford Site Biological Resources Management Plan (DOE-RL 1996). Finally, a comprehensive and accurate biodiversity inventory also helps address DOE's desire to accommodate tribal and stakeholder interest in the present and future condition of Hanford's natural resources.

Biological studies undertaken in the past by the Pacific Northwest National Laboratory and other Hanford Site contractors have been primarily project- or species-specific. Although these studies have contributed enormously to the body of knowledge on Hanford, they did not include a large-scale, detailed inventory of the rare species and plant communities present on the site. Therefore, the primary goal of the TNC inventory effort is to fill critical gaps in our knowledge of the biology of the

Hanford Site and to provide this information to decision-makers. Such an accounting also will assist DOE in affording the proper protection and mitigation required under the federal Endangered Species and National Environmental Policy Acts, as well as fulfilling requirements under numerous other applicable state and federal laws, regulations, policies, and guidelines in regard to rare species and biological diversity.

Biodiversity Inventory Findings

The Hanford Site Biodiversity Inventory has produced remarkable findings in each of the biological subject areas that were addressed: plant communities; rare plants; noxious weeds; small mammals; birds; insects (aquatic and terrestrial); amphibians and reptiles; and soil mosses and lichens (the microbiotic crust). A rich and diverse mix of native plant communities and rare and typical shrub-steppe species have been located and documented. Table A summarizes the findings by subject area. A brief description from each research area follows.

AREAS OF RESEARCH

PLANT COMMUNITIES

Purpose and Scope

The term “plant communities” refers to plant species that coexist in generally recognizable groups. Plant communities are important indicators of biodiversity because they form the biotic component of the habitat used by other organisms. Plant community surveys on the Hanford Site conducted as part of the biodiversity inventory covered the entire site, excluding only areas off-limits because of radiological hazards.

Plant communities were classified at one or more of three levels: potential plant community type, mapping unit, and cover type. Potential plant community types reflect the plant species that through time—based on climate and other abiotic factors present at the site—are projected to dominate an undisturbed site. A potential plant community type generally is identified by both its dominant shrub (when present) and dominant grass (or grasses when shrubs are absent). Vegetation mapping units identified the existing vegetation of an area. Vegetation mapping unit types were grouped into more generalized cover types. The conservation significance of each area mapped was determined by an assessment (ranking) of ecological condition, size, and the surrounding landscape using criteria developed by the Washington Natural Heritage Program. Areas that met minimum standards were designated “element occurrences” and will be entered into the Natural Heritage Program tracking system for significant state- and region-wide elements of biodiversity (As used here, an “element” is an entire biological system, such as a plant community or a wetland ecosystem.).

Findings

The diversity and vast size of native plant communities found on Hanford is unmatched in the ecoregion. Biodiversity inventory personnel and the Washington Natural Heritage Program identified a total of 17 terrestrial, potential plant community types (or elements) that occurred as 48 separate element occurrences on the ALE Reserve and North Slope. Only three of the 17 identified terrestrial plant community elements were common to the ALE Reserve, North Slope and Central Hanford. The terrestrial element occurrences covered approximately 90,000 acres, occupying significant amounts of the ALE Reserve and North Slope, and lesser though substantial amounts within Central Hanford. The condition and size of the big sagebrush (*Artemisia tridentata*) / bluebunch wheatgrass (*Pseudoroegneria spicata*) on the ALE Reserve, and the bitterbrush (*Purshia tridentata*) / Indian ricegrass (*Oryzopsis hymenoides*) and big sagebrush / needle-and-thread (*Stipa comata*) dune complex occurrences on the North Slope and Central Hanford are extensive and of particular regional

importance. Additionally, the inventory identified six riparian wetland communities along the southern (western) shore of the Hanford Reach as element occurrences. Such communities are rare elsewhere along a river system that is otherwise a series of lakes.

RARE PLANTS

Purpose and Scope

Rare plant species refers to any vascular plant species listed by the Washington Natural Heritage Program (WNHP 1997) as endangered, threatened, or sensitive in the state of Washington. Additionally, for the purposes of this report, species included in Review Group 1 also are referred to as rare plant species, though knowledge of their precise status in the state is generally not well known. Large-scale rare plant surveys were conducted during the 1994, 1995, and 1997 field seasons within each of the Hanford Site management areas. In total more than 40,000 acres were surveyed.

Findings

During three years of fieldwork, a total of 112 populations of 28 rare plant taxa were located on the Hanford Site. Although rare plants were found dispersed throughout the site, the highest densities occurred on the east end of Umtanum Ridge; the basalt-derived sands near Gable Mountain; the White Bluffs; Rattlesnake Mountain; and Yakima Ridge. A number of the riparian community rare plants are found within riverine emergent wetlands that are otherwise rare along the Columbia River system (Caplow and Beck 1996, Downs et al. 1993). When rare plants located by other workers before 1994 are included, a total of 127 populations of 30 rare plant taxa are now documented on the Hanford Site. This is a tremendous number of rare plants—both in terms of species richness and abundance—to occur in an area the size of the Hanford Site.

One of the highlights of the rare plant surveys on the Hanford Site was the discovery of two plant species, Umtanum desert buckwheat (*Eriogonum codium)* and White Bluffs bladderpod (*Lesquerella tuplashensis*), and one variety of a species (basalt milk-vetch (*Astragalus conjunctus* var. *rickardii*) that are new to science.

During 1997 eight special habitat areas were delineated. These areas encompass habitat for populations of certain rare plant species, generally annuals, whose locations are patchy, whose habitat is dynamic (e.g., dune fields), and whose occurrence over time may vary in response to changes in weather patterns. Special habitat areas were mostly located in proximity to the basalt ridges of Central Hanford. Among the most interesting special habitat areas were three previously undocumented clusters of approximately 20 vernal pools. Vernal pools in Washington are little known or studied and their occurrence on Hanford is significant. The Hanford Site pools were located on the eastern end of Umtanum Ridge, near Gable Butte, and on Gable Mountain. Each cluster contained one or more rare plant species.

No rare plant survey is 100% complete. The 1994–1998 biodiversity inventory should not be substituted for more detailed project-specific surveys when these are appropriate. Moreover, populations of rare plants are dynamic. Through time, new rare plant populations may become established, and existing ones may become larger, smaller, or shift in their location. Thus, continued monitoring of the status of rare plants on Hanford is essential.

NON-NATIVE PLANTS

Purpose and Scope

Although the primary purpose of the Hanford Site Biodiversity Inventory and Analysis has been to survey and document the native species and plant community diversity present at Hanford, some information has been gathered concurrently on the threats to that diversity. One of the primary threats is that of invasive, non-native plant species. Both federal and state regulatory agencies target certain

non-native plant species for eradication or control that pose a threat to natural ecosystems or agriculture. These species include state-designated noxious weeds. In Washington State noxious weeds are plants that when established are highly destructive, competitive, or difficult to control by cultural or chemical practices.

Findings

The biodiversity inventory documented the presence of several species of state-designated noxious weeds. Continued inventory of undesirable plant species and their distribution is recommended. The presence and spread of undesirable plant species, especially state-designated noxious weeds such as yellow starthistle (*Centaurea solstitialis*), poses a serious threat to the biodiversity of the Hanford Site. The next few years will be critical for initiating control measures for those species that pose the most imminent threats.

TERRESTRIAL INVERTEBRATES

Purpose and Scope

Because of their extraordinary diversity and intimate interactions with vegetation, insects may prove ultimately to be the most sensitive measure of ecosystem quality and function; however, data often are lacking with which to make comparative judgments among sites. The 1994 and 1995 portions of the terrestrial invertebrate inventory concentrated on several particular insect groups, including the leafhoppers and their relatives, true bugs, beetles, bees and wasps, true flies, and butterflies and moths. During 1996 and 1997, inventory efforts concentrated on mothsand other night active insects attracted to light traps, and on butterflies. The 1998 surveys broadened the sampling methods to include pitfall traps. As well as continuing sampling previously established sites, comparisons were made between native and non-native dominated habitats, and the West Lake area of Central Hanford was sampled.

Findings

The five years of insect inventory work on the Hanford Site represent the most intensive survey of its kind of any large geographic region in Washington and one of the few studies of its type conducted in the Pacific Northwest. Almost 40,000 specimens have been collected, correctly prepared, and identified or made available for identification. Thus far, 1509 species-level identifications have been completed through the efforts of biodiversity inventory personnel and 68 collaborators, and at least 500 more are expected. Many of these collaborators are world-recognized experts in the groups that they examined. Few studies conducted anywhere, can boast of this degree of taxonomic expertise in their identifications.

Forty-nine taxa of butterfly were observed during the inventory. Eight of these taxa are identified as monitor species by the state of Washington (WDFW 1998). To date a total of 318 species of moths have been collected on the Hanford Site as part of the biodiversity inventory. Twenty of these species are new to science and additionally, 14 species represent new state records for Washington. Butterflies and moths (Lepidoptera) are one of the few groups of insects that are commonly included in biodiversity studies. Although other groups of insects offer as much potentially valuable information, butterflies and moths are indeed noteworthy for their use in estimating diversity. This is primarily because of their association with host plants. With few exceptions, butterflies and moths are plant feeders, and many are monophagous (i.e., one host plant used as food) or restricted to a limited number of related host plants. Thus, a lepidopteran fauna often corresponds to a diverse flora.

During the course of the insect biodiversity inventory, a total of 41 species and two subspecies new to science have been identified and designated by world-recognized authorities. Additionally, numerous other specimens that have been collected but not yet identified may represent species new to science. At least 142 species were not previously known from Washington State. The key point about insect diversity on Hanford, however, is not that any single species is found there and no place else; rather,

it is that so many species, including rare or rarely collected species, are found there. These findings indicate that the Hanford Site still retains an assemblage of microhabitats large enough to support what at one time was a fauna typical of the arid interior West.

The source of Hanford's insect diversity can be attributed to the size, diversity and relatively undisturbed condition of its native shrub-steppe habitat. For these reasons it is important to maintain representative native plant communities and generalized habitats, such as the few springs and riparian zones present on the Hanford Site. The overall insect species composition and abundance at Hanford—and lack of introduced species that are more common in the surrounding agricultural fields or disturbed urban areas—provide strong evidence in support of these conclusions.

AQUATIC INVERTEBRATES

Purpose and Scope

Aquatic invertebrates are a vital part of ecosystems. They are so responsive to environmental conditions that their patterns of diversity and abundance have been used to develop an index of biological integrity for streams in some parts of the U.S. (Karr reference). More locally, aquatic insects are a key element supporting the thriving salmon population on the Hanford Reach. In order to increase understanding of the aquatic invertebrates of the Hanford Site the biodiversity inventory 1) conducted reconnaissance level surveys of aquatic invertebrates of the Columbia River, some tributary water sources and two spring streams on the Hanford Site; and2) surveyed published literature for historical records of aquatic invertebrates.

Findings

The results of this survey and literature review clearly indicate that the diversity found in terrestrial invertebrate species at Hanford is also found in the aquatic areas. Fifty-two taxa of aquatic macroinvertebrates were identified, including 21 not previously documented from the Hanford Reach. The total number of identified taxa within the Reach is now 145. Because this was a reconnaissance level survey with limited sampling, these findings are not likely to represent the full diversity of aquatic insects on the site.

This is the first study from this area of Washington that examined tributaries to the Hanford Reach. With one exception, the benthic fauna of the 4 tributaries represents a microcosm of the river. The Ringold hatchery stream was depauperate.

This study greatly expanded the knowledge of the invertebrate fauna of the spring streams, especially of the Trichoptera, Odonata, and Hemiptera. Thirty taxa of benthic invertebrates were collected from Rattlesnake Springs and 12 from Snively Springs, with 25 and 8 representing new Hanford records respectively. This brings the known total for the two sites to 43 and 24 respectively

AMPHIBIANS AND REPTILES

Purpose and Scope

Before 1995 no comprehensive surveys had been completed on the herpetofauna of major portions of the Hanford Site. The 1995 and 1998 inventory efforts were designed as a preliminary site-wide inventory to document the amphibian and reptile species present and the habitats they are using, with follow-up surveys of promising areas. Emphasis was placed on locating Species of Conservation Concern and breeding sites for frogs, toads and salamanders. All areas of the site received some amount of inventory effort, although areas perceived to have a high likelihood of supporting herpetofauna received relatively greater survey intensity.

Findings

Four species of amphibians and nine species of reptiles were found during the 1995 inventory. Three species, Woodhouse's toad (*Bufo woodhousii*), tiger salamander (*Ambystoma tigrinum*) and the night snake (*Hypsiglena torquata*), are Washington State Monitor species (WDFW 1998), whereas the northern sagebrush lizard (*Sceloporus graciosus graciosus*) is a federal Species of Concern (USFWS 1998). The tiger salamander was documented on the Hanford Site for the first time in 1998. Compared to other inventory research areas, few rare amphibian and reptile species were located by the inventory effort. Significantly, however, each of the typical shrub-steppe species was present in appropriate abundance, in sharp contrast to their absence or decline in other areas. Especially noteworthy was the linkage of sagebrush lizard with areas of mature sagebrush and sandy soils.

BIRDS

Purpose and Scope

Birds are conspicuous components of the biota of an area, and compared with other taxonomic groups, bird status and distribution within a particular geographic area tend to be documented more thoroughly. This characteristic makes bird inventories informative about the conservation importance of a geographic area relative to a broader region. The 1994 and 1995 bird inventory efforts mostly concentrated on the North Slope, the northern and eastern shores of the Hanford Reach, and the ALE Reserve. The main purpose of the 1997 effort was to extend the inventory of bird species to Central Hanford (mostly the northern portion), including the southern and western shores of the Hanford Reach. Inventory efforts continued on the ALE Reserve in 1997 and 1998.

Findings

The bird inventories documented a total of 221 species on the Hanford Site, including 22 not previously known, bringing the total for the Hanford Site to 258. Thirty-eight of the species, including 18 known to breed within Hanford are Species of Conservation Concern. The totals for the North Slope, Central Hanford and ALE were 193, 195 and 158, respectively.

Each management area supports a unique bird fauna. Indeed, only 110 species were common to all three sites, and each site has some species not found on the others. Considered within the scope of the 1997 Hanford Site bird inventories, more than twice the number of species unique to a particular area were observed on Central Hanford (57) as compared with the ALE Reserve (26). A similar finding resulted from the 1994 and 1995 bird inventories that indicated a higher number of unique species on the North Slope (77) as compared with the ALE Reserve (18) (Soll and Soper 1996). In both comparisons the higher number of unique species on the North Slope and Central Hanford can be attributed to the presence of the Columbia River and its associated abundant and diverse riparian and wetland habitats. Additional significant findings include:

- Thirty-nine of the 41 species of native birds that are considered steppe or shrub-steppe dependent within the Columbia Basin Ecoregion were documented on the Hanford Site.
- Eight species that breed in steppe or shrub-steppe habitats and are of regional management concern were documented as breeding on the Hanford Site. (Saab and Rich 1997: Black-throated Sparrow (*Amphispiza bilineata*), Sage Sparrow (*Amphispiza belli*), Sage Thrasher (*Oreoscoptes montanus*), Brewer's Blackbird (*Euphagus cyanocephalus*), Brewer's Sparrow (*Spizella breweri*), Lark Sparrow (*Chondestes grammacus*), Loggerhead Shrike (*Lanius ludovicianus*), and Western Meadowlark (*Sturnella neglecta*)

The results from the biodiversity inventory, along with the information gained from recent monitoring studies (Vander Haegen 1996), indicate the Hanford Site contains regionally significant breeding populations of steppe and shrub-steppe dependent birds, and illustrate Hanford's importance to bird conservation in the Columbia Basin Ecoregion. Additionally, the Hanford Reach and riparian /

wetland areas on the ALE Reserve and North Slope contain the highest diversity of bird species on the Hanford Site. These areas provide important stopover habitat for migratory birds, as well as breeding and post-breeding habitat for many resident species. Finally, the Hanford Reach is important wintering habitat for the Bald Eagle (*Haliaeetus leucocephalus*), American White Pelican (*Pelecanus erythrorhynchos*), and many species of waterfowl.

MAMMALS

Purpose and Scope

The biodiversity inventory conducted small mammal inventories on the Hanford Site in 1997 and 1998. There are fifteen small mammal species potentially present on the Hanford Site which are identified as Species of Conservation Concern. With two significant exceptions, small mammals present on the Hanford Site have been well documented (Downs et al. 1993, Fitzner and Gray 1991, Rickard and Poole 1989). First, there is limited published information on the occurrence of bat species on the Hanford Site. And second, previous inventory efforts did not focus on whether two species of concern, Ord's kangaroo rat (*Dipodomys ordii*) and Washington ground squirrel (*Spermophilus washingtoni*) occurred on the Hanford Site. There were five primary goals of the 1997 and 1998 inventory efforts:

- Update and supplement information on the occurrence of bats on the Hanford Site.
- Inventory areas that received little or no sampling effort in previous studies.
- Determine whether and where six Species of Conservation Concern (Ord's kangaroo rat, Merriam's shrew (*Sorex merriami*), northern grasshopper mouse (*Onychomys leucogaster),* pygmy rabbit (*Brachylagus idahoensis),* sagebrush vole (*Lemmiscus curtatus),* and Washington ground squirrel) occur on Central Hanford and the North Slope.
- Determine the status of species previously identified as relatively common at Hanford (e.g., black-tailed jack-rabbit (*Lepus californicus)* and Townsend's ground squirrel (*Spermophilus townsendii*).
- Compare species occurrence and relative abundance across the major plant community types of Central Hanford and the North Slope.

Findings

A total of eight bat species were documented on the Hanford Site with the possibility that one other species also occurred. The big brown bat (*Eptesicus fuscus*) had not been previously documented on the Hanford Site. The pallid bat (*Antrozous pallida*), western pipistrelle (*Pipistrellus hesperus*) and western small footed myotis (*Myotis leibii*) are identified as Species of Conservation Concern by the U.S. Fish and Wildlife Service (USFWS 1998) and the Washington Department of Fish and Wildlife (WDFW 1998). The White Bluffs, Columbia River, open water, and all cliff structures were found to be important for bats at Hanford.

Fourteen non-bat small mammal species were documented during the inventories. Surveys for Ord's kangaroo rat, Merriam's shrew, pygmy rabbit and Townsend's ground squirrel all were negative. Even previously documented species (i.e., Merriam's shrew, sagebrush vole and Townsend's ground squirrel) seem to be limited in their distribution on the Hanford Site. The limited distribution of Merriam's shrew and sagebrush vole on the Hanford Site demonstrates the importance of the ALE Reserve and Umtanum Ridge, and in particular remnant high quality big sagebrush / bluebunch wheatgrass and three-tip sagebrush (*Artemisia tripartita*) plant communities, for their conservation.

1998 inventory work confirmed the presence of the state candidate Washington ground squirrel just north of the crest of the Saddle Mountains. This is the first time this species has been documented to occur on the Hanford Site.

Despite the limited results in regard to the number of species observed, some findings from the small mammal inventory are noteworthy. By habitat area / plant community type, capture rates and biodiversity were highest in native shrub steppe, in particular the bitterbrush / Indian ricegrass dune complex and big sagebrush / needle-and-thread communities. Both of these community types have received the highest protection priority ranking assigned by the Washington Natural Heritage Program (WDNR 1995). The capture rates within these two community types were 8–12 times higher than the rate observed in disturbed communities dominated by cheatgrass (*Bromus tectorum*).

MICROBIOTIC CRUSTS

Purpose and Scope

Throughout much of the shrub-steppe region, a living crust covers some or all of the soil between plants. This soil crust - referred to as microbiotic, cryptobiotic, or cryptogamic - is composed of algae, fungi, lichens, and mosses. Microbiotic soil crusts are especially well developed in relatively undisturbed areas, such as portions of the Hanford Site. Although the ecological role of the microbiotic crust within the shrub-steppe is not well understood, it clearly plays an important role in ecosystem functioning by reducing erosion, contributing nitrogen and organic carbon to the soil, and increasing infiltration of precipitation into the soil. Intact crusts can also enhance native seedling establishment in arid ecosystems (St. Clair et al. 1984), and may discourage invasion by non-native species such as cheatgrass. This study was the first documentation of the microbiotic crust species present on the lower elevation portions of the Hanford Site.

Findings

This study of the soil mosses and lichens of the Hanford Reservation is the most intensive survey to date in the state of Washington. Seventeen sites were selected to represent a wide range of plant associations, ecological conditions and soil types in the lower elevation portions of the site. Thirty soil lichen and eight moss species have been identified. Three of the lichen species had not previously been described. Comparison with data from other studies conducted in shrub-steppe indicates that the Hanford Site supports a relatively diverse and unique crust flora.

Hanford Site Biodiversity Inventory: Status and Future Work

Many of the biodiversity inventory goals established at the outset have been met, and results have exceeded expectations. Progress in certain inventory research areas however, has been limited. Despite two field seasons of effort, amphibian and reptile inventories in most areas have remained at the reconnaissance level. The basic bird inventories have only partially covered Central Hanford. Additionally, with the exception of butterfly inventories, only the ALE Reserve and Central Hanford have been inventoried for other invertebrate taxonomic groups. Moreover, some insect taxonomic groups have yet to be inventoried in any systematic way. Finally, work on exploring the diversity of Hanford's microbiotic crust remains preliminary.

Conclusions: Significance of Findings to Date and Management Implications

Findings from the biodiversity inventory clearly demonstrate that the Hanford Site, including the Hanford Reach, is home to a spectacular, unduplicated and irreplaceable natural legacy. Within its mosaic of habitats, Hanford supports a wealth of relatively unaltered and increasingly uncommon native plant communities, the size and diversity of which is unmatched in the Columbia Basin. Not surprisingly, significant numbers of plants, insects, amphibians, reptiles, birds, and mammals, many of which are rare or declining in Washington, were found to be associated with or dependent on these

habitats. In its present condition the Hanford Site is not only a refuge, but also a genetic bank for both the common and rare plants and animals that are integral components of the shrub-steppe and Columbia River ecosystems. From a conservation standpoint, the Hanford Site is a vital—and perhaps the single most important—link in preserving and sustaining the diverse plants and animals of the Columbia Basin Ecoregion.

The 1994 and 1995 biodiversity inventory findings confirmed the significant ecological values of the ALE Reserve, Hanford Reach, and North Slope. The 1997 and 1998 biodiversity inventory findings clearly demonstrate that the Central Hanford management area also contains significant components of biodiversity as well. Each management area on Hanford contributes uniquely to the overall biodiversity of the Hanford Site. Hopefully, the exceptional ecological features of the Hanford Site will be given due consideration as land-use decisions are made. As these decisions are contemplated, DOE, potential future land stewards, Tribes, and other stakeholders should keep in mind several basic questions:

- What is the value of native biodiversity?
- How important is protecting one of the Columbia Basin Ecoregion's few remaining representations of an unfragmented, native shrub-steppe ecosystem and the last, non-tidal free-flowing stretch of the Columbia River in the United States?
- What types of land ownership and management will not sacrifice the ecological integrity of these ecosystems?
- What specific portions of the Hanford Site contain its most significant ecological features and how should their presence guide future land-use management?

In addition to their relevance for contributing to an informed land-use decision making process, the biodiversity inventory findings provide a basis for considering several additional management actions. Possibly the most unexpected finding after three years of inventory work is the critical state of the non-native plant (mostly noxious weed) invasion at Hanford. We are almost certainly in a critical window of opportunity in which to initiate control measures. To wait both risks the loss of some of Hanford's irreplaceable biological legacy and insures more costly management in the future.

To ensure that DOE's stewardship of the biodiversity of the Hanford Site is based on the best available information, the link between the biodiversity inventory data, and its use in the Hanford Site Biological Resources Management Plan (DOE-RL 1996) should be maintained. The ideal outcome is an updated version of the management plan.

An inventory represents a snapshot in time. To track the status of Hanford's biodiversity over the long-term, the establishment and maintenance of a comprehensive monitoring program is imperative. Monitoring provides the information needed to enable adjustments in management actions as resource conditions, or potential impacts to those resources, change over time.

Table A. Hanford Site biodiversity inventory: summary of findings, 1994-1998

Inventory Research Area	Project Reports	Areas Surveyed	1994-1998 Combined Totals*
Plant Communities	Wilderman 1994 Salstrom and Easterly 1995 James and Soll 1996 Easterly and Salstrom 1997	Entire site except inside facility boundaries	48 element occurrences of 17 terrestrial ecosystem elements totaling 90,000 acres; 6 element occurrences of 1 wetland and aquatic ecosystem element
Rare Plants	Caplow and Beck 1994, 1995, 1997	About 48,000 selected acres (19, 425 ha) across all management areas	112 populations / occurrences of 28 rare taxa**; 2 species and 1 variety new to science; 8 special habitat areas
Invertebrates	Zack et al 1994, 1995, 1997, 1998	Limited locations within the ALE Reserve and Central Hanford	1509 taxa documented; 400–500 specimen identifications pending; 41 species and 2 subspecies new to science
Butterflies and Moths	Ensor et al 1995, 1997 and Zack et al as above	Limited locations within all management areas	368 taxa documented; 50-100 specimen identifications pending; 3 species and 5 subspecies of conservation concern
Amphibians	Hallock 1995, 1998	Limited locations within all management areas	4 species documented; 2 Species of Conservation Concern
Reptiles	Hallock 1995, 1998	Limited locations within all management areas	9 species documented; 1 Species and 1 Subspecies of Conservation Concern
Birds	Greager 1994, 1995, 1997 Stepniewski 1994, 1995 LaFramboise 1997, 1998	ALE Reserve, North Slope, and northern portion of Central Hanford	221 species documented: ALE Reserve (158), Central Hanford (192), and North Slope (195); 35 Species and 3 Subspecies of Conservation Concern
Mammals	West et al 1997, 1998 Marr 1997	Selected locations within ALE Reserve, Central Hanford and North Slope	22 species documented; 6 Species of Conservation Concern (3 of which are bats)
Microbiotic Crust	Link et al 1999	17 locations within Central Hanford, North Slope and ALE Reserve	30 species of lichen 8 species of moss

*Specific definitions for elements of interest used in this table—element occurrences, ecosystem elements, rare plant occurrences, rare plant populations, rare plant taxa (species, subspecies, and varieties), special habitat areas, taxa of conservation concern, and taxa new to science—can be found in the appropriate sections of the main part of this report. The reader should consult these sections to gain a more detailed understanding of the findings summarized in this table. Adjustments have been made in this table to the numbers of element occurrences, rare plant taxa, and taxa of conservation concern previously reported in Pabst (1995), Soll and Soper (1996) and Hall (1998) to account for status changes that have occurred in the meantime.

**Two additional rare plant species are present at Hanford. They are not included in the numbers reported in this table because their populations originally were documented before 1994.

Contents

LIST OF TABLES

LIST OF FIGURES

Section 1 – Introduction

1 Introduction

1.1 History of the Biodiversity Inventory and Analysis of the Hanford Site

In 1992 the U.S. Department of Energy (DOE) and The Nature Conservancy of Washington (TNC) entered into a Memorandum of Understanding that called for a cooperative and coordinated inventory of plants, animals and ecologically significant areas at the Hanford Site. Through the use of its own resources, TNC began this effort in 1992 and 1993 with localized surveys for Western Sage Grouse (*Centrocercus urophasianus phaios*) and the rare riparian plant, persistentsepal yellowcress (*Rorippa columbiae*). In October 1993 DOE awarded TNC a grant that enabled a significant expansion of the inventory effort. The Nature Conservancy also raised private funds to support the project, now titled the "Biodiversity Inventory and Analysis of the Hanford Site." Although initially conceived as a three-year grant, budget cuts and their effect on grant funding levels have led to adjustments in the inventory scope and schedule.

The goal of the inventory was to identify and map occurrences of native plant communities, rare plant populations, and rare and characteristic animal taxa over large areas of the Hanford Site. The results of the inventory were provided to DOE to improve resource management and land-use decisions. Relevant findings from the 1994, 1995 and 1997 inventory efforts are provided in previous annual reports (Pabst 1995, Soll and Soper 1996, Hall 1998). Twenty-six technical reports provide additional details for individual subject areas (see bibliography). The inventory was inactive in 1996. Although this report is comprehensive, some emphasis is placed on findings from the 1998 field season.

Table 1.1 Biodiversity inventory subjects by year and management area

Subject Area	1994	1995	1997	1998
Plant communities	ALE, NS	HR	CH	–
Rare Plants	ALE, NS, HR	Sitewide	Sitewide	–
Birds	ALE, HR, NS	ALE, HR, NS	ALE, CH	ALE
Herpetofauna	–	Sitewide	–	CH, HR, NS
Small Mammals	–	–	Sitewide	CH, HR, NS
Microbiotic crusts	–	–	–	Sitewide
Insects	ALE	ALE	ALE, CH	Sitewide
Aquatic Insects	–	–	–	ALE, HR
Butterflies/Moths	ALE	ALE, CH, NS	CH, NS	–

ALE = Fitzner-Eberhardt Arid Lands Ecology Reserve, CH = Central Hanford, HR = Hanford Reach, NS = North Slope (see section 1.2.2 for descriptions of management areas).

1.2 Hanford Site History and Management Areas

1.2.1 HISTORY OF THE HANFORD SITE

The 560 mi^2 (1450 km^2) Hanford Site has been administered by DOE, or its predecessors, since it was first acquired in 1943 by the U.S. Government as a national security area for the production of weapons-grade plutonium. Nine plutonium production reactors were constructed and operated between 1943 and 1987. Energy-related research also has been an important component of Hanford's mission over the years (Becker 1990). Today, the site is administered by the DOE for nuclear waste management, environmental restoration, and research and development. Most of the Hanford Site has been closed to the public since 1943.

In addition to its national and international significance in nuclear weapons development, energy technology advancement, and scientific research, Hanford supports the economy of the Tri-Cities region. The site also has important cultural significance to the local Native American Nations: the Confederated Tribes of the Umatilla Indian Reservation, the Nez Perce Tribe, the Wanapum, and the Yakama Indian Nation. From an ecological perspective, placing such a large tract of land virtually off-limits to public access and development for over 50 years has preserved the Hanford Site's shrub-steppe ecosystem in a condition and to an extent that exists nowhere else.

1.2.2 MANAGEMENT AREAS

The Hanford Site, in its entirety, is one of seven DOE National Environmental Research Parks nationwide. The National Environmental Research Park Program was established by DOE in the 1970s to set aside land for ecosystem preservation and study and environmental education (DOE 1994). The Hanford National Environmental Research Park's specific purpose is to provide a protected area for research demonstrations and education in ecology (PNL 1977).

The Hanford Site can be divided into five management areas: Fitzner / Eberhardt Arid Lands Ecology Reserve, Saddle Mountain National Wildlife Refuge, Wahluke Unit Columbia Basin Wildlife Area (referred to as the Wahluke State Wildlife Recreation Area in previous annual reports), Hanford Reach, and what is referred to in this report as Central Hanford (Figure 1.1). The Saddle Mountain National Wildlife Refuge and Wahluke Unit Columbia Basin Wildlife Area are known, and will be referred to collectively in this report, as the North (or Wahluke) Slope. Each management area is discussed in additional detail below.

FITZNER / EBERHARDT ARID LANDS ECOLOGY RESERVE

The Fitzner / Eberhardt Arid Lands Ecology (ALE) Reserve is a 120 mi^2 (312 km^2) tract of land in the southwestern portion of the Hanford Site (Figure 1.1). After many years of management for DOE by the Pacific Northwest National Laboratory, the ALE Reserve currently is managed by the U.S. Fish and Wildlife Service under a use permit with DOE. The ALE Reserve generally is inaccessible to the public, though limited access occasionally is granted.

The ALE Reserve was established in 1967 to preserve "portions of vegetation types that once covered a great expanse of the West" (O'Farrell 1973). It is designated the Rattlesnake Hills Research Natural Area as a result of a federal interagency cooperative agreement (PNL 1993). Research Natural Areas are examples of relatively unaltered ecosystems that represent storehouses of natural diversity, serve scientific and educational purposes, and act as baselines for comparison with similar, but intensely managed areas (DOE-RL 1996). The ALE Reserve constitutes the single largest tract in the federal Research Natural Area system for Oregon and Washington (Franklin *et al*. 1972, Rickard 1972), and is one of the few remaining large tracts of shrub-steppe vegetation in Washington that retains a predominant pre-European settlement character (PNL 1993).

From the 1880s to 1943 portions of the ALE Reserve were used for winter and spring sheep grazing, cattle and horse grazing, several homesteads, limited gas well development, and small amounts of dryland and irrigated agriculture (Hinds and Rogers 1991). Livestock use was particularly heavy in the vicinity of Rattlesnake Spring during this period. After 1943, only a few stray cattle continued to water at the spring until all livestock use was precluded in 1962 by the erection of an exclosure fence (Rickard and Cushing 1982).

Wildfire also has played an important role in the ecology of the ALE Reserve. Extensive lightning-caused fires in 1957, 1973, 1981, and 1984 removed shrub cover from much of the site and created the large expanses of nearly shrubless grassland that typify the area today.

Prominent natural features of the ALE Reserve include the ridge top and mostly north-facing slope of Rattlesnake Mountain, portions of the Rattlesnake Hills, Dry Creek Valley, Cold Creek Valley, and the east end of Yakima Ridge. Two streams, Snively Creek and Dry Creek, and a number of cold springs occur within the ALE Reserve (DOE-RL 1996). Elevations across the ALE Reserve range from about 500 ft (150 m) in the Cold Creek Valley to 3450 ft (1050 m) on top of Rattlesnake Mountain.

SADDLE MOUNTAIN NATIONAL WILDLIFE REFUGE

The Saddle Mountain National Wildlife Refuge has been managed by the U.S. Fish and Wildlife Service since 1971 under a 30-day revocable use permit with DOE. The refuge is a 50 mi^2 (130 km^2) tract of land located north-northwest of the river and generally south and east of state Highway 24 (Figure 1.1). The area was originally acquired by the U.S. Government in 1943 as a buffer area for the plutonium production reactors located immediately across the Columbia River. The area has been closed to the public since 1943. Before 1943 livestock grazing and some crop farming occurred in the area (Downs et al. 1993).

Prominent natural features within the Saddle Mountain National Wildlife Refuge include a portion of the Wahluke Slope, the western end of the White Bluffs, the slopes and crest of the Saddle Mountains, and a portion of the Hanford Reach of the Columbia River. The refuge contains numerous lakes and wetlands created and sustained by raised water tables associated with irrigation drainage and runoff.

WAHLUKE UNIT COLUMBIA BASIN WILDLIFE AREA

The Wahluke Unit Columbia Basin Wildlife Area (Wahluke Wildlife Area) has been managed by the Washington Department of Fish and Wildlife since 1978 under a 30-day revocable use permit with DOE. The Wildlife Area is a 87 mi^2 (225 km^2) tract of land located north and east of both the Columbia River and the Saddle Mountain National Wildlife Refuge (Figure 1.1). It is bisected by Highway 24. The area originally was acquired by the U.S. Government in 1943 for purposes similar to the refuge lands described above.

The Wildlife Area has been accessible to the public since 1978. Legal hunting and fishing, and illegal off-road vehicle use occur. Several boat launches are maintained by the Washington Department of Fish and Wildlife in the southern portion of the Wildlife Area. Before 1943 much of the area was used for farming and livestock grazing. Subsequently, most crop farming ceased (that which remains has associated wildlife uses [DOE-RL 1996]) but some livestock grazing continued. Livestock grazing currently is permitted north of state Highway 24 during spring and summer. Portions of the Wildlife Area also were used historically for military training.Hanford Site.

Fire on the Wildlife Area has not been as extensive as on the ALE Reserve, but it still has been a factor in the area's ecology. A large fire or fires in the 1970s burned much of the area north of Highway 24 and resulted in plant communities that today have sparse shrub cover or relatively young shrubs. There also have been several human-caused fires within the Wildlife Area in the 1990s. In 1993 a fire burned several thousand acres just south of Highway 24 at the eastern edge of the Wildlife Area. It killed most of the shrubs and some of the native grasses. In 1994 at least three fires are known to have occurred, with the largest burning 1200 acres (485 ha) on and around Savage Island.

Prominent natural features found within the Wahluke Unit Columbia Basin Wildlife Area include: a portion of the Wahluke Slope, the eastern end of the White Bluffs, the large dune fields above the White Bluffs, the Saddle Mountains (which rise to over 2000 ft [610 m] within the Wildlife Area), and lakes and wetlands created and sustained by raised water tables associated with irrigation drainage and runoff. The White Bluffs Wasteway crosses the central portion of the Wildlife Area.

HANFORD REACH

Most of the Hanford Reach—that is, the stretch of the Columbia River between Priest Rapids Dam and the beginning of the McNary Dam reservoir—courses through the Hanford Site. The Hanford Reach is the only non-tidal, free-flowing stretch of the Columbia River within the United States, and supports the last healthy salmon runs on the mainstem of the Columbia. Future management of the Reach is currently being considered. Competing management visions have been proposed which would give management authority over the Reach and associated uplands either entirely to local concerns, or alternatively to a advisory board of local and national interests overseen by the United States Fish and Wildlife Service

For the purposes of this report, the Hanford Reach will refer to the Columbia River and immediately adjacent upland areas of the Hanford Site within 1/4 mi (0.4 km) of the high water mark of the river on each shore. Thus, portions of the Hanford Reach are within the boundaries of the Saddle Mountain National Wildlife Refuge, Wahluke Unit Columbia Basin Wildlife Area, and Central Hanford. Islands in the river are administered by various government agencies (Downs et al. 1993).

Much of the Hanford Reach has been accessible to the public since 1978. The Reach supports a variety of recreational activities, especially boating, fishing, and hunting (NPS 1994). The south and west shorelines and the shoreline within the Saddle Mountain National Wildlife Refuge are still closed to the public.

Prominent natural features within the Hanford Reach include the river and its islands, gravel bars, sloughs, and riparian areas, the White Bluffs, the steep slopes of Umtanum Ridge, and the 6320 acre (2560 ha) Hanford Dune Field.

CENTRAL HANFORD

For the purposes of this report, Central Hanford refers exclusively to portions of the Hanford Site not included in the ALE Reserve, Saddle Mountain National Wildlife Refuge, or Wahluke Unit Columbia Basin Wildlife Area. Central Hanford, defined as such, is a 303 mi^2 (785 km^2) tract of land located south and west of the Columbia River and north and east of the ALE Reserve (Figure 1.1).

Nuclear-related activities have been the primary land use on Central Hanford since the mid-1940s, though the associated facilities occupy only a small portion of the land. The 100 Areas along the southern shore of the Columbia River were the locations of the nine production reactors. At the center of Central Hanford, the 200 Areas provided fuel processing and past and present-day waste management facilities. The 300 Area, just north of Richland, was the location of fuel fabrication and research facilities. The 400 Area, in the southeastern portion of Central Hanford, is the location of the Fast Flux Test Facility. Most of Central Hanford is closed to the public.

Historical uses of the area included extensive native American use, limited irrigated agriculture, grazing and the Hanford townsite itself. Prominent natural features within Central Hanford include the eastern end of Umtanum Ridge, Gable Mountain, Gable Butte, the Hanford Reach, the Hanford Dune Field, and West Lake. The location of the 200 Areas and immediate surrounding lands often are referred to as the central plateau.

1.3 Natural History of the Hanford Site and Its Relationship to the Columbia Basin Ecoregion

Unless otherwise indicated, the information below is taken from the Draft Hanford Site Biological Resources Management Plan (DOE-RL 1996). Information extracted from this document on vegetation characteristics is a summary of information found in Daubenmire (1970) and Franklin and Dyrness (1973).

1.3.1 CLIMATE

Hanford is located within the driest and hottest portion of the Columbia Basin. An almost 50 year record of climate data is available for the central portion of Hanford (Hoitink and Burk 1994). Average weather conditions described here are based on that location and are taken from Cushing (1995). Still, it is important to remember that differences in the topography of the Hanford Site contribute to ecologically significant changes in some aspects of climate, particularly annual mean temperature and precipiatation (Cushing 1995). For example, although the average annual precipitation for central portion of Hanford is 6.3 in (16 cm), on the crest of Rattlesnake Mountain annual precipitation can reach up to 13.8 in (35 cm) (Downs et al. 1993). Most precipitation occurs during the winter, with more than half the amount occurring from November through February. Snowfall accounts for about 38% of all precipitation from December through February. Average monthly temperatures range from a low of 30° F (-0.9 ° C) in January to a high of 76 ° F (24.6 ° C) in July. Prevailing wind directions are generally from the northwest in all months of the year, but southwesterly winds also regularly occur. Monthly average wind speeds are lowest during the winter months and highest during the summer.

1.3.2 PHYSIOGRAPHY

The Hanford Site lies in the heart of the Pasco Basin. Columbia River Basalt, a result of lava flows occurring roughly between 17 and 2 million years ago, underlies the Hanford Site. Massive flood events occurred periodically towards the end of the Pleistocene epoch (until roughly 12,000 years ago) and the action of wind have since covered much of the site with deep sandy, loamy and gravelly soils. Several basalt ridges traverse Hanford and provide much of its topographic relief. These are described in the individual management area sections above. A stretch of the Columbia River (the Hanford Reach) runs through the northern part of Hanford and forms part of its eastern boundary. The Columbia River Plain constitutes the majority of the Hanford Site and is both its lowest (about 360 ft [110 m] along the river) and most arid region. Soils on the Hanford Site vary from sand and sandy loam to silt, with 15 types in all described (Hajek 1966). The silt loam soils tend to be found on the slopes and higher elevation areas of the Hanford Site, whereas sandier soils are found at the lower elevations of the Columbia River Plain. Large, active dune fields occur on both sides of the river. No perennial streams that originate within the Hanford Site feed the Columbia River, though a number of intermittent streams originate on the flanks of Rattlesnake Mountain and Umtanum Ridge.

1.3.3 SHRUB-STEPPE ECOSYSTEM

The Hanford Site is located within the Columbia Basin Ecoregion (DOE-RL 1996: Appendix C), an area that historically included over 14.8 million acres (6 million ha) of steppe and shrub-steppe

vegetation across most of central and southeastern Washington State (Franklin and Dyrness 1973) as well as portions of north-central Oregon. It is an area whose native, pre-settlement vegetation consisted primarily of shrubs, perennial bunchgrasses, a variety of forbs and a living soil crust composed of lichens, moss and algae.

A number of different plant association zones occur as climatic climaxes (*i.e.*, the plant association / community expected to occur in typical sites in the absence of disturbance) throughout the Columbia Basin Ecoregion. The largest and driest of these zones (about 8.2 million acres [3.3 million ha]) is the big sagebrush (*Artemisia tridentata*) / bluebunch wheatgrass (*Pseudoroegneria spicata* [=*Agropyron spicatum*]) association. This association occupies the center of the Columbia Basin Ecoregion, which includes the Hanford Site. In general, the big sagebrush / bluebunch wheatgrass association is characterized by four layers of vegetation: an overstory layer composed mostly of big sagebrush up to 2 meters tall, a tall understory layer of bluebunch wheatgrass, a short understory dominated by Sandberg's bluegrass (*Poa sandbergii* [included within *Poa secunda*]), and a layer of algae, lichens and mosses on the soil surface (i.e., the microbiotic crust). Perennial forbs are a minor constituent of the tall understory layer, whereas most annual forbs occur in the short understory layer. Other shrubs that may be present include rabbitbrush (*Chrysothamnus* spp.), bitterbrush (*Purshia tridentata*), spiny hopsage (*Grayia spinosa*), and three-tip sagebrush (*Artemisia tripartita*). Additional locally abundant bunchgrasses include needle-and-thread (*Stipa comata*), Indian ricegrass (*Oryzopsis hymenoides*), Cusick's bluegrass (*Poa cusickii* [included within *Poa secunda*]) and Idaho fescue (*Festuca idahoensis*).

Other associations, such as big sagebrush / Idaho fescue, bluebunch wheatgrass / Sandberg's bluegrass, and bluebunch wheatgrass / Idaho fescue can occur as topographic climaxes on moister sites within the big sagebrush / bluebunch wheatgrass association. Certain edaphic (soil-related) plant associations also are of ecological importance within the ecoregion. On deep soils dominated by gravel, sand, or strongly weathered volcanic ash, needle-and-thread and/or Indian ricegrass replaces bluebunch wheatgrass as the dominant grass in several associations. The dominant shrub in these associations can be either big or three-tip sagebrush or bitterbrush. On stony soils or extremely shallow soils over bedrock (lithosols), various species of buckwheat (*Eriogonum*) and / or stiff sage (*Artemisia rigida*) dominate the shrub layer and Sandberg's bluegrass dominates the understory.

As the hottest, driest, and lowest elevation part of the ecoregion, the Hanford Site also possesses a series of three plant associations found on reasonably deep, loamy (but dry) soils. These are the big sagebrush / Sandberg's bluegrass, spiny hopsage / Sandberg's bluegrass, and winterfat (*Ceratoides* [=*Eurotia*] *lanata*) / Sandberg's bluegrass associations. Each of these associations is characterized by the lack of large, perennial bunchgrasses (Sandberg's bluegrass is relatively small) and low overall plant diversity.

The steppe and shrub-steppe communities of the Columbia Basin Ecoregion have undergone substantial loss and/or degradation in the post-European era that can be attributed primarily to human-induced change (Dobler 1992, Noss et al. 1995). These changes include intensive livestock grazing, introduction of invasive non-native plants, such as cheatgrass (*Bromus tectorum*), advent of dryland wheat farming and irrigated agriculture, and altered fire regimes (primarily due to the presence of cheatgrass).

About 60% of the historic steppe and shrub-steppe vegetation in Washington has been lost, primarily to agriculture (Dobler 1992). This percentage estimate agrees with an analysis of data from the Interior Columbia Basin Ecosystem Management Project that evaluates change across the entire Columbia Basin Ecoregion (DOE-RL 1996). Moreover, much of what remains is either already degraded and fragmented, or is threatened by development and agricultural expansion (Noss et al. 1995). In Washington, continued losses are projected to be high for the next 50 years (Andelman and Stock 1994). The rarity and decline in quality of shrub-steppe affects a number of species dependent on shrub-steppe habitats for at least a portion of their life cycle.

The Hanford Site retains some of the largest remaining blocks of relatively undisturbed shrub-steppe in the Columbia Basin Ecoregion (Smith 1994, Soll 1999). Hanford's importance as a refuge for the shrub-steppe ecosystem is not based strictly on the ecosystem's rarity. The site's diversity of physical features has led to a corresponding diversity of plant communities and fauna (summarized in Pabst 1995, Soll and Soper 1996, Hall 1998 and this publication). Additionally, in many places on Hanford, the shrub-steppe is relatively free of non-native plant species and / or is extensive enough to retain characteristic populations of shrub-steppe plants and animals. Because it is located within the hottest and driest part of the ecoregion, Hanford also retains some of its own uniqueness and fragility. Finally, due to its location, Hanford provides opportunities for creating connectivity with other ecologically significant portions of the ecoregion, such as the Yakima Training Center and the Columbia National Wildlife Refuge.

1.3.4 HANFORD REACH

The Columbia River within the Hanford Site is unique within the post-dam Columbia River system in the United States. As opposed to the rest of the river system which is a series of slack-water reservoirs formed by damns; here, the river runs freely through an approximately 47-mile (76 km) segment — the so-called Hanford Reach — extending from the upper end of McNary Dam Reservoir to Priest Rapids Dam. Although overall flow volume and corresponding water levels are controlled by upstream damns, the Reach itself remains essentially free-flowing. As such, it contains significant riparian habitat, islands, riffles, gravel bars, oxbow ponds, and backwater sloughs, which are otherwise rare within the Columbia River system (USFWS 1980, NPS 1994). These once common habitats now provide remnant habitat for aquatic organisms, including salmon that were widespread before the remainder of the Columbia River system was converted to reservoir or slack-water habitat. Recent surveys have identified several rare plant associations along the south shore and islands of the Hanford Reach (Salstrom and Easterly 1995, Soll and Soper 1996), as well as an unusually diverse insect fauna (Newell 1998).

The Hanford Reach is regionally significant in that it provides important habitat for several species of anadromous salmonids (ocean going salmon and trout). Indeed, it contains the last mainstem spawning habitat in the Columbia River system for fall chinook salmon (*Oncorhynchus tshawytscha*). The fate of the aquatic ecosystem is tied closely to the adjoining uplands. For example, the White Bluffs—which are formed from 2 million year old consolidated sediments—create a prominent cliff along much of the eastern and northern shore of the river. The bluffs are subject to landslides as a result of irrigation activity east of the Columbia River (Cushing 1995, Stephens and Associates 1997). Such landslides could threaten the integrity of salmon spawning areas as well as flooding soils contaminated by radioactive and other toxic wastes.

1.4 The Need for a Biodiversity Inventory

The Department of Energy needs an accurate accounting of rare and typical species, plant communities, and ecosystems present on the Hanford Site to make informed decisions about future land use and resource management. Because the DOE's primary mission has changed from plutonium production to environmental cleanup and restoration, large-scale ground-disturbing activities are likely and, transfer of land ownership is eventually possible. Data provided by this biodiversity inventory project will help determine where cleanup and other activities might best be located, timed, or otherwise modified to avoid or at least minimize impacts to significant natural resources. Information obtained from the inventory also will assist DOE in biological resource management planning and implementation in the context of regional and statewide conservation values. Indeed, the DOE already has used the inventory information obtained by TNC in 1994 and 1995 (Pabst 1995 and

Soll and Soper 1996, respectively) during its preparation of the Draft Hanford Site Biological Resources Management Plan (DOE-RL 1996). Finally, a comprehensive and accurate biodiversity inventory also helps address DOE's desire to accommodate tribal and stakeholder interest in the present and future condition of Hanford's natural resources.

Biological studies undertaken in the past by PNNL and other Hanford Site contractors have been primarily project- or species-specific. Although these studies have contributed enormously to the body of knowledge on Hanford, they did not include a large-scale, detailed inventory of the rare species, plant communities, and ecosystems present on the site. Therefore, the primary goal of the TNC inventory effort was to fill the critical gaps in our knowledge of the biology of the Hanford Site and to provide this information to decision-makers. Developing such a data set will also assist DOE in affording to species the proper protection and/or mitigation required under the federal Endangered Species and National Environmental Policy Acts as well as fulfilling requirements under numerous other applicable state and federal laws, regulations, policies, and guidelines in regard to rare species and biological diversity.

1.5 Ownership and Use of Data

Although the data and information produced from this project is owned jointly by DOE and TNC, they are intended to be used by all parties interested and involved in the management of natural resources on the Hanford Site. To this end, all data collected have been or will be provided in hard copy and digital format, as appropriate, to DOE and PNNL in Richland and to the Washington State Department of Natural Resources / Washington Natural Heritage Program in Olympia. Eventually, geographic-based data will be entered into on-site Geographic Information Systems (GIS) for direct access, use, and analysis by DOE and others. Specifically, the information has been used directly or in modified form, and can be continued to be used in the: 1) Hanford Site Biological Resources Management Plan (1994 and 1995 inventory data were incorporated into the 1996 draft version of this plan [DOE-RL 1996]), 2) Benton County's analysis of critical areas as part of its comprehensive land-use planning for the Hanford Site, 3) the DOE's own land-use planning efforts for the Hanford Site, 4) environmental restoration and waste management planning activities at Hanford, and 5) the U.S. Fish and Wildlife Service's development of land-use management plans for the Fitzner/Eberhardt Arid Lands Ecology Reserve and the North Slope.

Other users may include (but are not limited to) the Confederated Tribes of the Umatilla Indian Reservation, Nez Perce Tribe, Wanapum, Yakama Indian Nation, U.S. Fish and Wildlife Service, Washington Department of Fish and Wildlife, Washington Department of Ecology, Franklin and Grant County governments, and other DOE Hanford Site contractors.

The Washington Natural Heritage Program (WNHP) is a branch of the Washington Department of Natural Resources (WADNR) that maintains a statewide data base containing information on the location and status of rare species, plant communities, and ecosystems throughout Washington. It is part of a unique national and international network of State Natural Heritage Programs and Conservation Data Centers. It is the only data handling system in place to track and allow analysis of the elements of biodiversity from state- and region-wide perspectives.

Section 2 – Plant Communities

2 Plant Communities

2.1 Introduction

This section provides an overview of plant community inventories that occurred from 1994 through 1997. More detailed information on these inventories can be found in Wilderman 1994, Salstrom and Easterly 1995, James and Soll 1996 and Easterly and Salstrom 1998.

2.2 Purpose and Scope

Plant communities — a term referring to the generally recognizable assemblages of plant species that occur in patterns across landscapes — are important and useful indicators of biodiversity because they form the biotic component of the habitat used by most other organisms. Different types of plant communities, and even different successional stages of a single plant community, provide distinctly different habitats. Conservation of the full range of native plant communities is therefore of fundamental importance for the conservation of regional biodiversity. Indeed, many of the rare and declining animal species in the Lower Columbia Basin ecoregion rely for part for all of their lifecycle on particular shrub-steppe plant communities.

At more than 360,000 acres, the Hanford Site is one of the largest contiguous pieces of shrub-steppe habitat remaining in the Columbia Basin. Equally important to its biodiversity value as its large size, is that Hanford contains both large expanses of common communities in good ecological condition, and examples of less common ones that are not well protected elsewhere in the region. Nearly everywhere else, livestock grazing and agricultural conversion have fragmented native shrub-steppe or drastically reduced its extent and quality. Similarly, the Hanford Site contains stream / riverine, riparian and wetland communities that are otherwise limited in occurrence throughout the Columbia Basin Ecoregion.

The shoreline of the Columbia River through the 51 mile stretch known as the Hanford Reach is unique. Because it is still “free flowing” (i.e. it is not a reservoir), it is the only portion of the river supporting healthy spawning grounds for wild salmon. Studying the vegetation of the Reach is the best opportunity to understand the natural riparian system of the Columbia. Although some plant community work has been done within the Hanford Reach of the Columbia River (Hanson and Eberhardt 1974, U.S. Army Corps of Engineers (USACE) 1976, Rickard *et al*. 1982, Sackschewski, pers. communication), the communities had not been adequately described.

There have been three separate surveys of plant communities on the Hanford Site as part of the biodiversity inventory:

- The Fitzner / Eberhardt Arid Lands Ecology (ALE) Reserve and North Slope, including the north shore of the Hanford Reach and Locke Island, were inventoried in 1994 (Wilderman 1994, summarized in Pabst 1995).
- Riparian communities along the islands and south shore of the Columbia River were inventoried in 1995 (Salstrom and Easterly 1995, summarized in Soll and Soper 1996).
- The Central Hanford portion of the site was mapped in 1996 and 1997 (James and Soll 1996, Easterly and Salstrom 1998; summarized in Hall 1998).

2.3 Methods

2.3.1 PLANT COMMUNITY CLASSIFICATION AND PLANT TAXONOMY

Throughout the project, plant communities were classified at one or more of three levels: potential plant community type (= habitat type of some authors), mapping unit, and cover type. Potential plant community types reflect the plant species that through time — based on climate and other abiotic factors —are projected to dominate the community if it is left undisturbed. Plant communities reaching this state are termed "climax" communities, whereas non-climax communities are described as successional or seral.

A potential plant community type is generally identified by both its dominant shrub (when present) and dominant grass (or grass**es** when shrubs are absent). When a non-dominant species provides important ecological information - a so-called indicator species - it may be used rather than a dominant one. Potential plant community types identified herein are based on descriptions and terminology found in Daubenmire (1970), Hironaka et al. (1983), and WDNR (1995). Some areas across the site (particularly within Central Hanford and along the river on the North Slope) have been heavily disturbed by past land-use practices (e.g., historic agricultural areas and intense and prolonged grazing). At times this precluded assignment of an area to a native potential plant community type. Many such areas were designated as potential plant community type unknown.

Vegetation mapping units identified the existing vegetation of an area. They were named according to the dominant and indicator shrub and grass present. Indicator species were included because they may show the potential vegetation of an area. To aid in future analysis of the plant community data for Central Hanford, any codominant species present also were included in the mapping unit name. Similar vegetation mapping unit types then were grouped into more generalized cover types (i.e., each cover type included one or more mapping unit types). Cover types were identified and named according to a species hierarchy (separate for shrubs and grasses) that prioritized indicator species (i.e., those representative of potential plant community types) when they were present.

Surveys done by Wilderman (1994) and Salstrom and Easterly (1995) and James and Soll (1996) used only potential community types and combined the mapping unit/cover type designation.

In some areas of the site cheatgrass has replaced native grasses due to sustained and intense cattle grazing, fire or other disturbances. Because once cheatgrass is established it appears to permanently replace native grasses, areas with an understory dominated by cheatgrass were typically mapped as big sagebrush / cheatgrass or community type unknown rather than the relevant big sagebrush / native grass species potential community type.

Plant taxonomy for the shrubs and grasses identified herein, including common names, generally follows Hitchcock and Cronquist (1973). Since 1973 however, several taxa have been revised taxonomically, no general publication can be cited that is universally up-to-date. Moreover, because of the desire to maintain continuity with the plant community information provided in the Draft Hanford Site Biological Resources Management Plan (DOE-RL 1996) — in which previous plant community information from the biodiversity project has been incorporated — nomenclature conforms to usage in that document.

2.3.2 FIELD INVENTORY AND MAPPING

Contrary to most previous plant community mapping projects at Hanford, which relied on remote sensing interpretation over field mapping, extensive walking surveys were conducted to assess plant species composition for each sampled area. Cover type and potential type were determined either in the field or after review of soil data and appropriate literature. Survey intensity was adjusted to

correspond to the plant community condition and complexity of an area. Better condition and more complex areas were surveyed more intensely. For each polygon, the vegetation was characterized by one or more of potential plant community type, mapping unit, and cover type.

Polygons were generally drawn in the field on aerial photographs, 1:24,000 U.S. Geological Survey topographic maps, or Geographic Information System maps. Polygon boundaries were confirmed using aerial photographs, with high-resolution (1:6000) photographs available for about half of Central Hanford. Polygon and plot locations were digitized by geographic information systems (GIS) laboratories at Western Washington University (Wilderman 1994), Central Washington University (Salstrom and Easterly 1995), The Nature Conservancy of Washington (James and Soll 1996) and the Washington Natural Heritage Program (Easterly and Salstrom 1998).

The minimum polygon size (i.e., resolution of mapped areas) used in mapping plant community boundaries ranged from 2 acres (1 hectare - Wilderman 1994, Salstrom and Easterly 1995) to 24.7 acres (10 hectares - Easterly and Salstrom 1998). Sand dunes, borrow sites and smaller patches of significant or interesting vegetation were mapped at a finer scale. Within Central Hanford, each classification level frequently occurred as repeating patches at a scale smaller than the minimum polygon size. These polygons were mapped as vegetation mosaics (Figure 2.3).

Visual estimates of vegetation composition and structure were conducted in 16.5 by 66 ft (5 by 20 m) plots, generally following methods developed by the Western Heritage Task Force Site and Community Survey Manual (Bourgeron 1992). Within each plot, the following estimates were recorded: cover of each shrub and bunchgrass species, cover of cheatgrass, average cover of soil lichens and mosses, average height of each shrub species (Easterly and Salstrom 1997 only), slope and aspect (where slope exceeded 2%), and cover of each forb species. For polygons in which vegetative conditions were highly variable, more than one plot was used. In total, data from more than 500 plots were collected.

Plots were subjectively located during field inventories with the objectives of: 1) gathering data representative of the plant communities involved, 2) providing information about significant natural communities, and 3) providing information from areas in which no data had been collected as part of earlier mapping efforts.

Detailed methodology for each individual study is available in the appropriate technical reference.

2.3.3 CONSERVATION RANKING EVALUATION

As an aid toward preserving Washington State's natural diversity, the Washington Natural Heritage Program (WNHP) has established a classification scheme and conservation ranking system for the state's natural resources through which Washington's natural diversity is classified into elements (WDNR 1995). An "element" is defined as a basic unit of Washington's biologic and geologic environment identified as a needed component of a system of natural areas. An element can be defined as an entire ecological system, such as a plant community (i.e., terrestrial ecosystem) or a wetland or aquatic ecosystem. Individual plant and animal species also can be considered elements. The WNHP assigns a protection priority ranking to each element that reflects the element's rarity (regionally as well as state-wide), degree of threat to its existence within Washington, and the adequacy of current protection for it (see Table 2.1 for definitions). By tracking the location and quality of the various occurrences of a particular element, the Natural Heritage Program can assess the conservation significance of a given occurrence relative to other occurrences in the state or region and make appropriate protection recommendations.

Each polygon that was assigned to a potential plant community type, or aquatic ecosystem type in the case of vernal pools and the Hanford Reach and that represented a particular element identified in the Natural Heritage Plan (WDNR 1995), was evaluated for its conservation potential. The evaluation was based on an assessment (ranking) of community condition, size, and surrounding landscape

(Chappel 1996). The big sagebrush (*Artemisia tridentata*) / Sandberg's bluegrass (*Poa sandbergii* [included within *Poa secunda*]) potential plant community type included herein was not identified as an element in the Natural Heritage Plan during the time period of the field inventory. It was added to the 1998 version and was assigned a protection priority ranking of 3 (WDNR 1998).

The community condition assessment considered: (1) cover and diversity of microbiotic crust; (2) cover of non-native annual species, such as cheatgrass; (3) cover of native taxa that increase in response to disturbance; and (4) correspondence of community composition to published community descriptions. For most of the plant community elements considered, especially at low elevations (i.e., flat deep-soiled areas), areas in excellent condition no longer exist in the region. For these elements, areas in moderately degraded condition can represent areas with significant conservation value. The landscape assessment considered the proximity to disturbance vectors, such as roads, power lines, or livestock grazing. More thorough assessment guidelines are provided in Wilderman (1994), Chappell (1996) and Easterly and Salstrom (1998: Appendix C). Polygons that met minimum standards for condition, size, and landscape represent areas of significant conservation value from a state and / or regional perspective. Such areas are designated element occurrences and are entered into the Natural Heritage Program's tracking system.

2.4 Findings

2.4.1 OVERVIEW

UPLANDS

Although Daubenmire (1970) placed the Hanford Site within the big sagebrush / bluebunch wheatgrass (*Artemisia tridentata* / *Pseudoroegneria spicata* [=*Agropyron spicatum*]) vegetation zone, the site spans a wide climatic and edaphic (soil) range resulting in equally diverse vegetation. Much of Central Hanford and the North Slope is drier than typical big sagebrush / bluebunch areas, receiving 6-8" or less of precipitation per year, and has sandy or coarse textured soils. Under these conditions, bluebunch wheatgrass grows poorly or not at all. At the other extreme, the more cool and moist (mesic) conditions with loamy soil at high elevation on Rattlesnake Ridge are typical of the three-tip sagebrush / Idaho fescue zone (Daubenmire 1970). This great range of climatic variation combined with equally diverse geologic and soil conditions has produced a remarkable diversity of potential plant community types. Thus, while the big sagebrush / bluebunch wheatgrass community represents the climatic climax plant community expected to occur in the area (i.e., the plant community predicted to occur on deep loamy soils in areas with a gentle slope, moderate drainage, and average chemical characteristics), over much of Central Hanford, the SMNWR and the WRA; as well as portions of ALE Reserve, other community types dominate. For the most part these are, edaphic (soil-related) climax communities, dominated in the grass layer by needle-and-thread (*Stipa comata*), Indian ricegrass (*Oryzopsis hymenoides*), Sandberg's bluegrass (more the result of low precipitation than soil type in some cases) or other species predominate.

HANFORD REACH

Although the Columbia River through the Hanford Site (the Hanford Reach) is considered "free-flowing," the water volume in the Reach is influenced by upriver manipulations, resulting in higher summer flows, smaller, less frequent flood events and large daily fluctuations. This altered flow regime undoubtedly affects riparian vegetation. Although some plant community work has been done within the Hanford Reach of the Columbia River (Hanson and Eberhardt 1974, U.S. Army Corps of Engineers (USACE) 1976, Rickard *et al.* 1982, Sackschewski, pers. communication), the communities have not been adequately described (but see Wilderman 1994).

2.4.2 GENERAL DESCRIPTION BY MANAGEMENT AREA

Each management area of the Hanford Site is characterized by a unique assemblage of plant communities. Although there are commonalties between management areas, each area has features or combinations of features not found on the others. A total of 21 different upland plant community types and 3 found in riparian areas or along the Hanford Reach ranging from 2 to 84,000 acres of total coverage were identified on the Hanford Site (Table 2.1). A total of 91,637 acres of 17 different types qualified as element occurrences. A brief description of the patterns and element occurrences found in each area are presented below. Figure 2.1 shows the potential plant communities of the ALE Reserve, Figure 2.2 those of the North Slope, Figure 2.3 those of Central Hanford and Figure 2.4 those of the south shore and Islands of the Hanford Reach. As indicated above, the potential plant community types on some portions of Central Hanford were identified with some level of uncertainty. Because of this, Figure 2.3 should be viewed as one interpretation of the potential vegetation of Central Hanford.

ALE

Eighteen natural and 1 man-made plant communities (Figure 2.1) ranging from 2 to 29,360 acres were identified and mapped on the ALE Reserve. The nineteen potential communities were composed of 28 different cover types. A total of 45,570 acres are in ecological condition suitable for listing as element occurrences (Table 2.1).

The ALE Reserve has the largest expanses of loamy soils and north facing aspects on the Hanford Site. In general, ecological condition on the ALE site improves with increasing elevation and more northerly aspect. Plant communities above roughly 900’ in elevation support the largest contiguous expanses of high-quality shrub-steppe on the Hanford Site and the single largest element occurrence of high quality bluebunch wheatgrass grassland in the Columbia Basin. Big sagebrush / bluebunch wheatgrass and three-tip sagebrush / bunchgrass communities cover over 40,000 unbroken acres. The crest of Rattlesnake Mountain supports high quality, low growing lithosol communities on the shallow rocky soil. While also ecologically valuable, the lower elevation areas are dominated by generally lower quality big sagebrush / Sandberg’s bluegrass and big sagebrush / cheatgrass. Element occurrences of Winterfat / Sandberg’s bluegrass, black greasewood / alkali saltgrass and a small occurrence of bitterbrush / dune complex at lower elevations add to the diversity and uniqueness of the site. Two major spring systems, Snively and Rattlesnake cross the western half of the site. These provide important aquatic and riparian habitats in an otherwise arid landscape.

The most ecologically important element occurrences on ALE are the large big sagebrush / bluebunch wheatgrass and three-tip sagebrush / bluebunch wheatgrass or Idaho fescue communities that cover nearly 40,000 contiguous acres on Rattlesnake Mountain. Other element occurrences of note include: more than 1000 acres of winterfat (*Eurotia lanata*) / Sandberg’s bluegrass on the lower slopes of Rattlesnake Mountain; the big sagebrush / Sandberg’s bluegrass occurrences on the flats in the Dry and Cold Creek Valleys; the willow riparian complex associated with the springs and creeks; and, a degraded but uncommon example of black greasewood / saltgrass (*Sarcobatus vermiculatus/Distichlus stricta*).

THE NORTH SLOPE

The North Slope supports 40 cover types of 16 unique potential plant communities, including 2 resulting from human activities (Table 2.1, Figure 2.2). Total coverage of these plant communities ranges from a low of 4 to a high of nearly 59,000 acres. Six types found on the North Slope do not occur to great extent on ALE. A total of 15,595 acres qualify as element occurrences including representaions of four types not found on the ALE Reserve.

Except on the predominantly south facing slope of the Saddle Mountains, the North Slope is dominated by sandier soils than the ALE Reserve. Vegetation spans a continuum from open sand dunes with sparse vegetation above the White Bluffs to loamy soil big sagebrush communities high on the Saddle Mountain Crest. There are no natural springs or lakes on the North Slope, but irrigation run-off has created several large, artificial wetlands that diversify the habitats available to wildlife in this area. A human use history, more intense than at the ALE Reserve that included farming, livestock grazing and military training has left its mark in large areas of the North Slope in the form of areas dominated by cheatgrass. The North Slope contains and buffers from surrounding agriculture the Hanford Reach, including the spectacular, unique and fragile White Bluffs with their unique caliche soils. The vegetation of the Hanford Reach is discussed separately below.

The most notable plant communities on the North Slope are large expanses of big sagebrush / needle-and-thread grass (5681 acres), antelope bitterbrush / Indian ricegrass dune complex (9314 acres) and spiny hopsage / Sandberg's bluegrass (1161 acres) found on the flats above the White Bluffs. Significant element occurrences occur within each of the community types. These particular element occurrences have value beyond that of most. Because these types generally occur on potentially arable soils, extensive occurrence have been converted to agricultural uses almost everywhere else they once existed. Large areas of big sagebrush / Sandberg's bluegrass on the lower slopes of the Saddle Mountains are also noteworthy.

CENTRAL HANFORD

The plant communities of Central Hanford were placed into nine potential types (Figure 2.3, Table 2.1). In all, 10 occurrences of six different potential plant community types totaling 30,472 acres qualified as element occurrences. Additionally, three clusters of low elevation alkaline vernal pools have been identified: one set on Gable Mountain, a second set on Gable Butte, and a third cluster of pools at the eastern end of Umtanum Ridge.

Most of Central Hanford is dominated by sandy and gravelly soil. Distribution of plant communities occurs along a continuum in which characteristics of the different potential community types merge across broad zones. Three factors contribute to this: variations in the landscape are generally subtle and based on nuances in the substratum; climate and soils combine to create conditions that are ecotonal (e.g., on the border of environmental tolerance) for some dominant species; and, the complex disturbance history of the area.

Sandy areas support variations of big sagebrush / needle-and-thread or bitterbrush / dune complex communities. Similar to lower elevation areas on ALE, areas within Central Hanford with finer textured soils were generally dominated by big sagebrush / Sandberg's bluegrass or degraded versions thereof. These types were mostly found north of Gable Mountain and in a swath from the western edge of the site through the middle, north of the 200 areas.

The northern portion of Central Hanford, especially along the river, has been heavily disturbed by human land use, including early agriculture and grazing, nuclear weapons production, and now the clean-up efforts. As a result, cover of bunchgrasses, microbiotic crust, and shrubs are low and cover of cheatgrass high. In these and other degraded areas, potential plant community types were identified with some level of uncertainty and were interpreted as representing early successional stages and / or ecotonal conditions of a particular potential plant community.

As for much of the Columbia Basin, north-facing slopes generally had higher cover of microbiotic crust and lower cheatgrass cover than adjacent areas. Element occurrences on Central Hanford were mostly bitterbrush / dune complex and big sagebrush / needle-and-thread grass on or around unstable sand. Small occurrences of 4 other types were also identified (Table 2.1). Of particular regional

importance are the active sand dune areas and surrounding areas of stabilized sand that cross the central portion of the area from the east.

Plant community element occurrences were identified in three configurations:

- As mosaics of multiple potential plant community types within which multiple types qualified as element occurrences. In these instances the element occurrence was named, and listed in Table 2.1, according to the largest type (by acreage) present.
- As mosaics within which only one of the types qualified as an element occurrence.
- As areas in which the element occurrence was the only potential plant community type present.

Because all but one of the mosaic element occurrences included within their boundaries some areas where the potential plant community type present did not qualify as an element occurrence, the actual acreage that qualified was only a percentage of the area shown in Figure 2.3. For each potential plant community type that was a component of a mosaic, only the actual acreage that qualified as an element occurrence was included in Table 2.1. However, because qualifying areas were dispersed within the boundaries shown in Figure 2.3, to be effective, management actions must address the full geographic extent of each element occurrence.

In 1996 additional inventory work was conducted on that portion of Central Hanford that is located to the north and west of state Highway 24 and south of the Columbia River (James and Soll 1996). This approximately 8970 acre (3630 ha) area — designated Riverland herein to facilitate further discussion — is dominated by the eastern portion of Umtanum Ridge. Umtanum Ridge is of particular conservation interest, because of all the east-west corridors in central Washington, it spans the widest variety of climate and vegetation zones. Umtanum Ridge runs west from the central plateau of the Hanford Site, through the Yakima Training Center and state-managed wildlife areas, to the foothills of the Cascade Mountains. It is a key physiographic feature that links the best remaining examples of shrub-steppe habitat in the state of Washington. This area also helps connect the ALE Reserve to the Columbia River and North Slope.

The plant communities of the Riverland area ranged from poor to good condition. The predominant potential plant community types present included: big sagebrush / bluebunch wheatgrass, big sagebrush / needle-and-thread, big sagebrush / Sandberg's bluegrass, and stiff sagebrush / Sandberg's bluegrass. Most of the poorer condition communities were associated with the gentle, south-facing slopes of Umtanum Ridge that had been heavily grazed and patchily burned in the past. Two areas qualified as element occurrences. The steep slopes on the north side of Umtanum Ridge supported a big sagebrush / bluebunch wheatgrass potential plant community type in good condition. In the midst of the preceding element occurrence, occurred the second: a stiff sagebrush / Sandberg's bluegrass potential plant community type that also was in good condition in places. These preceding areas need to be reevaluated as to their status, as after the inventory was completed, a fire originating from the Yakima Training Center burned much of the Riverland area in late August 1996.

HANFORD REACH

Eight riparian and 3 "island upland" communities/cover types were identified, including 6 occurrences of significant low elevation wetlands.

The assemblage of plant species changes from the river edge upward through the shoreline profile. The communities are clearly defined in some areas. In others, ecotones may be blurred due to hydrology, topography, overlapping habitat requirements and susceptibility to invasion by weedy species. These factors combine to create shifting mosaics of species, most pronounced low in the riparian profile. Plant communities were identified to the degree practicable. Where dominant species vare not confined to a specific zone, each zone is characterized by its physical features.

Although the Reach is ostensibly free-flowing, changes in the hydrology of the Reach from upstream dams have likely altered some riparian communities and substrates. For example, much of the substrate previously mapped as sand (USACE 1976) is now cobble. Thus, some communities may reflect a transient state. Because data are lacking to describe successional pathways, only the existing vegetation is described.

Six areas along the south shore and islands of the river were identified as significant occurrences of Columbia Basin low elevation riparian wetlands. Such wetlands are of statewide conservation significance. Although not all of these sites are pristine, they are of statewide importance because most comparable sites have been permanently flooded by the reservoir system. The 6 areas are: China Bar, Islands 2-5, Locke Island, White Bluffs Slough, 100-F Area Slough, and the Hanford Townsite Slough.

2.5 Major and Unusual Potential Community Types

The dominant potential plant communities and their distribution on the Hanford Site are discussed below. Also covered are some of the unique and unusual community types identified during this project. Descriptions of each community type and their condition on the Hanford Site are found in brief in Pabst, 1995 (ALE and North Slope), Soll and Soper, 1996 (Hanford Reach), Hall 1998 (Central Hanford) and in depth in the relevant technical reports (see above).

2.5.1 UPLAND COMMUNITY TYPES

BIG SAGEBRUSH / BLUEBUNCH WHEATGRASS

This potential community type is characterized by big sagebrush, bluebunch wheatgrass, Sandberg's bluegrass, diverse forbs, and where relatively undisturbed, a robust microbiotic crust. As the climatic climax for the region it is widespread in many (loamy) soil types, although frequently with a high cover of cheatgrass. Where fire has recently burned sagebrush is generally absent. Under more mesic conditions Cusick's bluegrass (*Poa cusickii*) can be a common component.

The ALE Reserve supports the biggest expanse of this type on the Hanford Site. It covers nearly 30,000 acres in a broad band between 900' and approximately 2500' in elevation, much of it in excellent ecological condition. In fact, the element occurrence of this type on ALE is the largest known example in the world.

The North Slope supports only small occurrences, mostly at high elevation on the Saddle Mountains or in other, mostly small areas with loamy (versus sandy) soil. Over much of the North Slope, precipitation is too low and soils are too sandy for bluebunch wheatgrass. In some large areas with apparently appropriate soils and climate, this community type may have been replaced by the big sagebrush / cheatgrass type or big sagebrush / Sandberg's bluegrass type as a result of over-grazing and fire.

Although it covers nearly 10,000 acres on Central Hanford, this community type is limited in distribution to relatively deep soil areas on the north slope of Umtanum Ridge in the Riverland area; to small areas mostly near basalt in the northern portion of Central Hanford; and, to an area along the Columbia River in the eastern portion of Central Hanford. The latter occurrence represents an unusual sandy phase of the community type that is ecotonal with the big sagebrush / needle-and-thread potential plant community type. With the exception of the Riverland area, which has an element occurrence on the north slope of Umtanum Ridge at most locations the condition of the community ranged from poor to marginal, with marginally good conditions reached on the north-facing slopes and shallower soils of basalt areas.

BIG SAGEBRUSH / SANDBERG'S BLUEGRASS

It seems likely that in Washington this plant community type is confined to locations too dry for bluebunch wheatgrass to become established, and on soil that is finer-textured than is typical for needle-and-thread types. It may also occur as a so-called zootic (literally from animals) climax where grazing has eliminated larger, later growing bunchgrasses. In general at Hanford, a high cover of big sagebrush and low forb diversity was characteristic of this type. Spiny hopsage (*Grayia spinosa*) may occur, especially at drier sites, with cover ranging from widely scattered individuals to a few locations at which it was codominant with big sagebrush.

On ALE this type covers over 9000 acres, nearly all of it in two large patches in the northwest corner between Dry Creek and the Benson Ranch. Elevation ranges from about 700' to 1000'. Condition ranges from poor to good, with some areas supporting relatively little cheatgrass and a continuous microbiotic crust. This type also occurs in large areas of the North Slope, totaling over 9000 acres scattered around the site in 4 large patches. As with ALE condition varies with site history.

Within Central Hanford this type occurred mostly south of Gable Mountain and areas farther to the west, where silt, rather than sand as at most lower elevations, dominates Pleistocene flood sediments (Gaylord and Stetler 1994). In these areas, recorded precipitation is the lowest on the Hanford Site (Hoitink and Burk 1995). Two areas qualified as element occurrences: a strip along a north-facing slope on the eastern end of Umtanum Ridge and an area south of Gable Mountain.

Although vegetation resembling this type existed over a large area especially within Central Hanford, it is difficult to distinguish from degraded occurrences of other types in which the larger bunchgrass taxa have been eliminated by historic use and / or fire. Therefore the possibility cannot be discounted that the big sagebrush / Sandberg's bluegrass potential plant community type is actually more widespread on Central Hanford than indicated here.

BIG SAGEBRUSH / NEEDLE-AND-THREAD

This community is present in a range of soils from those with a significant component of sand (sandy loam) to stabilized dunes. Big sagebrush is the dominant shrub, although bitterbrush commonly occurs at varying levels. Thickspike wheatgrass (*Agropyron dasystachum*) may occur in the understory with the needle-and-thread. Where it is intermixed with bluebunch wheatgrass, needle and thread grass is thought to increase with disturbance.

Of the three management areas, it is least abundant on ALE, where loamy soils generally predominate. It is limited there to small occurrences near the lower elevation boundary of the big sagebrush / bluebunch wheatgrass community.

Big sagebrush / needle-and-thread grass communities occurs in several areas on the North Slope. The most prominent include: a large area along the eastern boundary, south of highway 24, where much of the shrub cover has been eliminated by a recent fire; along the crest of the Saddle Mountains, where it intergrades with big sagebrush / bluebunch wheatgrass; and above the White Bluffs in the southeastern corner of the site. Much of the now degraded lower elevations on the North Slope probably supported this type before being converted to cheatgrass by grazing and fire. Although much of this community type has been degraded by grazing and fire, some areas retain significant native character. These include some of the area south of highway 24 and the southeastern portion of the site. That large examples of these communities exist at all is due to the protection afforded by the Hanford Site. Nearby sites that once supported this community have been converted to irrigated agriculture as part of the Columbia Basin project.

This type also occurred on sandy-textured soils throughout Central Hanford, including Riverland. It often intergrades with other types, including the bitterbrush / Indian ricegrass dune complex in the eastern portion, and a sandy phase of the big sagebrush / bluebunch wheatgrass type in the

southeastern section. Portions of the area mapped as this type have had more than one fire during recent decades. In these areas the cover of the indicator shrub and grass species usually were low. The cover and diversity of mosses and lichens in the microbiotic crust were variable, but generally low. Areas in better ecological condition (i.e., with a high cover of needle-and-thread grass and microbiotic crust) occurred mostly in the eastern portion of Central Hanford and south of the 200 Areas, often on stabilized sand. Compared with other plant communities and soil types within Central Hanford, plant communities on sandy soils seemed the most resilient to disturbance.

BITTERBRUSH / INDIAN RICEGRASS DUNE COMPLEX

This community type occurs on active dunes and other extremely sandy soils. It is not described by Daubenmire, but is recognized by the WNHP (Crawford 1986). As opposed to relatively cool and moist western and northern portions of the ecoregion where it grows in loamy soils, bitterbrush is only found in nearly pure sand within the hotter and drier central Columbia Basin. Plant composition is highly variable, changing with subtle shifts in substrate and presumably time since an active dune became stable (or vice versa), but sagebrush is generally absent. As such, the boundaries of this type are fluid and difficult to map. Succession and stabilization of a dune site apparently leads to the development of other potential plant community types (probably most often the big sagebrush / needle-and-thread type). As a result, the dune complex encompassed several related successional cover types, each composed of taxa adapted to different degrees of sand accumulation, loss, and stability.

On the North Slope, the antelope bitterbrush / Indian ricegrass (*Oryzopsis hymenoides*) dune complex covers large areas directly above the White Bluffs. Along with the occurrences in Central Hanford, it makes up the most extensive and highest quality occurrence of this type known in the state of Washington. This community type occurs in only two small patches on the ALE Reserve. Most of this area is far from pristine, with native grasses often replaced by cheatgrass and tumbleweeds. However, as it has been replaced by agriculture nearly everywhere else it once occurred, even small occurrences are ecologically important.

On Central Hanford this community type occurred as a large area of active dunes, the Hanford Dune Field, in the eastern portion; as another set of dunes north and east of Gable Mountain; in scattered dunes south of the 200 Areas; and on blowouts on otherwise stabilized sand throughout much of Central Hanford. The area of active dunes has decreased dramatically during the past 50 years (Gaylord and Stetler 1994). On the dunes north of Gable Mountain, the plant assemblage was diverse and was included in the dune complex for lack of a more appropriate classification. In addition to the dune areas associated with Gable Mountain, black basalt sand areas occurred north and south of the mountain. These sands differed in appearance from the “salt and pepper” sands found elsewhere on Central Hanford.

The active dunes on Central Hanford were in good to marginal condition. Within the dunes, the plant species composition was more diverse than elsewhere on Central Hanford and was dominated by native taxa. Some of these taxa are endemic to dunes or are not otherwise found on Central Hanford. Human-caused disturbance appeared to be minimal, though some evidence of historic grazing was still present. The black sands in proximity to Gable Mountain supported numerous rare plants (see Section 3.0).

BIG SAGEBRUSH / CHEATGRASS

This designation represents areas with high cheatgrass and other exotic species cover with or without big sagebrush in which the original / native potential plant community type could not be determined, or where it has likely been permanently replaced. Identification of potential plant community types was difficult over much of Central Hanford and indeed in highly degraded or sandy soil areas throughout Hanford. Particular difficulties were faced where historic disturbances were the

most intense (especially on historically farmed locations). Much of the unexplained big sagebrush die-off, recently documented in part by Cárdenas et al. (1997), was located in this area. Vegetation within this designation had highly variable shrub cover, high cover of cheatgrass, frequently a significant cover of Sandberg's bluegrass, and usually a low cover of microbiotic crust. This designation represents vegetation in a degraded condition; however, there is considerable variability in the amount and rate of successional changes of areas mapped as this designation. Some areas appeared to be recovering towards native vegetation, whereas other areas appeared to be permanently modified.

BITTERBRUSH / BLUEBUNCH WHEATGRASS

This unusual type occurred within only as a small area of the southeastern corner of Central Hanford near the Columbia River. It occurred in a mosaic with a number of other plant communities. Bitterbrush (*Purshia tridentata)* occurred in patches of high cover, whereas the cover of bluebunch wheatgrass was patchy and often low. The occurrence of this type was in a marginally degraded condition.

SAND DROPSEED (*SPOROBOLUS CRYPTANDRUS*) — SANDBERG'S BLUEGRASS

This type is characterized by a lack of shrubs and dominance by the two grass species for which it is named. Areas mapped as this type were located in the northern and northeastern portions of Central Hanford within the lowest elevation upland plant communities near the Columbia River and in similar location scattered throughout the North Slope. Sand dropseed was found along roadways and other highly disturbed areas scattered throughout the northern portion of Central Hanford. It was difficult to determine whether the species is present because of disturbance or if its presence represents a potential plant community type. It was mapped as a possible potential plant community type only adjacent to the river, usually within the river's probable maximum flood area (Cushing 1995). The cover of Sandberg's bluegrass was often sparse and that of cheatgrass high. Overall plant diversity within the type was low and many components were weedy. The climax status of the type is uncertain. When sand dropseed occurs without Sandberg's bluegrass, it probably represents a climax riparian community type (Johnson and Simon 1987) that occurred historically in a zone disturbed by floods frequent enough to exclude other bunchgrasses and shrubs.

SPINY HOPSAGE / SANDBERG'S BLUEGRASS

The spiny hopsage / Sandberg's bluegrass community occurs on dry sites with fine textured soils, and likely represents a unusual variant of the big sagebrush / Sandberg's bluegrass community. One explanation for the absence of sagebrush is intermittent pooling of water (Downs et al. 1993). Sandberg's bluegrass is the dominant grass, although on Hanford cheatgrass is a major or dominant component on most sites. Forb diversity and crust cover are generally low.

This type occurred as pure stands of spiny hopsage on the North Slope and Central Hanford, and mixed with big sagebrush throughout drier areas of the site in loamy soils. On the North Slope it occurs mostly below the White Bluffs look out, but also in scattered locations in the southwest portion of the site. Within Central Hanford it occurs in two small areas. One occurrence was located in Cold Creek Valley to the west of the 200 West Area and the second was located in the vicinity of Goose Egg Hill between Army Loop Road and state Highway 240. These areas are in the lee of Rattlesnake, Yakima, and Umtanum Ridges and likely receive lower rainfall than most other portions of Central Hanford.

WINTERFAT / SANDBERG'S BLUEGRASS

This unusual community has winterfat as the dominant shrub and Sandberg's bluegrass as the major grass. It occur occurs on Warden or Kennewick silt loam soils (notably calcareous) around 800' elevation on the ALE Reserve and North Slope. Overall species diversity is low in this community, although the rare plant *Erigeron piperianus*, frequently occurs. The largest occurrence on Hanford is on the lower slopes of Rattlesnake Mountain where it occurs in a 5 x 1 mile area on small ridges separating the numerous small draws that come off the mountain. The intervening draws typically support big sagebrush / bluebunch wheatgrass or needle-and-thread communities. A second smaller occurrence is on the North Slope near the northwest site boundary north of Highway 24.

STIFF SAGEBRUSH (*ARTEMISIA RIGIDA*) / SANDBERG'S BLUEGRASS

Stiff sagebrush grows on thin soils, over fractured basalt. This type occurrs on the crest of the Saddle Mountains, in a tiny occurrence on ridge crests in the Cold Creek Valley and intermittently on shallow soils over basalt on Gable Mountain, Gable Butte, and Umtanum Ridge. The cover of soil mosses and lichens was consistently high. The ecological condition of the type was generally marginal.

DESERT BUCKWHEAT (*ERIOGONUM* SPP.) / SANDBERG'S BLUEGRASS

These communities are characterized by various desert buckwheats (Thyme, Douglas' Rock), Sandberg's bluegrass, a microbiotic crust and diverse forbs. They typically occur on ridge tops above 1500' elevation on the Hanford Site, are generally in good ecological condition and are important habitat for butterflies. The only occurrences on the Hanford Site are on ridge tops throughout the ALE Reserve.

LOW ELEVATION ALKALINE VERNAL POOLS

Shallow vernal pools occurred on Gable Mountain, Gable Butte and the east end of Umtanum Ridge on basalt shelves and dips that formed internal drainages. Each pool was dominated by herbaceous vegetation that differed according to the depth, size, and condition of the pool. Surrounding potential plant community types included big sagebrush / Sandberg's bluegrass and big sagebrush / bluebunch wheatgrass. The pools had been impacted by historic livestock use and were mostly moderately to severely degraded. Several rare plant species were present (see Section 3.0) and on this basis the pools, especially those on Gable Butte, are still a high priority for conservation.

THREE-TIP SAGEBRUSH COMMUNITIES

At higher elevations on the ALE Reserve (primarily above 2000'), three-tip sagebrush (*Artemisia tripartita*)

begins to co-occur with or replace big sagebrush as the dominant shrub. Because unlike big sagebrush, three-tip resprouts following fire, it is frequently the only shrub present in what would otherwise be mixed sagebrush communities. Bluebunch wheatgrass is typically the dominant grass, but when Idaho fescue is present (typically on steep north slopes) the community is named for it (i.e. Three-tip sagebrush / Idaho fescue). Cusick's bluegrass (*Poa cusickii*) is also often present. These community types are characterized by high vegetation cover and diverse forbs. Most sites at Hanford are in good ecological condition.

2.5.2 RIPARIAN AND HANFORD REACH PLANT COMMUNITIES

Summaries of the major plant communities of the wetlands, springs and riparian areas on Hanford and within the Hanford Reach are described here. Descriptions of all the identified communities are available in Wilderman (1994) and Salstrom and Easterly (1995).

WILLOW RIPARIAN COMPLEX

This riparian (water-side) community is characterized by diverse shrubs and trees that include a substantial component of, or dominance by willow (S*alix*) species. It occurs on the ALE Reserve in the vicinity of Rattlesnake Springs, Snively Canyon and Benson Springs. Composition varies between the three sites. Because of its association with water and value as wildlife habitat, this type is a very important component of the site.

Small groves of *Salix exigua* occur sporadically above the *Solidago-Apocynum* zone throughout the Reach. Within the groves, *S. exigua* usually forms thickets averaging 1.5 meters in height. The understory is commonly dominated by *Phalaris arundinacea*. The *S. exigua*/*P. arundinacea* community was described by Wilderman (1994) and Evans (1989).

NON-PERSISTENT RIVERINE EMERGENT WETLAND

Backwater areas and sloughs often form in the lee of cobble bars where silt has been deposited. Wetland communities occur in these areas where silt has been deposited. The largest wetland systems are associated with the most developed cobble bars and on the lee side of Locke Island and scattere throughout the north shore.

Wilderman (1994) describes these wetlands, which are often relatively pristine. These systems are rich in species diversity, both within and between sites. Dominant species include: *Eleocharis palustris, E. acicularis, Scirpus maritimus, Lilaeopsis occidentalis, Typha latifolia* and *Juncus* sp.

This habitat system is thought to be rare elsewhere along the Columbia River, but may have been common before the extensive construction of hydroelectric dams (Downs et al. 1994). Three species that occur abundantly and consistently within these wetlands are currently considered sensitive in Washington (*Cyperus bipartitus, Lindernia anagallisea* and *Limosella acaulis;* Washington Natural Heritage Program 1994). Several other species common in these wetlands are being proposed for protection status (Beck and Caplow, personal communication).

UNCONSOLIDATED SHORE, COBBLE

A collar of mostly bare cobble usually occupies the lowest portion of the shoreline. This zone is inundated almost daily during the growing season due to waterflow manipulation upriver at Priest Rapids dam (Salstrom and Gehring 1994). A number of forbs including the rare species *Rorippa columbiae* occur in this zone. On flat profiles, this zone intergrades with the following community.

LOW SHRUB: SOLIDAGO OCCIDENTALIS-APOCYNUM CANNABINUM/COREOPSIS ATKINSONIANA

Farther up the riparian profile, but below daily high water, the rhizomatous shrubs *Apocynum cannabinum* and *Solidago occidentalis* commonly form a perimeter thicket. *A. cannabinum* is confined to this zone, but occurs irregularly. *S. occidentalis* is omnipresent, but also occurs in adjacent zones. Occasionally, particularly on slopes of over 15 percent, this zone is absent or is replaced by a monoculture of the weedy species *Phalaris arundinacea.*

PHALARIS ARUNDINACEA

This non-native species forms monotypic stands within all riparian and Hanford Reach communities described in this report, with the exception of island uplands.

IRRIGATION RUN-OFF CAUSED WETLANDS

This artificial "community type" includes lakeshores, riparian and wetlands on the North Slope that have been converted from shrub-steppe due to accumulated run-off from irrigated agriculture off-site. The largest examples are just south and 5 miles south of Highway 24 on the eastern end of the site; and around Saddle Mountain Lake on the western end. Small examples occur periodically along the White Bluffs due to water seepage through the Bluffs. These communities are typically dominated by non-native species such as tamarisk (*Tamarix parviflora*) and Russian olive (*Elaeagnus angustfolia*), but also support native willows (*Salix* spp.), comon cattail (*Typhus* sp.) and black cottonwoood (*Populus trichocarpa*). Although artificial, they can provide valuable wildlife habitat, especially for amphibians, birds and bats in an otherwise arid landscape.

ISLAND UPLAND

Three commnities were recognized on islands within the Hanford Reach: the *Artemisia campestris* ssp. *borealis* var. *scouleriana / Sporabolis cryptandrus* community occurs where upland areas are seasonally flooded but are above frequent high water; the *Ambrosia acanthicarpa / Oryzopsis hymenoides* community occurs on a small dune system on an unnamed island at the head of Wahluke Bend (Island number 3 in Rickard *et al.* 1982); and a *Bromus tectorum* community (see discussion above on unknown potential communities) covers portions of Locke Island. Patches of *Agropyron dasystachum* and *Elymus cinerius* occur within this zone.

2.6 Summary of Findings

These efforts have identified a total of 21 native upland, terrestrial, potential plant community types (i.e. Natural Heritage Plan elements). Among these are as many as 50 separate element occurrences on the Hanford Site (Table 2.1) totaling approximately 90,000 acres. Remarkably, only 7 of the 19 identified terrestrial plant community elements were common to the ALE Reserve, North Slope and Central Hanford. Although the ALE Reserve supports the highest proportion of communities in good ecological condition, plant community element occurrences occupy significant acreage within each of the management areas (Table 2.1). The condition and size of the big sagebrush / bluebunch wheatgrass (ALE Reserve) and bitterbrush / Indian ricegrass dune complex (North Slope and Central Hanford) communities are especially noteworthy; and are of regional and likely national conservation significance. Additionally, six riparian wetland communities along the southern (western) shore of the Hanford Reach, one low elevation stream and riparian system on the ALE Reserve, and two cold springs on the ALE Reserve were identified as element occurrences (DOE-RL 1996, Soll and Soper 1996). The Hanford Reach communities are rare elsewhere along a river system that is otherwise a series of lakes.

The data reported here for the number of terrestrial plant community elements differ somewhat from those previously reported in Pabst (1995) and Soll and Soper (1996) (but see Hall 1997). At the time of those publications and the work they reported, their findings in regard to element occurrences represented recommendations to the Natural Heritage Program. Some proposed element occurrences were rejected by the Natural Heritage Program, and others added (see DOE-RL 1996 and Hall 1997 for additional details). The numbers presented here represent the element occurrences accepted by the Natural Heritage Program for the Hanford Site. The only additional adjustments that may be made by

Natural Heritage Program staff to the element occurrence information reported here would be to combine, based on geographic location and occurrence size information, a number of occurrences of the same element into a single occurrence (Rex Crawford, Washington Natural Heritage Program, personal communication to editor). These changes would be unlikely to affect the acreage total, except to enlarge it based on management feasibility issues.

2.7 Further Inventory Needs

Although the basic plant community inventory work of the Hanford Site is complete, there are a number of further inventory needs that should be addressed in the future. These can be summarized as follows:

- Potential element occurrence areas on Umtanum Ridge identified by James and Soll (1996) should be reevaluated in their post-fire condition. Information relative to plant community mapping, acreage, and element occurrence status for the Riverland area should be incorporated into the biodiversity inventory information for the Hanford Site.
- Vernal pool cluster and spring areas on Umtanum Ridge should be evaluated for element occurrence status. The vernal pools contain significant populations of rare plants (see Section 3.0). One of the spring areas on Umtanum Ridge contains an endemic land snail not known from any other location (Frest and Johannes 1993). Additionally, an alkaline spring and marshy area was found during 1997 in a large shallow basin at the east end of Umtanum Ridge (see Section 3.0). It is perhaps the only spring of its kind on the Hanford Site.
- Landscape scale monitoring should be established to track changes over time in representative examples of each major community type.

2.8 Conclusions

The results of the plant community inventory are striking in both depth and breadth. The various mapping projects have clearly demonstrated that the Hanford Site supports a unique, valuable and irreplaceable combination of the plant communities that make up the shrub-steppe landscape of the Columbia Basin. The combined results of the various mapping projects make the Hanford Site a vital, and for at least certain components of its biodiversity perhaps the single most important, conservation link for preserving and sustaining the biodiversity of shrub-steppe within the Columbia Basin Ecoregion. Moreover, the element occurrences may be of conservation significance not only from the standpoint of Washington State, but nationally as well (Grossman et al. 1998, Noss et al. 1995). As population increases and development for residences and agriculture continue, the large, expansive and diverse plant communities of the Hanford Site will become increasingly valuable as a reservoir supporting biodiversity in Central and Eastern Washington, Oregon and Idaho.

2.9 Management Recommendations

To better ensure the preservation of Hanford's significant native plant communities, the following management actions are recommended.

2.9.1 UPLAND AREAS

Competing interests, including the needs of the clean-up effort will complicate future land-use planning. Upland areas are particularly vulnerable to activities that directly or indirectly will disturb or permanently alter the surface vegetation and important ecological processes. The following management actions will help avoid unnecessary degradation of Hanford's upland resources:

- Plant community element occurrences should be managed to avoid degrading natural resource value, including prohibiting activities that disturb the soil surface.
- Complete inventory and monitoring needs identified above.
- Incorporate findings of the 1997 field season and element occurrence information (as well as the information from the other sections of this report) into an update of the Draft Hanford Site Biological Resources Management Plan (DOE-RL 1996).
- Manage special habitat areas identified in Section 3 (rare plants) as equivalent to terrestrial plant community element occurrences.
- Control the effects of noxious weeds on the plant communities of the Hanford Site (see Section 10).

2.9.2 THE HANFORD REACH

The Hanford Reach is undeniably of regional significance. Because of the development of the Columbia and Snake Rivers for power generation, irrigation and navigation, plant communities similar to those on the Reach are scarce to non-existent in other areas. The recent listing of many northwest runs of salmon under the Endangered Species Act reinforces the need to protect the habitat of the best remaining runs on the main stem of the Columbia. The following recommendations are designed to prevent degradation of the important natural resources the Reach supports.

- Protect the White Bluffs from erosion and slumping caused by excess irrigation water.
- Backwater areas and sloughs are presumably maintained by periodic scouring. In the absence of scouring floods, the sites will likely become dominated by *Phalaris arundinacea* or other species. A hydrologist and weed expert should be consulted for control strategies.
- Long-term monitoring should be established for each riparian zone to detect changes in community structure and composition, especially non-native plants.
- Weeds control methods should be assessed for exotic species. Species such *Phalaris arundinacea, Morus alba* and *Lythrum salicaria* are increasing and can fundamentally alter important ecosystem processes.
- Limited access to the south shore and islands within the Hanford Site should be continued to avoid damage to the sensitive wetlands.

Table 2.1 Coverage of potential plant community types of the Hanford Site

Potential Plant Community	Total Acreage Mapped at the Hanford Site	WNHP Protection Priority Status*	North Slope	North Slope Element Occurrence	Central Hanford	Central Hanford Element Occurrence	ALE	ALE Element Occurrence
Agricultural / Old Fields	582	N/A	126	0	0	0	455	0
Alkali saltgrass	4	1	4	4	0	0	0	0
Big sagebrush / bluebunch wheatgrass	40,104	2	437	171	7,589	665	32,077	28,715
Big sagebrush / cheatgrass%	115,173	N/A	58,903	0	35,479	0	20,791	0
Big sagebrush / needle-and-thread	84,701	1	5,685	5,347	78,561	8,133	455	366
Big sagebrush / Sandberg's bluegrass	38,183	3	7,888	0	24,957	322	5,338	0
Bitterbrush / bluebunch wheatgrass	42	2	0	0	42	0	0	0
Bitterbrush / Indian ricegrass dune complex	34,384	1	9,317	8,445	24,711	20,993	356	265
Bitterbrush / needle-and-thread	1,385	1	102	62	1,257	349	26	0
Black greasewood / alkali saltgrass	299	1	0	0	0	0	299	299
Buckwheat / Sandberg's bluegrass#	252	N/A	0	0	0	0	252	249
Facility / Gravel Pit	2,966	N/A	28	0	2,895	0	43	0
Riparian / Wetland	2,595	N/A	2,595	0	0	0	0	0
Riverine emergent wetland, non-persistant	52	N/A	52	0	0	0	0	0
Sand dropseed - Sandberg's bluegrass	4,330	2	666	223	3,664	0	0	0
Spiny hopsage / Sandberg's bluegrass	2,710	3	1,157	37	1,552	0	0	0
Stiff sagebrush / Sandberg's bluegrass	143	3	74	74	67	10	2	0
Talus / Rock	77	N/A	12	0	20	0	45	0
Three-tip sagebrush / bluebunch wheatgrass	6,230	2	0	0	0	0	6,230	6,057
Three-tip sagebrush / cheatgrass	32	N/A	0	0	0	0	32	0
Three-tip sagebrush / Idaho fescue	4,705	2	0	0	0	0	4,705	4,705
Three-tip sagebrush / needle-and-thread	115	1	0	0	0	0	115	110
Three-tip sagebrush / Sandberg's bluegrass	4,899	N/A	1,232	1,232	0	0	3,668	3,668
Three-tip sagebrush / wildrye	2	N/A	0	0	0	0	2	0
Vernal pool	22	1	0	0	22	0	0	0

Potential Plant Community	Total Acreage Mapped at the Hanford Site	WNHP Protection Priority Status*	North Slope	North Slope Element Occurrence	Central Hanford	Central Hanford Element Occurrence	ALE	ALE Element Occurrence
White Bluffs	975	N/A	975	0	0	0	0	0
Willow riparian complex	62	1	18	0	0	0	44	44
Winterfat / Sandberg's bluegrass	1,163	3	71	0	0	0	1,092	1,092
TOTAL~	346,188		89,343	15,595	180,816	30,472	76,028	45,570
All numbers expressed as acres								
TerraLogic GIS, Inc. 9/6/99								

* Washington Natural Heritage Program (WNHP) Protection Priority Status (WDNR 1998): **N/A**—not applicable; **Priority 1**—Elements in the greatest jeopardy of being destroyed or degraded, limited distribution in Washington and few occurrences in natural condition, and little or no representation in existing natural areas or other protected areas; **Priority 2**—Elements at an intermediate level of jeopardy, regional distribution in Washington and few occurrences in natural condition, and little or no representation in existing natural areas or protected areas (may receive some *de facto* protection in other managed areas); **Priority 3**—Elements not in immediate jeopardy but are still significant components of the state's natural heritage, regional distribution in Washington and varying numbers of occurrences in natural condition, and may be partially represented in existing natural areas (or, if not in natural areas, are in areas that provide *de facto* protection).

Rock and thyme buckwheat types combined.

% This category includes those areas identified as potential type unknown in Easterly and Salstrom, 1998.

~ Totals for the site include only areas mapped and do not include facilities, quarries, islands in the Hanford Reach, and south shore Hanford Reach communities.

Section 3 – Rare Plants

3 Rare Plants

3.1 Introduction

This section provides information on rare plant inventories conducted in 1994, 1995 and 1997. More detailed information on these inventories can be found in Caplow and Beck (1995, 1996, 1997).

3.2 Purpose and Scope

The conservation of rare plants represents a challenge for land managers for several reasons. Many rare plant taxa occur in atypical habitats. Even those that do occur in more typical habitats tend to occur unpredictably, since by definition rare plants occur uncommonly. As a result they are difficult or impossible to protect through modeling or coarse filter / ecosystem management approaches. Finally, few people are skilled at proper identification, making recognition of unexpected or usual species by non-specialist field personnel uncertain. As a result, identification and conservation of rare plant populations requires special and focussed attention.

Plant species reconnaissance and collection have taken place on the Hanford Site for over 100 years (Sackschewsky et al. 1992). More recently, botanical work has occurred within the context of the many ecological studies conducted by the Pacific Northwest National Laboratory or through site-specific, small-scale plant surveys meant to satisfy compliance with environmental regulations associated with the conduct of U.S. Department of Energy (DOE) activities at Hanford. Before 1994, however, no large-scale botanical surveys, whose specific intent was to identify the presence and status of rare plant populations, had taken place at Hanford. As part of the Hanford Site biodiversity project, large-scale rare plant surveys have been conducted during the 1994, 1995, and 1997 field seasons within each of the Hanford Site management areas. Summaries of the 1994, 1995 and 1997 survey results are reported in Pabst (1995), Soll and Soper (1996) and Hall (1998), respectively.

3.3 Methods

3.3.1 TERMINOLOGY

Rare plant species refers to any vascular plant species listed as endangered, threatened, or sensitive in the state of Washington (WNHP 1997). Additionally, for the purposes of this report, species included in Review Group 1 also are referred to as rare plant species, though often knowledge of their status in the state is not well known. None of the species potentially present at Hanford that are on the rare plant species list are presently federally listed. Several, however, are identified as federal Species of Concern (see below). The 1997 revision of the state rare plant list brought many status changes to the rare plants of the Hanford Site, as well as some changes in status category definitions. Fifteen plant species occurring on Hanford, and previously without a conservation status, were assigned a status that ranged from Review Group 1 to Endangered. Four additional species were upgraded (i.e., assigned to a category of increased conservation concern), whereas four others were downgraded. Because the definitions apply to vascular plant taxa, they can be applied at the taxonomic rank of either subspecies or variety, as well as to species. In the remainder of this section and the report in

general, the term taxon (taxa) is used when not otherwise referring specifically to a species. The status categories are defined as follows:

1. **Endangered:** Taxon is in danger of becoming extinct or extirpated (i.e., locally extinct) in Washington within the near future if factors contributing to its decline continue.
2. **Threatened:** Taxon is likely to become endangered in Washington within the near future if factors contributing to its population decline or habitat degradation or loss continue.
3. **Sensitive:** Taxon is vulnerable or declining and could become endangered or threatened in Washington without active management or removal of threats.
4. **Review:** Category consists of two groups of taxa for which more information is needed to accurately assess their status. **Group 1** includes taxa for which more field work is needed to assess their rarity and the degree to which they are threatened. **Group 2** includes taxa with unresolved taxonomic questions.
5. **Watch:** Taxon is more abundant and / or less threatened in Washington than previously assumed. Although these species are not tracked in the database, they still warrant management attention.

On February 28, 1996 the U.S. Fish and Wildlife Service redefined the federal candidate species category (61 FR 7595). As a result several former categories of candidate species were eliminated. The previous candidate 1 category is now the only remaining candidate category. Many species previously included in the now eliminated categories are presently tracked as Species of Concern by state and local offices of the Service. Thus, the conservation standing of these species is still of concern to the Service; however, their identification as such will no longer be published in the federal register and they will not receive any formal recognition or protection under the Endangered Species Act. Species of Concern lists will be generated and maintained through partnerships between the Service and appropriate federal and state agencies and private organizations. Plant species identified herein as federal Species of Concern are based on a list provided by the Spokane office of the Service (USFWS 1998).

The term occurrence refers to rare plant populations that are currently part of the Washington Natural Heritage Program (NHP) rare plant data base, whereas population refers to rare plant locations identified during the 1994-7 rare plant surveys. Before entry into the statewide database, NHP botanists may determine that one or more populations of a rare plant species constitutes a single occurrence. Multiple populations of rare plants located during the 1994 and 1995 Hanford Site rare plant surveys have been combined into single occurrences in the updated Heritage Program database. To avoid confusion, the term occurrence is used herein to refer to only rare plant populations already included within the Heritage Program database.

Because of the rarity of many of the plants described in this section, common names are not widely recognized (WNHP 1997). Therefore, in contrast to other sections of this report, in this section scientific names of vascular plants are emphasized over common names. Still, Table 3.2 also provides a common name for each species. These are taken from WNHP (1997), which uses Hitchcock and Cronquist (1973) as its primary source.

3.3.2 PRE-FIELD

Before commencing fieldwork in 1994, a list was compiled of those rare plant species that potentially would be encountered within the study area (Table 3.1). The list was assembled from several sources, including: a search of the Washington Natural Heritage Program data base for rare plants documented at Hanford, information on listed plant species of Washington (WNHP 1997), published literature in regard to botanical information about the Hanford Site, and supplemental information from Hitchcock et al. (1955 - 1969). In addition, interviews were conducted with botanists, ecologists and biologists familiar with existing rare plant occurrences, high-quality native plant communities and unusual

habitats on various portions of the Hanford Site. Rare plant taxa known to be located in Benton, Franklin and Grant Counties were included on the list if their habitat appeared to be present on the Hanford Site. The potential species list was refined prior to each subsequent years efforts based on the previous years fieldwork. Based on the flowering times of species potentially encountered, a study plan was developed each year that included a methodology for field survey and appropriate timing of fieldwork.

3.3.3 FIELD METHODOLOGY

Walking surveys were conducted periodically from March through August to coincide with the time of flowering of taxa on the potential occurrence list. The total acreage surveyed on the Hanford Site during the three years of rare plant surveys was more than 48,000 acres (19,425 ha) (see Figure 3.1 for a depiction of areas searched). Four levels of survey intensity were used:

- Reconnaissance – walk through to assess potential for rare plant occurrences;
- Light – multiple, widely spaced transects;
- Moderate – multiple transects with higher intensity surveys concentrated in areas that appeared unique or that had a high potential for rare plant species; and,
- Complete – closely spaced transects and intense searching in areas with rare plant populations or with habitat that had a very high potential for rare plant species.

Most areas were surveyed at moderate to complete survey intensity.

Most plants were identified in the field using Hitchcock and Cronquist (1973). Identifications were supplemented by other taxonomic manuals, regional floras, literature published on specific genera and consultation with experts on specific genera as necessary to confirm identifications (see Caplow and Beck 1194, 1995 and 1997 for a listing of these additional references). Washington Natural Heritage Program sighting forms were completed for each rare plant population located.

All rare plant occurrences were fully documented using a protocol designed by the Washington Natural Heritage Program, and mapped with the aid of a Geographic Positioning System (GPS) unit or in the field using 1:24,000 scale United States Geological survey topographic maps. Photographs were taken of all rare plant taxa and their surrounding habitats to supplement documentation.

3.3.4 SURVEY EFFORTS BY YEAR

1994

Approximately 22,000 acres of the Hanford Site were surveyed during approximately 100 person days of field inventory between March and August, 1994 (Figure 3.1). In an effort to target areas with the highest priority for conservation and with the highest likelihood of supporting rare plants, survey efforts were largely limited to the ALE Reserve, North Slope and Hanford Reach.

1995

In 1995, 110 days of surveys were conducted. Approximately 16,000 acres of the Hanford Site and 75 miles of Columbia River shoreline were surveyed (Figure 3.1). All management areas were visited, but wetlands communities within the Hanford Reach were emphasized in 1995. Special survey techniques were required for riparian emergent wetlands along the Hanford Reach. The Reach was flown in a small airplane, floated in kayaks and potential wetlands were mapped. Foot surveys were used for detailed examination. Due to the complexity of the vegetation within each wetland, population boundaries of each species within each wetland were not mapped.

Precipitation during January through March 1995 at Hanford was more than twice normal (PNL 1995), and four times that of 1994 (NOAA 1994). Such abundant precipitation was reflected in the diversity, number and vigor of annuals found during the 1995 field season. In drier years many of these populations may not be detectable.

1997

About 75 person-days were spent conducting field surveys by foot during the period April 24, 1997 to August 31, 1997. Surveys focused on the basalt sands near Gable Mountain, vernal pools, and other areas of potentially high plant diversity (Figure 3.1). An estimated total area of 10,200 acres was surveyed during the 1997 field season.

Eastern Washington generally had above average precipitation in 1997 (PNNL 1997). Despite this, the emergence and bloom of annual plant species seemed less vigorous than in 1995 (a very high precipitation year). Still, most annual species that were observed in 1995 also were visible in 1997.

3.3.5 POST-FIELD

Plant specimens were collected only when identification required further scrutiny or when a taxon's presence on Hanford was being documented for the first time. Collected plant specimens were labeled and sent to the University of Washington Herbarium, Seattle, WA; and, if duplicates are available, to the Pacific Northwest National Laboratory Herbarium, Richland, WA.

To assist with plant taxa identification, numerous herbaria were visited during and after the completion of fieldwork. Also, several plant specimens were sent to taxonomic experts for verification or identification:

- The then unknown *Astragalus conjunctus* var. *rickardii* – Dr. Rupert Barneby of the New York Botanical Garden and Dr. Stanley Welsh at Brigham Young University;
- An unknown *Festuca* – Dr. Susan Aiken of the Canadian Museum of Nature, Barbara Wilson of Oregon State University;
- The then undescribed *Lesquerella tuplashensis* – Dr. Reed Rollins of Harvard University;
- The then undescribed *Eriogonum codium* and *Chorizanthe watsonii* – Dr. James Reveal of the University of Maryland
- *Cryptantha spiculifera* – Dr. Walter Kelley of Mesa State College;
- *Loeflingia squarrosa* var. *squarrosa* – Dr. Ronald Hartman of the University of Wyoming;
- *Gilia leptomeria* and *G. lottiae* – Dr. Alva Day at the California Academy of Sciences; and,
- *Mimulus suksdorfii* – Bob Meinke of Oregon State University;

3.4 Findings

3.4.1 OVERVIEW

During three years of fieldwork a total of 112 populations / occurrences of 28 rare plant taxa were located on the Hanford Site (Table 3.2, Figure 3.2). Twenty-three of these taxa were not previously known to exist on the site. In addition are numerous populations of 17 taxa that are not previously

known from Washington State, or otherwise of botanical interest and potentially of conservation and management concern (Table 3.3). Figure 3.2 provides a depiction of the generalized locations of rare plant populations identified during the biodiversity inventory, specific location data are available from the Washington Natural Heritage Program to qualified individuals. Each polygon displayed here may contain one or more populations. Additionally, eight special habitat areas also are depicted. These are areas meant to encompass habitat appropriate for populations of certain rare plant species, generally annuals, whose locations are patchy, whose habitat is dynamic (e.g., dune fields), and whose occurrence over time may be spotty in response to yearly changes in weather patterns. Rare plant populations were found throughout the Hanford Site in all management areas during the rare plant surveys.

The highest rare plant densities occurred on: the east end of Umtanum Ridge (including the known as Riverland: see section 2), basalt-derived sands near Gable Mountain, White Bluffs, Rattlesnake Mountain, Yakima Ridge, and within riparian communities along the Hanford Reach of the Columbia River (Figure 3.2). The findings included two plant species and one variety of a species that are new to science. When rare plant occurrences located before 1994 are included, a total of 127 populations / occurrences of 30 rare plant taxa are now documented on the Hanford Site (Table 3.2). This is a tremendous amount of rare plants — both in terms of species richness and abundance — to occur in an area the size of the Hanford Site.

A complete list of all taxa observed in the various management areas at the Hanford Site during the 1994, 1995, and 1997 field surveys is provided in Caplow and Beck (1997). This list of 508 plant taxa includes 85 plant taxa unknown from the Hanford Site before 1994 surveys, and can be considered an addendum to Sackschewsky et al. (1992).

No rare plant survey is 100% complete. Although the 1994-7 surveys represents the most comprehensive survey to date at the Hanford Site, it should not be substituted for more detailed project-specific surveys when these are appropriate. Moreover, populations of rare plants are dynamic; through time, new rare plant populations may become established, and existing ones may become larger, smaller, or shift in their location. Thus, continued monitoring of the status of rare plants on Hanford is essential.

3.4.2 FINDINGS BY SURVEY YEAR

Detailed discussion of the findings for each year, including discussion of population size, quality and management recommendations by taxa, are presented in each year's technical reference.

1994

During the 1994 inventory, 62 previously unknown populations of 15 rare plant taxa were located throughout the site, but mostly on ALE and the North Slope where survey efforts were focussed. This included 55 populations of ten rare plant taxa listed at the time in Washington as Endangered, Threatened or Sensitive: *Astragalus columbianus* (Columbia milk-vetch), *Astragalus geyeri* (Geyer's milk-vetch), *Camissonia pygmaea* (dwarf evening-primrose), *Cryptantha leucophaea* (gray cryptantha), *Cyperus bipartitus* (shining flatsedge), *Erigeron piperianus* (Piper's daisy), *Limosella acaulis* (southern mudwort – later downgraded partially based on our findings), *Oenothera caespitosa* subsp. *caespitosa* (desert evening-primrose), *Lomatium tuberosum* (Hoover's desert-parsley), and *Rorippa columbiae* (persistentsepal yellowcress). Six populations of four plant taxa included at the time in Washington State Monitor Groups 1 and 2 were also identified (WNHP 1994b). In addition, five plant species in Monitor Group 3 and eight non-listed but potentially significant plant taxa were located. Range extensions were found for several of the rare plant taxa.

Populations of three plant taxa included in Washington Monitor Groups 1 and 2 were found on the Hanford Site during the 1994 field season: *Cryptantha spiculifera* (Snake River cryptantha), *Cuscuta denticulata* (desert dodder), and *Hypericum majus* (Canadian St. John's-wort).

A previously undescribed species of *Lesquerella* was identified in the White Bluffs. It was later published as *Lesquerella tuplashensis* (White Bluffs bladderpod)

1995

Thirty-three new populations of eight plant taxa listed in Washington as Endangered, Threatened or Sensitive were located on the Hanford Site during the 1995 field season: *Astragalus columbianus* (Columbia milk-vetch), *Camissonia pygmaea* (dwarf evening-primrose), *Eatonella nivea* (white eatonella), *Erigeron piperianus* (Piper's daisy), *Lomatium tuberosum* (Hoover's desert-parsley), *Mimulus suksdorfii* (Suksdorf's monkeyflower), *Oenothera caespitosa* subsp. *caespitosa* (desert evening-primrose), and *Pectocarya setosa* (bristly combseed). Numerous new subpopulations of *Cyperus bipartitus* (shining flatsedge) and *Limosella acaulis* (southern mudwort) were also found. In addition, known occurrences of *Astragalus columbianus*, *Camissonia pygmaea*, *Erigeron piperianus*, and *Lomatium tuberosum* were revisited.

In addition, numerous new sub-populations of two Sensitive taxa; two new populations of one plant taxon included in Washington State Monitor Group 1 and 5 populations of three species not previously known from Washington were found. Furthermore, populations of the at that time previously undescribed species, *Eriogonum codium;* one population of the at that time previously undescribed variety *Astragalus conjunctus* var. *rickardii;* and twelve unlisted plant taxa of interest were located.

1997

During the 1997 rare plant survey of the Hanford Site, a total of 35 new populations were found of 14 rare plant taxa identified in Washington as either endangered, threatened, sensitive, or Review Group 1 (WNHP 1997; Table 3.1). New populations and revised occurrences were found of the following taxa: *Astragalus columbianus*, *Calyptridium roseum*, *Camissonia pygmaea*, *Cryptantha leucophaea*, *Eatonella nivea*, *Erigeron piperianus*, *Gilia leptomeria*, *Lesquerella tuplashensis*, *Loeflingia squarrosa* var. *squarrosa*, *Mimulus suksdorfii*, and *Oenothera caespitosa* subsp. *caespitosa*.

New Hanford Site populations of five rare plant taxa not described in previous survey reports and newly listed by the WNHP include: *Camissonia minor*, *Castilleja exilis*, *Nama densum* var. *parviflorum*, *Pectocarya linearis* var. *penicillata*, and *Penstemon eriantherus* var. *whitedii* (Table 3.2). All five of these taxa are currently listed as Review Group 1 in Washington (WNHP 1997).

Rare plant populations were found throughout the Hanford Site in all management areas during the 1997 rare plant surveys (Table 3.2). Most new rare plant populations, however, were found on Central Hanford because surveys efforts were focused there. Additionally, 10 occurrences of eight taxa were revisited and remapped. Finally, a population of an unlisted plant species, previously unknown from Washington, was discovered.

3.4.3 FINDINGS BY MANAGEMENT AREA

A summary of findings for each management area is provided below.

FITZNER / EBERHARDT ARID LANDS ECOLOGY RESERVE

During three years of fieldwork on the ALE Reserve, 26 populations / occurrences of nine rare plant taxa were located primarily on Yakima Ridge and the north slopes of Rattlesnake Mountain. A newly described variety of plant, *Astragalus conjunctus* var. *rickardii*, was located on the top and north

slopes of Rattlesnake Mountain (one of only two known occurrences). This taxon was named in honor of Dr. Bill Rickard, one of those responsible for the establishment of the ALE Reserve and its subsequent status as a Research Natural Area.

In addition, *Camissonia minor* and *Nama densum* var. *parviflorum* were found in lower Cold Creek Valley and in association with a *Sarcobatus vermiculatus* / *Distichlis stricta* (black greasewood / alkali saltgrass) community at Rattlesnake Springs.

SADDLE MOUNTAIN NATIONAL WILDLIFE REFUGE

During three years of fieldwork on the Saddle Mountain National Wildlife Refuge, 20 populations / occurrences of seven rare plant taxa were identified and mapped. Rare plants were found primarily on the gravelly bluffs north of Vernita Bridge, on the White Bluffs, and within riparian communities along the Columbia River.

Populations found on the steep, unstable slopes of the gravelly bluffs north of Vernita Bridge would be vulnerable to legal or illegal off-road vehicle use if the western boundary of the Hanford Site were opened to public access. If irrigation increases in agricultural areas upslope of these populations, the bluffs could be vulnerable to slumping.

WAHLUKE UNIT COLUMBIA BASIN WILDLIFE AREA

During three years of fieldwork on the Wahluke Unit Columbia Basin Wildlife Area, 31 populations / occurrences of 14 rare plant taxa were located, primarily on the White Bluffs and within riparian communities along the Columbia River.

One of the new *Gilia leptomeria* populations is the largest currently known in Washington. The single known population of *Lesquerella tuplashensis* occurs on the tops of the White Bluffs.

CENTRAL HANFORD

During three years of fieldwork on Central Hanford, 41 populations / occurrences of 20 rare plant taxa were located. Areas of highest rare plant density included: the east end of Umtanum Ridge, the basalt derived sands near Gable Mountain, in three sets of vernal pools, within the Hanford Dune Field, and within riparian communities along the Columbia River. For an area its size, Central Hanford has a tremendous number of occurrences and a high diversity of rare plant species.

Among the most interesting discoveries were three previously undocumented clusters of approximately 20 vernal pools (see Caplow and Beck 1997, Hall 1998 for additional details). Vernal pools in Washington are little known or studied; therefore, their occurrence on Hanford is significant. The Hanford Site pools were located on the eastern end of Umtanum Ridge, near Gable Butte, and on Gable Mountain. The pools often were characterized by a distinct zonation of species from the bottom of the pool, which might be barren throughout the growing season, to the upper pool edge, which was occupied by various annual plant species. The vernal pools also showed wide variation in their degree of development (i.e., some appeared to be pools that filled intermittently and were invaded by sagebrush during extended dry periods). Most pools apparently filled with water most years. The alkaline spring, as well as the vernal pool clusters, were mapped as special habitat areas (Figure 3.2).

Dominant species were typically annuals, including several rare species (see Caplow and Beck 1997). Some vernal pools had a high cover of moss and lichen species. In addition to their botanical resources, there was ample evidence of avian and other wildlife use of these vernal pools as they often provided water during dry times of the year.

3.4.4 FINDINGS BY INDIVIDUAL SPECIES

A brief review is provided below of significant findings in regard to selected individual species. For most of the species discussed throughout the rare plant section, information on state and federal status (from WNHP [1997] and USFWS [1998], respectively) and the specific number of populations / occurrences and their management area locations is provided in Table 3.2. An in-depth discussion of every rare and unusual species located during this survey is presented in the relevant technical reports.

3.4.5 SPECIES NEW TO SCIENCE

In addition to the overall diversity of rare plant species and abundance of rare plant occurrences / populations on the Hanford Site, one of the highlights of the rare plant surveys was the discovery of two species new to science.

ERIOGONUM CODIUM (UMTANUM RIDGE DESERT BUCKWHEAT)

Previous to the 1995 biodiversity surveys, this species was not described. It is listed as endangered by the state of Washington (WNHP 1997) and identified as a Species of Concern by the U.S. Fish and Wildlife Service (1998). Despite some mortality from a fire in 1996, a total of 5200 plants was estimated to be present. Long-term demographic monitoring was initiated on this species in 1997.

Eriogonum codium appears to be restricted to a discontinuous mile long strip generally less than 100 feet wide within Central Hanford. Some individual plants are estimated to be well over 100 years old (Reveal 1995). State-listed species *Lomatium tuberosum* (Hoover's desert-parsley), *Astragalus columbianus* (Columbia milk-vetch), and *Erigeron piperianus* (Piper's daisy) occur within the vicinity of the newly discovered population, as does a population of *Gilia leptomeria*, previously not known from Washington.

The *Eriogonum* population is within an area of Central Hanford receiving little use, and is officially not accessible to the public. However, fences in the area are regularly cut and trespassing occurs. A portion of the site has visible petrified wood, and there are signs of collecting within the *Eriogonum* population. Changes in management in this area which would allow off-road vehicles, livestock grazing, or unrestricted public access could have a devastating affect on this species.

LESQUERELLA TUPLASHENSIS (WHITE BLUFFS BLADDER-POD)

Previous to the 1994 biodiversity surveys, this species was not described. It is listed as endangered by the state of Washington (WNHP 1997) and identified as a species of concern by the U.S. Fish and Wildlife Service (1998). The total count of adult plants in 1997 was estimated to be 50,000 plants spread across an 8 mile long occurrence. Infestations of a noxious weed, *Centaurea solstitialis* (yellow starthistle), were located within the middle portion of the *Lesquerella* population. Long-term demographic monitoring was initiated on this species in 1997.

Several other rare plant populations exist in the immediate area, including: the Threatened species *Camissonia pygmaea*, the Sensitive species *Erigeron piperianus*, the Monitor Group 2 species *Cryptantha spiculifera*, and the Monitor Group 1 species *Cuscuta denticulata.*

The White Bluffs are a unique exposure of the Ringold formation, made of soft Pliocene lacustrine deposits of clay, sand, and silt (Newcombe 1958). The top is capped in many places by a harder calcium carbonate, "caliche" layer (Lindsey 1994). *Lesquerella tuplashensis* appears to be restricted to this caliche layer.

The primary threats to the *Lesquerella tuplashensis* population are erosion, conversion, weed invasions or slumping of the bluffs due to illegal ORV use or irrigation. Most of the population of *Lesquerella tuplashensis* is outside the Hanford Reach (technically 1/4 mile on either side of the river). The protection of this population and thus the species, requires that these issues be addressed in any mangement action.

ASTRAGALUS CONJUNCTUS VAR. *RICKARDII* (RATTLESNAKE MOUNTAIN MILK-VETCH)

A relatively common *Astragalus* (milk-vetch) on the north-facing slopes and summit of Rattlesnake Mountain has been determined to be *A. conjunctus* var. r*ickardii*. On the Hanford Site, the taxa is scattered in bunchgrass areas along the main ridges of Rattlesnake Mountain., where it has been mistakenly referred to as *A. reventiformis* for many years (Sackschewsky et al. 1992). The population includes several tens of thousands of plants. The population remains incompletely mapped.

The two known locations of *A. conjunctus* var. *rickardii* are both in Benton County; the large population on Rattlesnake Mt. and a small population from the Chandler Butte portion of the Horse Heaven Hills. These populations represent a northward range extension for the species.

The Hanford Site *Astragalus conjunctus* var. *rickardii* population is entirely included within the boundaries of ALE. The area currently has very limited access and low disturbance levels. Maintenance of public ownership, and the current management regime is the most likely method to insure the long term survival and viability of *A. conjunctus* var. *rickardii* on the Hanford Site.

3.4.6 ENDANGERED, THREATENED, SENSITIVE AND REVIEW 1 PLANTS

With few exceptions, management issues are addressed at the end of the section. For details see relevant technical references.

AMMANNIA ROBUSTA (SCARLET AMMANNIA)

Ammannia robusta is a wetland species which ranges from California to the central United States and Mexico, but which had been reported from Klickitat County, Washington. It is included on the Sensitive list in Montana, and List 3 (the review list) in Oregon . It also has an R1 designation in British Columbia, which is the highest degree of rarity. On Hanford it was found in 16 locations along the Hanford Reach, below high water. These locations are now considered one population.

The riverine wetlands in which this *Ammannia robusta* population occurs have been designated as "riverine emergent non-persistent" wetlands. Plants are located in the upper margins of the seasonally inundated zone below the high water mark of the Columbia River. The riverine wetlands in which these populations occur are completely submerged during the early portions of the growing season (March through June), and submerged periodically during the later portions of the growing season (July through September). These unique wetlands have a very high diversity of native wetland plants, and a low cover of weedy plants. Plants associated with this community include: rushes (*Juncus* spp.), spike rushes (*Eleocharis* spp.), toothcup (*Rotala ramosior*), scarlet ammannia (*Ammannia robusta*), and flatsedges (*Cyperus* spp.). Many of the native wetland plants which occur in these wetlands are annuals. Elevations range from 360 feet to 420 feet and slopes are generally 1% to 3%.

Several state listed or monitor plant taxa also occur in these wetlands with *Ammannia robusta,* including: the Sensitive species *Cyperus bipartitus*, the Sensitive species *Limosella acaulis*, the Endangered species *Rorippa columbiae*, and the Monitor Group 1 species *Hypericum majus*. Refer to the Hanford Reach portion Calypso 1996 for further discussion of these unusual riverine wetlands.

All previous collections of this species were made before dams were built on the Columbia and Snake rivers. Botanists familiar with the Columbia River Gorge stated that, to their knowledge, no other populations of *A. robusta* have been seen on the Washington side of the Columbia River (Jolley 1995, Kemp 1995).

Changes in the hydrologic regime as a result of upstream hydropower project management, boating and other recreational uses of these sensitive riparian wetlands all pose threats to the high quality native wetlands. Purple loosestrife (*Lythrum salicaria*) could pose a threat to *C. bipartitus* habitat unless controlled.

ASTRAGALUS COLUMBIANUS (COLUMBIA MILK-VETCH)

Astragalus columbianus is considered Threatened in Washington and is a federal Species of Concern (WNHP 1997). It is a local endemic and is found in Yakima, Kittitas, and Benton Counties in south-central Washington. It was once thought to be extinct, but has since been found to be relatively common on the Yakima Training Center and other locations within its limited range (Sauer et al. 1979). Nine occurrences are known from the Hanford Site.

Most of the Hanford populations grow in big sagebrush/bluebunch wheatgrass and big Sagebrush / Sandberg's bluegrass plant community types, mostly in well-drained sandy and gravelly loams, lithosols, and cobbly sand, most frequently in early seral stages following disturbance. It has been found on the sides and medians of lightly used, gravel roads; and its density and frequency has been found to increase dramatically after fire (Mastroguiseppe et al. 1983).

The Yakima and Umtanum Ridge populations represent small range extensions to the south and east of the known range of *Astragalus columbianus.* The farthest Yakima Ridge population is up to nine miles south (inland from) of the Columbia River. As of 1983, no population was more than 2.5 miles inland from the Columbia River (Mastroguiseppe et al. 1983)

ASTRAGALUS GEYERI (GEYER'S MILK-VETCH)

Astragalus geyeri var. *geyeri* is considered Sensitive in Washington, where it is disjunct from its main range (WNHP 1997). It is a Great Basin and Snake River Plain species known from southeast Oregon to California and Nevada, and eastward through southern Idaho to Wyoming and Utah. The taxon is also considered Sensitive in Montana (Lesica et al. 1991). Prior to 1994 survey, two WNHP occurrences of *A. geyeri* were known from Grant County, both verified since 1984 (WNHP 1997).

The general habitat of *A. geyeri* includes depressions in mobile or stabilized dunes, sandy flats, valley floors, draws in gullied hills and margins of alkaline sandy playas (Barneby 1989). During the 1994 field season, 4 populations of *Astragalus geyeri* were located in the Saddle Mountain National Wildlife Refuge portion of the Hanford Site, in Grant County, within the Hanford Reach. It is likely that more populations of *A. geyeri* will be located in the area.

CALYPTRIDIUM ROSEUM (ROSY CALYPTRIDIUM)

Calyptridium roseum ranges from central Oregon to California, east to Nevada and south-central Idaho. Before being located on the Hanford Site, *C. roseum* was not known from Washington and had not been collected north of Harney County, Oregon.

On Hanford its habitat is gravelly soils and sagebrush shrublands within the big sagebrush/Sandberg's bluegrass community. Vegetation cover at most sites is generally low. Associated plants species include: Sandberg's bluegrass *(Poa sandbergii*), and assorted native and exotic annual species. *C. roseum* plants grow in conjunction with the Sensitive species *Mimulus suksdorfii*, and two other taxa new to Washington: *Loeflingia squarrosa* var. *squarrosa*, and *Gilia leptomeria*.

Two populations and several sub-populations of *Calyptridium roseum* were found within Central Hanford north of Gable Mountain, in dark, basalt-derived sand and silt substrate associated with small, subtle depressions or swales. Because the species is an annual, population numbers and exact location is likely to vary from year to year according to weather conditions. It is estimated that there are less than 250 *C. roseum* plants, all located within one mile of each other. Because the terrain is flat and relatively undifferentiated, and because plants are not likely to germinate every year,

populations may be difficult to relocate. Therefore, marking vulnerable and difficult to relocate populations is recommended. Further surveys are likely to identify additional *C. roseum* populations in the vicinity of Gable Mountain.

CAMISSONIA MINOR (SMALLFLOWER EVENING-PRIMROSE)

Camissonia minor is listed as Review Group 1 in Washington where it has a scattered distribution in the Columbia Basin. It is at the northern edge of its range, which includes most western states. In Washington, it is known from Benton and Kittitas Counties. On the Hanford Site, *C. minor* generally occurs on very dry, often barren, and sometimes disturbed sites. Populations grow in conjunction with a number of rare plant species including: *Eriogonum codium*, *C. pygmaea*, *Astragalus columbianus*, *Oenothera caespitosa* subsp. *caespitosa*, *Erigeron piperianus*, *Gilia leptomeria*, *Loeflingia squarrosa* var. *squarrosa*, and *Calyptridium roseum.*

Six populations of *Camissonia minor* were located: three on Central Hanford, on and near Gable Mountain and Umtanum Ridge; two populations in ALE in the Cold Creek Valley and Rattlesnake Springs; and one in Saddle Mountains National Wildlife Refuge on the gravelly bluffs north of Vernita Bridge in Grant County. All six populations are relatively small.

CAMISSONIA PYGMAEA (DWARF EVENING-PRIMROSE)

Camissonia pygmaea is considered Threatened in Washington where is it has a scattered distribution and is a regional endemic (WNHP 1997). The taxon was believed to range from central Washington to eastern Oregon and adjacent southern Idaho (Hitchcock 1973). Botanists from Idaho are not aware of any populations of this taxon in the state (Mosely 1995). *C. pygmaea* occurrences grow gravelly soils in the big sagebrush / Sandberg's bluegrass association in conjunction with the Monitor Group 1 species *Cryptantha spiculifera*, the Threatened species *Eatonella nivea*, *Lesquerella tuplashensis*, the Sensitive taxon *Oenothera caespitosa* subsp. *caespitosa*, and the Watch list species *Pectocarya setosa*.

Fourteen occurrences on the Hanford Site were located including locations in the the White Bluffs in the Wahluke Wildlife Area and the Saddle Mountain National Wildlife Refuge; and on and around Gable Mountain in Central Hanford. These populations are in Franklin and Grant Counties. None of the new populations are within the Hanford Reach. The newly located populations on the White Bluffs make it one of the largest known concentrations of *C. pygmaea* plants in its range.

Illegal use of off-road vehicles (ORVs) in the publicly accessible Wahluke Wildlife Area threatens two previously known *Camissonia pygmaea* occurrences. ORV use affects these occurrences not only by physically damaging plants, but more significantly by rutting and eroding slopes. Another threat to these and all populations on the bluffs are hydrologic changes (i.e. increase in irrigation) up-slope of the White Bluffs, which could result in seepage and slumping of the exposed face of the bluffs.

CASTILLEJA EXILIS (SMALL-FLOWER ANNUAL PAINTBRUSH)

Castilleja exilis var. *minor* is the only annual species of paintbrush in Washington and is included in Review Group 1. It has a scattered distribution east of the Cascade Mountains. In Washington, it is known from Adams Grant, Okanogan, and Yakima Counties. It is near the northern edge of its range which includes most western states and British Columbia.

On Hanford, a population of 75 to 100 *Castilleja exilis* plants was found in an unusual, alkaline, marshy spring in a large, shallow, low basin at the east end of Umtanum Ridge. There is a historic sightings of *C. exilis* from the West Lake area, although it could not be located during the 1997 survey. On the Hanford Site, *C. exilis* grows in conjunction with the Sensitive species *Mimulus suksdorfii*.

CENTUNCULUS MINIMUS (CHAFFWEED)

Centuculus minimus is an diminutive, annual herb in the primrose family (Primulaceae). It is unusual in the shrub-steppe region although it ranges from California to British Columbia, and is widespread in eastern North America, South America and Europe. Its habitat is shores, seepage areas, vernal pools, and other moist areas from the coast to inland valleys. *C. minimus* is listed as Rare in British Columbia and Alberta.

On the Hanford Site, *C. minimus* was located on the Hanford Reach in two riverine emergent wetlands in conjunction with several other rare plant taxa (See *Ammannia robustior* above)

CRYPTANTHA LEUCOPHAEA (GRAY CRYPTANTHA)

Cryptantha leucophaea is considered Sensitive in Washington, where it is a regional endemic. It is known from the Columbia and lower Yakima Rivers in the western Columbia Basin, from Wenatchee, Washington to The Dalles, Oregon. In Oregon, it is included on a list of extirpated species. Prior to 1994, there were 36 known WNHP occurrences of *C. leucophaea* in Washington, 24 of which had not been visited since 1984. There were four known WNHP occurrences on the Hanford Site (WNHP 1997).

Cryptantha leucophaea grows on swales and slopes of somewhat to moderately well vegetated sand dunes and other sandy habitats in the White Bluffs and in the Hanford Dune Field. It is usually associated with the bitterbrush / Indian rice-grass dune coples plant association . Associated plant species include: antelope bitterbrush, Indian ricegrass, and needle-and-thread grass. Most populations have a low to moderate cover of weedy plants.

Populations of *Cryptantha leucophaea* are located in the Wahluke Wildlife Area, Central Hanford, and the Saddle Mountain National Wildlife Refuge (8, 1, and 1 populations, respectively). The size of the new *Cryptantha leucophaea* populations varies dramatically, ranging from 0.1 acre to over 600 acres in size. The smallest populations are 0.1 acres in extent, the Central Hanford Dune Field population is approximately 18 square miles.

ORV use, irrigation related groundwater changes, stabilization of sand dunes by weedy plants or changes in sand deposition, and agricultural conversion all pose threats to *Cryptantha leucophaea* populations throughout its range. Six out of the eight new populations at Hanford are accessible to the public. Illegal ORV use was observed in the vicinity of half of the populations. Several of the populations are located in areas where irrigation related groundwater movement could cause, or is causing, slumping of the White Bluffs and the sand dunes immediately up-slope of the bluffs. A significant number of sand dunes and sandy areas on private lands have been converted into orchards and agriculture, contributing to the rarity of this taxon.

CRYPTANTHA SCOPARIA (DESERT CRYPTANTHA)

Cryptantha scoparia is Review Group 1 species, a regional endemic which is most common on the Snake River Plains of Idaho, extending into a few counties in adjacent Oregon, Nevada, and Utah, and disjunct to Yakima County, Washington . It was not previously known from the Hanford Site. It is not listed as a species of concern in Idaho or Oregon; its status in Nevada and Utah is unknown. There have been no new collections during the last 50 years in Washington.

C. scoparia was found on Yakima Ridge within ALE on a sparsely vegetated, south-facing slope, with big sagebrush (*Artemisia tridentata*) and winterfat (*Eurotia lanata*). The population was not vigorous, even during an unusually wet year. There may be no germination in a dry year. Due to the superficial similarities between *C. scoparia* and other annual *Cryptantha* species, other populations

on Yakima Ridge or on the Hanford Site may have been overlooked. A population of the state listed Sensitive species *Erigeron piperianus* was found at the same site.

CRYPTANTHA SPICULIFERA (SNAKE RIVER CRYPTANTHA)

Cryptantha spiculifera is a state Sensitive species and is included on List 3 (the review list) in Oregon (ONHP 1993). *C. spiculifera* ranges from central Washington and eastern Oregon to northeastern California and northern Nevada, east throughout the Snake River Plains of Idaho, and western Montana, where it generally grows in dry, open sites, often in stony or shale soils

Four populations of *Cryptantha spiculifera* were located on Hanford Site during the 1994 field survey, 1 on ALE and 3 in the Wahluke Wildlife Area. The largest population is located on the sparsely vegetated White Bluffs in the Wahluke Wildlife Area. Associated vegetation includes big sagebrush (*Artemisia tridentata*), Sandberg's bluegrass (*Poa sandbergii*) and winterfat (*Eurotia lanata*); the state Threatened species *Camissonia pygmaea* and the Endangered *Lesquerella tuplashensis*. The population is discontinuously eight miles long with many thousands of plants.

Similar threats exist to this species as for all species found within the White Bluffs: ORV use, irrigation related groundwater changes, and agricultural conversion.

CUSCUTA DENTICULATA (DESERT DODDER)

Cuscuta denticulata is listed as Sensitive in Washington. It is also an Idaho State Priority 1 species, which is equivalent to the Washington State "Endangered" listing (CDC 1994). *C. denticulata* ranges from California to Utah, Nevada, Arizona and Baja California (Hickman ed. 1993). The Washington and Idaho populations are disjunct from the range of the species. In 1984, the single known population of *C. denticulata* in Washington was collected on private land in the Cold Creek Valley in Benton County just west of the western boundary of Hanford. It is likely that this population has since been destroyed by conversion into a wheat field (Sackschewsky et al. 1992).

The plant is a parasite on big sagebrush and at Hanford is found within the big sagebrush/Sandberg's bluegrass community. Three populations were located adjacent to the White Bluffs in the Wahluke Wildlife Area.

Potential threats to *Cuscuta denticulata* include vehicular traffic, road maintenance, wildfire, grazing, and agricultural conversion. The *C. denticulata* population is located within 50 feet of a small dirt road which is accessible to the public.

CYPERUS BIPARTITUS (SHINING FLATSEDGE)

Cyperus bipartitus is considered Sensitive in Washington where it is peripheral to its main range. It is also included on review lists in Idaho and Oregon (CDC 1994; ONHP 1993). It is rarely collected in our area. Prior to the 1994 field season, there were nine *C. bipartitus* WNHP occurrences in Washington (five of which have not been verified since 1985), two from the Hanford Site.

The species is known from stream banks and other wet, low places in the valleys and lowlands and is tolerant of alkaline conditions. In Washington, it is known exclusively from the more arid regions of the state in riverine wetlands in small embayments and backwaters of the Columbia River (see discussion of *Ammannia robusta* for details and management issues).

Cyperus bipartitus was found in eighteen new locations in wetlands on the Hanford Reach. Based on consultations with the WNHP, it was decided to merge these eighteen “subpopulations” and the six previous WNHP occurrences into one large population including approximately 40 miles of the Hanford Reach.

EATONELLA NIVEA (WHITE EATONELLA)

Eatonella nivea is considered Threatened in Washington, where it is disjunct from its main range (WNHP 1997) which includes Oregon, Idaho, California, and Nevada. In Idaho, it is included on a list of monitor species: taxa that are common within a limited range as well as those taxa which are uncommon, but have no identifiable threats (CDC 1994). Prior to the biodiversity inventory there were no known occurrences on the Hanford Site.

Its general habitat is dry, sandy or desert volcanic areas, often with sagebrush. While the substrate of *E. nivea* at the other Washington occurrences is typically red basalt gravel, the substrate at the Hanford Site populations is an open, loose, gray gravel, where it grows in conjunction the Threatened species *Camissonia pygmaea*, the Watch species *Pectocarya setosa*, and *Gilia leptomeria*, a species previously unknown in Washington (Table 3.3).. The slopes on which the *E. nivea* populations grow are relatively undisturbed and have a relatively low cover of weedy species.

All three populations are within the Saddle Mountain National Wildlife Refuge in the gravelly bluffs just north of the Columbia River in the vicinity of Vernita Bridge. It is possible there are more *E. nivea* populations on the Hanford Site.

ERIGERON PIPERIANUS (PIPER'S DAISY)

Erigeron piperianus is a Sensitive species in the state of Washington. It is a regional endemic, which is found only in the Columbia Basin of Washington. Prior to 1994, there were 65 known WNHP occurrences in Washington, 36 of which have not been visited since 1985 (WNHP 1995). Seven populations were previously known from Hanford.

Erigeron piperianus occurs most commonly in the winterfat/Sandberg's bluegrass plant community type and to a lesser extent in the big sagebrush/bluebunch wheatgrass plant community type. The taxon is most common in undisturbed areas of the sagebrush steppe.

Fifteen new populations were located; 10 on ALE, 1 on Central Hanford and 4 on the Wahluke. Concurrent with TNC surveys, workers at PNL also found several new *Erigeron piperianus* populations on Umtanum Ridge and the Arid Lands Ecology Reserve. It appears that the Rattlesnake Mountain populations are more or less continuous over more than 12,000 acres. A smaller population on Yakima Ridge is less vigorous. The density and extent of the populations varies widely. The dense concentrations are most prevalent on low ridges in the winterfat/Sandberg's bluegrass plant community type. Two very small populations were located on the Wahluke Slope south of Saddle Mountain in the Wahluke Wildlife Area, also in a winterfat/Sandberg's bluegrass plant community type.

The Rattlesnake Mountain *Erigeron piperianus* populations are thriving and do not have any present threats. The Wahluke Slope populations are in a highly disturbed habitat which is accessible to the public.

GILIA LEPTOMERIA (GREAT BASIN GILIA)

Gilia leptomeria is a Review Group 1 species whose range includes Great Basin areas in Oregon, California, Idaho, Colorado and New Mexico. Before being located on the Hanford Site during the 1995 field season, *G. leptomeria* was not known from Washington.

The habitat preference for *G. leptomeria* is open sandy or rocky areas and vegetation is generally low. The plant association is loosely dscribe as big asgebrtush / Sandberg’s bluegrass. Weedy species such as cheatgrass (*Bromus tectorum*) and Russian thistle (*Salsola kali*) are sometimes sub-dominant. Both habitat and substrate type show substantial variation. On the Hanford Site, small, isolated populations

of *Gilia leptomeria* occur in different high quality habitat areas where there is often an array of rare plant species (*Astragalus columbianus, Erigeron piperianus, Eriogonum codium, Lomatium tuberosum, Camissonia pygmaea, Eatonella nivea, Pectocarya setosa, Lesquerella tuplashensis, Cryptantha spiculifera* and *Camissonia pygmaea, Mimulus suksdorfii, Loeflingia squarrosa* var. *squarrosa*, and *Calyptridium roseum).*

Seven populations of *Gilia leptomeria* were located at widely varying places on the Hanford Site, including: the gravelly bluffs north of Vernita Bridge, the basalt sand dunes north of Gable Mountain, Umtanum Ridge, and the White Bluffs. Although widespread, most populations were small and discrete. One of the White Bluffs populations is the largest known in Washington with several hundred plants

HYPERICUM MAJUS (CANADIAN ST. JOHN'S-WORT)

Hypericum majus is a state Sensitive species. It is an Idaho State Priority 2 species, which is equivalent to the Washington State "Threatened" listing (CDC 1994). It also has an R1 designation in British Columbia, which is the highest degree of rarity (Straley et al. 1985). It ranges from British Columbia to Quebec, southward through Pennsylvania, New Jersey, Illinois, Iowa, and Colorado. *H. majus* is generally rare in western North America. It has a scattered distribution in Washington. It is not known from Oregon.

For a discussion of typical habitat and management issues see *Ammannia robusta.*

Three new populations of *Hypericum majus* were located within the Hanford Reach, two in Central Hanford and one in the Wahluke Wildlife Area.

The Hanford Site populations represent a southern range extension of *Hypericum majus* in the Pacific Coast region. It is also a departure in the type of habitat the taxon typically inhabits in western North America: a wetland adjacent a large river in the arid, shrub-steppe, as opposed to a pond or lakeside in montane or forested regions.

LIPOCARPHA ARISTULATA (ARISTULATE LIPOCARPHA)

Lipocarpha aristulata is review Group 1 wetland species that ranges from California to Washington and the southeastern United States (Hickman 1993). It was not previously known from the Hanford Site. It is included on List 3 (the review list) in Oregon (ONHP 1993) and it also has an R1 designation (as *Hemicarpha micrantha*) in British Columbia, which is the highest degree of rarity (Straley et al. 1985).

On Hanford it was found in thirteen locations along the Hanford Reach, below high water. These locations are being considered one population in this report (see *Ammannia robusta* for discussion of habitat and management issues)

LOEFLINGIA SQUARROSA VAR. *SQUARROSA* (LOEFLINGIA)

Loeflingia squarrosa (state Threatened) is a widespread western and southwestern species with a number of recognized varieties. The previous known range of *Loeflingia squarrosa* var. *squarrosa* was from northern Baja California and the South Coast of California, through the San Joaquin Valley, and north to Santa Cruz County, California (Hickman ed. 1993). The Hanford Site populations are disjunct from the range of the species by at least 300 miles and from the range of the variety by approximately 800 miles. *L. squarrosa* is not listed as a species of concern in California or Oregon.

On the Hanford Site, five small populations were found on low "basalt sand" dunes to the north and south of Gable Mountain, generally in small swales and depressions in sparsely vegetated but relatively stable dunes with big sagebrush. A high percentage of basalt in the sand produces sand that

is darker and strikingly different vegetation than that of the light-colored dunes of the Hanford Dune Field to the southeast of Gable Mountain. These basalt sand dunes are normally quite barren, but a high diversity of annual species were seen in 1995, after unusually high winter and spring rainfall.

Each population was invariably associated with *Mimulus suksdorfii*, a state listed Sensitive species. *Calyptridium roseum*, another California annual that had not been collected north of Harney County, Oregon, was also found in association with *L. squarrosa* var. *squarrosa* at several sites. It was also found with one population of *Gilia leptomeria*, an annual species not previously known from Washington.

LOMATIUM TUBEROSUM (HOOVER'S DESERT-PARSLEY)

Lomatium tuberosum is considered Threatened in Washington and is a federal Species of Concern (WNHP 1997). It is a local endemic found only in Benton, Grant, Kittitas, and Yakima Counties in southcentral Washington. Prior to 1995, there were 24 known WNHP occurrences of *L. tuberosum*, eight of which had not been visited since 1985. One of these occurrences is on the steep, north-facing basalt talus slopes of Umtanum Ridge on the Hanford Site (WNHP 1995).

At Hanford, the substrate is loose active basalt talus, averaging 3 to 8 inches in diameter. The vegetation community is generally big sagebrush/bluebunch wheatgrass. During the survey, nine new populations of *Lomatium tuberosum* were found they have been combined into one occurrence. All of them are in the Central Hanford portion of the Hanford Site near populations of the Threatened species *Astragalus columbianus* and *Eriogonum codium*.

MIMULUS SUKSDORFII (SUKSDORF'S MONKEY-FLOWER)

Mimulus suksdorfii is a Sensitive species in Washington, where is it considered peripheral to its main range (WNHP 1997) throughout the western U.S. As of 1995, there were six occurrences in Washington, from five counties in Eastern Washington (WNHP 1995). None of these occurrences have been verified since 1985 (WNHP 1995). Prior to the 1995 field survey, no occurrences were known from the Hanford Site.

Its general habitat is open, moist or rather dry places, from the valleys and foothills to moderate or occasionally rather high elevation meadows in the mountains. At Hanford, populations are located in the vicinity of Gable Mountain in dark, basalt-derived sand and silt substrate associated with swales or vernal pools. The depressions in the topography presumably collect a slightly higher amount of precipitation runoff during the winter and spring months. Because of the annual habit of the species and the dynamic, patchy nature of its habitat within the dark sands north and south of Gable Mountain, the actual and potential habitat of *M. suksdorfii* were combined and mapped as a special habitat area (Figure 3.2 and Hall 1998).

All six populations of *Mimulus suksdorfii* were located in the Central Hanford portion of the Hanford Site. The size of the new *M. suksdorfii* populations ranges from 40 plants to over 1300 plants. Three new populations were associated with sets of vernal pools. A yellow star thistle infestation appears to be a problem at some of these pools.

Because of the terrain is so flat and plants are not likely to germinate every year, there is a concern that some populations may be quite difficult to relocate. For this reason, marking vulnerable and difficult to relocate populations is recommended.

NAMA DENSUM VAR. *PARVIFLORUM* (SMALL-FLOWERED NAMA)

Nama densum var. *parviflorum* listed as Review Group 1 in Washington, where it has a scattered distribution in the lower Columbia Basin. It is at the northern edge of its range which includes most western states. In Washington, it is known from Benton, Douglas, and Grant Counties.

Its typical habitat is sandy to gravelly flats and slopes. Sackschewsky et al. (1992) states that *Nama densum* var. *parviflorum* is "common on open sands and dunes; widespread on the Hanford Site." On the Hanford Site, *N. densum* grows in conjunction with other rare plant species including *Cryptantha leucophaea* and *Pectocarya linearis* var. *penicillata*.

During the 1997 survey, *N. densum* var. *parviflorum* was found reliably, but sparsely scattered in sandy areas and grouped into four populations: one on ALE in the vicinity of Rattlesnake Springs, and three on Central Hanford. The Central Hanford populations were in the general areas of Gable Mountain, the area west of F Reactor, and at the east end of Umtanum Ridge.

OENOTHERA CAESPITOSA SUBSP. *CAESPITOSA* (DESERT EVENING-PRIMROSE)

Oenothera caespitosa Nutt. subsp. *caespitosa* or desert evening-primrose is considered a Sensitive taxon in Washington where it is peripheral to its main range (WNHP 1997) throughout the western U.S. There are a total of 3 recently documented occurrences and one occurrence which was located before 1985 known from outside the Hanford Site (WNHP 1995).

O. caespitosa subsp. *caespitosa* favors dry, open habitats, occurring as individuals or colonies on clay soils, rocky slopes composed of shales, volcanics, and sandstones, bluffs, and exposed rocky ridges. The taxon also colonizes roadcuts in grasslands and sagebrush.

Field survey located five new populations of *Oenothera caespitosa* subsp. *caespitosa*; two each on Central Hanford and the Arid Lands Ecology Reserve, and one on the Saddle Mountain National Wildlife Refuge. Two populations are located along the Columbia River, above the high water level on nearly flat river terraces. The *Oenothera caespitosa* subsp. *caespitosa* population at the southern base of Yakima Ridge on ALE is the largest population of plants found on the Hanford Site. While the surrounding area is quite weedy, the immediate area is relatively high quality. The population is probably stable as ALE is off limits to the public and grazing.

Populations of *Oenothera caespitosa* subsp. *caespitosa* adjacent to the river are vulnerable to changes in hydrology and disturbances due to river-related recreational activity. These populations and those on the gravelly Bluffs over the river are also vulnerable to competition with aggressive, weedy plants accentuated by physical disturbance (see discussion of managment on bluffs in *Lesquerella tuplashensis, Cryptantha leucophae* and *Camissonia pygmae*).

PECTOCARYA LINEARIS VAR. *PENICILLATA* (WINGED COMBSEED)

Pectocarya linearis var. *penicillata* is listed as Review Group 1 in Washington, where it has a scattered distribution in the lower Columbia Basin. It ranges from Baja California to British Columbia. The taxon is known from dry, open places in the lowlands, often with sagebrush. Sackschewsky et al. (1992) states that *Pectocarya linearis* var. *penicillata* is also "uncommon on Rattlesnake Ridge and Cold Creek Valley."

P. linearis var. *penicillata* sightings were grouped into three populations on Central Hanford: at the east end of Umtanum Ridge, at vernal pools near Gable Butte, and in the basalt derived sands near Gable Mountain. It tends to be widely scattered across large areas in appropriate gravelly or sandy habitats, but has small numbers of plants in any one location. It was occasionally associated with vernal pools and disturbed areas such as little-used gravel roads.

It appears as though this species can tolerate some disturbance as it is occasionally associated with little-used gravel roads. On the Hanford Site, *P. linearis* var. *penicillata* grows in conjunction with other rare plant species including: *Nama densum* var. *parviflorum* and *Mimulus suksdorfii*.

PENSTEMON ERIANTHERUS VAR. *WHITEDII* (FUZZYTONGUE PENSTEMON)

Penstemon eriantherus var. *whitedii* is listed as Review Group 1 in Washington, where it is locally endemic to the Columbia Basin. It is known from Chelan, Douglas, Klickitat, and Yakima Counties. Its general habitat is open, often rocky places in the foothills and lowlands (Hitchcock et al. 1973).

On Hanford, two populations of *Penstemon eriantherus* var. *whitedii* grow the White Bluffs near the southern boundary of the Wahluke Wildlife Area. One of the populations has approximately 400 plants on the steep, west-facing slopes of a series of six canyons, while the other has over 200 plants in two subpopulations. Associated plant communities are relatively high quality.

Populations are in an area of the Wahluke Wildlife Area that is open to the public. They could eventually be affected by irrigation-related slumping of the bluffs if the hydrology of the bluffs is substantially degraded by irrigation. Illegal ORV use has also been documented in the area. On the Hanford Site, *Penstemon eriantherus* var. *whitedii* grows in conjunction with a number of rare plant species including: *Lesquerella tuplashensis*, *Camissonia pygmaea*, and *Cryptantha spiculifera*.

RORIPPA COLUMBIAE (PERSISTENTSEPAL YELLOWCRESS)

Rorippa columbiae is a regional endemic that is considered Threatened in Washington and is a federal Species of Concern (WNHP 1997). In Oregon it is included on List 1, which contains taxa which are endangered or threatened throughout their range (ONHP 1993). Its range extends from California north to Washington, distributed in two distinct regions: along the Columbia River in Oregon and Washington, and south-central Oregon to northern California. The population within the Hanford Reach is the most vigorous in Washington State, and perhaps throughout the range of the species.

Twenty-two WNHP occurrences of *Rorippa columbiae* are found in three counties in south-central and southwestern Washington, all adjacent to the Columbia River. Seven of these have not been revisited since 1984. Sixteen of the WNHP occurrences are located on the Hanford Site along nearly 40 miles of the Hanford Reach. WNHP has recently merged these sixteen populations into one WNHP occurrence. In the last several years, extensive research, monitoring, and surveys have been done on *R. columbiae* in Washington and Oregon. A status report on this species has recently been prepared by the Washington Natural Heritage Program (Salstrom and Gehring 1995).

Rorippa columbiae grows in damp to wet soils near all types of bodies of water, but in Washington it is restricted to the riparian areas adjacent to the Columbia river near Hanford and below the Bonneville Dam. Populations can be ephemeral due to changes in hydrology. At Hanford the plants are found in open, lightly vegetated gravel, cobble, and sandy areas, especially gravel bars on shallow-water sections.

During the 1994 field survey, three new populations of *Rorippa columbiae* were located in the Wahluke Wildlife Area (later combined into one element occurrence by the Washington NHP). These populations range from 14 to over 200 plants, on approximately 0.01 to 3.0 acres. Plants are often found at or near the lower edge of the vegetated zone on riverbanks, usually in river cobble, sand, and silt. Vegetative cover at these sites is generally sparse. Many of the sites at which the populations occur are inundated until mid-summer and may also be inundated daily throughout much of the remainder of the growing season, depending on upstream hydropower project management. According to Harris (1992), flows of less than 100 kcfs at Priest Rapids Dam are needed to expose *R. columbiae* populations on the Hanford Reach. These lower flows do not become common until August, and daily higher flows are common throughout the growing season, resulting in regular inundation of the populations even after growth is initiated in August.

All Hanford reach wetland species are vulnerable to fluctuating water levels as a result of upstream hydropower project management. All of the new sub-populations are publically accessible by boating and other recreational users of these sensitive riparian areas. At least one sub-population could be

threatened by erosion from the bluffs above if irrigation use increases on the Wahluke Slope above the White Bluffs. In some locations, the riparian habitat of *R. columbiae* is being invaded by white mulberry (*Morus alba*) seedlings and shrubs.

ROTALA RAMOSIOR (TOOTHCUP)

Rotala ramosior is a Review Group 1 wetland species whose full range is from California to Washington, and in the eastern United States and South America. On the Hanford Site, it is uncommon and local in wet ground of the Columbia River edge (Sackschewsky et al. 1992). It is included on the Sensitive list in Montana, and List 3 in Oregon . It has an R1 designation in British Columbia, which is the highest degree of rarity. It was last collected in Washington in 1948, and most collections were made prior to 1900. All of the riverine collections were made before dams were built on the rivers.

Its general habitat is wet places and lake and pond margins. On Hanford it was found in five locations along the Hanford Reach, below the high water level (see discussion of habitat and managment in *Ammannia robusta*).

3.5 Relationship to Previous Findings and Further Inventory Needs

During three years of fieldwork a total of 112 populations / occurrences of 28 rare plant taxa were located on the Hanford Site (Table 3.2). Rare plants were widely distributed throughout the site, but concentrations occurred primarily on: the east end of Umtanum Ridge, basalt-derived sands near Gable Mountain, White Bluffs, Rattlesnake Mountain, Yakima Ridge, and within riparian communities along the Columbia River. The findings included two plant species and one variety of a species that are new to science. When rare plant occurrences located by other workers before 1994 are included, a total of 127 populations / occurrences of 30 rare plant taxa are now documented on the Hanford Site (Table 3.2). This is a tremendous amount of rare plants — both in terms of species richness and abundance — to occur in an area the size of the Hanford Site.

Survey efforts during 1994 and 1995 identified seven rare plant species associated with the riverine emergent wetlands found at various places along the Hanford Reach (Caplow and Beck 1996, Soll and Soper 1996). These seven species are: *Ammannia robusta, Centunculus minimus, Cyperus bipartitus, Hypericum majus, Lipocarpha aristulata, Rotala ramosior,* and *Rorippa columbiae* (see Table 3.2). The riverine emergent wetlands, and their associated rare plant species, are otherwise rare along a Columbia River system that has been mostly impounded by hydroelectric dams (Caplow and Beck 1996, Downs et al. 1993).

Botanical inventory should be an on-going process, as rare plant populations change over time. Although an estimated total of 48,200 acres (19,500 ha) of the Hanford Site has been surveyed at various levels of intensity during the 1994, 1995, and 1997 field seasons (Figure 3.1), many of the surveys were done only at a moderate survey intensity level. The surveys, however, focused on those habitats with the greatest potential for rare plants. Thus, a significant proportion of the highest quality habitat of the Hanford Site has been surveyed. Nonetheless, there are undoubtedly many more rare plant populations on the Hanford Site that have not been identified or mapped.

Areas that could harbor more rare plants include:

- Unsurveyed portions of the basalt sand habitats on Central Hanford for rare annuals;
- Ephemeral drainages and the Cold and Dry Creek valleys within the ALE Reserve, especially for *Nicotiana attenuata,* but also for rare annuals;
- The springs, seeps and crest of Rattlesnake Mountain and Rattlesnake Hills.

- The talus slopes of Yakima Ridge and China Bar, primarily for other populations of *Oenothera caespitosa* ssp. *caespitosa*.
- Islands of the Columbia River (as potential habitat for the state endangered *Artemisia campestris* ssp. *borealis* var. *wormskioldii* [northern wormwood]);
- Unsurveyed portions of the middle and upper slopes of the Saddle Mountains;
- Sandy areas at the top of the White Bluffs for populations of *Astragalus geyeri*.
- Sandy and high-quality areas west of Highway 24.

Furthermore, an effort should be made to revisit and confirm all Hanford rare plant populations not surveyed since 1986.

3.6 Conclusions and Management Recommendations

The Hanford Site is clearly one of the premier sites in the Columbia Basin ecoregion for rare plants. Rare plant populations however, are vulnerable to direct physical destruction of plants and to loss and degradation of habitat. It is likely that both the 30 rare plant taxa and the 17 unusual taxa on the Hanford Site were previously more widespread in the lower Columbia Basin. Since 1943, however, the lower Columbia Basin has undergone significant shifts in land use. Population growth, large-scale irrigation projects that have converted shrub-steppe to orchards and fields, continued livestock grazing and increases in noxious weeds have significantly reduced and/or degraded available habitat for many plants of conservation concern throughout the lower Columbia Basin. As these trends continue, the importance of the Hanford Site as an island of biodiversity will become increasingly great.

Three significant factors have contributed to the preservation of rare plant habitat on the Hanford Site. Maintaining these three factors will, in general, maintain or enhance rare plant habitat. They are:

- Public ownership;
- Minimal or no livestock grazing; and
- Minimal public access.

Other factors, however, can also affect the long-term viability of rare plants on Hanford. These include:

- Environmental restoration;
- Waste management and infrastructure improvement activities;
- Changes in the hydrology of the White Bluffs;
- Changes in the hydrologic regime of the Hanford Reach; and,
- The spread of weedy, invasive plant species.

With the preceding factors in mind, the present policy of restricting public access and prohibiting livestock grazing on the ALE Reserve, Saddle Mountain National Wildlife Refuge, and Central Hanford should provide adequate protection for most rare plants in these areas. The U.S. Fish and Wildlife Service signed a permit agreement with DOE in 1997 to manage the ALE Reserve and may enter into a similar agreement covering the North Slope. No substantial changes in management guidelines are expected. If, however, the Wildlife Refuge is opened to the public, recreation planning should consider the locations of rare plants in determining alternatives. For all management areas,

regular maintenance of damaged fences on the boundaries of the Hanford Site is important in helping to restrict access of stray livestock and motorized vehicles. In particular, damaged fences in the vicinity of Umtanum Ridge need attention.

3.6.1 CENTRAL HANFORD

Central Hanford has some additional management considerations in regard to rare plants:

- Ground-disturbing activities associated with environmental restoration, waste management, and infrastructure improvement activities pose a potential threat to rare plant populations in this management area. For example, borrow pits for soil, gravel, or basalt extraction should be located well away from rare plant locations and special habitat areas, including vernal pool clusters and the alkaline spring area.
- Project-specific surveys by individuals qualified to identify rare plants always should occur in locations where a disturbance may occur and rare plants are potentially present.
- Surveys should be conducted at the appropriate time(s) during the growing season for all rare plant species that may be present.
- The vernal pool and alkaline spring special habitat areas should be treated as unique biological features. Their status should be tracked as part of the Hanford Site biological resources monitoring strategy (DOE-RL 1996).
- Additional special habitat areas (Figure 3.2) should also be treated as unique biological features .

3.6.2 WAHLUKE WILDLIFE AREA

Because it is open to the public, land use within the Wahluke Unit Columbia Basin Wildlife Area is considerably different from other portions of the Hanford Site. Public use is concentrated near the Columbia River and on the White Bluffs. The rare plants of the White Bluffs are most vulnerable to illegal off-road vehicle use and to slumping of the White Bluffs as a result of off-site irrigation. Off-road vehicle and mountain bike use also could indirectly affect rare plants by increasing erosion on the bluffs, causing destabilization of the sand dunes at the top of the bluffs, starting wildfires, and providing a vector for weed dissemination. A number of rare plants grow along the edge or on the steep slopes of the bluffs. If irrigation is increased in the vicinity of the White Bluffs, this habitat would be particularly vulnerable to slumping and landslides.

WEED PROBLEMS

One of the most serious short-term threats to the persistence of rare plants on the Hanford Site comes from the presence and continued expansion of undesirable, non-native plant species. Many of these are aggressive weedy species that are classified as noxious weeds in the state of Washington. Section 10 provides additional information on these problematic species. One particularly problematic example is provided here. *Centaurea solstitialis* (yellow starthistle) has become a dominant weed in the Hanford and White Bluffs townsites and is rapidly invading adjacent areas such as the east end of Gable Mountain and some of the vernal pools there. It also is present on the top and slopes of the White Bluffs. These invasions pose a serious direct threat to a number of rare plant species and native plant communities. The next two to three years are a critical period in the control of *Centaurea solstitialis* on the Hanford Site. This is a highly aggressive weed capable of invading undisturbed habitats and areas of natural disturbance. To maintain the long-term biodiversity of the Hanford Site, it will be necessary to control the spread of this species.

RESEARCH AND MONITORING

Finally, little is known about the biology, ecology, and appropriate management for the 30 currently identified species of rare plants of the Hanford Site. Many of these species are diminutive desert annuals that present unique challenges for effective protection and management. Other species are extremely rare endemics that could face extinction without proper monitoring and management. To maintain or enhance the viability of their populations, management plans should be developed for each of the rare plants present on the Hanford Site.

A first step toward developing rare plant management plans can be initiating monitoring plans for the rarest or most vulnerable species. Monitoring may lead to a greater understanding of species biology and population dynamics and is critical over the long term for the assessment of population viability. Long-term demographic monitoring was initiated in 1997, with separate funding, for *Eriogonum codium* and *Lesquerella tuplashensis*. The following additional species also should be given a high priority for monitoring: *Calyptridium roseum, Loeflingia squarrosa* var. *squarrosa, Eatonella nivea*, *Oenothera cespitosa* ssp. *cespitosa*, and *Lomatium tuberosum.*

Table 3.1 Rare plant taxa potentially present at the Hanford Site (based on WNHP 1997). Taxa listed include those currently considered Endangered, Threatened, or Sensitive in Washington, and those for whom a status has not yet been assigned (Review Group 1).

Taxon	Typical Habitat	Status	ID+
Allium constrictum	shrub-steppe	S	5-7
**Ammannia robusta*	wet soil	R1	7-9
Artemisia campestris spp. *borealis* var. *wormskioldii*	sand dunes, gravel bars adj. riparian areas	E	3-4
Astragalus arrectus	shrub-steppe, grassy hillsides	S	5-6
**Astragalus columbianus*	sandy loam, gravelly soil, shrub-steppe	T	3-5
**Astragalus conjunctus* var. *rickardii*	shrub-steppe	R1	5-6
**Astragalus geyeri*	dunes, sandy areas	S	6-7
Astragalus misellus var. *pauper*	shrub-steppe	S	5-6
**Calyptridium ros*eum	shrub-steppe, swales	S	5-6
**Camissonia minor*	shrub-steppe; flood gravels	R1	5
**Camissonia pygmaea*	shrub-steppe; flood gravels	T	5-7
Camissonia scapoidea	shrub-steppe; sandy soil	S	5-6
Carex densa	riparian areas, wetlands, moist low ground	S	4-7
Carex hystericina	marshy areas, wetlands, moist low ground	S	5-8
**Castilleja exilis*	saline marshes	R1	6-9
**Centunculus minimus*	wet soil, river edges	R1	6-9
Collomia macrocalyx	shrub-steppe	S	5-6
**Cryptantha leucophaea*	sage steppe, dry open sandy areas	S	5-6
Cryptantha rostellata	shrub-steppe, talus, canyons	S	6
**Cryptantha scoparia*	shrub-steppe	R1	5-6
**Cryptantha spiculifera*	sage steppe, dry, open slopes and flats	S	5-7
**Cuscuta denticulata*	shrub-steppe	S	5-8
**Cyperus bipartitus*	marshy areas, floodplain, below high water	S	8-10
Eleocharis rostellata	stream edges, alkaline wetlands	S	6-9
Epipactis gigantea	Stream banks, lakes, springs, seeps	S	4-7
Erigeron basalticus	cliff crevices, rocky canyons	T	5-10
**Erigeron piperianus*	sage steppe, dry open areas	S	5-6
**Eriogonum codium*	basalt gravel on cliff edges	E	5-8
**Gilia leptomeria*	shrub-steppe	R1	5-6
Hackelia hispida var. *disjuncta*	cliffs, talus	S	5-6
Heterotheca oregona	sand and gravel bars along rivers	R1	6-9
**Hypericum majus*	wet soil	S	7-9
Juncus uncialis	wet soil	R1	6-8
**Lesquerella tuplashensis*	caliche soils in shrub-steppe	E	5-7
**Lipocarpha aristulata*	wet soil	R1	6-9
Lobelia kalmii	wetlands, along shores	E	7-8
**Loeflingia squarrosa* var. *squarrosa*	sage-steppe, sandy areas	T	5-6

Taxon	Typical Habitat	Status	ID+
**Lomatium tuberosum*	unstable talus, basalt outcrops, rocky hills	T	3-5
**Mimulus suksdorfii*	open, moist to dry places	S	4-6
Minuartia nuttallii var. *fragilis*	gravelly benches or talus	S	5-8
Monolepsis pusilla	desert valleys, alkaline soil	R1	6-7
**Nama densum* var. *parviflorum*	sandy areas, sage-steppe	R1	4-6
Nicotiana attenuata	dry sandy bottoms, dry open places	S	6-9
**Oenothera caespitosa* subsp. *caespitosa*	road cuts, dry hills and talus slopes	S	5-7
Oenothera flava	hard-packed soils, swales, vernal pools	EX	6-8
Opuntia fragilis	dry hillsides, open ground	R1	5-6
Oxytropis campestris var. *wanapum*	lithosol, ridgetops	E	5-6
**Pectocarya linearis* var. *penicillata*	open dry places	R1	4-5
Pediocactus simpsonii var. *robustior*	desert valleys, low mountains	R1	5-7
**Penstemon eriantherus* var. *whitedii*	foothills, sage-steppe	R1	5-7
Phacelia tetramera	alkaline flats and washes	R1	5-6
Polygonum austiniae	sage steppe, dry to moist flats or banks	S	6-8
**Rorippa columbiae*	riparian shorelines, moist sandy soil	T	7-10
**Rotala ramosior*	wet, swampy places	R1	6-9
Spartina pectinata	ditches, ponds, freshwater marshes	S	6-7
Tauschia hooveri	sagebrush scablands	T	2-4

+ Months during which the taxon is typically identifiable.

* Plant taxa currently known to occur on the Hanford Site.

E Endangered. Taxa that are in danger of becoming extinct in the state within the near future if factors contributing to their decline continue.

T Threatened. Taxa that are likely to become Endangered in the state within the near future if factors contributing their decline continue.

S Sensitive. Taxa that are vulnerable or declining, and could become Endangered or

Threatened in the state without active management or removal of threats.

R1 Review Group 1. Taxa for which there is insufficient data to support listing in the state as

Threatened, Endangered, or Sensitive.

EX Extirpated. Taxa possibly extirpated from Washington.

Sources of information include: the Washington Natural Heritage Information System, Flora of the Pacific Northwest by Hitchcock et al. (1955 - 1969) and The Jepson Manual: Higher Plants of California edited by J. Hickman (1993). The status of all the plant taxa listed in Table 1 reflect the most current information available; however, the status of a particular rare plant taxon is subject to change by the WNHP and/or the USFWS.

Table 3.2 Number of Hanford Site rare plant occurrenes/ populations by year and management area

Scientific Name (Common Name)	Washington State Status	Fitzner-Eberhardt Arid Lands Ecology Reserve		Central Hanford		Saddle Mountain National Wildlife Refuge		Wahluke Unit Columbia Basin Wildlife Area		Hanford Site Totals		
		94–97	Pre–94	94–97	Pre–94	94–97	Pre–94	94–97	Pre–94	94–97	Pre–94	All Years
Ammannia robusta+ (Grand redstem)	Review Group 1			1				1		1		1
Astragalus columbianus (Columbia milk-vetch)	Threatened#	7		1	3					8	3	11
Astragalus geyeri (Geyer's milk-vetch)	Sensitive					4				4		4
Astragalus conjunctus var. *rickardii* (Basalt milk-vetch)	Review Group 1	1								1		1
Calyptridium roseum (Rosy pussypaws)	Sensitive			2						2		2
Camissonia minor (Smallflower evening-primrose)	Review Group 1	2		3		1				6		6
Camissonia pygmaea (Dwarf evening-primrose)	Threatened	1		2	2	8		2		13	2	15
Castilleja exilis (Small-flower annual paintbrush)	Review Group 1			1						1		1
Centunculus minimus (Chaffweed)	Review Group 1			2						2		2
Cryptantha leucophaea (Gray cryptantha)	Sensitive			1	1	1		8		10	1	11
Cryptantha scoparia (Miner's candle)	Review Group 1	1								1		1
Cryptantha spiculifera (Snake River cryptantha)	Sensitive	1						3		4		4
Cuscuta denticulata (Desert dodder)	Sensitive							3		1		1

Table continued on next page

Scientific Name (Common Name)	Washington State Status	Fitzner-Eberhardt Arid Lands Ecology Reserve		Central Hanford		Saddle Mountain National Wildlife Refuge		Wahluke Unit Columbia Basin Wildlife Area		Hanford Site Totals		
		94–97	Pre–94	94–97	Pre–94	94–97	Pre–94	94–97	Pre–94	94–97	Pre–94	All Years
Cyperus bipartitus (Shining flatsedge)	Sensitive				1			3			1	1
Eatonella nivea (White eatonella)	Threatened					3				3		3
Erigeron piperianus (Piper's daisy)	Sensitive	10	2	1	4			4		15	6	21
Eriogonum codium (Umtanum desert buckwheat)	Endangered#			1						1		1
Gilia leptomeria (Great Basin gilia)	Review Group 1			3		1		3		7		7
Hypericum majus (Canadian St. John's-wort)	Sensitive			2				1		3		3
Lesquerella tuplashensis (White Bluffs bladderpod)	Endangered#							1		1		1
Lipocarpha aristulata (Awned halfchaff sedge)	Review Group 1			1				1		1		1
Loeflingia squarrosa var. *squarrosa* (Loeflingia)	Threatened			5						5		5
Lomatium tuberosum (Hoover's desert-parsley)	Threatened#			1	1					1	1	2
Mimulus suksdorfii (Suksdorf's monkey-flower)	Sensitive			6						6		6
Nama densum var. *parviflorum* (Small-flowered nama)	Review Group 1	1		3						4		4
Oenothera cespitosa ssp. *cespitosa* (Cespitose evening-primrose)	Sensitive	2		1		2				5		5

Scientific Name (Common Name)	Washington State Status	Fitzner-Eberhardt Arid Lands Ecology Reserve		Central Hanford		Saddle Mountain National Wildlife Refuge		Wahluke Unit Columbia Basin Wildlife Area		Hanford Site Totals		
		94–97	Pre–94	94–97	Pre–94	94–97	Pre–94	94–97	Pre–94	94–97	Pre–94	All Years
Pectocarya linearis var. *penicillata* (Winged combseed)	Review Group 1			3						3		3
Penstemon eriantherus var. *whitedii* (Fuzzytongue penstemon)	Review Group 1							2		2		2
Rorippa columbiae+ (Persistentsepal yellowcress)	Threatened#				1		1	1			1	1
Rotala ramosior (Lowland toothcup)	Review Group 1			1				1		1		1
Total		**26**	**2**	**39**	**13**	**19**	**1**	**33**	**0**	**112**	**15**	**127**

* The "94-97" and “pre-94" columns indicate the number of rare plant populations / occurrences located on the Hanford Site during: 1994-1997 and prior to 1994, respectively. Although there may have been more individual populations originally identified than indicated here, the occurrence numbers reflect how the Washington Natural Heritage Program currently combines or groups rare plant populations into occurrences. The population numbers for 1997 do not include either rare plant populations identified by Pacific Northwest National Laboratory and other workers on the Hanford Site during the 1997 field season or populations submitted to the Heritage Program after 25 April 1997. See text for additional details.

+ In accordance with guidance from the Heritage Program, separate (sub)populations of riverine species, such as *Ammannia robusta, Cyperus bipartitus,* and *Rorippa columbiae,* have been combined into a single large population that includes all plants occurring on the Hanford Reach of the Columbia River across all management areas on the Hanford Site. Because of this some row totals may not add up exactly.

Identified as a federal species of concern in eastern Washington (USFWS 1998).

Table 3.3 Washington Natural Heritage Program "Watch List" and other unusual/uncommon species found during biodiversity inventory surveys

Taxa	Ranking or Unique Quality	Management Areas
Allium robinsonii	Watch list; regional endemic;extirpated from Oregon	WWA, SMNWR
Artemisia lindleyana	Watch list	HR
Astragalus sclerocarpus	Watch list; regional endemic; dune species	CH, WWA
Astragalus succumbens	Watch list; regional endemic	SMNWR, WWA
Balsamorhiza rosea	Watch list; regional endemic, extirpated from Oregon	ALE
Chorizanthe watsonii	Unresolved taxonomic questions	CH
Hackelia diffusa var. *cottonii*	Unresolved taxonomic questions, related variety is WA sensitive	ALE, CH
Lilaeopsis occidentalis	New species for Hanford, range expansion	HR
Limosella acaulis	Watch list	HR
Mimulus ringens	Only one other record in Washington	HR
Myosurus x clavicaulis	Range extension	CH
Pectocarya setosa	Watch list, formerly sensitive	CH, SMNWR
Pediocactus simpsonii var. *robustior*	Review Group 1 – risk of over collection by gardeners	ALE
Penstemon glandulosus var. *chelanensis*	Regional endemic; uncommon	ALE
Talinum spinescens	Regional endemic	ALE

Section 4 – Birds

4 Birds

4.1 Introduction

This section summarizes bird inventories conducted as part of the biodiversity inventory. The following relevant technical references provide details for each of the management areas: ALE (Greager 1994, 1995, LaFramboise and LaFramboise 1997, 1998); Central Hanford / Hanford Reach (Greager 1997); and the North Slope / Hanford Reach (Stepniewski 1994, 1995). Summary information by year is found in Pabst (1995), Soll and Soper (1996) or Hall (1998).

4.2 Background and Purpose

Birds are conspicuous components of the biota of an area. Their visibility, variety and abundance appeals both to scientific investigations of biodiversity and to the aesthetic, recreational, and conservation interests of the general public. Thus, compared with other taxonomic groups, bird status, trends and distribution within a particular geographic area tend to be relatively well documented. Furthermore, the habitat factors responsible for species presence, absence and abundance are better understood for birds than for most other groups. These characteristics make bird inventories particularly informative about both the ecological quality of a site and its conservation importance relative to a broader region.

In the shrub-steppe of Washington and the Columbia Basin, many bird species that depend on big sagebrush / bunchgrass or bunchgrass habitats are considered Species of Conservation Concern at a state or federal level, or are known or suspected to be declining (see Table 4.1). Some species, such as the state Threatened Western Sage Grouse were commonly hunted in the recent past. Non-game species such as the state candidate Loggerhead Shrike and Sage Sparrow have fallen victim to habitat conversion and degradation. Many birds, especially migratory species, rely on riparian vegetation or other water based habitats for some or all of their lifecycle. These species have declined as the Columbia River has been converted into a series of reservoirs, and the vegetation along smaller creeks, springs and rivers has been degraded by agriculture and domestic livestock grazing.

Numerous publications have addressed the diversity of breeding, wintering, and migratory birds on the Hanford Site or its environs (see Ennor 1991, Fitzner and Gray 1991, Landeen et al. 1992). Other studies focussed on specific priority species such as Loggerhead Shrikes (Poole 1992) or Bald Eagles (PNNL date). As is typical for the Hanford Site, however, comprehensive, sitewide studies had not been carried out. For listed, candidate, and other species of conservation concern, the most up-to-date information on species status can be found in the Draft Hanford Site Biological Resources Management Plan (DOE-RL 1996). That document incorporates the findings of previous studies, including the 1994 and 1995 TNC Hanford Site bird biodiversity studies described in Pabst (1995) and Soll and Soper (1996).

The bird studies described here were designed to provide a comprehensive list of species using the Hanford Site within a limited time period. The primary focus was identifying the species and their breeding status, rather then providing quantitative data on abundance or reproductive success. Nonetheless, surveys were also designed to document the habitat types utilized by, and the relative abundance of those species present on the site. With the exception of the southern portion of Central Hanford, TNC bird inventory efforts covered all areas of the site.

4.3 Methods

4.3.1 GENERAL

Bird inventories (censuses) used a combination of point counts, walking transects, and driving transects. Census methodology generally followed that outlined in Ralph et al. (1993). Evidence of breeding status for each species was based on Breeding Bird Atlas criteria contained in Smith et al. (1997). In no cases were intrusive methods used to confirm breeding or nesting success. Census periods generally covered as much of the breeding and post-breeding dispersal season as was feasible given the financial and logistical constraints of the project (see below for details). Nomenclature conforms to the "Check-list of North American Birds," 6th edition (AOU 1983) as updated by subsequent supplements published in the journal *The Auk*. Thus, in accordance with the check-list, species common names are capitalized. Current listing (or conservation) status (see Table 4.1) is taken from WDFW (1998) for Washington State status and USFWS (1998) for federal status.

POINT COUNTS

Point counts are an easily replicable method for estimating diversity and abundance within specific habitat types. The dates during which the point count stations were visited was designed to bracket at least a portion of the breeding season for those bird species known or suspected to breed at Hanford. For all point count stations, the number and breeding status of birds of each species seen and/or heard within a 10 minute period was recorded.

DRIVING TRANSECTS

Driving transects have the advantage of quickly covering a large area. However, they restrict sampling to road edges, which limits the area that can be sampled and may create biases in the data. Standardized routes were driven with periodic stops to detect the species, abundance and breeding status of individuals present. Information was also collected on an *ad hoc* basis during travel between study sites.

WALKING TRANSECTS

Walking transects avoid the inherent bias in roadside sampling, but reduce the area that can be covered in a given amount of time. Bird diversity and abundance data was collected along both standardized and subjectively located walking routes. All species detected visually or by ear were recorded.

HABITAT TYPES

The major terrestrial and aquatic habitat types were categorized in the manner described below. The habitat type designations used in the bird inventory do not follow the plant community type designations described in Section 2, and several community types fall under one bird habitat category.

Native Shrub: Habitat dominated by big sagebrush with lesser amounts of bitterbrush and rabbitbrush. Spiny hopsage and winterfat may dominate in limited areas. Bluebunch wheatgrass, needle-and-thread grass and Sandberg's bluegrass are characteristic of the understory, but cheatgrass may occur at varying levels.

Native Bunchgrass: Grasslands dominated by native, perennial bunchgrasses like bluebunch wheatgrass, Sandberg's bluegrass and Idaho fescue. In areas with sandy soils, needle-and-thread grass and Indian ricegrass are prevalent.

Weedy Field:	Abandoned agricultural fields or degraded grasslands dominated by non-native annual plants, especially cheatgrass.
Recovering:	Seral, or successional stages of shrub-steppe recovering from fire or other historical disturbance.
Mountain Top:	For the North Slope, this refers to the crest of Saddle Mountain, which has exposed basalt cliffs and talus slopes. For the ALE Reserve, this refers to the crest of Rattlesnake Mountain.
Riparian:	On the North Slope, this refers to natural and artificially created ponds and wetlands adjacent to the Columbia River. On the ALE Reserve, this refers to a collection of springs and small streams. ON Central Hanford this type is limited to West Lake.
Riverine:	The Hanford Reach of the Columbia River, including islands and shoreline, and the White Bluffs (North Slope and Central Hanford only).
Canyon:	Dry, steep upper slopes of canyons, frequently with talus (ALE Reserve only).

DESIGNATION OF SPECIES OF CONSERVATION CONCERN

Species identified by Washington State (WDFW 1998) and/or the U.S. Fish and Wildlife Service (USFWS 1998) as either Endangered, Threatened, Candidate, Monitor, or Species of Concern are referred to collectively in this report as Species of Conservation Concern (Table 4.1). Although it includes 38 species known from the Hanford Site (Turkey Vulture and Vesper Sparrow are not included in Table 4.1), it is in fact a conservative designation that does not include numerous species experiencing long-term declines or loss of habitat that are recognized by national bird conservation organizations as priority species for conservation action.

4.3.2 STUDY METHODS BY MANAGEMENT AREAS

Figure 4.1 presents point count and transect locations. UTM coordinates of both the point count stations and transects are available in the technical references or via GIS layers available from DOE or TNC.

ALE

Because of the generous donation of 2 years of volunteer survey efforts, 4 years of surveys were conducted on the ALE Reserve (Greager 1994,1995; LaFramboise and LaFramboise 1997, 1998).

1994 – Thirty-two permanent point count stations were established. Every point count station was sampled at least once during the time period bracketing the breeding season. To supplement the point counts, numerous walking and driving routes/transects were performed, primarily along 5 “routes” (see Greager 1995) between April 22 and October 17, 1994. Special emphasis was given to visiting each significant riparian area on the ALE Reserve.

The following habitat types were included: big sagebrush; three-tip sagebrush (added in 1998); bluebunch wheatgrass; cheatgrass; canyon; ridgetop (Rattlesnake Mountain top); riparian; marsh; instream; flyover; roadside; power-pole, line or fence; buildings/facilities. Both the big and three-tip sagebrush types included several plant community types, including one or more of cheatgrass, bluebunch wheatgrass, Sandberg’s bluegrass, needle-and-thread grass and Idaho fescue in the understory.

1995 – Sampling protocol was the same as for 1994, except that the field season extended from March 11 to November 19, 1995. Point count stations were visited at approximately the same dates as in 1994.

1997 – The same 32 point count stations were used as in 1994 and 1995. However, each station was visited either one, two, or, three times within the period April 18, 1997 to June 27, 1997. Combination driving / walking transects were established and conducted multiple times with no set time limit on the amount of time taken to conduct the census (Table 2.4, LaFramboise 1998). Bird observations were recorded as they were noted. Additionally, twelve 200 meter long strip transects previously established by the Washington Native Plant Society at 6 different sites were censused once each (see Table 2.3, LaFramboise 1998)

1998 – A total of 33 point count stations were used in 1998. The original 32 stations used in 1994-1997 plus one added in three-tip sagebrush at the top of Bobcat Canyon. Each station was sampled multiple times between April 17 and June 6. The same driving and walking transects were used as in 1997, with the addition of 2 controlled walking transects added in upper Snively Canyon in three-tip sagebrush/bunchgrass communities.

CENTRAL HANFORD

Extensive surveys were conducted only during 1997. Limited driving surveys, mostly around Gable Mountain were performed in 1995. Thirty-seven point count stations were conducted within the northern portion of Central Hanford (Figure 4.1). Locations included: sites positioned in proximity to the southern and eastern shorelines of the Hanford Reach; sites with vegetation dominated by big sagebrush; abandoned agricultural fields and other sites now dominated by cheatgrass; other human disturbed sites (e.g., reactor areas, abandoned town sites, etc.); and West Lake. Point count stations were established in May. Each station was visited once between June 6 and June 18. Five driving and five walking transects were established and conducted multiple times between April 14 and September 14. Casual observations were made during all trips through the site.

NORTH SLOPE

Two years of inventory were conducted in the North Slope areas, including extensive sampling along the Hanford Reach. Data were also summarized from 33 survey routes mostly on the Reach performed between 1993 and 1994 by other researchers. In 1994 and 1995, 55 point count stations were established and sampled between mid-April and Mid-June. Two hundred and fifty driving/walking surveys along 23 routes were performed (157 in 1994, 93 in 1995) between March 27,1994 and November 17, 1995. In addition, were 4 surveys of the Hanford Reach (or portions thereof) and 1 of Saddle Mountain Lake, done by boat.

Sightings were divided between seven habitat types: Columbia River, riparian, shrub (big sagebrush and/ or bitterbrush), annual grasslands (cheatgrass), perennial grasslands (bluebunch wheatgrass, needle-and-thread grass, Sandberg's bluegrass), Saddle Mountain crest, and recovering shrub-steppe (smaller, less dense shrubs).

4.4 Findings

4.4.1 OVERVIEW

Two hundred and twenty-one (221) species were documented on the Hanford Site. Central Hanford supported 154 species, 158 species were found on the ALE Reserve, and 193 on the North Slope. These numbers include:

- 82 species that were probable or confirmed breeders at Hanford during the inventory period.

- 38 Species of Conservation Concern. Sixteen (16) of these species were probable or confirmed breeders at Hanford during the biodiversity inventory (Figure 4.2).
- 163 species associated with the Columbia River or related riparian vegetation.
- 38 of the 41 species of native birds that use steppe and/or shrub-steppe habitats within the Columbia Basin Ecoregion for at least a portion of their life cycle (see DOE-RL 1996)
- Nine species that breed in steppe and/or shrub-steppe habitats, and are of regional management concern (Saab and Rich 1997): Black-throated Sparrow (*Amphispiza bilineata*), Grasshoper Sparrow, Sage Sparrow, Sage Thrasher, Brewer's Blackbird (*Euphagus cyanocephalus*), Brewer's Sparrow (*Spizella breweri*), Lark Sparrow (*Chondestes grammacus*), Loggerhead Shrike, and Western Meadowlark (*Sturnella neglecta*). The latter five species are experiencing long-term population declines based on Breeding Bird Survey data [Saab and Rich 1997]).
- 22 species not previously known from the Hanford Site: Red-throated Loon, Red-necked Grebe, Wood Duck, Semi-palmated Plover, Short-billed Dowitcher, Black-legged Kitiwake, Vaux's Swift, Anna's Hummingbird, Least Flycatcher, Hammond's Flycatcher, Western Flycatcher, Gray Flycatcher, Pacific-slope Flycatcher, Mountain Chickadee, Black-throated Gray Warbler, Black-and-white Warbler, Blackpoll Warbler, Black-throated Sparrow, Snow Bunting, Gray-crowned Rosy Finch, Cassin's Finch. The complete species list known from the Hanford Site now stands at 258.

Each management area supports species not found on the others. Less than half (110) of all species were common to all three management areas. In a pair-wise comparison, more than twice as many species unique to a particular area were observed on Central Hanford (57) as compared with the ALE Reserve (26). A similar finding resulted from the 1994 and 1995 bird inventories that indicated a higher number of unique species on the North Slope (77) as compared with the ALE Reserve (18) (Soll and Soper 1996). In both comparisons, the higher number of unique species on the North Slope and Central Hanford can be attributed to the presence of the Columbia River and its associated abundant and diverse riparian, wetland and open water habitats.

4.4.2 FINDINGS BY HABITAT ASSOCIATION

RIPARIAN AREAS AND OPEN WATER

For species of conservation concern that were observed during the bird inventories, Table 4.1 provides information on their geographic distribution across the Hanford Site. Significantly, 21 of these species occurred within the Hanford Reach, either on the river or within the various, native or human-altered (e.g., planted tree stands) habitats present along the river corridor. As noted earlier, because sampling did not cover late fall and winter, the species that reside on Hanford during this period were not counted. Therefore the number of species presented here is undoubtedly an underestimate.

The importance of the presence of water in a semi-arid environment also is exemplified by the number of all species and Species of Conservation Concern that used riparian areas or the Hanford Reach for at least a portion of their life cycle. Nearly all of the species observed, both on the ALE Reserve and North Slope depend on or visited riparian areas at some point during the year. Some species typical of shrub-steppe environments (e.g. Sage Thrashers) will move to riparian areas after the breeding season to take advantage of new food sources. During these inventories, 162 out of 221 species were observed along the Hanford Reach. Additionally, West Lake provided resting and foraging habitat for migrating species and shore-birds within the dry interior of Central Hanford. A rare sighting on Hanford of a Black-necked Stilt occurred at West Lake.

SHRUB-STEPPE HABITATS

True shrub-steppe habitats support several Species of Conservation Concern and several other species that do not use highly altered shrub-steppe habitats. Especially noteworthy in this regard are Sage Sparrow, Sage Thrasher, Brewer's Sparrow, Loggerhead Shrike, Lark Sparrow and Vesper Sparrow. These species are entirely dependent on large occurrences of sagebrush or grassland with at least some component of native grasses in the understory. All three management areas provide regionally important habitat for these indicator species. Successful re-establishment of the Washington State Threatened Western Sage Grouse on the Hanford Site will depend on maintaining or developing extensive stands of mature big sagebrush / bunchgrass communities in proximity to riparian areas and open grasslands.

PERENNIAL AND EXOTIC GRASSLANDS

Perennial bunchgrass dominated steppe habitats support Grasshopper Sparrow, Savannah Sparrow, Long-billed Curlew, Western Meadowlarks and Vesper Sparrows among others. Grasslands dominated by cheatgrass and other weedy species support the lowest overall diversity of any habitat type on Hanford. Because of the numerous (mostly) human-caused fires and old agricultural fields on the Hanford Site, open grasslands and recovering shrub-steppe habitat are very common and likely to persist.

4.4.3 ADDITIONAL DISCUSSION ON SOME SPECIES OF CONSERVATION CONCERN AND THOSE CONSIDERED RARE OR ACCIDENTAL AT HANFORD

A few species deserve further mention for one of three reasons:

1. Because their recent documented presence at Hanford is an indication of possible breeding range extensions.
2. Because Hanford provides especially important habitat.
3. Because they are of particular conservation concern in the shrub-steppe regions of the Columbia Basin.

AMERICAN WHITE PELICAN

This state Endangered species is common on islands within the Hanford Reach. It does not occur elsewhere on the site.

BREWER'S SPARROW

Brewer's sparrow is primarily found at higher elevations on ALE and the North Slope in big sagebrush and three-tip sagebrush, especially where bunchgrass predominates as the ground cover. They are essentially absent from the lower elevation Columbia River plains.

BURROWING OWL

The Burrowing Owl is thought to be declining throughout central Washington and much of its range in North America. It is also apparently declining at the Hanford Site. Once thought relatively common, they are now rarely observed. Sightings of breeding pairs have been made during the biodiversity inventory on the lower elevation slopes of Rattlesnake Mountain (1 in 1997and 1998); in

Central Hanford; and at scattered locations on the North Slope (between 4 and 6 nests per year). The regional decline of ground squirrels, which provide nesting sites for these owls, is possibly linked with the apparent decline in owl populations.

BLACK-THROATED SPARROW

This species is characteristic of the most arid deserts of the American Southwest and is normally considered a rare and localized breeder in eastern Washington (Smith et al. 1997). During the summer of 1994 small numbers of birds were present along the White Bluffs and also on the ALE Reserve. In 1997 a single individual, in song, was found on the morning of June 12 on the north side of Gable Mountain. Additionally, a few pairs may have nested in 1997 at the Wanapum Park area (about 2 miles south of Vantage).

COMMON LOON

Although Common Loons were not confirmed to breed on the Hanford Site during the biodiversity inventory, observation by others (B. Rickard personal communication) suggest that they at least occasionally do breed in the Hanford Reach. Only 12 nesting pairs are known from central Washington. They are uncommon on the Hanford Reach, and not found elsewhere on the site.

FERRUGINOUS HAWK

There are numerous breeding Ferruginous Hawks within Central Hanford, where they occupy power towers. There are no nesting sites on the ALE Reserve and these hawks nest irregularly and with mixed success on the North Slope, but they forage widely both on the site and in surrounding areas.

GREAT EGRET

Until recently, this species typically only passed through the lower Columbia Basin during migration. In recent years there have been confirmed nesting records at Potholes Reservoir in Grant County and in 1996 a pair nested amidst a Great Blue Heron colony on one of the islands in the lower part of the Hanford Reach (Smith et al. 1997). In 1997 several sightings of this species occurred along the Hanford Reach as part of the Central Hanford bird censuses. More significant, was the establishment of a small breeding colony of four nesting pairs on the north shore of the Columbia River. Unfortunately, the colony was abandoned before the completion of nesting, possibly due to the high water levels present later in the nesting season (Randy Hill, U.S. Fish and Wildlife Service, personal communication to editor).

LOGGERHEAD SHRIKES

This shrub-steppe obligate and state Candidate and federal Species of Concern breeds widely within the sagebrush flats of Central Hanford and in remaining sagebrush on the ALE Reserve and North Slope. It also utilizes mixed sagebrush-bitterbrush in dune environments.

NORTHERN MOCKINGBIRD

Before 1995 there was only one well-known record of this species nesting anywhere in Washington State (Smith et al. 1997). In both 1995 and 1996 Northern Mockingbirds successfully nested near Vernita Bridge in Grant County and in West Richland. Additionally, during 1995 multiple birds were observed on both the North Slope and ALE Reserve. In 1997 a pair of Northern Mockingbirds occupied the Vernita Townsite for a couple of weeks at the end of June, but they did not nest there.

SAGE GROUSE

Sage Grouse have not been documented on Hanford during surveys conducted since 1993 despite intensive searches. There were no confirmed, and only one suspected sighting (on the Wahluke Wildlife Area) of this Washington State Threatened bird species during the biodiversity inventory. Declining shrub cover and loss of habitat connectivity to and along the Columbia River may be involved in the loss of this now rare, characteristic species of the shrub-steppe.

SAGE SPARROW

The Hanford Site, along with the Yakima Training Center to the west, supports the largest contiguous habitat patches in Washington for this state Candidate species. Exceptional habitats with apparent high densities of Sage Sparrows are found in big sagebrush stands along the base of the Saddle Mountains and above the White Bluffs on the North Slope; and throughout sagebrush habitats on the Columbia River plains within Central Hanford. Because of the loss of much of the big sagebrush from the ALE Reserve, habitats for this shrub dependent species there are more limited in extent.

SAGE THRASHER

The Washington State Candidate Sage Thrasher is found at Hanford primarily in higher elevation habitats on the ALE Reserve and North Slope in remnant patches of big sagebrush and three-tip sagebrush. They are essentially absent from the lower elevation Central Hanford and North Slope.

TURKEY VULTURE

The frequency of Turkey Vulture sightings in the lower Columbia Basin has been on the increase for the last 10 years. In 1995 an individual bird was sighted flying over the Yakima Barricade guard station and another was observed on the ground near State Highway 24 and south of Vernita Bridge. In 1997 a single bird was observed flying over the Hanford Townsite. The breeding status of the Turkey Vulture in southeastern Washington is uncertain, but at present it seems unlikely they are breeding (Smith et al. 1997).

4.5 Findings by Management Area

4.5.1 ALE

A total of 158 species were detected during the 4 years of survey including 54 probable or confirmed breeding species. Additionally, 4 species were reported by others or are listed by others as accidental at ALE. Twenty-one Species of Conservation Concern were documented, eight as probable or confirmed breeders (Table 4.1).

Three species new for the Hanford Site were added during the 1994 season, Black-Throated Sparrow, Gray Flycatcher and Pacific Slope Flycatcher. Four species were added during the 1998 field season: Vaux's Swift, Least Flycatcher, Ash-throated Flycatcher and Black and White Warbler. None are confirmed or probable breeders.

Each habitat had a unique association of birds. Of the 10 vegetation types sampled during the 4 years of survey, riparian areas had the highest overall diversity with 92 species observed. When all habitats associated with water are combined (i.e. adding marsh, in-stream to riparian) the total rises to 108. Of upland habitats, big sagebrush (20 species) and mountain top habitats (29) were most diverse, and cheatgrass habitats the least diverse. Big sagebrush, three-tip sagebrush and bluebunch wheatgrass habitats combined contain breeding populations of each of the shrub-steppe and steppe obligates known from Hanford.

On the ALE Reserve several Species of Conservation Concern primarily used big sagebrush dominated habitats: Loggerhead Shrike, Sage Sparrow, and Sage Thrasher (the last species in low numbers). Several other species, including Lark Sparrow and White-crowned Sparrow often were observed using big sagebrush habitats. With low numbers observed overall, Burrowing Owl and Short-eared Owl were observed infrequently in sagebrush dominated habitats. Although Brewer's Sparrow was common at higher elevations in big sagebrush habitat, it was associated more frequently with three-tip sagebrush habitat. Additionally, both Vesper Sparrow and Grasshopper Sparrow frequently inhabited three-tip sagebrush / bluebunch wheatgrass habitat, though both species also were common in habitats dominated by bluebunch wheatgrass with few or no shrubs present. Long-billed Curlews were observed most frequently in the cheatgrass fields that parallel State Highway 240, though they also frequented riparian areas to feed. Horned Lark, Savannah Sparrow, Western Meadowlark, and several raptor species were common across the ALE Reserve and occurred in a variety of habitats.

A limited number of Species of Conservation Concern used more specialized habitats on the ALE Reserve. Golden Eagle, Prairie Falcon, and Western Bluebird were observed along the crest of Rattlesnake Mountain. The first two species also could be found frequenting the canyon habitat of Snively Gulch.

4.5.2 CENTRAL HANFORD

A total of 154 species were observed within Central Hanford in 1995 and 1997, including those species found in the Columbia River or in riparian vegetation along the shoreline. Twenty-one Species of Conservation Concern (Table 4.1) were identified, including 5 as probable or confirmed breeders. Three species (Red-naped Sapsucker, Black-throated Finch and Cassin's Finch) were documented on Central Hanford for the first time.

The uplands of Central Hanford support large breeding populations of the state Candidate species Loggerhead Shrike and Sage Sparrow, and suspected breeding populations of the Candidate Burrowing Owl. The state Monitor species Long-Billed Curlew breeds in open grasslands. Most total species sightings and sightings of Species of Conservation Concern (13 of 21) were associated with the riparian vegetation or open water of the Hanford Reach and West Lake. Especially noteworthy are the state Endangered American White Pelican and the state Candidate Common Loon.

Compared with the ALE Reserve, the upland habitats of the northern portion of Central Hanford are more influenced by the presence of human facilities and historic and continuing human activities. As a result, they tend to be more fragmented, and tend to have more areas with higher percentages of non-native plant species (see Section 2). Still, some areas dominated by native shrubs (mostly big sagebrush) provide important habitat for shrub-steppe dependent birds. The large blocks of sagebrush-steppe in the southern portion of Central Hanford that are documented to support Sage Sparrows and Loggerhead Shrikes were not censused during this study. Because block size may affect habitat usage by area sensitive species, this portion of Central Hanford is likely to harbor regionally significant populations of shrub-steppe dependent birds. The Central Hanford sagebrush areas that were surveyed also supported important breeding populations of Loggerhead Shrike and Sage Sparrow, and were also used by Sage Thrasher, Swainson's Hawk, and Western Meadowlark. Non-shrub dominated habitats also produced a few findings of note. Burrowing Owl, Grasshopper Sparrow, Long-billed Curlew, and Short-eared Owl were observed infrequently, with owl observations confined to roadsides and the limited observations of the other two species mostly associated with disturbed (e.g., cheatgrass dominated) areas.

4.5.3 NORTH SLOPE

A total of 195 species of bird were recorded from the North Slope and adjacent Hanford Reach, including 68 as confirmed or probable breeders and 12 more as possible breeding species. In addition

to the numerous Species of Conservation Concern identified along the Reach (Table 4.1), are 8 confirmed breeding species that rely on upland habitats. Thirteen additional unusual, noteworthy or otherwise ecologically significant species were also documented. Nine species not previously documented on Hanford were documented on the North Slope and adjacent Hanford Reach during this study: Red-throated Loon, Red-necked Grebe, Short-billed Dowitcher, Black-legged Kitiwake, Anna's Hummingbird, Hammond's Flycatcher, Blackpoll Warbler, Black-throated Sparrow (also seen on Central Hanford and ALE during this study), and Snow Bunting.

Shrub-steppe habitats on the North Slope were found to support breeding populations of all the typical and rare sagebrush and grassland (shrub-steppe and steppe) obligates except Western Sage Grouse and Sharp-tailed Grouse. Species of Special Concern documented to breed in the uplands on the North Slope include: Swainson's Hawk, Ferruginous Hawk, Long-billed Curlew, Burrowing Owl, Sage Thrasher, Sage Sparrow, Loggerhead Shrike and Grasshopper Sparrow. Of particular note was the discovery that the North Slope supports one of the largest contiguous areas of occupied habitat for Sage Sparrows in Washington.

The Hanford Reach and related areas supported 163 species in total, 51 as confirmed breeders and 8 more as possible breeders. Among them are 10 Species of Conservation Concern not found in the uplands: Common Loon, Horned Grebe, Western Grebe, Clark's Grebe, American White Pelican, Great Blue Heron, Black-crowned Night Heron, Trumpeter Swan, Caspian Tern and Forster's Tern.

4.6 Relationship to Previous Findings

Based on the combined censuses over 4 years, a total of 221 different bird species were documented on Hanford, bringing the total for the Hanford Site to 258. The totals for the North Slope, Central Hanford and ALE were 193, 195 and 152, respectively. Twenty-two species not previously documented to occur on Hanford were recorded, although none were confirmed to breed. A total of 38 Species of Conservation Concern were documented to occur at Hanford, including 16 confirmed or probable breeding species.

Three other bird diversity studies were conducted concurrently with the biodiversity inventory. One recently completed study (Duberstein 1997) looked at patterns of migratory bird (i.e., those species that are passing through and do not breed at Hanford) usage of riparian and wetland habitats on the Hanford Site. This study, combined with the Hanford Reach and other riparian area inventories conducted as part of the biodiversity inventory, has added to our knowledge of usage of these habitats by migrating, wintering, and breeding birds. A second study focused on monitoring bird diversity within various upland habitats. Bird diversity monitoring was begun in 1996 as cooperative effort between the Washington Department of Fish and Wildlife and a U.S. Department of Energy (DOE) contractor, the Pacific Northwest National Laboratory. Thirty, almost 50 acre (20 ha), monitoring plots were established within continuous areas of steppe and shrub-steppe habitats of different types. Five point count stations were established within each plot. The results from the 1996 bird monitoring effort provide additional evidence of the importance of Hanford to steppe and shrub-steppe dependent bird species (Vander Haegen 1996). The last study, driving surveys conducted by Dr. W. Rickard document mostly roadside bird populations on ALE and the Columbia River Plains of Central Hanford.

4.7 Further Inventory Needs

The bird portion of the biodiversity inventory was primarily designed to document the species present and their breeding status on the Hanford Site over multiple years for all management areas. Funding based limitations prevented full completion of that objective. Undertaking the following projects would create a more complete data set for the Hanford Site.

- **At least one more year of data should be collected from Central Hanford.** The portions of Central Hanford not covered as part of the biodiversity inventory (i.e. the southern half) should be inventoried. Although, the south half of Central Hanford has been studied as part of concurrent research (Vander Haegen 1996), the methods utilized were different and did not include the sort of site and habitat wide inventory that would detect the full range of species potentially present on this portion of the site.
- **Avian research should shift from emphasizing basic inventory to determining habitat associations, and monitoring population trends.** In general, limited quantitative data on the habitat associations of individual species were collected during the biodiversity inventory. Better understanding of the distribution and relative abundance of species across the variety of Hanford's habitats and their relative significance toward bird conservation efforts in the Columbia Basin Ecoregion would provide greater benefit to land managers than further extensive basic inventory.
- **Additional monitoring plots are needed, especially in riparian habitats.** Moreover, now that plant community mapping of the Hanford Site is mostly complete (see Section 2), the present distribution of upland bird monitoring plot locations can be evaluated and added to or modified as necessary, for whether they are sufficiently representative of Hanford habitats. For edge-dependent species that prefer a shrub / grass ecotone, such as the Lark Sparrow and Loggerhead Shrike (Smith et al. 1997), some specialized monitoring plots may need to be established. Each new monitoring plot will need an initial census.
- **Burrowing Owls warrant a focused inventory effort.** The Burrowing Owl was reported by Fitzner and Gray (1991) as abundant at Hanford, however, Landeen et al. (1992) reported it as uncommon. This species has been observed only infrequently during the course of the biodiversity inventory and the numbers observed were especially low during 1997. This potential decline in population is not unique to Hanford and may be characteristic of the species population trend throughout eastern Washington (Smith et al. 1997).

4.8 Conclusions

Smith (1994) constructed large-scale habitat association models for bird species breeding in eastern Washington upland habitats that could be used to predict species richness centers (i.e. areas with high number of species) throughout the area. He predicted species richness for different species groups, including those species that were steppe or shrub-steppe obligates, those species that nested principally in sagebrush, those species that nested in grassland areas within the shrub-steppe, and those species with small or declining populations. For all these species groups, Hanford ranked as one of the highest centers of predicted species richness (Smith 1994). The results from the biodiversity inventory, along with data gained from recent monitoring studies (Vander Haegen 1996) support Smith's predictions. The consistent finding from each of these studies, is that Hanford contains significant breeding populations of nearly all steppe and shrub-steppe dependent birds: Loggerhead Shrike, Sage Sparrow, Sage Thrasher, Ferruginous Hawk, and other species of regional management concern (Saab and Rich 1997). These results clearly demonstrate Hanford's vital importance to bird conservation in the Columbia Basin Ecoregion. In brief, shrub-steppe dependent species are closely linked with big sagebrush and native grass cover, and with the exception of Sage Thrashers (found in high numbers only at upper elevations on the ALE Reserve) and Sage Grouse (known historically but not currently from Hanford) they are found throughout the site.

The Hanford Reach and riparian / wetland areas on the ALE Reserve and North Slope support the highest overall diversity of bird species on the Hanford Site. These areas provide important stopover habitat for migratory birds, as well as breeding habitat and post-breeding foraging habitat for many resident birds. Additionally, the Reach is important wintering habitat for the Bald Eagle, American White Pelican, and many species of waterfowl.

Table 4.1 Bird species of conservation concern: status, documented occurrence / abundance and distribution on the Hanford Site

Common Name	Scientific Name	Fed. Status / WA Status	Hanford Occurrence / Abundance#	Hanford Reach	Upland Central Hanford	Upland North Slope	ALE	Flyovers and Vagrants
American White Pelican	*Pelecanus erythrorhynchos*	/ E	YR / C	X				
Ash-Throated Flycatcher	*Myiarchus cinerascens*	/ M	S / R				X	
Bald Eagle	*Haliaeetus leucocephalus*	T / T	F, W / C	X				X-ALE
Bank Swallow	*Riparia riparia*	/ M	SP, SU / C	B				
Black-crowned Night-Heron	*Nycticorax nycticorax*	/ M	YR / U	B			X	
Black-necked Stilt	*Himantopus mexicanus*	/ M	SP / AC	X				
Black Tern	*Chlidonias niger*	SC / M	SP, F / U	X				
Caspian Tern	*Sterna caspia*	/ M	SP, SU / R	X				
Common Loon	*Gavia immer*	/ C	YR / U	X (B?)				
Ferruginous Hawk	*Buteo regalis*	SC / T	SP, SU, F / U		B	B	X	
Forster's Tern	*Sterna forsteri*	/ M	SP, SU, F / U	X				
Golden Eagle	*Aquila chrysaetos*	/ C	YR / U				X	
Grasshopper Sparrow	*Ammodramus savannarum*	/ M	SP, SU / U		B	B	B	
Great Blue Heron	*Ardea herodias*	/ M	YR / A	B				
Great Egret	*Ardea alba*	/ M	SP, SU / R	B				
Western Grebe	*Aechmophorus occidentalis*	/ M	W,S/ C	B				
Red-necked Grebe	*Podiceps grisegena*	/ M	SP,F / R	X				
Clark's Grebe	*Aechmophorus clarkii*	/ M	SP / U	B				
Horned Grebe	*Podiceps auritus*	/ M	SP, F, W / U	B				
Lewis' Woodpecker	*Melanerpes lewis*	/ C	SP, SU, F / U	X			X	
Loggerhead Shrike	*Lanius ludovicianus*	SC/ C	YR / C		B	B	B	
Long-billed Curlew	*Numenius americanus*	/ M	SP, SU / C		X	B	B	
Merlin	*Falco columbarius*	/ C	SP, F, W / FC				X	
Northern Goshawk	*Accipiter gentilis*	SC/ C	F, W / U				X	
Olive-sided Flycatcher	*Contopus borealis*	SC /	SP, SU, F/ R	X			X	

Common Name	Scientific Name	Fed. Status / WA Status	Hanford Occurrence / Abundance#	Hanford Reach	Upland Central Hanford	Upland North Slope	ALE	Flyovers and Vagrants
Osprey	*Pandion haliaetus*	/ M	SP, F / U	X			X	X- ALE
Prairie Falcon	*Falco mexicanus*	/ M	YR / R	X			B	
Sage Sparrow	*Amphispiza belli*	/ C	SP, SU / C		B	B	B	
Sage Thrasher	*Oreoscoptes montanus*	/ C	SP, SU, F / U		X	B	B	
Sandhill Crane	*Grus canadensis*	/ E	SP, F / U					X-CH & ALE
Swainson's Hawk	*Buteo swainsoni*	/ M	SP, SU, F / C	B	X	B	B	
Vaux's Swift	*Chaetura vauxii*	/ C	F/F				X	X - ALE
Western Bluebird	*Sialia mexicana*	/ M	SP, F / R				X	
Western Burrowing Owl	*Speotyto cunicularia hypugea*	SC / C	YR / R		B	B	B	
Western Grebe	*Aechmophorus occidentalis*	/ M	SP, F, W / U	X				
Willow Flycatcher	*Empidonax trailii*	SC /	SP, F / U				X	

X = present, B = confirmed or probable breeder in this locality; # Hanford occurrence / abundance data are taken from technical references and DOE-RL (1996), and may represent an average of conditions across management areas.

Occurrence:

YR = Year-round

SP = Spring

SU = Summer

F = Fall

W = Winter

Status

SC = Federal Species of Concern

E = Endangered

T = Threatened

C = Candidate

M = Monitor

W = Audubon Watch list

Abundance

A = Abundant (very often seen or heard in appropriate habitat)

C = Common (often seen or heard in appropriate habitat)

U = Uncommon (usually present in appropriate habitat but not always seen or heard)

R = Rare (present in appropriate habitat only in small numbers; seldom seen or heard)

AC = Accidental (occurs very infrequently and well outside its normal range)

F = Flyover only

Possible further inventory needs are described in the preceding section and consist of initial establishment and census of long-term monitoring plots. Continued monitoring of appropriate plots for bird species richness and relative abundance is highly recommended. Monitoring data can be used by DOE to determine the areas of Hanford best suited for management as bird conservation areas, as well as to detect changes in bird populations as the result of clean-up or other management activities. When considering such a conservation strategy, DOE should keep in mind that the threat to bird habitats at Hanford is not just the possibility of conversion to other non-compatible uses. Encroachment into native plant communities by undesirable, non-native plant species, in both riparian and upland areas threatens the integrity of these habitats and their use by birds. This management problem, and its conservation implications, is discussed in greater depth in Section W.

4.9 Specific Management Recommendations

As well as the general recommendations given above related to completing the inventory effort, controlling noxious weeds and establishing landscape level, long-term monitoring, the following specific recommendations are designed to enhance bird conservation efforts within the Hanford Site:

- Areas documented to support or recognized as having high potential to support bird Species of Conservation Concern should be designated as conservation areas. This is especially important within Central Hanford where planned and accidental (i.e. fire) disturbances are likely as part of the clean-up effort.
- Fire management plans should be developed specifically to restrict the spread of human ignited fires within big sagebrush habitats. In modern times, the majority of wildfires are human ignited and such fires reduce and degrade habitat for declining shrub-steppe species.
- Land use activities that disturb the ground surface should be minimized to reduce the encroachment of non-native species. Areas that must be disturbed should be actively replanted with native, perennial grasses and monitored for encroachment by noxious and aggressive weed species.
- Ferruginous Hawks are sensitive to human presence, and will abandon their nests if subject to human encroachment. Activities (especially noisy ones) near nesting sites should be limited during the breeding and fledging season.
- Habitat corridors should be maintained between core bird habitat areas and riparian areas along the Hanford Reach.
- Although not under DOE control, water management, both in the Hanford Reach and irrigation waste water channels can have a profound effect on bird populations. Avian biodiversity should be an important factor driving such decisions.

Section 5 – Terrestrial Invertebrates

5 Terrestrial Invertebrates

5.1 Introduction

This section provides information on terrestrial insect inventories conducted between 1994-1998 on the Hanford Site. More detailed information on these inventories can be found in Ensor 1995, Ensor 1996, Ensor et al undated (1997); Zack 1995, Zack 1996, Zack et al undated (1997) and Zack and Looney undated (1998). Aquatic invertebrate species are discussed in a separate section.

5.2 Purpose and Scope

Although they receive less attention than other biological subjects, insects may ultimately prove to be the most sensitive measure of ecosystem quality and function. For instance, aquatic insect diversity patterns have already been used to create a functional index of biological integrity for some aquatic systems (Karr 1993). At present, however, data are generally lacking with which to make comparative judgments between sites for most insect orders (groups) within the shrub-steppe. Butterflies (especially) and moths (Lepidoptera) are one of the few groups of insects that are commonly included in biodiversity studies. Although other orders of insects offer as much potentially valuable information, butterflies and moths are indeed noteworthy for their use in estimating diversity. This is primarily because of their association with specific host plants and their relative ease of identification. With few exceptions, butterflies and moths are plant feeders and many are monophagous (i.e., one host plant used as food) or are restricted to a limited number of related host plants. This is also true for many other orders of insect that rely on specific plant taxa for one or more aspects of their life cylce. Thus, a diverse lepidopteran fauna corresponds to a diverse flora.

Entomological surveys of various intensities that have focussed on a limited number of groups have been conducted at the Hanford Site since it was established (for example, see Rogers and Rickard 1975, Rogers et al. 1978, Sheldon and Rogers 1984 for representative studies on darkling beetles [family Tenebrionidae]). However, no attempt has been made to catalog the species or compile data from the many studies. In fact, much of the information has probably been lost. This is not because of lackadaisical record keeping or sloppy science — rather, it is because insects can be extremely difficult to identify, even to the family level. Due to the sheer number of insect species, many researchers will collect and identify a very limited group of taxa. Also, the time period between collecting and identifying can be years. Thus, it is little wonder that information is lost or projects are completed before a complete accounting of the insect fauna is made. To avoid this problem, insect specimens collected in this study were generally prepared and sent to recognized taxonomic authorities within a reasonably short period of time.

5.3 Methods

The first priority of the insect inventory was to select locations on the Hanford Site that could be sampled throughout the year. Insect diversity changes drastically over relatively short periods of time. This is especially true of an area such as the Hanford Site where fluctuations in insect populations are closely tied to rapidly changing floral food sources and weather. For some species, the season is short-lived and adults may be found for extremely short time periods. Not surprisingly, it is often the "rare" insects that exhibit short periods of activity. Later, insect inventory efforts were broadened in terms of both the location and sampling methods that were employed.

The 1994 and 1995 portions of the Hanford Site Biodiversity Inventory concentrated on several particular insect groups, including the leafhoppers and their relatives, true bugs, beetles, bees and wasps, true flies, and butterflies and moths. During 1996, 1997, as well as continuing ongoing general sampling, inventory efforts concentrated on moths, and other insects that are attracted to light traps, and on butterflies. Light trapping efforts focused on Central Hanford, whereas daylight collecting was conducted throughout the Hanford Site (pre-1998 findings summarized in Pabst 1995, Soll and Soper 1996, Hall 1998). Field efforts in 1998 included pitfall traps for the first time.

All collected specimens were mounted and labeled — a time-consuming activity but necessary for identification. For many insect species, accurate identifications can be provided only by a small number of specialists. To that end, 66 experts from North America and Europe were sent specimens. The value of obtaining accurate and reliable identifications can not be over-emphasized. Studies of insect diversity fail if material is not identified to the species level, or worse, if the identifications are wrong. In this study, everything has been done to avoid this situation. A list of collaborators is included as a part of Appendix B of this report. The collected specimens were deposited in the M. T. James Entomological Collection at the Washington State University, Pullman campus or at the Washington State University, Tri-Cities campus in Richland.

5.3.1 STUDY METHODS AND AREAS BY YEAR

1994 AND 1995

Initially, most of the inventory for butterflies as well as more general insect groups took place on the ALE Reserve, where diverse habitats are easily accessible across relatively short distances. Several permanent survey sites were established and surveyed on a weekly to biweekly basis from March 1994 through December 1995 (Figure 5.1). These sites included Rattlesnake Spring, Lower Snively Spring, the Snively Ranch site, a dirt access road off of the 1200 Foot Road, the radio telescope site on Rattlesnake Ridge, the area around the ALE headquarters, and the well site near the top of Rattlesnake Ridge. Other sites were sampled as time permitted or as interesting sites became known. In addition to the survey sites mentioned, the survey for butterflies and moths included Benson Spring on the ALE Reserve, all of Rattlesnake Ridge, and cursory surveys on the Wahluke State Wildlife Recreation Area, Saddle Mountain National Wildlife Refuge and the Hanford Reach of the Columbia.

During the first two years the inventory concentrated on several insect orders: Homoptera (leafhoppers and relatives), Heteroptera (true bugs), Coleoptera (beetles), Hymenoptera (bees and wasps), Diptera (true flies) and Lepidoptera (butterflies and moths). These are among the largest insect orders and contain the greatest diversity. Three collections of Hanford insects (made prior to the 1994 inventory) were evaluated to determine the historical presence of some taxa on the site.

In 1995 the number of sites routinely surveyed for butterflies was expanded to include the east and west portions of Gable Mountain, East White Bluffs, Hanford Townsite, Midway, China Bar, portions of the Wahluke Wildlife Area, and the ponds and lake areas of Saddle Mountain National Wildlife Refuge.

Additional locales were surveyed during the flight period of butterfly species with specific host plant or habitat requirements. These sites include the Hanford Dunes (with emphasis on *Purshia tridentata* sites), Umtanum Ridge and the junipers east and west of Vernita.

Sampling methods were simple and involved primarily hand-picking, sweep-netting and light trapping at the various survey sites. These methods tend to provide the most information on the insect fauna of an area over the shortest period of time.

1996-1997

The general insect surveys in 1996 and 1997 focussed more on night-time light trapping and focused on moth branch of the Lepidoptera order. Many insects are attracted to lights, especially moths, certain groups of bugs, beetles, lacewings, and a variety of other insects of numerous groups. Light trapping is one of the most efficient methods of conducting survey work for large numbers of insects in a relatively short time period. Often, light trapping is the only way to collect many of these nocturnally active insects. In 1997 especially, the survey emphasized night-flying moths. .A 150 watt mercury vapor lamp powered by a small generator was used for the light trap. Sampling began at dusk. A sheet was spread on the ground, the light turned on and the insects were hand-collected as they flew in towards the light.

Several locations were established during 1996-1997 specifically for light trapping (Figure 5.1). These locations were monitored on a weekly to biweekly basis throughout the field season (i.e., March through November). During 1996 a sample location was established in the Hanford Dune Field north of the Washington Public Power Supply System facility and about 1.5 mi (2.4 km) from the Columbia River. During 1997 several locations were established within Central Hanford (Figure 5.1), including in the vicinity of West Lake, Gable Mountain, and Hanford Townsite. In both years daylight collecting also was conducted throughout the Hanford Site.

Daytime sampling methods that focused specifically on butterflies and moths consisted of sight identification and hand netting. Site visits for butterflies covered three time periods during 1997: (1) at the end of March to search for the early butterfly species of Central Hanford, and specifically for sagebrush sheepmoth (*Hemileuca hera*) larvae in the mature (late-successional) big sagebrush (*Artemisia tridentata* subsp. *wyomingensis*) habitat surrounding parts of Gable Mountain; (2) during early August to confirm whether monarch (*Danaus plexippus*) breeding occurred along the Hanford Reach and to inventory butterfly species on the North Slope; and (3) during mid-September to inventory specific areas, such as China Bar, Rattlesnake Springs, etc., and to determine monarch and sagebrush sheepmoth habitats.

1998

Insect sampling in 1998 followed a different approach than in earlier years. Although periodic collection at regular study sites continued using the collection sites and methods described above, for the first time pitfall trapping was included. Pitfall traps are more efficient than hand collecting at sampling insects that spend substantial parts of their lifecycle on or near the ground, and thus allow more detailed analysis of the differences in these taxa between sites. Furthermore, because they collect continually, they allow better analysis of differences in phenology (biological timing) between sites. Pitfall traps are small containers placed flush with the ground surface. A series of guides are established to direct insects towards the trap, and antifreeze is placed in the bottom of the container to catch, hold and preserve the insects that fall into the trap. The contents of the traps are emptied periodically.

Pitfall traps were installed at 4 sites, 1 on ALE and 3 on Central Hanford (Figure 5.1).

ALE

1. Both sides of the road up to Rattlesnake ridge just before it begins to climb the hill (near the old "Hodges Ranch", N46°22.757'*W119°31.073'). One side of the road is composed of sagebrush and bunchgrasses, and the other dominated by cheatgrass. Although general collecting has occurred in this area throughout the study, the intensive sampling done in 1998 will help to elucidate the differences in insect fauna in high quality and degraded shrub-steppe.

Central Hanford

2. West Lake (N46°36.066'* W119°32.788') - West Lake is the only naturally occurring lake on the Hanford Site. It is highly alkaline but apparently uncontaminated by toxic or nuclear waste. A series of 15 pitfall traps were established in 5 "zones" defined as concentric rings around the lake, from the shoreline to typical central Hanford upland vegetation.
3. The ENE slope of Gable Moutain (N46°35.745'*W119°26.384') - 15 traps were established in typical shrub-steppe vegetation, within one of Battelle's longterm monitoring plots (see draft BRMaP).
4. The sand dunes west of the Columbia River (N46°31.369'*W119°21.192) - The extensive dunes of the Hanford dune field (see Hall 1998 and Easterly and Salstrom 1998) had been intensively sampled for insects by other methods during 1996 and 1997, and several new species have been discovered there. The 15 pitfall traps established in dunes and adjacent vegetation within the dune system helps complete the insect inventory of this fascinating and diverse area.

Contrary to earlier years, nearly all of the 1998 studies were established as two year studies. Thus, many of the prepared specimens from 1998 have been stored, rather than immediately identified, until completion of this phase of the research in late 1998 or even 1999. It is hoped that proceding in this fashion will produce more efficient identification of the collected specimens.

There were no focussed butterfly surveys during 1998.

5.4 Findings

5.4.1 OVERVIEW OF ALL MAJOR GROUPS

Ongoing identification of species from all orders of insects (and other invertebrates such as centipedes and spiders) continue to add to the biodiversity totals for Hanford. At this time 1536 species in 16 orders have been identified (Table 5.1). Because of the sampling methods utilized between 1994 and 1997, the bulk of the findings come from 5 orders: Coleoptera (beetles), Diptera (flies), Homoptera (leafhoppers and relatives), Hymenoptera (bees, wasps, and ants), Lepidoptera (moths and butterflies). There are more than 100 specimens still in the hands of collaborating experts and more than 300 for which an appropriate collaborator has yet to be identified. It is estimated that when all the samples from 1998 are identified that more than 2000 individual species will have been identified. These estimates are conservative ones, based on the sorting of specimens by perceived differences.

The remarkable number of species new to science and new to Washington State found during this inventory continues to be one of the major results. To date, 43 previously undescribed taxa have been discovered (Table 5.2), including 2 during the 1998 field season. Because many of the specimens collected in 1998 have not yet been identified it is a near certainty that the total number of new taxa will dramatically increase. One hundred and forty-two (142) taxa represent new records for Washington, meaning that at present, the only known locations for those species in Washington is at the Hanford Site.

Although the number of new species and state and Hanford Site records are noteworthy, equally important is the great diversity found in important groups like hymenoptera, coleoptera, homoptera and the moth branch of the lepidoptera (moths are discussed in detail in Hall 1997). Moths are important as pollinators, often of specific host plants. Beetles do a variety of ecological work including decomposing animal dung (dung beetles) and inset control (ladybird beetles). The hymenoptera includes bees (pollination), wasps (insect control) and ants (nutirent cycling). A complete list of taxa idenitified to date is available in Zack et al (undated) on file with The Nature Conservancy of Washington.

Table 5.1 Number of invertebrate species-level identifications, major orders

Order	Number of Species Identified	Approximate Number of Species Remaining to be Identified
Aranae (spiders)	0	50-100
Chilopoda (centipedes)	2	0
Coleoptera (beetles)	242	50-70
Dermaptera (earwigs)	1	0
Diptera (flies)	322	100-150
Hemiptera (bugs)	86	20-40
Homoptera (leafhoppers and relatives)	112	25-40
Hymenoptera (bees, wasps, and ants)*	364	75-150
Lepidoptera (butterflies)	50	0
Lepidoptera (moths)	320	50-100
Mantodea (mantids)	1	2
Neuroptera (lacewings)	26	0
Odonata (dragonflies and damselflies)	8	0
Orthoptera (grasshoppers and relatives)	1	10-20
Scorpiones (scorpions)	1	0
Siphonaptera (fleas)	0	1-2
Total	1536	383-672

*Combines figures from Ensor 1997 and Zack undated (1998 field season)

Table 5.2 Insect taxa (species and subspecies) new to science and new species records

Order	New Records for		Family	Genus	Taxa New to Science
	WA State	Science (by order)			
Coleoptera (beetles)	15	2	Scarabaeidae	*Aphodius**	1
				Glaresis$	1
Diptera (flies)	26	9	Anthomyiidae	*Paradelia*$	1
			Asilidae (robber flies)	*Efferia*$	2
			Dolichopodidae	*Asyndetus**	1
				*Sympycnus**	1
				*Thrypticus**	1
			Sarcophagidae (flesh flies)	*Blaesoxipha**	1
				Eumacronychia$	1
				*Senotainia**	1
Hemiptera (bugs)	35	0			

Table continued on next page

Order	New Records for		Family	Genus	Taxa New to Science
	WA State	Science (by order)			
Homoptera (leaf-hoppers and relatives)	16	5	Cicindellidae	*Aceratagallia*#	3@
				Auridius#	(1)
				Errhomus#	(1)
Hymenoptera (bees, wasps, and ants)	32	7	Andrenidae	*Andrena*$	1
				Perdita$	2
			Colletidae	*Colletes*$	1
			Megachilidae	*Osmia*$	2
			Perilampidae	*Perilampus**	1
Lepidoptera (moths and butterflies)	18	20	Coleophoridae	*Coleophora**	12
			Geometridae	???*	1
			Noctuidae	*Copablepharon**	1
				Oncocnemis#	1
				Protogygia#	1
				Spaelotis#	1
			Scythrididae	*Areniscythris**	1
				*Asymmetrura**	1
				*Neoscythris**	1
Total	142	43			41 species, 2 subspecies

*Known only from specimens collected at Hanford.

$Known from specimens collected at Hanford and possibly other locales.

#Known from specimens collected at other locales in addition to Hanford.

@Previously, three new species of *Aceratagallia* were thought to have been collected (Zack 1996). One of these turned out to be an already described species (Richard Zack, Washington State University, personal communication to the editor).

5.4.2 SIGNIFICANT FINDINGS FROM 1998

COMPARISON OF CHEATGRASS AND SAGEBRUSH/BUNCHGRASS HABITATS

One of the more noteworthy findings of the insect inventory in 1998 is still considered preliminary. Early findings show important differences between both the insect fauna and the timing of insect activity in degraded versus relatively intact shrub-steppe. Of particular note at this early stage is the lack of scorpions and scorpion flies (and see unusual findings below) in areas dominated by cheatgrass, despite their relative abundance in adjacent unburned areas that retain sagebrush and bluebunch wheatgrass. It also appears that ground dwelling beetle populations are quite different in the two habitat types.

INSECTS OF WEST LAKE

As was much of the 1998 work, work at West Lake is part of a 2 year study and thus most specimens remain to be identified. It is clear however, that the insect fauna from this area is unique for the Hanford Site and that it varies with distance away from the lakeshore.

OTHER UNUSUAL FINDINGS

The little known and poorly understood group of snow scorpionflies (Mecoptera: Boreidae) has been discovered in abundance on ALE as part of the comparison between burned (cheatgrass) and unburned (sagebrush - bunchgrass) areas. These species feed on moss, which is found in abundance as part of the microbiotic (living) soil crust that covers relatively undisturbed shrub-steppe soils.

A rarely collected winter-active dung-feeding beetle, *Aphodius washtucna* (Coleoptera: Scarabidae) was discovered on ALE. Since being first described near Ritzville and Washtucna in the 1930s it has rarely been collected.

A non-native predatory bug (Hemiptera: Heteroptera: Leptopodidae) previously known in the U.S. only from central California; Reno, Nevada; and southern Idaho has been identified among cobblestones lining the dirt road that traverses West Lake. Finding this bug in central Washington is a significant discovery and could be an indication that the species has used movement along major waterways to expand its range.

As data from these planned two year studies gets analyzed there is little doubt that numerous new species, new state and Hanford records and a variety of unusual, important and interesting ecological findings will be made.

5.4.3 BUTTERFLIES

Between 1994 and 1997 a total of 49 butterfly taxa (species and subspecies) were identified during survey efforts. Thirty-two of the butterfly species were documented on Hanford for the first time during this inventory. An additional species, the satyr anglewing (*Polygonia satyrus*) was not observed during the inventory but was identified within previously undocumented collections from the Fitzner / Eberhardt Arid Lands Ecology (ALE) Reserve, bringing the number of taxa known from the Hanford Site to 50. Eight of the identified taxa are listed as monitor species by the state of Washington (Table 5.3) (WDFW 1997). Table 5.3 provides cumulative distribution data by management area for butterfly species across the Hanford Site.

The ALE Reserve continues to show the highest butterfly diversity with a total of 46 taxa recorded (three of these taxa, the Queen Alexandra's sulphur, purplish copper and satyr anglewing, were recorded based on identifications within previously undocumented collections; the others were observed during the biodiversity inventory). Central Hanford supports 37 taxa. The totals for the Saddle Mountain National Wildlife Refuge and the Wahluke Unit Columbia Basin Wildlife Area are 15 and 17, respectively. A complete database of all butterfly records for the biodiversity inventory project is available, and Ensor 1994, 1996, undated (1997 field season report) as well as Soll and Soper (1996) should be consulted for additional information on butterfly findings for each of the different Hanford Site management areas.

Highlights from each management unit at the Hanford Site are presented below.

FITZNER-EBERHARDT ARID LANDS ECOLOGY RESERVE

This unit supports the greatest diversity of Lepidoptera found at the Hanford Site during the study. Forty-six butterfly taxa have been identified within ALE's boundaries; nine of these species have been

found only at ALE within Benton County. Three uncommon lithosol species (Nevada Skipper, Washington Hairstreak, and Veazie's Checkerspot) were found on Rattlesnake Ridge. The location of these butterflies together occurs at only one other site in the state. Twenty-seven additional species have been recorded on or near the crest of the ridge. Six State Monitor species were identified: Nevada Skipper, Juba Skipper, Canyon Green Hairstreak, Purplish Copper, Perkins' Copper, and Viceroy. Finally, two species (Glaucous and Silvery Blues) not recorded for more than 20 years in Benton County were found during survey work at ALE.

A xeric population of Indra Swallowtails inhabits ALE. All xeric sites with Indra Swallowtails have been recommended for protection in the *Washington Butterfly Conservation Report and Plan (Pyle 1989).*

CENTRAL HANFORD

Thirty-seven butterfly species were identified within this unit. Six taxa (Juba Skipper, Bonneville Skipper, Purplish Copper, and Viceroy,) have State Monitor status, four are found in habitats along the Columbia River shoreline. The other two species (the Western Sulphur and Nevada Skipper) were found on gable Mountain. Three of species known from Central Hanford (Sachem skipper, Bonneville Skipper (SM), and Large Wood Nymph) have not been found at ALE. The Sachem and Large Wood Nymph are 1995 Hanford Records. Gable Mountain appears to be an important site for butterfly diversity within Central Hanford.

SADDLE MOUNTAIN NATIONAL WILDLIFE REFUGE

Fifteen species were identified with limited sampling (the portion south and east of Highway 24), and the habitat appears better than the species count indicates. Further survey will almost certainly expand the species list. Two State Monitor species, the Viceroy and Purplish Copper, were found. In the early part of this century the Viceroy butterfly was found as far north as Brewster on the Columbia River and irregularly in the Snake River system in areas bordered by *Salix exigua* or *S. lasiolepis* willows in dry steppe habitat. Both of these willow species are found at this unit.

WAHLUKE WILDLIFE RECREATION AREA

Areas surveyed include the White Bluffs Wasteway, Columbia River shoreline sites, White Bluffs Lake, seeps, drainage areas, and several shrub steppe locations.

Seventeen butterfly species have been identified; all WRA records. Four species are State Monitor taxa: Juba Skipper, Perkins' Copper, Purplish Copper, and Viceroy. Identification of a few day-flying moths is pending. Night surveys of the WRA sand dunes could yield moth species similar to those obtained in 1995 at the Hanford Sand Dunes.

OTHER NOTEWORTHY FINDINGS

Monarch Monarchs were confirmed to breed along the Hanford Reach at locations where its host, showy milkweed (*Asclepias speciosa*), was found. Suitable sites also were noted along the irrigation ponds within the Saddle Mountain National Wildlife Refuge. Adults, but no larvae, were observed at these latter locations. Northwestern monarch population numbers in 1997 recovered somewhat from population lows experienced during the early to mid-90s. To assure continued recovery, retention of known breeding areas along migratory flyways is extremely important for monarch conservation. The Mid-Columbia region is one of the few known breeding areas for the monarch within Washington State.

Table 5.3 Hanford Site butterfly taxa identified as Washington State Monitor species

Common Name	Scientific Name	Management Area in Which the Species Has Been Located			
		Arid Lands Ecology Reserve	Central Hanford	Saddle Mountain National Wildlife Refuge	Wahluke Unit Columbia Basin Wildlife Area
Bonneville skipper	*Ochlodes sylvanoides bonnevilla*		X		
Canyon green hairstreak	*Callophrys sheridanii neoperplexa*	X			
Juba skipper	*Hesperia juba*	X	X		X
Nevada skipper	*Hesperia nevada*	X	X		
Perkins' copper	*Lycaena rubida perkinsorum*	X			X
Purplish copper	*Lycaena helloides*	X*	X	X	X
Viceroy	*Limenitis archippus lahontani*	X	X	X	X
Western sulphur	*Colias occidentalis occidentalis*		X		

*This occurrence is based on a 1966 record; all other entries are based on observations made between 1994–1997.

Mormon Metalmark Two locations are known for this localized butterfly, one on Gable Mountain the other along the high ridge of Rattlesnake Mountain.

Nevada Skipper Until 1997 Rattlesnake Mountain was the only known location for this species in the Columbia Basin. A male specimen was collected on the ridge of Gable Mountain during 1997. The host plant(s) in Washington is unknown.

Queen Alexandra Sulphur A specimen of this species was collected on Umtanum Ridge. This species was last collected and identified in 1975 from a specimen from Snively Canyon on the ALE Reserve.

Western Sulphur A specimen of this species was collected at West Lake. Only one other Columbia Basin record exists and that is from Yakima County directly west of Vernita. This species is found most commonly in open areas of pine and/or fir forest habitats. Its occurrence at Hanford may be atypical.

5.5 Relationship to Previous Findings

The five years of insect inventory work on the Hanford Site represent the most intensive survey of the overall entomofauna of any large geographic region in Washington, and one of the few studies of its type conducted in the Pacific Northwest. All major insect groups have been surveyed to some degree. More than 40,000 specimens have been collected, correctly prepared, and identified or made available for identification. Thus far, 1536 species-level identifications have been completed through the efforts of biodiversity inventory personnel and 68 collaborators. Another 100-200 species are being examined. Many of these collaborators are world-recognized experts in the groups that they examined. Few studies, conducted anywhere, can boast of this degree of taxonomic expertise in their identifications. Finally, more than 300 different specimens await the identification of an appropriate expert to provide identifcation.

During the course of the insect biodiversity inventory, a total of 41 species and two subspecies new to science have been identified and designated by world-recognized authorities (Table 5.2). Although a

taxon (i.e., species or subspecies) may be identified herein as new to science, this does not necessarily mean that specimens for a particular taxon have not been collected elsewhere. “New” means previously undescribed, and for some, but not all, of the new species findings reported as part of the biodiversity project a previously discovered taxon simply awaits naming by an appropriate authority. Moreover, new species that are known presently only from material collected at Hanford eventually may be found in other locales. Still, at least 26 of the species identified herein as new to science are known presently only from Hanford. Additionally, numerous other specimens that have been collected but not yet identified may represent species new to science.

At least 142 species represent new distribution records for Washington State (Table 5.2). State records are often hard to verify as few groups have been the subject of recent catalogs or distributional checklists. When the group was well known or was the subject of recent study or cataloging activities, a species was able to be designated as a species new to Washington. Unfortunately, this was not the case for most groups of insects. With the preceding in mind, the designation of species new to Washington was conservative.

As mentioned earlier the new species and records are exciting, but the greatest ecological value lies in the tremendously deep diversity of all insect groups studied to date. Hanford supports a diveristy of insects that is not known to be matched anywhere within the arid intermountain west. It serves as a benmchmark for comparison and a resevoir for lands that surround it.

5.6 Further Inventory Needs

Certain orders of insects, in which it is likely large numbers of species occur, have yet to be thoroughly surveyed. These include the Orthoptera (grasshoppers, crickets, and relatives), Trichoptera (caddisflies), Ephemeroptera (mayflies), and certain Hymenoptera (e.g., ants) . Some of these taxonomic groups were examined during 1998, but the results are not yet available. Results from a preliminary study of aquatic invertebrates (including Trichoptera and Ephemoptera) are presented in this report (Section x). Further inventories of the following areas will add significantly to the body of scientific information and may provide important information on which management decision can be based.

- Continued study of moths and wild bees (both groups of which can be host specific in regard to what plants are visited for feeding and pollination), especially in dune areas.
- For butterflies, the Gable Mountain area should be searched again to determine whether a second Hanford Site population of the Nevada skipper is present, as well as to inventory the area for other rare butterfly species. A search for the host plant of the Nevada skipper also should be considered.
- The North Slope was only cursorily surveyed as part of this project, and the entire area, but especially the sand dune areas should be inventoried for moths to enable a comparison with the moth diversity of the Hanford Dune Field within Central Hanford.
- Continued inventories of Umtanum Ridge and the Hanford Reach shoreline are recommended.
- As a large area not subject to significant drift of agricultural chemicals the Hanford Site undoubtedly supports insect species useful for biological control of agricultural pests and for pollination. Studies should continue to focus on predatory wasps, ladybird beetles, bees.
- Expansion of the comparison of insect diversity between native and degraded habitats would yield valuable insight.

5.7 Conclusions

Insects provide many important ecosystem functions including pollination, decomposition and ironically, insect control. Ecology aside, their roles as pollinators, biological control agents and agents of soil fertility in agriculture make them economically important as well. The results of surveys for invertebrates on the Hanford Site has demonstrated that Hanford is a resevoir of entomological wealth which is of significant regional ecological and economic importance. Put more simply, Hanford retains species that have been lost elsewhere due to habitat conversion, fragementation, degradation and spraying of pesticides. This is most obvious in the high species diversity found in groups with major economic importance such as ladybird beetles, bees and predatory wasps.

The recognition of 41 species and two subspecies new to science and at least 142 new species records for Washington is of course striking. The key point about insect diversity on Hanford, however, is not that any single species is found there and no place else, or even the remarkable number of new species. The most striking result of the survey is that so many species, including diverse assemblages of common species as well as rare or rarely collected species, are found at at Hanford. Such broad diversity is an indication that in contrast to most shrub-steppe sites, the Hanford Site contains a large enough assemblage of microhabitats to support what probably at one time was a fauna typical of the arid interior West.

During this project, many sampling locations were chosen on the basis of easy access (i.e., near roads) or, in some cases, because they provided species of interest proximity to a water source. Because these locations often showed signs of human-induced change, it could lead to the erroneous conclusion that the high diversity of species found at Hanford was associated with these disturbances. Instead, the source of Hanford's insect diversity can be attributed to the size, complexity and relatively undisturbed condition of its native shrub-steppe habitat. The overall insect species composition and abundance at Hanford — and the notable lack of introduced species common in the surrounding agricultural fields or disturbed urban areas — provide strong evidence in support of this latter conclusion.

The ALE Reserve remains the highest priority for the conservation and protection of insects, especially moths and butterflies. The natural springs, high ridges, diversity and quantity of host plants, large open spaces, elevational gradients, and the lack of pesticide drift are the keys to maintaining its conservation value. The ALE Reserve also contains an excellent representation of shrub-steppe and lithosol butterfly taxa that include a number of uncommon species and six state Monitor taxa. Moth species diversity also is notable and includes a viable sagebrush sheepmoth population which depends on mature sagebrush for reproduction.

Because native insect diversity closely corresponds to native plant diversity, findings from the insect portion of the biodiversity inventory should be viewed in the context of findings for native plant communities and rare plants, as well as other taxonomic groups. The integration of these various data sources can aid the U.S. Department of Energy in making land-use decisions, including those that designate biodiversity conservation areas. Additionally, because the population responses of insects are good indicators of environmental change, they should be considered a component of any long-term monitoring strategy that proposes to assess the condition of Hanford's biodiversity.

5.8 Management Recommendations

- Insect diversity is generally related to plant and habitat diversity. Large contiguous expanses of representative native plant communities and generalized habitats such as the few springs, lakes and riparian zones present on the Hanford Site should be maintained.
- Based on their butterfly diversity, Umtanum Ridge and the shorelines of the Hanford Reach have been identified previously to be of particular importance for Washington butterfly conservation (Pyle 1989). Findings from the biodiversity inventory support the conservation importance for butterflies and moths of the Hanford Dune Field and Gable Mountain areas as well. These areas should be maintained in their relatively undisturded condition.
- Retention of milkweed sites on the North Slope is strongly recommended. An estimated 90% decline in northwestern Monarchs in recent years has made retention of known breeding areas along flyways extremely important. The Mid-Columbia region is one of the few known breeding areas for the Monarch within Washington State.

Table 5.4 Butterflies of the Hanford Site

Common Name	Scientific Name	State Status	Record Type		Management areas in which the taxa has been located			
			Benton County[1]	Hanf.[2]	ALE	C. Hanf.	SM NWR	WRA
Common Checkered Skipper	*Pyrgus communis*				X	X		
Large White Skipper	*Hekiopetes ericetorum*				X	X		X
Common Sooty Wing	*Pholisora catullus*				X	X		
Juba Skipper	*Hesperia juba*	M	X	1966	X	X		X
Nevada Skipper	*Hesperia nevada*	M	X	1966	X	X		
Harpalus Skipper	*Hesperia comma harpalus*				X	X	X[3]	
Sachem	*Atalopedes campestris*			1994		X		
Bonneville Skipper	*Oclodes sylvanoides bonnevilla*	M				X		
Oregon Swallowtail	*Papilio bairdii oregonius*				X	X		
Anise Swallowtail	*Papilio zeliacon*				X	X		X
Indra Swallowtail	*Papilio indra indra*				X	X		
Becker's White	*Pieris beckerii*				X	X	X	X
Flavous White	*Pieris sisymbrii flavitincta*			1994	X	X		
Western White	*Pieris occidentalis occidentalis*			1966	X	X	X	
Cabbage White	*Pieris rapae*				X	X	X	
Large Marble	*Euchloe ausonides ausonides*			1980	X	X		

Common Name	Scientific Name	State Status	Record Type		Management areas in which the taxa has been located			
			Benton County[1]	Hanf.[2]	ALE	C. Hanf.	SM NWR	WRA
Southern Marble	*Euchloe hyantis lotta*				X	X		X
Clouded Sulphur	*Colias pihlodice eriphyce*			1992	X	X	X	X
Alflafa Butterfly	*Colias eurytheme*			1992	X	X	X	X
Western Sulphur	*Colias occidentalis occidentalis*	M	X	1997		X		
Quenn Alexandra's Sulphur	*Colias alexandra edwardsii*				X	X		
Perkin's Copper	*Lycaena rubida perkinsorum*	M		1990	X			X
Purplish Copper	*Lycaena helloides helloides*	M		1966	X	X	X	X
Washington Hairstreak	*Callophrys affnis washingtonii*		X	1994	X			
Canyon Green Hairstreak	*Callophrys sheridanii neoperplexa*	M		1995	X			
Newcomer's Hairstreak	*Callophrys sheridanii newcomeri*		X	1995	X			
Gray Hairstreak	*Strymon melinus setonia*				X	X		X
Western Tailed Blue	*Everes amyntula amyntual*		X	1994	X			
Glaucous Blue	*Euphilotes battoides glaucon*			1994	X			
Columbian Blue[4]	*Euphilotes enoptes columbiae*		X	1994	X			
Arrowhead Blue (Brown's)	*Glaucopsyche piasus toxeuma*			1966	X			
Silvery Blue	*Glaucopsyche lygdamus columbia*				X			
Melissa Blue	*Plebejus melissa melissa*				X	X		X
Pembina Blue	*Plebejus icariodes pembrina*		X	1966	X			
Acmon Blue	*Plebejus acmon acmon/lutzi*			1976	X	X	X	
Mormon Metalmark	*Apodemia mormo mormo*				X	X		
Mylitta Crescent	*Phyciodes mylitta mylitta*			1966	X	X	X	X

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Common Name	Scientific Name	State Status	Record Type		Management areas in which the taxa has been located			
			Benton County[1]	Hanf.[2]	ALE	C. Hanf.	SM NWR	WRA
Veazie's Checkerspot	*Euphydryas anicia veazieae*		X	1976	X			
Satyr Angelwing	*Polygonia satyrus*			1966	X			
Mourning Cloak	*Nymphalis antiopa antiopa*			1968	X	X	X	X
Milbert's Tortoise Shell	*Aglais milberti milberti*			1966	X	X		
Painted Lady	*Vanessa cardui*		X	1968	X	X	X	
West Coast Lady	*Vanessa annabella*			1992	X	X	X	
Red Admiral	*Vanessa atalanta rubria*			1992	X	X	X	X
Viceroy	*Limenitis archippus lahontani*	M		1992	X	X	X	X
Northwest Ringlet	*Coenonympha tullia ampelos*				X	X		X
LargeWood Nymph	*Cercyonis pegala arianae*			1995		X		
Small Wood Nymph	*Cercyonis sthenele paulus*				X	X		
Dark Wood Nymph	*Cercyonis oetus oetus*		X	1978	X			
Monarch	*Danaus plexippus*			1992	X	X	X	X
Total		8	10	32	46	37	15	17

1: County Record: Defined as a taxa not previously reported in the county in *the Butterflies of Washington: A Checklist of County Records* 1993 ed. Data is from speciemens located during 1994-1998 field inventory or the review of unreported an/or uninventoried Hanford collections both on- and off-site.

2: Hanford record: A date in this column indicates a specimen that was first doumented during the Biodiversity Inventory. The date of the earliest known collected specimen is listed. See "County record" above for additional information.

3: The subspecies could not be determined.

4: Provisional identification pending additional collection or testing.

Section 6 – Aquatic Invertebrates

6 Aquatic Invertebrates

6.1 Introduction

This chapter provides findings from the study of aquatic invertebrates of the Hanford Site conducted during the 1998 field season. Newell (1998) provides details not included here.

6.2 Purpose, Scope, and Background

Aquatic invertebrates are a vital part of aquatic ecosystems. They are so responsive to environmental conditions that their patterns of diversity and abundance have been used to develop an index of biological integrity for streams in some parts of the U.S (Karr 1993). More locally, aquatic insects are a key element supporting the thriving salmon population on the Hanford Reach. In order to increase our understanding of the aquatic invertebrates of the Hanford Site, this study was designed to: 1) conduct reconnaissance level surveys of aquatic invertebrates of the Columbia River and two spring streams on the Hanford Site; and, 2) to survey published literature for historical records of aquatic invertebrates. Because this was a reconnaissance level survey and sampling was limited, the findings presented here are not likely to represent the full diversity of aquatic insects on the site.

Early studies on Columbia River aquatic organisms (summarized by Becker, 1990) generally focused on accumulation of radiation or the effects of heated reactor water. This research did however, aid the study of the ecology and taxonomy of the local aquatic organisms and basic faunal lists were created (see Newell 1998 for a review). The first and possibly the most complete study of the bottom dwelling (benthic) aquatic invertebrates of the Hanford Reach was done by Davis and Cooper (1951). They used boats and a bottom dredge to collect samples during 1948-1950. No one since has used such an intense and comprehensive sampling approach.

In the early 1970's, research on benthic organisms was stimulated by the Washington Public Power Supply System (WPPSS) plans to build nuclear power plants near the Columbia River, on the Hanford Site. As a result, several years of ecological monitoring occurred (e.g. Battelle 1977, 1978, 1979a, b, c). These studies provided the bulk of river aquatic invertebrate data available in the published record.

Wolf and Cushing (1972) published one of the earliest studies on Rattlesnake Spring. Their work provided some productivity estimates and records of the occurrence of periodic severe floods that had a devastating effect on the biota. Schwab et al. (1979) conducted a survey of all springs on Hanford and provided maps, water chemistry data, elevations, and drawings.

6.2.1 Study Area and Sampling Locations

The Columbia River is the second largest river in the contiguous United States and is the dominant surface-water body on the Hanford Site. Columbia River flow is regulated by 11 dams, 7 upstream from Hanford. The closest upstream dam is Priest Rapids, opened in 1959. The closest downstream dam is McNary. The lake formed behind McNary Dam, 62 mile (100 km) long Lake Wallula, extends upstream to Richland. Except for the Columbia estuary, the only unimpounded stretch of the Columbia River in the United States is the Hanford Reach, which extends from Priest Rapids Dam to the head of Lake Wallula at Richland, Washington.

Flows through the Hanford Reach are controlled by Priest Rapids Dam and fluctuate greatly as power generating needs change. During the last ten years flows have averaged 120,000 ft^3/sec (340 m^3/sec).

Peak flows since the dam was installed have reached 415,000 cfs (1175 m^3/sec), still far from the levels reached during the most recent flood (1948), when flows reached 742,000 cfs (2101 m^3/sec) (Battelle, 1998). Current flow variations however,can cause water level fluctuations of about 25 ft (7.6 m) which can be devastating to aquatic invertebrates. Even during the summer and fall, daily water level fluctuations of nearly 5 vertical feet (1.5 m) are common, and the width of the river within the Hanford Site varies from approximately 1000 ft to 3300 ft (305-1005 m) (Battelle, 1998).

6.2.2 SAMPLING LOCATIONS

HANFORD REACH AND TRIBUTARIES

Sampling occurred within the Columbia River itself and several tributaries. Each of the river and spring sampling stations was visited at least twice during the winter, spring, or summer of 1998. Six sampling stations were located on the Columbia River (Figure 6.1). The study area extends from river mile 336, just above the confluence of the Yakima River and Columbia River (head of Lake Wallula) to the upper end at Priest Rapids Dam at river mile 397, a total of 61 miles (98 km) of river. River mile data were taken from U.S.G.S. 1:24000 scale topographical maps.

Station 1 - Approximately 980 feet (300 m) downstream from Priest Rapids Dam, east side of river, Franklin County, river mile 396.5.

Station 2 - Immediately upstream from the Vernita Bridge, highway 240, east bank, Franklin County, approximately 8 miles (12.9 km) downstream from Priest Rapids Dam, river mile 388.

Station 3 - Adjacent to the old Hanford Townsite, west bank, Benton County, river mile 361.5.

Station 4 - Downstream from the Ringold fish hatchery, east bank, Franklin County, from 200 meters to 3 miles downstream, depending upon water conditions, river mile 354-351.

Station 5 - 1 mile upstream from the Hanford 300 Area, east bank, Franklin County, river mile 346.

Station 6 - Columbia Point, approximately 328 feet (100 m) downstream from the I-182 highway bridge over the Columbia River, west bank, Benton County, river mile 336.

Each tributary was sampled once, in February, 1998. Tributary sampling stations were all within 328 feet (100 m) of the river during low flow periods, below the river's high water mark, except the Ringold spring stream station which was 164 feet (50 m) from the river. The Priest Rapids hatchery stream was river mile 395. The Ringold Hatchery outlet was river mile 355, and the Ringold irrigation return stream was river mile 354.5. The spring stream sampling station was immediately above the road to the Ringold Hatchery and above the river high water mark.

SPRINGS OF THE ALE RESERVE

Two of the largest spring streams - Rattlesnake and Snively springs - on the Hanford Site, both located within the ALE Reserve, were sampled twice during this study. Rattlesnake Spring is the larger of the two. its stream flows for about 0.6 mi (2.5 km) before disappearing into the ground (Battelle, 1998). Base flow is about 0.4 ft^3/sec (0.01 m^3/sec) (Cushing and Wolf 1982). Water temperature ranges from 36-72 F (2-22 C). Schwab et al. (1979) estimated the flow at Snively Spring at the lower road crossing to be 40-50 gpm (2266-3115 cm^3/sec). The two springs are of ecological importance because they provide water and riparian habitat to animals in an otherwise arid part of the

site. The major rooted plant, which covers the entire width of some portions of the streams is watercress *(Rorripa nasturtium-aquaticum*). Isolated patches of bulrush (*Scirpus* sp.), spike rush (*Eleocharis* sp.), and cattail (*Typha latifolia*) occupy <5% of the stream bed (Battelle, 1998).

Sampling stations on the two spring streams were in the following locations:

Snively Spring-downstream station: This station was located approximately 656 ft (200 m) downstream from the first road crossing. The stream flows against a steep dirt bank and the vegetation has been reduced by animal use (presumably elk) permitting access to the stream. Otherwise the riparian vegetation is so thick as to be very difficult to enter. Shwab et al. (1979) accurately described the riparian vegetation as a tangle of willows, chokecherry, wildrose, cottonwood and numerous other plants and grasses. The substratum is small gravel and sand with watercress forming a dense cover over the stream. Elevation at the first road crossing is about 1475 feet (450 m).

Snively Spring-upstream station: The station was located approximately 1 mile (1.6 km) upstream from the first road crossing, above the culvert at the second crossing, just before the road turns sharply west, at the site of the old Snively Ranch house. The stream is about 16 inches (41 cm) wide and 4 inches (10 cm) deep and choked with water cress. The substratum is small gravel and sand.

Rattlesnake Spring-upstream station: This station is adjacent to the aquatic laboratory building located at the spring. Riparian vegetation is dense, with much watercress in the stream. The substratum here is sand and some silt. Flow is approximately 0.4 cfs (0.01 m^3/sec) (Cushing and Wolf, 1982). The stream is approximately 3 feet (1 m) wide and up to 8 inches (20 cm) deep.

Rattlesnake Spring-downstream station: This sampling station is just above the road crossing, approximately 656 feet (200 m) downstream from the other station. The habitat here varies from sand and gravel to sand, with a plunge pool below a small weir, and a small pool behind the weir. The stream at this crossing is about 5 feet (1.5 m) wide and 6 inches (15 cm) deep. Since these stations are so close, the data from both were combined.

6.3 Methods and Materials

Samples were taken with a “D” ring aquatic net of mesh size 650 microns. The sampler waded into the stream and placed the net downstream. The substrate was disturbed and the current carried the dislodged organisms into the net. Typically, up to 20 feet (6 m) of river bottom was disturbed. The net contents were placed into an enamel pan, carefully cleaned of organisms and removed. The net contents and remaining organisms were preserved with 70% ethyl alcohol, labeled and returned to the laboratory. All adult insects and mollusks, except some Odonata, were placed into 70% ethyl alcohol and labeled. In the laboratory, adults were transferred for permanent storage. Some adult Odonata and Hemiptera were killed, labeled and pinned.

In the laboratory, all organisms were removed, labeled, and stored in 70% alcohol. The sample was checked under a dissecting microscope to ensure complete removal of organisms. All organisms were identified to the lowest possible taxon. A reference collection of all organisms is stored at the museum of the Washington State University/Tri Cities campus Richland, Washington. Taxonomists who identified organisms for this study are listed in the acknowledgement section.

Night collecting trips for adult insects were conducted at the laboratory building and on the access road near the road crossing of Rattlesnake Springs. Mercury vapor and ultraviolet lights were illuminated at dusk and sampling continued until approximately 2 hours after dark. Light sampling continued approximately twice monthly until October. Some adult aquatic insects were also collected from pheromone traps set to collect Lepidoptera.

6.4 Results

Hanford REACH

Fifty-two taxa of aquatic macroinvertebrates were identified during this portion of the study, including 21 not previously documented from the Hanford Reach (Table 6.1), bringing the total number of identified taxa within the Reach to145. A master list of aquatic benthic invertebrates collected on the Hanford Reach, and coded by study is presented in Newell 1998, Table 1.

TRIBUTARIES

With one exception, the benthic fauna of the 4 tributaries represent a microcosm of the river's mainstem fauna. Some organisms were collected here and not in the nearby river including: damselflies-*Argia* and *Enallagma* sp.; and riffle beetles of the family Elmidae. The irrigation return stream at Ringold had the most diverse fauna with 14 taxa collected. All taxa collected in these four locations are listed Newell 1998, Table 3. The fauna in the Ringold hatchery stream was depauperate. Perhaps the hatchery uses or has used some type of cleaning chemical or has reduced stream flows thus negatively impacting the benthic fauna.

SPRINGS

Thirty taxa of benthic invertebrates were collected from Rattlesnake Springs and 12 from Snively Springs, with 25 and 8 representing new Hanford records respectively. This brings the known total for the two sites to 43 and 24 respectively (Table 6.2). Newell 1998, Table 4 lists all aquatic macroinvertebrates captured in Rattlesnake and Snively Springs from all published studies.

6.5 Order by Order Discussion

Highlights of the discussion of important orders are discussed here. Newell (1998) provides details and complete species lists, including comparisons to previous work by order.

EPHEMEROPTERA (MAYFLIES)

Several adult mayflies were captured in the vicinity of the Columbia River (within ½ mile/1 km), but far enough to raise questions as to their habitat, e.g., the Yakima River, irrigation ditches, ponds, etc.

Davis and Cooper (1951) listed 7 taxa from the river. Three of the genera reported by Davis and Cooper (1951) were collected during the current study, *Ephemerella, Stenonema*, and *Baetis* sp. The current study found some previously unreported species from the river; *Acentrella insignificans, Baetis bicaudatus* and *B. tricaudatus, Ephemerella inermis, Ephemera simulans, Heptagenia solitaria, Nixe simplicioides, Stenonema terminatum*, and *Tricorythodes minutus.*

HEMIPTERA (TRUE BUGS)

Adult Corixidae and Notonectidae are excellent flyers and thus their dispersive powers are excellent. Records are from the Hanford Site (Benton County) and the immatures/adults may or may not live in the Columbia River or other Hanford water bodies.

MOLLUSCA (BIVALVES, SNAILS, LIMPETS)

The first published list of Mollusca specifically from the Hanford Reach was that of Davis and Cooper (1951) who listed 4 species of mussels, one limpet and 10 snails. The following Hanford

Reach studies listed mollusca not found by Davis and Cooper (1951): PNL studies (1972-1979a,b,c) listed one new snail; Beak (1980) listed one snail; NPS (1994) listed another snail; Neitzel and Frest (1993) listed yet another snail from springs tributary to the Columbia River-Hanford Reach; and Pauley (1968) listed another mussel. Other Mollusca data from this area of Washington State are found in Burch (1989), Taylor (1975), Clarke (1976,1981), WPPSS (1977, 1984-86) and Hershler et al. (1996). While the A.L.E. springs have been extensively studied, only one mollusc survey has been conducted (Frest et al., 1993), with 5 species collected.

The Columbia River has been extensively modified by man since the research of Davis and Cooper, done in the 1948-50 time period. Many changes have also occurred in the taxonomy of some of the species originally listed as occurring in the Reach. The biodiversity inventory used the taxonomy of Burch (1989), AFS (1988), Hershler et al. (1996), and recent collection records to attempt to determine the current taxonomic status of all mollusca reported in previous reports. Specimens from previous studies were not examined.

TRICHOPTERA

The caddisfly fauna of the Columbia River and the springs is rich and varied. A total of 14 species and 15 genera have been collected from the two springs. Gaines (1987a,b) has published the most complete benthic faunal list from these two springs. He reported two and three genera, respectively, from the spring streams. I found 15 genera and 14 species in Rattlesnake Spring and 2 genera in Snively Spring. The increase in the faunal list from Rattlesnake Springs was due largely to the light sampling after dark (Newell 1998, Table 9). To date, species of two genera have not been captured, *Parapsyche* sp., and *Nectopsyche* sp. Davis and Cooper (1951) reported 17 taxa of caddisflies from the river, 11 of which comprised the 13 taxa collected in this study.

This study collected 12 taxa of caddisflies from the Columbia River. Previous studies over the last 50 years noted 22 taxa. This study found one species not previously reported, *Ceraclea (Athripsodes) annulicornis*. Observations near the river suggest that the net-spinning caddis of the family Hydropsychidae are extraordinarily abundant .

ODONATA

Nymphs of damselflies and dragonflies (Odonata) were rarely encountered in the Columbia River. A single specimen of genus *Ophiogomphus* sp. was collected in 1998. The tributaries and spring streams contained a richer fauna than the river. The tributaries contained two genera of damselflies and the springs contained damsel- and dragonfly nymphs. Many adult Odonata were collected near the benthic sampling stations and elsewhere on the Hanford Site. Adult Odonata are very mobile and the nymphs may have lived miles from the adult collecting sites.

PLECOPTERA

This study collected no stoneflies in the river, tributaries, or the spring streams and no adults were captured anywhere on the Hanford Site. Davis and Cooper (1951) found three species in the river. Only two other studies (Battelle, 1979; WPPSS, 1977) noted Plecoptera (genus and species not listed) in their samples. No stoneflies have been captured in the Reach since 1979.

DIPTERA

The Diptera are a difficult group to identify past the family level in most cases. Becker (1972) did identify one blackfly to species, *Simulium vittatum*. Zack (undated report from 1998 field season) has compiled a list of shoreflies (Family Ephydridae) of the Hanford Site.

Table 6.1 Aquatic invertebrate taxa collected during the 1998 survey of the Hanford Reach of the Columbia River

ORDER EPHEMEROPTERA (Mayflies)	ORDER HEMIPTERA (Aquatic true bugs)
Family Baetidae	Family Corixidae (Water boatmen)
Acentrella insignificans (McD)*	*Sigara washingtonensis* Hungerford*
*Baetis bicaudatus Dodds**	ORDER LEPIDOPTERA (Aquatic moths)
Baetis tricaudatus Dodds*	Family Pyralidae
Family Ephemerellidae	*Petrophila confusalis**
Ephemerella inermis Eaton*	ORDER COLEOPTERA (Beetles)
Family Ephemeridae	Family Dytiscidae (Predacious diving beetles)
Ephemera simulans Walker*	*Dytiscus* sp.*
Family Heptageniidae	ORDER DIPTERA (True flies)
Heptagenia solitaria (McD.)*	Family Chironomidae (Midges)
Heptagenis species.*	Family Simuliidae (Blackflies)
Nixe simplicioides (McD.)*	ORDER ODONATA (Dragonflies and damselflies)
*Nixe species**	Family Gomphidae (Dragonfly)
Stenonema terminatum terminatum (Walsh)*	*Ophiogomphus* sp.*
Family Tricorythidae	ORDER AMPHIPODA (Scuds)
Tricorythodes minutus Traver*	Family Gammaridae
ORDER TRICHOPTERA (Caddisflies)	*Gammarus* sp.
Family Glossosomatidae	ORDER ISOPODA (Isopods/pillbugs)
Glossosoma sp.*	Family Asellidae
Glossosoma velonum Ross 1938	*Caecidotea* sp.*
Glossosoma parvulum Banks 1904	ORDER DECAPODA (Crayfish)
Family Hydropsychidae (Net spinners)	Family Astacidae
Ceratopsyche cockerelli Banks 1905	*Pacifasticus lenisculus towbridgii* (Dana)
Cheumatopsyche sp.	MOLLUSCA (Snails/clams)
Cheumatopsyche campyla Ross 1938	*Corbicula fluminea* (Muller)
Hydropsyche sp.	*Fluminicola* sp.
Hydropsyche californica Banks 1899	*Gyraulus parvus* (Say)*
Family Hydroptilidae (microcaddis)	*Pisidium* sp.*
Hydroptila sp.	*Vorticifex (Parapholyx)* sp.*
Hydroptila argosa Ross 1938	*Radix auricularia* (Linnaeus)*
Family Psychomyiidae	OLIGOCHAETA (Round worms)
Psychomyia flavida Hagen 1861	HYDRACARINA (Water mites)
Family Leptoceridae	BRYOZOA*
Ceraclea annulicornis (Stephens) 1836	

* Indicates taxa identified for the first time on the Hanford Site during this study.

Table 6.2 Aquatic invertebrate taxa collected from springs of the Hanford Site

ORDER	Family	*Species*	Findings
EPHEMEROPTERA		*Baetis tricaudatus**	RS SS
		Callibaetis sp.	SS
TRICHOPTERA		*Cheumatopsyche* sp.	RS SS
		Hesperophylax sp.*	RS
		Parapsyche sp.	SS
COLEOPTERA	Dytiscidae*		RS
		Hydaticus sp.	RS
	Unknown*		RS
	Elmidae*		SS
	Gyrinidae*		RS
	Hydrophilidae		SS
ODONATA		*Aeshna multicolor**	RS
		*Aeshna umbrosa**	RS
		*Archilestes californica**	RS
		Argia sp*	RS SS
HEMIPTERA	Belostomatidae	*Belostoma bakeri**	RS
	Corixidae	*Cenocorixa bifidahungerfordi**	RS
		*Corisella inscripta**	RS
		*Graptocorixa californica**	RS
		*Hesperocorixa laevigata**	RS
		*Sigara alternata**	RS
	Gerridae*		RS
		Notonoectidae*	RS
		*Notonecta kirbyi**	RS
		*Notonecta undulata**	RS
DIPTERA	Chironomidae		RS, SS
	Dixidae		SS
	Simuliidae	*Simulium* sp.	RS, SS
	Tipulidae	*Dicranota* sp.*	RS
AMPHIPODA		*Gammarus* sp.*	SS
		*Hyalella azteca**	RS
DECAPODA		*Pacifasticus lenisculustowbridgii**	RS
MOLLUSCA		*Physella* sp.*.	RS
		Pisidium sp.*	RS
		*Radix auricularia**	RS
	Oligochaeta*		RS

Rattlesnake Spring = RS and Snively Spring = SS; * indicates new Hanford Site record.

6.6 Conclusions and Comparison to Historical Findings

The results of this survey and literature review clearly indicate that the high biodiversity found in upland invertebrate species at Hanford (see Section I this report and associated technical references) is matched by the aquatic fauna. Although the field portion of this survey is considered preliminary and incomplete, the great number of new site records indicates that much remains to be learned about this important natural resource.

This is first study from this area of Washington that examined the tributaries to the Hanford Reach. The tributary fauna differs slightly from the river fauna. This study greatly expanded the knowledge of the invertebrate fauna of the spring streams, especially of the Trichoptera, Odonata, and Hemiptera. For example, the Trichoptera fauna increased from 4 genera recorded in previous studies to 15 genera and 14 species. Only two genera were left without at least one associated species identified. The Odonata and Hemiptera were largely ignored in past studies so this study greatly increased the knowledge of these two orders. The Odonata faunal knowledge was aided by the work of Paulson and R. Zack and the Hemiptera fauna by unpublished data from R. Zack.

The river results are more difficult to interpret. The river fauna described in the 1950 report is different from the 1998 results. This could be attributed to several reasons like habitat changes, collection methods, and the skill of the taxonomists. The Plecoptera seem to have decreased significantly. The mayfly fauna has changed slightly, but this work greatly expanded the known species. The caddisfly fauna has decreased in diversity. The caddisflies are difficult to study due to the sheer numbers of adults found at times. It is very obvious that the net spinning family Hydropsychidae is very successful in the Reach.

The mollusc faunal comparisons are confusing to interpret, due in part to the many taxonomic changes over the last 4 decades. One mollusc species that might require more investigation is the largest freshwater mussel in the state, *Margaritifera falcata*. This large mussel was once very abundant, as evidenced in Indian middens upstream from the study area. This study found no shells but anecdotal comments suggest that this species is still present in the Reach. More extensive survey of the river would help determine the presence or absence of species such as this large mussel.

Except for the Odonata, there is no statewide compendium of species know from Washington. The Plecoptera were last summarized in 1938, the Trichoptera in 1946 and the other oders have not been summarized. Many surrounding states have summarized their aquatic fauna such as: Ephemeroptera-Idaho, Oregon, Montana, and Utah; Trichoptera-Oregon, Montana, and Idaho; Plecoptera-Montana, Idaho; Odonata-Idaho. Without this basic information it is almost impossible to know about new state records and loss of species.

6.7 Inventory Priorities

- An effort to summarize all records of certain aquatic insect groups from Washington State would aid interpretation of the data collected both here an from the historic record.
- The crayfish population seems to have decreased significantly during the last 50 years. No intact specimens were located during this study. Fluctuating water levels undoubtedly impact this organism. The status of this subspecies should be studied.
- More intensive sampling of the river and shoreline should be considered to create a valid current species list. Appropriate taxonomic assistance should be utilized.
- The status of largest freshwater mussel in the state (*Margaritifera falcata)*is unclear within the Reach, and comprehensive surveys should be initiated.

6.8 Management Considerations

- Control of non-native plants both within the Hanford Reach and around associated springs will help protect important habitats dependent on hydrology.
- Ground disturbing activities in riparian areas should be avoided, or when unavoidable, active restoration methods employed, including before and after monitoring.

Section 7 – Herpetofauna

7 Herpetofauna

7.1 Introduction

This section summarizes work found in Hallock 1995 and 1998. Detailed methodology and findings are available with those documents.

7.2 Purpose and Background

Because they are predators, often rely on specific habitats, and are sensitive to environmental degradation, amphibians and reptiles (herpetofauna) can provide information about the ecological condition of a site. Furthermore, there is global concern that amphibians are declining as the result of climate change and/or habitat alteration (Wake and Morowitz 1991; Stebbins and Cohen 1995). Although the land surrounding the Hanford Site has been converted to agriculture, grazing and development at the expense of native vegetation, the Hanford Site is one of the few large tracts of shrub-steppe habitat remaining in Washington, and as such is likely to provide refuge for many species of herpetofauna. This is particularly important for species such as the Woodhouse's toad, sagebrush lizard, striped whipsnake and other species that are rare or have limited distributions in Washington.

Nineteen amphibian and reptile species potentially occur within the boundaries of the Hanford Site (Table 7.1) (Nussbaum et al. 1983; McAllister 1995; Dvornich et al. 1997). Previous surveys have documented fifteen species.

The main goals of these surveys were to search for and document the location of rare species, increase the species list for the site and collect life history information on those species found at the site. Although survey efforts were focused on detection of sensitive species and habitats, occurrences of more common species were also recorded. The information collected was used to make recommendations for management and to establish base-line information for future research and monitoring.

7.3 Previous Work Overview

Prior to 1995, amphibian and reptile research had been conducted mainly through site-specific, small-scale projects (Rickard 1968; Rogers and Rickard 1977; Folliard and Larson 1991) and in conjunction with waste clean up activities. Other reports came from incidental sightings. Summaries of species occurrences vary between reports, especially for amphibians. Most reports list the short-horned lizard, sagebrush lizard, side-blotched lizard, racer, gopher snake, striped whipsnake, night snake and Western rattlesnake (Table 7.1). The painted turtle (Fitzner and Gray 1991; Downs et al. 1993) and the common garter snake were also reported. Location data are vague or absent in many of the reports. No formal study had been conducted on the North Slope, although a brief summary of the amphibians and reptiles found in 1987 and 1989 were documented in "A Fisheries and Wildlife Service Annual Narrative Report" (Radke). No amphibian and reptile species had been documented for the Wahluke Wildlife Area (Fred Dobler, pers. comm. 1995).

Table 7.1 Amphibian and reptile species predicted and documented to occur at the Hanford Site

Species	Predicted	Documented	Documentation Sources
Tiger Salamander (*Ambystoma tigrinum*)	Yes	Yes*	
Pacific Treefrog (*Hyla regilla*)	Yes	Yes	Rogers & Rickard 1977; Gray & Rickard 1989; Fitzner & Gray 1991
Great Basin Spadefoot (*Scaphiopus intermontanus*)	Yes	Yes	Rogers & Rickard 1977; Marr et al. 1988; Gray & Rickard 1989; Fitzner & Gray 1991
Woodhouse's Toad (*Bufo woodhousei*)	Yes	Yes	Gray & Rickard 1989; Fitzner & Gray 1991
Western Toad (*Bufo boreas*)	No	Yes	Gray & Rickard 1989; Rogers & Rickard 1977
Bullfrog (exotic) (*Rana catesbeiana*)	Yes	Yes	Gray & Rickard 1989
Painted Turtle (*Chrysemys picta*)	Yes	Yes	Fitzner & Gray 1991
Western Skink (*Eumeces skiltonianus*)	Yes	No	
Short-horned Lizard (*Phrynosoma douglassii*)	Yes	Yes	Rickard 1972; Rogers & Rickard 1977; Rickard et al. 1988; Marr et al. 1988; Gray & Rickard 1989; Fitzner & Gray 1991; Folliard & Larsen 1991
Sagebrush Lizard (*Sceloporus graciosus*)	Yes	Yes	Rogers & Rickard 1977; Rickard et al. 1988; Marr et al. 1988; Gray & Rickard 1989; Fitzner & Gray 1991; Folliard & Larsen 1991
Side-blotched Lizard (*Uta stansburiana*)	Yes	Yes	Richard 1968, 1972; Rogers & Rickard 1977; Rickard et al. 1988; Marr et al. 1988; Fitzner 1988; Gray & Rickard 1989; Fitzner & Gray 1991; Folliard & Larsen 1991
Common Garter Snake (*Thamnophis sirtalis*)	Yes	Yes	Richard et al. 1988
W. Terrestrial Garter Snake (*Thamnophis elegans*)	Yes	Yes*	
Gopher Snake (*Pituophis catenifer*)	Yes	Yes	Rickard 1972; Rogers & Rickard 1977; Rickard et al. 1988; Marr et al. 1988; Fitzner 1988; Gray & Rickard 1989; Fitzner & Gray 1991; Folliard & Larsen 1991
Racer (*Coluber constrictor*)	Yes	Yes	Rickard 1972; Rogers & Rickard 1977; Rickard et al. 1988; Marr et al. 1988; Fitzner 1988; Gray & Rickard 1989; Fitzner & Gray 1991; Folliard & Larsen 1991
Nightsnake (*Hypsiglena torquata*)	Yes	Yes	Rogers & Rickard 1977; Rickard et al. 1988; Gray & Rickard 1989; Fitzner & Gray 1991; Folliard & Larsen 1991
Striped Whipsnake (*Masticophis taeniatus*)	Yes	Yes	Rogers & Rickard 1977; Rickard et al. 1988; Gray & Rickard 1989; Fitzner & Gray 1991
Ringneck Snake (*Diadophis punctatus*)	Yes	No	
Rattlesnake (*Crotalus viridis*)	Yes	Yes	Rickard 1972; Rogers & Rickard 1977; Rickard et al. 1988; Gray & Rickard 1989; Fitzner & Gray 1991

* A species documented for the first time on the Hanford Site during this study

7.4 Methods

7.4.1 STUDY FOCUS

The 1995 surveys were designed as a site-wide reconnaissance inventory to create a species list for the site and to document the habitats being used. Effort was focused on locating rare, threatened, sensitive and declining species. A smaller herpetofauna inventory was conducted from April to September 1998. It focused on surveying specified habitats, searching for rare species and searching habitats not surveyed in 1995. Specifically, the 1998 surveys focused on locating amphibian breeding sites and searching high-quality habitats for rare species within upland plant communities. The 1998 surveys focussed on Central Hanford, the North Slope and the Hanford Reach. Only one survey was conducted at the Arid Lands Ecology Reserve in 1998. Several revisits were made to sites that were surveyed in 1995 to compare results and consistency of habitat use over time.

7.4.2 LITERATURE AND DATABASE INFORMATION

Literature and database searches were conducted to gather information about the site. Information was requested from the University of Michigan, Michigan State University and WDFW. Biologists at Battelle Pacific Northwest Laboratory and other biologists familiar with Hanford were contacted for information.

7.4.3 SAMPLE SITE SELECTION AND DATA COLLECTION

Potential sample sites were chosen based on maps, habitat type and field visits (Figure 7.1). For each animal found, information was collected on life history, location, weather, habitat and microhabitat.

7.4.4 SAMPLING METHODOLOGY

One hundred six days of field work were conducted during the two years. Eighty-three days were spent in the field (Table 7.2) in 1995, between March 3 and October 15. The 1998 surveys began April 17 and ended September 6, with 23 days spent in the field.

Many techniques have been described for the inventory and monitoring of amphibian and reptile populations (Gibbons & Semlitsch 1981; Heyer et al. 1994; Olson et al. 1997). Each method varies in its detection success for certain species, cost, effort and feasibility for individual habitats. To optimize the number of detections, this inventory used eight techniques.

Visual Encounter Surveys (VES) – involve systematically walking through an area, searching for animals on the surface, in vegetation and under objects. This method is used to determine species richness of an area and relative abundance. VES works under diverse conditions and is especially useful in detecting the presence of a variety of species in a relatively short period, but may not detect more secretive or fossorial (burrowing) species. Attempts were made to perform VES during optimal times to encounter desired species. When necessary and possible, animals were captured, but most identification was made visually. VES were conducted daily during each visit to the site for both terrestrial and aquatic habitats.

Drift Fences – form artificial barriers that are used to direct animals into a trap (Fitch, 1987). Drift fences can be useful in detecting secretive or rare species. Disadvantages include the expense, limited sample area and the number of animals that die in the traps. Previous Hanford studies have used drift fence arrays (Fitzner 1988; Marr et al. 1988; Folliard and Larsen 1991).

Table 7.2 Results of herpetofauna surveys by method

Species	VES	DF	PT	CB	CS	DR	NR	AFT
Western Rattlesnake	X	X				X		
Racer	X	X		X				
Night Snake							X	
Gopher Snake	X						X	
W. Terrestrial Garter Snake	X							
Side-Blotched Lizard	X		X	X		X		
Sagebrush Lizard	X	X		X		X		
Short-horned Lizard	X							
Painted Turtle	X							
Bullfrog*	X				X			X
Woodhouse's Toad	X	X			X		X	X
Great Basin Spadefoot	X	X	X		X		X	X
Tiger Salamander	X							

* = non-native species;

No herpetofauna species were detected using seining during this survey.

VES: visual encounter survey; DF: drift fence; PT: pitfall trap; CB: cover board; NR: night road survey; CS: call survey; DR: day road survey

Drift fence arrays were installed in three places during 1995 (Hallock 1995). One was located in Bobcat Canyon (ALE) along the base of a talus slope. On SMNWR, an array was set at the western end of the White Bluffs and another was set on a sand dune near wasteway Pond 15.

Pitfall Traps – are smooth walled containers deep enough to trap the animals being surveyed. The containers are placed in the ground flush with the surface. Rickard (1968) and Fitzner (1988) used pitfall traps to capture lizards on the Hanford Site.

In 1995, one 4 x 4 pitfall grid was installed on the eastern end of the SMNWR in a sagebrush (*Artemisia tridentata*) and rabbit-brush (*Chrysomthamnus* sp.) habitat where no lizards had been found during VES surveys.

Cover Boards – are pieces of wood, metal or other materials placed in an area to attract amphibians and reptiles. Cover boards are especially attractive to lizards and snakes that use the boards for ecdysis, thermal buffering and hiding cover.

Thirty-nine plywood boards, 50 x 80 cm, were placed in five locations. Sites included: the bank above the Columbia River at the Central Hanford boat launch/field station; the southwest end of Gable Mountain (CH); the "central ponds" area of the WWA; the Yakima Barricade area (ALE), and at the crossroads south of Benson Ranch (ALE). Other boards, or large debris already in these areas, were also checked.

Call Surveys – vocalization is an important part of the breeding behavior of most species of anurans. Males "call" during the breeding season to advertise their location. The calls are species-specific (Porter 1972), and can be used to locate breeding habitat, determine species composition, record breeding phenology and estimate the relative abundance of adult males (Zimmerman 1994). Males of some species also produce sporadic territorial calls outside of the breeding season (e.g. Pacific treefrog, bullfrog).

Call surveys were used to identify anurans and to locate breeding habitats. Potential breeding sites were located using topographic maps. Roads paralleling bodies of water were driven with periodic stops to listen for calls. Where possible, the call areas were revisited and surveyed to collect information on habitat and to search for eggs and larvae.

Call surveys were conducted in both 1995 and 1998.

- ALE – Lower Snively Springs and along Dry Creek.
- SMNWR – Along the wasteway pond system and Saddle Mountain Lake.
- WWA – Ponds in: the boat launch area, the central portion of the site, near Highway 24, the Ringold area. At WB-10 Lake and along the irrigation wasteway canal draining WB-10 Lake and flowing to the boat launch area.
- Central Hanford – Five Columbia River sloughs and at West Lake.

Road Surveys – night road surveys are an effective survey method under correct conditions (Fitch 1987; Shaffer & Juterbock 1994) and can yield species not detected by other methods (Klauber 1939). The main advantages of this method are long distances can be surveyed quickly and it facilitates finding nocturnal species.

Aquatic Funnel Trapping (AFT) – is effective in measuring presence and relative abundance of aquatic amphibians (Richter 1995; Adams et al. 1997). "Pop bottle traps" were made using 2-liter plastic beverage bottles and used in June, 1995. Locations included Dry Creek at Benson Ranch

(ALE), wasteway ponds (SMNWR), a wetland (SMNWR), WB-10 Lake (WWA), and the "northern ponds" (WWA). Commercially available collapsible mesh minnow traps were used in 1998. Traps were set in June, July and August. Locations were at West Lake (CH), a Columbia River slough near the old school house (CH) and a pond in the Ringold fish hatchery area.

Seines – have been used successfully in eastern Washington to catch tiger salamanders and long-toed salamanders in ponds and irrigation wasteways (Fred Dobler, pers. comm). Seining was attempted in 1995. The seining was haphazard due to difficulties encountered including thick vegetation, deep water and unstable shores (deep mud). The seine was used at WWA in a Columbia River slough near Ringold, part of WB-10 Lake and in the "northern ponds." Seining at SMNWR included ponds along the irrigation wasteway and two ponds near the Columbia River.

7.5 Results

With all methods and management areas combined, four amphibian and nine reptile species were found during the 1995 and 1998 inventories (Tables 7.2, 7.3). Two species, the tiger salamander (*Ambystoma tigrinum*) and the Western terrestrial garter snake (*Thamnophis elegans)*, were reported for the first time on the Hanford Site. The other species observed included the Great Basin spadefoot (*Scaphiopus intermontanus*), Woodhouse's toad *(Bufo woodhousei*), bullfrog (*Rana catesbeiana*), painted turtle (*Chrysemys picta*), short-horned lizard (*Phrynosoma douglassii*), sagebrush lizard (*Sceloporus graciosus*), side-blotched lizard *(Uta stansburiana*), racer (*Coluber constrictor*), gopher snake (*Pituophis catenifer*), Western rattlesnake (*Crotalus viridis*) and night snake (*Hypsiglena torquata*). Three Washington State Monitor species (Woodhouse's toad, tiger salamander and night snake) and a Federal Species of Concern (sagebrush lizard) were found at the site.

Eight herpetofauna species were found on ALE, 11 on Central Hanford, 9 on the SMNWR and 12 on the WWA. Relative abundance, status and site location for each species is listed in Table 7.3. Relative abundance is speculative. It is based on the ease of detection under appropriate conditions and habitat for each species, the numbers found and the distribution throughout the site.

Table 7.3 Species list for the Hanford Site by management area

Common Name	Status	Relative Abundance at Hanford	ALE	CH	SMNWR	WWA
Tiger Salamander	State Monitor	unknown				X
Great Basin Spadefoot	None	locally common	X	X	X	X
Woodhouse's Toad	State Monitor	locally common		X	X	X
Pacific Treefrog	None	unknown				
Bullfrog	Introduced	common		X		X
Painted Turtle	None	unknown				X
Short-horned Lizard	None	uncommon	X	X	X	X
Sagebrush Lizard	Federal Sp. of Concern	common in sandy areas		X	X	X
Side-blotched Lizard	None	abundant	X	X	X	X
Racer	None	common	X	X	X	X
Night Snake	State Monitor	rare	X	X	X	
Striped Whipsnake	State Candidate	rare	X	X		
Gopher Snake	None	common	X	X	X	X
W. Terrestrial Garter Snake	None	unknown				X
Common Garter Snake	None	unknown				
Rattlesnake	None	common	X	X	X	X
TOTAL			8	11	9	12

Six hundred and six (606) individual amphibian and reptile records were entered during the 1995 and 1998 surveys. Although field work started in the first week of March 1995, with the exception of side-blotched lizards, no amphibians or reptiles were detected until the last week of March. Temperatures at ALE were below freezing at night and shallow springs still had ice. Most species were still being found in mid-October 1995. Spatial distribution maps for each species are presented in Figure 7.1.

Table 7.3 lists each species reported to occur on the Hanford Site, the Washington State and federal status, the property where each species was found and the relative abundance of each species. This table includes species that were not found during this inventory, but were reported from other sources. Detailed discussion of results by sampling method, abundance, distribution and life history traits for each species and by major group (reptile/amphibian) are provided in Hallock 1995 and 1998.

The Pacific treefrog (*Hyla regilla*), Western toad (*Bufo boreas*), Western skink (*Eumeces skiltonianus)*, striped whipsnake (*Masticophis taeniatus*) and common garter snake (*Thamnophis sirtalis*), species reported or predicted to occur on the site or in the vicinity, were not found in 1995 or 1998. Speculation, on the occurrence of these species and other species that may occur at the site, is discussed below and in more depth in Hallock 1998.

7.6 Discussion

Amphibians and reptiles are vulnerable to habitat alteration, especially those that affect reproduction and hibernation sites. The Hanford Site is one of the few large tracts of shrub-steppe habitat remaining in Washington and appears to provide an important refuge for amphibian and reptile populations. It is particularly important for species such as the Woodhouse's toad, sagebrush lizard, striped whipsnake and others that are rare or have limited distributions in Washington.

This is the first herpetofauna inventory to cover the entire Hanford Site. Results from this inventory and other studies have found 16 species. The Western terrestrial garter snake and tiger salamander were found for the first time in 1995 and 1998 respectively. The possibility still remains that other species may be found.

Three Washington State Monitor species (Woodhouse's toad, tiger salamander and night snake) and a Federal Species of Concern (sagebrush lizard) were found at the site. The striped whipsnake, a State Candidate Species, was not found, but is previously documented from the site. The majority of sightings reported for the Woodhouse's toad in Washington are from Hanford. Tiger salamanders were found in ponds at the base of the White Bluffs (WWA) and may be found elsewhere at the site. Night snakes are present and widespread, but are rarely detected. Sagebrush lizards are common on sand dunes on all properties except ALE.

Unusual weather conditions in 1995 may have influenced the survey results, particularly for anurans. It was the wettest year on record at the Hanford Site (Dana Hoitink pers. comm.) and temperatures were generally mild. As a result, anurans may have been more surface-active than normal. Dry Creek (ALE) extended past the Benson Ranch area killing the sagebrush and creating wetland areas. Great Basin spadefoots started calling as an area became flooded and tadpoles were found throughout the newly flooded areas.

The most notable difference between the 1995 and 1998 surveys was a decrease in side-blotched lizards in 1998 relative to 1995. In 1995, this species was abundant. and was easy to detect because they tended to occur in high densities. In 1998 they were much more difficult to find and were found in smaller numbers. The difference in rainfall between 1995 and 1998 may be the reason for the change. Observations on roads at night were also lower in 1998 than 1995. Snakes and anurans were found 81% of the time in 1995, but only 64% of the time in 1998. This probably had more to do with the roads that were driven than an actual change in the number of animals on the roads. In 1995, more time was spent on roads next to water bodies (SMNWR and ALE in particular) resulting in many toad and spadefoot observations.

7.7 Management Recommendations

The following recommendations, based on the results of the inventory will help maintain the diversity of the Hanford herpetofauna.Maintain undisturbed habitat corridors around springs, wetlands, ponds and sloughs. These are important habitats for amphibians, garter snakes and turtles.

1. Discourage night driving on the gravel roads that parallel the SMNWR irrigation wasteway ponds and Dry Creek (ALE), especially during the Woodhouse's toad and Great Basin Spadefoot breeding season (April) and fall dispersal (September) period. In April 1995, the SMNWR wasteway road averaged one adult toad every 1/10 mile.
2. Protect talus slopes and the western end of the White Bluffs. These areas are rattlesnake hibernation sites and may be used by other snakes. Rattlesnakes, racers, gopher snakes and striped whipsnakes can hibernate together, and show high fidelity to den sites.

3. Protect sand dune habitats. Sagebrush lizards were found almost exclusively in association with vegetated sand dunes. In addition, Woodhouse's toad, Great Basin spadefoot, short-horned lizard, side-blotched lizard, racer, gopher snake and rattlesnake occur in dune habitats.
4. Striped whipsnake hibernation den sites need to be located and protected. This species is rare and difficult to find. Field crews working on other projects should be encouraged to report striped whipsnakes if they encounter them. A radio-telemetry study of this species should be conducted to determine habitat use and den site location.
5. Develop and encourage the use of a standard sighting form for incidental observations of amphibians and reptiles that includes detailed location information. Maintain a database (or submit data to the Washington Department of Fish and Wildlife Herpetological database) of sightings, particularly of amphibians, rare species and new species to the site.
6. Amphibian populations should be monitored regularly. The following are potential threats to these populations at the Hanford Site, each justifies a regular monitoring program.
    - Fluctuating water levels in the Columbia River sloughs as a result of irrigation flows, causes rapid flooding and drying of ponds and egg mortality.
    - Irrigation return flows contaminated with pesticides and herbicides has been suggested as a cause of amphibian declines.
    - Increasing bullfrog populations on the WWA and in Central Hanford sloughs. Bullfrogs have been implicated as one of the causes of decline of some western frog species. The irrigation wasteway system provides travel corridors for a variety of aquatic species. Many of these species, including bullfrogs, may be detrimental to the native herpetofauna.

7.8 Inventory Recommendations

- Continued inventory of all areas is still likely to be productive, especially within Central Hanford.
- Inventory efforts should be enhanced for the striped whipsnake.
- Statistically valid sampling to produce comparisons between different habitat types and ecological conditions will greatly assist management decision making, as well as enhance knowledge of the biology of herpetofauna of the site.

Section 8 – Small Mammals

8 Small Mammals

8.1 Introduction

The sections below provide information on bat surveys conducted across the Hanford Site, other small mammal surveys conducted on Central Hanford and the North Slope, and more focused surveys for pygmy rabbits and Washington ground squirrels conducted in 1997 and 1998. More detailed information on these topic areas can be found in Marr (1997) and West et al. (1998, 1999).

8.2 Bats

8.2.1 Purpose and Scope

Because of a history of misperception regarding their behavior and role in natural ecosystems, as well as the difficulty in collecting information about them, bats are often under-studied and under appreciated. Historical perception not withstanding, bats are an important part of many ecosystems. They provide a measure of control on flying insects, cycle nutrients and pollinate some plant species. Finally, because they rely on specific and limited habitats for portions of their life-cycle, and are long-lived with a low reproduction rates, there is concern that some bat populations may be declining in Washington. Nine bat species potentially found at Hanford are Species of Conservation Concern in Washington.

Published information on the occurrence of bat species on the Hanford Site is limited. Fitzner and Gray (1991) summarized information on those bat species known to have frequented the Hanford environs through 1989. Much of the sighting information was poorly documented, leaving some observations in doubt. Becker (1993) reported the results of more recent surveys of retired reactor and other buildings for evidence of roosting bats, and summarized Hanford Site animal control operations data from 1991–1993 for bats recovered as carcasses or relocated from buildings. These previous studies documented the presence of up to nine species; seven other species are potentially present (Table 8.1; Sarell and McGuinness 1993). Many of the documented species and species potentially present are identified as species of conservation concern by Washington State and/or the federal government (Table 8.1; USFWS 1998, WDFW 1997). The purpose of the 1997 and 1998 inventory effort was to update and supplement information on the occurrence of bats on the Hanford Site.

8.2.2 Methods

General

Echolocation surveys were used to inventory bat species groups and compare bat activity between roosting and foraging habitat. Direct capture of bats was used to confirm species identity. Ultrasonic detection devices (i.e., Anabat II detectors) were used for the echolocation surveys. Surveys were conducted in association with nine different land cover types for which the dominant habitat feature can be summarized as follows: building, bunchgrass, cheatgrass, pond, river bank, rock outcrop/cliff, shrub (sagebrush), sand dune, and tree. Although several of these cover types (e.g., tree, building, etc.) are a result of human activities, they were included because of their potential use by some bat species. A survey night was considered valid only if the entire night was sampled (i.e. no interruption due to equipment or weather).

Table 8.1 Status, historic occurrence, and biodiversity inventory findings for small mammal species potentially present at the Hanford Site

Common Name	Scientific Name	Washington State Status / Fed. Status	Historic Occurrence at Hanford[$]	Survey Method	Encountered in 1997/1998
Bats					
Big brown bat	*Eptesicus fuscus*		Undocumented	Echolocation Harp trap, Mist net	Yes
Big free-tailed bat	*Nyctinomops macrotis*		Undocumented	As above	No
California myotis	*Myotis californicus*		Confirmed?	As above	Possible
Fringed myotis	*Myotis thysanodes*	Monitor	Undocumented	As above	No
Hoary Bat	*Lasiurus cinereus*		Confirmed	As above	Yes
Little brown myotis	*Myotis lucifugus*		Confirmed	As above	Yes
Long-eared myotis	*Myotis evotis*	Monitor	Undocumented	As above	No
Long-legged myotis	*Myotis volans*	Monitor	Confirmed	As above	No
Pale Townsend's big-eared bat	*Corynorhinus* (=*Plecotus*) *townsendii pallescens*	Candidate / SC	Undocumented	As above	No
Pallid bat	*Antrozous pallidus*	Monitor	Confirmed	As above	Yes
Red bat	*Lasiurus blossevillii* (formerly included in *L. borealis*)	Monitor	Undocumented	As above	No
Silver-haired bat	*Lasionycteris noctivagans*		Confirmed	As above	Yes
Spotted bat	*Euderma maculatum*	Monitor	Undocumented	As above	No
Western pipistrelle	*Pipistrellus hesperus*	Monitor	Confirmed	As above	Yes
Western small-footed myotis	*Myotis ciliolabrum* (formerly included in *M. leibii*)	Monitor	Confirmed	As above	Yes
Yuma myotis	*Myotis yumanensis*		Confirmed	As above	Yes

Common Name	Scientific Name	Washington State Status / Fed. Status	Historic Occurrence at Hanford[$]	Survey Method	Encountered in 1997/1998
Rabbits					
Black-tailed jack rabbit	*Lepus californicus*		Confirmed	Incidental, Spotlight	Yes
Mountain cottontail	*Sylvilagus nuttallii*		Confirmed	Incidental, Spotlight, Sherman pitfall	Yes
Pygmy rabbit	*Brachylagus* (=*Sylvilagus*) *idahoensis*	Endangered / SC	Confirmed	Incidental Visual (transect & meandering surveys)	No
White-tailed jack rabbit	*Lepus townsendii*		Confirmed	Incidental, Spotlight	Yes
Rodents					
American beaver	*Castor canadensis*		Confirmed	Incidental	Yes
Bushy-tailed woodrat	*Neotoma cinerea*		Confirmed	Tomahawk trap	Yes
Common porcupine	*Erethizon dorsatum*		Confirmed	Incidental	Yes
Deer mouse	*Peromyscus maniculatus*		Confirmed	Snap trap, Sherman pitfall	Yes
Great Basin pocket mouse	*Perognathus parvus*		Confirmed	Snap trap, Sherman pitfall	Yes
House mouse	*Mus musculus*	Introduced	Confirmed	Snap trap, Sherman pitfall	No
Least chipmunk	*Tamias minimus*		Confirmed	Snap trap, Sherman pitfall, tomahawk	No
Montane vole	*Microtus montanus*		Confirmed	Snap trap, Sherman pitfall	Yes
Muskrat	*Ondatra zibethicus*		Confirmed	Incidental	No
Northern grasshopper mouse	*Onychomys leucogaster*	Monitor	Confirmed	Snap trap, Sherman pitfall	Yes
Northern pocket gopher	*Thomomys talpoides*		Confirmed	Incidental	Yes (sign)
Norway rat	*Rattus norvegicus*	Introduced	Confirmed	Incidental, Sherman pitfall	No

Table continued on next page

Common Name	Scientific Name	Washington State Status / Fed. Status	Historic Occurrence at Hanford[$]	Survey Method	Encountered in 1997/1998
Rodents, continued					
Ord's kangaroo rat	*Dipodomys ordii*	Monitor	Undocumented	Rat trap, Tomahawk trap, Sherman pitfall, Visual	No
Sagebrush vole	*Lemmiscus* (=*Lagurus*) *curtatus*	Monitor	Confirmed	Snap trap, Sherman pitfall	Yes
Townsend's ground squirrel	*Spermophilus townsendii*		Confirmed	Incidental, Tomahawk trap, Visual (transect survey)	No
Washington ground squirrel	*Spermophilus washingtoni*	Candidate / SC	Undocumented	Incidental, Tomahawk trap, Visual (transect survey)	Yes
Western harvest mouse	*Reithrodontomys megalotis*		Confirmed	Snap trap, Sherman pitfall	Yes
Yellow-bellied marmot	*Marmota flaviventris*		Confirmed	Incidental	No
Shrews					
Merriam's shrew	*Sorex merriami*	Candidate	Confirmed	Snap traps, Sherman pitfall	No
Vagrant shrew	*Sorex vagrans*		Confirmed	Snap traps, Sherman pitfall	No

SC = federal Species of Concern (USFWS 1998).

[$]Historic occurrences are taken from Fitzner and Gray (1991). There is a possibility the California myotis documented by Fitzner and Gray (1991) was a misidentified Western small-footed myotis. The pygmy rabbit population present on the ALE Reserve before 1984 is thought to have been extirpated (Fitzner and Gray 1991).

Direct capture using mist nets and harp traps was used to verify species presence and provide demographic information on bats in the study area. Standard measurements were obtained from all captured specimens. Once identified, all bats were released at the point of capture and their echolocation calls recorded for inclusion in a reference call library. Detailed methodology including identifiaction guidelines for hard to identify species is provided in West et al 1998.

SPECIFIC METHODS BY YEAR

1997

Echolocation – Sampling was directed towards maximizing chances to locate and document all species present on the site. Multiple locations (usually 5 or 6), selected to ensure representation across the Hanford Site, were sampled for each identified cover type (Figure 8.1). Surveys began at dusk and continued for eight hours or until dawn. Most locations were surveyed from four to six times each during the summer (total of 274 survey nights covering 46 sample locations). Although attempts were made to obtain 4-6 valid sampling nights (see above), this was not possible at all locations.

Direct Capture – Seventeen locations, located in close proximity to locations used for the echolocation surveys, were trapped during August and early September (total of 79 trap nights). Mist nets and harp traps were placed in potential flyways along streams, ponds, and roads, as well as by potential roosting sites near buildings and tree clumps. Most trapping occurred within Central Hanford (Figure 8.1).

1998

Echolocation – Surveys were targeted at a relatively small number of sites expected to be heavily used by for roosting or foraging. Survey efforts were directed towards locating spotted bats, pallid bats, Townsend's big-eared bats and other non-myotis species, rather than the general survey approach taken in 1997. Detectors were generally moved from a location after a valid survey night was obtained.

For this study, eleven categories of call types were recognized. These were associated with the following species:

1. Myotis group (*M. californicus*, *M. ciliolabrum*, *M. evotis*, *M. lucifugus*, *M. thysanodes*, *M. volans* and *M. yumanensis*)
2. Big brown bat
3. Silver-haired bat
4. Big brown/silver-haired bat (calls undistinguishable between Type 2 or Type 3)
5. Hoary bat
6. Townsend's big eared bat
7. Western red bat
8. Western pipistrelle
9. Pallid bat
10. Spotted bat
11. Big free-tailed bat

Due to brevity of detection or questionable identity, an additional category of "unknown bat" was also recognized.

Direct Capture – Twelve sites were trapped during July - early September for a total of 56 trap nights. Targets included tree groves along the Columbia River, gullies in the White Bluffs, and the Hanford Townsite Pumphouse. Both mist-net and harp traps were used.

Auditory-Visual Surveys – Because spotted bats are audible to human ears, auditory and visual searches were performed for this species. Surveys were conducted around cliffs, the Columba River and the White Bluffs.

8.2.3 FINDINGS

ECHOLOCATION

A total of 6470 bat echolocation calls were recorded during valid survey nights (4414 in 1997, 2056 in 1998), with an additional 230 calls recorded during invalid surveys (Table 8.2). Because the echolocation calls of certain species were not distinguishable, detections were grouped into categories based on similar call characteristics. These could be associated with a particular species or group of species based on comparisons to calls of known identity. Five species of bats were identified based on detection and analysis of these calls: big brown bat, hoary bat, pallid bat, silver-haired bat, and western pipistrelle. Additionally, calls representing the *Myotis* genus of bats also were detected (the most common species group detected); however, many of the calls of the individual members of this genus are similar enough to preclude an unambiguous identification of individual species (Thomas and West 1989). Pallid bats were detected in highest numbers at the F-reactor and dunes above the White Bluffs, but also at the cliffs along Umtanum Ridge. Western pipistrelles were detected in nearly every rock site and at every White Bluffs location.

Table 8.2 Total number of calls recorded for each species group during valid surveys

Taxa	1997 Counts	1998 Counts	1997-1998 Total
Myotis group (MYGR)	2,775	1600	4,375
Big brown bat (EPFU)	60	46	106
Silver-haired bat (LANO)	41	5	46
Big brown / silver-haired bat	93	10	103
Hoary bat (LACI)	52	21	73
Western pipistrelle (PIHE)	98	110	208
Pallid bat (ANPA)	192	141	333
Unknown bat	1,103	123	1,226

Overall, bat activity was highest in roosting habitats (i.e., buildings, rock outcrops, and trees), next highest in riparian (foraging) habitats (i.e., ponds and river banks), and lowest in shrub-steppe cover types (i.e., bunchgrass, cheatgrass, shrub, and sand dune). The echolocation findings and the capture of post-lactacting females are consistent witht Becker's (1993) observation that the 100-F Reactor Building may serves as a roosting site for pallid bats.

8.2.4 DIRECT CAPTURE

Direct capture of bats was successful at 12 of the 29 trap locations. Eighty-six captures were made of 81 individual bats (28 in 1997, 58 in 1998). All but six captures were in harp traps. Five species were positively identified (Table 8.3). Two sets of species, California myotis (MYCA) / western small-

footed (MYCI), and the little brown myotis (MYLU) / Yuma myotis (MYYU) are difficult to distinguish from teach other (Nagorsen and Brigham 1993. Three bats were captured that could have been either one of MYCA / MYCI. Twenty-three were captured that could have been either MYLU / MYYU. Identification procedures are detailed in West et al 1998.

Table 8.3 Bat species directly captured during biodiversity inventory sampling efforts

Species	1997	1998	Total
Western small footed myotis (MYCI)*	8	2	10
California / Western small-footed myotis (MYCA / MYCI)	2	1	3
Little brown myotis (MYLU)	1	25	26
Yuma myotis (MYYU)	3	1	4
Little brown / Yuma myotis (MYLU / MYYU)	10	13	23
Myotis species (MYsp)	0	1	1
Silver-haired bat (LANO)	3	0	3
Pallid bat (ANPA)*	1	15	16
Total	**28**	**58**	**86**

* Indicates state Monitor species

Bats were successfully captured at 6 habitat categories: buildings (11), cliffs (9), 100-D/DR water intake hatch (4), planted trees (71), riparian areas (37) and White Bluffs (3). The MYLU / MYYU group was most frequently captured in human created areas, while the MYCA / MYCI group accounted for the most captures in "natural" areas. Interpretation of capture rates must be done cautiously. Because bats are skilled flyers, they are difficult to trap. As a result the high capture rates in certain areas may reflect the ease of capture, rather than higher relative use of that particular area.

8.2.5 AUDITORY - VISUAL SEARCHES

No spotted bats were detected during auditory-visual surveys. Pallid bats were observed at 108-F, Umtanum Ridge and the White Bluffs. Bats were most frequently observed flying in or adjacent to several likely roosting areas, including: Umtanum Ridge cliffs, the White Bluffs, the Hanford town site pump house, reactor 108-F, and the 100-D/DR reactor water intake tunnel.

8.2.6 ALL METHODS COMBINED

Based on the combined echolocation and direct capture findings, a total of eight species were documented on the Hanford Site during 1997-1998 with the possibility that one other species also occurred (Table 8.1). Three of the documented species and the possible species are identified as species of conservation concern by the U.S. Fish and Wildlife Service (USFWS 1998) and / or the Washington Department of Fish and Wildlife (WDFW 1997). As expected, cliff areas and open water were recognized as hot spots of bat activity. More ironically, several man-made structures appear to serve as valuable bat habitat as well. The White Bluffs are likely roosting habitat for at least three monitor species (western small-footed myotis, pallid bat and western pipstrelle). The 108-F bilding, Hanford town site pump house and other buildings on Central Hanford may be roost sites for large numbers of pallid bats and Myotis species.

8.3 Small Mammals

8.3.1 PURPOSE AND SCOPE

Small mammals play important, but often unappreciated roles in ecosystem functioning. They turn soil, increase water infiltration, provide habitat and serve as prey base for carnivores such as raptors, owls and snakes. They are also highly responsive to changes in vegetation or land management. With a few exceptions, the species of small mammals present on the Hanford Site have been well documented (Downs et al. 1993, Fitzner and Gray 1991, Rickard and Poole 1989), although the North Slope has historically been less well studied than either ALE or Central Hanford. Several documented species or species potentially present on the Hanford Site are identified as species of conservation concern by Washington State and/or the federal government (Table 8.1; USFWS 1998, WDFW 1997).

Ord's kangaroo rat has yet to be documented on the Hanford Site. The published Washington distribution of this species does not include the Hanford Site nor areas north of Hanford (Johnson and Cassidy 1997); however, during 1997 the presence of the species was confirmed in the Crab Creek Wildlife Area north of the Saddle Mountains (West et al. 1998, 1999). Additionally, although they did not confirm the presence of Ord's kangaroo rat, Payne et al. (1976) reported observing its tracks near the Priest Rapids Dam. Although Merriam's shrew, northern grasshopper mouse, and sagebrush vole frequently have been captured in previous Hanford studies, few captures of Merriam's shrew and sagebrush vole have been reported outside of the ALE Reserve. The pygmy rabbit and Washington ground squirrel are addressed mostly in Section 8.4 below.

The purposes of the 1997 and 1998 inventory effort were to:

1. Inventory areas that received little or no sampling effort in previous studies;
2. Determine whether and where six species of conservation concern (i.e., Ord's kangaroo rat, Merriam's shrew, northern grasshopper mouse, pygmy rabbit, sagebrush vole, and Washington ground squirrel) occur on Central Hanford and the North Slope;
3. Determine the status of species previously identified as relatively common at Hanford (e.g., black-tailed jackrabbit and Townsend's ground squirrel); and
4. Compare species occurrence and relative abundance across the major plant community types of Central Hanford and the North Slope.

8.3.2 METHODS

GENERAL OVERVIEW

Walking and driving (day and night) surveys and a variety of trapping techniques were employed throughout Central Hanford and the North Slope in an effort to categorize species presence and absence across a broad range of habitat (community) types and in areas of special interest (Table 8.4). Although the surveys targeted all small mammals, special focus was placed on identifying the presence of sagebrush vole, Washington ground squirrel, northern grasshopper mouse, Merriam's shrew and pygmy rabbits. Surveys in 1997 used mostly snaptrap transects, while 1998 surveys used pitfall, Sherman and Tomahawk grids and transects (Table 8.5).

1997

In 1997, species occurrence and relative abundance was compared across a broad range of community types and areas of special interest on Hanford. Goals for small mammal surveys were:

1. To inventory areas that received little or no sampling effort in previous studies,
2. To determine whether and where three species of special concern (the sagebrush vole, the northern grasshopper mouse, and Merriam's shrew) occur on Central Hanford and the North Slope, and
3. To compare species occurrence and relative abundance across the major plant community types of Central Hanford and the North Slope.

Several areas were identified as deserving special survey focus. These areas included habitat patches we considered most likely to support sagebrush voles and Merriam's shrews (higher elevation sagebrush/bunchgrass patches). The study focused on major plant community types and cover types as identified by previous TNC and DOE surveys. At least three sampling units in each community type were chosen though an equal number of locations in each community type were not sampled. More widespread community types (especially big sagebrush-dominated sites) received proportionately more sampling effort. In three community types, less than three locations were sampled due to time constraints.

Snap trap surveys to inventory shrews, mice, and voles were conducted in areas and plant community types of conservation interest on Hanford (i.e., native plant communities and specialized habitat areas such as dune fields) (Table 8.4). Trapping locations included those habitat patches considered most likely to support sagebrush voles and Merriam's shrews (i.e., higher elevation sagebrush / bunchgrass patches). Generally, at least three sample locations were trapped within each community type considered; however, a few community types received less sampling and the more widespread community types — especially areas dominated by big sagebrush (*Artemisia tridentata*) — received proportionally more sampling effort. At each sample location, a 1640 ft (500 m) long transect line was established — chosen randomly or selectively when patch size precluded random placement — along which trap stations were placed at about 32-ft (10-m) intervals (for a total of 50 trap stations per transect). Two Museum Special snap traps were placed within 3–10 ft (1–3 m) of each trap station. When possible, one trap at each station was placed near a cover object (e.g., a shrub or rock) and the other trap was placed in the open. Traps were baited with a mixture of peanut butter and oats. Each transect was trapped for a minimum of three nights. Forty locations were trapped for a total of 132 nights of sampling (13,200 trap nights).

Table 8.4 Hanford areas targeted as priorities for small mammal sampling, important habitat elements and potential small mammal species of special interest

Area	Important Habitat Elements	Potential Small Mammal Species of Special Interest
Central Hanford: Gable Mountain area	Bluebunch wheatgrass, stiff sagebrush, big sagebrush	Sagebrush vole, Merriam's shrew, and least chipmunk
Central Hanford: Hanford Dunes	Active dunes, bunchgrass	Northern grasshoper mouse
Central Hanford: Umtanum Ridge	Bluebunch wheatgrass, stiff sagebrush, big sagebrush	Sagebrush vole, Merriam's shrew and least chipmunk
North Slope: general	Dune/ricegrass, bunchgrass, big sagebrush	Northern grasshopper mouse and Ord's kangaroo rat
North Slope: Saddle Mountain crest	Bluebunch wheatgrass / needle-and-threadgrass	Sagebrush vole, Merriam's shrew, and Least chipmunk

Table 8.5 Summary of small mammal sampling, 1997-1998 (does not include trapping targeting ground squirrels)

Year	Trapping method	Number of Sites	Number of Trapnights
1997	Snaptrap transects	40	13,200
1998	Pitfall transects	6*	851
1998	Sherman trap transects	6*	2,394
1998	Sherman grid (12 x 12, Umtanum Ridge, targeting LECU)	1	576
1998	Sherman grid (16 x 16, targeting ONLE)	3	3,840
1998	Sherman dune transects	1	240
1997-1998	Tomahawk cliff transects	16	217
Total		**68**	**21,330**

*Pitfall and Sherman trap transects were on the same sites.

Ord's kangaroo rat primarily inhabits areas with sandy soils (Garrison and Best 1990). Search efforts for this species focused on bat echolocation or snap trap locations associated with sandy / dune areas near the White Bluffs, north of Saddle Mountain Lake, and west of Vernita Bridge. Additionally, suitable dune habitat was trapped with either Tomahawk live traps or rat traps (eight locations for a total of 240 trap nights).

Pilot surveys were conducted for jackrabbits (black-tailed and white-tailed) and the bushy-tailed woodrat. Each species can be an important prey item for various species of raptors (i.e., birds of prey) on Hanford (Fitzner et al. 1981). Jackrabbit surveys generally followed the methods of Smith and Nyedegger (1985) for spotlight (night) driving transects. Five different road routes (either paved or gravel / dirt) were driven on either Central Hanford or the North Slope (total of 71 miles [114 km]). The driver maintained vehicle speed at 5–10 mi/hr (8–16 km/hr) while a single observer shined a one million candlepower spotlight perpendicular to the road. Observations of all animals seen were recorded. Woodrat surveys targeted rock outcrops and areas with large trees containing woodrat stick nests. Five areas were trapped: northwest and southwest sides of Gable Mountain, just west of Gable Butte, base of Umtanum Ridge, and a clump of trees on the North Slope. Tomahawk live traps were baited initially with rolled oats or apples (later switched to a peanut butter / molasses / oat mixture) and left open during the night (for a total of 121 trap nights).

For all trapping efforts described above, all traps were checked at least once a day (several times a day for live traps left open during the day). This approach was followed to minimize the stress of capture encountered by any individual animal.

1998

1998 surveys were designed to follow up on questions raised by analysis of 1997 data, rather than to provide an additional year of data for sites sampled in 1997. While this approach rules out direct comparison of year to year variation, the combination of multiple trap types and sampling strategies allows stronger inference about species occurrence/absence in areas of high interest. In 1998, fewer areas, were sampled at a higher intensity than in 1997 including the Saddle Mountain crest, Umtanum Ridge, the Hanford dunes, a cottonwood grove along the Columbia River south of WPPSS and several locations on and around Gable Mountain.

In 1998, survey efforts were expanded in areas most likely to support Merriam's shrew, least chipmunk, and sagebrush vole. Trapping in 1997 did not produce any captures of these species. However, much of the 1997 survey effort focused on low elevation areas of the Hanford Site where

extensive studies by previous investigators have rarely or never captured these species. In 1998, sites in bunchgrass and sagebrush cover types were sampled near the ridgeline of the Saddle Mountains and Umtanum Ridge. No reports were found indicating that these areas had been surveyed for these species previously. Surveys in 1997 in these areas used snap trapping. To mitigate against the possibility that the lack of captures of these species was due partially to our choice of trap type, Sherman live traps and pitfall traps were used in 1998.

The northern grasshopper mouse was captured in extremely low numbers in 1997. To determine if mark-capture trapping using large trap grids was a more suitable for comparing abundance between habitat types or monitoring this species across years, a pilot study was performed at three low-elevation sites. Due to other sampling priorities, replicate sites were not trapped to compare community types. A small-scale test of patterns of occurrence of deer mice, pocket mice, and harvest mice near active dunes was also performed. During both years, Tomahawk live traps were used to determine if bushy-tailed woodrats and least chipmunks were present in rock outcrops on the Hanford Site.

8.3.3 FINDINGS

GENERAL

In 1997, a total of 427 individuals from four species were captured in snap traps during 13,200 trap nights. The Great Basin pocket mouse was the most frequently captured species: 263 captures with at least one individual captured from 29 of the 40 transects. The deer mouse followed next with 137 captures from 24 transects, then the western harvest mouse with 20 captures from 10 transects, and finally the northern grasshopper mouse with only seven captures from four transects. Significantly, no shrews or the sagebrush vole were captured.

In 1998, 7901 trapping nights produced 579 individual captures. Seven species were identified, adding mountain cottontail, sagebrush vole (Umtanum Ridge only) and montane vole (Umtanum Ridge only) from the list from 1997. As in 1997 the pocket mouse was the most common species, making up 98% of total captures. The northern grasshopper mouse (one site in Dunes on North Slope) and western harvest mouse (Umtanum Ridge only) were captured infrequently.

The Great Basin pocket mouse occurred in all habitat areas and plant community types trapped and based on capture rates was the most frequently encountered species in seven of the 10 habitat areas / plant community types. The deer mouse was the most frequently captured species in three habitat areas / plant community types, all of which tended to be either cooler, moister, or less sandy soil environments than where the Great Basin pocket mouse dominated the captures. The western harvest mouse and northern grasshopper mouse always were captured at relatively low rates. The highest capture rate for the western harvest mouse occurred in transects located along the Columbia River. Most of the 11 northern grasshopper captures were from two transects located within a single large big sagebrush / needle-and-thread (*Stipa comata*) community on the North Slope. The remaining captures occurred in bitterbrush (*Purshia tridentata*) / Indian ricegrass (*Oryzopsis hymenoides*) dune complex and big sagebrush / cheatgrass (*Bromus tectorum*) communities (the latter of which contained a significant bitterbrush component).

FINDINGS BY HABITAT AREA / PLANT COMMUNITY TYPE

Capture rates and biodiversity were highest in the bitterbrush / Indian ricegrass dune complex and big sagebrush / needle-and-thread communities. Both of these community types have received the highest protection priority ranking assigned by the Washington Natural Heritage Program (WDNR 1995; see Section 2). The capture rates within these two community types were 8–12 times higher than the rate observed in the cheatgrass grassland (i.e., minimal or no shrubs present) sample locations. The

cheatgrass sample locations had the lowest average capture rates of any habitat area / plant community type. A similar finding of reduced trapping success for small mammals within cheatgrass-dominated areas at Hanford was made by Gano and Rickard (1982). The bitterbrush / Indian ricegrass dune complex (in particular along a transect within the Hanford Dune Field) was the only habitat area / plant community type in which all four species captured in 1997 were found. The Umtanum Ridge area, which has diverse habitats in close proximity, had the highest species diversity in 1998.

8.3.4 DISCUSSIONS BY SPECIES

Distributions of selected small mammal species are discussed below. West et al 1997, 1998 provide additional details and discussion of all species.

BUSHY-TAILED WOODRATS

Bushy-tailed woodrats were frequently captured in rocky areas of Hanford including: Umtanum Ridge, Gable Mountain and Gable Butte.

JACKRABBITS

Both white and black-tailed jackrabbits are important prey animals for raptors. Many long-time residents and scientists in the Columbia Basin report apparent population declines, especially in black-tails. Driving surveys covering 118.5 kilometers throughout Central Hanford and the North Slope produced only 5 black-tailed and one unidentified jackrabbit sightings. Three dead white-tailed jackrabbits were observed: 2 on ALE and 1 north of Gable Mountain. Based on incidental observations, the highest number of black-tailed jackrabbits on the site is on Umtanum Ridge west of highway 24.

ORD'S KANGAROO RAT

Visual surveys and follow up trapping were conducted for Ord's kangaroo rat. All surveys were negative.

LEAST CHIPMUNK

Despite intensive sampling, no evidence was found of this species within Central Hanford or the North Slope.

MERRIAM'S SHREW

Despite intensive sampling, no evidence was found of this species within Central Hanford or the North Slope. Earlier work has shown it to be relatively abundant in three-tip sagebrush on ALE, although it is present in low numbers even in suitable habitat compared to most other small mammal species

NORTHERN GRASSHOPPER MOUSE

Grasshopper mice appear limited to sandy soil sites in relatively good ecological condition at lower elevations on the Hanford Site. All captures were in areas with big sagebrush / needle-and-thread-grass, bitterbrush / Indian-rice grass : needle-and thread grass. The highest number of captures were in big sagebrush / needle-and-thread communities on the North Slope and in the Hanford Dunes. These findings are noteworthy as both these community types are listed as Priority 1 by the WNHP (WNHP 1997). Similar to other studies, grasshopper mice were always infrequently captured, and in low numbers even on sites in which they are present.

PYGMY RABBIT

No observations of pygmy rabbit were made during this study.

SAGEBRUSH VOLES

Sagebrush voles were not captured in 1997 and only 2 individuals were captured in 1998. A big sagebrush/ needle-and-thread * bluebunch wheatgrasss stand on Umtanum ridge was the only site to be proven to support this species.

TOWNSEND'S GROUND SQUIREL

This species is not known from north of the Columbia River. Visual surveys and follow up trapping were conducted on Central Hanford including Umtanum Ridge (Riverland). Likely Townsend's ground squirrel burrows were detected on Umtanum ridge south of the ridge line, but trapping in early July failed to detect any animals. Because trapping was conducted so late in the season, the species may be present, but was not vulnerable to trapping at that time. The lack of success in identifying Townsend's ground squirrel on Central Hanford was surprising given that previous reviews reported it as common at least in some areas.

WASHINGTON GROUND SQUIRREL

In Washington, this species is known only from north / east of the Columbia River. Visual surveys and follow up trapping were conducted throughout the North Slope. The Washington ground squirrel was identified on the Hanford Site for the first time during these surveys on the crest of the Saddle Mountains (see Section 8.4 more details).

OTHER INCIDENTAL OBSERVATIONS

Incidental observations were made of elk, mule deer, burrowing owls (3), common porcupine, mountain cottontail, and one potential mountain lion track. One large "mountain lion" track (11*9cm) was seen in loose soil on Umtanum Ridge by three observers who judged it a clear mountain lion track. Because no other tracks were found in the area it was considered potential.

8.4 Pygmy Rabbits and Washington Ground Squirrels

8.4.1 PURPOSE AND SCOPE

Pygmy rabbits and Washington ground squirrels are inhabitants of shrub-steppe habitats characterized by deep, friable soils suitable for the construction of permanent burrows (Betts 1990; Weiss and Verts 1984). Such soils also are attractive to human agricultural development and other uses. As a result, except in areas such as the Hanford Site where agricultural development has been precluded for over 50 years, much of the available habitat for pygmy rabbits and Washington ground squirrels in Washington has been converted to other uses or fragmented into small parcels. Washington State lists the pygmy rabbit as a state endangered species and Washington ground squirrels as a state candidate species (WDFW 1997). Both species are identified by the U.S. Fish and Wildlife Service as federal Species of Concern (USFWS 1998).

Fitzner and Gray (1991) reported a population of pygmy rabbits on the ALE Reserve prior to 1984 (in a location that subsequently burned). There have been no sightings since on Hanford despite the fact some recent surveys — mostly covering the western portions of the ALE Reserve and Central Hanford — have been conducted that focused specifically on locating pygmy rabbits (Cadwell 1994).

Prior to the 1997 inventory there were no known records of the Washington ground squirrel on Hanford; however, Washington ground squirrels have been found near Hanford in Adams, Franklin, and Grant Counties (Betts 1990, Carlson 1980). Because of their conservation status and potential for occurrence, it is important to ascertain whether Washington ground squirrels and pygmy rabbits are present on the Hanford Site. Therefore, locations with suitable habitat conditions outside the ALE Reserve were surveyed for evidence of occurrence by these two species.

8.4.2 METHODS

GENERAL

Surveys for pygmy rabbits and Washington ground squirrels included strip transects and meandering searches on both the North Slope and Central Hanford (Figure 8.1). Two approaches were taken to locating survey areas. Based on vegetation maps, site reconnaissance and the Hanford Site soil map of Hajek (1966), Marr (1997) prioritized potential search areas into 4 categories that corresponded with the likelihood of detecting each species, and randomly located transect locations. West et al (1997 and 1998) used a combination of site reconnaissance, vegetation maps and guidance provided by Marr (1997) to locate study areas subjectively, in areas perceived of as having a relatively high likelihood of supporting the species.

1997

Marr (1997) divided potential search areas into numbered 3.1 mi^2 (5 km^2) blocks and ranked them according to apparent potential habitat for ground squirrels and pygmy rabbits. Within priority one areas (i.e., highest likelihood areas), a 10% random sample of transect lines was chosen for survey from among the maximum number of potential transect lines that could be placed within the area spaced slightly less than 200 ft (60 m) apart. The same procedure was followed for priority two areas (i.e., fewer but significant detections expected), except only the odd-numbered blocks were surveyed. Transects lines were located on the ground by scaling their position relative to recognizable features on topographic maps. Transect lines were walked at a rate of 3.1 mi/hr (5 km/hr) while observing for the evidence of ground squirrels and pygmy rabbits (i.e., direct species observation, alarm calls of ground squirrels, droppings, and burrows). Based on similar type surveys at the Naval Weapons Systems Training Facility near Boardman, Oregon the effective distance from the transect line searched (i.e., a strip transect) was three meters for burrows and 60 m for calls. Transect lines were not walked during rain or sustained winds greater than 10 mi/hr (16.1 km/hr). Transect lines were surveyed by Marr on 15 different days between March 22, 1997 and June 7, 1997. Between mid-April and the end of May, an emphasis was placed on searching for ground squirrels rather than pygmy rabbits because they are most likely to call after the young emerge and are still associated with their natal territories.

Some priority two areas were searched by walking a meandering course while observing for evidence of ground squirrels and pygmy rabbits. Meandering searches were conducted on seven different days between June 7, 1997 and June 29, 1997. Searches were biased within the area to be searched toward habitats that appeared most suitable for pygmy rabbits.

West et al (1997) employed visual searches for ground squirrels (Townsend's and Washington), pygmy rabbits and their burrows along 3280 ft (1000 m) survey transects during May and June (23 surveys along 22 transects). According to the survey estimates decribed above, this accounted for 34.5 acres (14 hectares) searched for burrows and 345 acres (140 hectares) for calls. A single observer walked slowly along a fixed bearing and noted potential burrows. At several locations at which burrows potentially dug by ground squirrels were observed (i.e., three transect locations), Tomahawk live traps were placed. Traps were baited with apple chunks and left open for one or more days.

1998

Meandering searches targeting Washington ground squirrels were performed in 17 “patches” during March and April, 1998 (Figure 8.1, Table 8.6). Survey effort was not randomly distributed. High potential areas received more survey effort and greater survey time within a “patch” than those with apparently low suitability. Follow up tomahawk live trapping (156 total trap days) using apple chunks was done in areas judged to have high potential for animals.

Table 8.6 1998 Ground squirrel visual survey locations and habitat

Area	Habitat	Trapping Performed?
Saddle Mountain Patch 1	Big sagebrush/cheatgrass, small bunchgrass areas	No
Saddle Mountain Patch 2	Big sagebrush / needle-and-thread grass	Yes
Saddle Mountain Patch 3	Big sagebrush / needle-and-thread grass and bluebunch wheatgrass-	No
Saddle Mountain Patch 4*	Big sagebrush / needle-and-thread grass	Yes
Saddle Mountain Patch 5	Big sagebrush / bluebunch wheatgrass	No
Saddle Mountain Patch 6	Big sagebrush/cheatgrass and big sagebrush / Sandberg’s bluegrass	No
Saddle Mountain Patch 7*	Big sagebrush / needle-and-thread grass	Yes
Saddle Mountain Patch 8	Big sagebrush / bluebunch wheatgrass and sagebrush /cheatgrass	No
Saddle Mountain Patch 9*	Big sagebrush / needle-and-thread grass	No
Saddle Mountain Patch 10*	Big sagebrush / needle-and-thread grass and bluebunch wheatgrass-	No
Saddle Mountain Patch 11	Big sagebrush / cheatgrass, small areas of bunchgrass	No
Gable Mountain: East half, from radio tower west to gravel pit (sections 19-20), top and north slope down to base	Big sagebrush / bluebunch wheatgrass, sagebrush / cheatgrass	No
Gable Mountain: West half, from radio antenna to about 1 km east, on plateau and top of south-facing slope	Big-sagebrush /bluebunch wheatgrass and needle-and-thread grass	No
South east base of Gable Mountain (surveyed in 1997 also)	Big sagebrush / Sandberg’s bluegrass	No
Gable Butte: southeast side	Mosaic: stiff sagebrush, big sagebrush / bunchgrass	No
East of 100-D	Sand dropseed	No
Umtanum Ridge: from base to ridgeline and south of ridgeline, sections 13-14, 23-24	Mix, including sagebrush / bluebunch wheatgrass, needle-and-thread grass, and sagebrush/Sandberg’s bluegrass	Yes

* Indicates Washington ground squirrel observed within patch

8.4.3 FINDINGS

OVERVIEW

No pygmy rabbits were detected within Central Hanford or the North Slope in any of the survey efforts. A single population of Washington ground squirrels was detected in several habitat patches near the crest of the Saddle Mountains within the Wahluke Wildlife Area.

1997

Marr (1997) and West et al (1999) did not detect evidence for the presence of either pygmy rabbits or Washington ground squirrels during walking surveys. A single visual sighting of a Washington ground squirrel was made near the crest of the Saddle Mountains late in the year during casual surveys. Because it was detected late in the year, the sighting was noted but no further work was conducted. Similar surveys conducted near Boardman. Oregon detected Washington ground squirrels at rates ranging from 0.25 detections/km of transect line within habitat similar to priority one areas to 0.03 detections/km for priority two type areas. Thus, if present, both species presence should have been detected. Based on possible detection distance data from Boardman, over 300 acres (125 ha) was searched for pygmy rabbit and Washington ground squirrel burrows and 3000 acres (1250) ha for Washington ground squirrel calls. Additionally, 10 meandering searches accounted for an additional 11,510 acres (4658 ha) of area searched.

1998

Definite, active Washington ground squirrel holes were detected in 5 of 17 survey patches, all near the site boundary north of the Saddle Mountain Crest (West et al 1999). Washington ground squirrels were observed in 4 patches and were trapped in two patches during 156 trapping days. The occupied patches were characterized by big sagebrush / bluebunch wheatgrass and/or needle-and-thread grass in good ecological condition, but subject to grazing by livestock. Although population size was not estimated, the researchers believe a large population may be present. Trapping may have been hindered by bait choice. Other researchers have used peanut butter and whole oats with greater success. Future sampling efforts should alter the bait mixture accordingly.

Despite intensive survey efforts, no burrows likely to be from ground squirrels were detected at Gable Mountain, Gable Butte, or east of the 100-D area.

8.5 Relationship to Previous Findings

Table 8.1 summarizes the historic occurrence and biodiversity inventory findings for bats and other small mammals. The 1997–1998 bat findings added one new species, the big brown bat, to the list of bat species that have been documented to occur at the Hanford Site. The direct capture findings also raised the possibility that the California myotis (previously documented [Fitzner and Gray 1991] but perhaps based on a misidentification) might occur at Hanford. Several Washington State Monitor and Candidate small mammal species seem to be limited in their distribution on the Hanford Site. Historically, sagebrush voles (Monitor species) have been captured mostly at high elevations on the ALE Reserve in big sagebrush / bluebunch wheatgrass (*Pseudoroegneria spicata*) plant communities. They also have been captured in limited numbers at low elevation riparian areas on the ALE Reserve and just south of the 200 Areas (distribution information summarized in Downs et al. 1993 and Fitzner and Gray 1991; also see O'Farrell 1972). None were captured during 1997 on Central Hanford or the North Slope and they were captured only in small numbers on Umtanum Ridge during 1998. Similarly, the distribution of Merriam's shrew (Candidate species) was thought to be limited to the upper elevations of the ALE Reserve (Fitzner and Gray 1991). No shrews were captured in 1997 on Central Hanford or the North Slope. The northern grasshopper mouse (Monitor species) is more

widespread on the Hanford Site than the preceding two species; however, compared with the Great Basin pocket mouse and deer mouse, it is relatively uncommon (Rickard and Poole 1989). The findings from 1997 confirm the relatively low abundance of the northern grasshopper mouse, but also suggest that this species associates preferentially with plant communities located on relatively sandy soils in relatively good ecological condition.

The presence of Ord's kangaroo rat (state Monitor species) has never been documented at the Hanford Site. Still, its confirmed or probable occurrences north of the Saddle Mountains (West et al. 1998), near Priest Rapids Dam (Payne et al. 1976), and at McNary National Wildlife Refuge (West et al. 1998) suggest that it may be present in suitable habitat on the Hanford Site. The North Slope, because of its proximity to the above locations, the most likely locale. However, surveys conducted during 1998 in appropriate habitat failed to detect the species.

Pygmy rabbits (state Endangered species and federal Species of Concern) have not been observed on the Hanford Site since 1984 (Fitzner and Gray 1991). The surveys reported by Cadwell (1994) and herein did not reveal the presence of this species. Pygmy rabbit surveys can be continued in areas containing a relatively high cover of sagebrush (*Artemisia* spp.). The North Slope has additional areas that may represent suitable habitat; however, most of the high cover sagebrush areas on Central Hanford and the ALE Reserve now have been surveyed. The area adjacent to the eastern boundary of the Hanford Site and suitable areas of the western portion of the North Slope should receive the highest priority for future surveys, followed by any remaining suitable areas of Central Hanford and the ALE Reserve.

Washington ground squirrels were found on the site for the first time during these surveys (West et al 1999). Washington ground squirrels (state Candidate species and federal Species of Concern) have been found near the Hanford Site in Adams, Franklin, and Grant Counties (Betts 1990, Carlson 1980. The area between the irrigation canal that traverses east-west across the North Slope and the Saddle Mountains, relatively low gradient slopes in the Saddle Mountains, and upland areas adjacent to the east boundary of the Hanford Site should be given priority for future Washington ground squirrel surveys.

Although its distribution may be spotty and restricted to certain shrub-steppe habitats on the Hanford Site, Townsend's ground squirrel generally is considered to be relatively common in those areas in which it does occur (Downs et al. 1993, Fitzner and Gray 1991, Rickard and Poole 1989). No ground squirrels were captured or visually observed during these surveys; however, the period during which surveys for Townsend's ground squirrel were conducted may not have been optimum. All surveys were conducted in late May and June, a time at which this species begins to estivate (i.e., summer hibernates).

Black-tailed jackrabbits have been reported as relatively common at Hanford in areas where a dense overstory of sagebrush is present, whereas observations of white-tailed jackrabbits have been rare and restricted to the higher elevations of Rattlesnake Mountain (Fitzner and Gray 1991, Rickard and Poole 1989). Few black-tailed jack rabbits were detected during the 1997 spotlight driving transects. A low number of observations make density estimates tenuous. The findings from such transects, however, may still be useful as an index procedure for long-term monitoring of jackrabbit population levels. Habitat utilization and relative abundance estimates may be determined with more confidence by use of pellet surveys. The road-kill white-tailed jackrabbit observation north of Gable Mountain is the first documented observation of a white-tailed jackrabbit at a location on the Hanford Site other than above about 1310 ft (400 m) on the ALE Reserve (Fitzner and Gray 1991).

8.6 Further Inventory Needs

The findings herein raise several questions that deserve follow-up research and/or monitoring.

- Determining the full extent of Washington ground squirrel populations on the North Slope, both within and outside of the Hanford Site boundary. The areas with the highest likelihood include gullies along the base of the Saddle Mountains, the eastern site boundary and the north-facing slope of the Saddle Mountains.
- Determining whether pygmy rabbits exist on the Hanford Site. Future survey efforts should focus on unsurveyed loamy soiled areas of the North Slope.
- The distribution and abundance of sagebrush vole and Townsend's ground squirrel outside the ALE Reserve remains poorly understood. Efforts should focus on Umtanum Ridge.
- The northern grasshopper mouse remains poorly understood. Efforts should focus on high quality areas with sandy soils.
- Demographic studies and additional direct trapping, especially on cliff outcroppings and the White Bluffs will likely yield valuable information on species of conservation concern and on the poorly understood Myotis group.
- Given its importance as prey for raptors and its apparent decline throughout Washington, black-tailed jackrabbits should be studied more intensively.

8.7 Discussion

The inventory findings support the conclusion that Merriam's shrew and the sagebrush vole (as well as the least chipmunk) are generally absent or only local in the lower elevation areas of the Hanford Site. With the exception of a single historic capture of a sagebrush vole from just south of the 200 Areas and one more recently on Umtanum Ridge, captures of these species have been restricted to the ALE Reserve and generally at the upper elevations. Although the upper elevation areas of Gable Mountain, Saddle Mountains, and Umtanum Ridge potentially support populations of these species and though all three locations were trapped during the inventory, no Merriam's shrews, Townsend's ground squirrels, sagebrush voles or least chipmunks were captured. O'Farrell (1972) concluded that sagebrush voles occurred in big sagebrush stands containing a large bunchgrass (especially bluebunch wheatgrass) component. Although several of the "high elevation" trap transects and grids were in big sagebrush / bluebunch wheatgrass plant communities, in each a significant sagebrush component was lacking.

Based on historic distribution information (Johnson and Cassidy 1997), Merriam's shrew has a more restricted range of elevation than the sagebrush vole. Although Gable Mountain may provide suitable habitat for these species, it may be at the low end of their elevational ranges in Washington. Additionally, Gable Mountain is isolated from other areas of suitable habitat. Although perhaps borderline in regard to elevation, Umtanum Ridge and the crest of the Saddle Mountains likely are connected to other suitable habitat outside of the Hanford Site and, thus, may present an opportunity for locating these species outside of the ALE Reserve. The limited distribution of Merriam's shrew and sagebrush vole on the Hanford Site demonstrates the importance of the ALE Reserve, and in particular the presence of remnant big sagebrush / bluebunch wheatgrass (and perhaps three-tip sagebrush [*Artemisia tripartita*]) plant communities, for their conservation.

The association of the northern grasshopper mouse with a bitterbrush and big sagebrush / needle-and-thread plant community had not been previously documented. Moreover, nearly all captures of this species in occurred in relatively undisturbed areas. Excluding bats, of the six small mammal species of state and / or federal conservation concern that potentially are present on the Hanford Site, the

northern grasshopper mouse is the only species to be documented in the lower elevation areas of the site. Its presence could be another indication of the conservation significance of low elevation shrub-steppe, terrestrial plant community element occurrences. Further inventory work for this species, and for Ord's kangaroo rat for sandy soil habitats, may identify additional areas of conservation interest.

Based on Hajek (1966), most of the soils at Hanford are poor soils for mammals that need to construct durable burrows up to 6.5 ft (2 m) deep (i.e., ground squirrels and pygmy rabbits). Although some of the silt loam soils on Hanford may be adequate, bedrock, caliche, or hardpan often occurs at depths less than 3 ft (1 m). At the Naval Weapons System Training Facility near Boardman, Oregon, Warden silt loam hosts the majority of Washington ground squirrel sites; however, caliche occurs at greater depths than at Hanford and other obstructions are rare. Ground squirrel populations also respond to variations in annual precipitation (Smith and Johnson 1985); presumably, pygmy rabbit populations may respond in the same manner. Over most of the Hanford Site, soil conditions and precipitation patterns probably limit the potential for occupation by ground squirrels and pygmy rabbits.

8.8 Management Recommendations

The following management recommendations are specifically designed to protect small mammal biodiversity on the Hanford Site.

- Protect all high quality plant communities, especially in sandy soils.
- Prevent wildfires from consuming extensive stands of big sagebrush.
- Protect cliff areas, including the White Bluffs from destructive clean-up activities.
- Survey all human created structures for bat use before destruction is planned.
- To the extent possible limit clean-up and other surfacing disturbing activities near open bodies of water.
- Manage the riverland (Umtanum Ridge) area in a fashion consistent with its importance as a habitat connection between ALE and other large areas of shrub-steppe habitat, as well as its apparent diversity of small mammals.

Section 9 – Microbiotic Crusts

9 Microbiotic Crusts

9.1 Introduction and Background

Throughout much of the Intermountain West a living crust covers some or all of the soil between plants (Nash, 1996a.b). The soil crust - referred to as microbiotic (our preference), cryptobiotic, or cryptogamic - is composed of algae, fungi, lichens, and mosses (Johansen, 1993). Microbiotic soil crusts are especially well developed in relatively undisturbed areas, such as portions of the Hanford Site. Although the ecological role of the microbiotic crust within the shrub-steppe is not completely understood, it is thought to play an important role in ecosystem functioning. Microbiotic crusts can stabilize the soil, thus reducing wind and water erosion (Metting 1991; Johansen 1993; Eldridge and Greene 1994). Some crust organisms contribute nitrogen (Harper and Pendleton 1993) and organic carbon (Johansen et al.1993) to the soil. Some researchers have found an increase in the infiltration of precipitation into the soil with microbiotic soil crusts (Brotherson and Rushforth, 1983). Intact crusts can also enhance native seedling establishment in arid ecosystems (St. Clair et al. 1984), and may discourage invasion by non-native species such as cheatgrass.

Although identification of the algae and fungal crust components can be difficult, the lichens and mosses are more easily identified. Such identification is an important first step in understanding their role within the ecosystem

There have been few organized collections in the Columbia Basin, and fewer yet in the shrub-steppe of Washington. Thirty-two soil lichen species are recognized in the Columbia Basin based on collections described by Ryan (1994). Daubenmire (1970) lists 13 lichen and seven moss species in typical shrub-steppe communities in Washington, with many of the lichens identified only to the genus level. Recently, McCune and Rosentreter (1995) provided a field key to soil lichens of central and eastern Oregon. They recognize 74 species from alpine to lower elevation shrub-steppe ecosystems and covering acidic to basic soils. There are no reports on the soil crust floristics in the *Artemisia tridentata-Stipa comata* association common on Hanford (Soll and Soper 1996, Hall 1998), nor on the Hanford Reservation.

The objective of this study was to document the species of lichens and mosses on the soil of the Hanford Reservation, particularly those of the lower elevation plant communities. Inferences are drawn about the lichen species composition of Hanford by comparison with similar studies in the Intermountain West.

9.2 Methods

Seventeen sites were selected to represent a wide range of plant associations, ecological conditions and soil types in the lower elevation portions of the site. Site elevation ranged from 133 m to 807 m above sea level (Table 9.1, Figure 9.1). Sites were examined by working along a 100m line transect through a representative patch of the given community type, collecting examples of all apparently different entities found in the immediate vicinity of the tape. No time limit was placed on collecting. Samples were placed in petri plates or paper bags and labeled.

In the laboratory, samples were soaked in white glue and water for stabilization, then glued onto 3 x 5 inch cards. Samples were then identified and placed in bryophyte packets. Voucher specimens are retained in the herbaria of Arizona State University (lichens), Washington State University at Tri-Cities (lichens and mosses) and in the private collection of Jeanne Ponzetti.

9.3 Results

Thirty soil lichen (Table 9.2) and eight moss species (Table 9.3) have been identified. There are 19 lichen and 6 moss genera. Twelve (40%) lichen species are of the crustose growth habit, eight (27%) are squamulose, seven (23%) are foliose, and three (10%) are fruticose.

Three lichen species were previously undescribed. Two lichen species were identifiable only to the genus level because they were sterile. Five (17%) lichen species fix nitrogen. Two of the eight moss species were given species names without the aid of fruiting structures, and thus are only tentatively named (cf).

9.4 Discussion

This study of the soil mosses and lichens of the Hanford Reservation is the most intensive survey to date in the state of Washington. Comparison with those of previous workers in semi-arid and arid regions of the Great Basin and in the semi-arid shrub-steppe indicate that the Hanford Site has a relatively unique crust flora.

A recent review of soil lichens in the Intermountain West by St. Clair et. al (1993) describes 12 species in steppe habitats, only three of which are common to Hanford. Common species include *Aspicilia reptans*, *Aspicilia* sp., and *Collema tenax.* Only five species were common between this study and a recent list of 13 for the Great Basin (St. Clair et al. 1993). The high number (30) of species observed in this study suggests that the lower Columbia Basin is rich in soil lichens compared to shrub-steppe in the greater Intermountain West. In addition, because so few of these species are also listed in St. Clair et al. (1993), it appears that the soil lichen flora of the lower Columbia Basin at Hanford is unlike that of most of the Intermountain West.

Surveys of lichens and mosses in the shrub-steppe of Idaho also show profound differences with Hanford. The Idaho National Engineering Laboratory in southeastern Idaho has only 8 soil lichens in common with those of Hanford (Pearson and Rope 1987). Thirty different lichen species have been identified near Boise (Rosentreter 1986), only 11 of which (35%) are also found at Hanford. Rosentreter (1986) also recognized six moss species, of which three are in common with those of Hanford. These are *Tortula ruralis, Ceratodon purpureus*, and *Bryum argenteum.*

On the basis of the studies done by St. Clair et al. (1993), Pearson and Rope (1987), and Rosentreter (1986) we conclude that there is little similarity between the soil lichen floras of the Great Basin and of the Idaho shrub-steppe and the soil lichen flora of Hanford. Our lichen species list has more in common with the 74 species occurring on soils in central and eastern Oregon (McCune and Rosentreter 1995). Only eight (of 27) lichens ideintified to species are not found in McCune and Rosentreter (1995).

In Washington, in areas generally comparable to Hanford, Daubenmire (1970) recognized 13 species and genera of soil lichens and mosses, of which only three species were found in this study. A possible reason for this difference is soil differences. The soils examined in this study ranged from sands to silts while Daubenmire (1970) describes lichens and mosses found on silty soils.

An exhaustive survey of herbaria for lichens of Washington found all but six of the species found in this study (Ryan 1994). We report *Acarospora geogena, Aspicilia filiformis*, and *Endocarpon pusillum* as new records for Washington. The three undescribed species in this report were not reported in Ryan (1994). In contrast to the report that the genus *Cladonia* is not represented in the soil crust communities of the Great Basin or Colorado Plateau (St. Clair et al., 1993), The range of the *Cladonia* species have beem extended to Benton and Franklin counties.

Table 9.1 Sampling sites for microbiotic crusts, Hanford Nuclear Reservation, 1997

Site #	Elevation (meters)	Soil type	Vegetation
1	160	Rupert sand	*Purshia tridentata*/ native bunchgrass
2	807	Silty loam, loam, sand	*Artemisia tripartita*/ native bunchgrass
3	210	Warden silt loam	*A. tridentata - Grayia spinosa*/mixed grass
4	261	Warden silt loam	Mixed grasses
5	318	Kiona silt loam	Basalt outcrops ??????
6	447	Silty loam, loam, sand	*A. tridentata - Grayia spinosa*/mixed grass
7	167	Ephrata sandy loam	*A. tridentata/ Poa secunda - Bromus tectorum*
8	413	Ritzville silt loam	Native bunchgrasses
9	159	Burbank loamy sand	*B. tectorum/Poa secunda*
10	133	Burbank loamy sand	Old fields (*Bromus tectorum*) ??????
11	186	Burbank loamy sand	*A. tridentata - G. spinosa*/ mixed grasses Bunchgrasses/*B. tectorum*
12	209	Hezel sand	*Sarcobatus vermiculatus/P. secunda*
13	254	silty loam, loam, sand	*P. tridentata - A. tridentata/* native bunchgrass
14	268	silt, sand	*P. tridentata/A. tridentata/* mixed grasses *B. tectorum*
15	–	sand	*A. tridentata*/ native bunchgrass
16	–	silt loam	Mixed grasses
17	–	??	??

mixed grasses = mixture of native grass and *Bromus tectorum*

Ten percent of lichens fix atmospheric nitrogen (Nash 1996b). St. Clair et al., (1993) report only one nitrogen fixing soil lichen out of 34 species (3%) found in the Intermountain West. The 17% of the soil lichen flora at Hanford capable of fixing nitrogen appears relatively high.

Lichen species composition is influenced by soil pH and calcium content (Nash1996a). The generally acidic or neutral nature of the surface soils at Hanford is possibly responsible for differences between the lichen flora of Hanford and the Great Basin (dominated by basic soils). Soil pH, nutrient levels that are affected by pH or the sensitivity of species to Al^{3+} may also explain some of the differences between the shrub-steppe sites in Idaho and Hanford (Nash 1996a).

9.5 Conclusions

This study provides the first detailed soil lichen and moss floristics survey for the lower Columbia Basin in Washington. Based on the large differences between these results and those of previous workers, the Hanford Reservation appears to support a relatively unique microbiotic crust flora. Although further research is necessary, the lichen and moss identifications for the Hanford Reservation in this study have added significantly to the biodiversity knowledge base.

Table 9.2 Lichens occurring on soils of the Hanford Nuclear Reservation, 1997

Lichens	Growth Form	Nitrogen Fixer?
Acarospora geogena H. Magn.	c	
Acarospora schleicheri (Ach.) A. Massal.	s	
Amandinea punctata (Hoffm.) Coppins & Scheid.	c	
Arthonia sp. (undescribed)	c	
Arthonia glebosa Tuck.	c	
Aspicilia sp. (A. calcarea group) sterile	c	
Aspicilia filiformis Rosentreter	fr	
Aspicilia reptans (Looman) Wetmore	s	
Caloplaca jungermanniae (Vahl) Th. Fr.	c	
Caloplaca tominii Savicz	c	
Candelariella terrigena Rasanen	c	
Cladonia fimbriata (L.) Fr.	fr	
Cladonia pyxidata (L.) Hoffm.	fr	
Collema cf. tenax (Sw.) Ach.	fo	*
Diploschistes muscorum (Scop.) R.Sant	c	
Endocarpon pusillum Hedw.	s	
Lecanora hagenii (Ach.) Ach.	c	
Lecanora muralis (Schreb.) Rabenh.	c	
Leptochidium albociliatum (Desm.) M. Choisy	fo	*
Leptogium lichenoides (L.) Zahlbr.	fo	*
Massalongia carnosa (Dickson) Korber	fo	*
Peltigera rufescens (Weis) Humb.	fo	*
Physconia enteroxantha (Nyl.) Poelt	fo	
Physconia isidiigera (Zahlbr.) Essl.	fo	
Placynthiella sp. (sterile)	c	
Psora globifera (Ach.) Mass.	s	
Psora luridella (Tuck.) Fink	s	
Psora montana Timdal	s	
Trapeliopsis sp. 1 (undescribed)	s	
Trapeliopsis sp. 2 (undescribed; aff. wallrothii)	s	

Growth form (c = crustose, s = squamulose, fo = foliose, fr = fruticose) and the ability to fix nitrogen (*) are indicated.

9.6 Management Implications

- Areas with reasonably intact crusts should not be subjected to physical disturbance. At a minimum, this includes all plant community element occurrences identified during the biodiversity inventory.
- Site surveys for potential clean-up actions and all vegetation surveys should record overall crust cover as a percentage at the minimum.

9.7 Suggestion for Further Research

The soil crust remains a poorly understood feature of the Hanford Site ecosystem and the Columbia Basin in Washington as whole. The following studies would greatly enhance our knowledge of these areas.

- Each recognized plant community type on the Hanford Site should be sampled at multiple locations for crust species, including sites at higher elevations than were included in this study.
- The species list should be linked to specific plant community or cover types and degree of disturbance.
- The crust species list for all sites should be broadened to include algae and fungal components. These largely unseen features of soil crusts are the most important crust features in some parts of the world and may be an essential ingredient for successful restoration projects.
- Similar surveys should be conducted on remnant sandy soil shrub-steppe sites elsewhere in Washington to determine if species found at Hanford are widely distributed.

Table 9.3 Mosses occurring on soils of the Hanford Nuclear Reservation, 1997

Mosses
Bryum argenteum Hedw.
Bryum cf caespiticium Hedw. (sterile)
Ceratodon purpureus (Hedw.) Brid.
Encalypta rhaptocarpa Schw.
Grimmia cf montana Bruch. (sterile)
Pterygoneuron ovatum (Hedw.) Dixon
Tortula papillosissima (Coppey) Brotherus
Tortula ruralis (Hedw.) Gaertn

Section 10 – Non-Native Plants

10 Non-Native Plants

10.1 Purpose and Scope

Although the primary purpose of the Hanford Site Biodiversity Inventory has been to survey and document the native species and plant community diversity present at Hanford, some information has been gathered concurrently on the threats to that diversity. One of the primary threats is that of invasive non-native plant species. Once introduced, these species can proliferate because of the lack of natural predators or because they can out compete native plant species in disturbed habitats. Moreover, some species are aggressive enough to be successful in invading even intact native plant communities. This section briefly describes some of the findings of the biodiversity surveys in regard to the presence of particular, undesirable non-native plant species. Most of the information is taken from Caplow and Beck (1997). Additional information on undesirable plant species that have been documented or are potentially present on the Hanford Site can be found in the Draft Hanford Site Biological Resources Management Plan (DOE-RL 1996).

10.2 Background and Terminology

Both federal and state regulatory agencies target certain non-native plant species for eradication or control that pose a threat to natural ecosystems or agriculture, though categories of plants (and their definitions) differ between levels of government. The federal government and Washington State define a similar group of plant species—known as noxious weeds—that require some form of management to eliminate or minimize their threat. To achieve the purposes of resource protection, however, federal agencies also are authorized to manage on federal lands a broader range of species defined as undesirable plants (Code of Federal Regulations, Title 7, Chapter 61). This definition includes state-designated noxious weeds. Moreover, under both federal and state law, federal agencies can enter into cooperative agreements with state agencies to manage undesirable plants on federal lands.

In Washington noxious weeds are plants that when established are highly destructive, competitive, or difficult to control by cultural or chemical practices. They are divided into three categories (see Chapter 16–750 of the Washington Administrative Code).

- **Class A**: are non-native species that have a limited distribution or are unrecorded in the state.
    - **Class B**: are non-native species that have a limited distribution or are unrecorded in a region of the state.

      When a Class B noxious weed is identified as **Class B designate** for a particular geographic area, it is a noxious weed whose populations in that region or area are such that all seed production can be prevented within a calendar year.
    - **Class C**: are any other noxious weed.

      Non-federal landowners in the Hanford region are required to eradicate (eliminate within an area of infestation) all Class A noxious weeds, prevent all seed production and prevent the spread of all Class B designate noxious weeds; as well as any Class B nondesignate and Class C noxious weeds mandated for local control by the applicable county weed board (see Chapter 17.10 of the Revised Code of Washington).

10.3 Findings and Management Recommendations for Individual Species

Centaurea solstitialis (yellow starthistle) is a Class B designate noxious weed over the entire Hanford Site. This is a highly aggressive weed capable of invading both undisturbed habitats and areas of natural disturbance. *Centaurea solstitialis* has become a dominant species at the Hanford and White Bluffs Townsites and is rapidly invading adjacent areas, including the east end of Gable Mountain (an area containing a number of rare native plant populations). It also has begun to invade the White Bluffs, part of which is directly across the river from the townsites. In 1995 one small population of *Centaurea solstitialis* was found on the White Bluffs. Despite control efforts at the time and subsequent early season efforts in 1997 by the Washington Department of Fish and Wildlife, the invasion had persisted on the face of the bluffs by the end of the field season (specifically in T13N, R27E, S24 and suspected elsewhere). The White Bluffs and Gable Mountain invasions pose a serious direct threat to the state endangered *Lesquerella tuplashensis* (White Bluffs bladderpod), state threatened *Camissonia pygmaea* (dwarf evening-primrose), and a number of other rare plant species. The next two to three years are a critical period in the control of *Centaurea solstitialis* on the Hanford Site. To maintain the long-term biodiversity of the Hanford Site, it will be necessary to control the spread of this species.

Centaurea diffusa (diffuse knapweed) is a Class B designate noxious weed for Franklin County and for Grant County downstream of Vernita Bridge, but is nondesignate for Benton County. *Centaurea diffusa* is most common in the gravelly areas within 1/4 mi (0.4 km) of the Columbia River and is often dominant in the gravelly areas just above high water. This weed presents a threat to the state sensitive species *Oenothera cespitosa* ssp. *cespitosa* (cespitose evening-primrose) and to the integrity of the gravel bar communities adjacent to the Columbia River. Weed control is recommended as long as weed controllers are aware of the locations and appearance of *Oenothera cespitosa* ssp. *cespitosa* and other native species.

Cyperus esculentus (yellow nutsedge) is a Class B designate noxious weed over the entire Hanford Site. It is known from wetlands along the Columbia River (Sackschewsky et al. 1992) and was recorded during the 1995 wetland rare plant survey. It is a highly invasive weed in wetlands and could affect the high-quality riverine wetlands that are habitat to a number of state listed species.

Lepidium latifolium (perennial pepperweed) is a Class B nondesignate noxious weed over the entire Hanford Site. *Lepidium latifolium* was recorded in two locations on Central Hanford: south of Vernita Bridge adjacent to state Highway 24 and in a vernal pool on the east end of Umtanum Ridge (not far from the highway population). Previous Hanford reports of *Lepidium latifolium* characterized its distribution as widespread in disturbed areas and mostly found in deep soils and bottomlands, but rarely in sand (Sackschewsky et al. 1992). Because this weed species may be at a relatively early stage of invasion on the Hanford Site, active control is recommended, as it seems to have some affinity for moist areas and vernal pool habitat.

Lythrum salicaria (purple loosestrife) is a Class B designate noxious weed for Franklin County and for Grant County within the Hanford Site, but is nondesignate for Benton County. *Lythrum salicaria* is present along the Columbia River in scattered patches below the high water level. There has been an increase in the population levels of this species since 1994. This is a critical time to begin control of *Lythrum salicaria*. It has been found in 20 out of 36 wetlands along the Hanford Reach (Caplow and Beck 1996, Soll and Soper 1996). Moreover, it occurs with a number of rare plant species, including *Cyperus bipartitus* (shining flatsedge) and *Rorippa columbiae* (persistentsepal yellowcress). Further invasion into the riparian wetlands poses a serious threat to these species. Populations of this highly invasive weed are still relatively small, and it could be controlled at this point with an aggressive program of manual removal.

Linaria dalmatica (Dalmatian toadflax) is a Class B designate noxious weed for Benton and Franklin Counties and for a portion of Grant County. *Linaria dalmatica* is a colonizer of dry areas that is as yet relatively uncommon on the Hanford Site.

In addition to the above species, *Cardaria draba* (hoary cress), *Cirsium arvense* (Canada thistle), *Convolvulus arvensis* (field bindweed), *Hypericum perforatum* (common St. Johnswort), *Solanum dulcamara* (bitter nightshade), *Secale cereale* (cereal rye), and *Verbascum thapsus* (common mullein) are all Class C noxious weeds that were recorded during the biodiversity surveys on the Hanford Site. Finally, although not a state-designated noxious weed, *Salsola kali* (Russian thistle) is a non-native, fast growing and highly invasive annual species that is widespread on portions of Hanford. *Salsola kali*'s occurrence was particularly apparent in the Cold Creek Valley, on the Wahluke Slope, and within portions of the Hanford Reach corridor. It can form dense patches in which no other vegetation can compete. *Salsola kali* presents a significant threat to all of the upland rare plant populations at Hanford.

10.4 Relationship to Previous Findings and Further Inventory

Several other Class B noxious weeds, some designate and others not for the Hanford Site, previously have been documented to occur on the Hanford Site. These include *Acroptilon repens* (Russian knapweed), *Chondrilla juncea* (rush skeletonweed), and *Sphaerophysa salsula* (Swainsonpea). Several Class C noxious weeds also have been previously documented (e.g., *Tamarix* spp. [saltcedar]). Other noxious weeds may be present that have not yet been located. For example, before the biodiversity surveys, *Cardaria draba* was suspected to occur on the Hanford Site but had not been confirmed (see DOE-RL 1996 for information on previously documented noxious weeds). Continued inventory of undesirable plant species and their distribution is recommended.

10.5 Conclusions and Management Recommendations

The presence and spread of undesirable plant species, especially state-designated noxious weeds, poses a serious threat to the biodiversity of the Hanford Site. The next few years will be critical for initiating control measures for those species that pose the most imminent threats.

The U.S. Department of Energy (DOE) recently signed a Memorandum of Understanding (effective May 28, 1997) in regard to the management of noxious weeds and undesirable plants on the Hanford Site with the Washington State Department of Agriculture and the County Noxious Weed Control Boards of the four counties that border the Hanford Site. This agreement should be used by DOE to facilitate control actions against those noxious weed and undesirable plant species that threaten Hanford's biodiversity.

Section 11 – Tribal and Stakeholder Workshop on Biological Resource Inventory Needs for the Hanford Site

11 Tribal and Stakeholder Workshop on Biological Resource Inventory Needs for the Hanford Site

11.1 Introduction and Purpose

Along with the U.S. Department of Energy (DOE) and Pacific Northwest National Laboratory, The Nature Conservancy (TNC) cosponsored a tribal and stakeholder workshop held in Richland, Washington on May 12, 1997 (Hall 1997). The workshop addressed biological resource inventory and monitoring needs on the Hanford Site within a bioregional context. Workshop participants were asked to identify what inventory and monitoring needs they wanted DOE to consider and with what priority. Because TNC has conducted biodiversity inventories on the Hanford Site within the past few years and planned to continue to conduct such inventories in the near future, it had an interest in tribal and stakeholder concerns as they relate to outstanding biological resource inventory needs at the Hanford Site. Thus, the workshop also provided TNC an opportunity to hear these concerns.

11.2 Identification of Data Gaps

To set the stage for subsequent roundtable discussions, workshop participants were provided information on the current state of knowledge of Hanford's biodiversity and then presented some examples of, at the time, assumed biodiversity inventory data gaps. These data gaps can be summarized as follows.

- Ground-truthed delineation of habitats and plant community element occurrences within Central Hanford (Some areas are at risk from environmental cleanup actions, whereas other areas may qualify as element occurrences.)*
- Floral and faunal surveys of the Hanford Dune Field*
- Faunal surveys of Fitzner / Eberhardt Arid Lands Ecology (ALE) Reserve desert streams*
- Riverine habitat survey of the Hanford Reach
- Plant community mapping of Hanford Reach islands*

11.3 Identification of Inventory Needs

Based on the above information and subsequent roundtable discussions, workshop participants identified a number of inventory needs. Although participants did not explicitly prioritize inventory needs, the list below is based on what needs seemed to be stressed by participants during the roundtable discussions. Those needs addressed by biodiversity inventory work subsequent to the workshop are marked with an asterisk, (see appropriate section within this document).

- Complete plant community mapping within Central Hanford. *
- Characterize Hanford's microbiotic crust (e.g., species composition and condition). * (initial work completed).

- Inventory areas now that have a reasonable expectation of being impacted by future DOE activities, such as environmental cleanup, and that potentially contain biological resources of concern to enable biological resource information to be used as a part of the land-use decision process and not just to document impacts.
- Inventory areas containing medicinal and / or food plants of concern to local Tribes.Inventory species
- Inventory exotic plant / noxious weeds especially species such as diffuse knapweed (*Centaurea diffusa*), purple loosestrife (*Lythrum salicaria*), salt cedar (*Tamarix* spp.), and yellow starthistle (*Centaurea solstitialis*)—and processes that pose a threat to biological resource integrity.
- Acquire the data necessary to construct Geographic Information System (GIS) historical data layers (e.g., past fires, previous land-use practices, and shoreline vegetation and physical feature changes associated with the Hanford Reach).
- Inventory Hanford Reach molluscs and other invertebrate fauna, map the Reach's substratum, and characterize the fauna of ALE Reserve springs* and streams*.

In addition to the above list, several general findings from the workshop were of importance. First, there was a need for additional inventory work beyond that accomplished by TNC in 1997. Second, inventory [and monitoring] data, once acquired, must be linked with appropriate management action. As an example, participants were highly concerned with the escalating problem with undesirable plant species on the Hanford Site, especially in regard to those species that threatened the integrity of biological resources of concern. Participants strongly felt that inventory data should lead expeditiously to the implementation of appropriate control measures. Third, local Tribe views toward biological resources of concern to them, such as traditional food and medicinal plants, must be considered. The Tribes will need to be closely involved in deciding how to best inventory [and monitor] these resources in a manner that meets resource management needs and yet still honors tribal cultural values.

Section 12 – Status of the Hanford Site Biodiversity Inventory

12 Status of the Hanford Site Biodiversity Inventory

12.1 Introduction

With this report the Hanford Site Biodiversity Inventory and Analysis project is considered complete. The 1993 grant agreement between The Nature Conservancy (TNC) and the U.S. Department of Energy (DOE) called for three years of field study and analysis. Subsequent budget shortfalls have reduced the scope of the biodiversity inventory and extended its schedule. After a full complement of inventory activities in 1994, the 1995 inventory scope was reduced and the entire 1996 field season eliminated. The 1997 and 1998 field seasons were tailored to fill the most important remaining data gaps. Through the efforts of both DOE and TNC in acquiring supplemental funding, almost 90% of the funding originally proposed was made available.

Regardless of funding and scheduling difficulties, the 1994-1998 biodiversity inventories provide extensive and striking data on Hanford's biodiversity on a geographic and taxonomic scale that was previously absent. Table 12.1 provides an overview of the status of the Hanford Site biodiversity inventory.

Table 12.1 Status of the Hanford Site biodiversity inventory as of April 1999

Inventory Research Area	Original Grant Proposal	Work Completed as of April 1999
Plant communities	Map all management areas for type and condition	Entire site mapped except inside facility boundaries
Rare plants	Inventory all potential locations at moderate survey intensity	Highest priority areas surveyed over three years, totaling about 13.5% of the site, mostly at moderate survey intensity
Microbiotic crust	Subset of plant community characterization	Samples collected from locations across the site
Invertebrates	Inventory all management areas	Butterflies inventoried in all management areas; focused sampling of other taxonomic groups within the ALE Reserve, Central Hanford and the Hanford Reach
Amphibians	Inventory all management areas	Two years of inventories within all management areas at light to moderate intensity
Reptiles	Inventory all management areas	Two years of inventories within all management areas at light to moderate intensity
Birds	Three years of inventory for all management areas	Four years of inventories ALE Reserve; two years North Slope; one year Central Hanford
Mammals	Inventory all management areas	Two years of light intensity inventories within all management areas

12.2 Remaining Inventory Data Gaps

Although many of the biodiversity inventory goals have been met or are near completion, progress in certain inventory research areas has been limited. Although two years of amphibian, reptile, and small mammal (including bats) inventories have been conducted, they have been mostly at or near a reconnaissance level of intensity. Additionally, with the exception of butterfly inventories, only the Fitzner / Eberhardt Arid Lands Ecology (ALE) Reserve, Central Hanford and the Hanford Reach have been inventoried for other invertebrate taxonomic groups. Moreover, some insect taxonomic groups have yet to be inventoried in any systematic way. Despite these limitations, most of the new species finds have been among the insects. Finally, work on exploring the diversity of Hanford's microbiotic crust remains preliminary. The following points summarize overall remaining inventory priorities. More precise recommendations for further inventory effort are included within each subject chapter.

- Although plant community mapping of the entire Hanford Site is mostly complete, some loose ends remain. The remaining needs are mostly associated with the Riverland area and Umtanum Ridge are summarized in Section 2. Hopefully, these loose ends can be addressed before land-use decisions are made final.
- TNC did not map the plant communities within the fences of the industrial areas, and DOE should be aware that tribes and stakeholders are still concerned with the remnant habitat areas within these areas (principally within the 200 Areas).
- Microbiotic crust characterization has barely scratched the surface of what is needed. This valuable feature of shrub-steppe should be fully characterized on the Hanford Site.
- The relationship of small mammal populations to habitat type within Central Hanford needs further exploration, as does the population boundary of Washington ground squirrel. Bat roosting and nesting locations also require further research
- Inventory of undesirable plant species has been only an incidental part of the biodiversity inventory. It is recommended that DOE aggressively and energetically track the status of these non-native plants on Hanford.
- Only a preliminary inventory of aquatic invertebrates has been accomplished. A more complete study should be conducted.
- Surveys for invertebrates have focussed on ALE and to a lesser extent Central Hanford. The survey effort should be expanded on both Central Hanford and the North Slope.
- The extent of populations of amphibian and reptile species of conservation concern is poorly understood. More extensive survey is necessary to delineate species / habitat relationships.
- The "special habitat areas" for rare plants within central Hanford should be further explored during a good year for annual species.

No matter how much more is accomplished in filling the above data gaps and others, the Hanford Site Biodiversity Inventory will still represent a snapshot in time. Habitats and populations can shift in size (or population level) and/or location over time. Therefore, inventory will need to give way to monitoring. As long as there are biological resources of concern at Hanford, an effective monitoring effort will be needed to help manage and protect these resources over the long term. Additionally, because of the broad-scale nature of the biodiversity inventory, it should not be substituted for environmental evaluations needed for location-specific development projects or cleanup activities.

Section 13 – Conclusions: Significance of Findings to Date and Management Implications

13 Conclusions: Significance of Findings to Date and Management Implications

13.1 Significance of Findings to Date

Simply put, the biodiversity inventory has amply demonstrated that the Hanford Site is home to an extraordinary and irreplaceable natural legacy. Within its mosaic of habitats, Hanford supports a wealth of relatively unaltered and increasingly uncommon native habitats; the variety, size, and quality of which are unmatched. Not surprisingly, such high quality and diverse habitats support an equally diverse array of plants, animals and insects. In every subject area that was addressed (plants, insects, amphibians, reptiles, birds, and mammals), species known to be rare and declining in Washington and the Columbia Basin were found throughout the Site. Equally important as the spectacular number of rare and declining species, however, was the finding that more typical shrub-steppe species have been maintained at Hanford in appropriate abundance. This is in sharp contrast to findings from other, smaller locations that often show the absence of once common species.

In its present condition the Hanford Site is not only a refuge, but also a genetic bank for the common and rare plants and animals that are integral components of the shrub-steppe and Columbia River ecosystems. The Hanford Site is also a valuable reference point. As the wild habitats of the Columbia Basin continue to be fragmented and/or degraded by incompatible uses, large and relatively intact areas such as Hanford must serve as baselines to guide management of smaller areas. Clearly, from a conservation standpoint, the Hanford Site is a vital—and, perhaps the single most important—link in preserving and sustaining the diversity of plants and animals in the Columbia Basin Ecoregion.

13.2 Relevance to Future Disposition and Uses of U.S. Department of Energy Property

After many years of management for the U.S. Department of Energy (DOE) by the Pacific Northwest National Laboratory, the Fitzner / Eberhardt Arid Lands Ecology (ALE) Reserve now is managed by the U.S. Fish and Wildlife Service under a use permit with DOE. Despite the change in management authority, the ALE Reserve will continue to be managed as a Research Natural Area within the federal system of natural areas. Although the ALE Reserve's status as an ecological jewel has been known for many years, the findings of the 1994–1998 biodiversity inventory contributed additional justification for the ALE Reserve's long-term maintenance as a site for ecological education, research, and preservation.

In the coming years, major land-use decisions will dictate the future of the other portions of the Hanford Site. It is currently anticipated that the North Slope will be managed under a long-term use permit as a National Wildlife Refuge by the U.S. Fish and Wildlife Service. An Environmental Impact Statement with respect to this potential action is due to be completed in 1999.

Important pending land-use decisions which will benefit from the findings of the biodiversity inventory include the following:

- Determining specific locations to be used for environmental cleanup, mitigation, and restoration activities within Central Hanford;

- Potential transfers of land ownership or management as environmental cleanup is completed and the Hanford Site is made available for new uses;
- Potential designation of the Hanford Reach of the Columbia River as a recreational river under the federal Wild and Scenic Rivers Act;
- Designation of the North Slope as a National Wildlife Refuge and transfer of long-term management authority to the U.S. Fish and Wildlife Service.

Because of all these pending decisions, an uncertain fate remains for many of the native habitats and species that currently are protected under the stewardship of DOE. As Hanford Site land-use decisions are made, DOE, potential future land stewards, Tribes, and stakeholders should keep in mind several basic questions:

- What is the value of the irreplaceable native biodiversity found on the site?
- How important is protecting one of the Columbia Basin Ecoregion's few remaining representations of an unfragmented, native shrub-steppe ecosystem?
- How important is protecting the last, non-tidal free-flowing stretch of the Columbia River in the United States with its healthy salmon runs?
- What types of land ownership and management will not sacrifice the ecological integrity of these ecosystems?
- What specific portions of the Hanford Site contain its most significant ecological features and how should their presence guide future land-use decisions?

The 1994 -1998 biodiversity inventory findings confirmed the unique and significant ecological values of each of the Hanford Site management areas. Each management area on Hanford contributes in its own unique way to the overall biodiversity of the Hanford Site, and the loss or degradation of significant portions of any of the areas would in turn lead to losses and degradation of the site as a whole. Hopefully, the exceptional ecological features of the Hanford Site—as illustrated in part by the findings from the biodiversity inventory work reported herein (and previously)—will be given due consideration as land-use decisions are made.

13.3 Other Management Considerations Relevant to the Biodiversity Inventory Findings

In addition to their relevance for contributing to an informed land-use decision process, the biodiversity inventory findings provide a basis for considering other possible management actions. Possibly the most unexpected finding after three years of inventory work is the critical state of the non-native plant (especially noxious weed) invasion at Hanford. The biodiversity inventory effort not only has documented the unique biodiversity of Hanford, but unfortunately also has witnessed one of the gravest threats to that biodiversity. The specifics of some of these plant invasions and the threats they pose are detailed elsewhere in this report. A general recommendation is provided here, which is for DOE to adopt an aggressive strategy of eradication and control of target species, especially in those instances in which unique biological resources are threatened. Weed control is best and most inexpensively practiced when infestations are small. Delay in action means increased financial and ecological costs. At present, we maybe in a small and critical window of opportunity in which to initiate control measures. To wait risks the loss of some of Hanford's irreplaceable biological legacy.

The draft version of the Hanford Site Biological Resources Management Plan (DOE-RL 1996) made extensive use of the biodiversity inventory data from 1994 and 1995. The 1997 and 1998 inventory effort added significant information about the biological resources of the site, especially within

Central Hanford. To ensure that DOE's continued stewardship of Hanford's biodiversity is based on the best available information, a linkage between the biodiversity inventory data and the management plan should be maintained, with the preferred outcome being an updated version of the management plan. Future versions should contain mechanisms to allow adaptive management based on future inventory findings.

As has been alluded to previously in this report, an inventory represents a snapshot in time. To track the status of Hanford's biodiversity over the long-term and to insure its long-tem conservation, it is imperative that a comprehensive monitoring program be implemented and maintained. Sound ecological monitoring is the only way to provide the information needed to adjust management actions as resource conditions, or potential impacts to those resources, change over time.

Section 14 – References

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