Shelly 1996

TECHNICAL DRAFT

HOWELLIA AQUATILIS
(Water Howellia)

RECOVERY PLAN

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Literature citations of this plan should read as follows:

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EXECUTIVE SUMMARY

Current Status: *Howellia aquatilis* (Water Howellia) was Federally listed as a Threatened species on July 14, 1994, (U.S. Fish and Wildlife Service 1994) and is extant in Idaho, Montana, and Washington. It is currently known from a total of five geographic areas: one in Idaho (Latah County); three in Washington (one each in Spokane, Clark and Pierce counties); and one in Montana (Lake and Missoula counties). Four of these five geographic areas include significant federal ownership.

In addition, *Howellia aquatilis* was historically known from one location in California (Mendocino County), four locations in northwestern Oregon (Clackamas, Marion and Multnomah counties), two additional locations in Washington (Mason and Thurston counties), and one location in northern Idaho (Kootenai County) (Shelly and Moseley 1988).

Approximately two-thirds of the known occurrences (101/153) are located in the Swan River valley in northwestern Montana. There is a single known occurrence in northern Idaho and 51 occurrences in Washington. Recent intensive searches in California and Oregon have failed to relocate any extant occurrences; *H. aquatilis* is thus thought to be extirpated from those states.

Habitat Requirements and Limiting Factors: *Howellia aquatilis* is globally rare (occupying less than 200 acres of habitat rangewide), has extremely narrow ecological adaptations, and electrophoretic tests indicate that it lacks detectable genetic variation within and among occurrences. For these reasons, it is particularly vulnerable to habitat alteration and loss (Gamon 1992, Shelly and Moseley 1988).

Howellia aquatilis is an aquatic plant restricted to small, vernal, freshwater wetlands that have an annual cycle of filling up with water over the fall, winter and early spring, followed by drying during the summer months. These wetland habitats are generally small (< 1 ha) and shallow (< 1m deep). Furthermore, *Howellia aquatilis* generally occupies only a fraction of the basin of each wetland. The wetlands typically occur in a matrix of forest vegetation, and are usually bordered in part by broadleaf deciduous trees. The bottom surfaces of the wetlands usually consist of firm, consolidated clay and organic sediments. Fall drying of the wetlands is required for seed germination, while spring submergence is required for the growth and subsequent flowering.

Recovery Objective: The objective of this recovery plan is to provide an adequate level of protection for the species and its habitat so that there will be self-sustaining populations distributed throughout its extant range.

Recovery Criteria: Delisting will be considered when monitoring demonstrates that management practices, in accordance with habitat management plans, have been effective in maintaining the species and its habitat throughout its currently known range on federally managed lands, i.e., in each of the four geographic areas with federal ownership, for a minimum of ten years, assuming that the management plans will continue to be in place if delisting occurs. The only geographic area not included within this criterion is Latah County, Idaho; this site does not include any federal land ownership.

Actions Needed:

1. Maintain extant geographic range and habitat integrity through development and implementation of management plans, promotion of special management designations for public lands, and voluntary protection on private lands.

2. Conduct the research and monitoring that is necessary to answer critical questions about the habitat requirements and species biology of *Howellia aquatilis* in order to design sound management and monitoring plans.

3. Identify potential *Howellia aquatilis* habitat and conduct surveys for it during appropriate years.

4. Disseminate information about the species to appropriate audiences, including landowners.

5. Evaluate the appropriateness and feasibility of reintroducing *Howellia aquatilis* into portions of its historic range, in consultation with all appropriate parties, and after intensive surveys have confirmed extirpation.

6. Promote state-level legal protection for all non-federal occurrences.

Costs (000's):

Years	Need 1	Need 2	Need 3	Need 4	Need 5	Need 6
1996-2005	$24	$455	$40	$5	$50-100	$0

Total Cost of Recovery: $574-624K

Date of Recovery: If needed recovery actions are implemented and recovery criteria have been met, the species could be delisted by the year 2006.

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I. INTRODUCTION

A. Listing History

Action by the federal government to protect *Howellia aquatilis* was initiated on December 15, 1980, when the species was designated as a Category 2 candidate for listing (U.S. Fish and Wildlife Service 1980). In 1990, the species' status was changed to Category 1 (U.S. Fish and Wildlife Service 1990). The U.S. Fish and Wildlife Service received a petition to list the species as endangered in October, 1991. The Service subsequently published a listing proposal in April, 1993 (U.S. Fish and Wildlife Service 1993) and a final rule listing the species as threatened in July, 1994 (U.S. Fish and Wildlife Service 1994).

B. Description

Howellia aquatilis A. Gray (Water Howellia) is an annual aquatic species in the Campanulaceae (bellflower family). An illustration is provided in Figure 1. Individuals are mostly submerged and rooted in the bottom sediments of the vernal freshwater wetlands to which the species is adapted. Individual plants sometimes persist in the outer edges of these wetlands, but generally they disappear as the habitat dries at the end of the summer. The stems branch several inches from the base and each branch then extends to the surface of the water. The numerous leaves are an inch or two long and very narrow. *Howellia aquatilis* produces both cleistogamous and chasmogamous flowers. The small, cleistogamous flowers, which lack a conspicuous corolla (floral tube), develop along the stem beneath the water surface. As the growing branches reach the surface, more conspicuous chasmogamous flowers develop above the water. These emergent flowers are white, have five lobes on one side of the corolla, and are about 1/4 inch across. Both cleistogamous and chasmogamous flowers give rise to thin-walled fruits that are ultimately an inch or more long, and which contain one to five large, shiny brown seeds that are about 1/4 inch long.

Described in technical terms, *H. aquatilis* is a flaccid, annual, aquatic herb, mostly submergent, often with shortly emergent branches; plants are naked below, branched above; the entire plant is glabrous, green, and about 10-60 cm tall, occasionally taller; leaves are numerous, alternate, or some of them subopposite or whorled in threes, linear or linear-filiform, entire or nearly so, 1-5 cm long, and up to 1.5 mm wide; flowers are white, mostly 3-10, axillary, often scattered, pedicellate or subsessile, both petaliferous (when emergent) or much reduced and inconspicuous (when submerged), the fully-developed, emergent corollas about 2-2.7 mm long, irregular, with the tubes deeply cleft dorsally, and five-lobed; filaments and anthers are connate,

two of the anthers are shorter than the others; calyx lobes are 1.5-7 mm long; pedicels are stout, 1-4 mm long, merging gradually with the base of the capsule; ovary is unilocular, with parietal placentation; stigma is 2-lobed; fruit is 5-13 mm long, 1-2 mm thick, irregularly dehiscent by the rupture of the very thin lateral walls; seeds are large, 2-4 mm long, 5 or fewer, and shiny brown (adapted from Hitchcock et al. 1959; Dorn 1984).

Although other members of the Campanulaceae can occur in similar habitats (e.g. *Downingia* spp.), none are likely to be confused with the monotypic *Howellia aquatilis*. In California, *Legenere limosa* (Campanulaceae) occurs in wet areas and vernal pools within the same geographic region from which *Howellia aquatilis* was historically collected. However, the pattern of branching of *L. limosa* is different from that of *Howellia aquatilis* and its leaves are not as long, nor as linear, as those of *H. aquatilis*.

An unrelated species that is vegetatively similar to *H. aquatilis*, and that is frequently found growing with it, is *Callitriche heterophylla* (Callitrichaceae). However, the submergent linear leaves of the latter species are most often opposite (only rarely whorled), and the floating leaves are broadly obovate. In addition, the flowers of *C. heterophylla* are axillary, very inconspicuous, and do not have a corolla.

C. Distribution - Collection History

Howellia aquatilis was first collected in May, 1879, by two Oregon botanists, Thomas and Joseph Howell. The initial discovery was made in a slough on Sauvies Island along the Columbia River near Portland, Oregon. The first specimens included only submerged cleistogamous flowers. The collectors returned to a nearby area in August of that year and collected specimens bearing emergent chasmogamous flowers. These specimens were determined to represent a new genus and species by Asa Gray, and it was described in the same year (Gray 1879).

Subsequent collections were made in Oregon during the period 1881-1928 (Oregon Natural Heritage Data Base); Idaho (1892, 1988) (Shelly and Moseley 1988); California in 1928 (Smith and Berg 1988); Washington (1937-1993) (Washington Natural Heritage Program); and Montana (1978).

Howellia aquatilis is currently known from five distinct geographic areas: one in Idaho (Latah County); three in Washington (one each in Spokane, Clark and Pierce counties); and one in Montana (Lake and Missoula counties). In addition, it was historically known from one location in California (Mendocino County), four locations in northwestern Oregon (Clackamas, Marion and Multnomah counties), two additional locations in Washington (Mason and Thurston counties), and one location in northern Idaho (Kootenai County) (Shelly and Moseley 1988). The overall extant range is indicated in Figure 2.

The five geographic areas identified above contain a total of 153 individual wetlands, many of which are aggregated into wetland complexes, that harbor *Howellia aquatilis.* Throughout the remainder of this document, the term "occurrence" is used to refer to the individual wetlands that harbor *Howellia aquatilis*.

However, the occurrences within three of the five geographic areas may represent metapopulations in that they are clustered in discrete areas within the landscape: Spokane County, Washington (45 occurrences), Pierce County, Washington (5 occurrences), and Lake and Missoula counties, Montana (101 occurrences). Murphy et al. (1990) define a metapopulation as "... a collection of interdependent populations affected by recurrent extinctions and linked by recolonizations." See Section 1.F. ("Reasons for Listing") for additional information on the importance of metapopulation dynamics and maintenance for *Howellia aquatilis*.

The other two geographic areas (Latah County, Idaho and Clark County, Washington) consists of only one occurrence each; these isolated occurrences may represent recent colonization events, or they may be remnants of former metapopulations.

In Oregon and California, the historically documented occurrences have not been relocated, despite intensive field surveys; thus, the species is thought to be extirpated from these states.

A more detailed account of the collection history and current distribution within each state is provided below. The information was obtained from files, primarily Element Occurrence Record databases, maintained by the respective state Natural Heritage Programs and Conservation Data Centers.

California

The species has only been collected once from the state of California. In 1928, it was collected by Alice Eastwood from near Howard Lake, Mendocino County (Jokerst 1980). Extensive efforts in 1980 failed to relocate the species at this site. Other nearby sites were also unsuccessfully searched during 1980.

Oregon

There are no known extant occurrences in Oregon. However, the species has been collected from at least four different places in the state. As noted above, it was first collected in 1879 from Sauvies Island, Multnomah County. It was collected from Sauvies Island again in 1886, but not since then. It was collected from two places in the Salem area, most recently in 1977. It was also collected from Clackamas County in 1892. Numerous attempts to relocate these sites have all been unsuccessful.

Idaho

The first collection of *Howellia aquatilis* from Idaho was apparently by Sandberg in 1892 from the vicinity of Spirit Lake, Kootenai County. Subsequent attempts to find this population have been unsuccessful; the location information provided by Sandberg was quite imprecise. The only other known Idaho site for the species was discovered *circa* 1968 in Latah County. It is still considered to be extant (Bursik 1995). Extensive searches during the last several years, particularly 1994, have resulted in no new populations being located in Idaho.

Montana

There are 101 occurrences, comprising 66% of the rangewide total, currently known in Montana, all within the Swan River drainage. The occurrences are located in Lake and Missoula counties and are concentrated in three general locales. The Swan River valley distribution of *Howellia aquatilis* is shown on the map in Figure 3.

The first collection in Montana was made by Bruce McCune in 1978 (McCune 1982), when it was found in the Swan River valley in Missoula County. Further surveys in the Swan River drainage (1983-1986), primarily by John Pierce and Peter Lesica, located 15 additional occurrences in three areas within the drainage. In 1987, the Montana Natural Heritage Program (MTNHP) initiated a status survey under sponsorship of the U.S. Fish and Wildlife Service, conducted by Steve Shelly, with assistance from Lisa Campbell, Peter Lesica, and Anne Morley. Additional surveys, sponsored by the Flathead National Forest, were conducted from 1988-1990 by Steve Shelly, Lisa Schassberger, Peter Lesica, and Anne Morley. In 1995, which was an exceptional year for the species owing to optimal seed germination conditions in the fall of 1994, 43 new occurrences were found in the Swan River drainage during surveys conducted by the Flathead National Forest and The Nature Conservancy.

Washington

There are 51 known extant occurrences in Washington, comprising 33% of the rangewide total. The distribution of *Howellia aquatilis* in eastern Washington is detailed in Figure 4. The county distribution of these occurrences is as follows:

Clark County	1
Pierce County	5
Spokane County	45

Howellia aquatilis is known from both the lowlands west of the Cascade Mountains and the forested portions of the channelled scablands of eastern Washington. It was collected first on the west side of the Cascades on June 20, 1937 by John Rudd from a roadside pond in or near Millersylvania State

Park in Thurston County. On August 15, 1937, W.J. Eyerdam made the second known collection of the species from Washington. His collection was from about 20 miles north of Shelton, Mason County (lowlands west of the Cascades). The species then went uncollected for more than 40 years. In 1978, Tom Rogers found the species in eastern Washington in the Dishman Hills area of Spokane. In 1980 it was discovered by Lois Kemp within the Ridgefield National Wildlife Refuge in Clark County, Washington (lowlands west of the Cascades). This site is immediately across the Columbia River from the type locality. A number of other locations in Spokane County (eastern Washington) were found between 1986 and 1990. Turnbull National Wildlife Refuge, located in Spokane County, undertook an extensive inventory effort in 1993, resulting in several additional occurrences being found. The U.S.D.I. Bureau of Land Management also found one occurrence on lands that they administer in Spokane County. In 1994, *Howellia aquatilis* was located by John Gamon in Pierce County within McChord Air Force Base and Fort Lewis Military Reservation (lowlands west of the Cascades).

D. Habitat

Howellia aquatilis is an aquatic plant restricted to small, vernal, freshwater wetlands that generally have an annual cycle of filling and drying. These wetlands fill with water over the fall, winter and early spring, but then dry out to varying levels by the end of the growing season, depending on annual patterns of temperature and precipitation. The sites that support *Howellia aquatilis* are generally shallow (< 1m deep), although the species has occasionally been observed in water up to approximately 2m in depth.

Howellia aquatilis wetlands typically occur in a matrix of forest vegetation. In Montana and Idaho, the adjacent forests have a diversity of conifer species. In contrast, the eastern Washington sites are bordered by forests that have ponderosa pine as the clear dominant conifer. The forests adjacent to the western Washington sites are dominated by Douglas fir.
Throughout the range of the species, the wetlands that support *Howellia aquatilis* are virtually always bordered in part by broadleaf deciduous trees. In Montana, black cottonwood is most commonly the dominant deciduous tree in these habitats, while in eastern Washington it is quaking aspen and in western Washington it is Oregon ash.

Most of the wetlands have a well developed shrub component within them or around their periphery. Red-osier dogwood (*Cornus stolonifera*) is found throughout the species range, whereas hardhack (*Spiraea douglasii*) is found only in the western Washington habitats.

The bottom surfaces of the wetlands usually consist of firm, consolidated clay and organic sediments. *Howellia aquatilis* occurs at elevations from 3m (10 feet) in Washington to 1350m (4420 feet) in Montana; all Montana occurrences are between 945m (3100 feet) and 1350m (4420 feet).

More complete descriptions of the habitats found within each state are provided below:

Montana

In Montana, most *H. aquatilis* occurrences are in glacially-formed wetlands surrounded by diverse coniferous forests in the bottom of an exceptionally mesic valley. These forests contain varying amounts of the following tree species: *Abies grandis*, *Abies lasiocarpa*, *Larix occidentalis*, *Picea engelmannii*, *Pinus contorta*, *Pinus monticola*, *Pinus ponderosa*, and *Pseudotsuga menziesii*. The broadleaf deciduous tree most frequently associated with the pond margins is *Populus trichocarpa*, but *P. tremuloides* is also often present. In the northern end of the Swan Valley, *Betula papyrifera* is found near some pond margins. Shrub species bordering the ponds include: *Alnus incana*, *Cornus stolonifera*, *Juniperus communis*, *Rhamnus alnifolia*, and *Salix bebbiana*. Aquatic herbaceous species most commonly associated with *H. aquatilis* include *Carex vesicaria*, *Callitriche heterophylla*, *Equisetum fluviatile*, *Potamogeton gramineus*, *Ranunculus aquatilis*, *Sium suave*, and *Sparganium minimum*.

Washington

In Washington, *Howellia aquatilis* occurs in three different landscape settings. A majority of the occurrences are in small, ephemeral wetlands found within the forested portions of the channelled scablands of the extreme eastern edge of the state. The dominant tree species in these areas is *Pinus ponderosa*, although all of the wetlands have a broadleaf deciduous component, usually *Populus tremuloides* and occasionally *Betula occidentalis*. The dominant shrub species bordering these wetlands are *Cornus stolonifera* and *Symphoricarpos albus*.

The Pierce County, Washington sites are in all in the Puget Trough lowlands and are bordered by Douglas fir dominated forests. These wetlands all have a significant Oregon ash (*Fraxinus latifolia*) component, as well as a well-developed shrub component consisting of *Spiraea douglasii*.

The Clark County, Washington site is located in the broad floodplain of the Columbia River. It is within a mosaic of wetlands and Oregon ash communities. Much of the surrounding area has been converted to pastures.

The emergent vegetation present at the various Washington sites is similar. Species commonly present include *Carex vesicaria*, *Sium suave*, *Callitriche heterophylla* and *C. stagnalis*, *Ranunculus aquatilis*, *R. flammula*, *R. flabellaris*, *Alisma plantago-aquatica*, *Equisetum fluviatile*, and *Sparganium* sp.

California

Little descriptive information is available for the historical site in California. It is within what Hickman (1993) refers to as the North Coast Ranges subregion. There are apparently both permanent and vernal ponds in the general vicinity. The immediate area surrounding the vernal pond is described as a "grassy meadow-like area."

Oregon

The Oregon sites are located within the Columbia River floodplain and in the broad valley of the Willamette River. They can best be characterized by information on the various herbarium labels, since there are no known extant populations. Information on the labels includes the following words and phrases: "Ponds in woods," "pond in shaded woods," and "stagnant ponds in the timber." It is probable that the historical Oregon sites were similar to the sites in Clark and Pierce counties, Washington.

Idaho

Excerpted from Shelly and Moseley (1988): In Idaho, *Howellia aquatilis* occurs in a small pond in a cutoff river channel, in a broad valley bottom surrounded by low, forested hills dominated by a mixture of coniferous species, including *Pinus contorta*, *Larix occidentalis*, *Thuja plicata*, *Abies grandis*, *Pinus ponderosa*, and *Abies lasiocarpa*. Species immediately bordering the pond include *Crataegus douglasii*, *Cornus stolonifera*, *Alnus incana*, *Symphoricarpos albus*, *Phalaris arundinacea*, and *Rosa* sp. Associated aquatic species include *Alisma plantago-aquatica*, *Sium suave*, *Carex utriculata*, *Lemna minor*, *Eleocharis* sp., and *Callitriche heterophylla*.

E. Life History/Ecology

Detailed information regarding the life history and population biology of *H. aquatilis* can be found in Lesica et al. (1988), Lesica (1990), Shelly (1988), and Shelly and Moseley (1988). Important aspects are summarized below.

1. Reproductive Biology and Phenology

Howellia aquatilis is an annual species, reproducing exclusively by seed. It grows as a mostly submerged, weak-stemmed plant. The plants produce both submerged, cleistogamous flowers (those that do not form a conspicuous corolla) and emergent, chasmogamous flowers (those that

produce a visible corolla just above the water surface). Soon after the plants begin growth in the spring (by early April in lowland western Washington; by early May in eastern Washington and Montana), the underwater flowers begin to form; the first fruits from these have been observed in May (western Washington) and June (eastern Washington to Montana). The emergent flowers begin to bloom when the stems reach the water surface, and are usually present from late June until August. Seed dispersal begins in June from the underwater fruits, and extends until late summer as the emergent fruits mature; fruit and seed production declines as the wetlands dry at the end of summer. The formation of fruits from the cleistogamous and chasmogamous flowers spreads seed production over most of the growing season and potentially distributes seeds over the entire seasonally inundated zone. Seed germination occurs in the fall within those portions of the wetland edge from which the water has receded. The plants overwinter as seedlings (Lesica 1990).

The cleistogamous flowers are, by definition, strictly self-pollinating. The emergent chasmogamous flowers are also predominantly self-pollinated (Lesica et al. 1988).

2. Reproductive Ecology

The seeds of *H. aquatilis* are deposited in the wetland substrates and do not germinate unless they are exposed to an aerobic environment by drying of the habitat (Lesica 1990). Seed germination occurs in October, if the wetlands have dried out enough to expose the seeds to the atmosphere. Optimal germination occurs on peaty, coarse-textured surfaces (Lesica 1992). Further evidence indicating that the seeds do not germinate under water was provided by transplant experiments, in which plants did not appear in two wetlands that did not dry out by the end of the season, but did germinate and grow in two wetlands that were dry at the time of transplanting (September 1989) (Schassberger and Shelly 1991). Because the seeds will not germinate without exposure to the atmosphere, the number of individuals present in a given year is directly influenced by the extent of wetland drying at the end of the previous growing season. The results of monitoring studies that reflect this relationship are provided in previous reports (Shelly 1989; Shelly and Schassberger 1990; Schassberger and Shelly 1991).

The seed bank dynamics, and the longevity of seed viability, are not well understood. Seed production is likely to be higher in years when the wetlands retain more water, but the subsequent effect of high water level retention on seed bank persistence is largely unknown. Recent monitoring studies suggest that the seeds can retain viability for at least two years; one occurrence in Montana consisted of 400-500 plants in

1989, 20 plants in 1990, and several hundred plants again in 1991 (Schassberger and Shelly 1991; J.S. Shelly, pers. obs.). The recovery of the occurrence in 1991 may not have occurred to this extent if the majority of the seeds live for only one year. However, Lesica (1991) found that seeds exposed to optimum germination conditions following eight months of dry storage began to germinate after 60 days, but the germination percentage was only 53%. These observations suggest variability in the duration of seed viability, perhaps depending on the extent of wetland drying in a given year. Germination, combined with whatever losses may have occurred through predation and disease, resulted in the seed bank in one occurrence declining to 10% of its September peak by mid-May of the following year (Lesica 1992).

The rapid formation of seeds early in the season by the submerged cleistogamous flowers allows for at least some reproduction in dry years during which the water levels recede rapidly. In years when water levels remain higher longer, this initial fruiting is augmented by later, above-water formation of chasmogamous flowers and fruits, which prolongs seed production. This expanded seed-producing period probably provides a buffer against dry years, in which production of fruits by the later-blooming, emergent flowers would be limited.

In summary, the reproductive biology of *Howellia aquatilis* restricts the species to the seasonally inundated zone of ephemeral wetlands. However, this zone moves from year to year, depending on the water levels within individual wetlands. The species' response to this annual shifting of suitable habitat has not been well characterized. Understanding the dynamics of this relationship and the mechanisms by which *Howellia aquatilis* survives significant yearly variation in water levels will be critical to the long term success of recovery efforts.

3. Seed Dispersal

   a. Within individual wetlands: The seeds of *H. aquatilis* are relatively large (2-4 mm long). They do not possess any wings, appendages, or other structures that appear to provide buoyancy. Though capable of floating on the surface owing to water surface tension, the seeds sink readily when pushed or released below the surface. It is likely that all of the seeds produced by the submergent cleistogamous flowers sink directly to the bottom upon release. Although seeds released from emergent capsules could float for a short distance from the point of dispersal, it is likely that these seeds sink fairly soon after release as well (Shelly and Moseley 1988).

In numerous cases, broken stems bearing fruits produced by both cleistogamous and chasmogamous flowers, have been observed floating in the water. These free-floating fragments could be dispersed to other areas within the same wetland by small currents generated by the wind or animal movement (Shelly and Moseley 1988).

b. Between wetlands: The majority of the occurrences of *H. aquatilis* are in wetlands that are not connected by surface water. The exception to this is the Swan River Oxbow site, where the species occurs in four adjacent wetlands on the floodplain of the Swan River. During years of high spring run-off this area is inundated, and it is likely that these wetlands are thus interconnected. Water from the Swan River was observed flowing through the surrounding forests in June, 1986. In this situation, it is possible that some dispersal of seed by water movement is occurring (Shelly and Moseley 1988).

In the case of adjacent pothole wetlands, a likely means of seed dispersal is by wildlife. Migrating waterfowl use these habitats in the late summer and fall. It is possible that, when feeding on aquatic vegetation, seeds are ingested and/or become attached to their feet or feathers and get deposited later in other wetlands. In addition, seed movement by mammals (i.e., deer, bears, moose) also appears to be likely. Deer and, in Montana, moose browse in these wetlands, and could ingest and transport seeds. Also, signs of bear foraging were noted at one Montana site late in the summer, after all water had dried from some of the wetlands. Seed movement between wetlands, in sediments lodged in the feet of these bird and mammal species, is feasible. Such dispersal could have produced the clustered arrangement of adjacent occurrences in the Swan Valley, eastern Washington and the Puget lowlands (Shelly and Moseley 1988).

These potential seed dispersal mechanisms need to be considered in the management of the forested habitats within which the wetlands are located. While the buffer recommended in the Flathead National Forest strategy (USDA Forest Service 1994) is intended to maintain the microclimate of the wetlands, larger buffers and corridors should be retained, where possible, to provide habitats for the wildlife species that may be serving as seed dispersal vectors.

F. Reasons for Listing

Howellia aquatilis is historically or currently known from five states in the western United States. However, recent field surveys have failed to relocate previously known occurrences in two states (California, Oregon). In addition, the species is believed to have been extirpated from at least one historical location in Idaho (Shelly and Moseley 1988). Thus, there has been a substantial curtailment of the known geographic range of the species. The majority of the presently known occurrences are found in two areas: the Spokane, Washington vicinity, and the Swan River drainage in northwestern Montana (USDA Forest Service 1994).

Howellia aquatilis has been and continues to be jeopardized by both natural and human-caused disturbances, which, if they continue, could lead to eventual extinction of the species. Five reasons for listing the species as threatened were addressed in the U.S. Fish and Wildlife Service (Service) final rule (U.S. Fish and Wildlife Service 1994). These reasons are excerpted below, with additional information from other recent sources, including the Flathead National Forest conservation strategy for the species (U.S.D.A. Forest Service 1994) and a revision to a report on the status of the species in Washington (Gamon 1995).

1. The present or threatened destruction, modification, or curtailment of its habitat or range

   Howellia aquatilis and its habitat have been, and continue to be, threatened by a number of human-related factors, including timber harvest activities, livestock grazing, invasion by non-native plant species, outright conversion of habitat to other uses, road construction and maintenance, and military training exercises. Each of these factors is briefly discussed below.

   Timber Harvest

   Timber harvest activities can affect wetland vegetation, including *Howellia aquatilis*, primarily via two processes: alteration of the hydrologic regime and increased siltation of the wetland. Regarding changes in the hydrologic regime, timber harvest may result in two opposing processes. First, removal of trees from around wetland margins may result in an increase in the rate of evaporation and subsequent early drying out of the wetland. Second, removal of trees might lead to increased runoff and decreased evapotranspiration from the adjacent uplands, which might result in prolonged inundation of the wetland.

Whether a given wetland undergoes more rapid drying or prolonged inundation undoubtedly depends on the existing vegetation, the physical characteristics of the wetland and adjacent uplands, and the extent and method of timber removal. In either scenario, such alterations in hydrologic regime could have direct, potentially negative, effects on occurrences of *H. aquatilis*, owing to the sensitive relationship of reproductive success to annual fluctuations in water levels and drying patterns (see E.2. Reproductive Ecology). Although wetland drying appears to enhance fall seed germination and abundance in the subsequent growing season, repeated years of early drying and reduced seed production lead to a rapid decline and potential extirpation of the occurrence. Prolonged inundation reduces fall germination and population size in subsequent years (Shelly and Schassberger 1992).

The second process by which timber harvest may impact wetland vegetation is increased siltation as a result of erosion. An increase in bottom sedimentation may result in a successional shift favoring emergent over submergent vegetation. Most wetlands around which timber harvest has occurred contain dense emergent vegetation, while those in intact forests tend to have more open water and fewer dense patches of the typically associated species (i.e., *Carex vesicaria*, *Equisetum fluviatile*, *Sium suave*). The resultant increase in competition from other vegetation could have an adverse effect on *H. aquatilis* populations.

The Montana portion of the range of *Howellia aquatilis*, i.e., the lower elevations in the Swan River drainage, is heavily forested and has been managed for commercial timber harvesting since the early 1900s. Ownership consists of a mixture of federal, state, and corporate timberlands, and private individuals.

Of the occurrences in the Swan River drainage, at least 16 have experienced timber harvest directly adjacent to the wetlands. In many cases, all coniferous trees have been removed from the wetland margins, with only a few broadleaf deciduous species left standing. In fewer instances, no trees have been left around wetland margins, and in one case logging slash was placed in the water.

At least 15 occurrences within the Swan River drainage are located in areas where nearby forests have been logged (within 300 feet of the wetland margin), but the forests on the wetland margins are still intact.

Although similar data are not available for Washington, timber harvest has been increasing within the vicinity of the eastern Washington occurrences of *Howellia aquatilis*. In at least one instance, harvest occurred right up to the high-water margin of a wetland containing *H. aquatilis* (Gamon 1992). The eastern Washington occurrences may have the added impact of vehicles and other equipment operating within or immediately adjacent to the wetlands.

Another related factor for the habitat in eastern Washington has been the popularity of aspen as a source of firewood. Although data are not available, a significant amount of aspen has been harvested over the years. The impacts on the habitat and *Howellia aquatilis* have not been documented.

Livestock Grazing

Livestock can also adversely affect howellia populations. Individual plants are very easily uprooted. Disturbance of the bottom sediments may adversely affect the seed bank and the consolidated substrate which appears to be necessary for germination. Livestock waste also increases nutrient loading in wetlands, which may lead to changes in wetland vegetation composition. *Howellia aquatilis* still exists in a number of areas that have been grazed in the past (N. Curry, pers. comm., 1993; B. Wiseman, Ridgefield National Wildlife Refuge, pers. comm., 1992). However, there is presumably some threshold beyond which *Howellia aquatilis* is not able to survive. The timing, magnitude, and duration of grazing probably all influence the response of *Howellia aquatilis* to grazing.

According to Griggs and Dibble (1979), the California population may have been eliminated by cattle grazing and trampling. A majority of the occurrences within the Swan River drainage are in grazing allotments, although grazing effects have been noted in the vicinity of only five occurrences: two on private lands and three on Flathead National Forest lands (USDA Forest Service 1994). In Washington, the eleven occurrences that are on private lands are currently subject to grazing. All of the occurrences in Washington, with one exception, had grazing pressure in the past.

Invasion by Weedy Plant Species

Reed canarygrass is a highly competitive species that invades wetlands with the potential of forming dense monocultures, resulting in the decline of nearly all other plant species (Apfelbaum and Sams 1987). It is

present in a majority of the wetlands in Washington that are occupied by *Howellia aquatilis*. It is also present in several of the Montana locations of *Howellia aquatilis* and can be found in wetlands near the single known site in Idaho.

Although *Howellia aquatilis* has been observed growing within stands of reed canarygrass, it is clearly most abundant in areas with little or no other aquatic vegetation. Reed canarygrass is thought to pose a significant threat to the long term presence of *Howellia aquatilis* within these wetlands. Reed canarygrass may also accelerate the rate of wetland succession, causing changes in the wetland substrate and affecting the water levels (Gamon 1992).

There has been an ongoing debate regarding the origin of reed canarygrass (Naglich 1994). However, regardless of whether or not the species is native, its presence and potential dominance in wetlands that harbor *Howellia aquatilis* appears to be related to human-caused habitat disturbances. Continued expansion of reed canarygrass could result in extirpation of *Howellia aquatilis* from individual wetlands. Monitoring studies to assess this possibility are in progress on The Nature Conservancy's Swan River Oxbow Preserve (Lesica 1991, 1994 and 1995).

Lythrum salicaria (purple loosestrife) is another aggressive exotic plant which poses a threat to howellia; it can out-compete and eliminate other aquatic plants (West 1990). Purple loosestrife is present in Lake County, Montana, as well as in the general vicinity of the eastern Washington and Puget lowland occurrences of *Howellia aquatilis* (West 1990; N. Curry, pers. comm. 1993; D. Rolph, pers. comm. 1995).

Noxious Weeds on Adjacent Uplands

Noxious weeds are present on uplands adjacent to a number of the wetlands that support *Howellia aquatilis* in eastern Washington. Some of these weeds have the ability to invade the wetlands and their perimeters as they dry out (e.g., *Cirsium* spp.), while others are restricted to the drier uplands. Those that can invade the microsites occupied by *Howellia aquatilis* pose a direct threat through competition. Chemical control of any noxious weeds in the vicinity of ponds poses the potential risk of accidental contamination of the wetland and its perimeter.

Conversion of Habitat

Historically known areas in Oregon have been lost to urbanization. An increase in residential development is occurring in the immediate vicinity of occurrences within Spokane County, Washington. Additionally, the construction of dams along the Columbia and Willamette rivers has led to a loss of suitable wetland habitats (Shelly and Moseley 1988; Gamon 1992). Many wetlands within the historic range of *H. aquatilis* have been drained, filled, or excavated for other uses (Gamon 1992).

Road Construction and Maintenance

Construction of road prisms has altered the natural landforms in the vicinity of numerous *Howellia aquatilis* wetlands in Montana and Washington and may have permanently influenced the local hydrology. Road maintenance activities may also impact *Howellia aquatilis* habitat. A majority of the roads near *Howellia aquatilis* wetlands are gravel; dust from a road adjacent to a *Howellia aquatilis* site in Montana resulted in cloudy water in the wetland (USDA Forest Service 1994).

Military Training Exercises

All currently known occurrences of *Howellia aquatilis* within the Puget lowlands are within military installations. Training exercises have been conducted in the immediate vicinity of three occurrences. However, it is not clear whether these exercises ever included entry into the wetlands, although training activities have certainly resulted in changes to the vegetation in the adjacent uplands.

2. Overutilization for commercial, recreational, scientific, or educational purposes

Overutilization for commercial, recreational, scientific, or educational purposes is presently not a threat to *H. aquatilis*. However, the listing of this species and its taxonomic status as a monotypic genus may generate increased public and scientific interest. Individual occurrences may face an increased threat of trampling and habitat degradation from increased visitation. The Service has not designated critical habitat because the publication of precise maps and descriptions of critical habitat in the Federal Register could lead to increased taking and vandalism.

3. Disease or predation

Howellia aquatilis may be subject to foraging by native and domestic animals, although livestock have not been observed feeding on *Howellia aquatilis*. Incidence of seed predation or disease is not known.

4. The inadequacy of existing regulatory mechanisms

Prior to federal listing, *Howellia aquatilis* received some protection as a result of the sensitive species policies of the U.S. Forest Service and the U.S.D.I. Bureau of Land Management. Federal laws, such as the Clean Water Act and the Food Security Act, and some State laws may have indirectly provided protection to the species via measures designed to protect wetlands. Listing the species under the Endangered Species Act (ESA) provides direct protection for the species on federally managed lands. However, the ESA provides only limited protection to populations of plant species on non-federal lands.

5. Other natural or manmade factors affecting its continued existence

Howellia aquatilis is presumably adapted to natural changes (succession, environmental disturbances, etc.) in its habitat. However, these natural changes may threaten *Howellia aquatilis* due to human-induced reductions in available suitable habitat. That is, *Howellia aquatilis* may not be able to keep pace with the combination of an increased rate of habitat modification (both natural and human-caused) and a reduction in suitable habitat. In this context, *Howellia aquatilis* is potentially threatened by several natural factors, each of which is discussed below.

Narrow Ecological Requirements

Howellia aquatilis has narrow ecological requirements; it is restricted to the zone around freshwater wetlands that is seasonally inundated. All sites have similar substrates and similar patterns of inundation and subsequent drying. Subtle changes in its habitat, including altered water chemistry, hydrology, substrate, and species composition of the microsites, could have serious negative impacts on a given population. If such changes occurred simultaneously over a significant portion of the range of the species, e.g., climate change), the species itself could be at risk.

Genetic Variation

The apparent lack of genetic variation between populations of *Howellia aquatilis* may add to the vulnerability of the species; it may have only limited ability to adapt to abrupt environmental changes (Lesica et al. 1988).

Recent studies using gel electrophoresis techniques that analyze respiration enzymes have revealed a lack of detectable genetic variation within or among occurrences of *H. aquatilis* (Lesica et al. 1988). The lack of detectable genetic variation corresponds with the species' strict adaptation to aquatic habitats with highly specific hydrological characteristics (Huenneke 1991). This lack of variation would severely restrict the adaptability of the species in the face of changing environmental conditions. All of these genetic and ecological factors render the species particularly vulnerable to habitat alteration and loss.

Climatic Change

Short- and long-term climatic changes could affect *H. aquatilis* by influencing the seasonal flooding and drying patterns of wetlands. Successive years of exceedingly wet or dry weather would be expected to cause declines or even extirpations of some of the occurrences. The seed bank, depending on its longevity, may buffer occurrences from wet or dry periods. However, recent studies suggest that seed viability is relatively short-lived (Lesica 1992). Thus, climatic change, whether it results in excessive drying or water retention in the wetlands, might ultimately lead to extinction of the species.

Succession

Natural wetland succession may eventually result in the extirpation of individual occurrences of *Howellia aquatilis*. Shelly and Moseley (1988) suggest that some of the Montana sites may eventually become sedge meadows with a water table lowered to a point that it would not support *H. aquatilis*. For sites in the Puget lowlands, expansion of stands of *Spiraea douglasii* is a concern. Rangewide, the expansion of reed canarygrass and its effects on successional change are of concern. However, the successional pathways and rates in these wetland habitats, and the various environmental and human-related factors that influence them, have not been studied.

Fire

The effects of fire on *Howellia aquatilis* are not known. However, fire could result in a loss of shading around wetland perimeters, altered wetland evaporation rates, altered evapotranspiration from the adjacent uplands, increased siltation, and increased runoff. All of these factors could result in changes in the vegetation composition within the wetland, including a decline in *Howellia aquatilis*. More directly, late summer and early fall fires, which are typical within the range of the species, could burn through those sites that had dried sufficiently and that had enough dried vegetation to carry a fire. The seeds are not very deeply buried in the substrate and might not be able to survive even low intensity burns. However, in some cases fire may set back plant succession, thereby improving the habitat suitability for *Howellia aquatilis*.

Metapopulation Dynamics

The clustered distribution pattern of *H. aquatilis* suggests that the occurrences within at least three geographic areas (e.g., the Swan Valley in Montana and Spokane and Pierce counties, Washington) represent "metapopulations." A metapopulation is defined as "...a collection of interdependent populations affected by recurrent extinctions and linked by recolonizations" (Murphy et al. 1990). The importance of metapopulation maintenance is summarized by Rohlf (1991). Metapopulation dynamics play an important role in the persistence of many species. The existence of many populations is critical for species that inhabit patches in a shifting mosaic of habitats. Multiple populations also serve as a source of colonists and thus as a hedge against environmental stochasticity. Metapopulation dynamics are likely to become increasingly important as habitat areas become fragmented. Thus, the maintenance of as many occurrences of *H. aquatilis* as possible within each geographic area will best insure the ability of the individual metapopulations to persist in the face of future natural environmental changes and land use effects (i.e., global climate warming, habitat loss on private lands, vegetation succession in currently occupied habitats). As such factors exert themselves, currently occupied ponds may become unsuitable for *H. aquatilis*, while others may become suitable habitat.

G. Conservation Measures

Federal Endangered Species Act

Action by the Federal government to protect *Howellia aquatilis* was initiated on December 15, 1980, when the species was designated as a Category 2 candidate for listing (U.S. Fish & Wildlife Service1980). The notice of review issued in 1990 then changed the species' status to Category 1 (U.S. Fish & Wildlife Service 1990). The U.S. Fish and Wildlife Service was petitioned to list the species in October, 1991; the Service subsequently published a listing proposal in April, 1993 (U.S. Fish & Wildlife Service 1993), and a final rule listing the species as threatened in July, 1994 (U.S. Fish & Wildlife Service 1994).

As stated in the final rule (U.S. Fish & Wildlife Service 1994):

> Section 7(a) of the Act, as amended, requires Federal agencies to evaluate their actions with respect to any species that is proposed or listed as endangered or threatened and with respect to its critical habitat, if designated. Regulations implementing this interagency cooperation provision of the Act are codified at 50 CFR Part 402. Section 7(a)(2) requires Federal agencies to ensure that activities they authorize, fund, or carry out are not likely to jeopardize the continued existence of a listed species or to destroy or adversely modify its critical habitat. If a Federal action may affect a listed species or its critical habitat, the responsible Federal agency must enter into formal consultation with the Service.
>
> In the case of Howellia, Federal activities that might be affected by listing this plant as threatened include timber harvest, livestock grazing, road construction, military training activities and filling of wetlands. Such Federal activities may be subject to section 7 review.

U.S. Forest Service and National Forest Management Act

Rules for protection of listed plants in the National Forests are in the USDA Forest Service Manual Title 2600--Wildlife, Fish, and Sensitive Plant Habitat Management, Chapter 2670--Threatened, Endangered and Sensitive Plants and Animals. The U.S. Forest Service (U.S. Forest Service) must abide by the Act and the National Environmental Policy Act in managing their Forests. The National Forest Management Act of 1976 mandates that a Management Plan be written for each National Forest.

The Flathead National Forest Land and Resources Management Plan was amended in May, 1994, to adopt conservation measures for *Howellia*

aquatilis. These measures were initially put forth in a conservation strategy for *H. aquatilis* that was accepted by the Flathead National Forest in April, 1994 (and subsequently amended in November, 1994) (U.S. Forest Service 1994). These measures are considered an important step in the recovery of *Howellia aquatilis* in implementing management direction found in the Flathead National Forest Land and Resources Management Plan and the recovery plan, as they will provide a broad umbrella under which management activities will occur that will not adversely impact howellia on Forest Service lands, and will provide a framework for implementing a meaningful monitoring program specific to the Flathead National Forest.

U.S. Bureau of Land Management

The protection, management and conservation measures for federally listed and candidate species required of the BLM are spelled out in USDI Bureau Manual Section 6840. At the time of discovery of *Howellia aquatilis* on BLM administered lands (1993), *Howellia aquatilis* had not yet been listed. As a candidate, the Bureau's policy was to "...manage the habitat to conserve the species." Current protection measures at this site are mentioned below.

Current protection

As noted above, the Flathead National Forest has adopted a conservation strategy for *Howellia aquatilis*. As part of this strategy, ten occurrences are within one proposed botanical Special Interest Area. Additionally, the habitat of four occurrences on private lands is under protective management. The majority of the Swan River oxbow occurrence is within a preserve acquired by The Nature Conservancy to protect one of its largest population numbers. Three other occurrences are afforded voluntary, non-binding protection via a landowner registry program, whereby the landowners voluntarily agree to maintain the current management practices and to notify The Nature Conservancy if they plan to sell their property or alter management activities.

The Idaho occurrence, currently under private ownership, has been willed to a conservation organization (Shelly and Moseley 1988; Moseley, pers. comm. 1995).

In Washington, two populations of *Howellia aquatilis* are within U.S. Fish & Wildlife Service Research Natural Areas: Blackwater Islands RNA within Ridgefield NWR and Pine Creek RNA within Turnbull NWR. The major management concern at both sites is the invasion of *Phalaris arundinacea* (reed canarygrass). Although there are no control efforts currently being undertaken within occupied *H. aquatilis* habitat, the refuge managers and staff are aware of the significance of the problem and are considering possible courses of action.

In addition to the one population within Pine Creek RNA, there are several other populations of *Howellia aquatilis* within Turnbull National Wildlife Refuge. Several of these are within areas closed to the public; others are within areas open to the public. Public use levels are currently quite low, with virtually no impacts to the sites.

The Dishman Hills Pond population is within a Natural Resources Conservation Area, managed by the Washington State Department of Natural Resources. A management plan for the site was developed in August, 1995 (Washington State Department of Natural Resources 1995). A number of trails in the area lead to the pond that harbors *Howellia aquatilis*. The area has been signed to keep people out, but the signs have recently been vandalized.

The U.S.D.I. Bureau of Land Management site was fenced in the spring of 1994 to exclude cattle. Although the general area receives light recreational use, the *Howellia aquatilis* site probably receives little or no such use.

The McChord AFB site is under consideration for special management status that would recognize the biological importance of the area. Two of the Fort Lewis sites are within an area that receives little to no human use. Two additional sites on Fort Lewis are within areas used for military training exercises. Access to both McChord AFB and Fort Lewis is tightly controlled.

Two of the sites on private lands have been included on the Washington Register of Natural Areas. This voluntary program does not bestow any formal protection on the sites. One of the two, however, has been fenced in order to keep cattle out. The other, however, has recently had the timber harvested from its perimeter.

H. Strategy of Recovery

The recovery strategy is based upon maintaining the current geographic range of the species and the integrity of the habitat within that range. The strategy relies heavily on development and implementation of habitat management plans that will ensure the maintenance of self-sustaining populations of *Howellia aquatilis* on federally managed lands, since such lands harbor a significant proportion of the total number of known occurrences. Federal agencies involved in management of *Howellia aquatilis* habitat include the U.S. Forest Service, the U.S. Bureau of Land Management, the U.S. Fish and Wildlife Service, and the U.S. Department of Defense.

The recovery strategy also promotes efforts to protect occurrences on non-federal lands, since such lands are critical to maintaining the species' current geographic distribution.

Research and monitoring are also key elements of the recovery strategy. Critical questions regarding habitat requirements and species biology remain unanswered. Threats need to be assessed and population trends need to be monitored. The information gathered will be critical to the successful management of the habitat for this species.

II. RECOVERY

A. Recovery Plan Objective

The objective of this recovery plan is to provide an adequate level of protection for the species and its habitat so that there will be self-sustaining populations distributed throughout its extant range.

B. Recovery Criteria

Delisting will be considered when monitoring demonstrates that management practices, in accordance with habitat management plans, have been effective in maintaining the species and its habitat throughout its currently known range on federally managed lands, i.e., in four of the five geographic areas, for a minimum of ten years, assuming that the management plans will continue to be in place if delisting occurs. The only geographic area not included within this criterion is Latah County, Idaho; this site does not include any federal land ownership.

C. Step-down Outline

U.S. Fish & Wildlife Service guidelines classify recovery actions into three priority classes. Priority 1 tasks are those that **must** be taken to prevent extinction or to prevent the species from declining irreversibly in the **foreseeable** future. Priority 2 tasks are those that must be taken to prevent a significant decline in species population/habitat quality, or some other significant negative impact short of extinction. Priority 3 actions are other actions necessary to meet the recovery objective.

1. Maintain habitat integrity and extant geographic range.

    11. Develop and implement habitat management plans that sustain *Howellia aquatilis* occurrences on federal lands. The U.S. Fish and Wildlife Service will provide a list of considerations to be addressed in these plans to each agency (Priority 1).

111. Conservation strategy, Flathead National Forest

112. Management plan, Turnbull NWR

113. Management plan, Ridgefield NWR

114. Management plan, McChord AFB

115. Management plan, Fort Lewis Military Reservation

116. Management plan, Spokane District, Bureau of Land Management

12. Promote protection of key occurrences on non-federal lands including those that are within metapopulations as well as significant outlying geographic extensions (Priority 2).

13. Promote special management designations (e.g., Research Natural Areas, Botanical Special Interest Areas) on federal lands (Priority 3).

14. Pursue appropriate protection under Section 404.

2. Promote the highest level of state legal protection appropriate for all occurrences.

21. Promote compliance with all state laws and regulations protecting *H. aquatilis* (Priority 3; not currently applicable in Washington, Idaho, and Montana).

22. Promote development and implementation of new laws for the protection of *H. aquatilis* in those states not now offering statutory protection (Priority 2).

3. Conduct research and monitoring necessary to answer critical questions about the habitat requirements and species biology of Howellia aquatilis in order to identify the habitat conditions needed to maintain natural populations, to design sound management plans for maintaining natural populations, and to gauge the success of implemented management plans.

31. Conduct research necessary to identify the habitat conditions needed to maintain natural populations (Priority 2).

311. Conduct study of seasonal and cyclic hydrologic characteristics of occupied habitat.

312. Determine which occurrences are hydrologically linked and characterize the nature of the relationship

313. Evaluate successional dynamics of upland community types surrounding occupied *H. aquatilis* habitat, and how those dynamics may affect the species.

314. Evaluate successional dynamics of occupied wetland vegetation types.

315. Determine the relationship between *H. aquatilis* abundance and nutrient availability in wetland substrates and surface water.

316. Determine optimum physical characteristics of the associated habitat features.

32. Conduct research and monitoring necessary to elucidate threats, as well as the response of the species to specific management actions (Priority 2).

321. Forest management practices (road building, timber harvest, fire, disease control, salvage).

322. Grazing.

323. Military training activities.

324. Elucidate the effects of spread of *Phalaris arundinacea* on *H. aquatilis* occurrence trends and develop management practices as needed.

325. Assess the effect of predation and disease on the species, especially seeds and seedlings.

33. Conduct monitoring to assess occurrence trends (Priority 2).

34. Conduct necessary research to determine critical aspects of species' biology (Priority 2).

341. Genetic variation, within core areas/metapopulations and across the species' range.

342. Mechanisms of seed dispersal.

343. Longevity of seed viability.

344. Relative contributions of submergent and emergent fruits to the seed bank, and assess possible variation in seed germination biology from each fruit type.

4. Identify and search potential habitat, especially in years favorable for large occurrence sizes.

41. Conduct intensive surveys in the areas of known historical occurrence in California and Oregon (Priority 2).

42. Continue efforts to relocate historically known occurrences in Washington (Priority 2 or 3).

43. Conduct *de novo* inventories in suitable habitats throughout the remaining extant range (Priority 3).

5. Evaluate the appropriateness and feasibility of reintroducing *Howellia aquatilis* into unoccupied areas of its former range, in consultation with all appropriate parties, after intensive surveys have confirmed extirpation.

51. If reintroduction is found to be appropriate and feasible, a reintroduction plan will be developed and implemented (Priority 3).

6. Disseminate information about the species to appropriate audiences and landowners.

61. Develop and conduct training programs (e.g., to be given for wetland delineation, ecology, and other concerned agency personnel, as well as private landowners, etc.) (Priority 3).

611. Conduct training for appropriate field personnel in Oregon and California.

62. Develop a brochure or fact sheet for public dissemination, and provide presentations as appropriate (Priority 3).

63. Develop and disseminate species information to private landowners (Priority 3).

631. Provide information to private landowners in Washington who are applying for timber harvest permits on their lands.

632. Provide information to the public, as requested, through the state Natural Heritage Programs and other appropriate agencies.

7. Establish a technical working group to periodically review the status of the species and assess the effectiveness of the management plans and other recovery tasks (Priority 2).

D. Narrative

1. Maintain extant geographic range and habitat integrity.

There are currently only five geographic areas within which *Howellia aquatilis* is known to occur. Tests to date indicate that the species lacks detectable genetic variation both within and among these geographic areas (Lesica et al. 1992). Therefore, the species may have a limited genetic ability to respond to changes in its habitat, whether those are environmental or human-related. Maintaining the species' current extant range will provide the best hedge against environmental and human-related stochastic events that might otherwise cause the extinction of the species.

Each of the five geographic areas is subject to a number of current and potential threats, all of which compromise the integrity of the habitat. Since *Howellia aquatilis* is adapted to very specific habitat conditions, maintaining the integrity of the habitat is extremely important. This will include protection of the vegetational, hydrologic and geomorphologic conditions that determine natural seasonal inundation and drying patterns of the habitat.

11. Develop and implement habitat management plans that will sustain *Howellia aquatilis* occurrences on federal lands. The U.S. Fish and Wildlife Service will provide a list of considerations to be addressed in these plans to each agency (Priority 1).

A significant proportion of the total number of occurrences of *Howellia aquatilis* are found on lands managed by federal

agencies. Additionally, federal lands comprise a major proportion of the species' habitat within four of the five general areas within which the species is found. Successful management on these lands will be critical to the success of recovery efforts.

Current management activities, as well as threats, vary from site to site, necessitating management plans tailored to the individual areas and agencies. These plans should include provisions for the protection of those sites having the best potential for providing long-term stable habitat, and maintenance of unoccupied, potential habitat in suitable condition, since such areas represent sites for potential future colonization.

111. Conservation strategy, Flathead National Forest

The Flathead National Forest developed a conservation strategy for *Howellia aquatilis* in 1994. The strategy has been approved and signed by the Forest Supervisor. This strategy provides management direction for 67 known occurrences, which is a significant percentage of the known occurrences both rangewide (44%) and in Montana (67%).

The stated goals of this strategy include protecting all known, and newly discovered, occurrences on U.S. Forest Service lands in Montana, maintaining unoccupied, potential habitat in suitable condition, and allowing aquatic and adjacent upland vegetation to recover from previous disturbances.

The approved conservation strategy includes a proposal to establish a botanical special interest area in the vicinity of one of the three water howellia concentration areas in the Swan Valley.

112. Management plan, Turnbull NWR

There are currently 33 known individual occurrences within Turnbull National Wildlife Refuge. These are found within three different land use categories on the refuge: Research Natural Area, public access, and restricted public access. Reed canarygrass is a primary concern within this refuge. Considerable manipulation of adjacent uplands continues and needs to be done in a manner compatible with *Howellia aquatilis*. The refuge is currently in the process of writing a land management plan (Curry, pers. comm. 1995).

113. Management plan, Ridgefield NWR

The occurrence of *Howellia aquatilis* within this refuge is within a Research Natural Area. A major potential threat to the population is the increase of reed canarygrass following removal of livestock grazing with establishment of the RNA.

114. Management plan, McChord AFB

Military training exercises occur in the vicinity of the occurrence on this military installation. The invasion of reed canarygrass, and potentially purple loosestrife, are also of concern.

115. Management plan, Fort Lewis

Additional inventory of Fort Lewis will take place in 1996. Currently known sites are within ammunition storage areas and in areas used for military training. In addition, the invasion of reedy canarygrass, and potentially purple loosestrife, are of concern.

116. Management plan, Bureau of Land Management, Spokane District

At present, there is only one known occurrence of *Howellia aquatilis* on BLM-managed lands in the Spokane District. However, there is potential for additional occurrences to be found. The one known site has been fenced to exclude livestock. However, reed canarygrass may still constitute a significant threat and a significant blowdown event in 1995 may lead to timber salvage in the area. Other potential sites are currently within actively grazed areas. The Spokane District is in the process of writing a management plan for this area (Fishtrap Lake). Their current mode of operation is to survey potential ponds each spring. If *Howellia aquatilis* is found, their plan is either to remove cattle from the area or fence the pond to exclude them (Aldrich, pers. comm. 1995).

12. Promote protection of occurrences on non-federal lands (Priority 2).

Implementation of the ESA represents the highest level of legal protection for plant occurrences on federal lands, but not on non-federal lands. A significant number of occurrences (51 of 153;

including 5 of joint ownership) are on non-federal lands that are state or private lands. Ownership of private lands includes individuals, corporations, and non-profit organizations. Non-federal lands constitute a significant proportion of the habitat for two of the five general areas within which the species is found (Swan Valley and eastern Washington). The area in Idaho is entirely privately owned. These non-federal lands are critical to maintaining the species across its extant geographic range.

All private landowners should be contacted regarding the presence of the species on their lands and the significance of their lands to the conservation of the species. Various protection options, including registry, conservation easements, fee Acquisition, binding management agreements, etc. should be considered. At least four occurrences (one in Washington and three in Montana) are currently in the voluntary landowner protection programs. The Idaho site is apparently currently under voluntary protection as well (Moseley, pers. comm. 1995).

13. Promote special management designations (e.g., Research Natural Areas, Botanical Special Interest Areas) on federal lands (Priority 3).

Two occurrences of *Howellia aquatilis* are already on federal lands that have been designated as Research Natural Areas. Such a designation provides the highest level of protection available, essentially identifying *Howellia aquatilis* as the highest priority resource within the areas. Designation of a Botanical Special Interest Area has been proposed in an area of Flathead National Forest in an area with 10 occurrences. Other management designations could also provide increased protection.

14. Pursue appropriate protection under Section 404.

2. Promote the highest level of state legal protection available to all occurrences.

Due to the limited number of known areas that harbor this species, and the limited number of known occurrences within those areas, it is important to secure the maximum legal protection available to all occurrences.

21. Insure compliance with all laws and regulations protecting *H. aquatilis* (Priority 3; not applicable in Washington, Idaho, and Montana).

Although there are no known extant occurrences in California or Oregon, those two states have state endangered species laws providing protection for listed plant species. If the species is rediscovered in either or both of those states, their respective endangered species laws could and should be used to provide maximum protection.

22. Promote development and implementation of new state laws and/or regulations for the protection of *H. aquatilis* in those states not now offering statutory and/or regulatory protection (Priority 2).

The individual states should be encouraged to pursue state-level avenues for protection on non-federal lands that would compliment ESA protection on federal lands.

3. Conduct research and monitoring necessary to answer critical questions about the habitat requirements and species biology of *Howellia aquatilis* in order to identify the habitat conditions needed to maintain natural populations, to design sound management plans for maintaining natural populations, and to gauge the success of implemented management plans.

Successful management of this species and its habitat will depend upon gathering additional information about its habitat requirements and biology, as well as effectively monitoring populations and their response to management activities.

31. Conduct research to identify the habitat conditions needed to maintain natural populations (Priority 2).

Although it is known that *Howellia aquatilis* is restricted to a narrow range of habitat conditions, those conditions have not been fully described and quantified. A complete characterization of the physical parameters of sites and an understanding of the hydrologic requirements, successional dynamics within and around microsites and the nutrient level limitations is needed to effectively manage this species.

311. Conduct study of seasonal and cyclic hydrologic characteristics of occupied habitat.

Howellia aquatilis is restricted to microsites that are seasonally inundated. However, there is considerable variability from year to year and across the geographic range of the species in the timing and duration of inundation.Information is needed regarding the source of water for these wetlands. Is it all surface runoff? or is some of it groundwater recharge? Knowledge of the factors that influence the seasonal and cyclic fluctuations in water level of these habitats is critical to the long term maintenance of the suitability of the habitat. Knowing the extremes in hydrologic conditions (both drought and prolonged inundation) in which *Howellia aquatilis* can survive is also critical.

312. Determine which occurrences are hydrologically linked and characterize the nature of the relationship.

The degree to which individual *Howellia aquatilis* occurrences are hydrologically linked (or potentially linked) is unknown, yet it may be important in the successful management of individual wetlands and the adjacent uplands.

313. Evaluate successional dynamics of upland community types surrounding occupied *H. aquatilis* habitat, and how those dynamics may affect the species.

Adjacent upland plant communities may affect the hydrology of *Howellia aquatilis* microsites through capturing runoff before it reaches the wetland, through variable evapotranspiration, and through varying amounts of shade provided to the water surface. An understanding of how these factors operate is important to understanding how to manage these adjacent uplands.

314. Evaluate successional dynamics of occupied pond/wetland vegetation types.

Little is known about the successional dynamics in the various habitat types within which *Howellia aquatilis* is found, yet succession could have a significant effect on the habitat suitability of individual sites.

315. Determine the relationship between *H. aquatilis* abundance and nutrient availability in wetland substrates and surface water.

Results of laboratory experiments suggest that the abundance of *Howellia aquatilis* is influenced by levels of available nutrients, particularly total phosphorous, nitrate and ammonium (Lesica 1990). Clarification of this relationship may have implications for management of the microsites and the adjacent uplands. For example, livestock grazing, timber harvest and fires (whether wild or prescribed) all affect nutrient cycling.

316. Determine optimum characteristics of the physical features of the habitat.

Physical parameters such as slope within the seasonally inundated zone, landscape position, etc. may affect the suitability of a given wetland to harbor *Howellia aquatilis*. Definition of optimum characteristics would allow better predictive capabilities for potential sites.

32. Conduct research and monitoring necessary to elucidate threats, as well as the response of the species to specific management actions (Priority 2).

Several potential threats to *Howellia aquatilis* have been identified, including timber harvest and related activities, grazing, military training activities, reed canarygrass invasions, etc. Knowing how serious each of these threats is and how each of them operates will enable land managers to make more informed management decisions. Monitoring the response to various management activities will help elucidate the threats and provides a mechanism of fine-tuning future management.

321. Assess the effects of forest management practices (road building, timber harvest, fire, disease control, salvage) on *Howellia aquatilis* and its habitat.

Forest management practices have the potential to effect *Howellia aquatilis* habitat in a number of ways. Road construction adjacent to habitat may influence the hydrologic regime. It may also contribute to siltation and nutrient influx. Removal of trees adjacent to habitat, whether through timber harvest or fire, may have similar impacts. Fire suppression may also affect these parameters.

322. Assess the effects of grazing on *Howellia aquatilis* and its habitat.

A number of known occurrences have been grazed in the past, and several continue to have some degree of grazing pressure. Potential threats associated with grazing include direct removal and/or trampling of live material, trampling and/or compaction of the substrate impacting seed germination and seedling establishment, changes in nutrient levels within the wetlands, and changes in composition of associated plant species. Conversely, grazing has been suggested as a possible tool to reduce the competition with reed canarygrass. The effects of grazing in various habitats need to be elucidated and assessed in order to provide sound management direction.

323. Assess the effects of military training activities on *Howellia aquatilis* and its habitat.

The degree to which habitat has been used in the past for military training exercises needs to be established, as well as identification of what any such training consisted of, what the impacts may have been, and what future military training can be expected in such habitats.

324. Elucidate the effects of the spread of *Phalaris arundinacea* on *H. aquatilis* occurrence trends, and develop management practices as needed.

Reed canarygrass has invaded many of the individual sites in which *Howellia aquatilis* is found. The ability of this rhizomatous grass to spread rapidly has caused concern that it might exclude other vegetation, including *Howellia aquatilis*. There is also some concern regarding the long term effect on hydrology and successional patterns as a result of this grass becoming established. These effects need to be quantified and the nature of any threat to *Howellia aquatilis* characterized. To the extent that reed canarygrass is found to pose a threat, effective control measures need to be identified.

325. Assess the effects of predation and disease on the species, especially seeds and seedlings.

Because *Howellia aquatilis* is an annual species, it is dependent on successful seed production, the subsequent survival of those seeds until germination, and then successful seedling establishment. Although no predation or disease have been noted, the topic has not been investigated.

33. Conduct monitoring to assess occurrence trends (Priority 2).

Successful management of individual occurrences will depend on the ability to detect long-term changes in the population or changes in the habitat and subsequently making specific management decisions based upon those changes.

34. Conduct research necessary to determine critical aspects of species' biology (Priority 2).

A thorough understanding of the biology of *Howellia aquatilis* should improve the chances for its successful management.There are several critical aspects of the biology of *Howellia aquatilis* that are unknown.

341. Determine and characterize the genetic variation within each of the five geographic areas as well as across the species' range.

Genetic variation is generally thought to be positively correlated with the ability to survive in different, or changing, environmental conditions. Electrophoretic tests indicate a lack of detectable genetic variation. However, due to the potential impact on future management, particularly that relating to reintroductions or population augmentations, the possibility of genetic variation within the species warrants a closer look.

342. Identify seed dispersal mechanisms.

The methods of seed dispersal are unknown, particularly local dispersal from one pond or wetland to another, given that most occurrences are hydrologically isolated from each other. The mechanisms(s) by which new sites are colonized has implications for management of the individual sites and potentially for management of dispersal corridors. The method of seed dispersal may also affect the rate at which new sites are colonized, which may in turn affect the total number of sites necessary to maintain a population over time.

343. Investigate longevity of seed viability.

The duration of time that seeds remain viable potentially affects the species' ability to withstand unfavorable

environmental conditions (i.e., both drought and prolonged inundation).

344. Quantify the relative contributions of submergent and emergent fruits to the seed bank, and assess possible variation in seed germination biology from each fruit type.

Howellia aquatilis produces cleistogamous flowers when the plant is still submerged and chasmogamous flowers when the stems reach the surface of the water or are on the muddy edge of the pond or wetland. Quantitative studies of the relative contributions of submergent and emergent fruits to the annual seed bank would provide a measure of the extent to which early fruit production may provide a buffer during drier years.

Do the cleistogamous and chasmogamous flowers have the same potential? i.e., do they simply respond to the environment to produce chasmogamous flowers, or are they genetically predisposed to do so? If the latter is the case, then there might also be a genetic "gradient" relating when the individual plants grow and flower to their ability to germinate or their ability to survive drought or inundation.

4. Identify and search potential habitat, especially in years favorable for large occurrence sizes.

Despite the on-going efforts of many agencies and individuals, numerous areas still need to be inventoried for this species. The susceptibility of the habitat to variations in yearly climatic conditions complicates completing inventories for this species. That is, during drier years, some potential sites won't have enough water to support a visible population, and even in those sites that do, the window of opportunity for finding plants is narrower and there may well be fewer plants.

41. Continue intensive surveys in the areas of known historical occurrences in California and Oregon (Priority 2).

The historically known sites in Oregon and California, or newly discovered sites in those states, would play a significant role in the long term management of this species.

42. Continue surveys for historical records in Washington (Priority 2 or 3).

Historically known occurrences in Mason and Thurston counties, Washington, should continue to be a priority for survey. If such occurrences are still extant, successful management of them would contribute significantly to recovery efforts.

43. Conduct *de ovo* inventories in suitable habitats throughout the remaining extant range (Priority 3).

Apparently suitable habitat remains to be inventoried for this species, primarily within the vicinities of the five general areas in which the species is currently extant. Finding additional occurrences could increase the chances of successful recovery of this species.

5. Evaluate the appropriateness and feasibility of reintroducing *Howellia aquatilis* into unoccupied areas of its former range, in consultation with all appropriate parties, after intensive surveys have confirmed extirpation.

Having self-sustaining populations of *Howellia aquatilis* distributed throughout its natural range would ensure the best chances for long term success with this species. However, prior to reintroducing the species to former sites, extirpation should be confirmed by intensive surveys.

51. If reintroduction is found to be appropriate and feasible, develop and implement a reintroduction plan (Priority 3).

Reintroduction should be pursued only if it follows a specific plan. Such a plan needs to include a methodology by which success or failure can be measured, identification of parties responsible, a commitment of funds adequate to optimize the chance of success, etc.

6. Disseminate information about the species to landowners and appropriate audiences.

Numerous individuals are directly or indirectly involved in the management of habitat for *Howellia aquatilis*. The better informed these individuals are regarding the species and its habitat requirements, the better the chances of successful recovery.

61. Develop and conduct training programs (e.g., to be given to wetland delineators, ecologists, and other concerned agency personnel, as well as private consultants and landowners, etc.) (Priority 3).

Numerous individuals conduct field work in habitats potentially suitable for *Howellia aquatilis*. A more complete inventory of habitats could be accomplished through training these individuals in the recognition of *Howellia aquatilis* and its habitats.

611. Conduct training for appropriate field personnel in Oregon and California.

Inventories for *Howellia aquatilis* will be more effective if those conducting the inventories are familiar with the species and the variety of habitats within which it has been found. Oregon and California should be targeted because of the historic presence of the species and the potential availability of at least some suitable habitat.

62. Develop a brochure or fact sheet for public dissemination, and provide presentations as appropriate (Priority 3).

Efforts to manage this species and its habitat would benefit from an interested, well-informed public.

63. Develop and disseminate species information to non-federal landowners and managers of *Howellia aquatilis* habitat (Priority 3).

The cooperation of private landowners will be essential to the success of this recovery effort. To that end, the more knowledgeable these individuals are, the better able they will be to manage their individual sites in a compatible manner.

631. Provide information to private landowners in Washington who are applying for timber harvest permits on their lands.

Private landowners in Washington planning to harvest timber from their property must apply to the Department of Natural Resources for a permit. All such applications are routinely checked against the Natural Heritage database. The forest practices regulations in Washington do not allow the DNR to condition applications, but the process provides an opportunity to present the landowner with information about rare species that are, or that may be, present and to make recommendations regarding protection. This process is strictly voluntary on the part of the landowner; the DNR does not have the authority to require the landowner to alter their harvest plan to provide protection specifically for rare plants, including *Howellia aquatilis*.

632. Provide information to the public, as requested, through the state Natural Heritage Programs and other appropriate agencies.

An understanding of the need to protect and preserve *Howellia aquatilis* by the general public, particularly within the geographic areas in which it occurs, is desirable.

7. Establish a technical working group to periodically review the status of the species and assess the effectiveness of management plans and other recovery tasks (Priority 2).

In order to ensure the success of recovery efforts, some oversight of the progress being made is necessary. Through periodic review, improvements to the overall recovery effort can be made, thereby accelerating recovery.

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III. IMPLEMENTATION SCHEDULE

The Implementation Schedule that follows (p. 45) outlines actions and estimated costs for the recovery program. It is a guide for meeting the objective discussed in Part II of this Plan. This schedule indicates task priorities, task numbers, task descriptions, duration of tasks, the responsible agencies, and lastly, estimated costs. These actions, when accomplished, should bring about the recovery of the species and protect its habitat. It should be noted that the estimated monetary needs for all parties involved in recovery are identified and, therefore, Part III reflects the total estimated financial requirements for the recovery of this species.

Priorities in the first column of the implementation schedule are assigned as follows:

1. **Priority 1** - An action that **must** be taken to prevent extinction or to prevent the species from declining irreversibly in the **foreseeable** future.

2. **Priority 2** - An action that must be taken to prevent a significant decline in species population/habitat quality, or some other significant negative impact short of extinction.

3. **Priority 3** - All other actions necessary to meet the recovery objectives.

Draft Recovery Plan Implementation Schedule for Water Howellia (*Howellia aquatilis*)

Priority	Task #	Task Description	Task Duration	Agency	Total Cost[1]	Comments
1	11.	Develop and implement habitat management plans that sustain *Howellia aquatilis* occurrences on federal lands (provide list of considerations to be addressed in the plans to each agency).	Ongoing	All federal	$24	Some management plans have already been written, others are in preparation, and others may need to be revised. Plans will need to be flexible in order to be responsive to research and monitoring.
1	111.	Conservation strategy, Flathead National Forest	Ongoing	USFS		Conservation Strategy completed; currently being implemented.
1	112.	Management plan, Turnbull NWR	Ongoing	USFWS		Land management plan underway.
1	113.	Management plan, Ridgefield NWR	Ongoing	USFWS		Population occurs within established Research Natural Area.
1	114.	Management plan, McChord AFB	Ongoing	DOD		Special management designation is being considered for the area that harbors *Howellia aquatilis*.
1	115.	Management plan, Fort Lewis Military Reservation	Ongoing	DOD		Two year inventory and management recommendation project underway; will lead to development of management plan.
1	116.	Management plan, Spokane District, Bureau of Land Management	Ongoing	BLM		Land management plan currently being developed.
2	12.	Promote protection of key occurrences on non-federal lands, including those that are within metapopulations, as well as significant outlying geographic extensions.	Ongoing	-	$0	Although not part of the recovery criteria, protection on non-federal lands will contribute significantly to conservation of the species.
3	13.	Promote special management designations (e.g., Research Natural Areas, Botanical Special Interest Areas) on federal lands.	Ongoing	Federal agencies	$0	
2	14.	Pursue appropriate protections under Section 404.	Ongoing	USACE	$0	This is an ongoing responsibility of the Army Corps.

[1] Cost figures which are blocked are tallied to determine the recovery cost total. Some are followed by subcost estimates.

2	22.	Promote development and implementation of new laws for the protection of *H. aquatilis* in those states not now offering statutory protection.	Ongoing	USFWS, State agencies	$0	
2	31.	Conduct research necessary to identify the habitat conditions needed to maintain natural populations.	Minimum of 5 years	Federal agencies	$90	Information gained from this research should feed back into habitat management plans (see Task 11).
2	311.	Conduct study of seasonal and cyclic hydrologic characteristics of occupied habitat.	5 years	Federal agencies	$25	Sites from all geographic areas should be studied over a 5-year period.
2	312.	Determine which occurrences are hydrologically linked and characterize the nature of the relationship.	2-5 years	Federal agencies	$10	Will entail a review of existing information, analysis, and subsequent report preparation.
2	313.	Evaluate successional dynamics of upland community types surrounding occupied *H. aquatilis* habitat, and how those dynamics may affect the species.	3-5 years	Federal agencies	$10	
2	314.	Evaluate successional dynamics of occupied wetland vegetation types.	3-5 years	Federal agencies	$20	
2	315.	Determine the relationship between *H. aquatilis* abundance and nutrient availability in wetland substrates and surface water.	1-3 years	Federal agencies	$10	
2	316.	Determine optimum physical characteristics of the associated habitat features.	1-2 years	Federal agencies		
2	32.	Conduct research and monitoring necessary to elucidate threats, as well as the response of the species to specific management actions.	5-10 years	Federal agencies	$180	Information gained from this research should feed back into individual mangement plans.
2	321.	Forest management practices (road building, timber harvest, fire).	5-10 years	USFS, USDOD	$50	
2	322.	Grazing.	5-10 years.	BLM, USFS, USFWS	$50	
2	323.	Military training activities.	1-2 years	USDOD	$10	

2	324.	Elucidate the effects of spread of *Phalaris arundinacea* on *H. aquatilis* occurrence trends and develop management practices as needed.	5-10 years	USFWS, USDOD	$50	
2	325.	Assess the effect of predation and disease on the species, especially seeds and seedlings.	3-5 years	Federal agencies	$20	
2	33.	Conduct monitoring to assess occurrence trends.	Ongoing	All federal agencies	$140	Trend information should be used to guide management actions.
2	34.	Conduct necessary research to determine critical aspects of species' biology.	5-10 years	Federal agencies	$45	Information gained should be used to help guide management.
2	341.	Genetic variation, within core areas/metapopulations and across the species' range.	1-2 years	Federal agencies	$20	
2	342.	Mechanisms of seed dispersal.	1-2 years	Federal agencies	$10	
2	343.	Longevity of seed viability.	1-2 years	Federal agencies	$5	
2	344.	Relative contributions of submergent and emergent fruits to the seed bank, and assess possible variation in seed germination biology from each fruit type.	1-2 years	Federal agencies	$10	
2	41.	Conduct intensive surveys in the areas of known historical occurrence in California and Oregon.	Min. 3-5 years	USFWS, State agencies	$20	
2	42.	Continue efforts to relocate historically known occurrences in Washington.	Ongoing	USFWS, WANHP	$10	
3	43.	Conduct *de novo* inventories in suitable habitats throughout the remaining extant range.	Ongoing	USFWS, State agencies	$10	
3	51.	If reintroduction is found to be appropriate and feasible, a reintroduction plan will be developed and implemented.	Ongoing	Federal agencies	$50-100	

3	61.	Develop and conduct training programs (e.g., to be given for wetland delineation, ecology, and other concerned agency personnel, as well as private landowners, etc.).	Periodical	USFWS, State agencies	$2.5
3	611.	Conduct training for appropriate field personnel in Oregon and California.	1-2 years	Federal & State agencies	$2.5
3	62.	Develop a brochure or fact sheet for public dissemination, and provide presentations as appropriate.	Ongoing	Federal & State agencies	$2.5
3	63.	Develop and disseminate species information to private landowners.	Ongoing	Federal & State agencies	$0
3	631.	Provide information to private landowners in Washington who are applying for timber harvest permits on their lands.	Ongoing	WANHP	$0
3	632.	Provide information to the public, as requested, through the state Natural Heritage Programs and other appropriate agencies.	Ongoing	Federal & State agencies	$0
2	7.	Establish a technical working group, to periodically review the status of the species and assess the effectiveness of the management plans and other recovery tasks.	Ongoing	USFWS & other federal agencies	$0

Cost Totals: $574-624*

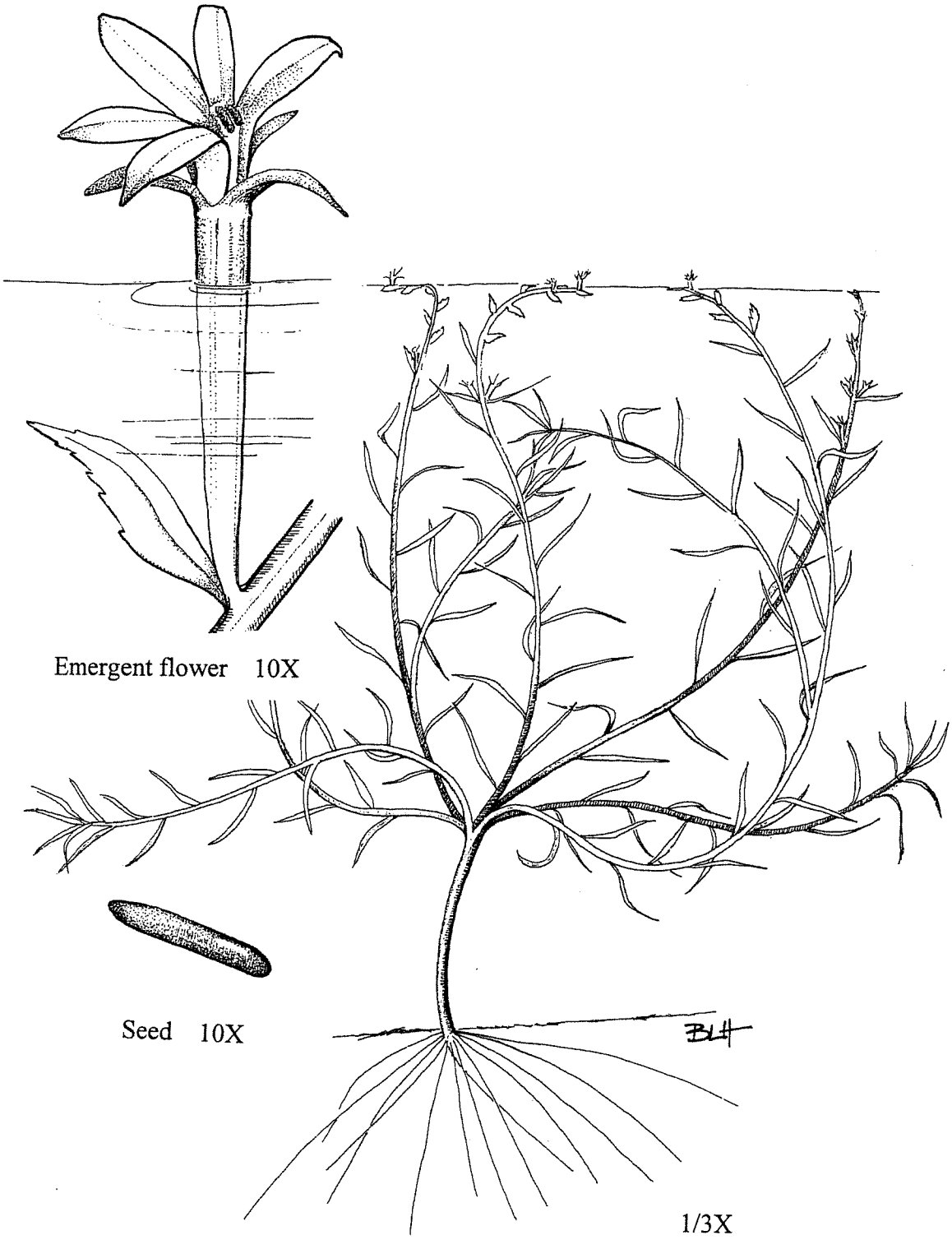


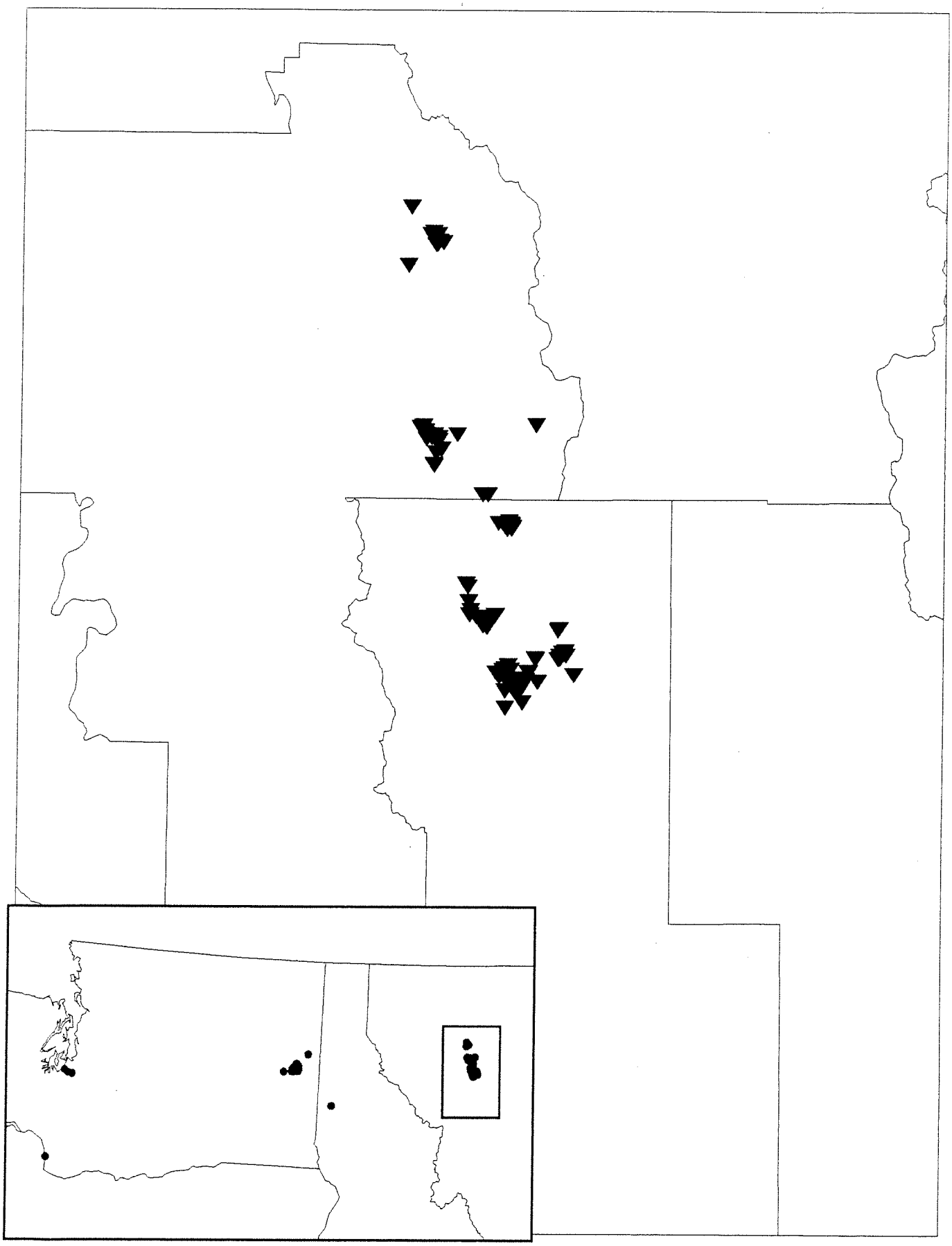
Figure 1. ***Howellia aquatilis***

Figure 2. Rangewide Distribution of Howellia aquatilis (extant)

Sources: Montana Natural Heritage Program, Idaho Conservation Data Center, Washington Natural Heritage Program.

January, 1996

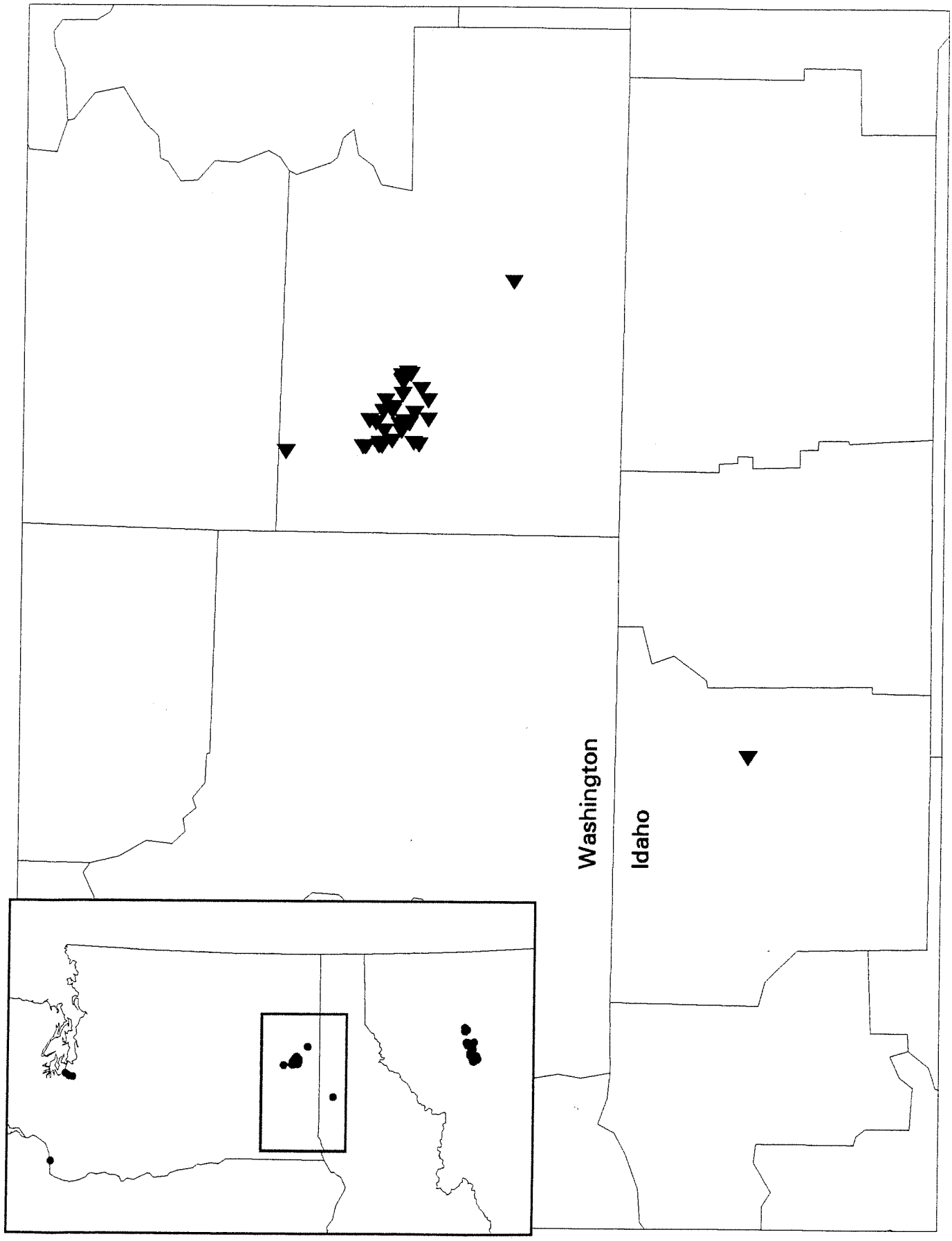
Figure 3. Distribution of Howellia aquatilis in Montana



Source: Montana Natural Heritage Program.

January, 1996

Figure 4. Distribution of Howellia aquatilis in eastern Washington



Source: Washington Natural Heritage Program.

January, 1996

V. APPENDICES

APPENDIX A. Land Ownership

Rangewide Summary

Rangewide, the 153 known occurrences of *Howellia aquatilis* occur on lands owned or managed by the following:

United States government (102 total):
- USDA Forest Service: 62
- USDI Bureau of Land Management: 1
- USDI Fish and Wildlife Service: 34
- USDOD McChord Air Force Base: 1
- USDOD Fort Lewis: 4

Plum Creek Timber Company: 16

State of Washington: 1

Private, non-corporate, landowners: 29

Joint ownership:
- USDA Forest Service and private landowners: 2
- USDA Forest Service and Plum Creek Timber Company: 2
- USDA Forest Service and The Nature Conservancy: 1

APPENDIX B. Federal and State laws applicable to the protection of *Howellia aquatilis* and its habitat

U.S. Fish & Wildlife Service: **Listed Threatened** (U.S. Fish and Wildlife Service 1994).

U.S. Forest Service: **Sensitive** in Regions 1 and 6 (those species identified by a Regional Forester for which population viability is a concern, as evidenced by: a.) significant current or predicted downward trends in population numbers or density, and/or; b.) significant current or predicted downward trends in habitat capability that would reduce a species' existing distribution (FSM 2670.5.19). The objectives of management for such species are to ensure their continued viability throughout their range on National Forest lands, and to ensure that they do not become threatened or endangered because of Forest Service actions (FSM 2670.22).

States: **Montana: Threatened** (likely to become endangered throughout all or a significant portion of its range in Montana in the foreseeable future; specific threats to known occurrences have been identified (unofficial designation; (Lesica and Shelly 1991)); S2 (Montana Natural Heritage Program 1995).

Idaho: Federally listed as threatened (no state status assigned by Idaho Native Plant Society); S1 (Idaho Conservation Data Center 1994).

Washington: Endangered (in danger of becoming extinct or extirpated in Washington within the near future if factors contributing to its decline continue. Populations are at critically low levels or habitats have been degraded or depleted to a significant degree (Washington Natural Heritage Program 1994)).

California: List 1A (plants presumed extinct in California (Skinner and Pavlik 1994)).

Oregon: List 1-ex (taxa threatened throughout range), and possibly extirpated from the state (Oregon Natural Heritage Data Program 1995).

TNC: **G2** (imperiled globally).