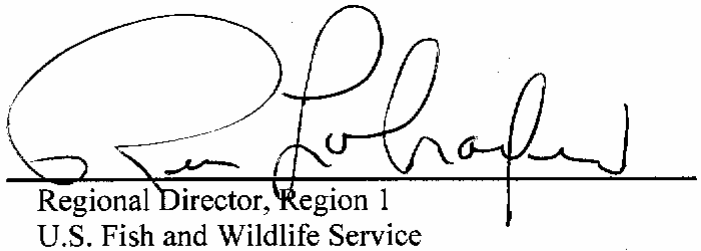
Recovery Plan for *Hackelia venusta* (Showy Stickseed)

Photo by Tim McCracken, U.S. Fish & Wildlife Service.

Recovery Plan
for
Hackelia venusta
(Showy Stickseed)

Region 1
U.S. Fish and Wildlife Service
Portland, Oregon

Approved: 

Regional Director, Region 1
U.S. Fish and Wildlife Service

Date: Oct 10, 2007

The Recovery Plan for *Hackelia venusta* (Showy Stickseed) was developed in cooperation with the U.S. Forest Service.

Date: 9/27/07

for Linda Goodman
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Recovery plans delineate reasonable actions that are believed to be required to recover and/or protect listed species. Plans are published by the U.S. Fish and Wildlife Service, sometimes prepared with the assistance of recovery teams, contractors, State agencies, and others. The objectives in the plan will be attained and funds made available subject to budgetary and other constraints affecting the parties involved, as well as the need to address other priorities. Recovery plans do not necessarily represent the views or the official positions or approval of any individuals or agencies involved in the plan formulation, other than the U. S. Fish and Wildlife Service. They represent the official position of the U.S. Fish and Wildlife Service *only* after they have been signed by the Director or Regional Director as *approved.* Approved recovery plans are subject to modification as dictated by new findings, changes in species status, and the completion of recovery actions.

Literature citation of this document should read as follows:

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An electronic copy of this recovery plan will be made available at:

<http://pacific.fws.gov/ecoservices/endangered/recovery/default.htm>
and also at <http://endangered.fws.gov/recovery/index.html>

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EXECUTIVE SUMMARY

Current Status: *Hackelia venusta* (showy stickseed) is a narrow endemic plant in the borage or forget-me-not family (Boraginaceae) known only from Chelan County in central Washington. The species occurs in a single population that occurs primarily on Federal land. *Hackelia venusta* was listed as an endangered species in 2002 (U.S. Fish and Wildlife Service 2002).

Habitat Requirements and Limiting Factors: *Hackelia venusta* is restricted to 1 small population of roughly 600 plants scattered over approximately 16 hectares (40 acres) of unstable, granitic sand and granite cliffs on the middle and lower slopes of Tumwater Canyon, Chelan County, Washington. Clusters of plants are concentrated in open, unstable areas of granitic sand and talus, and on ledges and cracks of vertical granite cliffs. The feature common to the variety of habitats where the species is found is the relatively sparse cover of other vascular plants and low canopy cover. The species appears to be dependent upon the maintenance of open habitat.

Major threats to *Hackelia venusta* include: collection, physical disturbance to the plants and habitat by humans, mass wasting (landslides), competition and shading from native trees and shrubs; encroachment onto the site by nonnative noxious weed species, fire suppression and associated activities, and low seedling establishment. Highway maintenance activities also threaten portions of the population. Reproductive vigor may be depressed because of the species' small population size, a limited gene pool, and loss of pollinators. A single natural or human-caused environmental disturbance could destroy a significant percentage of the population or the entire population, leading to the extinction of the species.

Recovery Strategy: The first step toward recovery of *Hackelia venusta* is to protect, manage, and increase the single known population. Continuing survey efforts will focus on identifying any additional populations that may exist but are currently unknown. In order to reduce the potential for extinction due to the catastrophic loss of the single small population, recovery actions will likely require increasing the area occupied by the existing population where space and

habitat allow, as well as establishing new populations within the estimated historical range of the species. Threats such as collection by the public, noxious weeds, and competition and shading must be sufficiently controlled to allow for this population expansion. The effective management and reintroduction of *H. venusta* will require gaining further knowledge about the life history of the species and the functioning of the ecosystem on which it depends. Therefore, research and monitoring are key components of the recovery strategy.

Recovery Goal: The ultimate goal of recovery planning is to recover species to the point where they no longer require the protections of the Endangered Species Act. We have determined that at this time the identification of credible delisting criteria is not possible for *Hackelia venusta,* given the current lack of information about the species' biology and habitat requirements, the magnitude of current threats, and the precarious location and highly unstable environment where the species occurs. As a result, this recovery plan addresses an interim goal of recovering *H. venusta* to the point that it may be downlisted to threatened status.

Recovery Objective: The interim objective is to stabilize the existing population and reduce the threats to the species sufficient to accomplish increases in population size and geographic distribution across its presumed historical range so that the species is no longer in danger of extinction.

Recovery Criteria: *Hackelia venusta* will be considered for downlisting to threatened status when all of the following conditions have been met to address the threats to the species:

1. **Listing/Recovery Factor A: The present or threatened destruction, modification, or curtailment of its habitat or range.** In order to ensure the long-term recovery needs of *Hackelia venusta*, threats to the species habitat must be reduced or removed. This will have been accomplished if the following have occurred:

a. Tree and shrub cover in all populations is maintained at a level equal to or more open than that present in 2007* in the original population, through manual removal or controlled burns.
b. Noxious weed populations are not present within any populations or close enough to them to pose a significant threat of invasion, or are annually removed.
c. Herbicide and de-icer use continues to be minimized within all populations or close enough to them that individuals may be affected .
d. All population sites have been evaluated for mass wasting potential and plans have been developed and implemented to minimize the effects of landslides on *H. venusta*.

2. **Listing/Recovery Factor B: Overutilization for commercial, scientific, or educational purposes.** *Hackelia venusta* is vulnerable to overcollecting of seeds or plants, and to habitat damage through substrate disturbance. In order to ensure the long-term recovery of *H. venusta*, threats to the species through collecting and visitation must be reduced or removed. This will have been accomplished if the following have occurred:

a. Seed collection guidelines are established.
b. A guideline of not sharing specific site information with the public or the press has been accepted by the U.S. Forest Service.
c. The pullout across the highway from the population has been modified or removed to discourage the public from stopping their vehicles and crossing the highway.
d. The U.S. Forest Service has an entry log in place and all permitted entries into the population are logged.
e. All research within the population is approved by the U.S. Fish and Wildlife Service and the U.S. Forest Service after review by the recovery team.

* The quantitative measure of tree and shrub cover must be determined (Recovery Action 1.7.1).

3. **Listing/Recovery Factor C: Disease or predation.** The viability of *Hackelia venusta* could be compromised by the presence of the borage-specific biocontrol weevil, *Mogulones cruciger.* In order to ensure the long-term recovery needs of *H. venusta*, threats to the species through predation by the biocontrol agent must be reduced or removed. This will have been accomplished if the following have occurred:

    a. A monitoring program is in place to inspect *H. venusta* and identified populations of *Cynoglossum officinale* (gypsyflower) in Chelan County on an annual basis for the presence of the biocontrol weevil, *Mogulones cruciger*.
    b. A written plan is in place for actions to undertake if the weevil is found and determined to have negative effects on *H. venusta*.

4. **Listing/Recovery Factor D: Inadequacy of existing regulatory mechanisms.** In order to ensure the long-term recovery needs of *Hackelia venusta*, regulatory mechanisms need to be strengthened. This will have been accomplished if the following have occurred:

    a. Habitat management plans have been developed and implemented by the U.S. Forest Service. Management plans will include provisions, as appropriate, for habitat maintenance and restoration, noxious weed control, fire management, recreational activities, monitoring, and research.
    b. A revised management plan has been developed and implemented by the Washington Department of Transportation. The management plan will include provisions, as appropriate, for habitat maintenance and restoration, noxious weed control, and highway maintenance activities.
    c. All *H. venusta* populations on public lands are within management areas where maintenance of the species is a primary management goal.

5. **Listing/Recovery Factor E: Other natural or manmade factors affecting its continued existence.** The long-term recovery needs of *Hackelia venusta* require more populations that are stable and self-sustaining. The genetic resources of the species must also be adequately protected through seed storage, in case of catastrophic events in Tumwater Canyon. This will have been accomplished if the following have occurred:

    a. At least **three** stable, self-sustaining populations are present within Tumwater Canyon on protected sites (owned or managed by a government agency or private conservation organization that identifies maintenance of *H. venusta* as the primary management objective for the site), separated by at least 2 kilometers (1.2 miles) or by the Wenatchee River. These populations could be the result of identification through further inventory, or through reintroduction or augmentation. If a new population is discovered outside of Tumwater Canyon, it may contribute to meeting this criterion. To be deemed stable and self-sustaining, a population must maintain a 5-year average of at least 1,000 adult plants, must show evidence of positive or neutral population growth over the same 5-year period, and must show evidence of natural reproduction and establishment.
    b. Genetic material, in the form of seeds adequately representing the geographic distribution and genetic diversity within the species, is stored in at least one facility approved by the Center for Plant Conservation.

6. **Monitoring.** In order to ensure the efficacy of recovery actions and allow for adaptive management, as necessary, population and habitat monitoring will have been established for all populations of the taxon at appropriate intervals. Habitat monitoring should include census, monitoring of *Hackelia venusta*, and of shrub and tree cover and nonnative species. Monitoring must be planned and conducted to minimize the potential negative impacts on the species and its habitat.

Written agreements to continue monitoring after downlisting must be in place.

Actions Needed:

1. Maintain the current geographic distribution of the species through maintaining habitat integrity.
2. Continue surveys in Tumwater Canyon and other appropriate areas; identify potential habitat for reintroductions.
3. Establish, if necessary, new populations of *H. venusta* within the estimated historical range of the species.
4. Collect seed adequately representing the genetic diversity within the species and store in a Center for Plant Conservation approved facility.
5. Establish a technical working group to periodically review the status of the species and assess the effectiveness of management plans and other recovery actions.

Estimated Cost to Downlist to Threatened: The estimated cost to recover *Hackelia venusta* to the point where it may be downlisted to threatened status is approximately $292,000 (Table 1).

Estimated Date to Downlist to Threatened: If all recovery criteria have been met, it is currently estimated that *Hackelia venusta* will be eligible for downlisting in or before the year 2027.

Table 1. Expanded Cost Estimates Through Plan Year 2027 (in $1,000 units). Actions refer to the primary recovery actions identified in this plan (see "Actions Needed," above).

Year	Action 1	Action 2	Action 3	Action 4	Action 5	Year Totals
2008	33	9	21	3	-	66
2009	26	8	16	-	2	52
2010	15	5	19	3	-	42
2011	7	4	15	-	-	26
2012	7	2	5	3	2	19
2013	2	-	-	-	-	2
2014	2	-	-	3	-	5
2015	3	-	3	-	2	8
2016	2	-	-	3	-	5
2017	5	-	-	-	-	5
2018	3	-	3	3	2	11
2019	2	-	-	-	-	2
2020	2	-	-	3	-	5
2021	3	-	3	-	2	8
2022	5	-	-	3	-	8
2023	2	-	-	-	-	2
2024	3	-	3	3	2	11
2025	2	-	-	-	-	2
2026	2	-	-	3	-	5
2027	3	-	3	-	2	8
TOTALS	$129	$28	$91	$30	$14	$292

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I. Background

The purpose of a recovery plan is to guide the implementation of recovery of a listed species. A recovery plan is mandated by the Endangered Species Act (16 United States Code [USC] 1531 *et seq*.), unless such a plan will not promote the conservation of the species, and is an advisory document. This recovery plan outlines the strategy and actions needed to recover *Hackelia venusta* (showy stickseed), an endangered plant that is known from a single population in Tumwater Canyon, Chelan County, in central Washington (Figure 1). The recovery recommendations in this plan are based on resolving the threats to the species and ensuring the persistence of self-sustaining populations in the wild. This recovery plan reflects any changes in distribution, status, and threats since the publication of the final rule to list the species (see Section A, Listing History and Recovery Priority).

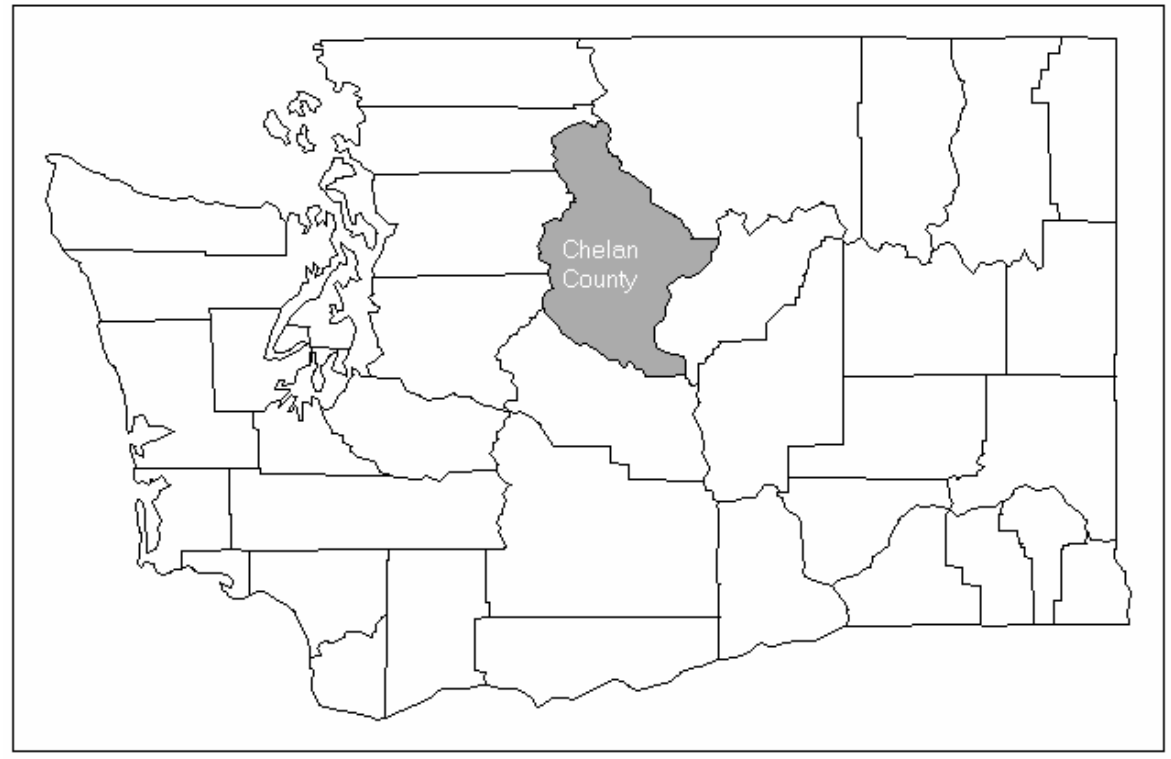

Figure 1. Location of Chelan County in the State of Washington.

A. Listing History and Recovery Priority

Hackelia venusta was listed as an endangered species in 2002 (U.S. Fish and Wildlife Service [USFWS] 2002). The species was included in a Smithsonian Institution report on those plants considered to be endangered, threatened, or extinct in the United States in 1975. A notice was published in the July 1, 1975, Federal Register announcing the decision to treat the Smithsonian report as a petition within the context of section 4(c)(2) of the Endangered Species Act and the intention to review the status of those plants (USFWS 1975). *H. venusta* was included in this petition as an endangered species. On December 15, 1980, we (the USFWS) published a Notice of Review for plants that included *H. venusta* as a category 1* candidate species (USFWS 1980). The plant Notice of Review of September 27, 1985 included *H. venusta* as a category 2 candidate (USFWS 1985). Pending completion of updated status surveys, the status was changed to category 1 in the February 21, 1990, Notice of Review (USFWS 1990). In the September 30, 1993, Notice of Review, *H. venusta* remained a category 1 candidate (USFWS 1993). In the February 28, 1996, Notice of Review, the use of multiple candidate categories was discontinued and former category 1 candidates were considered as simply "candidates" for listing purposes (USFWS 1996). However, in that Notice of Review, *H. venusta* was removed from the candidate list due to questions regarding the species' taxonomic status. An updated status review, completed in June 1997, reflected the new taxonomic information that determined only a single population of *H. venusta* currently existed (Gamon 1997). In the October 29, 1999, Notice of Review, *H. venusta* was included as a candidate species with a listing priority of 2 (USFWS 1999). A proposed rule to list the species as endangered was published on February 14, 2000 (USFWS 2000), and the final rule was published on February 6, 2002 (USFWS 2002).

The State of Washington listed *Hackelia venusta* as State endangered in 1981 (Washington Natural Heritage Program [WNHP] 1981), and this designation

* A "Category 1" candidate had sufficient information on biological vulnerability and threat(s) available to support a proposal to list the species as endangered or threatened. "Category 2" candidates had information indicating that a proposal to list the species as endangered or threatened was possibly appropriate, but substantial data on biological vulnerability and threat were not available to support a proposed listing at the time.

has been retained in subsequent updates of the State's endangered species list (available at www.dnr.wa.gov/nhp/refdesk/lists/plant_changes.html). However, this listing does not provide any regulatory protection for the plant. *Hackelia venusta* is also considered a U.S. Department of Agriculture Forest Service Region 6 sensitive species (USFS 2004).

The recovery priority number for *Hackelia venusta* is a 5 on a scale from 1C (highest) to 18 (lowest). This ranking is based on a high degree of threat to the species, low potential for recovery, and its status as a full species (Appendix B). The recovery actions for *H. venusta* are not anticipated to present any conflict with economic development.

B. Species Description and Taxonomy†

Hackelia venusta is a showy perennial herb of the borage or forget-me-not family (Boraginaceae) (Figure 2). The plant was originally described by Charles Piper as *Lappula venusta,* based on a collection from Tumwater Canyon, Chelan County, Washington, made by J.C. Otis in 1920 (Piper 1924). In 1929, Harold St. John reexamined the specimen and placed it in the related genus *Hackelia* (St. John 1929).

Hackelia venusta is a short, moderately stout species, 20 to 40 centimeters (8 to 16 inches) tall, often with numerous, erect to ascending stems from a slender taproot. It has large, showy, five-lobed flowers that are white or white washed with blue, and are approximately 1.9 to 2.2 centimeters (0.75 to 0.87 inch) across when measured from above from tip of petal to tip of petal. The fornices (appendages at the base of each petal) are showy, truncate or very slightly emarginated, but not papillate. The basal leaves are 7 to 14 centimeters (2.8 to 5.5 inches) long and 0.64 to 1.3 centimeters (0.25 to 0.5 inches) wide, while the upper stem leaves are 2.5 to 5.1 centimeters (1 to 2 inches) long and 0.38 to 0.64 centimeters (0.15 to 0.25 inches) wide (Barrett *et al*. 1985). The leaves have a fringe of marginal hairs. The fruit consists of four prickly nutlets

† A glossary of technical terms is provided in Appendix C.

Figure 2. *Hackelia venusta* in flower. Photo by Carolyn Alfano, Washington Rare Plant Care and Conservation, used with permission.

per flower, approximately 0.38 to 0.43 centimeters (0.15 to 0.17 inches) long. The marginal prickles are united for up to one-half of their length, forming a flange around the nutlet (Gentry and Carr 1976).

Hackelia venusta is a tetraploid species, morphologically uniform, and distinct from other species of *Hackelia* occurring in central Washington (Gentry and Carr 1976). The congeneric *H. diffusa* var. *arida* also occurs in Tumwater Canyon, but *H. venusta* can be distinguished by its smaller stature, shorter leaf length, fewer basal leaves, leaves that do not diminish in size toward the inflorescence, lack of papillate fornices, and larger flowers. Occasional plants with various combinations of intermediate features (most often large flower size) between *H. venusta* and *H. diffusa* var. *arida* have been collected, particularly within Swakane Canyon and near Lake Chelan (Gamon 1997). The habitat for these intermediate plants most closely resembles that of *H. diffusa* var. *arida*, and Gentry and Carr (1976) felt that since *H. venusta* appears to be genetically

stable, these plants may be the result of past gene flow toward *H. diffusa* var. *arida*. No intermediates have been seen in Tumwater Canyon, although both taxa occur there, sometimes within 20 meters (60 feet) of one another.

High elevation blue-flowered *Hackelia* populations that have, in the past, been assigned to *Hackelia venusta* have distinct morphological features and are now considered a separate species, although the species description has not yet been published (Harrod *et al.* in review). While isozyme analysis conducted by Hipkins *et al.* (2003) suggested that *H. venusta* and the undescribed blue-flowered *Hackelia* (Harrod *et al*. 1999) are recently derived from a common ancestor, it did not provide evidence for a clear separation at the species level. Using a taxonomic or phenetic species concept, taxonomic separation is not based on enzyme phenotypic data alone (Grant 1981; Winston 1999). Other lines of evidence such as morphology, habitat, and phenology indicate that *H. venusta* and the undescribed taxon are distinct (Harrod *et al*. 1999). *H. venusta* flowers are white and on rare occasion are washed with blue, while the undescribed high elevation *Hackelia* populations are uniformly blue. Other distinct morphological differences are limb width, plant height, and radical leaf length (Harrod *et al.* 1999). Although the two forms of *Hackelia* occupy similar substrates, they reside in distinctly different habitats. The undescribed taxon is found in high elevation sites and *H. venusta* is found at one low elevation site. Finally, the taxa are separated in timing of reproduction, with flowering of *H. venusta* taking place in April and May and in the blue-flowered species in August (L. Malmquist, U.S. Forest Service, pers. comm. 2007). Genetic analysis of both species is currently under way at the University of Washington to determine what level of taxonomic separation, if any, is required (Sarah Reichard, Professor of Botany, University of Washington, pers. comm. 2007).

C. Population Trends and Distribution

The type specimen for *Hackelia venusta* was collected in 1920 at a site between Tumwater and Drury in Tumwater Canyon, west of Leavenworth, Washington. *Hackelia venusta* has never been found other than within this single population in Tumwater Canyon. An occurrence of what was originally

labeled as *H. venusta* was found in 1948 in Merritt, Washington in Chelan County; however, the taxonomy of this specimen, currently housed at the University of Washington herbarium, remains unconfirmed (J. Arnett, Botanist, Washington Natural Heritage Program, pers. comm. 2007). A revisit to another suspected *H. venusta* site near Natapoc by Lauri Malmquist of the U.S. Forest Service and Florence Caplow of the Washington Natural Heritage Program found only *H. diffusa* var. *arida* (F. Caplow, Botanist, Washington Natural Heritage Program, pers. comm. 2004). This being the case, the Tumwater Canyon population of *H. venusta* may have been the only location for the species throughout the last century.

In 1968, the taxon appeared "limited to a few hundred acres" (Gentry and Carr 1976), although there is no record of the number of individuals that may have been present in the population at that time. In 1981 the population was estimated to have approximately 1,000 plants over an area of 3.5 hectares (8 acres) (R. Schuller, Washington Natural Heritage Program, *in litt*. 1981). In 1984, and again in 1987, fewer than 400 individuals were found over an area of approximately 5 hectares (12 acres) (Gamon 1988a). In 1981, 1984, and 1987, the areas surrounding the known population were also searched, but no additional plants were found. An intensive census by Ted Thomas of the U.S. Fish and Wildlife Service, Richy Harrod of the U.S. Forest Service, and Paul Wagner of the Washington Department of Transportation on May 11, 1995, revealed fewer than 150 individuals growing on less than 1 hectare (2.5 acres) of suitable habitat (Ted Thomas, pers. comm. 2007). In 1996, the area occupied by *Hackelia venusta* was greatly reduced and the number of individual plants had seriously declined since Dr. Carr, a species expert on *Hackelia*, first visited the Tumwater Canyon population in the early 1970s (R. Carr, Eastern Washington University, pers. comm. 1996).

During the late 1990s, and since the publication of the proposed rule to list the species on February 14, 2000 (USFWS 2000), the population of *Hackelia venusta* has been monitored semi-annually. Annual monitoring is hampered by extreme slope instability and the damage to plants and seedlings as a result of monitoring. In May 2000, nearly 300 plants were counted over 4 hectares (10 acres), and in May 2001, the number of plants in the population approached 500 plants over 4 hectares (10 acres) (L. Malmquist, *in litt.* 2000, pers comm. 2001).

In the summer of 2004, Florence Caplow (Washington Natural Heritage Program) and Tim McCracken (U.S. Fish and Wildlife Service), along with volunteers from Rare Care (Washington Rare Plant Care, University of Washington), undertook an intensive search within all habitat perceived as potentially suitable on the west facing slopes of Tumwater Mountain within 3.2 kilometers (2 miles) to the south of the known population. The search revealed nine small clusters of plants across the slope and above the known population for nearly 0.8 kilometer (0.5 mile) to the southeast, including a small number of plants on private land. The elevation ranges for this extension of the population were from 472 to 823 meters (1,550 to 2,700 feet), and plants were found in cracks on cliff faces as well as in small patches of habitat that resembled the known portion of the population. Due to their proximity to the known portion of the population, these newly found clusters are considered part of the one existing population, and not separate populations. Plants were also found downslope of Highway 2 in the vicinity of the known portion of the population. A total of 272 plants were found in these 9 clusters, bringing the total number of plants in the population (assuming a population size of 300 to 500 plants in the formerly known portion of the population), to between 572 and 772 plants (F. Caplow, pers. comm. 2004; WNHP 2007). It is assumed that these clusters are not the result of recent colonization events or an expansion of the population, but are instead portions of the population that had been overlooked in previous surveys, due to the steep terrain and their relative inaccessibility.

Monitoring where negative surveys have been conducted for *Hackelia venusta* is valuable in planning further inventory efforts. It is probable that surveys have been made for the species in areas not reported, especially efforts made since its rarity and vulnerability were first recognized. Unfortunately, few records remain that document where botanists have looked for *H. venusta* specifically. Forest Service records of negative rare plant surveys have inadvertently been lost, and the only such information that can presently be found in the Washington Natural Heritage Program files are maps of surveys made by Jim Barrett, a botanist working in the area in 1984 (WNHP 2007; J. Barrett, *in litt.* 1984). Maps compiled of these surveys and the 2004 surveys referenced above are available in WNHP (2007).

The 2004 surveys did not indicate an appreciable increase in the number of plants in the population, and from a demographic perspective the total population is still extremely small, but the known geographic extent of the population increased from approximately 4 hectares (10 acres) to approximately 16 hectares (40 acres). It is possible, but now somewhat less likely, that a single catastrophic event such as a large landslide could cause the extinction of the species. The population is still smaller in area and/or numbers of individuals than the estimates made in 1968 or in 1981, but appears to have increased from the very low numbers of the mid-1990s. Furthermore, it is reasonable to assume that the original geographic range of the species has been greatly diminished, since the spatial extent of the population noted in 1968 had already been subjected to plant succession as a result of fire suppression for many years prior to the 1968 observation reported by Gentry and Carr (1976), and presumably was already reduced by that time (see Section F, Threats/Reasons for Listing).

The moderate increase in the population size from 1995 to 2000 may be attributed to several events that occurred within the habitat for the species, including wildfire, treatment of the nonnative noxious weed problem within Tumwater Canyon, and a U.S. Forest Service restoration project within the habitat of *Hackelia venusta*. In 1998, about 35 small trees and 1 very large standing dead tree were felled and removed from the site (R. Harrod, U.S. Forest Service, pers. comm. 2000, 2007; L. Malmquist, *in litt.* 2001), operating over a deep snowpack to avoid impacts to the soil and protect the dormant *H. venusta* population. Each of these projects improved the habitat suitability for the plant by reducing shade, increasing light onto the slope, reducing overstory trees, and providing new germination substrates for the establishment of seedlings.

Based on the life history characteristics of *Hackelia venusta* (a perennial that occupies an unstable habitat) and the observed variability in the numbers of individuals present in the one known population over the years, a population that maintains at least 1,000 flowering plants is presumed to be by the recovery team to be minimally viable for this taxon. Population viability analysis has not been undertaken for *H. venusta*, and would not be feasible for this species, given that the intensive demographic monitoring needed for population viability analysis would negatively affect the stability of the habitat and the survival rate of germinants. Minimum viable population size is affected by many factors,

including life history of the species and the degree of stochasticity (unpredictability) of the environment (Shaffer 1987). Effective population sizes as small as 500 plants have allowed the maintenance of genetic heterogeneity for some species (Barrett and Kohn 1991). For species that occupy habitats with high levels of environmental uncertainty, the estimated minimum size for viability is estimated to be more on the order of at least 1,000 individuals (Nunney and Campbell 1993). Plants are especially vulnerable to disturbance events due to their sessile nature (Menges 1991), and particularly in cases such as this when there are few populations of the species left, there is little room for variance in setting the minimum number of individuals needed (Shaffer and Samson 1985). Given the highly unpredictable nature of the environment of *H. venusta*, its extreme vulnerability to stochastic events, and observed past levels of variability in numbers of individuals in the population, the recovery team felt that a population of *H. venusta* would likely not be viable without at least 1,000 plants.

D. Life History and Ecology

Hackelia venusta is perennial, and individual plants can live for at least 10 years. Flowers begin to open in late April, and new flowers are continuously added to each inflorescence until late June. By mid-June, the lowest flowers have nearly mature fruits. Dispersal begins with the lowest flowers and continues for several weeks into early July (Gamon 1997). Germination timing is not known, but seedlings have been observed in May and June.

The pollination biology of the species is not well known, but daylight pollinator observations in 2004 of both *Hackelia venusta* and *H. diffusa* var. *arida* found a wide range of potential pollinators on *H. diffusa* var. *arida* and few to no potential pollinators on *H. venusta* (J. Taylor, graduate student, University of Washington, pers. comm. 2005). A similar observation was made in 1984 (J. Barrett, *in litt.* 1984). It is possible that *H. venusta* could be pollinated by moths; however, this is unlikely because the relatively long tongues of moths are an apparent mismatch with the short corolla tube length of *H. venusta*. Numerous thrips (Thysanoptera) have been observed on *H. venusta* flowers. Thrips breed inside the protected parts of the corolla and commonly pollinate plants of a similar morphological type (J. Taylor, pers. comm. 2005). If the species is insect

pollinated, bee and fly species appear to be the most likely candidates, as they have shorter tongues that better match the corolla tube length of *H. venusta*. In the past, *H. venusta* has been assumed to be an obligate outcrosser (Harrod 1999). University of Washington graduate student Jeanie Taylor investigated breeding system, pollinators, and seed germination requirements for *H. venusta* from 2004 to 2006. During these years at the field site near Leavenworth, Washington, three pollinators were verified on the *H. venusta* plants: two bees, *Andrena nigrocaerulea* and *Protosmia rubifloris,* and one fly, *Eulonchus sp.* This work has indicated *H. venusta* is primarily outcrossing, with the possibility of geitonogamous selfing (pollination by other flowers on the same plant); autogamous selfing (pollination within a single flower) is possible since the stigma and anthers do appear to be in close proximity with one another at anthesis, but is unlikely to be a major contributor because most of a flower's pollen is produced before its stigma is receptive (J. Taylor, pers. comm. 2005, 2007).

A number of observers have seen high rates of ovule or seed abortion in *Hackelia venusta*. Gamon (1997) estimated that in 1984 60 to 70 percent of the seeds were aborted, and in many individuals, few or no fruits developed properly. Only a few individuals had most of the fruit develop properly. A pattern of low seed production has been observed in other years as well (L. Malmquist, pers. comm. 2003). Seed production in the Boraginaceae family tends to be low; 30 to 40 percent is not unusual or alarming in this family (S. Reichard, pers. comm. 2005). However, seed collection of *H. venust*a in 2004 found relatively high rates of seed production, so seed production apparently varies from year to year. In 2004 a sample of 60 seeds (2 from each plant from which seed was collected) was sent to Ransom Seed Laboratory in Carpinteria, California. Fifty-eight percent of the seed was viable; the rest were dead, broken, or empty (F. Caplow, pers. comm. 2004).

Most nutlets seem to fall directly to the ground around the parent plant, but the topography is so steep and unstable that many nutlets are carried downslope. Small concave areas near parent plants often have seedlings (L. Malmquist, pers. comm. 2003). The prickly nutlets are also well adapted for dispersal by adhesion to the coats of passing animals (Gamon 1997).

Germination testing by Ransom Seed Laboratory found that, out of 35 viable seeds, none germinated without treatment. Four germinated when cut through the cotyledons (seed leaves), 26 germinated when cut through the cotyledons and then exposed to 400 parts per million gibberillic acid, and 5 were determined to be viable only through tetrazolium staining (F. Caplow, pers. comm. 2004). These results confirm that seeds of *Hackelia venusta* are dormant, and explain the difficulty that others have experienced in germination trials. Germination trials by the Center for Urban Horticulture at the University of Washington found that cold stratification alone for 30 to 60 days did not result in successful germination. Only when seeds were left in cold stratification for up to 4 months did 50 percent of the seeds germinate, and those seeds may have been the result of unintended previous crosses of *H. venusta* with the unnamed high elevation blue-flowered *Hackelia*. It is unknown whether germination was related to the longer cold exposure or hybridization between the two genotypes (S. Reichard, pers. comm. 2005). In 1988, the Berry Botanic Garden in Portland, Oregon, was able to successfully germinate 70 percent of a small number of seeds by sequentially: a) rinsing seeds in 10 percent bleach, b) scarifying the seed coat, and c) placing the seeds on moist filter paper with light at room temperature. Using this protocol, Berry Botanic Garden staff germinated seed within 1 week. Chilling without scarification resulted in a 10 percent germination rate (E. Guerrant, Berry Botanic Garden, pers. comm. 2003).

Due to the perceived difficulty with germination, micropropagation experiments with *Hackelia venusta* have been underway since 1993 (Edson *et al.* 1996). Micropropagation was successful from approximately 30 parent plants, and there are still surviving clones from an outplanting in 1995 in the Icicle Creek drainage in Chelan County, Washington. These clones have produced germinants on site. Some clones are still maintained by the Center for Urban Horticulture at the University of Washington, but micropropagation of *H. venusta* was discontinued in 2003 (S. Reichard, pers. comm. 2005)(Also see Section G; conservation Measures). In her graduate work, Jeanie Taylor observed *H. venusta* seeds beginning to germinate after approximately 16 weeks of cold (35 to 38 degrees Fahrenheit), moist stratification to break dormancy. The seeds continued to germinate for up to 8 weeks after the first germination. Additionally, some genetic lines of *H. venusta* seemed to germinate at a higher percentage than others, although these seed germination studies need to be replicated due to an

imperfect germination. A prior germination trial with a close relative, *H. diffusa var. arida*, reinforces the expected period and temperature for cold stratification. Taylor also found container culture of *H. venusta* to be problematic, and recorded plant survival for 1 or 2 years if handled carefully (J. Taylor, pers. comm. 2007).

An isozyme study by Hipkins *et al.* (2003) found little variation in *Hackelia venusta* when compared to one population of the high elevation blue-flowered *Hackelia* (unnamed), seven populations of *H. diffusa* var. *arida,* one population of *H. diffusa* var. *cottonii*, and one population of *H. diffusa* var. *diffusa*. However, they found "no reason to believe that lack of overall genetic variation limits survival of white-flowered *H. venusta*" (Hipkins *et al.* 2003:175).

E. Habitat and Ecosystem Characteristics

Hackelia venusta is shade-intolerant (R. Carr, pers. comm. 1998) and grows in openings within *Pinus ponderosa* (ponderosa pine) and *Pseudotsuga menziesii* (Douglas-fir) forest types. This vegetation type is described as the Douglas-fir zone by Franklin and Dyrness (1973). Common associates include *Penstemon subserratus* (finetooth beardtongue), *Phacelia hastata* (silverleaf phacelia), *Lomatium triternatum* (nineleaf biscuitroot), *Lupinus wyethii* (Wyeth's lupine), *Eriogonum compositum* (arrowleaf buckwheat), *Eriogonum umbellatum* var. *hypoleium* (sulphur-flower buckwheat), *Hieracium cynoglossoides* (houndstongue hawkweed), and *Pseudoroegneria spicata* (bluebunch wheatgrass).

Hackelia venusta is found on open, steep slopes (minimum 80 percent inclination) of loose, well-drained, granitic weathered and broken rock fragmented soils, and on ledges and cracks on granitic cliff faces, at elevations between 472 meters (1,550 feet) to 823 meters (2,700 feet). Aspect ranges from 192 degrees (south-southwest [SSW]) to 310 degrees (west-northwest [WNW]), with most plants at an aspect of 265 degrees (west [W]). Plants are found on concave, convex, or flat slopes. The primary subpopulation is on an area of slope between drainages, but a number of the smaller subpopulations occur along the steep south-facing sides of dry drainages or on vertical cliff faces.

Hackelia venusta appears to be somewhat adapted to natural and possibly human-caused substrate disturbance (R. Carr, pers. comm. 1998), and occurs within the right of way along both sides of Highway 2. Although potential habitat for this species exists elsewhere in Tumwater Canyon, and occasionally single plants are seen elsewhere along Highway 2, no other populations have yet been found.

Wildfires play a role in maintaining open, sparsely vegetated sites as suitable habitat for *Hackelia venusta*, a requirement of this shade-intolerant plant (R. Carr, pers. comm. 1998, *in litt*. 2000). The species prefers habitat that has been burned, has little competing vegetation (D. Werntz, Northwest Ecosystem Alliance, *in litt.* 2000), and likely has soil low in organic matter (R. Carr, pers. comm. 1998). A 1994 fire killed much of the understory vegetation and scattered trees in the population, but did no visible harm to the *H. venusta* population (Harrod 1994).

F. Threats/Reasons for Listing

The threats to *Hackelia venusta* are each classified according to the five factors identified in section 4(a)(1) of the Endangered Species Act for consideration in listing, delisting, and reclassification decisions. These five factors are as follows:

A – The present or threatened destruction, modification, or curtailment of habitat or range;
B – Overutilization for commercial, recreational, scientific, or educational purposes;
C – Disease or predation;
D – Inadequacy of existing regulatory mechanisms; and
E – Other natural or man-made factors affecting the continued existence of a species.

The five listing factors and their application to *H. venusta* are as follows:

1. The present or threatened destruction, modification, or curtailment of its habitat or range (Factor A). The range of *Hackelia venusta* has been reduced to a small single population occurring in a scattered distribution across roughly 16 hectares (40 acres) in Tumwater Canyon, Washington, almost entirely on Federal lands of the Okanogan-Wenatchee National Forest. This restricted population consisted of between approximately 572 and 772 plants in 2004, and this constitutes the sole known population of *H. venusta*.

The primary loss of habitat for *Hackelia venusta* has resulted from changes in habitat due to plant succession in the absence of fire. Fire suppression has been a factor in reducing the extent of the Tumwater Canyon population (Gamon 1988a, b; D. Werntz, *in litt.* 2000), and most likely the few hundred acres of occupied habitat recorded in 1968 (Gentry and Carr 1976) represented a population that had already been reduced in both numbers and range due to fire suppression activities that had been ongoing for many years. Historically, fuels in the forest type where *H. venusta* is found were rarely at high levels because of the frequent fires that consumed forest floor fuels and pruned residual trees (Agee 1993). In the past, fires suppressed the encroachment of woody vegetation and maintained open areas presumably more conducive to *H. venusta* reproduction and growth. As described above, wildfires play a role in maintaining open, sparsely vegetated sites as suitable habitat for this shade-intolerant species (R. Carr, pers. comm. 1998; D. Werntz, *in litt.* 2000).

Hackelia venusta prefers habitat that has been burned, has little competing vegetation (D. Werntz, *in litt*. 2000), and has low levels of organic matter in the soil (R. Carr, pers. comm. 1998). The species has expanded its distribution into canopy openings created by a wildfire in 1994, where it was not previously found (T. Thomas, U.S. Fish and Wildlife Service, pers. obs. 1998; P. Wagner, Washington Department of Transportation, *in litt.* 2000). Seeds were likely carried to the open substrate by wind or gravity, and germination and survival may have been aided by the increase in light and moisture within these canopy gaps where there is reduced competition. The continued suppression of fires in this forest type could bring about additional losses to suitable habitat for the

species (Barrett *et al*. 1985; Gamon 1997; D. Werntz, *in litt*. 2000). Habitat surveys to date have identified some locations within Tumwater Canyon that appear to have the habitat attributes necessary to support *Hackelia venusta* and may be suitable for reintroduction; the carrying capacity of these locations has yet to be determined. Other suitable locations may exist, as only a small proportion of Tumwater Canyon has been surveyed for suitable habitat.

Two nonnative, Washington State-listed noxious weeds (Washington Administrative Code Chapter 16-750 and Revised Code of Washington Chapter 17-10) occur within the habitat of *Hackelia venusta* in Tumwater Canyon. *Linaria dalmatica* (dalmatian toadflax) and *Centaurea diffusa* (diffuse knapweed) are present along the roadside, and the former also occurs above the main portion of the population (F. Caplow, pers. obs. 2004). During visits to the *H. venusta* population in 1995 through 1998, U.S. Fish and Wildlife Service staff noted that the cover and distribution of the noxious weeds had increased over this time period (T. Thomas, pers. obs. 1998). Both of these noxious weeds outcompete many native plant species through uptake of water and nutrients, interference with photosynthesis and respiration of associated species, and production of compounds that may directly affect seed germination and seedling growth and development. Without intervention, these species have the ability to outcompete *H. venusta* and replace native vegetation, and eventually dominate the site (J. Wentworth, King County Noxious Weed Control Board, *in litt*. 2001).

Highway maintenance activities are an ongoing threat to the population of *Hackelia venusta*. The highway is sanded during winter months, and de-icers are also occasionally applied, affecting the immediate roadside habitat where *H. venusta* is found. Since 1998, the Washington Department of Transportation has been using de-icers on the roadway during winter months. The de-icer used by the Department is called CalBan, a formulation of calcium chloride, which is a salt. Solutions of the salts accumulate in the soil and are retained on soil particles. The decline of *H. venusta* along the roadcut and right of way corresponds to an increase in noxious weeds and the Washington Department of Transportation's use of de-icers starting in 1998. De-icers may be associated with the decline of individual plants in the right-of-way and it is now considered a threat to the species. A study of the effect of de-icers used by the Washington Department of Transportation on surrogate species found deleterious effects on survival and

biomass at concentrations above 1:100 (Chalker-Scott and Brickey 2004), although the authors do not believe concentrations this high occur at the *H. venusta* site. The Washington Department of Transportation is aware of the potential threat to *H. venusta*, and has been actively cooperating with the U.S. Fish and Wildlife Service, U.S. Forest Service, and the Washington Department of Natural Resources to plan and manage their maintenance activities so as to minimize impacts on the rare plant species of Tumwater Canyon (Washington Department of Transportation [WDOT] 2000; see Section G, Conservation Measures, for further details).

Although the roadsides have not been sprayed with herbicides in recent years by the Washington Department of Transportation, spraying did occur for a considerable period of time prior to 1980. The residual effect of herbicide spraying on *Hackelia venusta* is unknown. Some herbicides are known to reside in the soil for long periods of time, affecting the plants that persist there. In 1999 and 2000, the application of herbicides by U.S. Forest Service personnel was used as a method for reducing the amount and distribution of nonnative, noxious weeds (L. Malmquist, pers. comm. 2003). Although they were used with great caution by U.S. Forest Service staff with knowledge of *H. venusta*'s presence, the threat from herbicide drift and residue remains.

Small surface erosion events and large landslides on the unstable slope where the *Hackelia venusta* population is located are a continuing threat to the species. The steepness of the slope exceeds 100 percent (45 degree) inclination in many places, and the slope's instability constitutes a significant threat as a major landslide could bury most of the population (Gamon 1997). The last time a large landslide occurred, in 1992, the road was closed for emergency repairs by the Washington Department of Transportation. The repairs undercut the slope and at least 50 *H. venusta* plants were destroyed (R. Harrod, pers. comm. 2001). The population census numbers continued to decrease for several years after the landslide.

The threat of soil being dislodged and the burying, trampling, or dislodging of plants below these soil releases has been witnessed as more people visit the habitat to photograph or collect *Hackelia venusta* (S. Ballinger, Biologist,

in litt. 2000; P. Camp, Bureau of Land Management, *in litt.* 2000; F. Caplow, *in litt.* 2000; J. Frazee, U.S. Forest Service, *in litt*. 2000; K. Robson, Cowlitz and Wahkiakum Conservation Districts, *in litt*. 2001). The potential for slumping (deep-seated mass movement) at the site has increased since 1994, when wildfires burned through the forest in Tumwater Canyon where the species is located. The increased potential for landslides occurs when water uptake by trees and other vegetation that were killed by the 1994 fire is reduced, along with transpiration, so there is more soil water, which increases instability. This is a case where the response to fire may have negative consequences. Another contributing factor is that when tree roots decompose, their ability to bind soil particles and water is decreased. When this happens, the potential for landslides increases. A large landslide in the location of the Tumwater Canyon population of *H. venusta* would severely degrade the habitat and reduce the plant population.

Although there are no data regarding the effects of automobile emissions on *Hackelia venusta* specifically, such emissions should be considered a potential threat, given the proximity of the road to the population. The highway is heavily used, with between 3,900 to 5,200 automobiles traveling daily through Tumwater Canyon, which is very narrow (WDOT 1996). Automobile emissions are likely to increase along this heavily traveled corridor. These emissions, containing ozone and sulphur and nitrate oxides, are known to negatively affect photosynthesis of coniferous and herbaceous plants (Bega 1979), and may increase nitrogen in the soil, thereby increasing the cover and vigor of competing vegetation.

2. Overutilization for commercial, scientific, or educational purposes (Factor B). There is a long history of collection pressure on *Hackelia venusta*. (R. Carr, *in litt.* 2000; L. Malmquist, *in litt*. 2000; J. Brickey, University of Washington, *in litt*. 2001; R. Crawford, Washington Department of Natural Resources, *in litt*. 2001; E. Guerrant, *in litt*. 2001; K. Robson, *in litt*. 2001). *H. venusta* is very showy and has been collected by scientists, amateur wildflower enthusiasts, and other visitors to the population for more than 30 years. The availability of highway turnouts, and a general increase in knowledge and interest in the species are likely to have increased collecting pressure. Collecting activities may have reduced the number of plants in the population and have also degraded the habitat (Gamon 1997; R. Carr, *in litt*. 2000; R. Crawford,

in litt. 2000, 2001; R. Harrod, *in litt*. 2000; G. Hoffman, U.S. Forest Service, *in litt*. 2000; F. Caplow, *in litt*. 2001).

An associated and serious threat is physical disturbance to the habitat and the individual plants from people trampling the slope to collect or see plants, photograph the plants, and monitor the population. Physical disturbance to the substrate increases instability, may damage the root systems of adult plants, and may also cause higher mortality of germinants (F. Caplow, pers. obs. 2003).

3. Disease or predation (Factor C). Disease is not currently known to be a threat to this species. No livestock or wildlife are known to graze on *Hackelia venusta.* However, there is a potential threat from a new biocontrol agent. *Mogulones cruciger* is a weevil that attacks the nonnative hound's-tongue, *Cynoglossum officinale* (gypsyflower), which is also in the borage family. *Cynoglossum officinale* is known from Chelan County. The biocontrol agent has not been formally released in the United States, but has been released in Canada.

A laboratory-based study, using tissue-culture clones of *H. venusta*, found that *M. cruciger* was able to develop and feed to a limited extent on *H. venusta*. However, in both laboratory and field experiments *M. cruciger* demonstrated a strong preference for *Cynoglossum* (J. Andreas, University of Idaho, *in litt.* 2004). The investigator concluded that *M. cruciger* could pose some risks to native species of Boraginaceae and recommended that the weevil not be released in the United States. However, the weevil may spread from Canada and has been identified in the Okanagan Region of British Columbia (S. Reichard, pers. comm. 2003).

4. Inadequacy of existing regulatory mechanisms (Factor D). Although most of the known population of *Hackelia venusta* is located in an area designated as a special management area by the U.S. Forest Service, the species remains vulnerable to threats. The Tumwater Canyon Botanical Area was designated by the Wenatchee National Forest in 1938 because of the occurrence of the plant *Cistanthe tweedyi* (Tweedy's pussypaws). *Cistanthe tweedyi* has since been found to be more widespread than previously known and is no longer a species of concern for the area. The Wenatchee National Forest has maintained

the Botanical Area designation and has implemented special management practices specifically targeted to conserve rare species, such as *H. venusta* and *Silene seelyi* (Seely's catchfly). Both species are listed on the Forest Service Regional Forester's Sensitive Species List (U.S. Department of Agriculture 2004), which requires the Forest Service to maintain or enhance the viability of these species by considering them in their project biological evaluations, and to mitigate actions that may adversely affect the species. The Forest Service also prohibits the collection of native plants without a permit, although this regulation has been difficult to enforce (R. Harrod, pers. comm. 1998). *Silene seelyi* grows in rock outcrop crevices near where *H. venusta* is located and is known to occupy talus habitat, but it does not currently occupy the habitat where *H. venusta* is found.

The Washington Department of Natural Resources designated *Hackelia venusta* as State endangered in 1981 (WNHP 1981), and this designation has been retained in subsequent updates of the State's endangered species list. However, this listing does not provide any regulatory protection for the plant (www.dnr.wa.gov/nhp/refdesk/lists/plant_changes.html).

5. Other natural or manmade factors affecting its continued existence (Factor E). Low seed production is a factor in the decline of *Hackelia venusta*. At the Tumwater Canyon site, an estimated high proportion (60 to 70 percent) of *H. venusta* seeds did not develop in 1984 (Barrett *et al.* 1985). Fruit development was poor on many plants; only a few individuals exhibited mature fruit development. Low fruit production has been observed in other years as well (L. Malmquist, pers. comm. 2002). This low or variable reproductive potential may be a major factor in the small number of plants at the type locality. The age structure of the extant population at Tumwater Canyon, poor seed production and germination of new seedlings, and historical estimates of population size indicate that the population has been in decline (Barrett *et al*. 1985; Gamon 1997), although recent monitoring of the population shows that the population has increased during the period from 1995 to 2004. The increase in population size can likely be attributed to the improved habitat conditions brought on by restoration activities and the effects of a wildfire that burned through Tumwater Canyon in 1994.

The small size of the only known population of *Hackelia venusta* is a major problem for recovery. Seedling establishment is most critical, and trampling may significantly affect the germination of seedlings (R. Carr, pers. comm. 1998, *in litt.* 2000; K. Robson, *in litt.* 2001). The small number of individuals (roughly 600 plants) remaining in the sole population located in Tumwater Canyon makes *H. venusta* vulnerable to extinction due to random events such as slope failure (mass wasting or surface erosion) or drought. A single random environmental event could extirpate a substantial portion or all of the remaining individuals of this species, leading to extinction. Also, changes in gene frequencies within small, isolated populations can lead to a loss of genetic variability and a reduced likelihood of long-term viability (Franklin 1980; Soulé 1980; Lande and Barrowclough 1987; R. Carr, *in litt*. 2000).

G. Conservation Measures

Conservation measures have included development of micropropagation tissue culture techniques for *Hackelia venusta*, experimental outplantings of tissue culture plants, weed pulling and herbicide treatment, habitat restoration, management plans, removal of roadside turnouts, and testing of vulnerability to biocontrol agents.

Beginning in 1992, researchers at the University of Idaho began experimental work in micropropagation tissue culture of *Hackelia venusta*. They successfully developed tissue culture protocols (Edson *et al*. 1996), which have been continued by volunteers and researchers at the Center for Urban Horticulture at the University of Washington. To date, approximately 200 plants have been produced through micropropagation, from approximately 30 original genotypes, though many plants failed in the move from agar to soil (S. Reichard, pers. comm. 2005). Plants that were produced in this way have been used for experimental outplanting (see below), experimental hand-pollination (Harrod 1999; J. Taylor, *in litt.* 2004), and for testing the effects of weevil biocontrols on *H. venusta* (J. Andreas, *in litt*. 2004). Despite the continued experimental tissue culture, the cloned *H. venusta* plants do not appear to survive for extended periods in ex-situ populations.

Three populations were experimentally established in 1995: one in the Icicle Creek canyon and two in Tumwater Canyon. Each population had 136 plants, grown from micropropagation tissue culture from 25 to 30 genotypes. In 2003 the Icicle Creek site had approximately 18 adult plants and numerous germinants, one Tumwater canyon site had no plants (the plants did not survive the planting process), and the other Tumwater Canyon site had 1 adult plant (F. Caplow, pers. obs. 2003). As of 2007 the Icicle Canyon outplanting site is the only one of the three experimental sites where living *Hackelia venusta* plants remain. In a visit in June 2007, six living plants were reported, four flowering and two immature but healthy looking plants (J. Arnett, Botanist, Washington Natural Heritage Program, pers. comm. 2007). The Icicle site is much more open and rocky than the Tumwater outplanting sites; the living plants are all clustered along one edge of the planting area, where the soils are extremely loose and sliding, similar to the unstable soils at the location of the naturally-occurring *H. venusta* site in Tumwater Canyon. Both of the experimental Tumwater sites were higher in organic material and canopy cover than the site of the natural population, and the substrate was more stable than within the natural population. Numbers of germinants have been anecdotally observed to be declining or absent in the experimental populations, although regular monitoring visits were discontinued (L. Malmquist, pers. comm. 2007).

To reduce the threat of nonnative weeds to *Hackelia venusta*, the Wenatchee River Ranger District staff, Wenatchee National Forest, have both removed weeds by hand and carefully applied herbicides to weeds near *H. venusta* habitat. Under an agreement with the Washington Department of Transportation, U.S. Forest Service staff currently hand-pull invasive species along the right-of-way within 0.8 kilometer (0.5 mile) of the known population. This project was implemented in 1999 and 2000, emphasizing treatment to the habitat directly adjacent to the State highway where invasive species tend to become established and then spread into the remainder of the population (R. Harrod, pers. comm. 2001).

Management activities in the Botanical Area have emphasized ecological values (T. Lillybridge, U.S. Forest Service, pers. comm. 1998). In

2000, the U.S. Forest Service developed a habitat restoration plan and implemented restoration activities to improve and restore *Hackelia venusta* and *Silene seelyi* habitat. In 2001 they felled and removed 34 snags that were killed by the 1994 fire within the *H. venusta* population. Felling was done over frozen ground and snow 0.6 meter deep (2 feet) to reduce impacts to the populations. The intent was to reduce soil disturbance hazards, protect the population from wind-throw, and open up the canopy layer (Mueller and Murphy 2000). The combination of the fire and the further opening of the habitat through management has resulted in a more vigorous *H. venusta* population (R. Harrod, pers. comm. 2002). The Botanical Area is also managed as a designated Late-Successional Reserve (LSR) under the Northwest Forest Plan, which permits some silvicultural and fire hazard reduction treatments (U.S. Department of Agriculture and U.S. Department of the Interior 1994).

The *Final Management Plan for Rare Plant Species in Tumwater Canyon, Wenatchee National Forest with Associated Best Management Practices* was developed by the Washington Department of Transportation and provides guidance and best management practices for road crews conducting maintenance activities along the stretch of the highway in Tumwater Canyon that *Hackelia venusta* occupies (WDOT 2000). Funding for maintenance activities is covered through base allocations to keep the highway cleared of snow, debris, and overhanging vegetation. The guidelines outlined in the plan are implemented during the course of routine maintenance operations. The management practices outlined in the plan enable the Washington Department of Transportation crews to accomplish maintenance goals without harming the plant or its habitat. The plan was developed in coordination with the U.S. Forest Service, Washington Department of Natural Resources, and the U.S. Fish and Wildlife Service. Funding for implementation of this plan fluctuates, but it is unlikely these fluctuations will affect current management of the right of way and use of best management practices (C. Belmont, Washington Department of Transportation, pers. comm. 2005).

The Washington Department of Transportation constructed a small asphalt roadside turnout directly below and on the same side of the highway as the *Hackelia venusta* population during the spring of 2000. This turnout was

constructed to provide a safe place for highway crews to park their vehicles in the narrow canyon when conducting road maintenance. However, because this turnout provided easier access to the *H. venusta* population, the U.S. Forest Service coordinated with the Washington Department of Transportation to remove the turnout in order to protect the plant species and its habitat (L. Malmquist, *in litt.* 2001). Removing the turnout also eliminates some of the danger to pedestrians who tended to stop along the roadside to photograph the scenery or collect the plant.

The Washington Natural Heritage Program, in coordination with the Wenatchee National Forest, developed management guidelines for *Hackelia venusta* in 1988 (Gamon 1988b). The plan contains recommendations that specific actions be taken to protect the plant on National Forest land. These guidelines included the recommendation that the Wenatchee National Forest develop a species management guide to provide management direction for the habitat of this species. The Wenatchee National Forest developed a draft management guide several years ago, but it has not been finalized (T. Lillybridge, pers. comm. 1997; T. Thomas, *in litt*. 2005).

H. Biological Constraints and Needs

Hackelia venusta is an extremely narrow endemic, and recovery within the historical range is likely limited to a small area within Tumwater Canyon. Surveys adjacent to the known population and elsewhere in Tumwater Canyon have shown that areas of unoccupied habitat closely resembling the known population are very limited, so reintroduction sites will be limited. The failure of previous experimental outplantings also suggests that habitat constraints are a strong limiting factor. Limiting habitat constraints have not yet been identified, but it is suspected that open areas with limited competition may be essential.

Other factors that influence recovery efforts are the fragility and instability of the substrate and the low rates of seed production and germination. The instability of the substrate means that census, monitoring, seed collection, and

experimental work are all potentially damaging to the population, which complicates and slows the recovery process. The small population size and low seed production limits the seed collection that is possible without affecting the demographics of the population. In addition, the low germination rates and high dormancy of seed means that a percentage of the seed that is collected is unlikely to germinate, increasing the amount of collection needed for seed-banking or other recovery actions.

II. Recovery

A. Recovery Strategy

The first step in the recovery of *Hackelia venusta* is to protect and stabilize the known population. This includes management to maintain an open habitat, noxious weed control, minimizing the damage of collection and trampling within the population, seed collection and long-term seed banking to protect the genetic resources of the species, and the development and implementation of management plans. Many of these actions are currently occurring.

Because a major threat to the species is the small size and limited spatial extent of the one known population, an important component of recovery is increasing the size of the known population, and either finding additional populations or establishing additional populations within the estimated historical range of the species in Tumwater Canyon. The need for multiple populations to avoid extinction of the species through the elimination of a single population in a chance catastrophic event is one of the fundamental tenets of conservation biology (Soulé and Simberloff 1986). Habitat management may be able to encourage population growth within the known population, but some population augmentation may also be necessary. Past surveys in Tumwater Canyon have not been successful in finding other populations of *Hackelia venusta*, so it is likely that the establishment of additional populations will be necessary. Research into the specific habitat needs of *H. venusta*, identification of reintroduction sites, and development of propagation and outplanting protocols must all take place before new populations are likely to be successful. Research on *H. venusta* is complicated by the small size and vulnerability of the population, and the low seed production and germination rates of the species.

Monitoring is also an important aspect of recovery of *Hackelia venusta*, but is complicated by the steep, unstable substrate on which most plants occur. Although critical information is gathered through monitoring, such activities are potentially damaging or even lethal to the plants. Monitoring must therefore

balance the need for information about the population against considerations of the potential damage of intensive monitoring, particularly to germinants.

B. Recovery Plan Goal and Objectives

The goal of this recovery plan is to recover *Hackelia venusta* to the point where it is no longer in danger of extinction and downlisting of the species to threatened status is warranted. The ultimate goal is to recover the population to the extent that it no longer needs protection under the Endangered Species Act. In order to downlist, the recovery plan identifies ways to protect *H. venusta* and enhance its habitat so that there will be less likelihood of extinction through habitat loss and/or demographic or environmental stochasticity. The objective is to stabilize the existing population and reduce the threats to the species sufficient to accomplish increases in population size and geographic distribution across its estimated historical range. If this is achieved, *H. venusta* can be considered for downlisting to threatened under the Endangered Species Act. We have determined that the definition of credible delisting criteria is not possible at this time given the current lack of information about the species' biology and habitat requirements, the magnitude of current threats, and the precarious location and highly unstable environment where *H. venusta* is found. However, recovery actions identified in this document have been developed that would help provide this information. These recovery actions are summarized in Section III, the Implementation Schedule.

C. Recovery Criteria

We set recovery criteria to serve as objective, measurable guidelines to assist us in determining when an endangered species has recovered to the point that it may be downlisted to threatened, or that the protections afforded by the Endangered Species Act are no longer necessary and the species may be delisted. However, the actual change in status (downlisting or delisting) requires a separate rulemaking process based upon an analysis of the same five factors considered in the listing of a species (see Section I-F, Threats/Reasons for Listing). The

recovery criteria presented in this recovery plan thus represent our best assessment of the conditions that would most likely result in a determination that downlisting of *Hackelia venusta* is warranted as the outcome of a formal five-factor analysis in a subsequent regulatory rulemaking. Achieving the prescribed recovery criteria is an indication that the species is no longer threatened or endangered, but this must be confirmed by a thorough analysis of the five listing factors.

Downlisting of *Hackelia venusta* to threatened status may be considered when all of the following conditions have been met to address the threats to the species:

1. **Listing/Recovery Factor A: The present or threatened destruction, modification, or curtailment of its habitat or range.** In order to ensure the long-term recovery needs of *Hackelia venusta*, threats to the species habitat must be reduced or removed. This will have been accomplished if the following have occurred:

    a. Tree and shrub cover in all populations is maintained at a level equal to or more open than that present in 2007 in the original population,[1] through manual removal or controlled burns.

    b. Noxious weed populations are not present within any populations or close enough to them to pose a significant threat of invasion, or are annually removed.

    c. Herbicide and de-icer use continues to be minimized within all populations or close enough to them that individuals may be affected.

    d. All population sites have been evaluated for mass wasting potential and plans developed and implemented to minimize the effects of landslides on *H. venusta* within 3 years of obtaining funding.

[1] The quantitative measure of tree and shrub cover must be determined (Recovery Action 1.7.1).

2. **Listing/Recovery Factor B: Overutilization for commercial, scientific, or educational purposes.** *Hackelia venusta* is vulnerable to overcollecting of seeds or plants, and to habitat damage through substrate disturbance. In order to ensure the long-term recovery needs of *H. venusta*, threats to the species through collecting and visitation must be reduced or removed. This will have been accomplished if the following have occurred:

    a. Seed collection guidelines finalized within three years of publishing this plan.

    b. A guideline of not sharing specific site location information with the public or the press is accepted by the U.S. Forest Service.

    c. The pullout across the highway from the population has been modified or removed to discourage the public from stopping their vehicles and crossing the highway.

    d. The U.S. Forest Service has an entry log in place, and all permitted entries into the population are logged.

    e. All research within the population is approved by the U.S. Fish and Wildlife Service and the U.S. Forest Service after review by the recovery team.

3. **Listing/Recovery Factor C: Disease or predation.** The viability of *Hackelia venusta* could be compromised by the presence of the borage-specific biocontrol weevil, *Mogulones cruciger*. In order to ensure the long-term recovery needs of *H. venusta*, threats to the species through predation by the biocontrol agent must be reduced or removed. This will have been accomplished if the following have occurred:

    a. A monitoring program is in place to inspect *H. venusta* and identified populations of *Cynoglossum officinale* in Chelan County on an annual basis for the presence of the biocontrol agent, *Mogulones cruciger*.

b. A written plan is in place for actions to undertake if the weevil is found and determined to have negative effects on *H. venusta*.

4. **Listing/Recovery Factor D: Inadequacy of existing regulatory mechanisms.** In order to ensure the long-term recovery needs of *Hackelia venusta*, regulatory mechanisms need to be strengthened. This will have been accomplished if the following have occurred:

   a. A habitat management plan has been developed and implemented by the U.S. Forest Service. The management plan will include provisions, as appropriate, for habitat maintenance and restoration, noxious weed control, fire management, recreational activities, and monitoring and research.

   b. A revised management plan has been developed and implemented by the Washington Department of Transportation. The management plan will include provisions, as appropriate, for habitat maintenance and restoration, noxious weed control, and highway maintenance activities.

   c. All *H. venusta* populations on public lands are within management areas where maintenance of the species is a primary management goal.

5. **Listing/Recovery Factor E: Other natural or manmade factors affecting its continued existence.** In order to ensure the long-term recovery needs of *Hackelia venusta*, there must be more populations that are stable and self-sustaining. The genetic resources of the species must also be adequately protected through seed storage, in case of catastrophic events in Tumwater Canyon. This will be accomplished if the following have occurred:

   a. At least **three** stable, self-sustaining populations are present within Tumwater Canyon on protected sites (owned or managed by a government agency or private conservation organization that identifies maintenance of *H. venusta* as the primary management objective for the site), separated by at least 2 kilometers (1.2 miles) or by the Wenatchee River. These could be the result of identification through

further inventory, or through reintroduction or augmentation. If a new population is discovered outside of Tumwater Canyon, it may contribute to meeting this criterion. To be deemed stable and self-sustaining, a population must maintain a 5-year average of at least 1,000 adult plants, must show evidence of positive or neutral population growth over the same 5-year period, and must show evidence of natural reproduction and establishment.

b. Genetic material, in the form of seeds adequately representing the geographic distribution and genetic diversity within the species, is stored in at least one facility approved by the Center for Plant Conservation.

6. Monitoring. In order to ensure the efficacy of recovery actions and allow for adaptive management, as necessary, population and habitat monitoring will have been established for all populations of the taxon at appropriate intervals. Habitat monitoring should include census, monitoring of shrub and tree cover, and inventory of nonnative species. Monitoring must be planned and conducted to minimize the potential negative impacts on the species and its habitat. There must be written agreements to continue monitoring after downlisting.

D. Narrative Outline of Recovery Actions

1. Maintain the current geographic distribution of the species through maintaining habitat integrity.

There is only 1 known native population of *Hackelia venusta,* of about 572 to 772 plants, covering approximately 16 hectares (40 acres). Because there are threats from the presence of the nearby State highway, continuing and increasing coordination between the U.S. Forest Service and the Washington Department of Transportation will be necessary. Planning for the future maintenance of this habitat is essential to facilitate the timely implementation of recovery actions.

1.1 Develop and implement habitat management plans for *Hackelia venusta*.

Because the great majority of the population is located on Federal land (U.S. Forest Service), a detailed management plan would provide a structured document for all potential partners to use as a reference. This document should be reviewed and updated as necessary. The Washington Department of Transportation will also continue to be an important partner in the conservation of *H. venusta* because of the proximity of the single population to the State highway and the potential impact of highway maintenance.

1.1.1 Develop and implement a U.S. Forest Service management plan (Priority 2).

Although the U.S. Forest Service has been active in research and management of *Hackelia venusta*, a written plan would help guide future management. This plan should lay out the future coordination between the U.S. Forest Service and Washington Department of Transportation regarding access and procedural issues.

1.1.2 Revise the Washington Department of Transportation management plan (Priority 1).

The revision should reflect increased coordination between the U.S. Forest Service and the Washington Department of Transportation, including the most current conservation recommendations from the recovery team. Revisions should address the following issues: de-icer applications, landslide response, weed control, alteration or removal of pullouts, and the nature and implementation of best management practices.

1.2 Develop and implement a monitoring plan to assess trends (Priority 2).

Results from past monitoring efforts have not proved sufficient to provide the quality or quantity of information required to detect

population trends and other demographic statistics. A cohesive plan would utilize the best information from past efforts to develop protocols that are effective over the long term. Monitoring must balance the need for information with considerations of potential damage to the population, particularly to germinants.

1.3 Conduct annual weed inventory and control (Priority 1).
Although it must be balanced with potential trampling effects or other habitat disturbance, an annual weed inventory is important to reduce the severity of the threat of displacement via invasive weeds over time. Planned control measures should happen concurrently to minimize the number of entries into *Hackelia venusta* habitat. Occasional selective cutting and removal may be necessary to prevent encroachment of competing trees and other vegetation.

1.4 Monitor and manage for presence of borage biocontrol agent *Mogulones officinale* (Priority 3).
Mogulones officinale has not been identified in the United States as yet and its effects on *Hackelia venusta* specifically are not known. A monitoring program to detect this species would allow time to take action if it is located south of the mouth of the Okanogan River (confluence with Columbia R.) and found to be moving southward toward Tumwater Canyon. It must be determined whether *M. officinale* presents a threat to *H. venusta*, and if so, the appropriate steps to protect the population against this new threat must be identified.

1.5 Promote protection of portions of occurrence on private land.
A small portion of the known population of *Hackelia venusta* is located within private ownership. Protecting this location would be an important link in securing the conservation of the species.

1.5.1 Pursue the highest level of protection agreeable to landowners, including land purchase or designation or purchase of conservation easements (Priority 2).
An unprotected population of *Hackelia venusta*, or a portion of it on private land, is inherently vulnerable and cannot be used to meet the criteria for this recovery plan. Land purchase from willing sellers, conservation easements, or conservation agreements are possible approaches for protecting populations on private land.

1.6 Protect population from overutilization.
Collections of *Hackelia venusta* plants have been documented in the past, indicating steps will need to be taken to prevent this type of activity from occurring. To further protect this species, access for research and monitoring also must be strictly controlled.

1.6.1 Maintain an entry log to the population's existing habitat (Priority 1).
Human impacts on *Hackelia venusta* and its habitat may be potentially severe, whether stemming from collection or trampling by unauthorized visitors or legal research and monitoring activities. Creation of an entry recording system, likely kept at the Wenatchee River Ranger District office, will help control, monitor and document the levels of disturbance occurring at the site, and help reduce the potential impacts on the species by coordinating activities that are necessary on site and minimizing the number of entries needed.

1.6.2 Finalize seed collection guidelines (Priority 1).
Completing this task will provide a protocol for seed collection that will minimize effects to the *Hackelia venusta* population while allowing seed collection to take place. The number of seeds collected and the collection

interval would resemble the most current standards and models used by the National Center for Plant Conservation.

1.6.3 Develop U.S. Forest Service guidelines for sharing information on the known population with the public or press (Priority 3).

To minimize unauthorized access and potential damage to *Hackelia venusta* habitat, a uniform set of guidelines promoting the well-being of the species should be developed to allow appropriate access to information by the public, press, and the academic community.

1.6.4 Develop Washington Department of Transportation policy on minimizing the effects of pullouts near the population (Priority 2).

Removal or alteration of a highway pullout near the population of *Hackelia venusta* would likely reduce the amount of unauthorized collections and resultant habitat damage.

1.7 Conduct research that will guide successful management of existing populations and make possible the establishment and maintenance of new populations.

Because there are many large gaps in knowledge of the life cycle and ecology of *Hackelia venusta,* continued research will be critical.

1.7.1 Characterize terrestrial habitat requirements of the species (microclimate, soil texture, chemistry, moisture, associated species, woody cover, and hydrology) (Priority 1).

Understanding the habitat requirements of the known population is the first step in the identification of possible reintroduction sites, and is also important in the proper management of the known population. Data on tree and

shrub cover at the existing population site must be collected to guide future reintroduction efforts.

1.7.1.1 Analyze existing data (Priority 1).
Monitoring data have been gathered on some of the habitat requirements above, but little analysis has been done. The analysis of the existing data and the identification of further characterization work is an important first step.

1.7.2 Identify breeding system and pollinators (Priority 1).
If it is determined there are insect pollinators, knowing their presence and density may be essential to the viability of the current population and the suitability of potential reintroduction sites.

1.7.3 Characterize and map soils, geology, and mass wasting potential at the known population and any proposed reintroduction sites (Priority 2).
Documenting the physical, chemical and climatic profiles necessary to support this plant may reveal why and how this population has come to be found in only one known location. Knowing the risks of mass wasting associated with the walls of Tumwater Canyon will help manage the current population and guide any future reintroductions.

1.7.4 Assess taxonomic status of historical occurrences if possible (Priority 3).
In order to clarify the historical range of *Hackelia venusta* and appropriately plan reintroductions, it would be helpful to examine the 1948 Merritt specimen to assess its genetic similarity to *Hackelia venusta* and *H. diffusa* var. *arida*.

2. Continue surveys in Tumwater Canyon and other appropriate areas, and identify potential habitat for reintroductions.

Although considerable inventory work has been undertaken for this species, the discovery in the last few years of previously unknown sites, and the highly convoluted terrain of the Wenatchee Mountains, suggests that other populations may yet be discovered.

2.1 Conduct field investigations of potential habitat to evaluate for reintroduction and to search for previously unknown populations (Priority 2).

Field searches may identify new populations or areas for potential reintroductions.

2.2 Create a spatial database for inventory efforts, including negative searches (Priority 3).

In order to complete the inventory effort for the species before moving toward reintroduction, a systematic approach and protocol for information management should be developed.

3. Establish if necessary, additional populations of *Hackelia venusta* within the estimated historical range of the species.

Further field inventory may reveal previously unknown populations which meet the criteria for recovery. If so, reintroduction efforts will not be necessary. However, if no other large populations are found through further inventory work, reintroduction may be necessary to ensure the viability of the taxon into the foreseeable future. A carefully prepared reintroduction plan and propagation and reintroduction research will be necessary before reintroduction is undertaken. Reintroduction may only take place in the Tumwater Canyon watershed, which is the only watershed known to have supported populations of the species, based on historical collections. Based on habitat surveys to date, there appear to be few locations suitable for reintroduction having all habitat attributes necessary to support *H. venusta*.

3.1 Develop a plan for augmentation of the existing population, and reintroducing *Hackelia venusta* into unoccupied areas of

its estimated former range, if intensive surveys have been unable to find additional populations (Priority 3).
Many factors need to be evaluated by the recovery team before reintroduction is undertaken, including: a) the consequences of the reintroduction effort; b) where it will take place; c) who will maintain and manage the populations(s); d) how, from a biological perspective, the effort should be conceived and carried out; and e) whether reintroduction is technically feasible.

3.2 Determine how to quickly establish viable populations, including germination, propagation, and outplanting experiments (Priority 1).
Experiments are necessary to develop efficient, effective techniques for establishing *Hackelia venusta* in the field. Methods for preparing sites, preparing and growing seed, and growing and setting out plants need to be considered and tested.

3.3 Implement the reintroduction plan (Priority 3).
If necessary for the recovery of *Hackelia venusta*, the reintroduction plan should be fully implemented.

4. Collect seed adequately representing the genetic diversity within the species and store in a Center for Plant Conservation approved facility (Priority 1).
The single known population, small number of individuals, and extremely restricted distribution of *Hackelia venusta* make this species highly vulnerable to random environmental and human-caused events. As a hedge against the loss of significant genetic material, seed representing the diversity within the taxon should be collected and stored in at least one Center for Plant Conservation approved facility. The stored seed could also be used in efforts to establish new populations. Periodic testing will be necessary to estimate the rate of viability loss of stored seed. This will help estimate the correct interval and adequate quantity of seed to recollect for storage.

5. **Establish a technical working group to periodically review the status of the species and assess the effectiveness of the management plans and other recovery actions (Priority 2).**
   Annual review of all progress toward recovery and all ongoing research and monitoring is critical for successful implementation of this plan and for modifications to the plan that may be needed in future.

6. **Determine the suitability for establishing appropriate delisting criteria (Priority 3).**
   As more information becomes available over time, the conditions necessary for delisting *Hackelia venusta* should become apparent.

III. Implementation Schedule

The Implementation Schedule that follows outlines the actions and estimated costs for the recovery program for *Hackelia venusta*, as set forth in this recovery plan. It is a guide for accomplishing the objectives and actions suggested in this plan. The Implementation Schedule includes the following elements:

1) Priority. The actions identified in the Implementation Schedule are those that, in our opinion, should bring about the recovery of this species. The actions, however, are subject to modification as dictated by new findings, changes in the species' status, and the completion of other recovery actions. The priority for each action is assigned as follows:

> ***Priority 1*** An action that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future.
>
> ***Priority 2*** An action that must be taken to prevent a significant decline in the species' population/habitat quality or some other significant negative impact short of extinction.
>
> ***Priority 3*** All other actions deemed necessary to meet the recovery objectives.

2) Action Number and Description. The action number and description are extracted from the recovery action narrative found in Part II of this plan.

3) Action Duration. The action duration column indicates the number of years estimated to complete the action if it is a discrete action, or if it is a continuous or ongoing action. Actions are defined as follows:

Continuous	Action will be implemented on an annual basis once it is begun.
Ongoing	Action is currently being implemented and will continue until no longer necessary for recovery.
Intermittent	Action will be implemented on an "as needed" basis.
TBD	To Be Determined; costs are not possible to estimate at this time.

4) Responsible Parties. Only Federal agencies are mandated to take part in recovery efforts. However, the recovery of *Hackelia venusta* may require the involvement of the full range of Federal, State, and private interests. The expertise and contributions of additional agencies and interested parties has been and will continue to be needed to implement certain recovery actions and to accomplish the objectives of this plan. The "responsible parties" identified in the Implementation Schedule are those agencies, non-governmental organizations, or interested individuals, such as private landowners, that may voluntarily participate in any aspect of recovery actions listed. We have listed the agencies and other parties that we believe are the primary stakeholders in the recovery process, and have the authority, responsibility, or expressed interest to implement a specific recovery action. However, the list of possible stakeholders is not limited to those below; other stakeholders are invited to participate. The listing of a party in the Implementation Schedule does not require, nor imply a requirement, that the identified party has agreed to implement the action(s) or to secure funding for implementing the action(s). However, parties willing to participate may benefit by being able to show in their own budgets that their funding request is for a recovery action identified in an approved recovery plan and is therefore considered a necessary action for the overall coordinated effort to recover *H. venusta*. Also, section 7(a)(1) of the Endangered Species Act directs all Federal agencies to utilize their authorities in furtherance of the purposes of the Act by carrying out programs for the conservation of threatened and endangered species.

When more than one responsible party is listed, the proposed lead agency (based on authorities, mandates, and capabilities) has been identified with an

asterisk (*). The following abbreviations are used to indicate the responsible party for each recovery action:

BBG	Berry Botanic Garden, Portland, Oregon
FWS	U.S. Fish and Wildlife Service
USFS	U.S. Forest Service
University	May be any interested academic or research institution
WDNR	Washington Department of Natural Resources
WDOT	Washington Department of Transportation

5) Cost Estimates. Cost estimates are shown for each recovery action, both for the first 5 years after release of the recovery plan and for the total estimated cost of recovery over a period of 20 years (2008 through 2027). Total costs for continuous and ongoing actions are based on estimated time to downlisting. The inclusion of estimated costs in this recovery plan does not commit any agency or party to an expenditure of funds. Therefore, initiation and completion of these actions is subject to the availability of funds, as well as other constraints affecting the stakeholders involved.

Implementation Schedule for the *Hackelia venusta* Recovery Plan

Recovery Action Priority	Recovery Action Number	Recovery Action Description	Action Period (years)	Resp. Parties (* = lead)	Cost Estimate (in $1,000 units)						Comments
					Total Costs	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	
1	1.1.2	Revise WDOT management plan	Ongoing	WDOT	6	2	2	2	-	-	
1	1.3	Conduct annual weed inventory and control	Ongoing	USFS	28	4	3	3	2	1	Cost reflects less control required over time. Through 2027 at $1,000/year.
1	1.6.1	Maintain entry log	Ongoing	USFS							Minimal associated costs.
1	1.6.2	Finalize seed collection guidelines	1	FWS, WDNR,* USFS, University	1	1	-	-	-	-	
1	1.7.1.1	Analyze existing habitat data collected by USFS	1	USFS	5	5	-	-	-	-	
1	1.7.2	Identify breeding system and pollinators	2	FWS, WDNR,* USFS, University	8	4	4		-	-	
1	3.2	Determine how to most quickly establish viable populations	4	FWS, WDNR, USFS, University*	35	15	10	5	5	-	Initial figure represents start-up costs. Less short-term, more ongoing projects over time. Through 2011.
1	4	Collect seed representing genetic diversity within the species and store in approved facility	Intermittent	FWS, WDNR*, BBG, USFS, University	14	-	2	-	-	2	Cost assumes seed collection occurs only in highly productive years. Figure estimated at $2,000 per 3-year interval, through 2027.
2	1.1.1	Develop and implement USFS management plan	Ongoing	FWS, USFS*, WDNR	33	4	5	4	3	2	Cost assumes some level of habitat management; $1,000 per year after 2012.

Implementation Schedule for the *Hackelia venusta* Recovery Plan

Recovery Action Priority	Recovery Action Number	Recovery Action Description	Action Period (years)	Resp. Parties (* = lead)	Cost Estimate (in $1,000 units)						Comments
					Total Costs	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	
2	1.2	Develop and implement a trend monitoring plan	Ongoing	FWS, USFS, WDNR*	12	3	2	1	-	1	Cost assumes $1,000 per 3-year interval after 2012.
2	1.5.1	Pursue highest level of protection agreeable to landowners for private portion	Ongoing/ TBD	FWS*, USFS	-	-	-	-	-	-	No estimate is available for land purchase or cost of conservation easement.
2	1.6.4	Develop WDOT policy on minimizing effects of highway pullouts	2	WDOT	2	1	1	-	-	-	
2	1.7.1	Characterize and write up habitat requirements for *H. venusta*	2	WDNR,* University	8	2	2	2	2	-	
2	1.7.3	Conduct research into soils, geology, and mass wasting potential	3	FWS, WDNR,* USFS, University	15	6	6	3	-	-	
2	2.1	Conduct field investigations for reintroduction sites and new populations	5	FWS, WDNR, USFS, University	22	6	6	4	4	2	Decrease in cost reflects reduced effort over time, ending in year 2012.
2	5	Establish a technical working group to review status, assess effectiveness of management plans	Intermittent	FWS, WDNR, USFS, University	30	3	-	3	-	3	Continues through 2027.

Implementation Schedule for the *Hackelia venusta* Recovery Plan

Recovery Action Priority	Recovery Action Number	Recovery Action Description	Action Period (years)	Resp. Parties (* = lead)	Cost Estimate (in $1,000 units)						Comments
					Total Costs	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	
3	1.4	Monitor and manage for presence of borage biocontrol agent	Intermittent	FWS, WDNR,* USFS, University	9	-	-	-	-	3	Three inspections during life of the plan, with actions prioritized should the agent be identified near the population.
3	1.6.3	Develop USFS guidelines for sharing information with the public and press	2	USFS	2	1	1	-	-	-	
3	1.7.4	Assess taxonomic status of historical occurrences if possible	1	University	2.5	2.5					
3	2.2	Create spatial database for inventory efforts, including negative searches	Ongoing	USFS, WDNR*	6	3	2	1	-	-	Cost assumes reduced survey data collection over time.
3	3.1	Develop a plan for reintroduction of *H. venusta* into areas not occupied currently; explore augmenting the existing population	3	FWS, WDNR,* USFS, University	16	6	6	4	-	-	Reintroduction of *H. venusta* will occur only after intensive surveys have been unable to locate additional populations.
3	3.3	Implement reintroduction plan. May include augmentation of existing population	Intermittent	FWS, WDNR, USFS, University	40	-	-	10	10	5	Implement as determined by research (Action 3.2) as necessary. Reintroductions will require monitoring. Assumes $3,000 per 3-year interval after year 2012.
TOTALS					$292	$66	$52	$42	$26	$19	$87,000 for years 2013 to 2027

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V. Appendices

APPENDIX A. SUMMARY OF THREATS FOR HACKELIA VENUSTA *AND RECOMMENDED RECOVERY ACTIONS.*

Recovery criteria addressed by the recommended actions are also identified.

Listing Factor[1]	Threat to the Species	Recovery Criteria[2]	Recovery Action(s)
A	Competition for resources by other species due to plant succession/fire exclusion	1,3,4,5,6	Develop/revise management plans (Actions 1.1.1, 1.1.2, 1.2), Conduct noxious weed inventory and control (Action 1.3), Characterize and write up habitat requirements (Action 1.7.1), Establish technical working group to review plan effectiveness (Action 5)
A	Invasion of noxious weeds	1,3,4,6	Conduct noxious weed inventory and control (Action 1.3), Monitor and manage for presence of borage biocontrol agent (Action 1.4) Develop/revise management plans (Actions 1.1.1, 1.1.2, 1.2), Create spatial database (Action 2.2), Establish technical working group to review plan effectiveness (Action 5)
A	WDOT use of de-icers during winter months	1,4,5,6	Revise WDOT management plan (Action 1.1.2) Develop/implement a trend monitoring program (Action 1.2)
A	Landslides and surface erosion events	1,4,5,6	Develop/revise management plans (Actions 1.1.1, 1.1.2, 1.2), Conduct research into soils, geology, and mass wasting (Action 1.7.3) Conduct field investigations for reintroduction sites (Action 2.1)
B	Unregulated and illegal collections and associated habitat disturbance	2,3,4,5,6	Develop/revise management plans (Actions 1.1.1, 1.1.2, 1.2), Control access to known population (Actions 1.6.1, 1.6.2, 1.6.3, 1.6.4), Develop/implement reintroduction plan, including possible augmentation (Actions 3.1, 3.2), Characterize and write up habitat requirements (Action 1.7.1), Enforce ESA section 9 prohibitions

APPENDIX A (*CONTINUED*). SUMMARY OF THREATS IDENTIFIED FOR* HACKELIA VENUSTA *AND RECOMMENDED RECOVERY ACTIONS.

Recovery criteria addressed by the recommended actions are also identified.

Listing Factor[1]	Threat to the Species	Recovery Criteria[2]	Recovery Action(s)
C	Potential invasion of biocontrol agent *Mogulones cruciger*	1,3,5,6	Conduct noxious weed inventory and control (Action 1.3), Monitor and manage for presence of borage biocontrol agent (Action 1.4) Develop/revise management plans (Actions 1.1.1, 1.1.2, 1.2), Create spatial database (Action 2.2), Establish technical working group to review plan effectiveness (Action 5)
D	Some Federal, but not State, management and/or regulatory protection	4,5	Develop/revise management plans (Actions 1.1.1, 1.1.2, 1.2), Establish technical working group to review plan effectiveness (Action 5), Enforce ESA section 9 prohibitions
E	Low fruit and seed production	1,2,4,5,6	Conduct research (Actions 1.7.1, 1.7.2, 1.7.4, 3.2) Analyze, write up data and seed collection guidelines (Actions 1.6.2, 1.7.1, 1.7.1.1, 1.7.2, 3.2, 5), Develop/revise management plans (Actions 1.1.1, 1.1.2, 1.2) Establish technical working group to review effectiveness (Action 5)
E	Small population size	1,2,3,4,5,6	All recovery actions address or are influenced by small population size (See Implementation schedule, page 39); Collect and store seed adequately representing the genetic diversity of the species, is a hedge against further reductions in population size (Action 4)

[1] See Listing Factors, page 13

[2] See Recovery Criteria, page 26

*APPENDIX B. RECOVERY PRIORITY NUMBER GUIDELINES**

Degree of Threat	Recovery Potential	Taxonomy	Conflict?†	Priority
High	High	Monotypic Genus	Yes	1C
			No	1
		Species	Yes	2C
			No	2
		Subspecies	Yes	3C
			No	3
	Low	Monotypic Genus	Yes	4C
			No	4
		Species	Yes	5C
			No	5
		Subspecies	Yes	6C
			No	6
Moderate	High	Monotypic Genus	Yes	7C
			No	7
		Species	Yes	8C
			No	8
		Subspecies	Yes	9C
			No	9
	Low	Monotypic Genus	Yes	10C
			No	10
		Species	Yes	11C
			No	11
		Subspecies	Yes	12C
			No	12
Low	High	Monotypic Genus	Yes	13C
			No	13
		Species	Yes	14C
			No	14
		Subspecies	Yes	15C
			No	15
	Low	Monotypic Genus	Yes	16C
			No	16
		Species	Yes	17C
			No	17
		Subspecies	Yes	18C
			No	18

* Adapted from Listing and Recovery Priority Guidelines Federal Register 48:4309-43105.
† Priority is given to those species that are, or may be, in conflict with construction or other development projects or other forms of economic activity, designated by a "C" in the priority ranking system.

APPENDIX C. GLOSSARY OF TECHNICAL TERMS

anthesis	the time and process of flowering; the period during which the flower is fully open and functional
autogamous selfing	self-fertilization when pollination occurs within a plant's own flower prior to opening
borage, Boraginaceae	a plant of the family Boraginaceae, which includes plants such as forget-me-nots and hound's tongue; the family is characterized by herbs or woody plants with bisexual flowers, usually regular and with five sepals, five petals forming a tube or funnel, five stamens and a superior ovary
congener	a member of the same genus
corolla	the collective name for all of the petals of a flower
emarginate	having a notched tip
fornices	a set of small crests or scales in the throat of the corolla; a common flower characteristic in the family Boraginaceae
geitonogamous selfing	self-fertilization by dispersal of pollen between different flowers on the same plant. Geitonogamy may be due to self-pollination between flowers on the same branch, different flowering branches of the same plant, or different ramets of the same clonal genet
germinant	a young plant that has only recently sprouted
inflorescence	the flowering part of a plant; a flower cluster; the arrangement of flowers on the flowering axis of the plant
isozyme	one of several forms of an enzyme (a protein that catalyzes a biochemical reaction) found in an individual or population, each coded by a different allele of a gene; isozymes are often used as a measure of genetic variability or for taxonomic purposes
morphology	the shape, general appearance, or form of an organism

nutlet	one of the lobes or sections of the mature ovary of some members of the Boraginaceae, Verbeneaceae, and Laminaceae
outcrossing	fertilization occurring between two different plants
papillate	having papillae — short, rounded bumps or projections
phenology	seasonality or timing of recurrent natural phenomena
phenotype	the observable structural and functional properties of an organism
phenetic species concept	a method of classification based on the criteria of overall morphological, anatomical, physiological or biochemical similarity or difference, with all characters equally weighted and without regard to phylogenetic history
radical leaf	a leaf arising from or near the roots
tetraploid	with four representatives of each type of chromosome, or four complete sets of chromosomes in each cell (for comparison, most animals, including humans, are diploid, have two complete sets of chromosomes in each cell)
truncate	appearing to terminate abruptly at the tip, as a leaf

APPENDIX D. SUMMARY OF AGENCY COMMENTS ON DRAFT RECOVERY PLAN AND SERVICE RESPONSES

On March 13, 2006, we released the Draft Recovery Plan for *Hackelia venusta* for a 60-day comment period. The notice of availability, published in the Federal Register (USFWS 2006), solicited written comments on the draft plan. This comment period ended on May 12, 2006. Peer review of the draft recovery plan was provided by our Washington D.C. office, U.S. Forest Service, Washington Department of Natural Resources, and the University of Washington Center for Urban Horticulture.

This section provides a summary of general information about the comments we received. All comment letters are kept on file in the Central Washington Field Office of the U.S. Fish and Wildlife Service, 215 Melody Lane, Suite 119, Wenatchee, Washington 98801.

A total of four responses were received, one each from the U.S. Forest Service, the Washington State Department of Natural Resources Natural Heritage Program, the University of Washington, and the Washington State Department of Transportation (WSDOT). The majority of the comments pointed out minor corrections or suggested topics in need of further explanation or clarification. These have been incorporated into the final plan, where appropriate. Significant comments regarding the substance of the plan are summarized below, along with our responses to those comments. We thank those who took the time to read the draft recovery plan and provide us with their suggestions for improvement.

Summary of Comments and our Responses

Comment: I think that it is important to make a clear distinction between the distribution of the species when Gentry and Carr studied it in the late 1960s and its probable distribution at earlier times. The latter by necessity can only be estimated, but restricting reintroduction and/or augmentation efforts to Tumwater Canyon may in the long run un-necessarily restrict recovery. It seems very likely to me that historically the species was more widely distributed. As you noted in the [draft] Plan, by the time of Gentry and Carr fire suppression had already been well established for many years, and forested vegetation had likely encroached into suitable *H. venusta* habitat. Going farther back in time, the distribution of this species has almost certainly changed, perhaps considerably, shifting up and down in elevation in response to climatic fluctuations.

Response: Although it is reasonable to assume, there is currently a lack of substantial information to suggest historical populations of *H. venusta* existed in areas outside of Tumwater Canyon, where the species is extant. The final recovery plan does not preclude the establishment of populations outside the known historic range of the species or their potential contribution to future recovery. However, unless documentation to support the existence of current or historic populations outside of Tumwater Canyon is discovered, regulatory protection under the Endangered Species Act will likely not be afforded those “introduced” populations in other watersheds.

Comment: Pertaining to this question [previous comment, above], one reference to historic range needs to be clarified. On page 5 in the [draft] Plan you refer to the 1948 collection from Merritt, Washington and cite Gamon (1997) as the source of a determination that this collection was more similar to *H. diffusa* var. *arida*. However, Gamon (1997) actually refers on pages 2 and 8 to these plants as an apparently extirpated population of *H. venusta*. He makes no mention of the plants being more similar to *H. diffusa* var. *arida*. The 1948 Merritt specimen in question is housed at the herbarium at the University of Washington. It should be examined and its identity determined, if possible. Until there has been a review of the specimen from Merritt, this record also supports the likelihood that the historic range of *Hackelia venusta* extended beyond Tumwater Canyon.

Response: This comment is appropriate to the substance of the recovery plan, therefore, the final recovery plan has been clarified with respect to Gamon (1997) to reflect the unknown taxonomic status of the Merritt specimen. If funding becomes available in the future, it is likely an attempt will be made to identify the true taxonomic status of the Merritt specimen, and thus adjust the historic range of the species accordingly. This task has been added to the Implementation Schedule as Recovery Action 1.7.4.

Comment: Recent discussions of the blue-flowering *Hackelia* that grows at high elevation are consistent in treating these plants as taxonomically distinct from *Hackelia venusta*, and the USFWS listing in 2002 specifically excluded these plants from the listing of *Hackelia venusta* as endangered. However, because these high elevation plants have not yet been formally described, their taxonomic rank (whether species, subspecies, or variety) has not yet been established. This should be explicit in the Plan.

Response: This comment is important to clarification of the state of taxonomy within *Hackelia*. The final recovery plan has been edited to better reflect the undescribed nature of the high elevation blue-flowered plants, and current research underway to determine their taxonomic ranking.

Comment: Page 13 [of the draft recovery plan]. I would add the effect of potential climate change.

Response: While it is probable that climate change could have an effect on *H. venusta* or its habitat, it is beyond the scope of recovery planning to speculate until more is known about the specific effects of climate change on Tumwater Canyon. As more is learned about the exact habitat parameters required for this species to thrive, more may be predicted regarding potential effects to the species itself driven by global climate change.

Comment: The Draft Recovery Plan states: [*The recent development of highway turnouts, and a general increase in knowledge and interest in the species are likely to have increased collecting pressure*]. However, there has been no recent development of highway turnouts in the area.

Response: The phrase "recent development" may have been unclear in the Draft Recovery Plan. The final recovery plan has been clarified to read "The *availability* of turnouts..." Although turnout opportunity has been reduced in the area of the *H. venusta* population, it still exists near enough to allow access by potential collectors.

Comment: The Draft Recovery Plan states: [*Develop Washington Department of Transportation policy on minimizing the effects of pullouts, habitat maintenance and restoration, noxious weed control, highway maintenance activities, de-icer applications, and best management practices near the population*]. However, the Draft Recovery Plan is unclear what the current recommendations are that the plan is referencing and where the current management [WSDOT] plan is deficient.

Response: These issues are part of the *Narrative Outline of Recovery Actions* section of the draft and final recovery plan. The intention of these actions (1.1.2 and 1.6.4) is to work closely with the WSDOT in future planning to further reduce actual and potential threats to the species caused by activities associated with maintaining the state highway. We do not consider the management plan developed by WSDOT for Tumwater Canyon to be deficient; the term is not found in either the draft or final document. The listed recovery actions are benchmarks by which recovery will be measured. Some of these benchmarks may have already been met, because current practices can or will not be improved upon. Others may require new tactics or techniques, incorporating new information. The next revision of the WSDOT management plan for Tumwater Canyon is expected to reflect increased coordination between the affected agencies and their best ideas regarding how to respond to current threats.

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