WASHINGTON NATURAL HERITAGE PROGRAM

Studies of Hanford Rare Plants
2002

Prepared for Washington Office of The Nature Conservancy

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March 2003

Natural Heritage
Report 2003-04

WASHINGTON STATE DEPARTMENT OF
Natural Resources
Doug Sutherland - Commissioner of Public Lands

Introduction

The Washington Natural Heritage Program was asked by the Washington Office of The Nature Conservancy to conduct a number of studies on the rare plants of the Hanford site. This document consists of four separate reports which summarize the results of the studies by species. All four reports are described briefly below under Tasks #2-#5, and are included in this document. The sighting forms for new rare plant populations or subpopulations are in Appendix A.

Task #1 Survey special habitat areas in Central Hanford, the Fitzner-Eberhardt Arid Lands Reserve, and Saddle Mountains for rare plants if growing conditions appear favorable

Unfavorable growing conditions prevailed in 2002. Although late 2001 was relatively wet, there was only 1.73 inches of precipitation from January through May 2002, or 55% of the normal 3.14 inches (Hanford Meteorological Station 2002). Low precipitation levels in the spring dramatically reduce the annual flora, which was the intended focus of rare plant surveys. The time that was allocated for this task was transferred to other tasks, specifically Task 2, *Rorippa* monitoring. Two new rare plant populations were found in the course of fieldwork for *Rorippa* and sighting forms are in Appendix A.

Task #2. Document current status and summarize demographic data from previous years for *Rorippa columbiae*

Rorippa columbiae (Columbia yellowcress) is a Species of Concern with the USFWS and is considered Threatened in Washington. Section 1 of this report summarizes its status on the Hanford Reach based on fieldwork in 2002 and a review of BLM monitoring from 1994 through 2002.

Task # 3. Document current status and summarize demographic data from previous years for *Eriogonum codium*

Eriogonum codium is a Candidate species with the USFWS and is considered Endangered in Washington. Its only known population occurs on the Hanford Site and has been the subject of an intensive demographic monitoring project since 1997. Section 2 of this report summarizes the results of monitoring from 2000-2002, with further discussion of the trends over the six years since monitoring began.

Task # 4. Document current status and summarize demographic data from previous years for *Lesquerella tuplashensis*

Lesquerella tuplashensis is a Candidate species with the USFWS and is considered Threatened in Washington. We began studies in 1997 on the only known population of the species, which occurs on the Hanford site. The studies had two components: life history plots placed non-randomly throughout the population, and counts of reproductive individuals in 100 meter transects placed randomly throughout the northern half of the population. Section 3 of this report is a summary of the results of the transect portion of the monitoring study.

Task # 5. Survey on the islands of the Columbia River at Hanford for occurrences or potential habitat of *Artemisia campestris* subsp. borealis var. wormskioldii

Artemisia campestris subsp. *borealis* var. *wormskioldii* is a Candidate species with the USFWS and is considered Endangered in Washington. It occurs in riparian areas of the Columbia River. The Hanford site appears to have suitable habitat for the species and there was no record of a comprehensive survey of the islands in the Hanford Reach. Section 4 of this report summarizes the results of the 2002 survey and mapping of potential habitat.

Section 1. Current status of *Rorippa columbiae* on the Hanford Reach

Introduction

Rorippa columbiae (Columbia yellowcress) is a Species of Concern with the USFWS and is considered Threatened in Washington (Washington Natural Heritage Program 1997). Columbia yellowcress is a low growing perennial herb in the mustard family. Although its habitat varies across its range, there are several habitat characteristics that all populations share: inundation for part of the year, seasonal fluctuation of water level; wet soil well into the growing season, and; open habitats with a low cover of competing vegetation. Population numbers can fluctuate from year to year, and these fluctuations seem to be hydrologically driven (Kaye 1996). The plants grow and reproduce in late summer and early fall, when water levels are lowest. They are rhizomatous and may also spread vegetatively by rooting at the nodes of above-ground stems. Stems are found in clusters, indicating the possibility of large clones (Gehring 1994).

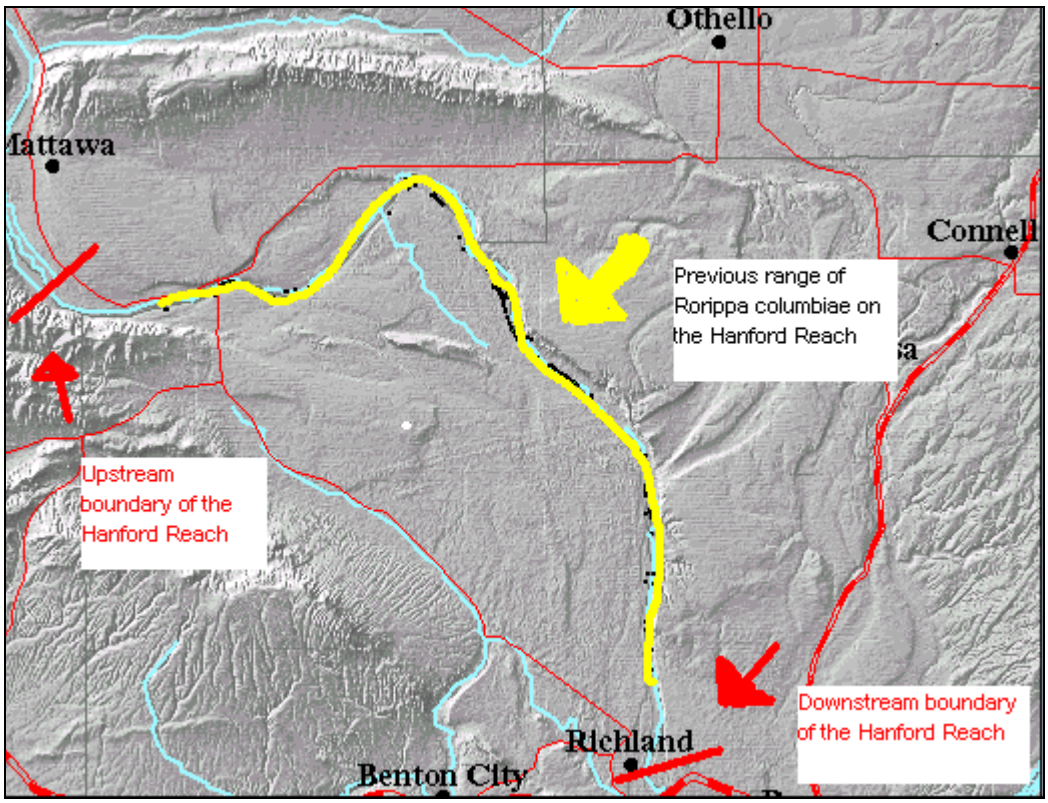


Figure 1-1. General range of *Rorippa columbiae* on the Hanford Reach

The Hanford Reach population is one of 11 populations of the species, which is known from the Hanford Reach of the Columbia, the lower Columbia, south-central Oregon, and the Modoc Plateau in northeastern California. Based on fieldwork in 1982 and 1994, the Hanford Reach population of Columbia yellowcress had been considered the most vigorous population known of the species (Salstrom and Gehring 1994). The other ten populations supported a total of between 12,000 and 22,000 plants in 1996 (Kaye 1996).

Methods

Two methods were used in 2002 to document the current status of *Rorippa columbiae* on the Hanford Reach:

1. Re-reading of the BLM long-term monitoring plots at the downstream end of the reach.
2. Direct visual surveys of areas along the reach which once supported large numbers of *R. columbiae* plants.

BLM Monitoring transects
In 1991 Janet Gehring and the BLM installed seven transects within the Hanford reach population of *R. columbiae* (Figure 1-2). The transects are located on three islands: Homestead Island (three transects), Plow Island (three transects) and North Forked Island (one transect). The monitoring was designed based on the protocol developed by Janet Gehring (1992). Two-meter wide transects were subjectively placed in areas that support *R. columbiae*. Transects varied in length depending on the spatial organization of the *R. columbiae* subpopulation. Within each transect, subjectively chosen 2 X 5 meter macroplots were placed in1991 within areas that supported *R. columbiae*. These macroplots have been used since 1991. The number of macroplots per transect also varies. Sixteen 0.5 m X0.5 m microplots within each macroplot were chosen in 1991. We recorded the number, height, and reproductive status of all stems in each microplot.

I do not have the data from 1991 through 1993, but these data are available in Gehring (1994). The transects were read by the BLM in 1994, 1995, 1997, (partial), 1998, and 2002. The 1997 data has not been used in this analysis, since only two transects were read. Transect #3 on Plow Island has not been relocated since 1994, so the monitoring has focused on six transects rather than seven. Although the monitoring was designed for data analysis within macroplots rather than by transect, the number of plants per transect have dropped to such low levels that I have chosen to analyze the data by transect.

The BLM monitoring plots were visited on October 8, 2002 by Pam Camp and Kevin Kane of the BLM, Eliza Habegger and Jim Evans of the TNC, Heidi Brunkal of the Hanford Reach National Monument, and Florence Caplow of WNHP. Another visit was made on November 1 by Kevin Kane and Florence Caplow, to see if any of the plants had produced flowers or fruit between October 8 and November 1.

Visual surveys
Some visual survey work took place on October 8, 2002 in the vicinity of the BLM monitoring plots. An attempt at a visual survey was made by Florence Caplow of WNHP and Devin Malkin of Framatone-AMP on October 9, but water levels were too high. A visual survey by boat of populations at the lower end of the Hanford Reach (Figure 1-4) was made by Kevin Kane of the BLM and Florence Caplow on November 1, 2002.

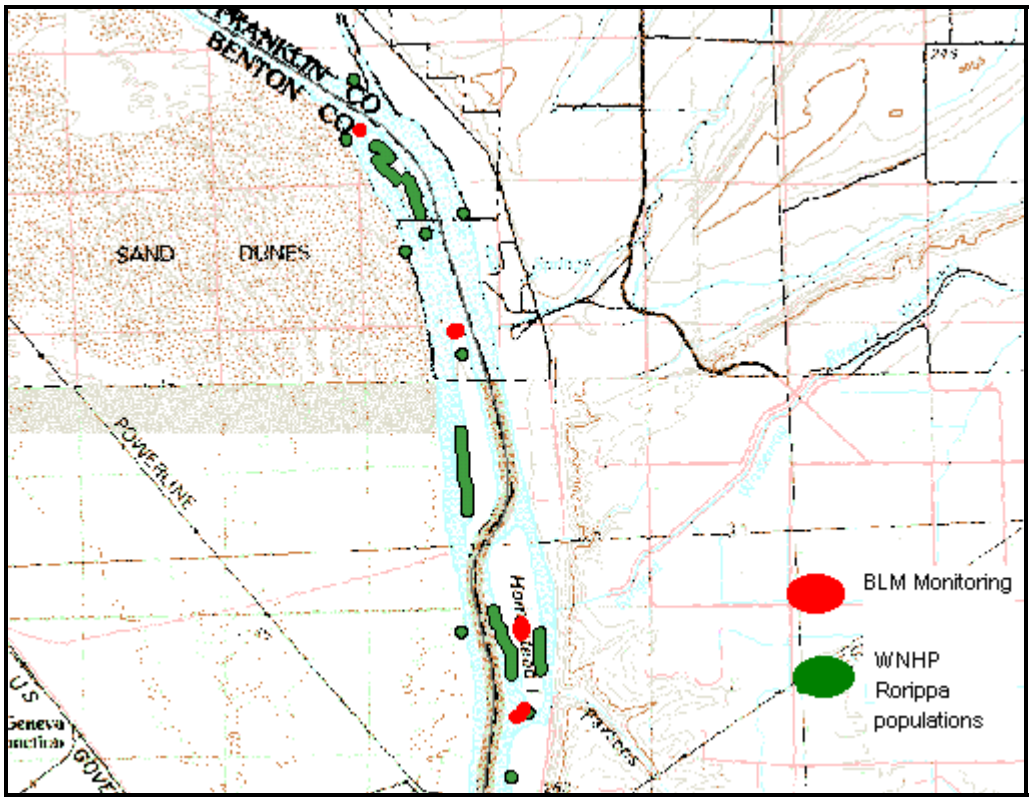


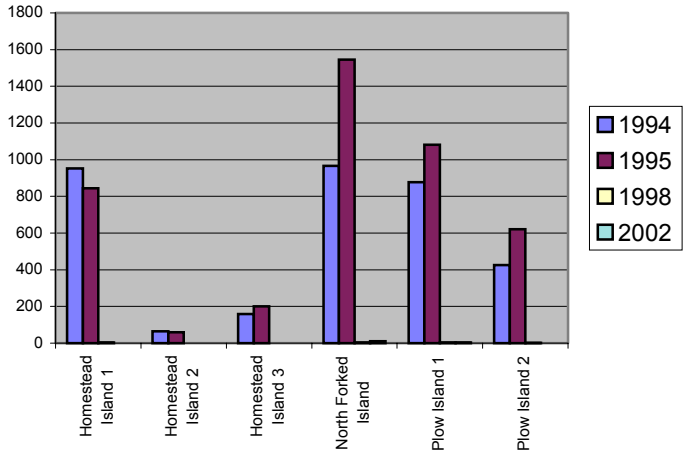
Figure 1-2. Location of BLM Monitoring Transects

Results

BLM monitoring transects

One can see in Figure 1-3 and Table 1-1 that the loss of stems per transect between 1995 and 1998 was precipitous, and there has been little recovery between 1998 and 2002. One can also see that there is some correlation between transects in each year, so the relative performance in one transect can provide some estimate of the performance of the other transects.

Figure 1-3 Number of stems by transect 1994-2002



The presence of flowers and fruits (Table 1-2) also decreased precipitously between 1995 and 1998. These data combined with the visual observations of the Hanford Reach population in 2002 suggest that virtually no sexual reproduction took place in the Hanford Reach population in 1998 or 2002.

Table 1-1. Number of stems in each transect, 1994-2002

	1994	1995	1998	2002
Homestead Island 1	953	845	3	0
Homestead Island 2	64	59	0	0
Homestead Island 3	159	201	0	0
North Forked Island	967	1546	3	10
Plow Island 1	878	1082	3	4
Plow Island 2	425	621	1	0

Table 1-2. Presence or absence of flowers and/or fruit in each transect, 1994-2002

	1994		1995		1998		2002	
	Flowers	fruit	flowers	fruit	flowers	fruit	flowers	fruit
Homestead Island 1	Y	Yes	Y	Yes	No	No		No
Homestead Island 2	No	Yes	No	No	No	No	No	No
Homestead Island 3	Yes	Yes	Yes	Yes	No	No	No	No
North Forked Island	Yes	Yes	Yes	Yes	No	No	No	No
Plow Island 1	Yes	No	No	No	No	No	No	No
Plow Island 2	Yes	Yes	No	No	No	No	No	No

Results of the Visual Survey

The visual survey included islands and shoreline from Homestead Island upstream to just below the White Bluffs boat launch (Figure 1-4). Plants were found in five areas: within two BLM monitoring transects (see results of the monitoring), On Homestead Island outside of a monitoring transect, and on an island just below the White Bluffs boat launch. A total of seven patches totaling 110 stems were found on the island south of the White Bluffs boat launch. No stems had either flowers or fruit. A sighting form for the last area is included in Appendix A. No other areas supported plants, and at least some of these areas supported plants as recently as 1995.

Discussion

Decline of the Hanford Reach population

In 1982 and in 1994, the Hanford Reach supported millions of stems of Columbia yellowcress in numerous clumps along a 50 mile stretch of river (Sauer and Leder 1985, P. Camp pers.obs.). Since 1997 there has been a precipitous decline in the number of observed stems and patches of stems on the Hanford reach. In 2002 less than 200 stems were seen in the area from the White Bluffs boat launch to the Ringold Boat Launch, which once supported at least 36,000 stems (Camp 1992). In 2002 there were no observed flowers or fruits on any stems.

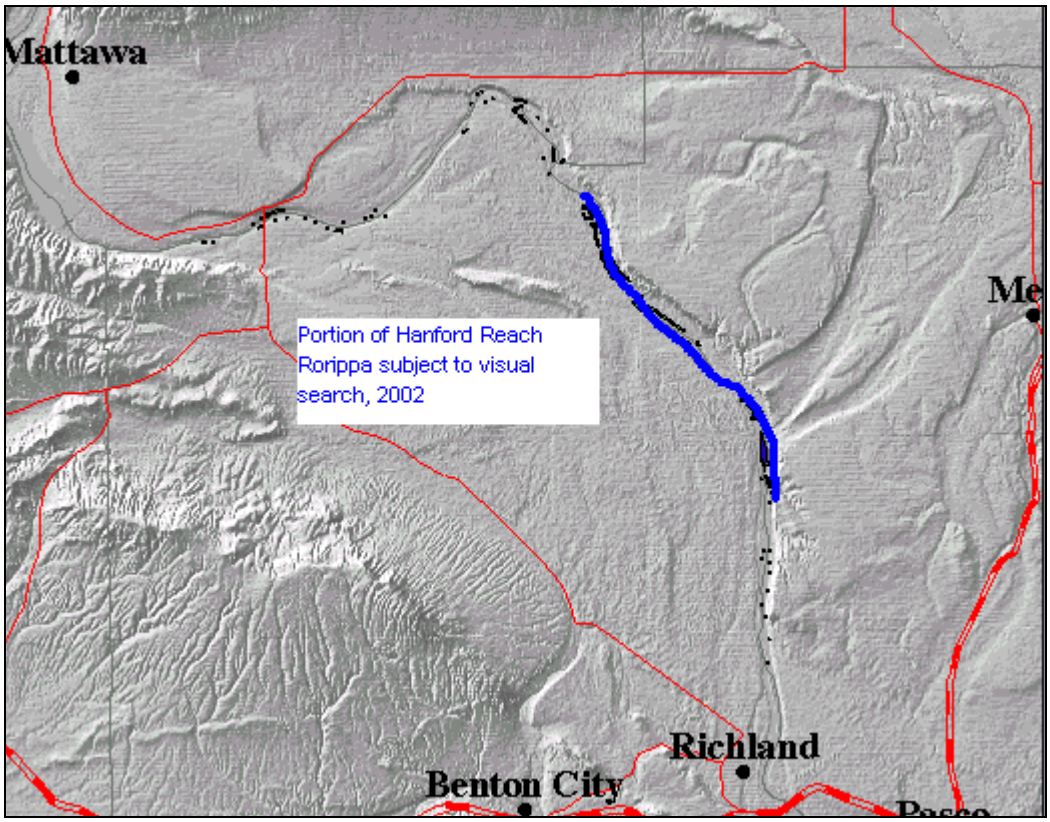


Figure 1-4. Portion of Hanford Reach *Rorippa columbiae* subject to search

Possible causes of the decline of the Hanford Reach population

It seems likely that some hydrologic change may be implicated in the current decline. Simmons (2000) conducted an experimental manipulation of an artificial population of *Rorippa columbiae*, and found that continuously submerged plants exhibited leaf chlorosis, weak stems, and negative growth. Monitoring of several populations has shown that hydrologic changes influence population levels of Columbia yellow cress (Kaye 1996). Gehring (1994) hypothesized that sexual reproduction may depend on "long days" and so plants exposed too late in the season to experience long photoperiods will not flower.

Gehrings' work from 1991 through 1993 on the Hanford Reach took place through the month of September (Gehring 1994). Sauer and Leder (1985) also commented that in 1982 the areas where the plants grew were more or less continuously exposed after late August. Observation on the Hanford Reach since 1997 suggests that plants are not regularly exposed until October, and during the period of maximum growth for plants (late summer and early fall), the elevation at which the plants grow on the Hanford Reach is submerged for most of the daylight hours.

Plants are submerged during daylight hours on the lower Hanford Reach even after Reverse Load Factoring begins in mid-October, due to the 6-8 hour lag time from Priest Rapids Dam to the lower Hanford Reach. Reverse load factoring is a river management strategy designed to keep river levels low over Vernita Bar to allow for redd counting,

and it begins in mid-October and continues until mid-November. However, at least one subpopulation of *R. columbiae* close to Vernita Bar also appears to be extirpated. Hydrologic changes include Reverse Load Factoring (which began in 1988), summer spill for non-listed fish species (July 1-August 15), and/or higher river levels for power production prior to Reverse Load Factoring. There have also been lower spring peaks since 1995 (T. Dresser, Grant County PUD, pers.comm.). Further work should be done to characterize the hydrologic changes on the Hanford Reach since 1982 and their possible impacts on *R. columbiae*. The USFWS has requested this work from Grant County PUD.

The lack of spring scouring floods and the subsequent development of woody vegetation in the riparian zone has been implicated in the decline at Pierce Island on the lower Columbia (Habegger *et al.* 2000), but seems unlikely as a major causative factor in the current decline of the Hanford Reach population. The combination of very high population levels during portions of the last 20 years and the presence of large areas of suitable non-vegetated habitat upslope from the existing clusters of plants suggests that the current decline is probably attributable to more recent hydrologic changes. Siltation, also implicated at Pierce Island (Habegger *et al.* 2000), may be another factor in the decline of *R. columbiae* on the Hanford Reach.

Table 1-3. General trends in *Rorippa columbiae* populations on the Hanford Reach

Year	Population	Information	Agency
1982	**high**	**survey**	**PNNL**
1988	low	monitoring	BLM
1989	low	monitoring	BLM
1991	**high**	**monitoring**	**BLM**
1992	**high**	**monitoring**	**BLM**
1993	**high**	**monitoring**	**BLM**
1994	**high**	**survey, monitoring**	**BLM, PNNL, TNC**
1996	**high**	**monitoring**	**PNNL**
1997	none	monitoring	PNNL
1998	low	monitoring	PNNL
1999	low	monitoring, survey	PNNL
2000	low	monitoring	PNNL
2002	low	monitoring, survey	BLM, WNHP

Significance of decline of the Hanford Reach population

It is difficult to evaluate the significance of the current decline. We have records on the Hanford Reach population from 1982 through 2002. There was a strong decline in the late 1980's and then high population levels from 1990-1994. The current very low population levels were first seen in 1997 and have been low in every year since 1997. No hourly analysis of the flow rate at Priest Rapids dam has been done to see if there are correlations between river regulation and the decline of the Hanford population.

Recommendations

- Gather information on the status of the species throughout its range. (WNHP)

- Continue annual monitoring of BLM sites for at least the next three years and conduct further surveys along the Hanford Reach to evaluate the population as a whole. I would not suggest altering monitoring protocols at this time. (BLM, Hanford Reach National Monument)
- Perform an analysis of river flows on an hourly basis and patterns of decline of the species (Grant County PUD).
- Re-evaluate the known information in 2-3 years and consider further action if decline continues. Further action could include hydrologic manipulation, establishment of new subpopulations, or control of riparian vegetation (all parties).

References

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Section 2. Current Status of *Eriogonum codium* on the Hanford site

Introduction

Eriogonum codium (Umtanum desert buckwheat) is a Candidate species with the USFWS and is Endangered in Washington. *Eriogonum codium* Reveal, Caplow & Beck (Polygonaceae) was described in 1995 (Reveal et. al 1995), and is referred to as "Umtanum desert buckwheat". There are approximately 5000 plants over a one mile linear area on Umtanum Ridge. It is not closely related to any other Washington species of *Eriogonum* (Reveal et. al 1995). It forms low mats up to 1 m in diameter.

E. codium has been the subject of an intensive demographic monitoring project since 1997. Initial findings from 1997 through 1999 were reported in 2000 (Dunwiddie *et al.* 2000). In 2000 we concluded that *Eriogonum codium* is a long lived species (greater than 100 years) with high flower production, low germination rates, high seedling mortality, and high variability of growth between individuals and between years. Annual adult mortality ranged from 0% to 4%. One hundred and sixty-nine new seedlings were observed in 1997-1999, and none survived more than one year. Most died between May and July. Mortality exceeded recruitment in the three growing seasons between 1997 and 1999.

Here I will summarize the results of monitoring in the next three year period, 2000-2002, with further discussion of the trends over the six years since monitoring began.

Methods

In 1997 a series of 24 1 m X 2 m permanent plots were randomly selected along three 50 meter belt transects within the largest subpopulation of *Eriogonum codium*. More than 100 individually tagged adult plants have been followed annually since 1997, and we have collected data on length and width of plants, number of inflorescences, and "percent dead" within each adult. Seedlings are mapped within the 24 one by two meter plots and are counted in May and again in July. We omitted the May seedling search in 1998 and 2002. For a detailed discussion of monitoring methods, see Dunwiddie *et al.* 2000.

Results

Annual mortality and recruitment

One adult plant died between 1999 and 2000, four adult plants died between 2000 and 2001, and one adult plant died between 2001 and 2002 (Table 2-1). This pattern is consistent with what we have seen since 1998. The average annual mortality rate between 1998 and 2002 is 2%. 1999 and 2001 were high mortality

Table 2-1. Annual mortality and recruitment

Year	No. of plants that died	Mortality rate	No. of new plants
1998	0	0	1
1999	4	0.04	0
2000	1	0.01	0
2001	4	0.04	0
2002	1	0.01	0
TOTAL	10		1
Ave./year	2	0.02	

years, while 1998, 2000, and 2002 were low mortality years.

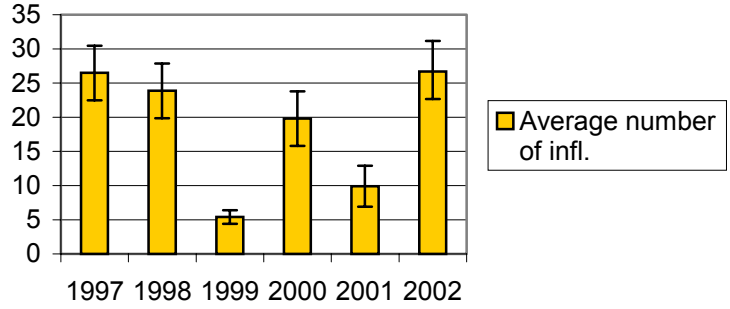
Recruitment has continued to be very low. No recruitment was observed between 2000 and 2002. Only one recruitment event has been observed since monitoring began. A single plant which we first observed in 1999 and which we believe to be a 1998 seedling was still alive in 2002. It is now 24 cm^2 in area but has not yet flowered. Another plant suspected to be from the 1995 cohort has also not yet flowered.

Inflorescence production

Inflorescence production varies widely between years and between plants (Figure 2-1). Average production has varied from a high of 27.1 inflorescences per plant and a range of 0-209 (1997) to a low of 5.4 inflorescences per plant and a range of 0-61 (1999). A small number of plants (7) produced more than 100 inflorescences in 2002, while more than half of the plants produced less than 10 inflorescences in 2002. This pattern has also been seen in other years. In other words, a small number of plants are producing a disproportionate percentage of the inflorescences.

When inflorescence production of all the plants within our data set is averaged, it appears that 1999 and 2001 were years of low production. These were the same years that had the highest mortality.

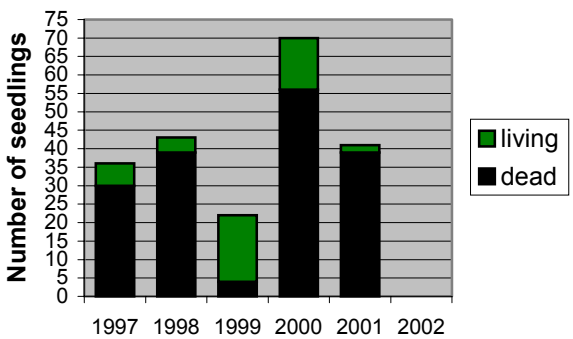
Fig. 2-1 Average number of inflorescences per plant per year



Seedling production

Seedling production varies between years (Figure 2-2). The highest year for seedling production was 2000 (72 seedlings). The lowest year for seedling production was 2002 (0 seedlings). Seedling production also varies widely between quadrats: three quadrats out of a total of 24 quadrats have produced 45% of the total number of seedlings counted since the study began (Figure 2-3), and three quadrats have produced no seedlings at all. Only one quadrat has

Fig. 2-2 Seedling production per year, 1997-2002 (July survey)



produced seedlings in every year, and only eight quadrats have produced seedlings in at least half the years.

Seedling mortality has been 100% from one year to the next, with the exception of 1998. The 1998 seedling that survived was not found during the July survey, so it may have germinated later in the season. Seed viability studies conducted by Ransom Seed Laboratory in 2002 found that 5% of the seed was not dormant and germinated in 21 days with moisture and light. This suggests that a fraction of the seed would not require stratification to germinate and could potentially germinate during summer or fall. This is further suggested by the 1999 data, in which more seedlings were found in July than in May. The weather from May through July in 1999 was unusually cool and dry (Hanford Meteorological Station web site, February 6, 2003).

Fig. 3-1 Proportion of total seedlings produced by three most productive quads, 1997-2002 (n=24)

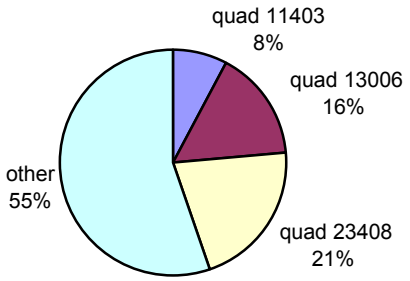


Table 2-2. Total seedling production

	living	dead	**total**
1997 June	41	0	**41**
1997 July	6	29	**35**
1998 July	5	38	**43**
1999 May	0	1	**1**
1999 July	18	6	**24**
2000 May	54	18	**72**
2000 July	16	56	**72**
2001 May	36	1	**37**
2001 July	3	45	**48**
2002 July	0	0	**0**

Mortality between May and July has varied from 70% to 92% (Table 2-2). In general, we have been successful at re-finding May seedlings during the July survey, whether living or dead. This suggests that most of the year's seedlings were found in the 1998 and 2002 July survey.

Discussion

The years of 1999 and 2001 were both years of relatively low flower production and high mortality of adult plants. 1999 was also a year of low seedling production. Due to the correlation between annual mortality and annual inflorescence production, I investigated the meteorological patterns between 1997 and 2002, with particular attention to 1998-1999 and 2000-2001 (Hanford Meteorological Station web site, February 6,2003). In general, there were no extreme patterns, with the exception of March and April of 1999 (unusually dry) and November and December of 2000 (unusually cold). The dry conditions of 1999 might explain the low seedling production, but March and April of 2001 (another year of high mortality and low flower production) were quite wet. There were also no unusual cold periods in the winter of 1998-1999 or

2000-2001. In fact, most winters since 1997 have been slightly above average in temperature. However, low seedling production in 2002 could be correlated with dry conditions: all months from March through July were below average precipitation, with the exception of June, At this point there is only a weak potential relationship between meteorological conditions and plant performance or mortality.

We still don't know if we're seeing a true decline of the population or a situation of extremely episodic recruitment. Most years since the monitoring began have been years of average precipitation. 1999 was an unusually dry year (50% of normal precipitation), and 2000 was a somewhat wet year (116% of normal precipitation). 1995 and 1996 were the wettest years since records began in 1946 (200% average precipitation), so one would expect those years, if any, to be years of recruitment. We have one suspected 1995 cohort plant in the study, but when monitoring began in 1997 we saw very few small plants (Dunwiddie *et al.* 2000).

We continue to be concerned about the low recruitment in the population. Further studies on the seed bank and competition with cheatgrass are planned for in 2003.

Because this monitoring design is demographically based and designed to evaluate population viability, I would recommend annual monitoring for at least four more years, for a total of ten years of annual monitoring. Within a ten year period there may be at least one year of significant recruitment, and by skipping one or more years we may miss the year in which recruitment occurs. Effects on the population could be minimized by continuing to ask crew members to wear smooth soled footwear and by eliminating the May seedling count. We could also check portions of the populations that are not within the monitoring area to make sure that recruitment patterns are equally low outside the monitoring area, and are not the result of the monitoring itself.

It would also be helpful to include a method for evaluating cheatgrass cover within the plots, as an adjunct to the cheatgrass study. It may require an additional nested plot, since cover of cheatgrass is generally very low within the larger 1 m X 2 m plot.

References

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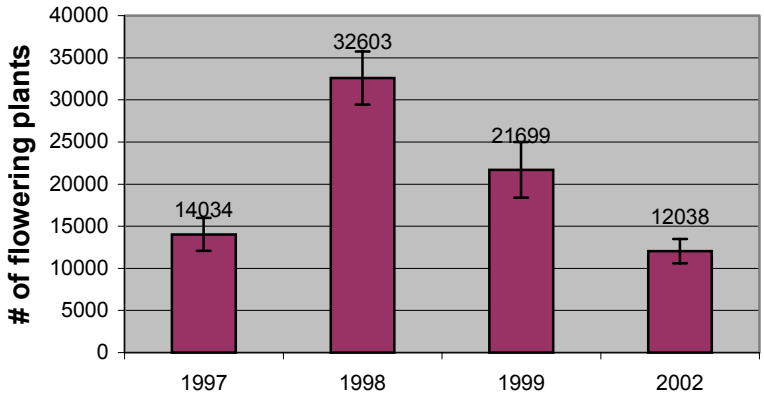
Section 3. Current status of *Lesquerella tuplashensis* on the Hanford site

Lesquerella tuplashensis is a Candidate species for listing under the Endangered Species Act with the USFWS and is considered Threatened in Washington (Washington Natural Heritage Program1997). We began studies in 1997 on the only known population of *Lesquerella tuplashensis*, a species that is endemic to the Hanford Site. The species occurs as a single population in a narrow 17 km long band along the top of the White Bluffs of the Columbia River. The species is a short-lived perennial most closely related to *Lesquerella douglasii*, whuch grows on cobble bars on the Columbia River. The studies had two components: life history plots placed non-randomly throughout the population, and counts of reproductive individuals in 100 meter transects placed randomly throughout the northern half of the population. In 2002 only the transects were counted, and so I will only be summarizing the results of the transect portion of the monitoring study. Results from the life history plots from 1997 to 1999 were presented at the 2000 Washington Rare Plant Conference in Seattle, and a manuscript is available from Florence Caplow of WNHP or Peter Dunwiddie of TNC.

Methods

We chose the northern 6 km of the population for our population sampling for the following reasons: the northern portion is the most contiguous and least disturbed portion of the population; there are no evident impacts from nearby agricultural activities; and this portion of the population is generally <1 km from a vehicle track. Our sampling area totaled 3,700 m in length. In 1997 we chose ten 100-m transects at random from this portion of the population for sampling, and permanently marked the endpoints with rebar stakes. An additional ten transects were added in 1998. All flowering plants were counted along each transect, and tallied according to their location: “Top” plants are those growing on the top of the bluff, “caliche” plants are growing in the cross-section of the caliche layer exposed at the top of the bluffs, and “slope” plants are growing below the caliche on the upper slope. Plants were censused in mid-May to early June in 1997, 1998, 1999, and 2002.

Fig. 3-1 Estimated number of flowering plants in the northern 3.7 km of population
(95% confidence intervals. Based on 20 transects except 1997, which is based on 10 transects)



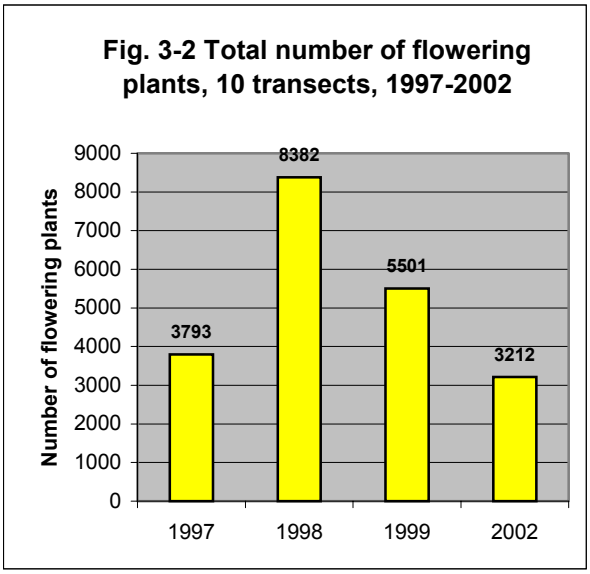
Results

Data from the 10 permanent transects installed in 1997, supplemented with an additional 10 installed in 1998, provide some indication of the magnitude and direction of trends in the overall population from 1997-2002 (Figure 3-1). Since these transects were randomly selected

only within the northern portion of the site, they may not necessarily represent changes in the overall population. However, they should be representative of changes that occur in over half of the area occupied by *L. tuplashensis*.

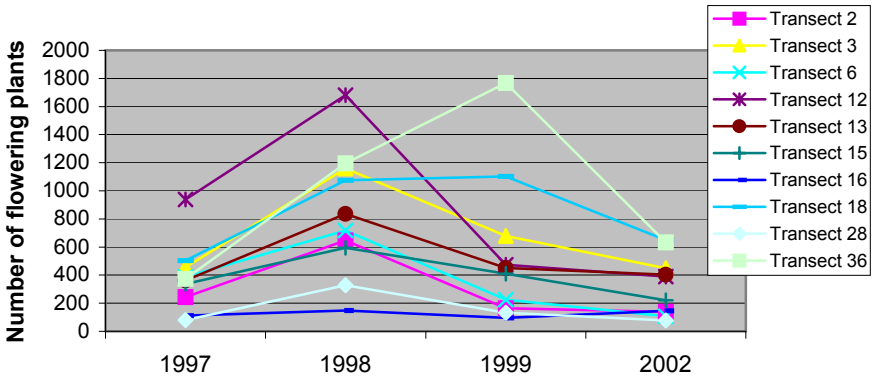
The numbers of adult *L. tuplashensis* varied greatly between years. Our counts increased 121% on the transects between 1997-98, decreased by 65% between 1998-99, and decreased by 58% between 1999-2002 (Figure 3-2). The ten transect total of 3,212 plants in 2002 is the lowest since the study began, but that figure is within the possible surveyor error of the 1997 count of 3,793. Projecting the transect data to the 3.7 km portion of the population from which these samples are derived, one may conclude that the number of adult plants within the 3.7 km area varied between a low of approximately 12,000 plants in 2002 to a high of approximately 32,000 plants in 1998. Therefore, it is reasonable to conclude that White Bluffs population is probably well in excess of 50,000 plants in "good" years. More monitoring is needed to determine the magnitude and frequency of high and low-number years, as well as to obtain an understanding of the causes of these annual fluctuations.

Fig. 3-2 Total number of flowering plants, 10 transects, 1997-2002



It should be noted that the results from the life-history plots showed that nearly all adult plants flower every year; therefore, our counts of flowering plants represent most of the adults in the population.

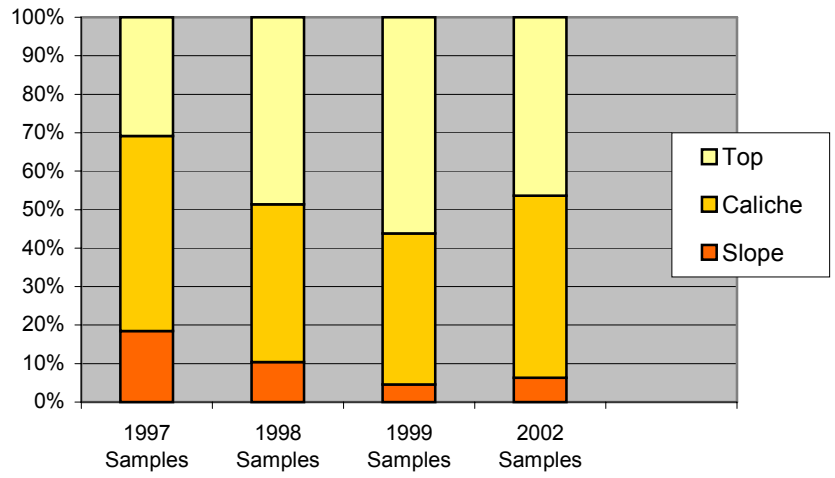
Fig. 3-3 Total number of flowering plants per transect, 10 transects, 1997-2002



Lesquerella tuplashensis is not uniformly distributed in the study area. Counts of plants along the 100 m transects varied considerably. However, plants along most of the transects appear to respond similarly to annual conditions (Figure 3-3).

There are also changes in the spatial distribution of plants along the slope (Figure 3-4). For instance, between 1997 and 1999 the proportion of plants found on the slope itself vs. in the caliche or on top of the caliche decreased from nearly 20% to less than 5%. Conversely, the proportion of plants on the flat top of the caliche layer increased from slightly more than 30% to nearly 60% between 1997 and 1999. The trend and significance of these findings is not known. Given the relatively short life span of individual plants (4-5 years, based on life history plots), there may be cyclical colonization of and extirpation from various portions of the slope.

Fig. 3-4 Relative spatial distribution of flowering plants, 10 samples, 1997-2002



Discussion

A critical methodological question is the number of transects and the frequency of monitoring needed to detect a significant change in the population, particularly when natural fluctuations in the population can be 100% or more from year to year.

One approach is to assume that the years from 1997 to 2002 represent a normal range of variation: i.e. the northern portion of the population can range from 12,000 +/- 1450 plants to 33,000 +/- 3100 plants without affecting the viability of the population. The lower end of the confidence interval of the lowest population estimate is 10,550, so a conservative threshold for concern could be 10,500 plants. We have also seen that the population can fluctuate widely from year to year, so just one year of a population below 10,500 may not be cause for concern. Multiple years of low population levels are likely to be of greater significance.

A possible management objective for *Lesquerella tuplashensis* might be:

Maintain at least 10,500 reproductive plants of *Lesquerella tuplashensis* in the northern 3.7 km of the White Bluffs population from 2003-2013. If the population remains below 10,500 plants for two years or more, initiate further research into the causes of decline and/or initiate management action(s).

A possible sampling objective could then be:

We want to be 90% confident that the population estimates are within 25% of the estimated true value.

There are at least three other sampling questions:

1. How many transects should be sampled?
2. How often should sampling take place?
3. Is it necessary to sample all portions of the slope?

1) The data strongly suggest that all 20 transects must be sampled in order to be within 25% of the estimated true value. There is a definite decrease in confidence intervals between 10 and 20 transects, and for one year (1999) the confidence interval is 35% of the mean if only ten transects are sampled.
2) A full monitoring of once every three to five years seems adequate for the current degree of threat for this population. However, if the population estimate (including its confidence interval) is at or below the threshold of 10,500 plants, the population should be sampled again in the following year. In years where full monitoring is not taking place, a visual survey of the northern end of the population should take place.
3) Due to the annual fluctuations of the population on various portions of the slope, it might increase the degree of uncertainty to sample just one portion of the slope. At this time I recommend that we continue to sample all three portions of the slope during the full monitoring, although "slope" and "caliche" could be combined into one category.

Table 3-1. Confidence intervals using 10 or 20 transects

95% confidence	**20 transects (except 1997)**			**10 transects**			
year	est. total	1/2 conf. interval	confidence interval	% of mean	est. total	1/2 conf. interval	confidence interval	% of mean
					14034	2745	5491	0.39
1998	32603	3144	6287	0.19	31013	5197	10394	0.34
1999	21699	3295	6589	0.30	20354	6012	12025	0.59
2002	12038	1446	2893	0.24	11884	2452	4904	0.41

90% confidence	**20 transects (except 1997)**			**10 transects**			
year	est. total	1/2 conf. interval	confidence interval	% of mean	est. total	1/2 conf. interval	confidence interval	% of mean
					14034	2304	4608	0.33
1998	32603	2638	5276	0.16	48211	4361	8723	0.28
1999	21699	2765	5530	0.25	34854	5046	10091	0.50
2002	12038	1214	2428	0.20	20609	2058	4116	0.35

References

Washington Natural Heritage Program. 1997. Endangered, threatened, and sensitive plants of Washington with working lists of rare non-vascular species. Department of Natural Resources, Olympia, Washington.

Section 4. Survey for *Artemisia campestris* subsp. borealis var. wormskioldii and potential habitat on the islands of the Hanford Reach

Artemisia campestris subsp. *borealis* var. *wormskioldii* is a Candidate species for listing under the Endangered Species Act with the USFWS and is considered Endangered in Washington (Washington Natural Heritage Program1997). It occurs in riparian areas of the Columbia River at two locations: Miller Island at the eastern end of the Columbia Gorge and the Beverly site in Grant County. The Beverly site, upstream of the Hanford Reach, currently supports the largest known population of *Artemisia campestris* subsp. *borealis* var. *wormskioldii*.

The islands of the Hanford Reach were visited and surveyed in their entirety on April 22-23 by Florence Caplow and staff from the Hanford Reach National Monument. We visited all the islands from Richland upstream to Vernita Bridge, with the exception of one island in the vicinity of Coyote Rapids and one island upstream of Locke Island (both of which have some contamination issues). We found no populations of *Artemisia campestris* subsp. *borealis* var. *wormskioldii.*

However, a number of islands were highly similar to the Beverly site. The Beverly site has the following characteristics (Framatome AMP 2003):

- Stabilized cobble or sand substrate.
- Elevation of most of the population between 1' and 6' of the elevation of the high water line.
- Most of the population on gravel islands or peninsulas surrounded on two or more sides by water.
- Low total vegetation cover.
- High cover of bare ground.
- Low noxious weed cover.
- Most common associated native species: *Eriogonum compositum*, *Artemisia campestris* var. *scouleriana*, *Lesquerella douglasii, Descurainia pinnata, Lomatium grayii, Draba verna.*

The areas on the islands which most resembled the Beverly site in terms of substrate, vegetation, and elevation above high water were mapped as potential reintroduction sites (see Figures 4-1 through 4-6). Each polygon was identified as being either "moderate" or "excellent" habitat, based on the presence or absence of weedy species and the similarity of the site to the Beverly population area. Further detailed work is necessary before choosing a particular site as a reintroduction area. Areas on the islands of the reach which are not within these polygons are less likely to be appropriate habitat for the species. Where possible, island names on the USGS topographic maps were used. Numbered islands are from Hanson and Eberhardt (1971).

It is possible that potential habitat on the shoreline could be identified using vegetation maps developed by PNNL by Salstrom and Easterly, but these maps were not used in the preparation of this document. Shoreline habitat would be a lower priority as a reintroduction area due to its greater vulnerability to disturbance. In addition, both extant populations occur on islands, so there may be aspects of island hydrology that are particularly important for the species.

Table 4-1. Potential habitat for Artemisia campestris subsp. borealis var. wormskioldii on islands in the Hanford Reach

Island	Sub-area on island	Quality of habitat for reintroduction
Locke Island	West side	moderate
Rosseau Island	Most of island	moderate
E of 100F	East side	excellent
Plow Island (Island 12)	North end	moderate
Plow Island (Island 12)	Center	moderate
Homestead Island	Southeast side	moderate
Island 15	West side	moderate
Wooded Island	North end	moderate
Johnson Island	North end	excellent
Island 18	North end	excellent
Island 19	Most of island	excellent

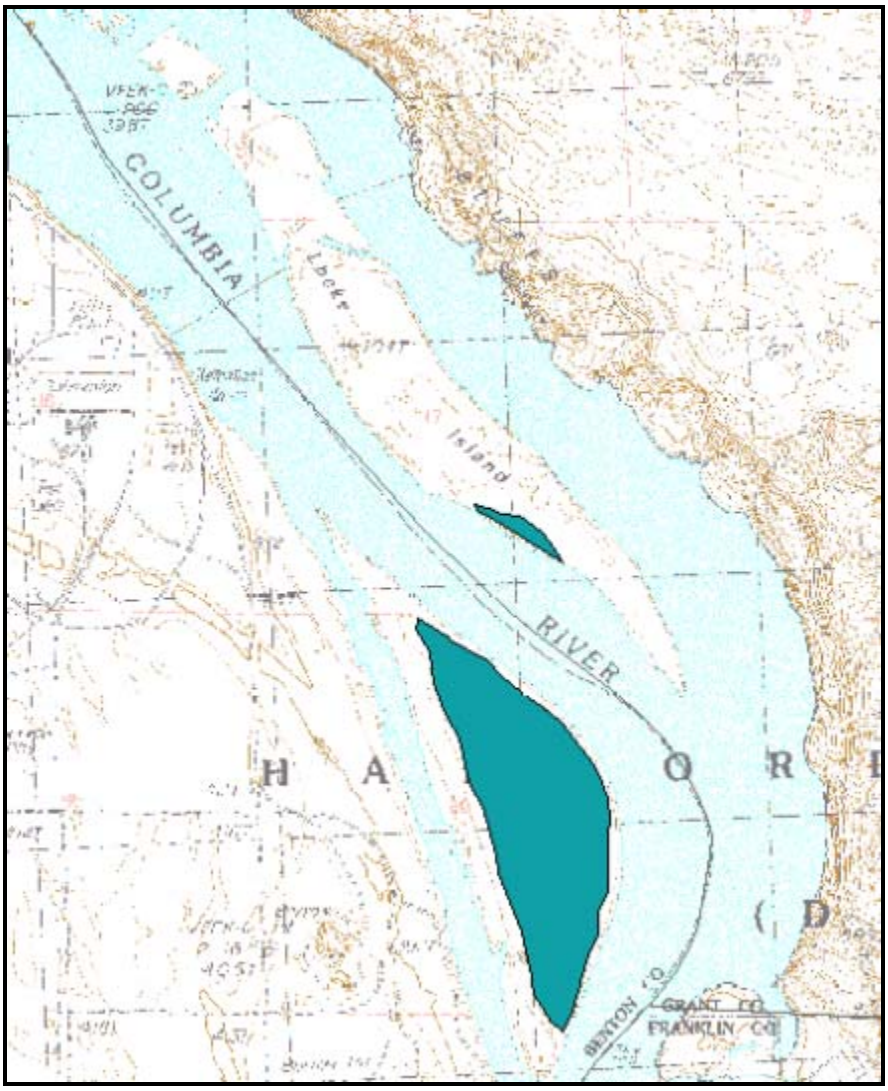


Figure 4-1. Northern wormwood habitat: Locke Island and Rosseau Island

Turquoise: moderate habitat for northern wormwood
Green: excellent habitat for northern wormwood

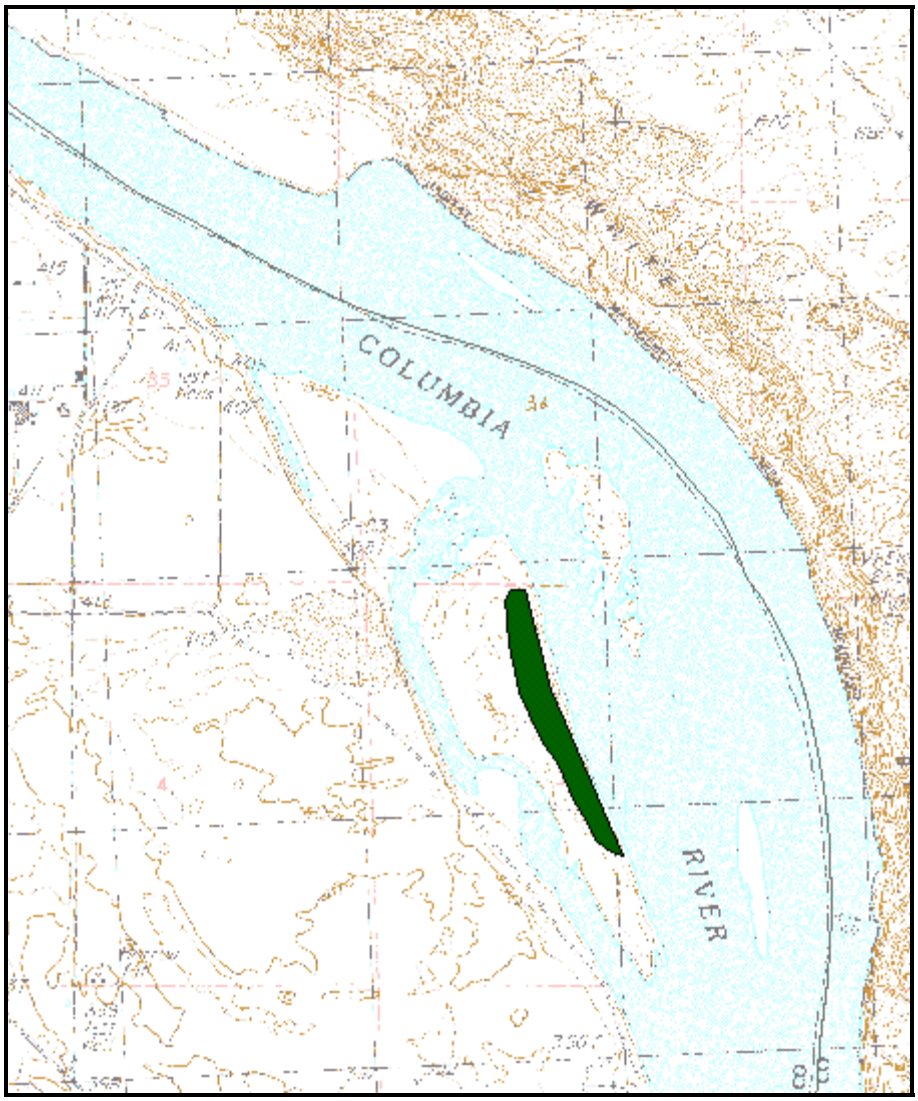


Figure 4-2. Northern wormwood habitat: Island east of 100 F Slough

Turquoise: moderate habitat for northern wormwood
Green: excellent habitat for northern wormwood

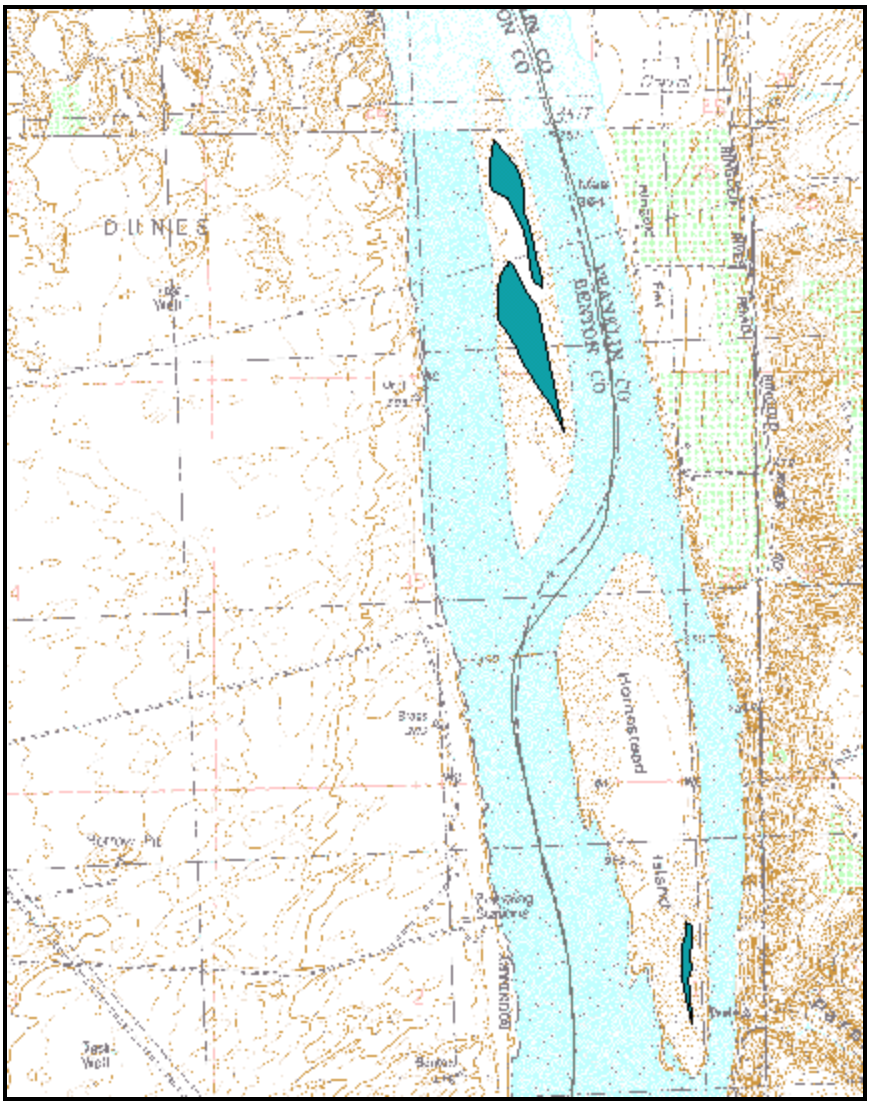


Figure 4-3. Northern wormwood habitat: Plow Island (Island 12) and Homestead Island

Turquoise: moderate habitat for northern wormwood
Green: excellent habitat for northern wormwood

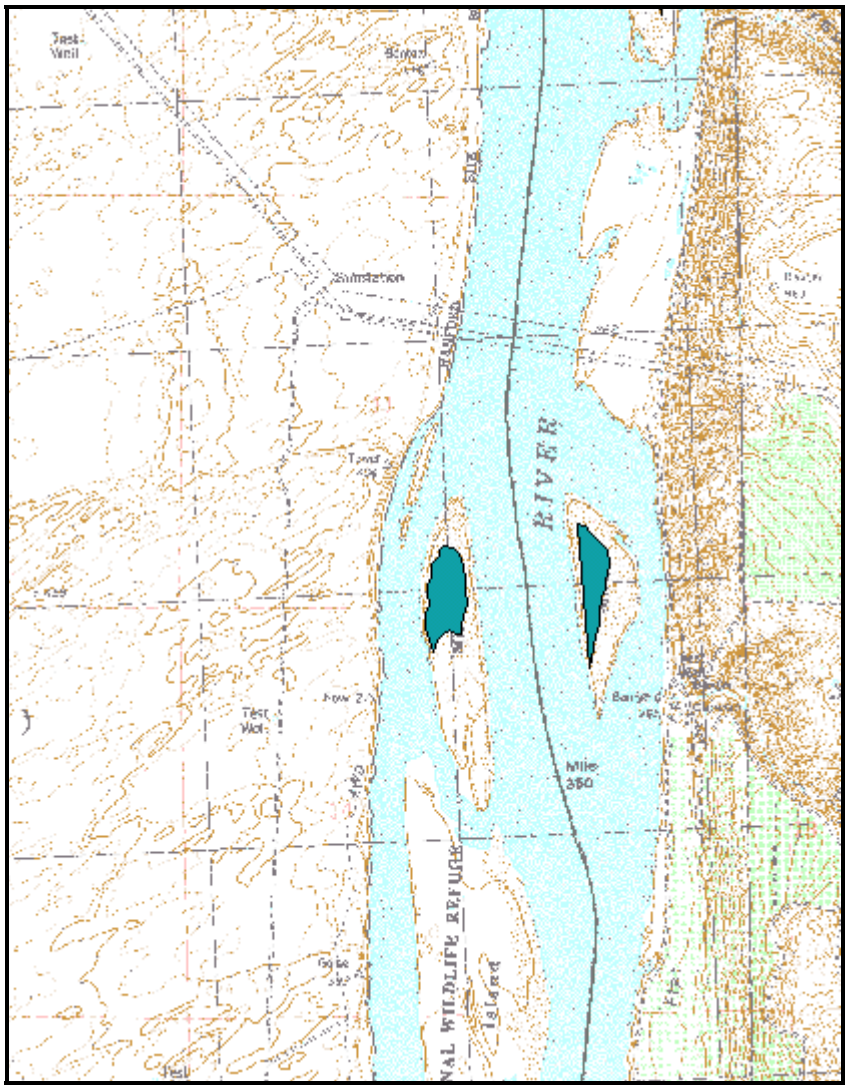


Figure 4-4. Northern wormwood habitat: Wooded Island and Island 15

Turquoise: moderate habitat for northern wormwood
Green: excellent habitat for northern wormwood

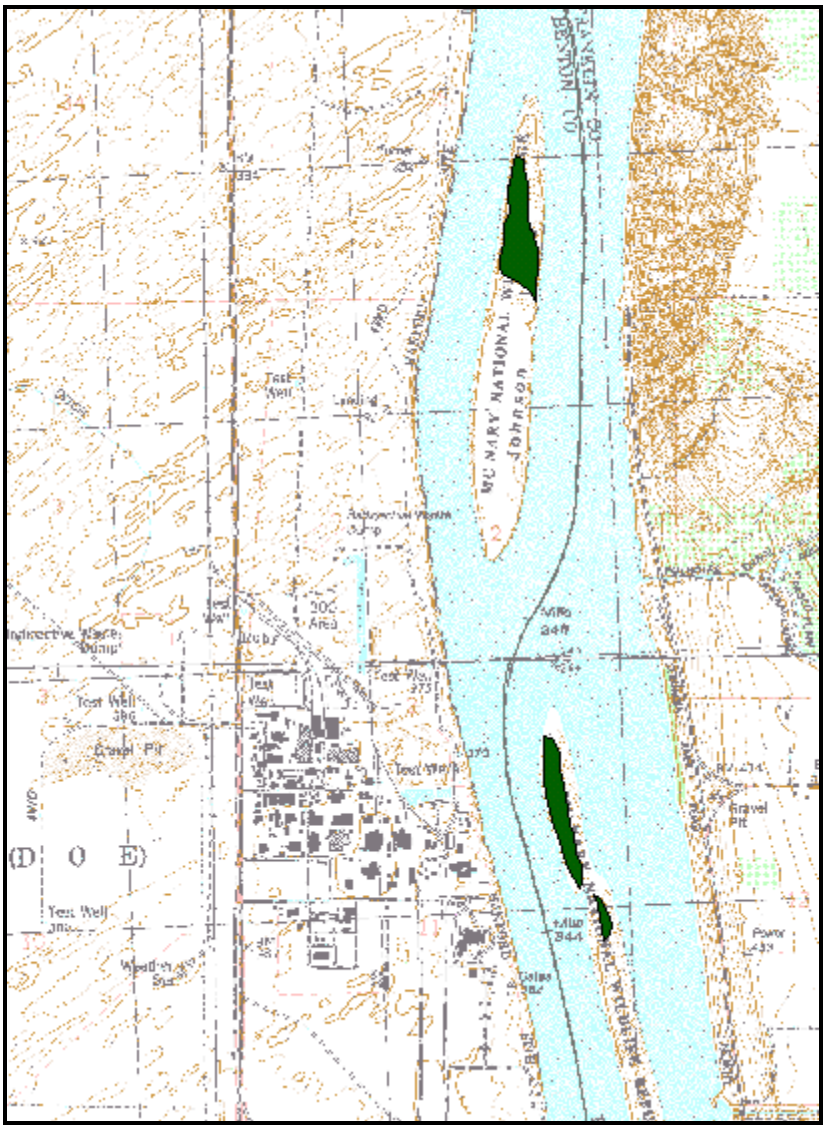


Figure 4-5. Northern wormwood habitat: Johnson Island and Island 18

Turquoise: moderate habitat for northern wormwood
Green: excellent habitat for northern wormwood

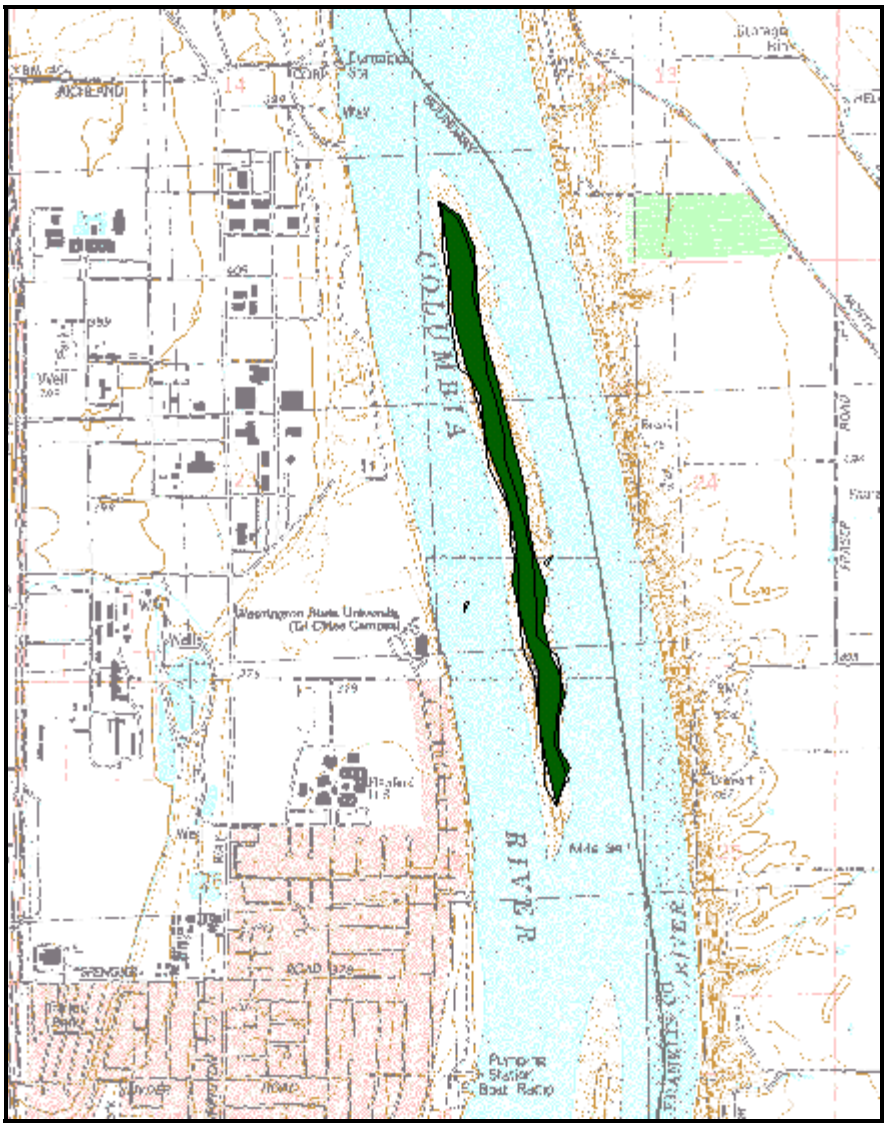


Figure 4-6. Northern wormwood habitat: Island 19

Turquoise: moderate habitat for northern wormwood
Green: excellent habitat for northern wormwood

References

Hanson, W.C., and L.L.Eberhardt. 1971. A Columbia River Canada goose population. Wildlife Monographs 28: 1-61.

Framatome ANP DE&S. 2003. Research summary and threats assessment for *Artemisia campestris* subsp. *borealis* var. *wormskioldii*. Draft report to Grant County PUD #2, Ephrata, Washington.

Washington Natural Heritage Program. 1997. Endangered, threatened, and sensitive plants of Washington with working lists of rare non-vascular species. Department of Natural Resources, Olympia, Washington.

Appendix A

Sighting form and maps of rare plant populations found during 2003 fieldwork.

Washington Natural Heritage Program

Rare Plant Survey Form

Please read instructions page.

Boxed areas to be completed by Natural Heritage Staff only.

Taxon Name: Rorippa columbiae_____ EO #

Are you confident of the identification? X yes ❑ no Explain:

Survey Site Name: Hanford Reach – island south of White Bluffs Boat launch

Surveyor's Name/phone/email: Florence Caplow,WNHP

Survey Date: _11/8/02_____ (yr–mo–day) County: Benton

Quad Name: Hanford 15' Quad Code: _____

Township: __13N____ N Range: __27E_____ Section(s): ___3 E ½ of E1/2

Directions to site: By boat: From the White Bluffs Boat Lunch travel 2 ½ miles downstream to a low island in the middle of the channel. Look for plants on the east side of the island in cobble below high water level.

_____

_____

Mapping (see instructions): Attach a copy of the USGS 7.5 minute quad with the location and extent of the rare plant population clearly drawn. Do not reduce or enlarge the photocopy or printout of the map. If you're using a map at a different scale (not recommended) please write the scale on the map. Please answer the following:

1. I used GPS to map the population: U No (skip to #2) XYes (complete #1 & #3)

XCoordinates are in electronic file on diskette (preferred) U Coordinates written below

Description of what coordinates represent: ends and middle of population.

GPS accuracy: U Uncorrected X Corrected to <5m

GPS datum: NAD 27

GPS coordinates

2. I used a topographic map to map the population:

❑ yes (complete #2) Xno (provide detailed directions & description above, and skip to #3)

I am confident I have accurately located and mapped the population at map scale:
❑ yes (skip to #3)

❑ no, but I am confident the population is within the general area indicated on the map as follows:

On the same map, use a highlighter to identify the outer boundary of the area where the population could be, given the uncertainties about your exact location.

3. I used the following features on the map to identify my location (stream, shoreline, bridge, road, cliff, etc.):

_____

_____

To the best of my knowledge, I mapped the entire extent of this population

❑ yes ❑ no Xunknown If no or unknown, explain: This is a small areas of a much larger population. However, there may be few plants within the larger population.

Is a revisit needed? ❑ no X yes - if yes, why?: Population seems to be in steep decline._____

Ownership (if known): Department of Energy

Population Size (# of individuals or ramets) or estimate: 7 patches totaling 100 stems

Population (EO) Data (include population vigor, microhabitat, phenology, etc.): _None in flower. All below high water.

Plant Association (include author, citation, or classification, e.g. Daubenmire):

Associated Species (include % cover by layer and by individual species for dominants in each layer):

General Description (include description of landscape, surrounding plant communities, land forms, land use, etc.):

7 patches totaling 100 ramets on east side of low gravel island below high water._

Minimum elevation (ft.): ___370 Maximum elevation (ft.): _____370

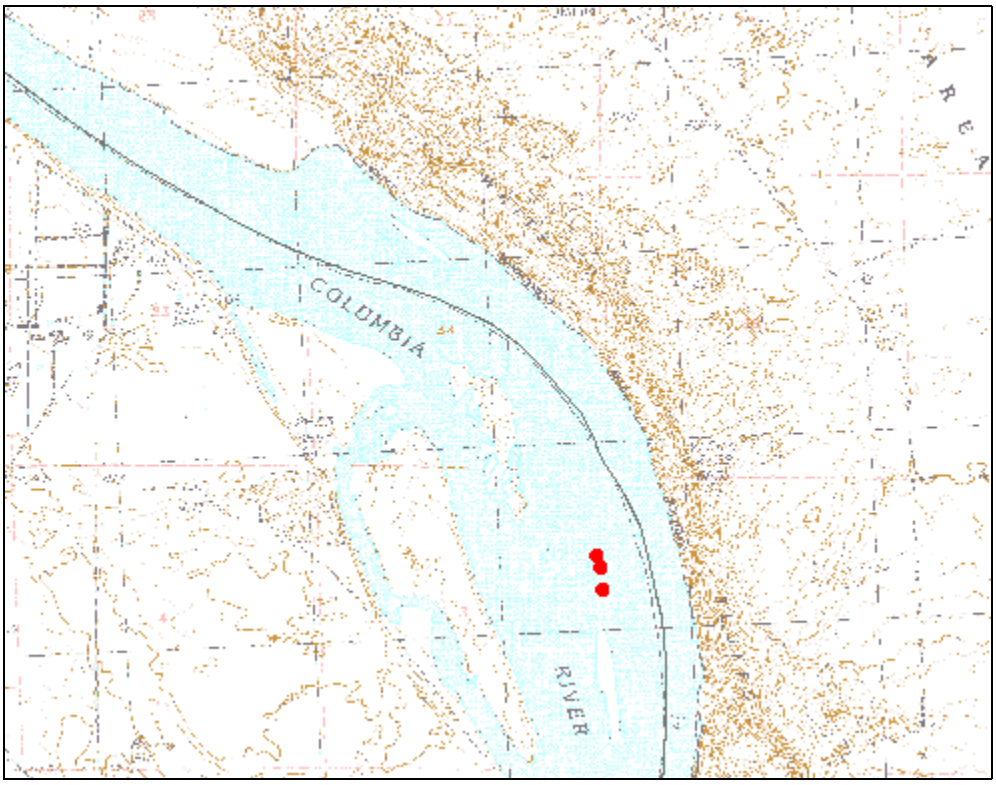
Size (acres): ____<2acres_____ Aspect: ___east_____ Slope: ___3%_____

Photo taken? ❑ yes X no

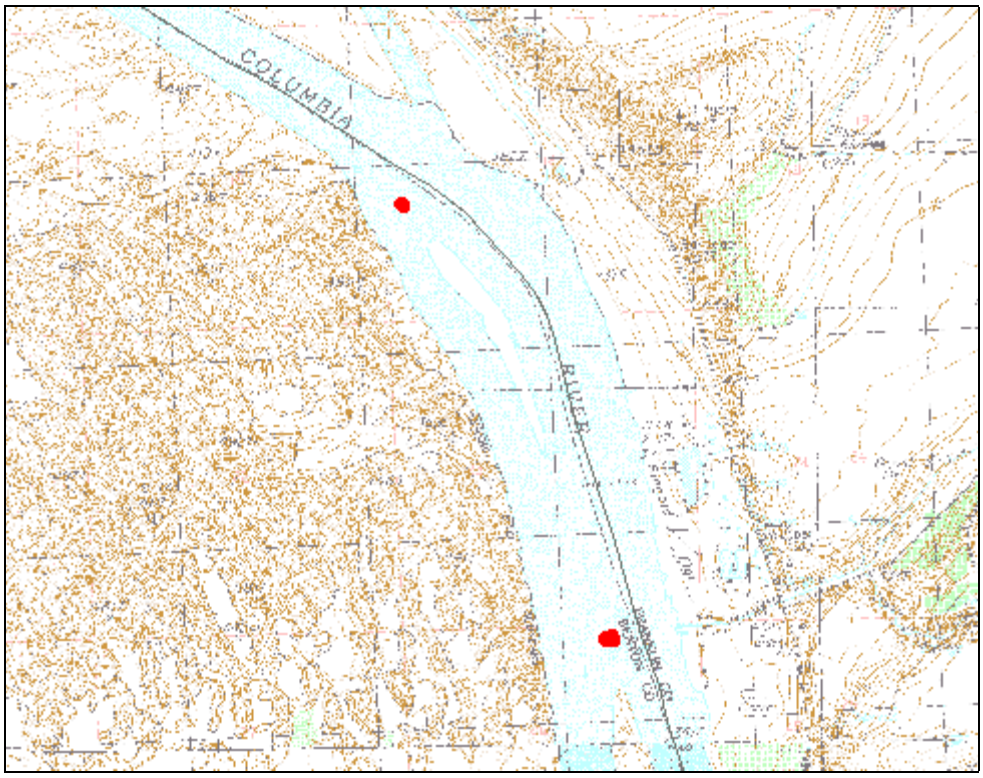
Management Comments (exotics, roads, shape/size, position in landscape, hydrology, adjacent land use, cumulative effects, etc.):

Protection Comments (legal actions/steps/strategies needed to secure protection for the site):

Additional Comments (discrepancies, general observations, etc.):



Location of Rorippa columbiae found 11/8/02



Location of Rorippa columbiae found in BLM monitoring transects 10/02 (no sighting form)

Washington Natural Heritage Program

Rare Plant Survey Form

Please read instructions page.

Boxed areas to be completed by Natural Heritage Staff only.

Taxon Name: Rotala ramosior EO # new EO

Are you confident of the identification? ☒ yes ☐ no Explain:

Survey Site Name: Homestead Island

Surveyor's Name/phone/email: Florence Caplow, WNHP

Survey Date: 2002 10 08 (yr–mo–day) County: Franklin

Quad Name: Wooded Island Quad Code: 4611943

Township: 11N N Range: 28E Section: 1 ¼ of ¼: NW of SW

Township: N Range: Section: ¼ of ¼:

Township: N Range: Section: ¼ of ¼:

Directions to site: By boat, travel to the southern end of Homestead Island and look for plants in a wetland area just east of the gravelly tip of the island.

Mapping (see instructions): Attach a copy of the USGS 7.5 minute quad with the location and extent of the rare plant population clearly drawn. Do not reduce or enlarge the photocopy or printout of the map. If you're using a map at a different scale (not recommended) please write the scale on the map. Please answer the following:

1. I used GPS to map the population: ☒ No (skip to #2) ☐ Yes (complete #1 & #3)

☐ Coordinates are in electronic file on diskette (preferred) ☐ Coordinates written below

Description of what coordinates represent:

GPS accuracy: ☐ Uncorrected ☐ Corrected to <5m

GPS datum:

GPS coordinates:

2. I used a topographic map to map the population:

☒ yes (complete #2) ☐ no (provide detailed directions & description above, and skip to #3)

I am confident I have accurately located and mapped the population at map scale:

☒yes (skip to #3)

☐ no, but I am confident the population is within the general area indicated on the map as follows:

On the same map, use a highlighter to identify the outer boundary of the area where the population could be, given the uncertainties about your exact location.

3. I used the following features on the map to identify my location (stream, shoreline, bridge, road, cliff, etc.):end of Homestead Island, shoreline of island

To the best of my knowledge, I mapped the entire extent of this population
☒ yes ☐ no ☐ unknown If no or unknown, explain:

Is a revisit needed? ☒no ☐ yes - if yes, why?:

Ownership (if known):

Population Size (# of individuals or ramets) or estimate: 500-1000

Population (EO) Data (include population vigor, microhabitat, phenology, etc.): Healthy population in wetland area with a number of the common associated species in backwater wetland, well protected from disturbance.

Plant Association (include author, citation, or classification, e.g. Daubenmire): N/A

Associated Species (include % cover by layer and by individual species for dominants in each layer):

Lichen/moss layer: N/A

Herb layer: Ammannia robusta,Limosella acaulis, Lindernia dubia, Cyperus acuminatus, Eleocharis acicularis

Shrub layer(s): Salix exigua

Tree layer:

General Description (include description of landscape, surrounding plant communities, land forms, land use, etc.):

Backwater wetland at southern end of Homestead island, just below high water line in mud and silt. Mostly herbaceous dominated.

Minimum elevation (ft.): 345 Maximum elevation (ft.): 345

Size (acres): .02 Aspect: South Slope: 3%

Photo taken? ☐ yes ☒ no

Management Comments (exotics, roads, shape/size, position in landscape, hydrology, adjacent land use, cumulative effects, etc.):

Area is well protected from disturbance, though changes in hydrology could affect population.

Protection Comments (legal actions/steps/strategies needed to secure protection for the site): With Hanford Reach National Monument

Additional Comments (discrepancies, general observations, etc.):

Washington Natural Heritage Program

Rare Plant Survey Form

Please read instructions page.

Boxed areas to be completed by Natural Heritage Staff only.

Taxon Name: Ammannia robusta EO # new EO
Are you confident of the identification? ☒ yes ☐ no Explain:

Survey Site Name: Homestead Island

Surveyor's Name/phone/email: Florence Caplow, WNHP

Survey Date: 2002 10 08 (yr–mo–day) County: Franklin

Quad Name: Wooded Island Quad Code: 4611943

Township: 11N N Range: 28E Section: 1 ¼ of ¼: NW of SW

Township: N Range: Section: ¼ of ¼:

Township: N Range: Section: ¼ of ¼:

Directions to site: By boat, travel to the southern end of Homestead Island and look for plants in a wetland area just east of the gravelly tip of the island.

Mapping (see instructions): Attach a copy of the USGS 7.5 minute quad with the location and extent of the rare plant population clearly drawn. Do not reduce or enlarge the photocopy or printout of the map. If you're using a map at a different scale (not recommended) please write the scale on the map. Please answer the following:

1. I used GPS to map the population: ☒ No (skip to #2) ☐ Yes (complete #1 & #3)

☐ Coordinates are in electronic file on diskette (preferred) ☐ Coordinates written below

Description of what coordinates represent:
GPS accuracy: ☐ Uncorrected ☐ Corrected to <5m
GPS datum:
GPS coordinates:

2. I used a topographic map to map the population:
☒ yes (complete #2) ☐ no (provide detailed directions & description above, and skip to #3)

I am confident I have accurately located and mapped the population at map scale:
☒yes (skip to #3)

☐ no, but I am confident the population is within the general area indicated on the map as follows:
On the same map, use a highlighter to identify the outer boundary of the area where the population could be, given the uncertainties about your exact location.

3. I used the following features on the map to identify my location (stream, shoreline, bridge, road, cliff, etc.):end of Homestead Island, shoreline of island

To the best of my knowledge, I mapped the entire extent of this population
☒ yes ☐ no ☐ unknown If no or unknown, explain:

Is a revisit needed? ☒no ☐ yes - if yes, why?:

Ownership (if known):

Population Size (# of individuals or ramets) or estimate: 500-1000

Population (EO) Data (include population vigor, microhabitat, phenology, etc.): Healthy population in wetland area with a number of the common associated species in backwater wetland, well protected from disturbance.

Plant Association (include author, citation, or classification, e.g. Daubenmire): N/A

Associated Species (include % cover by layer and by individual species for dominants in each layer):

Lichen/moss layer: N/A

Herb layer: Rotala ramosior, Limosella acaulis, Lindernia dubia, Cyperus acuminatus, Eleocharis acicularis

Shrub layer(s): Salix exigua

Tree layer:

General Description (include description of landscape, surrounding plant communities, land forms, land use, etc.):

Backwater wetland at southern end of Homestead island, just below high water line in mud and silt. Mostly herbaceous dominated.

Minimum elevation (ft.): 345 Maximum elevation (ft.): 345

Size (acres): .02 Aspect: South Slope: 3%

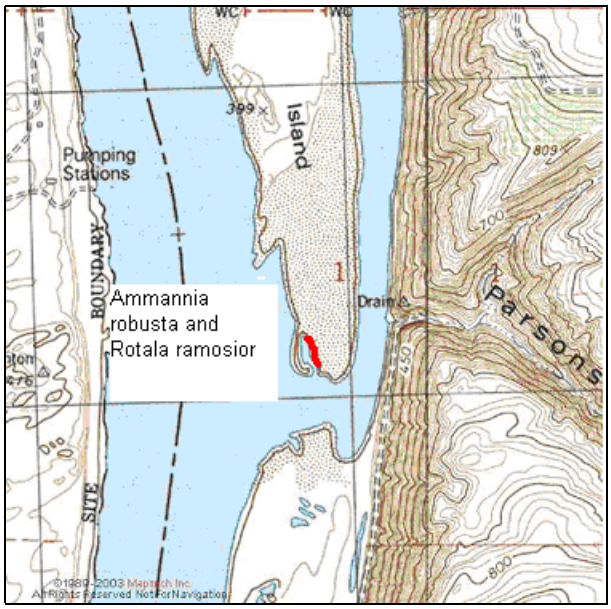
Photo taken? ☐ yes ☒ no

Management Comments (exotics, roads, shape/size, position in landscape, hydrology, adjacent land use, cumulative effects, etc.):

Area is well protected from disturbance, though changes in hydrology could affect population.

Protection Comments (legal actions/steps/strategies needed to secure protection for the site): With Hanford Reach National Monument

Additional Comments (discrepancies, general observations, etc.):



Location of Ammannia robusta and Rotala ramosior found 10/8/02