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W. H. Rickard
C. A. Schuler

March 1988

Prepared for the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830

Pacific Northwest Laboratory
Operated for the U.S. Department of Energy
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# DESCRIPTIONS OF PLANT COMMUNITIES AT THE PROPOSED REFERENCE REPOSITORY LOCATION AND IMPLICATIONS FOR RECLAMATION OF DISTURBED GROUND

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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 were part of the Basalt Waste Isolation Project (BWIP). Pacific Northwest Laboratory (PNL) was contracted by the DOE to do the environmental studies. The DOE was 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 . . ."

This document is part of the Environmental Topical Report series. Each report presents the results of the environmental monitoring studies at the BWIP site, up until BWIP was closed in response to the enactment of the Nuclear Waste Amendments Act of 1987. Some of the reports are preliminary because not all task objectives were completed at project close-out. However, they can serve as a reference source for other BWIP environmental reports related to site closure and reclamation. These Environmental Topical Reports are listed below:

1. *Cold-Blooded Vertebrates at the Proposed Reference Repository Location in Southeastern Washington*, by R. E. Fitzner, January 1988, PNL-6440.

2. *Natural Vegetation at the Proposed Reference Repository Location in Southeastern Washington*, by W. H. Rickard, February 1988, PNL-6402.

3. *Bird Associations With Shrubsteppe Plant Communities at the Proposed Reference Repository Location in Southeastern Washington*, by C. A. Schuler, W. H. Rickard, and G. A. Sargeant, March 1988, PNL-6493.

4. *Descriptions of Plant Communities at the Proposed Reference Repository Location and Implications for Reclamation of Disturbed Ground*, by W. H. Rickard and C. A. Schuler, March 1988, PNL-6494.

5. *Habitat Associations of Vertebrate Prey Within the Controlled Area Study Zone*, by N. V. Marr, C. A. Brandt, R. E. Fitzner, and L. D. Poole, March 1988, PNL-6495.

6. *Productivity, Mortality, and Response to Disturbance of Nesting Swainson's Hawks on the Hanford Site*, by L. D. Poole, N. V. Marr, R. E. Fitzner, and S. M. McCorquodale, March 1988, PNL-6496.

7. *Water Quality: Historic Values and Impact of Drilling Activities During FY1988 at the Reference Repository Location in Southeastern Washington*, by P. A. Eddy, W. H. Biershank, S. S. Teel, and J. R. Raymond, March 1988,. PNL-6497.

## SUMMARY

This report presents an ecological description of the natural vegetation in the Cold Creek Valley located in the west central portion of the U.S. Department of Energy's (DOE) Hanford Site in southeastern Washington state. The site studied was a proposed reference repository location (RRL) as part of the Basalt Waste Isolation Project (BWIP). The description includes plant species composition, canopy cover, and shrub density obtained from 10 study plots distributed in three habitat-types: sagebrush/Sandberg's bluegrass, spiny hopsage/Sandberg's bluegrass, and sagebrush/needle-and-thread grass.

There were relatively few species of shrubs and herbs in the Cold Creek Valley. The most abundant shrubs were sagebrush and spiny hopsage. The most abundant herbs were cheatgrass, Sandberg's bluegrass, and needle-and-thread grass. The amount of canopy cover provided by shrubs ranged between 7.4 and 33% in seven plots without a history of recent burning. Herbaceous plants in these same plots provided canopy cover that ranged between 18 and 41%. The three plots placed in areas with a recent history of burning had more herbaceous cover than did adjacent plots without a recent burn history. This was attributed to absence of living shrubs and freedom from competition for soil water and nutrients. There was less living herb cover in 1987 than in 1986 which is likely due to the lesser amount of growing season precipitation in 1987 (i.e. 10.3 cm vs 17.1 cm). Even with the absence of livestock grazing for 44 years, cheatgrass, an exotic annual, generally provided more canopy cover than native perennial grasses. However, in the few places with good stands of Sandberg's bluegrass, cheatgrass was less abundant.

A case is made for revegetating ground disturbed during the geological and hydrological characterization phases of the BWIP. Reclamation strategies should include the use of native plant species well adapted to the climatic regimen and soils of the Cold Creek Valley and the reconstitution of vegetation that provides both structure and forage for native wildlife species.

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# INTRODUCTION

Much of eastern Washington is characterized by a semiarid climate with a rigorous physical environment. Precipitation is low, and the daily and annual temperature range is frequently extreme. The regional climate imposes severe seasonal thermal and water stresses on plant growth. The Cascade Mountains, in central Washington, creates a rain shadow over eastern Washington that has produced vegetation best described as shrubsteppe (Daubenmire 1970). Floristically the natural vegetation is relatively simple and shoot production is at the lower end of the scale of primary production as compared to natural plant communities in other semiarid regions of the western United States (Rickard et al. 1976). Soils are generally sandy and plant communities are dominated by desert shrubs, annual exotic grasses, and native bunch grasses. Natural vegetation of eastern Washington has been altered by 150 years of intensive land use. Dryland wheat farming, artificial irrigation, shrub removal, and livestock grazing have converted natural plant communities to intensively managed crops or plant communities dominated by a few exotic species, especially cheatgrass. Today, there are only a few places in the entire shrubsteppe region that have not had a long, continuous history of livestock grazing or else have not been converted permanently to dryland or irrigated farming. The largest contiguous expanses of ungrazed shrubsteppe in eastern Washington are located on the U. S. Department of Energy's (DOE) Hanford Site in Benton County, Washington (Figure 1). The Hanford Site was established in 1943 when the entire resident human population on the 1470 $km^2$ (560 $mi^2$) area was relocated and farming and livestock grazing ceased. Since 1943, a major use of the land has been to serve as a buffer zone around a few widely spaced clusters of industrial buildings connected by a network of railroads, highways, buried pipelines, and aboveground electrical transmission lines. There has been no resident human population on the site since 1943 and public access is still strictly controlled. The principal land use of the Hanford Site is for DOE activities related to nuclear energy and nuclear materials production, with a secondary land use as wildlife habitat.

At the proposed reference repository location (RRL) for the Basalt Waste Isolation Project (BWIP) on the Hanford Site (Figure 1), desert shrubs especially big sagebrush (*Artemisia tridentata*) and spiny hopsage (*Grayia spinosa*) are the overstory dominants with a sparse understory of herbs and grasses, primarily cheatgrass (*Bromus tectorum*) and Sandberg's bluegrass (*Poa sandbergii*) (Rickard 1988). Natural vegetation near the proposed RRL was studied for BWIP. This report describes natural vegetation at the RRL in 1987 and addresses changes in herbaceous cover between the 1986 and 1987 growing seasons. This information is useful for developing reclamation strategies for areas disturbed by BWIP site characterization activities.

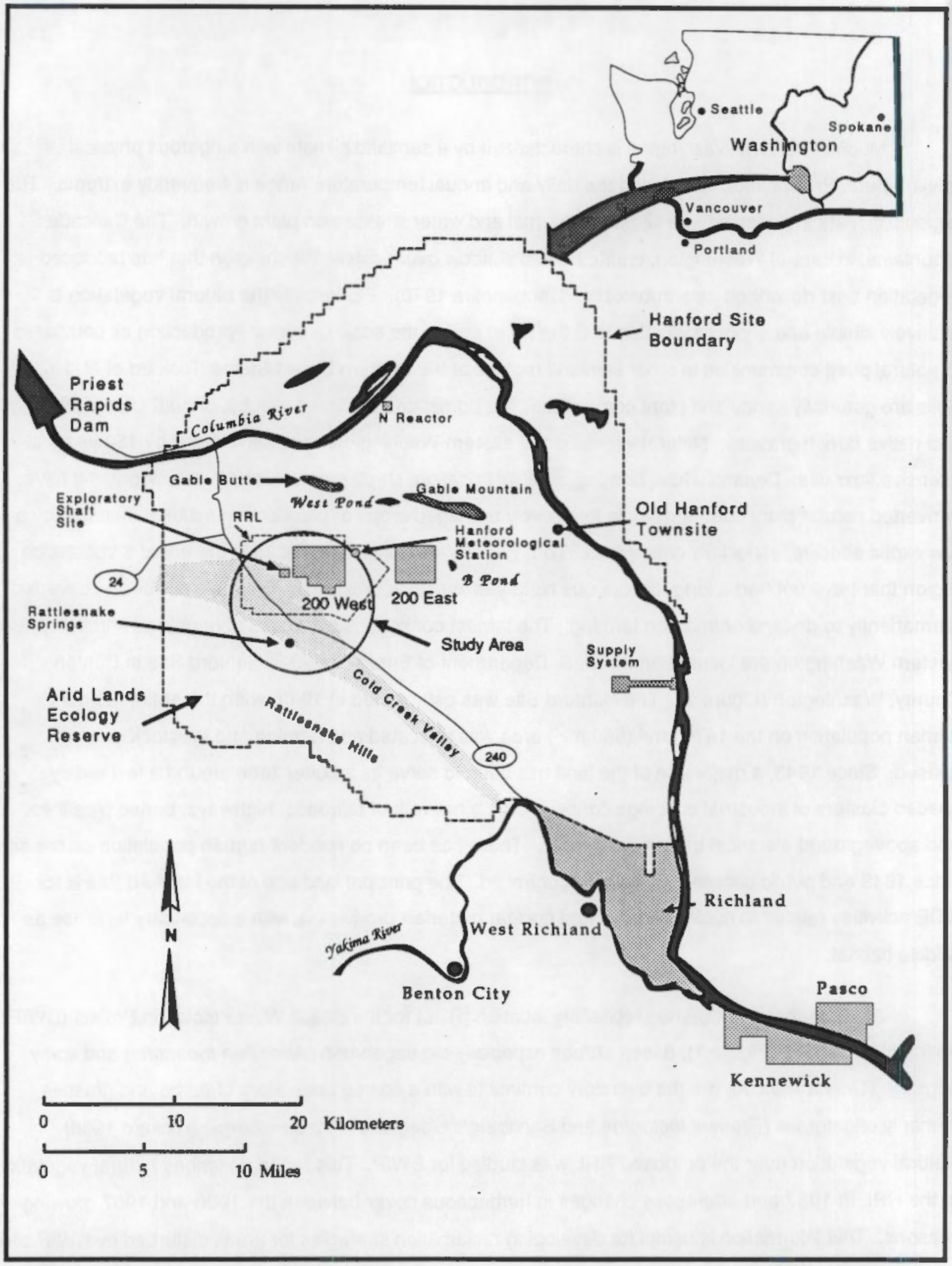


FIGURE 1. Map of the U.S. Department of Energy's Hanford Site Showing the Locations of Cold Creek Valley, General Study Area, and the Hanford Meteorological Station

## STUDY AREA

The RRL is situated near the center of the Hanford Site in the south-central portion of the state of Washington (Figure 1). Elevation of the study area ranges from a low of approximately 200 m above mean sea level in the Cold Creek Valley basin to 260 m on the lower slopes of Yakima Ridge to the west and similar elevations on the broad flat ridge located to the east. The land within fenced exclusion zones around the chemical separation facilities and radioactive waste storage tanks in the 200 Areas is not included in the study area (Figure 1).

The existing vegetation is a mosaic of shrub- and grass-dominated stands created by recent wildfires. Natural vegetation is a mixture of annual and perennial grasses, especially cheatgrass, and Sandberg's bluegrass, with an overstory of short-statured, widely spaced desert shrubs, especially big sagebrush (Rickard 1988). Other shrubs common to this area are spiny hopsage, gray rabbitbrush (*Chrysothamnus nauseosus*) and green rabbitbrush (*Chrysothamnus viscidiflorus*). Three plant habitat-types are recognized in the study area. These are *Artemisia tridentata/Poa sandbergii* (sagebrush/Sandberg's bluegrass), *Artemisia tridentata/Stipa comata* (sagebrush/needle-and-thread grass), and *Grayia spinosa/Poa sandbergii* (spiny hopsage/Sandberg's bluegrass) (Daubenmire 1970).

The Hanford Meteorological Station (Figure 1) is located at an elevation of 240 m (750 ft) above mean sea level and has been in operation since 1948 (Stone et al. 1983) . Annual precipitation averages only 16 cm (6.40 inches) with most falling in fall and winter. Summers are characteristically hot and dry.



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## METHODS

Ten study plots (Figure 2) were distributed among the three shrubsteppe habitat types recognized for this region by Daubenmire (1970). The study plots also encompassed the range of elevations present within the RRL as well as areas of recently burned vegetation. The plots were thought to be large enough to provide ground truthing for aerial photography and remote sensing using satellite imagery.

Each plot was 50 x 50 m (0.25 ha) and permanently marked with steel fence posts. Three parallel lines oriented east-west were systematically located within each study plot. These lines were 40 m long and 40 plot frames, 0.2 x 0.5 m, were spaced at 1 m intervals along the north side of each line. Canopy coverage of herbs was visually estimated using the method of Daubenmire (1959). Herb coverage was estimated at the peak of shoot development of cheatgrass during the first week of May 1987, and shrub cover was measured during the summer months of 1987. Shrub canopy cover was determined using the line intercept method (Canfield 1941). Shrub canopy cover was measured on 22 lines, each 50 m long and spaced at 5 m intervals. Eleven lines were run in a north-south direction and eleven lines were run in an east-west direction for each of the seven plots with shrubs as a way to determine the efficiency of line intercepts for estimating shrub cover on 0.25 ha plots. Three of the study plots did not support living shrubs because of wildfires that burned through the study zone as recently as the summer of 1984.

All living shrubs rooted inside study plots and greater than 30 cm tall were counted to determine shrub density.

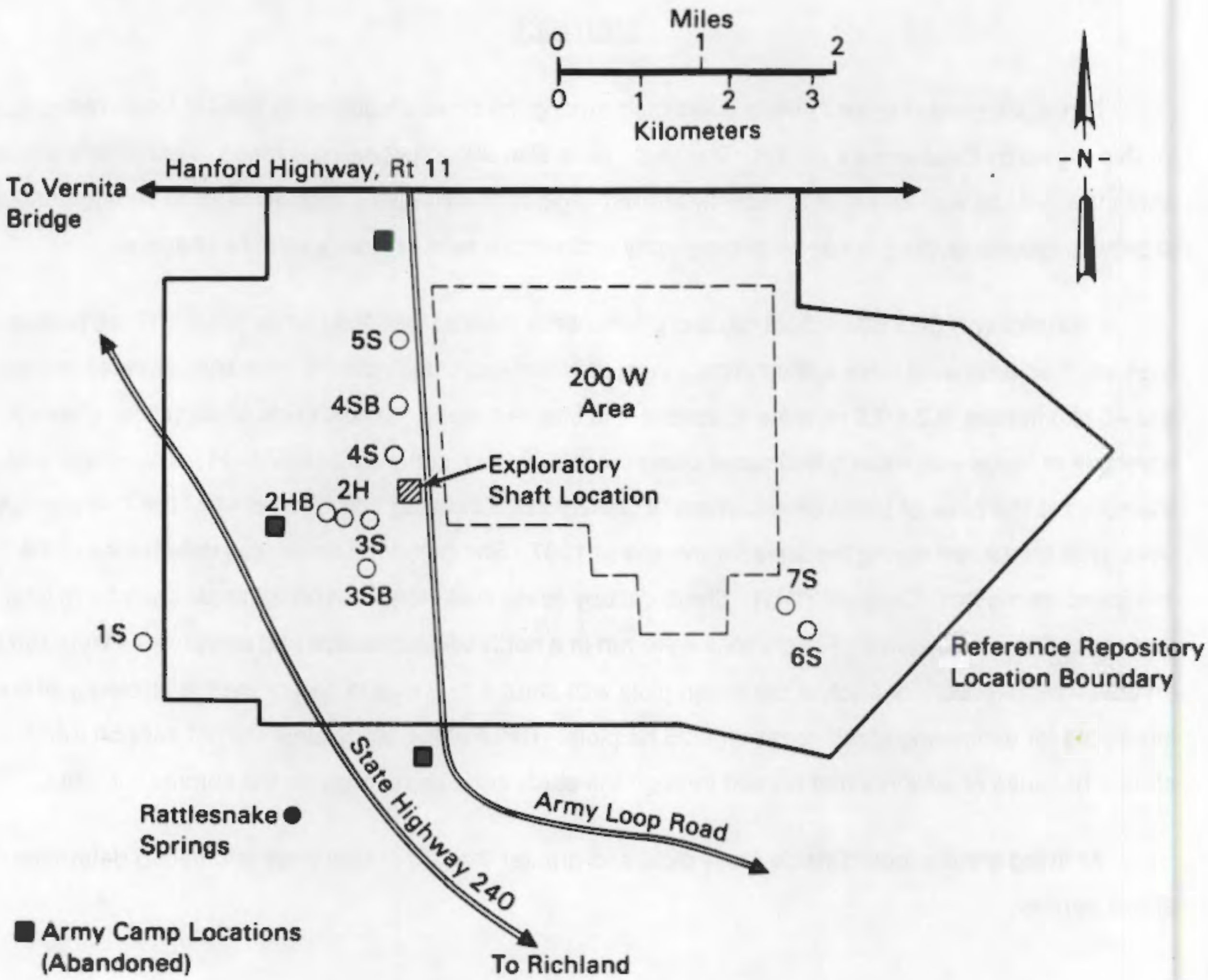


FIGURE 2. Map of the Proposed Reference Repository Location, Showing the Location of the Exploratory Shaft and 10 Vegetation Study Plots. Sagebrush dominated plots are designated 1S, 3S, 4S, 5S, 6S, and 7S; spiny hopsage dominated plot is designated 2H, and burned plots are designated as 2HB, 3SB, and 4SB.

# RESULTS AND DISCUSSION

## PLANT COMMUNITY STRUCTURE

Plant species in the study plots were grouped into six general categories: shrubs, low shrubs, perennial grasses, annual grasses, perennial forbs, and annual forbs (Table 1). Of the 37 species listed, 5 were shrubs, 5 were perennial grasses, and 10 were perennial forbs. There were 16 species of annual plants of which 8 were aliens (Table 1). Only 5 of the 37 species were important contributors to canopy cover. These were big sagebrush, spiny hopsage, Sandberg's bluegrass, needle-and-thread grass, and cheatgrass. Sagebrush, Sandberg's bluegrass, and cheatgrass were ubiquitously distributed in the study zone, but needle-and-thread grass and hopsage were more restricted (Table 1). Cheatgrass was the only exotic species in this group. The data show that the ground surface was only partially covered by herbs (grasses and forbs) and shrubs. Shrub coverage ranged between 7 and 33% in the seven plots (Tables 1, 2) without a recent burn history and herb cover ranged between 18 and 39% (Table 1). The three plots with a recent burn history had greater amounts of herb cover than did unburned stands located in the same habitat types (Table 1). Greater coverage in recently burned areas is attributed to a more favorable soil water and soil mineral nutrient supply in the absence of a stand of living shrubs.

To determine the effectiveness of line-transects in estimating shrub canopy cover, 11 parallel lines, spaced 5 m apart and each 50 m long, were run in east-west and north-south directions across each plot. Running averages were calculated for each set of 11 parallel lines (Figure 3). The percent canopy cover in plot 3S was 18.6 for the north-south lines and 18.5 for the east-west lines (showing essentially no difference). The percent canopy cover in plot 4S was 20.0 for the north-south lines and 17.9 for the east-west lines (a difference of 2.1). The percent canopy cover on plot 7S was 15.2% for the north-south lines and 13.8% for the east-west lines (a difference of 1.40%). After measuring six lines (300 m), additional lines did not change the average canopy cover to an appreciable extent (Figure 3), indicating that the intensity of the sampling was sufficient to estimate canopy cover on the 50 x 50 m plots.

Shrub counts on the seven unburned shrub-dominated study plots ranged between 227 and 1263 shrubs per 0.25 ha (Table 3). Plots 1S and 2H supported only a single shrub species, and plot 6S contained five species. Sagebrush was usually the most abundant shrub in the *Artemisia/Poa* and *Artemisia/Stipa* plots. Hopsage was the only shrub species in the *Grayia/Poa* plot (2H).

TABLE 1. Canopy Cover (%) by Species on 10 Study Plots Located on the Reference Repository Location, Hanford Site, Washington, in the Spring of 1987. Shrub cover was estimated by line interception and herb cover by plot frames.

| | Sagebrush | | | | | | Hopsage | Burned | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1S | 3S | 4S | 5S | 6S | 7S | 2H | 3SB | 4SB | 2HB |
| **SHRUBS** | | | | | | | | | | |
| *Artemisia tridentata* (Big sagebrush) | 33.0 | 18 | 9.0 | 25.0 | 3.7 | 12.6 | 0.0 | 0 | 0 | 0 |
| *Chrysothamnus nauseosus* (Gray rabbitbrush) | 0 | 0 | 8.8 | 0 | 1.8 | 1.8 | 0 | 0 | 0 | 0 |
| *Chrysothamnus viscidiflorus* (Green rabbitbrush) | 0 | 0 | 1.2 | 0 | 1.3 | 0 | 0 | 0 | 0 | 0 |
| *Grayia spinosa* (Spiny hopsage) | 0 | +[a] | 0 | + | 0 | 0 | 23 | 0 | 0 | 0 |
| *Purshia tridentata* (Bitterbrush) | 0 | 0 | 0 | 0 | 0.5 | 0 | 0 | 0 | 0 | 0 |
| TOTAL | 33 | 18 | 19 | 25 | 7.4 | 14 | 23 | 0 | 0 | 0 |
| **Low Shrubs** | | | | | | | | | | |
| *Phlox longifolia* (Long-leaved phlox) | 0 | + | 0 | 1.3 | 0 | 1.3 | 0 | 0 | 0 | 0 |
| **HERBS** | | | | | | | | | | |
| **Perennial Grasses** | | | | | | | | | | |
| *Koeleria cristata* (Junegrass) | 0 | 0 | 0 | 0 | 3.4 | 11 | 0 | 0 | 0 | 0 |
| *Oryzopsis hymenoides* (Indian rice-grass) | 0 | 0 | 0 | 0 | + | 0 | 0 | 0 | 0 | 0 |
| *Poa sandbergii* (Sandberg's bluegrass) | 19 | 1.1 | 0.3 | 7.9 | 0 | 1.3 | 34 | 16 | 7 | 32 |
| *Sitanion hystrix* (Bottlebrush squirreltail) | + | 0 | + | 0 | 0 | + | + | 0 | 1 | 2 |
| *Stipa comata* (Needle-and-thread grass) | 0 | 0 | 0 | 0 | 22 | 11 | 0 | 0 | 0 | 0 |
| TOTAL | 19 | 1.1 | 0.3 | 7.9 | 25 | 23 | 34 | 16 | 8 | 34 |

TABLE 1. (contd)

| | Sagebrush | | | | | | Hopsage | Burned | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1S | 3S | 4S | 5S | 6S | 7S | 2H | 3SB | 4SB | 2HB |
| **Perennial forbs** | | | | | | | | | | |
| *Astragalus* spp. (Milk-vetch) | 0 | 0 | 0 | 0 | + | + | 0 | 0 | 0 | 0 |
| *Aster canescens* (Hoary aster) | + | + | 0 | + | 0 | 0 | 0 | 0 | 0 | 0 |
| *Balsamorhiza careyana* (Carey's balsamroot) | 0 | 0 | 0 | + | 0 | + | 0 | 0 | 0 | 0 |
| *Comandra umbellata* (Toad flax) | 0 | + | 0 | 0 | 0 | + | 0 | 0 | 0 | 0 |
| *Cymopterus terebinthinus* (Turpentine cymopterus) | 0 | + | 0 | 0 | 2.2 | + | 0 | 0 | 0 | 0 |
| *Helianthus cusickii* (Cusick's sunflower) | 0 | 0 | 0 | 0 | 0 | 0 | + | 0 | 0 | 0 |
| *Oenothera pallida* var. *pallida* (Pale evening-primrose) | 0 | 0 | 0 | 0 | + | + | 0 | 0 | 0 | 0 |
| *Sphaeralcea munroana* (White-stemmed globe-mallow) | 0 | + | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Townsendia florifer* (Showy townsendia) | + | 0 | 0 | 0 | 0 | 0 | 0 | 0 | + | 0 |
| TOTAL | + | + | 0 | + | 2.2 | + | + | 0 | + | 0 |
| **Annual Grasses** | | | | | | | | | | |
| *Bromus tectorum*[(b)] (Cheatgrass) | 1.0 | 19 | 18 | 13 | 14 | 10 | 5.1 | 34 | 32 | 11 |
| *Festuca octoflora* (Slender fescue) | + | + | + | + | + | + | + | 0 | + | 0 |
| TOTAL | 1.0 | 19 | 18 | 13 | 14 | 10 | 5.1 | 34 | 32 | 11 |

TABLE 1. (contd)

| | Sagebrush 1S | 3S | 4S | 5S | 6S | 7S | Hopsage 2H | Burned 3SB | 4SB | 2HB |
|---|---|---|---|---|---|---|---|---|---|---|
| **Annual forbs** | | | | | | | | | | |
| *Cryptantha circumscissa* (Matted cryptantha) | 0 | + | + | + | + | + | 0 | 0 | 0 | 0 |
| *Cryptantha pterocarya* (Winged cryptantha) | 0 | 0 | 0 | + | 0 | 0 | 0 | 0 | 0 | 0 |
| *Draba verna*(b) (Spring draba) | 0 | + | 0 | + | + | 0 | 0 | 0 | 2 | 0 |
| *Descurainia pinnata* (Tansy mustard) | + | + | + | + | + | 0 | + | 0 | 0 | + |
| *Epilobium paniculatum* (Autumn willow-weed) | + | 0 | 0 | 0 | 0 | 0 | 0 | 0 | + | 0 |
| *Eriogonum vimineum* (Broom buckwheat) | 0 | 0 | + | 0 | 0 | 0 | 0 | 0 | + | 0 |
| *Holosteum umbellatum*(b) (Jagged chickweed) | 0 | + | 0 | 0 | 0 | 0 | 0 | 6 | 2 | + |
| *Lactuca serriola*(b) (Prickly lettuce) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | + | 0 | + |
| *Mentzelia albicaulis* (White-stemmed mentzelia) | 0 | 0 | + | 0 | 0 | 0 | + | 0 | 0 | 0 |
| *Microsteris gracilis* (Microsteris) | 0 | 2.9 | + | + | 0 | 0 | + | + | + | 0 |
| *Polemonium micranthum*(b) (Littlebells polemonium) | 0 | 0 | 0 | 0 | 0 | 0 | + | 2 | 0 | 0 |
| *Salsola kali*(b) (Russian thistle) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | + | + | + |
| *Sisymbrium altissimum*(b) (Tumble mustard) | 0 | + | + | 0 | 0 | 0 | + | 0 | 2 | 4 |
| *Tragopogon dubius*(b) (Yellow salsify) | 0 | 0 | 0 | + | 0 | 0 | + | 4 | 0 | 4 |
| TOTAL | + | 2.9 | + | + | + | + | + | 12 | 6 | 8 |
| TOTAL HERBS | 19 | 23 | 18 | 21 | 27 | 33 | 39 | 62 | 46 | 64 |
| TOTAL CANOPY COVER | 52 | 41 | 37 | 46 | 34 | 47 | 62 | 62 | 46 | 64 |
| NUMBER OF SPECIES | 9 | 15 | 13 | 14 | 14 | 15 | 12 | 8 | 13 | 9 |

(a) +=<0.1 % canopy cover.
(b) Alien species.

TABLE 2. Mean Canopy Cover and Standard Deviation for Seven Study Plots at the Reference Repository Location

| | 1 S | 3S | 4S | 5S | 6S | 7S | 2 H |
|---|---|---|---|---|---|---|---|
| N | 22 | 22 | 22 | 22 | 22 | 22 | 22 |
| Mean | 32.9 | 18.5 | 19.0 | 25.3 | 7.4 | 14.5 | 23.0 |
| Standard Deviation | 6.0 | 6.0 | 6.0 | 7.3 | 4.7 | 5.1 | 6.2 |

There was a significant relationship ($R^2$=0.73, P=0.015) between canopy cover and shrub counts (density), as density increased canopy cover increased (Figure 4).

Vegetation surveys made in 1986 (Rickard 1988) were compared with those made in 1987. Plots 1 through 5 were surveyed for herbaceous cover in both years. There was less herbaceous cover in the plots in 1987 than in 1986. Cheatgrass cover showed a decrease in all five plots for 1987 as compared to 1986, and Sandberg's bluegrass decreased in all plots except plot 5S which showed a slight increase (Table 4). The decrease in herb cover is likely attributed to the relatively dry growing season in 1987 (Table 5).

## ECOLOGICAL CONSIDERATIONS

Vegetation analyses performed during this survey provide a list of these plant species that are adapted to the soil and climate of the Cold Creek Valley. The number of species is relatively low as compared to more arid, south Nevada deserts (Rickard 1963). This suggests that the Cold Creek Valley environment is very hostile for most temperate zone plants and that relatively few species have the capacity to grow and reproduce in a climate characterized by cold winters followed by hot, dry summers.

The five plant species that contributed most to canopy cover in the Cold Creek Valley have distinctive patterns of growth and flowering times (Figure 5). Sagebrush retains at least some of its leaves year-round. New leaves emerge in early spring and most of the leaf drop occurs in mid-summer (Rickard and Warren 1981). Flowering occurs in early autumn. The year-round presence of at least some leaves suggests that sagebrush is capable of performing photosynthesis at any time of year providing that soil water is adequate and temperatures are between 10° and 20° C (DePuit and Caldwell 1973). In contrast, spiny hopsage retains its leaves for only a short time. New leaves emerge in late winter. Flowering occurs in early spring and leaf drop occurs at the onset of summer. Hopsage is not capable of leaf photosynthesis for 7 months of most years.

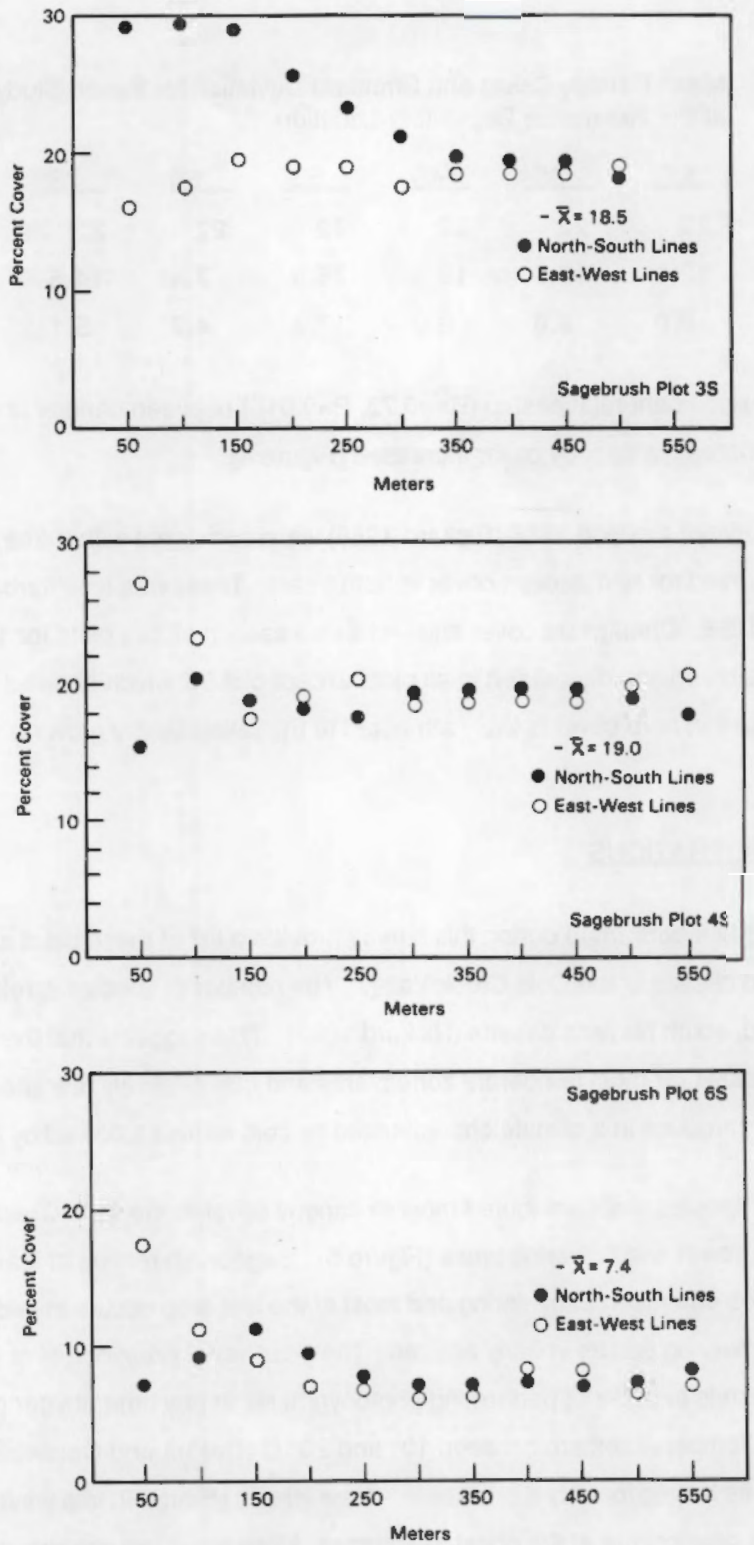


FIGURE 3. Comparison of Running Averages of Shrub Canopy Cover (%) Measured on 11 Parallel 50 m Lines Spaced 5 m Apart (North-South vs. East-West on Plots 3S, 4S, and 6S)

TABLE 3. Density of Shrub Species in Seven Study Plots in Three Habitat Types in the Cold Creek Valley, Hanford Site, Washington for 1986 and 1987

| | *Gravia/Poa* | *Artemisia/Poa* | | | | *Artemisia/ Stipa* | |
|---|---|---|---|---|---|---|---|
| | 2H | 1S | 3S | 4S | 5S | 6S | 7S |
| Sagebrush | 0 | 1263 | 349 | 250 | 524 | 71 | 269 |
| Spiny Hopsage | 530 | 0 | 39 | 12 | 8 | 6 | 0 |
| Gray Rabbitbrush | 0 | 0 | 0 | 423 | 0 | 73 | 89 |
| Green Rabbitbrush | 0 | 0 | 0 | 80 | 0 | 74 | 0 |
| Bitterbrush | 0 | 0 | 0 | 0 | 0 | 3 | 0 |
| TOTAL SHRUBS | 530 | 1263 | 388 | 765 | 532 | 227 | 358 |

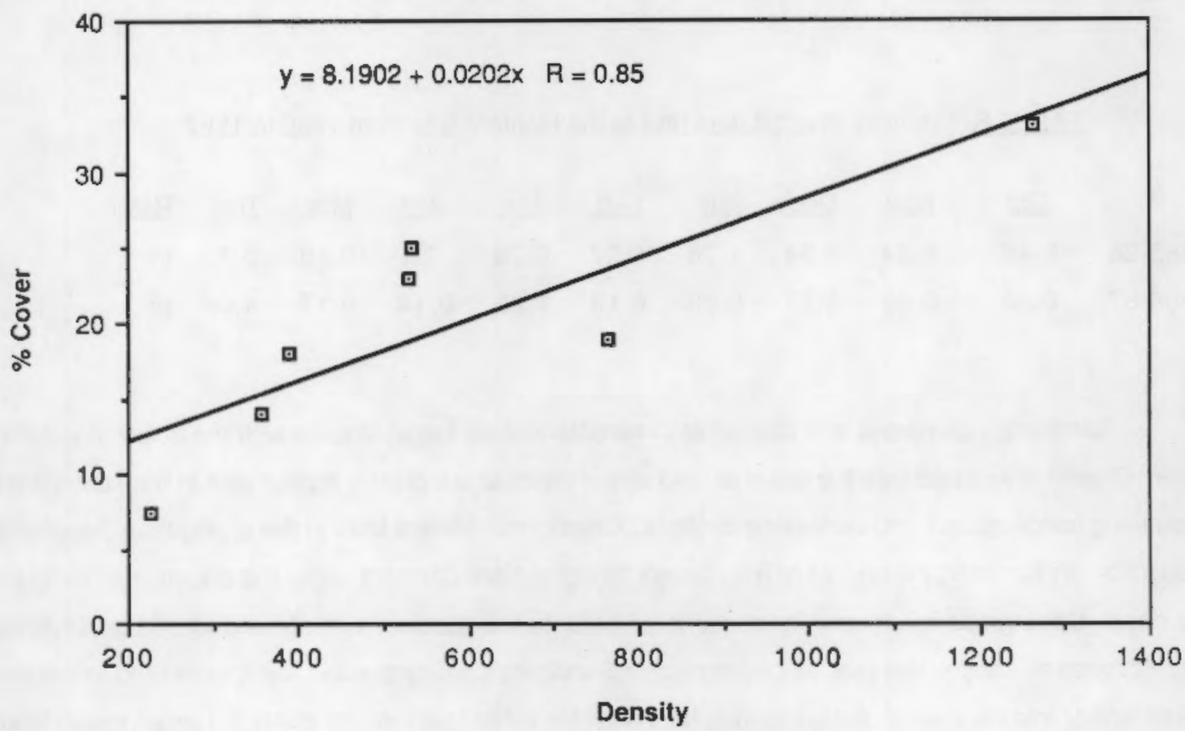


FIGURE 4. Simple Linear Regression of Shrub Counts Against Percent Cover for Seven Study Plots at the Reference Repository Location

TABLE 4. Comparison of Canopy Cover (%) of Sandberg's Bluegrass, Cheatgrass, and Total Herb Cover at the Proposed Reference Repository Location for 1986 and 1987.

| | Plots | | | | |
|---|---|---|---|---|---|
| | 1S | 2H | 3S | 4S | 5S |
| Sandberg's bluegrass | | | | | |
| 1986 | 28 | 41 | 1.1 | <0.1 | 5.3 |
| 1987 | 19 | 34 | 1.1 | 0.3 | 7.9 |
| Cheatgrass | | | | | |
| 1986 | 2.1 | 5.7 | 2.5 | 27 | 21 |
| 1987 | 1.0 | 5.1 | 19 | 18 | 13 |
| TOTAL HERBS | | | | | |
| 1986 | 31 | 51 | 35 | 29 | 30 |
| 1987 | 19 | 37 | 23 | 18 | 21 |
| Change | -12 | -12 | -12 | -11 | -9 |

TABLE 5. Monthly Precipitation (in.) at the Hanford Site from 1985 to 1987.

| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | T(in) | T(cm) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1985-86 | 0.46 | 1.24 | 0.84 | 1.76 | 1.37 | 0.76 | TR | 0.30 | 6.73 | 17.1 |
| 1986-87 | 0.29 | 0.65 | 0.77 | 0.80 | 0.19 | 1.05 | 0.14 | 0.17 | 4.06 | 10.3 |

Sandberg's bluegrass and cheatgrass characteristically begin to grow with the onset of autumn rains. Growth is arrested with the onset of cold winter weather but greatly accelerates in the spring with increasing temperatures and increasing daylight. Cheatgrass flowers later in the spring than Sandberg's bluegrass. In summer, the shoots of Sandberg's bluegrass are dormant, while the shoots of cheatgrass are dead. Cheatgrass relies upon its seeds to perpetuate the species. Needle-and-thread grass does not begin growth as early in the year as cheatgrass or Sandberg's bluegrass, but the shoots tend to remain green longer into the spring. It also flowers later than the other species. Its ability to remain green longer is attributed to a deeper root system that can use soil water, which percolates below the rooting zone of cheatgrass and Sandberg's bluegrass. Sagebrush generally has a deeper root system than the grasses, and it is reported to be capable of bringing water from as deep as 2.5 m (Campbell and Harris 1977) and exuding it into near surface soil layers (Richards and Caldwell 1987).

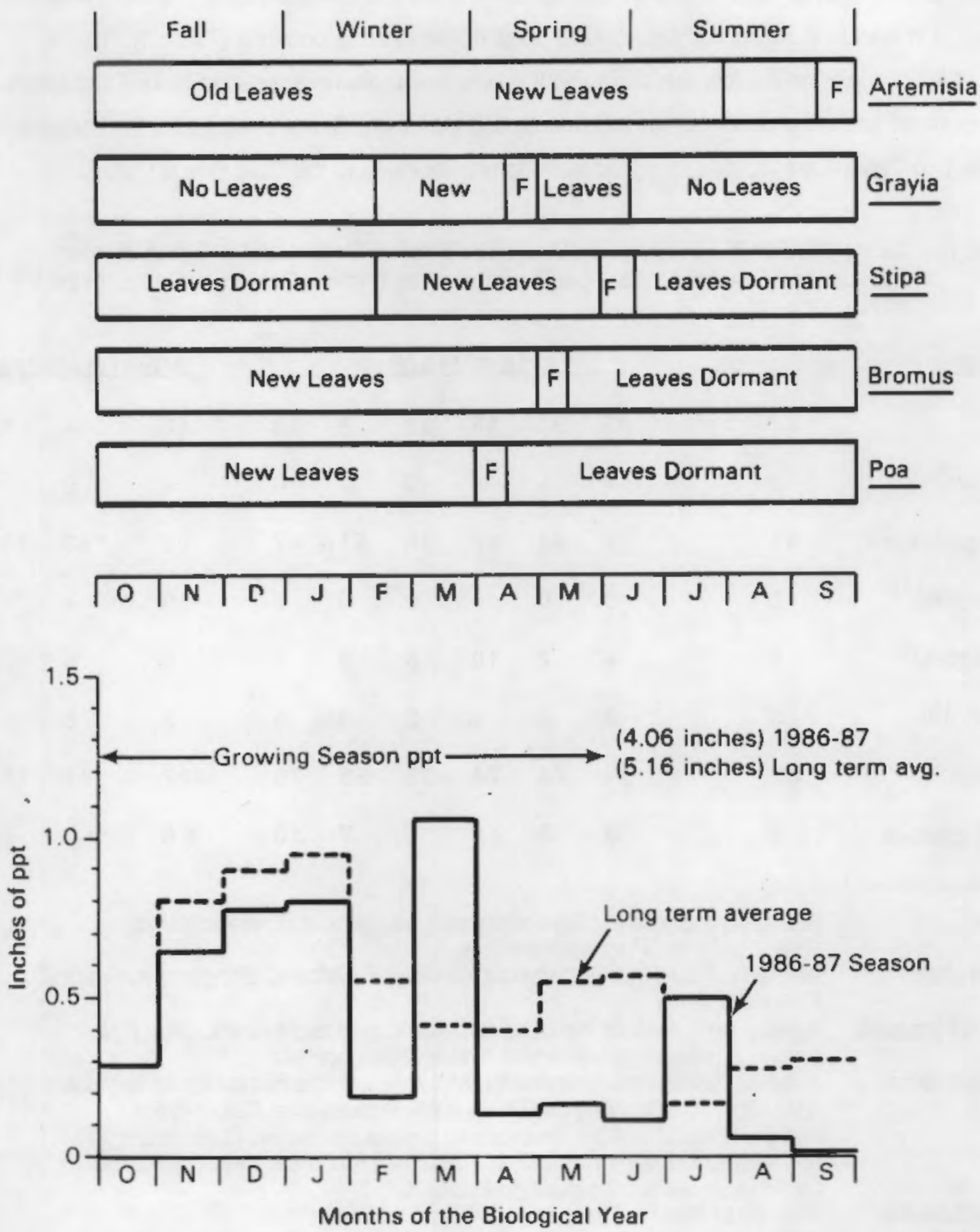


FIGURE 5. Phenological Calendar for Five Plant Species in the Cold Creek Valley in Relation to the Annual Precipitation (ppt) Regimen (F = Flowering-Period). The 1986-1987 growing season precipitation (Oct through May) was 0.39 in. less than long-term average.

The amount of canopy coverage provided by herbs in the Cold Creek Valley (Table 1) was less than that measured in stands in similar habitat-types located in surrounding locations (Table 6). This is attributed, at least in part, to the low elevation and the very low annual precipitation in the Cold Creek Valley. In general, precipitation increases with increasing elevation (Stone et al. 1983), and most of the stands shown in Table 6 are located at higher elevations than those of the Cold Creek Valley.

TABLE 6. Canopy Cover (%) Provided by Vascular Plants in Three Habitat Types, Benton, Franklin and Grant Counties, Southeastern Washington (Data from Daubenmire 1970)

| Canopy Cover | Grayia/Poa | Artemisia/Poa | | | | | | Artemisia/Stipa | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Shrubs(1) | 37 | 35 | 31 | 18 | 38 | 8 | 13 | 13 | + | 13 |
| Low shrubs(2) | 0 | + | + | + | 0 | 0 | 0 | + | 0 | 4 |
| Perennial grasses(3) | 41 | 47 | 41 | 46 | 48 | 51 | 47 | 109 | 143 | 133 |
| Perennial forbs(4) | 0 | 0 | 0 | + | 0 | 0 | 0 | 19 | + | 1 |
| Annual grasses(5) | 6 | + | 2 | 10 | 5 | 3 | 5 | 5 | 5 | 2 |
| Annual forbs(6) | 3 | 2 | 0 | + | 2 | 3 | 5 | 3 | 3 | 4 |
| Total cover | 87 | 84 | 74 | 74 | 93 | 65 | 70 | 117 | 151 | 156 |
| Number of species | 9 | 9 | 5 | 11 | 10 | 7 | 10 | 26 | 10 | 24 |

(1) Shrubs: *Artemisia tridentata, Chrysothamnus nauseosus,C. viscidiflorus, Grayia spinosa, Purshia tridentata.*

(2) Low shrubs: *Arenaria Franklinii, Erigeron piperianus, E. filifolius, Eriogonom niveum, Phlox longifolia.*

(3) Perennial grasses: *Agropyron spicatum, Koeleria cristata, Oryzopsis hymenoides, Poa ampla, P. sandbergii, Sitanion hystrix, Stipa comata.*

(4) Perennial forbs: *Achillea millefolium, Antennaria dimorpha, Arabis holboellii, Astragalus spaldingii, A. sclerocarpus, Balsamorhiza careyana, Calochortus macrocarpus, Castilleja thompsonii, Crepis atrabarba, Delphinium nuttallianum, Erigeron pumilus, Lomatium macrocarpum, L. trinertatum, Lupinus serecius, Tragopogon dubius.*

(5) Annual Grasses: *Bromus tectorum, Festuca octoflora, F. pacifica.*

(6) Annual forbs: *Collomia linearis, Descurainea filipes, D. pinnata, Draba verna, Gilia minutiflora, Lappula redowskii, Lactuca serriola, Microsteris gracilis, Myosurus aristatus, Plantago patagonica, Pectocarya linearis, Salsola kali, Sisymbrium altissimum.*

(7) + = <0.1 % cover

Vegetation study sites outside the Cold Creek Valley were selected by Daubenmire (1970), in part, because of the scarcity of cheatgrass. Lack of cheatgrass was regarded as a biological indicator of freedom from livestock grazing damage. The Cold Creek Valley stands generally showed greater amounts of cheatgrass than the offsite plots even after 44 years without livestock grazing. In the Cold Creek Valley, cheatgrass was not readily displaced by the native Sandberg's bluegrass or other native herbs even with long-term absence of grazing livestock. Nevertheless, it is noted that in those plots (both within and outside the Cold Creek Valley) in which Sandberg's bluegrass was a major contributor to canopy cover, cheatgrass cover was correspondingly suppressed (Figure 6).

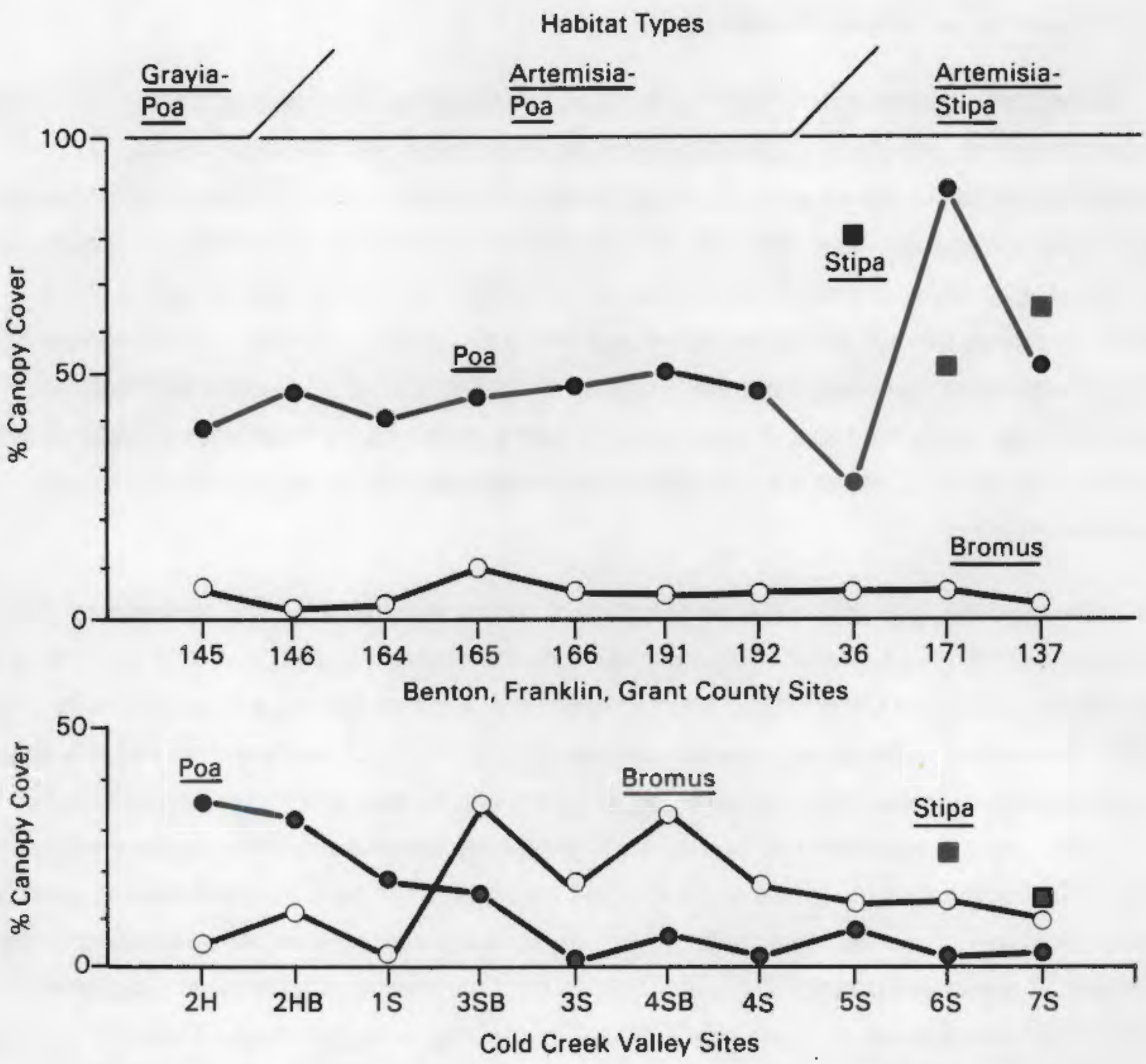


FIGURE 6. Canopy Cover Provided by Needle-and-Thread Grass (*Stipa Comata*), Cheatgrass (*Bromus Tectorum*), and Sandberg's Bluegrass (*Poa sandbergii*) in 10 Study Plots in the Cold Creek Valley as Compared to 10 Study Plots Located Outside the Cold Creek Valley but in Nearby Counties

At present, there are no data that describe chemical and physical properties of the rooting substrate in the 10 study plots. Nevertheless, there were indications that differences in soil were at least partly responsible for the spatial dominance of cheatgrass, Sandberg's bluegrass, spiny hopsage, and needle-and-thread grass. Needle-and-thread grass appeared to be restricted to the most sandy soils and Sandberg's bluegrass and spiny hopsage contributed most to canopy coverage on the finer textured soils. On sandy soils, cheatgrass contributed more cover than Sandberg's bluegrass. Spiny hopsage occurred mixed with sagebrush on some of the study plots, but it was present in a pure stand only across a relatively small area in the portions of the Cold Creek Valley that appeared to be a dry lake bed or playa.

## BIOLOGICAL LAND USE AND RECLAMATION

Although the vegetation of the Cold Creek Valley has been free from livestock grazing for more than 40 years, other kinds of human-induced disturbances have occurred in the interim. The natural vegetation as well as the surface soil in the study zone has been disrupted in patches by human activities. These include damage from road and powerline construction, construction camp siting, fencing, ditching, pitting and off-road vehicular traffic including many kilometers of firebreaks created by blading with a bulldozer. A primary disturbance has been from well-drilling and various construction activities associated with the geological and hydrological activities from site characterization of the Basalt Waste Isolation Project (BWIP) on the Hanford Site. It is necessary to initiate environmental reclamation of BWIP disturbed sites following closure to conform to the Nuclear Waste Policy Act (as revised), good practices, and environmental ethics.

Future biological land uses of the Hanford Site will, in part, determine the long-term strategies for reclamation of BWIP disturbed sites. Three general kinds of biologically based future land use options can be considered for the Cold Creek Valley: irrigated agriculture, livestock grazing, and wildlife habitat. The climate is too dry to consider dryland wheat as a viable farming option. Of the three different kinds of land uses, wildlife habitat is clearly the land use most compatible with the long-term industrial mission of the Hanford Site. Shrubsteppe habitat on the Hanford Site supports a variety of wildlife, but there are only a few passerine birds that regularly nest in shrubsteppe vegetation. The most abundant nesting species in our study area were the western meadowlark *(Sturnella neglecta)*, sage sparrow *(Amphispiza belli)*, and horned lark *(Eremophila alpestris)*. Other shrubsteppe birds that nested in the area were loggerhead shrikes *(Lanius ludovicianus)*, burrowing owls *(Athene cunicularia)*, mourning doves *(Zenaida macroura)*, and long-billed curlews *(Numenius americanus)*.

Manipulating large acreages of shrubsteppe habitat to accommodate Hanford Site Operations and BWIP activities, over an extended time period has resulted in general diminishment of habitat acceptable for native wildlife. Several bird species, especially sage sparrows, have a strong dependence upon mature stands of sagebrush for nesting habitat. Assuming a future biological land use as wildlife habitat, reclamation of sites bared of vegetation during the site characterization phases of BWIP should consider revegetation with combinations of species (primarily native species) that can provide food, cover, or nest sites for wildlife. Revegetation for wildlife habitat would require re-establishment or conservation of sagebrush stands at least in some areas because of the dependence of sage sparrows upon mature stands of sagebrush for nesting. Revegetation practices aimed at providing habitat for nesting sage sparrows meets the intent of the Endangered Species Act, which instructs federal agencies to exercise their authorities to conserve wild native plants and animals especially those whose populations are dwindling in response to man-induced land uses that are not compatible with the survival of a particular species (e.g., irrigated agriculture). Furthermore, use of native plant species in reclamation efforts could potentially reduce wildfire occurrences. Herbaceous plantings should consider re-establishment of Sandberg's bluegrass rather than cheatgrass because Sandberg's bluegrass decomposes more easily than cheatgrass and provides less fuel for wildfires which in turn are destructive to shrubs. Once cheat-grass invades disturbed ground, it is able to resist reinvasion by native species for decades even when stands comprised mostly of native species are nearby to provide seed sources (Daubenmire 1970, Rickard and Sauer 1982).

The conservative use of land as practiced on the Hanford Site for the past four decades has been more conducive to conservation of native terrestrial wildlife species than has the intensive agricultural use of much of the land bordering the Hanford Site. However, to continue to conserve remnant populations of native wildlife will require that stands of natural vegetation be conserved and reclaimed in a fashion suitable for native species. Results of this study provide a partial basis for determining achievable goals at locations having similar micro-environmental conditions and rooting substrates.



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