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Natural Vegetation at the Proposed Reference Repository Location in Southeastern Washington

W. H. Rickard

February 1988

Prepared for the U.S. Department of Energy
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Pacific Northwest Laboratory
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W. H. Rickard

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Pacific Northwest Laboratory
Richland, Washington 99352

PREFACE

In 1986, the U.S. Department of Energy (DOE) selected the Hanford Site, Washington, for further study as a permanent repository for commercial spent nuclear fuel and high-level radioactive waste. The DOE then initiated a site characterization program to obtain the information necessary for evaluating the suitability of locating a repository at the Hanford Site. These characterization activities are part of the Basalt Waste Isolation Project (BWIP). Pacific Northwest Laboratory (PNL) was contracted by the DOE to do the environmental studies. The DOE is required by Section 113(a) of the Nuclear Waste Policy Act (NWPA) to "conduct site characterization activities in a manner that minimizes any significant adverse environmental impacts identified . . ."

Because the site characterization program requires underground testing, clearing of the land surface, and other activities that may impact the environment, the Office of Civilian Radioactive Waste Management developed an Environmental Monitoring and Mitigation Plan (EMMP) to document compliance with Section 113(a) of the NWPA. The EMMP is to provide an overview of programs to be used for detecting potentially significant adverse environmental impacts resulting from site characterization, as identified in consultation with the affected states and Indian tribes. Additional information on technical approaches is provided in the Environmental Field Activity Plans (EFAPs) for EMMP-mandated programs.

This document is part of the Environmental Topical Report series. These topical reports, presenting the results of the environmental monitoring studies at the BWIP site, will be issued intermittently as specific project objectives are met. Topical reports will be a reference source for other BWIP environmental reports, including the 6-month EMMP reports, BWIP Environmental Reviews, and environmental licensing reports.

SUMMARY

The information in this interim report will be used to design future environmental monitoring plans and assess impacts related to Basalt Waste Isolation Project (BWIP) activities. New reports will be issued as more data become available.

Five 50- x 50-m permanent study plots were set out in the spring of 1986, and information on species composition and canopy cover provided by shrubs and herbs was obtained on each plot. The dominant shrubs were sagebrush and spiny hopsage; the herbs were dominated by cheatgrass and Sandberg bluegrass.

Spiny hopsage appeared to be vulnerable to burning and also to damage by off-road vehicular traffic. It appears to have little or no ability to reproduce through seedlings; once the existing plants are killed they are not likely to be replaced, even if seed-producing plants are nearby. The only pure stand of spiny hopsage known to exist on the Hanford Site is on and near study plot 2H.

Sagebrush, like spiny hopsage, is killed by burning and is easily crushed and killed by heavy vehicles. However, sagebrush is capable of reproducing via seeds, indicating that it is an inherently aggressive species with a capacity to reestablish itself if parent plants are in the vicinity to act as seed sources.

Alien, annual plants, especially cheatgrass, were a major contributor to the herbaceous canopy cover in plots 3S, 4S, and 5S. However, native perennial grasses, especially Sandberg bluegrass, were a major contributor to the canopy cover in plots 1S and 2H. These differences are probably caused by differences in soil properties (e.g., water retention capacity), rather than to historical disturbances such as livestock grazing or wildfire.

Both native and alien herbaceous plants help to protect the soil against wind erosion. In addition, some species provide food for wildlife; for example, seeds are important foods for horned larks, meadowlarks, and pocket mice. The role of plants as forage and habitat for birds and mammals will be addressed in other reports.

Specimens of Sandwort, *Arenaria franklinii*, growing near the Reference Repository Location were collected for examination by taxonomists to

determine if the specimens are of the variety *A. f. thompsonii*, a taxon currently listed as threatened in the state of Washington.

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INTRODUCTION

A location in the lower Cold Creek Valley on the U.S. Department of Energy's Hanford Site in Benton County, Washington, has been selected as a possible site for the geological disposal of commercially produced high-level radioactive waste (see the Reference Repository Location in Figure 1). Although most of the site characterization studies associated with the proposed repository location are to be concerned with the geological and hydrological features of basalt formations, site characterization also considers surface features, including terrestrial plants and animals. This interim report is an initial characterization of the natural vegetation in the vicinity of the proposed Exploratory Shaft, and includes a brief history of the major man-induced vegetational changes that have taken place over the past century. Updated information will be recorded in future reports. The information will be used for designing future environmental monitoring plans and assessing impacts on plants from well drilling, water pumping, and related construction work. It can also lend insight as to the kinds of revegetation practices most likely to be successful on severely disturbed ground. The information is also expected to be useful for characterizing wildlife habitats, and as a ground truth for aerial photographs used as aids in mapping the location and extent of vegetational and ground disturbance induced by fires, or by site characterization activities in general. Additional information is available in Laboratory Record Book 51523.

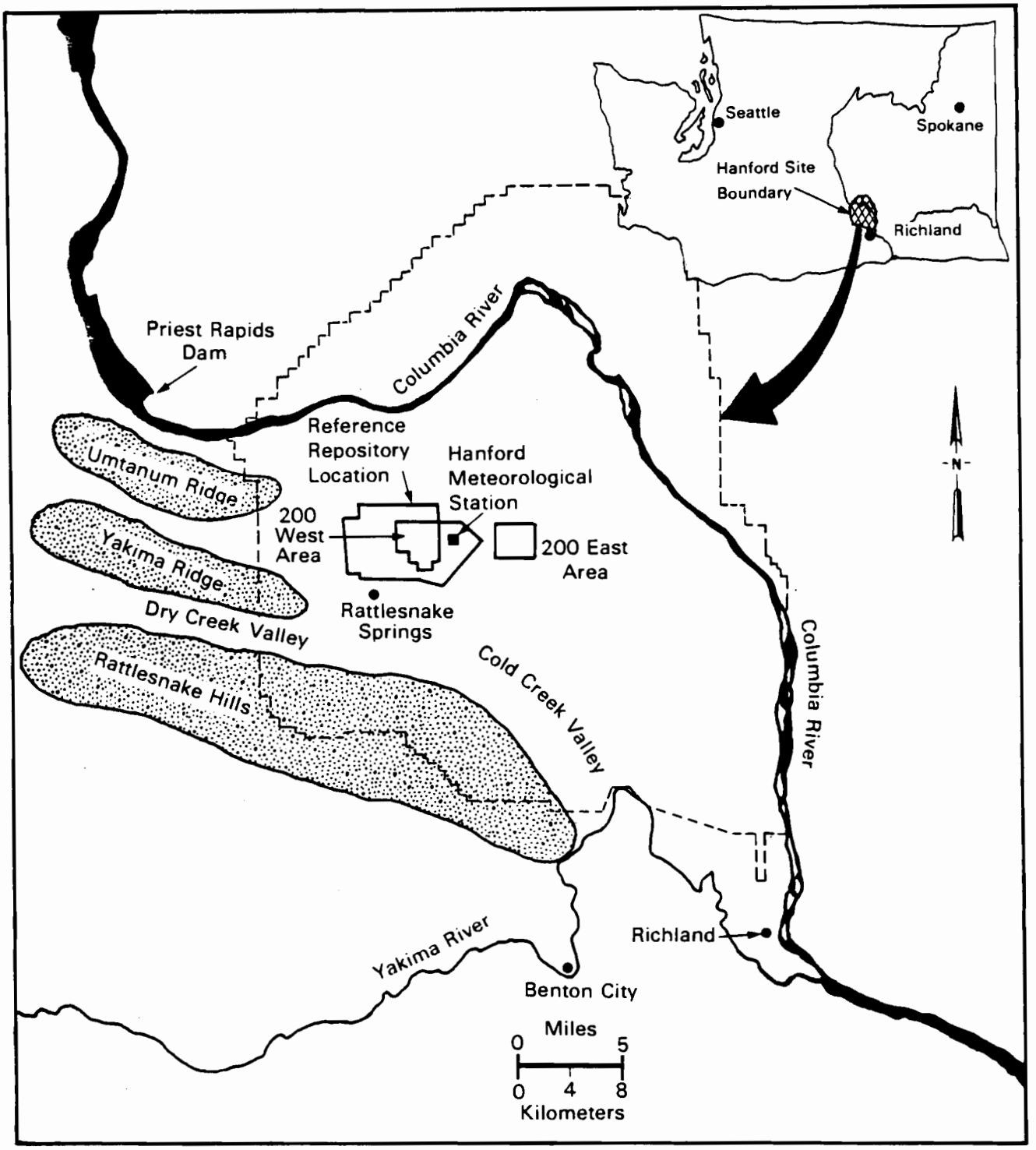

FIGURE 1. Map of the Hanford Site and Reference Repository Location

DESCRIPTION

THE AREA STUDIED

Studies were conducted in representative vegetation near the proposed Exploratory Shaft (Figure 2). The lowest elevation on the valley floor is approximately 190 m above mean sea level; however, elevations rise abruptly to 240 m on the plateau north of the Exploratory Shaft. The highest elevation (in excess of 300 m) is on Yakima Ridge, southwest of the Exploratory Shaft.

The lower Cold Creek Valley receives surface water runoff from a 223-km^2 watershed that extends westward beyond the Hanford Site boundaries (Skaggs and Walters 1981). Water flows are intermittent, occurring mostly during periods of unusually heavy rainfall or rapid snow melt. However, there is no apparent channel connecting the Cold Creek drainage to the Dry Creek drainage, located south of the Exploratory Shaft. The annual precipitation measured at the nearby Hanford Meteorological Station is low, averaging 16 cm, with most occurring in the late autumn and winter months (Stone et al. 1983).

The natural vegetation of the area is mostly comprised of a mixture of annual and perennial grasses, especially cheatgrass, *Bromus tectorum*, and Sandberg bluegrass, *Poa sandbergii*, with an overstory of short-statured, widely spaced desert shrubs, especially big sagebrush, *Artemisia tridentata*.

LIVESTOCK GRAZING

In 1943 the area studied was acquired by the government as part of a 1480-km^2 area set aside for one of the nation's major plutonium production facilities. Sheep and cattle had probably grazed in the area for 70 years or more before 1943. The nearest permanent source of drinking water is Rattlesnake Springs, located approximately 4.8 km southwest of the Exploratory Shaft (Figure 2). Grazing and trampling occurred during the many years of livestock use, accelerating the invasion of cheatgrass, an alien annual grass. Cheatgrass was probably well established by 1943 (Daubenmire 1970). Livestock grazing ceased under government management, except for the land near Rattlesnake Springs, which continued to be grazed

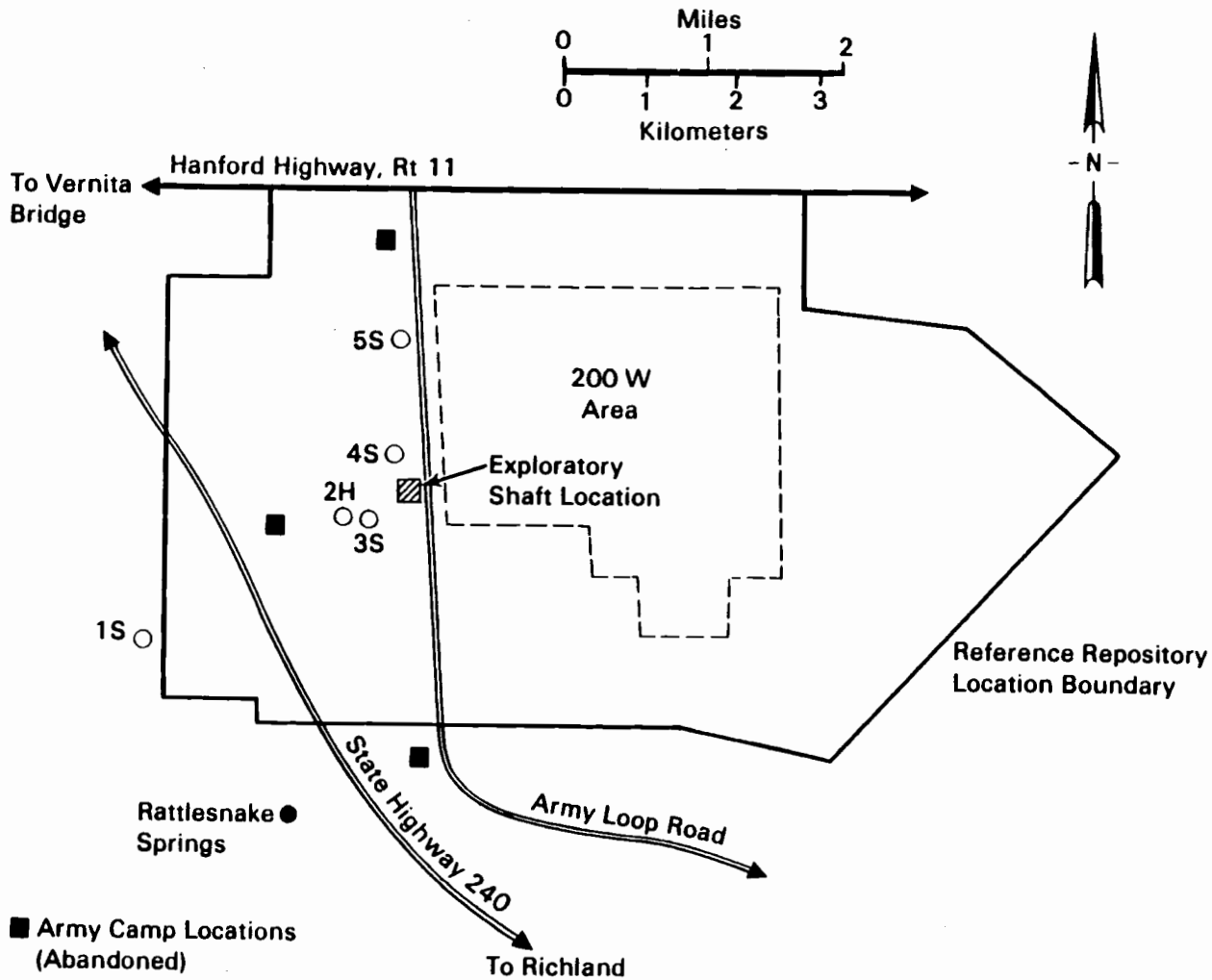

FIGURE 2. Map of the Reference Repository Location, Showing the Location of the Proposed Exploratory Shaft and Five Vegetation Study Plots

until the early 1960s. Years of heavy, localized livestock grazing at the springs impaired the ability of native willow trees (Salix spp.) to regain vegetational dominance along the spring stream (Rickard and Cushing 1982).

INDUSTRIAL DEVELOPMENT

Immediately following the government's acquisition of the land, a large-scale industrial complex was constructed on the elevated plateau 2.4 km east of the Exploratory Shaft. This facility, completely surrounded by a chain-link security fence, is known as the 200-West Area (Figure 2).

ABANDONED MILITARY FACILITIES

In the early 1950s, military outposts were established around the 200-West Area to protect the industrial buildings against attack from hostile aircraft. Three of these outposts were located within the study area (Figure 2). All of them were abandoned in the early 1960s and all buildings were dismantled or moved.

PLANTED TREES AND GRASSES

After 25 years, some of the trees that had been planted and irrigated to provide shade and act as windbreaks at the military facilities are still alive without benefit of irrigation, suggesting that they now have roots deep enough to tap a persistent source of subsurface water. These trees are used as nest sites for birds (e.g., Swainson's hawks and northern orioles) that otherwise would not nest in the study area.

Crested wheatgrass, Agropyron desertorum, a drought-resistant, alien, perennial grass, was planted to help retard wind erosion of ground areas bared by construction activities. Some clumps of crested wheatgrass are still alive, indicating a potential for its use in future revegetation.

NATURAL FIRE, INSECT DEFOLIATION, AND VOLCANIC ASH FROM MOUNT ST. HELENS

Wildfires have destroyed the sagebrush shrubs on hundreds of acres of the Hanford Site, including the area studied, leaving "fire scars." The herbaceous understory plants associated with the shrubs are generally more tolerant of burning than the shrubs, and the herbs usually recover quickly.

Like sagebrush, spiny hopsage (Grayia spinosa)[a] can be killed by summer burning (Rickard and McShane 1980). However, gray rabbitbrush, Chrysothamnus nauseosus, and green rabbitbrush, C. viscidiflorus, sometimes can sprout after being burned. This ability has a great competitive advantage in maintaining rabbitbrush populations in areas that are susceptible to summer burning.

The death of sagebrush shrubs following defoliation by insects has been reported in the literature (Gates 1964). However, such severe damage has not been observed in sagebrush on the Hanford Site.

The eruption of Mount St. Helens in May 1980 deposited large amounts of volcanic ash in parts of eastern Washington (Fruchter et al. 1980); however, there was only a very light dusting in the study area. Nevertheless, volcanic ash remains faintly visible on the soil surface in a few places.

OFF-ROAD VEHICULAR TRAVEL, GRAVEL PITS, AND RETIRED BURIAL SITES

Other changes in the vegetation have resulted from human activities. For example, wheeled and tracked vehicles have crisscrossed the area, leaving persistent, visible scars in the vegetation. Sagebrush and spiny hopsage have brittle wood that is crushed by the passage of these heavy vehicles. Long firebreak lines also have been made from time to time by shearing off plants at ground level with a bulldozer blade, leaving 3-m-wide swaths of disturbed ground that are devoid of shrubs. An operating gravel pit is located at the junction of Army Loop Road and Hanford Highway, Rt. 11 (Figure 2). There are also several areas outside the fenced boundaries of the 200-West Area that have been land-filled, graded, and artificially planted with perennial grasses as a part of the radioactive-waste monitoring and stabilization programs associated with the industrial operations of the 200-West Area.

Aerial photographs are expected to be a useful way to document the extent of vegetational disturbance by mechanical devices, as well as the extent of burning in, and adjacent to, the Reference Repository Location.

(a) Referred to as Atriplex spinosa in Hitchcock and Cronquist (1973)

RADIONUCLIDE RELEASES FROM HANFORD SITE OPERATIONS

Long-lived radionuclides released into the local environment in controlled amounts during the 44-year industrial history of the Hanford Site have the potential to participate in mineral cycling processes and appear in terrestrial plant tissues via direct contact with leaf surfaces, and/or uptake from contaminated soil and contaminated groundwater. Some of the very long-lived radionuclides that have been released into the air from the nearby industrial facilities are carbon-14, iodine-129, and plutonium-239 and -240. Carbon-14 is released into the air as gaseous carbon dioxide. In this form it enters leaves, participates in the process of photosynthesis, and may become incorporated into the stem wood of sagebrush plants. Elevated levels of carbon-14 occur in the wood of sagebrush plants growing adjacent to the 200-East Area (Price 1981). Over the years, iodine-129 has accumulated in very small quantities on the surface soil (Rickard and Price 1984). Iodine-129 is also present in elevated levels in the thyroid glands of mule deer; the source of this iodine-129 is believed to be the plants eaten by the deer. Airborne plutonium-239 and -240 have accumulated in very small amounts in the surface soil, particularly near the 200 Areas (Price 1985).

Radionuclides in solid and aqueous forms have been placed below ground with a substantial cover of overlying earth. Plants growing on the earth backfill over these burial sites (landfills) can take up radionuclides, especially if the radionuclides are in a wetted part of the soil matrix and shallow enough to be within the root zone. Rabbitbrush shrubs have accessed moderately long-lived (30-year half-life) cesium-137 from a depth of 2.4 m (Klepper et al. 1978).

Tritium (12-year half-life) is one of the most mobile of the radionuclides that have been released to the ground in aqueous streams. Tritium has entered the unconfined aquifer and is widely distributed in a broad zone between the 200 Areas and the Columbia River to the southeast (Price 1985). It is not known if any of the deep-rooted shrubs and trees growing in the study area have root access to tritiated groundwater.

Tumbleweed, *Salsola kali*, (also called Russian thistle) is a common summer annual plant that often grows on the earth backfill material placed over buried radioactive wastes. In the autumn, these plants become mature and their stems break off at ground level. The stiff-stemmed, globular-

shaped shoots can be rolled long distances by wind, dispersing seeds along the way before becoming lodged against fences, buildings, or shrubs. The contribution of Hanford-produced radionuclides to the lower Cold Creek valley via this unusual wind-aided biotic transport mechanism is unknown. Rabbits that eat contaminated plants or soil particles inside waste management zones may also disperse radionuclides in feces and urine over long distances (O'Farrell and Gilbert 1975).

VEGETATIONAL ANALYSES

SELECTION OF STUDY PLOTS

Study plots were selected for vegetational analysis in the spring of 1986. Plots were located in stands with mature desert shrubs because it was thought that the presence of shrubs indicated climax condition (Daubenmire 1970).

Five locations were chosen for detailed vegetational analysis. Three of these are located on the valley floor: 2H, 3S, and 4S; and two on the adjacent uplands: 1S and 5S (Figure 2). A plot in each location was established by surveying from the nearest ground reference point. Each plot was 50 x 50 m and was marked with steel fence posts at 5-m intervals around the plot perimeter. The posts were aligned in north-south and east-west directions.

METHODS

The shrub cover, by species, was determined by line intercept. A 50-m line was tightly stretched between the steel fence posts used to mark the boundaries of each 50- x 50-m plot. In all, eleven lines were run in a north-south direction, and eleven lines were run in an east-west direction. All lines were used to calculate percent canopy cover. Shrub density was measured by counting all shrubs greater than 3-dm tall within each plot.

The species composition and canopy cover provided by herbs was determined using the canopy coverage method of vegetational analysis specially designed for use in steppe vegetation by Daubenmire (1959). Three east-west lines, each 40-m long, were located within each 50- x 50-m plot. Forty 2- x 5-dm plots, systematically spaced along each line at 1-m intervals, were visually examined. Observations were made in early May to determine the canopy cover provided by the spring maturing herbs. The same lines were remeasured in September to obtain the amount of cover provided by herbs maturing in late summer and autumn. Plant specimens were collected, pressed, and dried for identification purposes. Ground-level photographs were taken at each study plot (Figure 3).

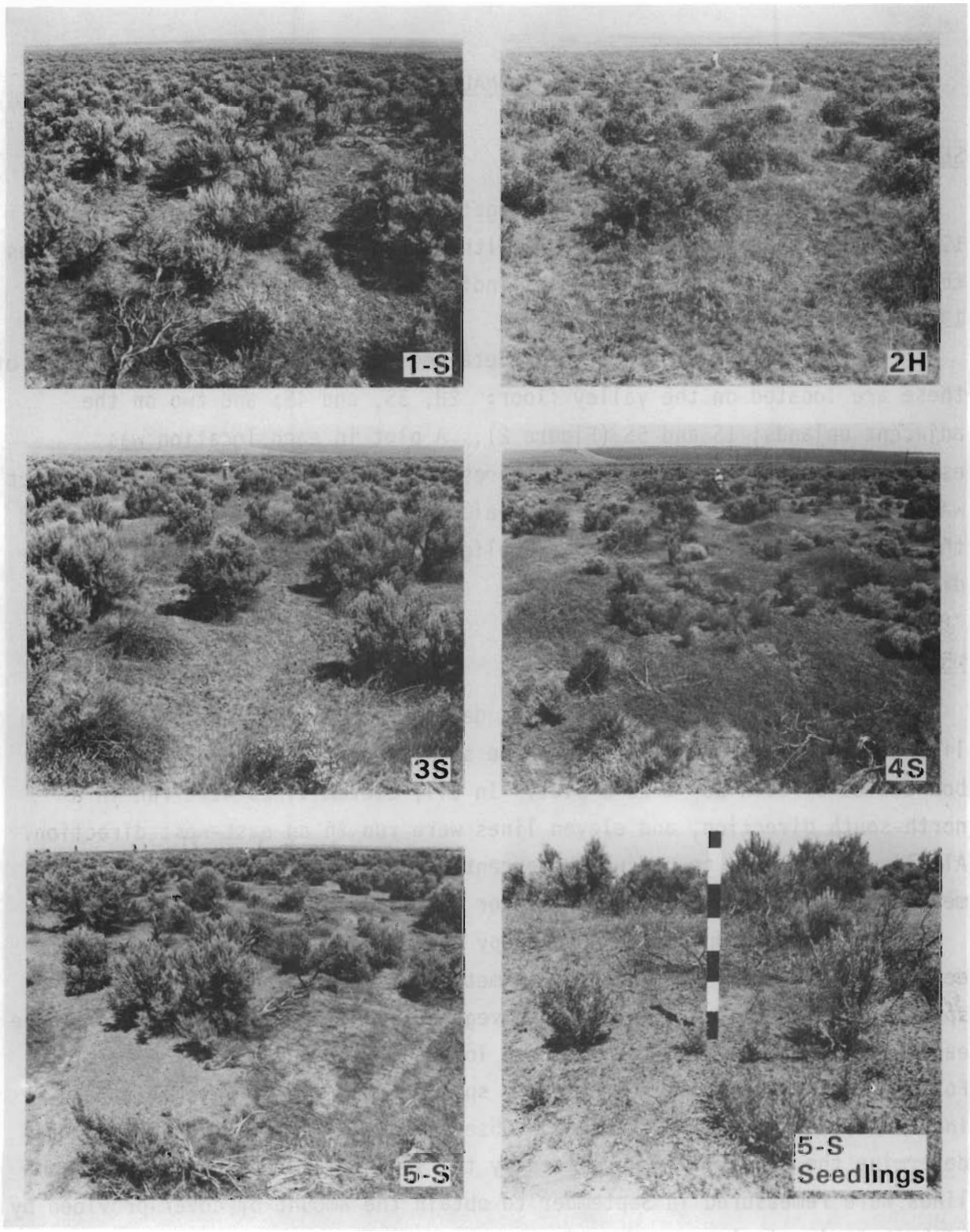

FIGURE 3. Photographs of the Five Vegetation Study Plots in June 1986. The view is looking toward the north. Plots 1S, 3S, 4S, and 5S are dominated by sagebrush, and plot 2H by spiny hopsage. Plot 5S (seedlings) shows young sagebrush plants. The stake is marked at 1-dm increments.

RESULTS AND DISCUSSION

Shrubs

Only four species of desert shrubs were seen in the area. Sagebrush occurs throughout the area, but is absent at those places recently burned by wildfire. Sagebrush was not present on plot 2H, which was occupied by a pure stand of spiny hopsage (Table 1). Mixed stands of sagebrush and spiny hopsage occurred on plots 3S, 4S, and 5S, but sagebrush was much more abundant in terms of number of plants per plot and in terms of canopy-cover (Figure 4). Spiny hopsage did not occur on plot 1S. Rabbitbrush shrubs were present on plot 4S in greater numbers than either sagebrush or spiny hopsage (Table 2). However, sagebrush provided most of the canopy cover because the sagebrush shrubs were generally much larger.

Young sagebrush plants were present in plots 3S, 4S, 5S, and 1S. This indicated that sagebrush has the capacity to sustain itself from seedlings after the natural mortality of parent plants or eradication by burning. However, all the spiny hopsage shrubs appeared to be old and there was no evidence that they were reproducing via seedlings.

The sequence of historical events that has led to the segregation of pure stands of sagebrush and spiny hopsage is unknown, but the formation of pure stands may be related to historical surface-water runoff events and the periodic pooling of water for days or possibly weeks at a time during winter in the lower parts of a closed drainage system. Relatively long periods of wetting may be favorable to seed germination and seedling survival of hopsage, and it may also be less favorable to sagebrush seeds and seedling survival.

In the summer of 1986, four medium-sized sagebrush shrubs were cut off near ground level, one each near plots 3S, 4S, 5S, and 1S, to determine their minimum ages. These plants were all more than 40 years old, as determined by counting the annual growth increments of stem wood. The 1976-1977 growing season on the Hanford Site was marked by the most severe October to May drought in 50 years of record, with <6 cm of precipitation. Sagebrush shrubs at plots 3S, 4S, and 5S all produced very small amounts of stem wood growth in 1977. The shrubs collected at plot 1S were not as deleteriously affected by drought as the others, judging by the less suppressed growth ring

TABLE 1. Canopy Cover Provided by Shrubs on Five Plots near the Proposed Exploratory Shaft in June 1986

Taxa	Plots % Canopy Cover 2H	3S	4S	5S	1S
Sagebrush[a]	0	17.7	11.4	24.7	32.7
Spiny hopsage[b]	23.3	0.77	0.47	0.34	0
Gray rabbitbrush[a]	0	0	5.6	0	0
Green rabbitbrush[a]	0	0	1.5	0	0
Total	23.3	17.5	19.0	25.0	32.7

(a) Autumn flowering
(b) Spring flowering

TABLE 2. Number of Shrubs on Five Plots, each 2500 m^2, near the Proposed Exploratory Shaft in June 1986

Taxa	Plots 2H	3S	4S	5S	1S
Sagebrush	0	349	250	524	1263
Spiny hopsage	530	39	12	8	0
Gray rabbitbrush	0	0	423	0	0
Green rabbitbrush	0	0	80	0	0
Total	530	388	765	532	1263
Shrubs/hectare	2120	1552	3060	2128	5052

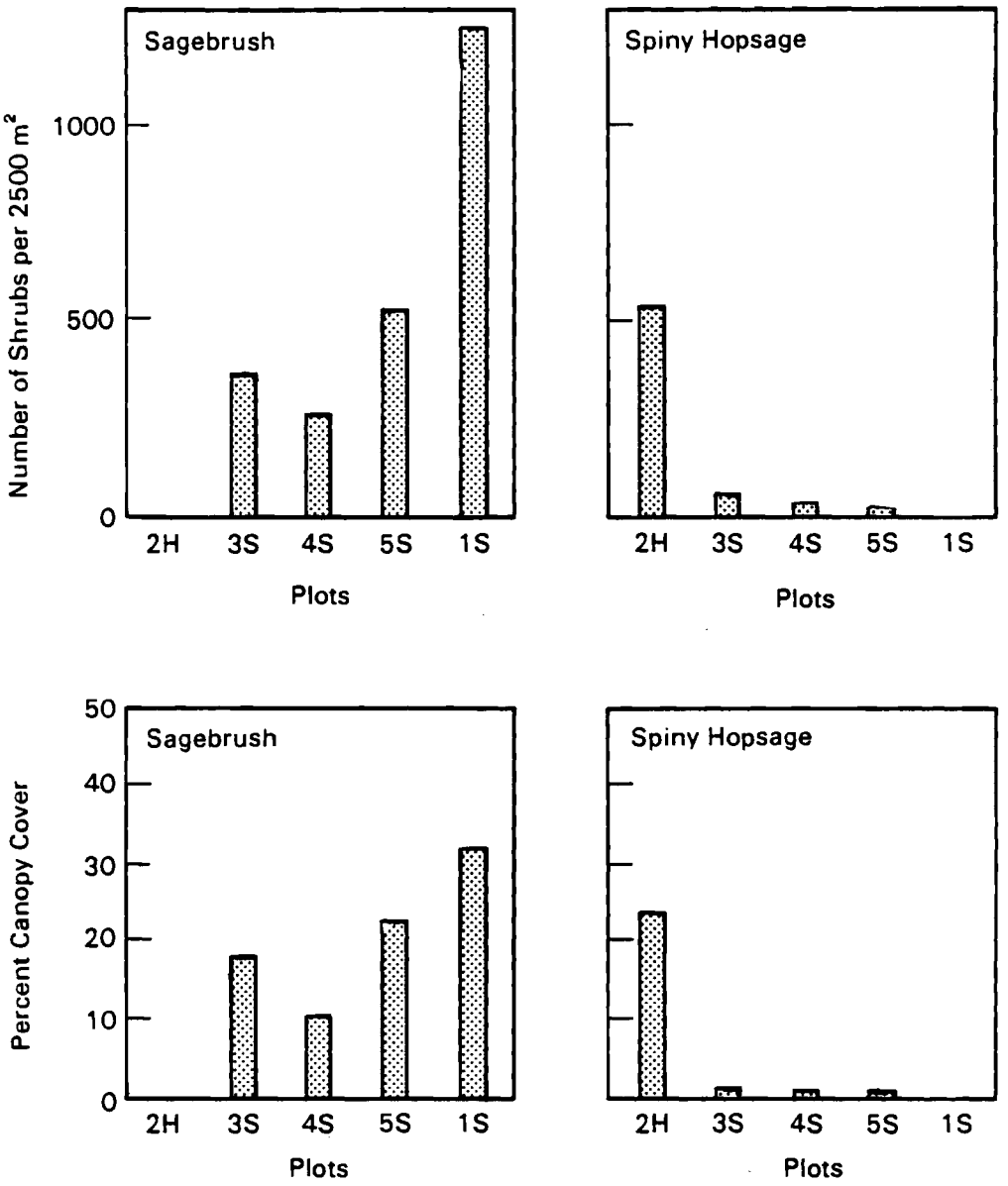

FIGURE 4. Numbers of Sagebrush and Spiny Hopsage Shrubs, and Canopy Cover Provided by Sagebrush and Spiny Hopsage near the Proposed Exploratory Shaft, June 1986.

(Figure 5). These few observations indicate that the growth of drought-tolerant sagebrush shrubs can be suppressed in those occasional years with unusually low precipitation. Rickard and Warren (1981) reported that spiny hopsage produced very few leaves in the 1976-77 drought year; however, the same plants not only survived, but produced a full complement of leaves in the next growing season.

Herbs

The herbaceous plant species observed on the five study plots are listed in Table 3. Forbs were represented on the study lines by 14 species of annuals and 6 species of perennials (Figure 6). Only four species of grasses were encountered, two perennials and two annuals. The two most important contributors to the herbaceous canopy cover were Sandberg bluegrass and cheatgrass. Sandberg bluegrass provided most of the canopy cover on plots 2H and 1S, but cheatgrass provided most of the canopy cover on plots 3S, 4S, and 5S. Clearly, the most important herbaceous species, as judged by canopy cover, are the grasses.

Herbaceous canopy cover was greatest on plot 2H at 51% (Table 3). All other plots ranged between 29% and 35%. Herbs provided more ground cover than did shrubs in plots 2H, 3S, and 4S, but herb cover and shrub cover were about the same on plots 5S and 1S (Figure 7). On those plots where perennial grasses dominated canopy cover, the annual grasses provided low amounts of canopy cover and vice versa. The plots with relatively large amounts of Sandberg bluegrass appeared to have silty soil while those with cheatgrass had sandy soil.

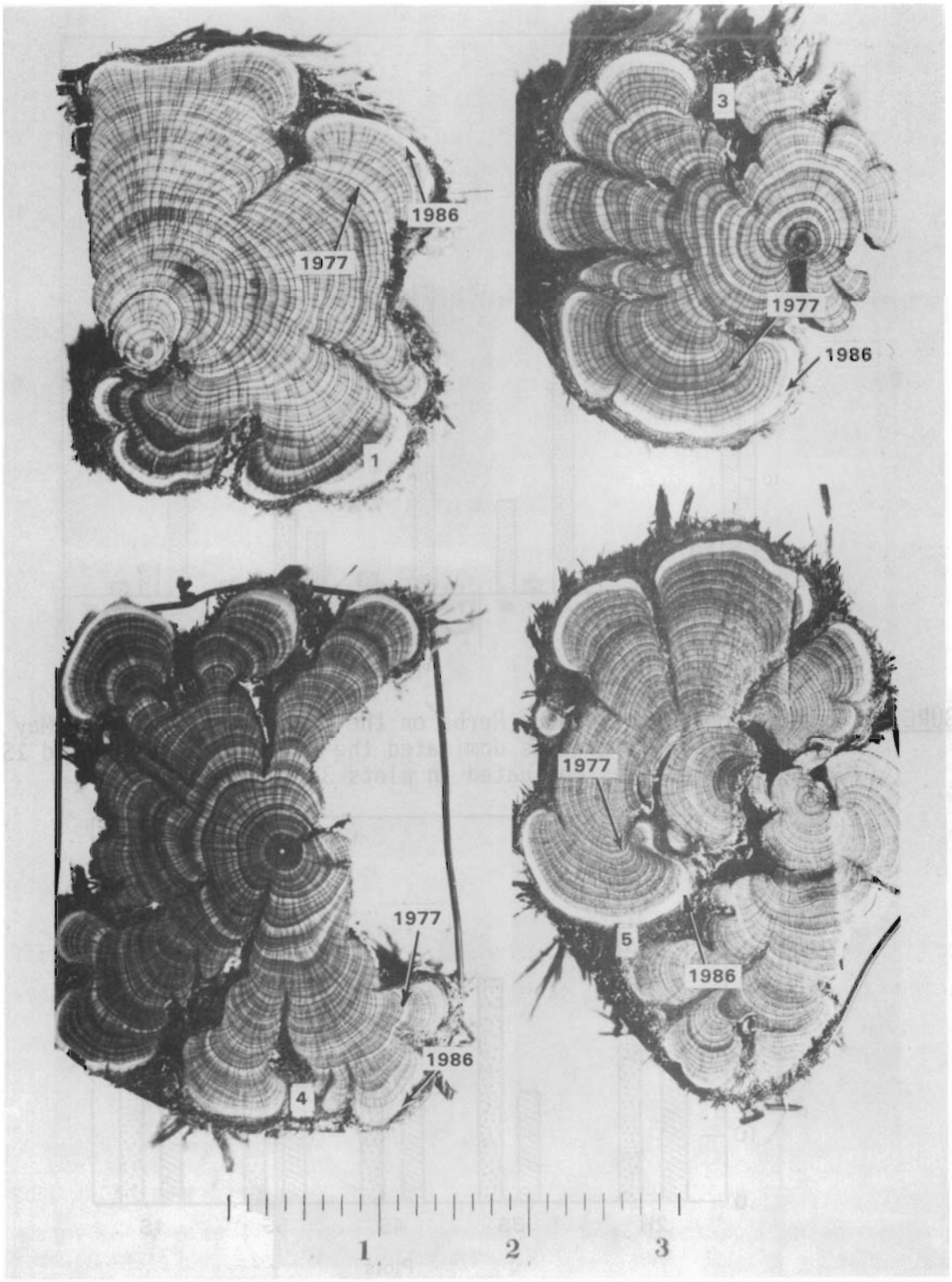

FIGURE 5. Cross Sections of Cut Sagebrush Stems. The wood growth in plots 3S, 4S, and 5S was suppressed by unusually severe drought in the fall and winter of 1976-77. The scale is in inches.

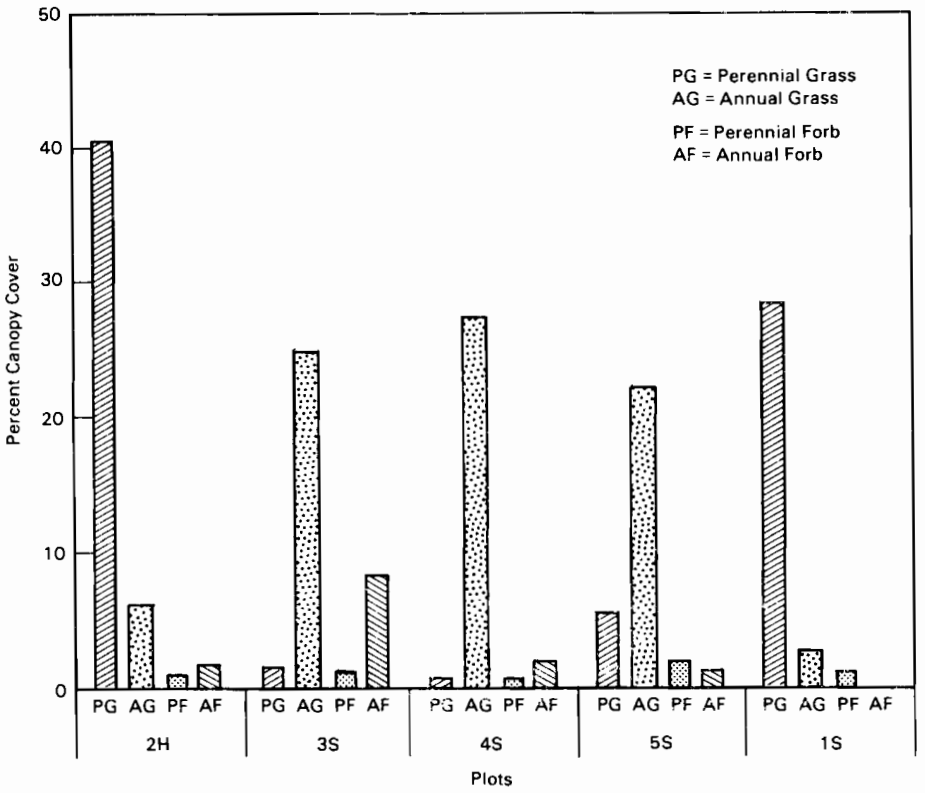

FIGURE 6. Canopy Cover Provided by Herbs on the Study Plots in Early May 1986. Perennial grasses dominated the cover in plots 2H and 1S, and annual grasses dominated in plots 3S, 4S, and 5S.

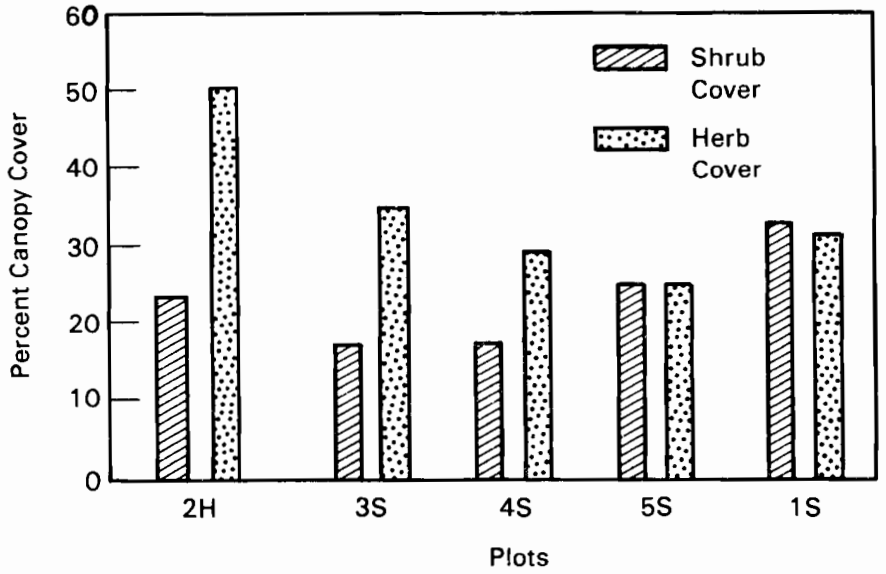

FIGURE 7. Canopy Cover Provided by Shrubs and Herbs on the Study Plots in 1986. Shrub cover was greatest on plot 1S. Herb cover was greatest on plot 2H. Herb cover greatly exceeded shrub cover on plots 2H, 3S, and 4S, but herb and shrub cover had similar values on plots 5S and 1S.

TABLE 3. Canopy Cover provided by Herbs on Five Study Plots near the Proposed Exploratory Shaft in May 1986

	Plots % Canopy Cover				
	2H	3S	4S	5S	1S
Perennial grasses					
Poa sandbergii	41	1.1	<0.1	5.3	28
Sitanion hystrix	0.12	0	0	0	0.14
Total	41	1.1	<0.1	5.3	28
Annual grasses					
Bromus tectorum[a]	5.7	25	27	21	2.1
Festuca octoflora	0	<0.1	0	0.62	1.2
Total	5.7	25	27	22	2.2
Perennial forbs					
Aster canescens[b][c]	0	0.41	<0.1	0.18	<0.1
Sphaeralcea munroana	0.25	0.15	0	0	0
Phlox longifolia	0	0.48	0	0.83	0
Crepis atrabarba	0	0	0	<0.1	<0.1
Balsamorhiza careyana	0	0	0	0.60	0
Comandra umbellatua	0	<0.1	0	0	0
Helianthus cusickii	0.65	0	0	0	0
Total	0.90	1.1	<0.1	1.7	<0.1
Annual forbs					
Descurainea pinnata	0.48	0.27	<0.1	0.58	0
Lactuca serriola[a][d]	0.50	<0.1	0.17	0	0
Epilobium sp.[d]	<0.1	0.62	0.10	0	0
Microsteris gracilis	0.56	5.5	<0.1	0	0
Sisymbrium altissimum[a]	0.69	1.2	0.73	0	0
Tragopogon dubius[a]	0.66	0.12	0	0	0
Polemonium micranthum	1.4	0	0	0	0
Cryptantha circumscissa	0	<0.1	<0.1	0.44	0
Holosteum umbellatum[a]	0	0.12	0	0	0
Eriogonum vimineum	0	0	0.25	0	0
Mentzelia albicaulis	0	0	0.23	0	0
Amsinckia lycopsoides	0	0	0	<0.1	0
Salsola kali[a][d]	0	0	<0.1	0	0
Ambrosia acanthicarpa[d]	0	<0.1	0.12	0	0
Total	4.3	7.9	1.8	1.0	0
Total Herb Cover	51	35	29	30	31

(a) Alien taxon
(b) Summer flowering perennial
(c) Referred to as *Machaeranthera canescens* in Hitchcock and Cronquist (1973)
(d) Summer flowering annual

ENDANGERED, THREATENED, AND SENSITIVE PLANTS

The Department of Natural Resource's Natural Heritage Program (Washington Natural Heritage Program 1984) is responsible for monitoring the status of Washington State vascular plants. A major threat to native plants in the semiarid portions of eastern Washington is the conversion of rangeland to irrigated crops and dryland wheat. Entire populations of native plants can be extirpated by plowing. Also, native plants growing on rangelands adjoining cultivated crops may be killed or damaged by chemical herbicides that are applied as aerosols on cropland to kill weeds.

Botanists of the Washington Natural Heritage Program have identified Columbia milk vetch, *Astragalus columbianus* Barneby, as a local endemic, restricted to a relatively small rangeland area near Priest Rapids Dam on the western shoreline of the Columbia River. *Astragalus columbianus* is on the U.S. Fish and Wildlife Service's list of threatened, endangered, and candidate species for possible future classification of threatened or endangered status. It is likely that *A. columbianus* does not occur on the Reference Repository Location.

The Natural Heritage Program lists Thompson's sandwort (*Arenaria franklinii* Dougl. var. *thompsonii* Peck) as threatened. It has been recorded in Benton and Franklin Counties, Washington. Scattered stands of *A. franklinii* occur on stabilized sand dunes at several places on the Hanford Site. However, the taxonomic status of the Hanford Site population is not clear. It is not known if the variety living on the Hanford Site is *A. franklinii* var. *franklinii*, or *A. franklinii* var. *thompsonii*. The Natural Heritage Program is currently investigating the taxonomic status of the Hanford Site *Arenaria* population.

Gray cryptantha, *Cryptantha leucophea* Dougl. Pays, is listed by the Natural Heritage Program as a sensitive species in the state of Washington. It occurs along the western edge of the Columbia Basin. Gray cryptantha grows on stabilized sand dunes on the Hanford Site, but its status on the Reference Repository Location is unknown at this time.

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