



Monitoring Select Occurrences of *Howellia aquatilis*  
(water howellia) in Washington Prior to Delisting from  
the Endangered Species Act (1978-2021)

Prepared for  
U.S. Fish and Wildlife Service, Region

Prepared by  
Sienna Wessel and Walter Fertig  
19 March 2024

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Cover: Seasonally flooded wetland habitat of *Howellia aquatilis* (water howellia). Photo by Joe Arnett, former WNHP botanist; Emergent chasmogamous flowers of *Howellia aquatilis*. Photo by Walter Fertig, former WNHP botanist

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## Executive Summary

*Howellia aquatilis* (water howellia) is an aquatic annual plant that is endemic to the Pacific Northwest and is known to occur at 73 occurrences in Washington state. This species was delisted by the U.S. Fish and Wildlife Service in 2021 but remains a G3/S2 Threatened species in Washington state. A post-delisting monitoring plan has since been established which includes 30 Washington occurrences to track future population trends and determine if federal delisting remains appropriate. This report, which is the first of a two-part series, reviews historical trends for *Howellia aquatilis* occurrences in Washington up to 2021 and establishes updated baseline counts based on field surveys conducted in 2020 and 2021 in support of future interpretations of post-delisting monitoring data. *Howellia aquatilis* appears to be stable in Washington, with the number of statewide individuals estimated at 11,590-13,583. More occurrences have experienced at least slight increases in number both over the last 10 years (16%) and over the long-term (41%) than have experienced declines (10-yr 8%, long term 30%) and the viability of most occurrences with current survey data (45%) ranks as “Excellent” to “Good/Fair”. However, population sizes and trends differ across ecoregions and land management agencies and there are persistent threats at the occurrence level which should be addressed to ensure the long-term survival of *Howellia aquatilis* in Washington. Larger counts and upward trends were recorded in the Puget Trough and on U.S. Department of Defense and U.S. Fish and Wildlife Service managed lands where the abundance of the exotic grass *Phalaris arundinacea* (reed canary grass) is minimal to none. Declines are occurring in the Columbia Plateau on private lands and lands managed by the Washington Department of Natural Resources and Department of Fish and Wildlife and at occurrences with high exotic species cover. Additionally, up to 30% of occurrences (22/73) may now be extirpated but need resurvey to confirm the status.

## Introduction

### Species Description

*Howellia aquatilis* is a globally rare aquatic annual herb in the Campanulaceae (bellflower family) with slender stems that are submerged and rooted in mud or free-floating on the surface of water (U.S. Fish and Wildlife Service, 1996; Washington Natural Heritage Program, 2023). It is endemic to northwestern North America and is dependent on seasonally flooded ponds that have an annual cycle of filling with water from melting snow and spring rains and then drying partially or completely in the late summer and early fall. Its self-pollinated cleistogamous flowers, which produce most of the seeds, require submergence while seed germination requires exposed but moist mudflats (Kleinknecht et al., 2019; Lesica, 1992; Lesica et al., 1988). A second set of chasmogamous out-crossing flowers emerge just above the surface of the water in May through June (Washington Natural Heritage Program, 2023). The scattered distribution, narrow ecological requirements, limited dispersal ability, and low genetic diversity of this species have put it at high risk of extinction both across its range and in the state of Washington (Lesica et al., 1988; Mincemoyer, 2005).

## Distribution

*Howellia aquatilis* occurs sporadically across Washington, northern Idaho, western Montana, western Oregon, and northern California (Washington Natural Heritage Program, 2023). In Washington, extant occurrences are found in Clark, Pierce, Spokane, and Thurston counties, occurring both in the lowlands west of the Cascade Range in the Puget Trough ecoregion and in the channeled scablands of the Columbia Basin in eastern Washington (U.S. Fish and Wildlife Service, 1996). Of the minimum 307 reported global occurrences of *Howellia aquatilis*, 73 (24%) occur in Washington state (U.S. Fish and Wildlife Service, 2020).

## History in Washington

*Howellia aquatilis* was first collected on the west side of Washington state on June 20, 1937 by John Rudd from a roadside pond in or near Millersylvania State Park in Thurston County (U.S. Fish and Wildlife Service, 1996). A second collection was made soon after in Mason County from an occurrence that is now presumed to be extirpated. More than 40 years passed before several occurrences were discovered and vouchered in eastern Washington in Spokane County by former Washington Natural Heritage botanist John Gamon. Additional occurrences were soon discovered at the Ridgefield National Wildlife Refuge in Clark County by Lois Kemp and on Turnbull National Wildlife Refuge land by USFWS biologists. In 1994, *Howellia aquatilis* was located within Joint Base Lewis-McChord (JBLM) in Pierce County. Today, *Howellia aquatilis* is known from 73 occurrences in Washington separated by distances ranging from 0.1-287 mi/0.16-463 km. Of these occurrences, 13 have not been revisited since before 2000 and 11 were not successfully relocated in recent surveys and may now be extirpated.

## Washington Habitat

*Howellia aquatilis* has a very narrow ecological niche in the emergent portion of ephemeral ponds where the water level is not too shallow nor too deep (no more than 3-6 feet deep; U.S. Fish and Wildlife Service, 1999). Its dependence on habitat in a narrow ecotone between wetlands and uplands contributes to its rarity. In Washington, it is found in small vernal ponds produced as a result of glacial activity and wetlands associated with channeled scablands (Fertig, 2021). It occurs in the North American Arid West Emergent Marsh; Northern Columbia Plateau Basalt Pothole Ponds; North Pacific Shrub Swamp; and Temperate Pacific Freshwater Emergent Marsh ecological systems (Rocchio & Crawford, 2015).

## Protected Areas

In Washington, *Howellia aquatilis* is found in Blackwater Island Research Natural Area, Dishman Hills Natural Resources Conservation Area, Joint Base Lewis-McChord, Pine Creek Research Natural Area, Ridgefield National Wildlife Refuge, Scatter Creek Wildlife Area, Spokane BLM, and Turnbull National Wildlife Refuge (Washington Natural Heritage Program, 2023). Overall, 85% of *Howellia aquatilis* occurrences in Washington occur on public lands which have management plans in place. For example, the Endangered Species Management Plan for *Howellia aquatilis* in

Joint Base Lewis-McChord prohibits military training within 165 ft of *Howellia aquatilis* habitat (Environmental Division Directorate of Public Works, 2017). The Turnbull National Wildlife Refuge Habitat Management Plan similarly requires all wetlands to be surveyed for *Howellia aquatilis* prior to manipulation for restoration work or exotic species control so that potential harms can be mitigated (U.S. Fish and Wildlife Service, 1999).

However, occurrence on public land does not guarantee species protection and occurrences in Washington are still potentially subject to recreation impacts, timber harvest activities, military exercises, and livestock grazing (Table 1). Only 38 occurrences (53%) are located within sites with official protections for *Howellia aquatilis* (Fertig and Kleinknecht 2022), including Blackwater Island and Pine Creek Research Natural Areas (USFWS), Ridgefield and Turnbull National Wildlife Refuges (USFWS), Scatter Creek Wildlife Area (WDFW), and Dishman Hills Natural Resources Conservation Area (WDNR). The other 15% of occurrences are on lands that are privately owned or are under unknown management and are likely to be at greater risk than those with management plans or special protections in place.

### Legal Status

*Howellia aquatilis* was formerly listed as a Threatened species under the Endangered Species Act (ESA) in 1994 (US Fish and Wildlife Service 1994). In 2013, USFWS issued a five-year review of the status of *Howellia aquatilis*. The Service concluded that *Howellia aquatilis* was more common and widespread and less threatened than originally suspected and no longer warranted listing under the Endangered Species Act (US Fish and Wildlife Service 2013). A formal proposal for delisting was published by USFWS in October 2019 and a final ruling issued in June 2021, which took effect in July of 2021 (US Fish and Wildlife Service 2019, 2021). Though *Howellia aquatilis* is more abundant than when it was listed under the ESA, the species is still relatively rare, often with very small population sizes, and its habitat is expected to be especially sensitive to the effects of climate change (Kleinknecht et al., 2019). Therefore, it remains ranked as a G3/S2 Threatened species in Washington (Washington Natural Heritage Program, 2023) and is listed as a sensitive species by the Bureau of Land Management and U.S. Forest Service.

### Project Objectives

In accordance with Section 4(g) of the Endangered Species Act of 1973, the U.S. Fish and Wildlife Service developed a post-delisting monitoring (PDM) plan and associated protocol for *Howellia aquatilis* in cooperation with conservation partners which was published in 2020 (U.S. Fish and Wildlife Service, 2020). The goal of the monitoring plan is to revisit a minimum of 60 of the 307 known *Howellia aquatilis* occurrences across its range, with a minimum of 30 being from Washington. The high number of Washington occurrences selected for monitoring is commensurate to the proportion of the entire range of *Howellia aquatilis* occurrences which are in the state. The post-delisting plan states that monitoring data are to be compiled and analyzed at metapopulation levels at six timepoints over 15 years to determine if populations are declining, increasing, or remaining stable at each occurrence and across the entire



species range. If declines are detected at more than 33% of occurrences during monitoring, another full status review of *Howellia aquatilis* may be triggered (U.S. Fish and Wildlife Service, 2020).

Thirty occurrences were selected for post-delisting monitoring of *Howellia aquatilis* in Washington starting in 2022. These include 11 occurrences at Joint Base Lewis-McChord (JBLM), one at Ridgefield National Wildlife Refuge, 11 from Turnbull National Wildlife Refuge (NWR), three from Washington Department of Natural Resources (DNR) lands and private lands near Spokane, and three others from Dishman Hills National Resource Conservation Area, Hog Lake (Bureau of Land Management), and Scatter Creek State Wildlife Area. These occurrences were selected based on their history of consistent monitoring and their representation of *Howellia aquatilis* habitat and geographic locations. Monitoring data has been collected for years 1 and 2 post-delisting and is planned for years 7, 8, 14 and 15. Protocols employ qualitative abundance categories (none, <50 plants, 50-100 plants, > 100 plants) within quarter-acre survey subdivisions and include additional photo monitoring of habitat condition, qualitative assessment of competing *Phalaris arundinacea* (reed canary grass) cover, and measurements of water depths.

As of 2019, trend data were lacking or incomplete for approximately 40% of all Washington occurrences of *Howellia aquatilis* (Fertig, 2021). The purpose of this project is to add additional years of census estimates to existing datasets and to establish an updated baseline up to the point of federal delisting in 2021. This report, which is the first part of a two-part series, will describe historical trends of *Howellia aquatilis* occurrences in Washington and provide an updated status report to inform future post-delisting monitoring comparisons and conclusions. The second report of this series will review the results of years 1 and 2 of occurrence data collected using the standardized post-delisting monitoring protocols outlined above.

## Methods and Data Caveats

Element occurrence data collection was conducted by the Washington Natural Heritage Program (WNHP) and program partners following NatureServe data standards between 1978 and 2021. Element occurrences are mappable areas of species presence which have practical conservation value and may include an entire population, part of a population, or a closely located group of populations (metapopulation) depending on the distance of unsuitable habitat in between (NatureServe 2002). The default distance used for plants is 1km, but occurrences of the wetland obligate *Howellia aquatilis* are distinguished by uplands which separate the individual ponds where it is found. A comprehensive survey of wetland habitat and a census of *Howellia aquatilis* individuals was conducted at each of 73 known occurrences during field visits whenever possible, though some descriptive estimates or partial surveys were recorded due to challenges with site access, field hazards, or time constraints. Field surveys took place between June and July of each survey year to capture *Howellia aquatilis* when emergent chasmogamous flowers were at their peak and most visible. Incomplete pond surveys are noted in data tables (Table 3).

Individuals of *Howellia aquatilis* are very challenging to distinguish and define due to the branching, matted growth habit of the species but were generally considered to be separate if rooted separately or floating as a distinct, fragmented ramet. The delineation of individuals is further complicated by poor visibility at most ponds and the ability of broken stems to persist and reproduce. These challenges should be considered when interpreting the raw census counts which were collected prior to delisting and are the basis for this report. Post-delisting monitoring protocols call for the use of binned estimates for these reasons. Additionally, *Howellia aquatilis* occurrences in Washington are separated and delineated by individual ponds due to dispersal constraints of the seasonal wetland-obligate species, rather than the standard 1.5 km minimum distance criteria set by NatureServe. If individual ponds were aggregated into larger “metapopulations” by this distance criteria, occurrences would be reduced from 73 to as few as 10-12 in Washington (Fertig 2021).

Quantitative estimates of *Howellia aquatilis* counts were used for data analysis and visualization, and qualitative/descriptive estimates (e.g., “few individuals”) were considered in the general discussion of occurrence counts and trends. All values recorded as ranges to capture uncertainty were converted to the midpoint prior to any quantitative analysis. Abundance estimates of the exotic competitor *Phalaris arundinacea* (reed canary grass) were derived from field notes or cover estimates and then converted to a categorical abundance (Table 2) in congruence with post-delisting monitoring protocols developed for *Howellia aquatilis* (U.S. Fish and Wildlife Service, 2020).

Differences in survey approach, intensity, precision, and delineation of “individuals” across occurrences and through time are expected to impact census estimates, therefore the trends described in the report should be interpreted with extra caution. The most recent estimates recorded at each of the 30 occurrences selected for post-delisting monitoring represent the highest quality quantitative data available for assessing the status of *Howellia aquatilis* in Washington up to 2021. Data collected prior to 2000 or at other occurrences are typically sparse, quantitative estimates that are frequently derived from incomplete surveys which are less precise. However, these data were not excluded from analyses in this report because general conclusions remained the same regardless of inclusion.

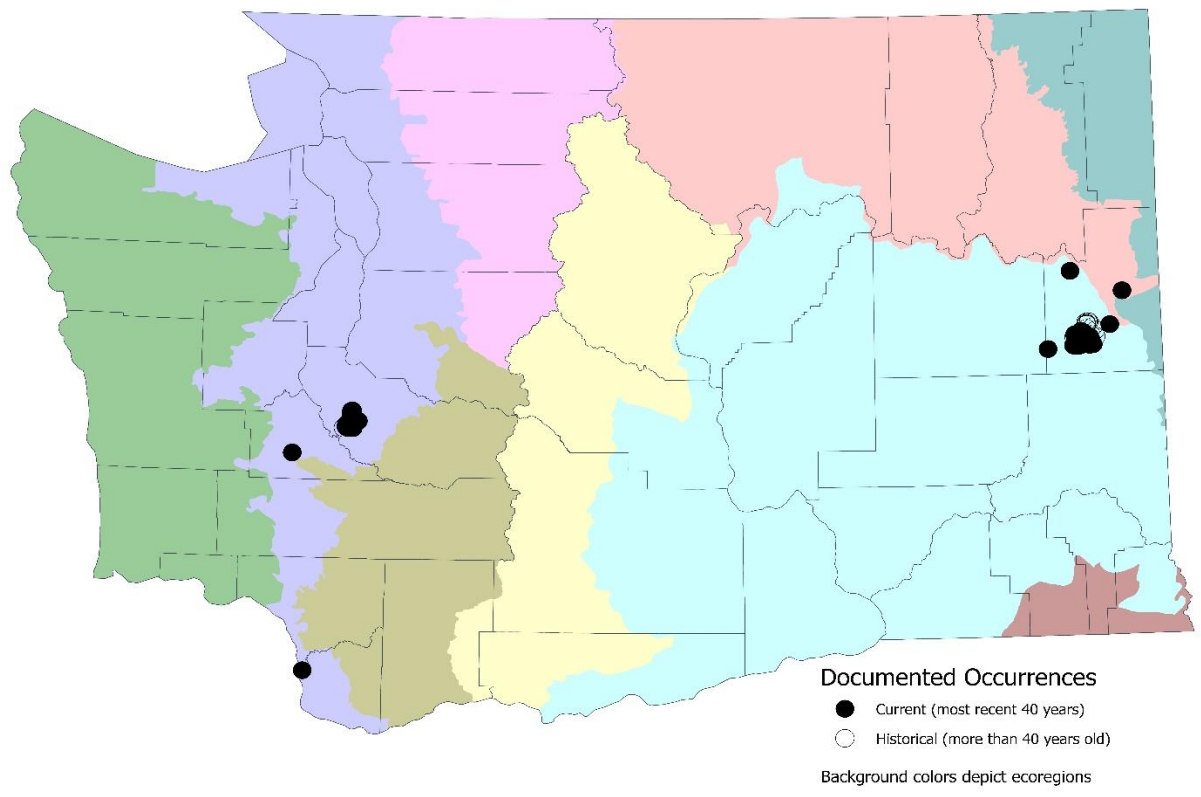
Information on the distribution, habitat, population size, and life history of *Howellia aquatilis* was derived from scientific literature, published reports, field notes, and WNHP databases. Maps and census data for current and historical occurrences were derived from the WNHP Biotics database. Element occurrence ranks were calculated by the Washington Natural Heritage Program following NatureServe guidelines and definitions (Hammerson et al., 2010). Ranks are assigned based on estimated viability of an occurrence which is determined by a combination of factors including population size, condition of the occupied habitat, and landscape context (e.g., proximity to development).

All but one occurrence selected for resurvey in 2020 and 2021 to establish updated baseline counts are among the 30 occurrences selected for post-delisting monitoring of *Howellia aquatilis* beginning in 2022. New surveys conducted for this

project in 2020 focused on revisits to 11 of 21 occurrences (52%) on Joint Base Lewis-McChord in Pierce County which were last visited in 2018: EO #39 Foot Lake, EO #43 Shaver Kettle, EO #44 Trench Wetland, EO #47 West Shaver Pond, EO #48 Crone Marsh, EO #49 Joseph Marsh, EO #53 Chambers East, EO #66 Willow Kettle, EO #71 Lynch, EO #72 Roy, and EO #74 Shaver Puddle. In 2021, five of 35 occurrences (15%) at the Turnbull National Wildlife Refuge in Spokane County were revisited for the first time since 2007-2009: EO #14 Squirrel View, EO #32 Pond 29 Turnbull NWR, EO #55 Turnbull NWR Pond 82, EO #57 Turnbull NWR Pond 32, and EO #58 Turnbull NWR Pond 120.

## Baseline Monitoring Results

**Known distribution of *Howellia aquatilis* in Washington**



**Figure 1. Washington distribution of *Howellia aquatilis*.** Map derived from Washington Natural Heritage Program element occurrence data (2024).

### Washington Element Occurrences

The 73 known occurrences of *Howellia aquatilis* in Washington (Figure 1) have been surveyed periodically between 1978 and 2021, with an average of four visits each (min=1, max=18). One additional historical observation from Mason County is presumed to be extirpated (Mincemoyer 2005; Washington Natural Heritage Program,

2023) and is not discussed further in this report. After the addition of 2020 and 2021 survey data, 54 occurrences (74%) have been confirmed extant as of 2000 with 29 (40%) relocated since 2010.

Most occurrences (50 of 73) are in Spokane County within the Columbia Plateau ecoregion in eastern Washington, with only 23 occurring in Pierce County within the Puget Trough ecoregion on the western side of the Cascade Range. Pond occurrences are separated by stretches of unsuitable upland habitat ranging from 0.1-287 mi/0.16-463 km in distance. One occurrence is located on Bureau of Land Management property, four are on lands managed by the Washington Department of Fish and Wildlife (DFW) or the Department of Natural Resources (DNR), 21 are on the Joint Base Lewis McChord (JBLM) managed by the U.S. Department of Defense, 36 are managed by the U.S. Fish and Wildlife Service (USFWS) with all but one located on the Turnbull National Wildlife Refuge (NWR), and 11 are on private property or are managed by an unknown entity.

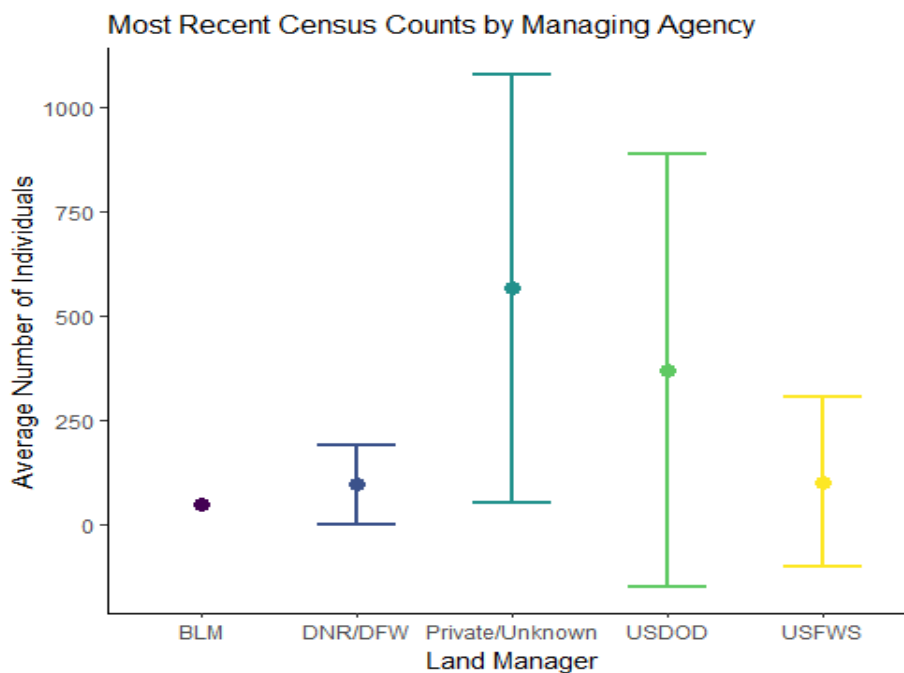
Powder Factory (EO #64) is the only occurrence in Thurston County and Blackwater Island Research Natural Area (EO #2) is the only occurrence in Clark County. These may be important population strongholds at the regional level. No quantitative estimates have been recorded at the Powder Factory occurrence but field notes describe a very small occurrence that has not been revisited since 2008. Blackwater Island appears to be a comparatively viable occurrence with a recent 2018 estimate of 500 individuals.

### Census Counts

In 2020, 11 occurrences were censused and a total of 7,409 individuals of *Howellia aquatilis* were counted with an average of 674 individuals. This represents an increase from 2018 estimates which reported 3,909 total individuals with an average count of 391 over 10 occurrences, most of which were the same occurrences surveyed in 2020 (Fertig, 2021). Only five occurrences (previously monitored between 2007 and 2009) were revisited in 2021. At three of these occurrences, no individuals were successfully found, one occurrence survey reported five individuals, and the other reported 1000 individuals.

Assuming no major changes to threats or population sizes, there were 11,590-13,583 *Howellia aquatilis* individuals in Washington as of 2021, according to the last recorded estimates for all known occurrences with the low-end estimate including only counts recorded since 2000 and the high-end estimate including all most recent counts regardless of year last censused (1986-2021). These values are within the mid-range estimates from the last comprehensive statewide tabulated census report for Washington which estimated 6,724-37,694 plants statewide for an average of 137-769 plants per occurrence (Mincemoyer 2005). Most *Howellia aquatilis* individuals are in the Puget Trough ecoregion in western Washington (8,265 individuals) in comparison to the Columbia Plateau ecoregion (5,318 individuals) on the eastern side, even though more occurrences are in the Columbia Plateau (50) versus the Puget Trough (23). Accordingly, counts as of last census are larger for occurrences in the Puget Trough ecoregion (average=376) than the Columbia Plateau ecoregion (average=126).

The majority of *Howellia aquatilis* individuals in Washington are located at JBLM on USDOD land (7,765 individuals) and Turnbull NWR on USFWS land (3,779 individuals), followed by lands with private or unknown ownership (1700+ individuals). The most recent census counts recorded at each occurrence (1987-2021) range from 0-2000 individuals with an average count of 238 individuals. The largest average counts occurred on lands with private or unknown ownership (567 individuals), followed by USDOD (370 individuals) and USFWS (105 individuals) occurrences (Figure 2). DNR/DFW counts (96 individuals) were only marginally smaller than those recorded at USFWS occurrences. However, counts for occurrences on land with private or unknown ownership should be interpreted with great caution as most have not been visited since the 1980s or 1990s and very little quantitative data was able to be extracted from descriptive qualitative estimates (e.g., “small population”; Table 3). The smallest average census count was for the single occurrence on BLM land (50 individuals).



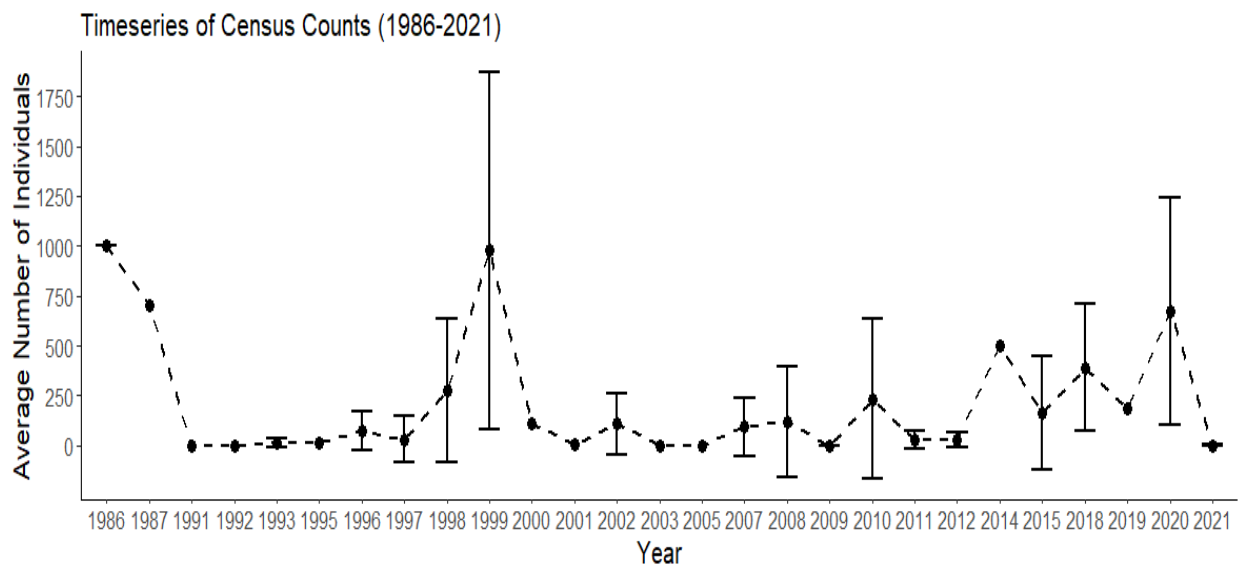
**Figure 2. Most recent average *Howellia aquatilis* census counts by managing agency** showing average counts, or mean number of individuals, with the standard error across occurrences. The year of the last survey ranges from 1986 to 2021, with most recent surveys occurring since 2000 (74%). Only years with numeric counts are included. When counts were recorded as ranges, the midpoint was used.

Importantly, 13 occurrences (18%) have not been revisited since before 2000 and 12 occurrences (16%) have not been successfully relocated in recent surveys and may now be extirpated. At occurrences with more recent survey data, individual census counts remain concerningly small; of the 54 occurrences that have been successfully relocated since 2000, 33 (62%) contained fewer than 100 plants as of their most recent monitoring visit (Table 2). Occurrences should have more than 100 individuals for *Howellia aquatilis* to be considered in high abundance per post-delisting monitoring protocols (U.S. Fish and Wildlife Service, 2020). Small populations may be at risk of

extinction after one major disturbance event and could be at risk of genetic drift and inbreeding depression.

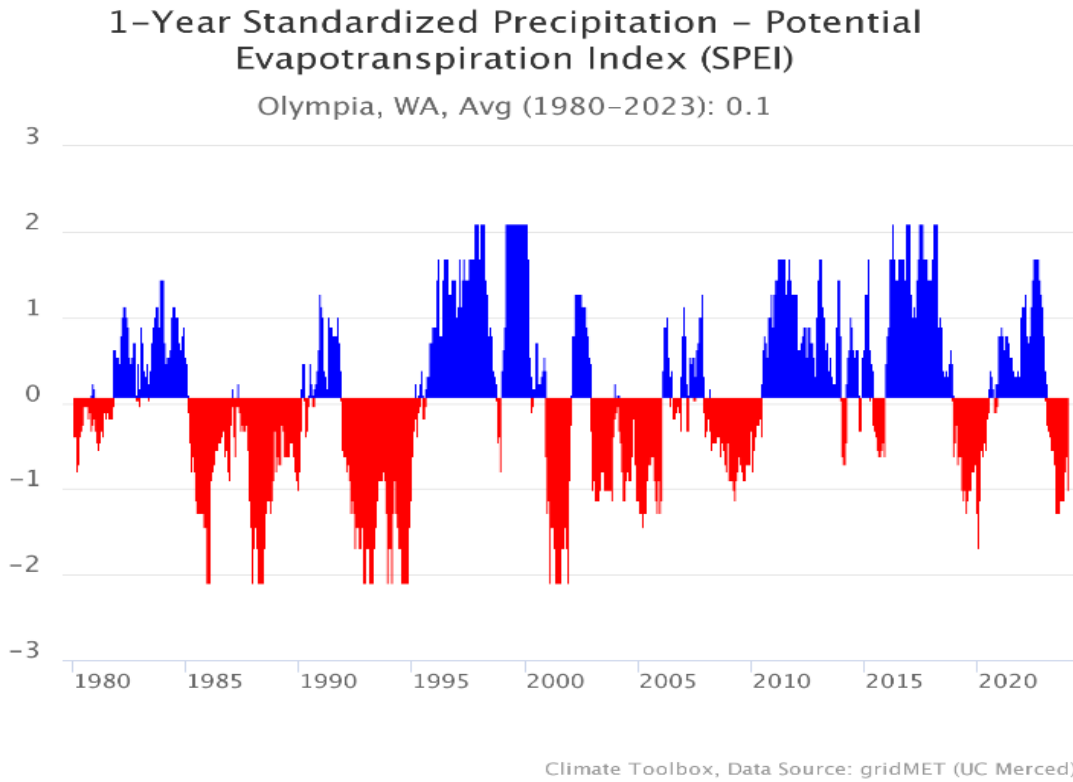
### Statewide Occurrence Trends in Washington

Overall, the number of *Howellia aquatilis* individuals at each Washington occurrence has exhibited more interannual fluctuation oscillating around a relatively stable mean than monotonic change in a single direction (Figure 3). As *Howellia aquatilis* is an annual species, such fluctuations are not surprising and can be related to density dependent growth rates, climatic variability, and changing pond hydrology (Lesica, 1992; Mincemoyer, 2005; U.S. Fish and Wildlife Service, 1996). Despite the prevailing annual oscillations, a simple regression of census counts through time (1986-2021) reveals a marginal increase of approximately 6.5 individuals on average per year across all occurrences. Of the 73 known occurrences, counts at 30 occurrences (41%) have increased from first visits to the most recent visits by an average of 216 individuals while counts at 22 occurrences (30%) have decreased by an average of 275 individuals.



**Figure 3. Timeseries of *Howellia aquatilis* census counts from 1986-2021** showing average counts, or mean number of individuals, across the 73 monitored occurrences. Bars represent standard error. Only years with numeric counts are shown. When counts were recorded as ranges, the midpoint was taken.

Over just the last 10 years (2011-2021), 12 occurrences (16%) increased by an average of 221 individuals, and six occurrences (8%) decreased by an average of 95 individuals. Remaining occurrences experienced no change or did not have enough quantitative data to estimate change over the long term (1986-2021) or the last 10 years (2011-2021). Few occurrences were visited in 2021 and therefore 2021 census counts are probably not appropriate for year-to-year comparisons of averages and are not discussed further here.

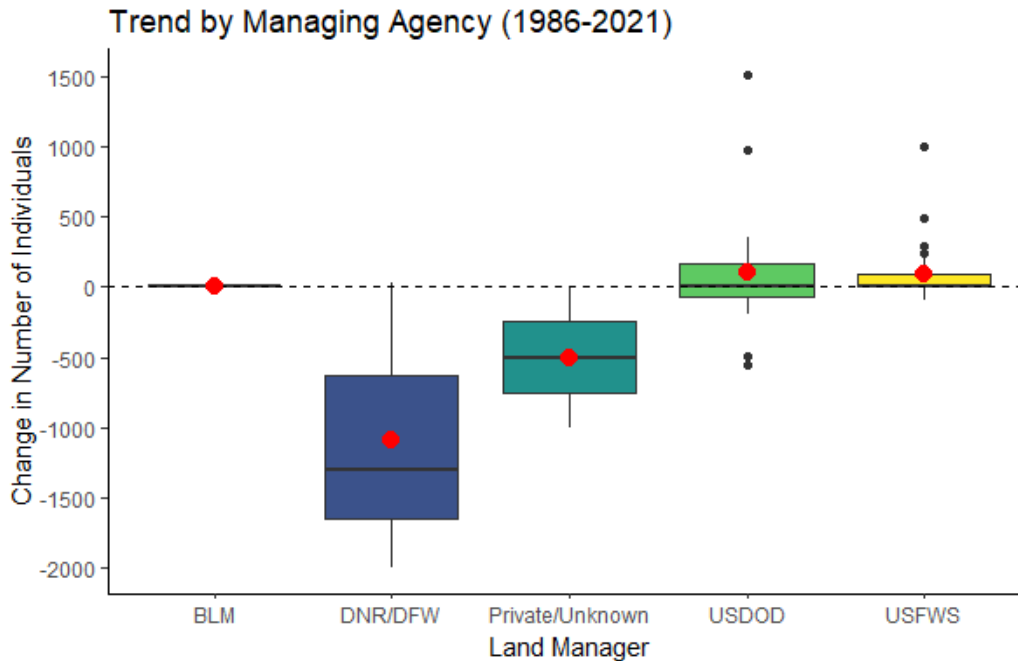


**Figure 4. Annual variation in the Standardized-Potential Evapotranspiration Index (SPEI) for Olympia, WA from 1980-2023.** Data were sourced and visualized using the “Historical Climate Tracker” tool from climatetoolbox.org (Hegewisch & Abatzoglou, 2023). SPEI is a drought index which takes into account both precipitation and potential evapotranspiration (Vicente-Serrano et al., 2010). Red years indicate more severe drought while blue years indicate less drought stress.

Census counts in Washington peaked in 1986 (average=1000), 1987 (average=700), 1999 (average=977), 2010 (average=583), 2014 (average=500), and 2020 (average=674). Years where counts of individuals were very low ( $\leq 5$  individuals) or no plants were successfully found include 1991, 1992, 2001, 2003, 2005, 2009, and 2021. General climatic trends were similar across the regions where the species occurs in Washington (Hegewisch & Abatzoglou, 2023). Peak and low counts (Figure 3) did not appear to couple as tightly with climatic variation (Figure 4) as anticipated based on known hydrologic relationships. However, peaks occurred with higher temperatures and slightly positive SPEI which represents less droughted conditions (Vicente-Serrano et al., 2010), though there did not appear to be a relationship between precipitation and peak counts. Other factors such as lag effects, demographic stochasticity, and challenges with survey standardization and visibility may have contributed to the fluctuating numbers observed. Future research should address these factors as well as the direct role of climatic variation at a finer scale. Pond drying transects established in congruence with post-delisting monitoring protocols (U.S. Fish and Wildlife Service, 2020) will help to further elucidate direct relationships between *Howellia aquatilis* and hydrological fluctuations.

## Trends by Agency and Ecoregion

The most recent available census data (Figure 2) reveals that BLM (average=50 individuals) and DNR/DFW (average=96 individuals) occurrences have some of the smallest counts, followed by USFWS occurrences (average=105 individuals). The largest counts were at privately owned occurrences (average=567 individuals) followed by USDOD occurrences (average=370 individuals).

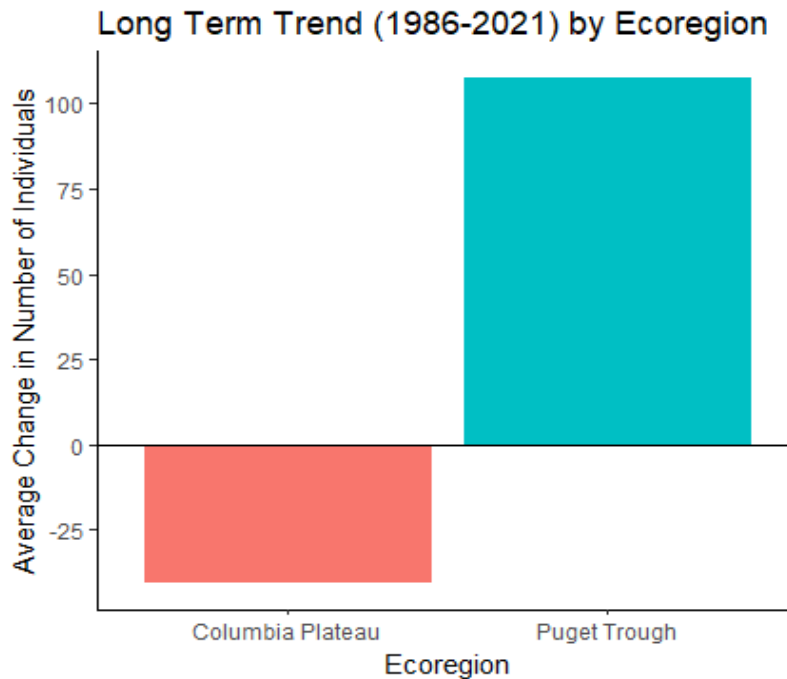


**Figure 5. Boxplots of average long term change in *Howellia aquatilis* counts by managing agency.** Long term changes were calculated as the difference between first census counts (recorded between 1986 and 2015) and most recent census counts (recorded between 1992 and 2021) regardless of year. Qualitative estimates were excluded from analysis and only years with numeric counts were used. When counts were recorded as ranges, the midpoint was taken for a data point. Values above the 0 line indicate increases in size, while values below the 0 line indicate decreases in size. Averages are indicated by red points while the median is indicated by a black line. Outliers are shown as black points.

USDOD occurrences have increased the most with 43% of occurrences experiencing long term increases (average=108; Figure 5), especially over the last 10 years (average increase=395 individuals). USFWS occurrences have increased similarly with 56% of occurrences increasing long-term (average increase=89) and a total average increase of 167 individuals over the last 10 years. BLM occurrences have remained unchanged over the long term but have experienced slight increases (average=+50 individuals) since the previous survey. Occurrences on DNR/DFW lands have decreased more than others over the long term (average=-1091 individuals) with only 25% of these occurrences increasing, followed by occurrences on privately owned lands which experienced no count increases (average=-500 individuals). Trends on private lands are heavily skewed by one data point (EO#5 Bretz Pothole, Table 3) that changed from an



estimate of “100s-1000s” to “not found” and should be interpreted with caution. The other occurrences on privately owned lands have not been revisited a second time.



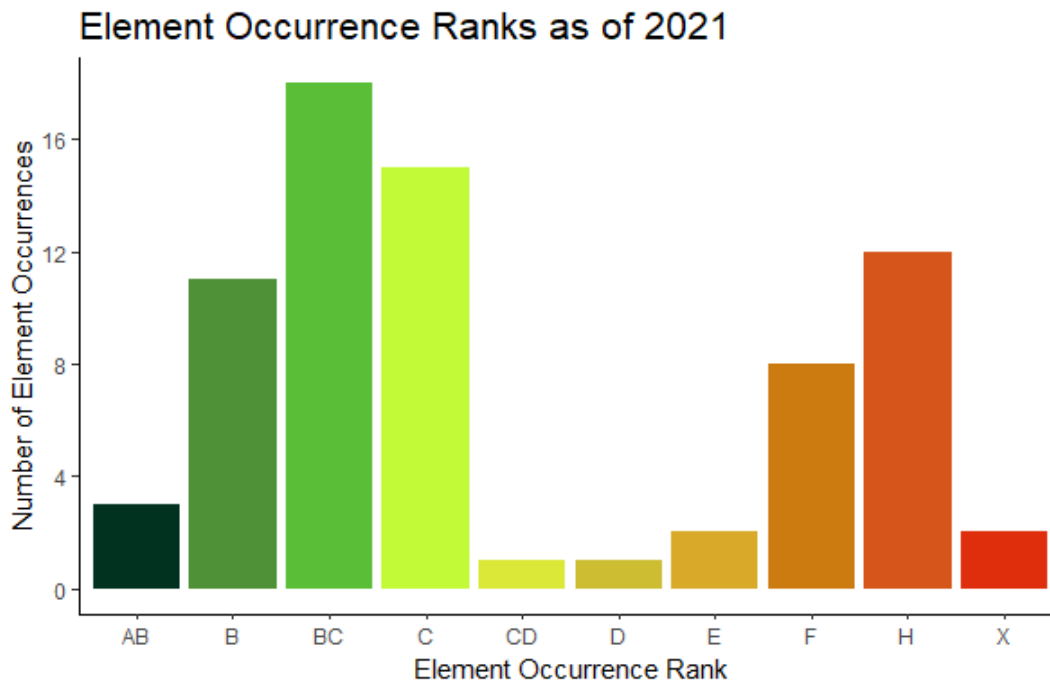
**Figure 6. Bar chart of average long-term change in *Howellia aquatilis* by ecoregion.** Qualitative estimates were excluded from analysis and only years with numeric counts were used. Long term changes were calculated as the difference between first census counts and most recent census counts regardless of year. Bars above 0 indicate an increase in census counts, while bars falling below 0 indicate a decrease in census counts.

Puget Trough occurrences are larger on average based on most recent counts (average=376 individuals) and have increased (average=+108) over the long term (1986-2021) while counts at Columbia Plateau occurrences are smaller (average=126 individuals) and have declined (average=-42; Figure 6). However, both have increased over just the last 10 years, with the greatest increases seen at Puget Trough occurrences. The percentage of occurrences increasing across ecoregions has remained roughly equal over the long term, with 40% of Puget Trough and 42% of Columbia Plateau occurrences increasing. Counts have increased at occurrences across both ecoregions over the last 10 years alone, with upward trends exhibited at a greater percentage of Puget Trough occurrences (35%) compared to Columbia Plateau occurrences (8%).

Other occurrences have experienced no change or do not have enough quantitative data to estimate trends. Occurrences which have experienced the largest increases include two USDOD occurrences: EO#44 Trench Wetland (long term: +970, 10-yr: +710) and Lynch #71: (long term: +1515, 10-yr: +1515), and one USFWS occurrence: EO#57 Turnbull Pond 32 (long term: +999, 10-yr: +1000). The most severe declines have occurred at two DNR/DFW occurrences: EO#68 Burnett Rd. (long term: -2005, 10-yr: NA) and EO#67 Smythe Rd. N (long term: -1265, 10-yr: NA), and one privately owned occurrence: EO#5 Bretz Pothole (long term: -1000, 10-yr: NA).

## Habitat Quality

Element occurrence rankings are based on the estimated viability of a population combined with an assessment of the ecological integrity of the immediate habitat (Hammerson et al., 2010). According to Washington Natural Heritage Program element occurrence rankings updated by data collected through 2021, the majority of *Howellia aquatilis* occurrences in Washington which have recent survey data are in “Excellent” to “Fair” standing (Figure 7). Nearly 45% of occurrences (32/73) are ranked “Good/Fair” or better with 20% are in the top two quality rankings; “Excellent/Good” and “Good”. Another 20% (15/73) are in “Fair” condition. A single occurrence is ranked “Fair/Poor,” another single occurrence is ranked “Poor,” and two are ranked “Extant,” meaning that the occurrences are noted as present but cannot be ranked due to a lack of information about population size or ecological integrity of the habitat. Several occurrences do not have survey data from the last 20 years and are ranked “Historical” (16%, 12/73) and several others were not successfully relocated in recent survey years and are now ranked as “Failed to Find” (11%, 8/73) until they can be confirmed as extant or extirpated in future surveys. Two others are ranked as “Extirpated” (EO#17 Tritt Lake, EO#72 Roy). Concerningly, up to 30% (22/73) of occurrences may now be extirpated and need resurvey to confirm their status which would significantly impact our understanding of the overall standing of *Howellia aquatilis* in Washington state.

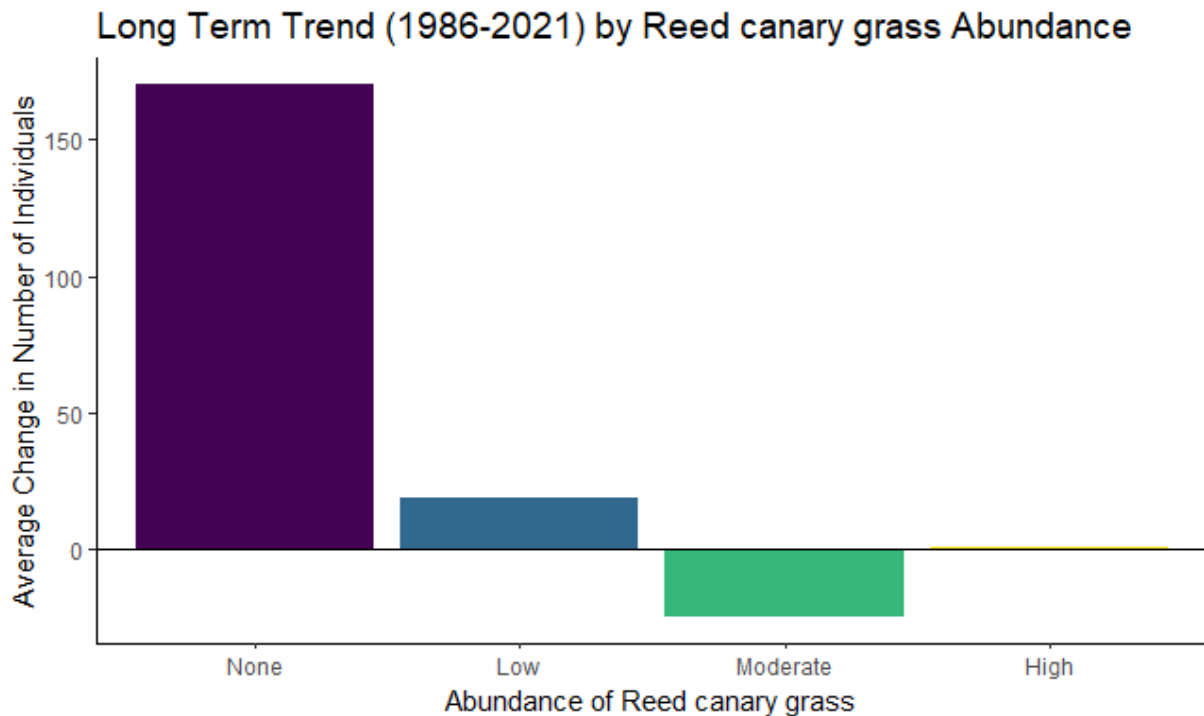


**Figure 7. Number of *Howellia aquatilis* element occurrences by rank as of 2021.** Ranks were calculated by the Washington Natural Heritage Program following NatureServe protocols (Hammerson et al., 2010). The green to red (left to right) color gradient represents a respective range from “AB-Excellent/Good” viability element occurrences to “D-Poor”, “F-Failed to Find”, “H-Historical”, and “X-Extirpated” occurrences. Other ranks are as follows: “B-Good”, “BC-Good/Fair”, “C-Fair”, “CD-Fair/Poor”, and “E-Extant.”

## Impacts of Reed Canary Grass

*Phalaris arundinacea* (reed canary grass) is an aggressive exotic grass with a rhizomatous growth habitat that is known to encroach into the thin pond margins where *Howellia aquatilis* occurs, quickly outcompeting and shading out suitable habitat (Lesica, 1997). This species has been described as a “major conservation concern” for *Howellia aquatilis* which is known to be poor competitor. Field notes from surveys in Washington confirm that *Howellia aquatilis* is not typically found in pond sections or along shorelines that are dominated by *Phalaris arundinacea* but will sometimes appear in small open pockets within tall *Phalaris arundinacea* monocultures.

For the 73 occurrences of *Howellia aquatilis* in Washington, *Phalaris arundinacea* abundance has been categorized as “None” at 9 occurrences (12%), “Low” at 16 occurrences (22%), “Moderate” at 30 occurrences (41%), and “High” at 18 occurrences (25%). More occurrences in the Puget Trough have “None” (30%) or “Low” (22%) *Phalaris arundinacea* abundance than “Moderate” (35%) or “High” (13%) abundance, while Columbia Plateau occurrences have more “Moderate” (44%) and “High” (30%) abundance occurrences. *Phalaris arundinacea* abundance is typically the lowest at USDOD occurrences, moderate at BLM, DNR/DFW, and USFWS occurrences, and the highest at privately owned occurrences. Occurrence-level invasion ranks do not always capture the invasion levels and trends in surrounding potential habitat managed by each agency but are an assessment of the potential suitable habitat remaining within ponds where *Howellia aquatilis* is already known to occur.



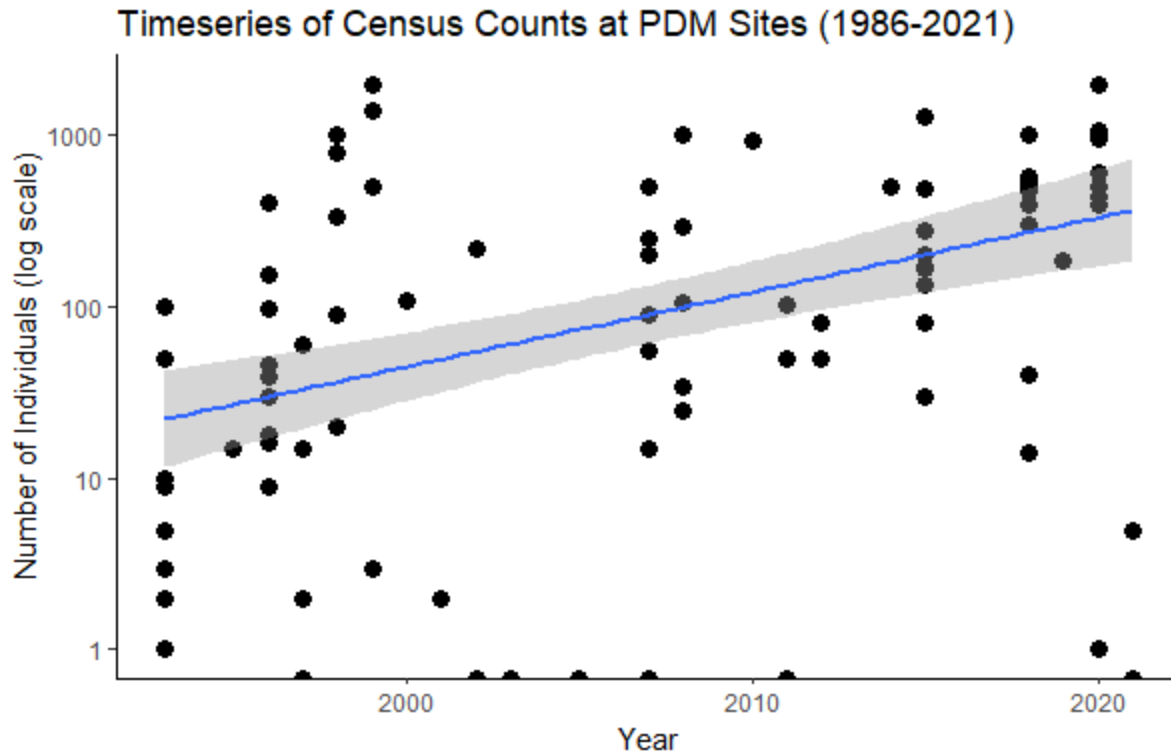
**Figure 8. Bar chart of average long term change across *Howellia aquatilis* occurrences by *Phalaris arundinacea* (reed canary grass) categorical abundance. *Phalaris arundinacea* abundances were categorically estimated for each element occurrence in**

congruence with post-delisting monitoring protocols (U.S. Fish and Wildlife Service, 2020). Long term changes were calculated as the difference between first census counts and most recent census counts regardless of year. Bars above 0 indicate an increase in census counts, while bars falling below 0 indicate a decrease in census counts.

Census counts as of most recent survey are the highest at sites with “Low” *Phalaris arundinacea* categorical abundance (average= 403 individuals). The greatest long-term (1986-2021) count increases have been at occurrences where the *Phalaris arundinacea* categorical abundance is “None” while occurrences ranked as “Moderate” have decreased the most over time (Figure 8). Surprisingly, this effect appears to diminish when examining trends over the last 10 years as occurrences with “High” *Phalaris arundinacea* abundance have increased the most and have the highest count estimates as of last survey. Future post-delisting monitoring will employ more defined protocols for assessing *Phalaris arundinacea* abundance during field surveys (U.S. Fish and Wildlife Service, 2020).

### Post-Delisting Monitoring Occurrences

In accordance with federal policies for recently de-listed federally Endangered species, a post-delisting monitoring (PDM) plan was developed to begin in 2022 at 30 select occurrences of *Howellia aquatilis* in Washington (U.S. Fish and Wildlife Service, 2020). These select occurrences include 1 BLM occurrence, 4 DNR/DFW occurrences, 10 USDOD occurrences, and 15 USFWS occurrences. PDM occurrences have been previously visited between 1 and 18 times for an average of 5 visits between 1986-2021 with the most recent occurrences visits taking place between 2007 and 2021. Three PDM occurrences on USFWS land were not relocated at their last occurrence visit: Turnbull Pond 29 (EO #32), Turnbull Pond 82 (EO #55), and Turnbull Pond 120 (EO #58).



**Figure 9. Time series regression of *Howellia aquatilis* census counts at selected post-delisting monitoring occurrences.** The model  $R^2=0.08$  is with year alone. Model fit is improved to  $R^2=0.41$  if land management is included as a variable.

Baseline data and trends for PDM occurrences follow those previously described for all Washington occurrences but are representative of the best available data and quantitative census counts. The average count across PDM occurrences as of last survey is 372 individuals, which is significantly higher than the estimated average across all Washington occurrence data (average=238 individuals). Additionally, PDM occurrence census counts have increased over time (Figure 9) more than the average across all occurrences over the long term (1986-2021; average=+374 individuals) and especially over the last 10 years (average=+551 individuals). A greater percentage (63%) of PDM element occurrences are ranked better than ‘BC-Good/Fair’ when compared to all Washington occurrences (45%). Other trends and threats across ecoregions and land management agencies are generally the same as those described across all occurrences.

## Discussion and Recommendations

### Results Summary

The overall outlook of *Howellia aquatilis* in Washington is positive and the data gaps filled by the additional surveys associated with this project provide a solid baseline for future comparisons with post-delisting monitoring data planned for collection starting in 2022. Most Washington occurrences have been relocated and re-surveyed in recent years, with the major exclusion of occurrences on private lands. Census counts for most occurrences have increased slightly over time, with counts increasing the most

over the last 10 years. Interannual variation in *Howellia aquatilis* counts is likely related to climatic variation and hydrological fluctuations.

Trends vary across occurrences in the eastern and western ecoregions, with Puget Trough occurrences remaining larger in size and growing more steadily in the long term (1986-2021) than Columbia Plateau occurrences, which have declined over the same period. However, both exhibited upward trends over the last 10 years. Trends also differ across occurrences managed by different agencies. USDOD occurrences are largest and have experienced the biggest count increases both in the short and long term, followed by occurrences on USFWS lands. DNR/DFW lands are among the smallest occurrences by count and have experienced some of the largest count decreases, followed by occurrences on private lands. According to field notes, these occurrences have been subject to more anthropogenic impacts than the average across Washington; primarily from public recreation and timber harvest.

Most Washington occurrences appear to be viable with largely intact habitat. Habitats determined to be in good condition were those with minimal invasion, significant sections of open water, and little to no anthropogenic impacts. However, several occurrences are now ranked “Historical” due to the age of available data or “Failed to Find” as no individuals of *Howellia aquatilis* were found during the last survey. Therefore, as many as 22 Washington occurrences (30%) may truly be extirpated, including two other confirmed extirpations, and need resurveys to confirm their status. There is not enough available information to clearly identify stressors that may have contributed to extirpation, other than a history of very small census counts at each occurrence. *Phalaris arundinacea* continues to be a persistent competitor and is at least moderately abundant at most occurrences. Occurrences with moderate to high *Phalaris arundinacea* have smaller counts of *Howellia aquatilis* that have decreased over the long term but do not appear to have been as significantly affected over the last 10 years.

The 30 occurrences selected for post-delisting monitoring represent the most viable, fastest growing occurrences with the best available census data but otherwise follow similar trends as all other Washington occurrences.

### Persistent Threats

*Howellia aquatilis* is among a small number of species of concern in Washington showing both short-term and long-term increases in number that are small but significant. Despite these upward trends, the outlook for *Howellia aquatilis* should be tempered by the continuing loss of habitat due to competition from exotic plants such as *Phalaris arundinacea*, encroachment of woody vegetation, and projected environmental impacts from predicted climate change that are anticipated to impact critical seasonal hydrological regimes (Fertig, 2021; Kleinknecht et al., 2019).

Several of the wetlands supporting *Howellia aquatilis* in Washington are very small and shallow “kettle” ponds, particularly on the eastern side of the state in the scablands of the Columbia Plateau. Field notes indicate that these ponds have been completely dry multiple years in a row when *Howellia aquatilis* has not been relocated

and that ponds are drying earlier in the year than anticipated. Climatic changes and associated hydrological shifts may completely dry out these ponds and extirpate *Howellia aquatilis* from these occurrences in the near future.

Under the worst climate projections (RCP 8.5), some occurrences such as EO#1 Dishman Hills have been projected to lose all suitable habitat (Kleinknecht et al., 2019), though most Spokane occurrences would retain some viable habitat in 2080 under optimal scenarios. A recently conducted climate change vulnerability analysis ranked *Howellia aquatilis* as “Extremely Vulnerable” due to its biological dependence on aquatic habitats, poor dispersal ability, low genetic diversity, short-lived seedbank, and poor ability to compete with encroaching vegetation (Fertig, 2021; Young et al., 2016). The phenological response of *Howellia aquatilis* to changing seasonal and precipitation dynamics is unknown but the notes recorded for the most recent field surveys across occurrences appear to document greater proportions of vegetative individuals than flowering individuals compared to past surveys. Further study and confirmation of these potential changes is warranted as these metrics are not formally included in surveys and data on phenology is lacking for most years.

Previous reviews of threats from competing vegetation have focused almost exclusively on *Phalaris arundinacea*, but several other exotic and native species are documented as crowding out *Howellia aquatilis* in recent field surveys. Other potential species to watch at Washington occurrences include *Schoenoplectus acutus* (hardstem bulrush), *Typha latifolia* (broadleaf cattail), and *Scirpus* spp., all of which can be abundant in habitat occupied by *Howellia aquatilis*. Native woody species that typically occur in *Howellia aquatilis* habitat, such as *Fraxinus latifolia* (Oregon ash), *Cornus sericea* (red-osier dogwood), and especially *Spirea douglasii* (hardhack) can create thickets that dominate open water pockets that could support *Howellia aquatilis*. Algal blooms and dense mats of *Lemna minor* (duckweed) are also noted as potential issues, particularly at DNR/DFW occurrences. Notes from field surveys frequently indicate that *Howellia aquatilis* is only found in open, unshaded areas where these species are not abundant.

Several other stressors that were recorded in survey data and field notes should be considered in management plans. Off-road and off-trail recreation, logging, grazing, road crossings, land development, and ditches altering hydrology were noted as actively impacting occurrences across the state of Washington (Table 1).

### Persisting Data Gaps

Private land occurrences, including those on conservation easements and land trusts, have not been revisited since the 1980s or 1990s and are not included in post-delisting monitoring plans due to a lack of updated baseline and trend information. These 11 occurrences, all of which occur in Spokane County, include EO #3,4,5,6,7,8,9,10,12,15, and 16. Two additional occurrences at Turnbull National Wildlife Refuge have not been revisited since the 1990s: EO#62 Turnbull Pond 149 and EO#65 NW of Campbell Lake. There are 12 total occurrences where *Howellia aquatilis* has not been relocated in recent years which may now be extirpated. Revisits are needed to confirm the status and make the change from the current “Failed to Find” ranking

(Tables 1 and 3). Additionally, several of the 30 selected post-delisting monitoring occurrences were last surveyed between 2007-2012 and were not able to be revisited in 2020 or 2021 in conjunction with this project due to time constraints. Finally, based on the time gaps between historical discoveries of *Howellia aquatilis* occurrences, habitat suitability modeling may help to identify additional undiscovered occurrences of *Howellia aquatilis* in Washington.

### Monitoring Challenges and Recommendations

Several challenges that were encountered and noted when monitoring *Howellia aquatilis* over the last five decades will be useful to consider during the implementation of post-delisting monitoring protocols beginning in 2022. Unlike the small glacial pothole pond which support *Howellia aquatilis* in other states such as Montana (Shelly and Moseley 1988), ponds in Washington are sometimes very large with wide areas of open water, densely vegetated, and filled with submerged downed logs which combined make access and viewing of obscure individuals of *Howellia aquatilis* very difficult. Algae and duckweed (*Lemna* spp.) cover is dense at some occurrences, further obscuring visibility during surveys. Many past surveys did not cover complete ponds due to these conditions.

Surveys are difficult to time appropriately, especially as the climate changes in Washington. The minute emergent flowers of *Howellia aquatilis* only appear for a short time and are highly dependent on annual weather conditions and the timing of hydrological cycles at the pond level. Several surveyors note that ponds were already completely dried out by the end of June or early July and that *Howellia aquatilis* individuals had already died back too much to survey. Conversely, in years with heavy rainfall, persistent high water in ponds may delay flowering and the potential for pond access into late July or early August. Individuals may be nearly impossible to spot until they are in the emergent stage depending on water clarity.

Individuals of *Howellia aquatilis* are difficult to define due to their matting, branching nature and nearly complete submergence under murky or algae-covered water with significant amounts of downed wood. As a result, different surveyors are likely to delineate individuals in different ways, ranging from stem counts to area estimates to numbers of floating versus rooted fragments, which greatly affects count estimates. Clear guidance should be developed for future surveys and post-delisting monitoring to ensure that estimates are conducted in a consistent manner across occurrences, even if categorical abundances are being used as designated in PDM protocols. Surprisingly, patches of *Howellia aquatilis* do not appear to move much around ponds despite the expectation that seeds and fragments could float and re-establish readily. As a result, clearly marked maps and field notes indicating the locations of patches are likely to improve the accuracy and precision of surveys across future study years.

### Management Recommendations

The encroachment of exotic grasses and woody vegetation clearly threatens *Howellia aquatilis* occurrences in Washington. Field notes confirm that open areas of



ponds have decreased as upland vegetation has moved in, perhaps because of increasing periods without inundation and continued degradation of upland communities near some ponds. Control of these species can be complicated because herbicides may be harmful to *Howellia aquatilis* and other ecologically important wetland vegetation. Additionally, reports indicate that commonly used glyphosate-based herbicides do not work on *Phalaris arundinacea* (Lichthardt, 2007). Managers could consider other techniques to control competing vegetation along shorelines, such as manual excavation, suppression via smothering/shading, and strategically timed trimming, as well as those that could decrease invasion within surrounding uplands (Lichthardt, 2007). It is recommended that efforts to suppress competing vegetation consider other species as potential threats to *Howellia aquatilis* in addition to *Phalaris arundinacea*.

The long term persistence of *Howellia* occurrences may depend on a mix of shallow and deep ponds being available, with shallow ponds being especially important during wet years and deep ponds important during prolonged drought (Lesica 1992). Future re-survey efforts should target small, shallow ponds that are at risk of drying out completely after consecutive drought years. It also tends to occur specifically in ponds with downed wood or decomposing vegetation, which may be critical elements of its required microtopography and habitat conditions and should be studied further. Field visits may need to be moved earlier in the year to accommodate potential phenological change and may need to be conducted in multiple consecutive years to confirm whether *Howellia aquatilis* has truly been extirpated from an occurrence or is simply delaying germination until conditions are ideal to break dormancy.

Several occurrences are threatened by off-road recreation of various kinds, vandalism, and garbage disposal. Positive language signage at these occurrences may help to deter harmful behaviors. Extreme disturbances that have altered the natural hydrology of wetlands known to support *Howellia aquatilis* may require augmentations or manipulations to topography to restore necessary seasonal filling and drying cycles (Kleinknecht et al., 2019).

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## Tables

**Table 1. Washington occurrences of *Howellia aquatilis* with associated ranks and threats.** Occurrences in red were selected for continued post-delisting monitoring using an expanded protocol starting in 2022 (U.S. Fish and Wildlife Service, 2020). Element occurrence ranks were calculated by the Washington Natural Heritage Program using standard NatureServe methods (Hammerson et al., 2010). Threats were derived from field survey data and notes.

Occurrence	County	Ownership	Ecoregion	Year Last Obs	EO Rank	Habitat Description	Threats
<b>BLM</b>							
W of Hog Lake (#37)	Spokane	Spokane BLM	Columbia Plateau	2012	C-Fair	Small, moderately shallow pond near Hog Lake with a narrow outlet. Plants found in patches all throughout pond where other vegetation transitions to open water without shade, such as channels and near the outlet.	Abundant cover and thick density of <i>Phalaris arundinacea</i> , <i>Scirpus</i> spp., <i>Sparganium</i> spp., and shrubs, shaded by deciduous and coniferous trees along shore, off road trails and cattle paths in vicinity
<b>DNR/DFW</b>							
Dishman Hills (#1)	Spokane	Dishman Hills NRCA	Columbia Plateau	2019	C-Fair	Algal mats, <i>Phalaris arundinacea</i> and <i>Scirpus</i> spp. present, dense <i>Schoenoplectus acutus</i> and <i>Typha latifolia</i> , significant human and dog traffic from nearby trail, vandalism and trash, pond drying	Algal mats, <i>Phalaris arundinacea</i> and <i>Scirpus</i> spp. present, dense <i>Schoenoplectus acutus</i> and <i>Typha latifolia</i> , significant human and dog traffic from nearby trail, vandalism and trash, pond drying
Powder Factory (#64)	Thurston	Scatter Creek SWA	Puget Trough	2008	BC-Good/Fair	Large wetland: water depth ~10-15 cm. Plants found in open water areas.	Dense algal mats, thick <i>Salix</i> , very small population, <i>Phalaris arundinacea</i> present
Smythe Rd N (#67)	Spokane	Washington DNR	Columbia Plateau	2011	B-Good	Small, shallow kettle pond with gentle sloping shoreline. Lots of fallen logs in pond. Surrounded by <i>Pinus ponderosa</i> savanna with patches of scabland	High cover of <i>Phalaris arundinacea</i> , dense barrier of trees and shrubs lining pond, residence in proximity, timber harvest

Burnett Rd (#68)	Spokane	Washington DNR (access via private land)	Columbia Plateau	2013	B-Good	Two ponds, Pond 2: 2-3 acres in size. Pond 4: ~2 acres in size. Pond 11: 1.5 acres in size. Surrounded by scablands	Dense <i>Lemna</i> spp. and algae cover, some <i>Phalaris arundinacea</i> and <i>Schoenoplectus acutus</i> , timber harvest, camping/recreating/parking in wetlands causing damage to ponds
<b>USDOD</b>							
Foot Lake (#39)	Pierce	Joint Base Lewis McChord	Puget Trough	2020	B-Good	High quality pond with few impacts, small shrub islands throughout wetland, uplands dominated by <i>Pseudotsuga menziesii</i>	Islands of <i>Spiraea douglasii</i> and <i>Fraxinus latifolia</i> among wetland, weedy uplands, overall few threats
S of Bensten (#40)	Pierce	Joint Base Lewis McChord	Puget Trough	1998	C-Fair	Plants occur in open water around N perimeter under shade where shrubs are sparse and along an outlet channel, uplands in good condition	Small pond at risk of drying, shrubs dominating shore ( <i>Spiraea douglasii</i> , <i>Fraxinus latifolia</i> , <i>Salix</i> spp.), past alteration of hydrology
Bentsen (#41)	Pierce	Joint Base Lewis McChord	Puget Trough	2015	B-Good	Pond with slightly degraded shoreline, less invasion than typical, lined with <i>Spiraea douglasii</i>	Shrubby shoreline with very dominant <i>Spiraea douglasii</i> , previously altered drainage, homesteading
Binocular Pond (#42)	Pierce	Joint Base Lewis McChord	Puget Trough	2015	C-Fair	Small pond (<2 acres) with generally open water, lots of floating vegetation and logs. <i>Fraxinus latifolius</i> lining the shore.	Some sections with a lot of <i>Phalaris arundinacea</i> , <i>Fraxinus latifolius</i> dominates shoreline, small pond
Shaver Kettle (#43)	Pierce	Joint Base Lewis McChord	Puget Trough	2020	B-Good	Small kettle pond with steep to gentle shoreline, surrounded by dense <i>Fraxinus latifolia</i> forest in former forest/prairie mosaic	Small kettle wetland at risk of drying, <i>Typha latifolia</i> , <i>Myosotis scorpioides</i> , and <i>Phalaris</i> present
Trench Wetland (#44)	Pierce	Joint Base Lewis McChord	Puget Trough	2020	B-Good	Plants found throughout wetland, one of the largest populations, small, narrow wetland surrounded by forest/wetland/prairie mosaic	Small and narrow wetland at risk of drying, shrubs dominate shoreline
NE Chambers Satellite (#45)	Pierce	Joint Base Lewis McChord	Puget Trough	2015	C-Fair	Small wetland that may sometimes connect to a larger lake. Can be deep in the center. Snags in water. Isolated from another wetland complex by low ridge.	Significant cover of <i>Phalaris arundinacea</i> , wetland small and at risk of drying, isolated from larger wetland complex
N Chambers Pond (#46)	Pierce	Joint Base Lewis McChord	Puget Trough	2015	B-Good	5 to 8 ac. wetland within <i>Pseudotsuga menziesii</i> dominated lowland forest, surrounded by steep uplands	Scattered <i>Phalaris arundinacea</i> , weedy upland, trails and unofficial roads through wetland

W Shaver Pond (#47)	Pierce	Joint Base Lewis McChord	Puget Trough	2020	B-Good	Shallow 2 to 5 acre wetland with mostly open water but significant cover of <i>Carex</i> spp. and islands of <i>Salix</i> spp. Many floating logs	Some <i>Phalaris arundinacea</i> present, dense <i>Carex</i> spp. and <i>Juncus</i> spp. cover, very shallow and subject to drying, military training roads nearby
<b>USDOD</b>							
Crone Marsh (#48)	Pierce	Joint Base Lewis McChord	Puget Trough	2020	B-Good	Large U-shaped wetland basin with several sections of plants, a lot of potentially suitable habitat. Uplands with thick shrubs and ferns.	Road crossing wetland, trash, <i>Spiraea douglasii</i> and <i>Fraxinus latifolia</i> on shoreline, thick <i>Equisetum</i> spp.
Joseph Marsh (#49)	Pierce	Joint Base Lewis McChord	Puget Trough	2020	B-Good	30-35 acre wetland with gradual shoreline and plants found throughout. Very dense shrub cover along pond. <i>Pinus ponderosa</i> upland.	Very dense <i>Spiraea douglasii</i> and <i>Fraxinus latifolia</i> on shoreline, training activity nearby, some <i>Phalaris arundinacea</i>
Middle East Chambers (#50)	Pierce	Joint Base Lewis McChord	Puget Trough	1998	C-Fair	Small (0.5 ac.) wetland that is connected to Chambers Lake during high water.	Shoreline shaded by <i>Fraxinus latifolia</i> , with dense <i>Phalaris arundinacea</i> throughout.
Dailman Lake (#51)	Pierce	Joint Base Lewis McChord	Puget Trough	2015	B-Good	Open water pond with <i>Fraxinus latifolia</i> overstory and surrounding moderately sloping lowland forest	Dense <i>Phalaris arundinacea</i> throughout wetland and <i>Spiraea douglasii</i> along shore, human activity and trails in wetland
Hamilton Lake (#52)	Pierce	Joint Base Lewis McChord	Puget Trough	2015	C-Fair	Lake with generally open water, surrounded by sloping uplands with deciduous trees and shrubs	<i>Phalaris arundinacea</i> dense in some areas
Chambers East (#53)	Pierce	Joint Base Lewis McChord	Puget Trough	2020	BC-Good/Fair	Small pond just east of Chambers Lake. Deep, open water pond with lots of floating logs at N end, surrounded by steep slopes and lowland forest	Moderate <i>Phalaris arundinacea</i> , trails immediately adjacent
Willow Kettle (#66)	Pierce	Joint Base Lewis McChord	Puget Trough	2020	B-Good	Small, shallow (~60 X 30 meters) elliptical kettle, plants found in central portion of kettle pond where there is little competing vegetation, canopy is mostly open	Pond at risk of drying, highly weedy uplands, some <i>Phalaris arundinacea</i> , <i>Sparganium</i> spp. and <i>Myosotis scorpioides</i> , military roads and training nearby
Combs (#70)	Pierce	Joint Base Lewis McChord	Puget Trough	2015	E-Extant	None	None described

Lynch (#71)	Pierce	Joint Base Lewis McChord	Puget Trough	2020	B-Good	One of the larger known populations at a seasonal kettle pond with deep water and partially shaded shore of <i>Fraxinus latifolia</i> forest	Some <i>Fraxinus latifolia</i> and <i>Phalaris arundinacea</i> cover, relatively low
Roy (#72)	Pierce	Joint Base Lewis McChord	Puget Trough	2015	X-Extirpated	None	None described
<b>USDOD</b>							
Ressa (#73)	Pierce	Joint Base Lewis McChord	Puget Trough	2015	E-Extant	None	None described
Shaver Puddle (#74)	Pierce	Joint Base Lewis McChord	Puget Trough	2020	D-Poor	Small (10 X 20 meter) ephemeral kettle, with moderately steep banks surrounded by mixed <i>Psuedotsuga menziesii</i> forest. Aquatic vegetation is dense. Little suitable habitat.	Very small kettle wetland, dense aquatic vegetation including <i>Myosotis scorpioides</i> , very small population
<b>USFWS</b>							
Blackwater Island RNA (#2)	Clark	Blackwater Island RNA, Ridgefield NWR	Puget Trough	2018	B-Good	Plants found in 3 small ponds between two grassy basalt knobs	Past heavy grazing, some <i>Phalaris arundinacea</i>
Turnbull Pond 76 (#11)	Spokane	Turnbull NWR	Columbia Plateau	2007	B-Good	Plants found at S end of wetland in deeper, open areas without <i>Sparganium</i> spp. Very deep, open water pond with steep shoreline at the base of basalt cliffs.	Herbivory from waterfowl, somewhat abundant <i>Phalaris arundinacea</i> and <i>Sparganium</i> spp., Thick <i>Lemna</i> and <i>Utricularia</i> cover. Possibly past grazing in uplands.
E of Campbell Lake (#13)	Spokane	Turnbull NWR	Columbia Plateau	2008	BC-Good/Fair	Basalt rimmed pond with open water at the center, surrounded by <i>Typha latifolia</i> , <i>Pinus ponderosa</i> , and <i>Populus tremuloides</i>	Moderate to high <i>Phalaris arundinacea</i>
Squirrel View (#14)	Spokane	Turnbull NWR	Columbia Plateau	2021	C-Fair	Small, murky kettle pond. Very shallow, contoured for waterfowl. Bordered by <i>Pinus ponderosa</i> and <i>Populus tremuloides</i>	Algal mats, <i>Schoenoplectus detritus</i> , <i>Phalaris arundinacea</i> very dominant and in monoculture patches, past grazing, wetland has been modified and is at risk of drying
N of W Tritt Lake (#17)	Spokane	Turnbull NWR	Columbia Plateau	1990	F-Failed	Shallow pond within area dominated by <i>Pinus ponderosa</i> and some <i>Populus</i>	Past grazing, dominant <i>Phalaris arundinacea</i> and some <i>Scirpus</i> spp.,

						<i>tremuloides</i> . Surrounded by degraded uplands that have experienced fire in recent years. No remaining open water.	nearby fire activity, shallow pond subject to drying, uplands degraded by grazing
Turnbull Pond 10 (#18)	Spokane	Turnbull NWR	Columbia Plateau	2007	BC-Good/Fair	Southernmost of two ponds, long, narrow, and shallow wetland surrounded by <i>Pinus ponderosa</i> and some <i>Populus tremuloides</i>	Abundant <i>Phalaris arundinacea</i> , shallow pond at risk of drying
<b>USFWS</b>							
S of W Blackhorse Lake (#19)	Spokane	Turnbull NWR	Columbia Plateau	2010	C-Fair	Deep open water pond near auto tour route. Lots of <i>Phalaris arundinacea</i> in certain patches of pond, plants found only in peripheral transition zone between open water and shallows shaded by dense willow. Lots of logs and floating debris.	Dense shrubs on shoreline, nearby tour road, lots of <i>Phalaris arundinacea</i> and <i>Hippuris</i> spp. in areas
Turnbull Pond 85 (#20)	Spokane	Turnbull NWR	Columbia Plateau	2009	BC-Good/Fair	Small pond with steep banks NE of Long Lake. Deep, open water with very dense shrubs along shoreline. Heavily grazed pine savannah uplands	Herbivory/heavy grazing, dense shrubs on shoreline
Turnbull Pond 21A (#21)	Spokane	Turnbull NWR	Columbia Plateau	2009	C-Fair	Long, shallow pond with dense <i>Scirpus</i> spp. in center. Surrounded by steep cliffs and pine savannah uplands.	Dense <i>Phalaris</i> along shore and <i>Juncus</i> spp. in center of pond, shallow pond at risk of drying
Turnbull Pond 77 (#22)	Spokane	Turnbull NWR	Columbia Plateau	2007	B-Good	Small pond NE of large lake surrounded by basalt cliffs, plants found in areas with sparse vegetation along shore and steeper banks	Dense <i>Lemna minor</i> and <i>Utricularia</i> spp., shoreline dominated by shrubs and some dense <i>Phalaris arundinacea</i> patches
Turnbull Pond 72 (#23)	Spokane	Turnbull NWR	Columbia Plateau	2010	B-Good	Pond is a small depression among pine woods with open water center	Shore lined by <i>Phalaris arundinacea</i> and <i>Scirpus</i> spp.
Turnbull Pond 55 (#24)	Spokane	Turnbull NWR	Columbia Plateau	2008	B-Good	Pond with downed wood, surrounded by scattered <i>Populus tremuloides</i> and shrubs, little open water	Dominant <i>Phalaris arundinacea</i> , shrubby shoreline, little open water, old highway nearby
Turnbull Pond 39 (#25)	Spokane	Turnbull NWR	Columbia Plateau	2008	C-Fair	Steep basalt cliffs surround most of the pond, plants found in the shallower part of the pond where shores are more gradual	Herbivory, small population, thick <i>Scirpus</i> spp. and <i>Typha latifolia</i> , narrow band of <i>Phalaris arundinacea</i> , some <i>Sparganium</i> spp., shallow pond
Turnbull Pond 21C (#26)	Spokane	Turnbull NWR	Columbia Plateau	2009	B-Good	Shallow water pond with steep banks, surrounded by <i>Pinus ponderosa</i> and <i>Populus tremuloides</i>	Moderately abundant <i>Phalaris arundinacea</i> , shrubs dominate shoreline, little open water



Turnbull Pond 61 (#28)	Spokane	Turnbull NWR	Columbia Plateau	2007	B-Good	Long, shallow pond surrounded by moderately steep slopes and dense pine forest. West end is mostly dry.	<i>Phalaris arundinacea</i> and <i>Carex</i> spp. lining pond and decomposing, dense <i>Scirpus</i> spp. in center of pond, shallow pond with little open water at risk of drying
Turnbull Pond 18 (#29)	Spokane	Turnbull NWR	Columbia Plateau	2008	BC-Good/Fair	Murky, shallow, and narrow pond containing significant downed wood, <i>Populus tremuloides</i> along shore. Located within a basin and bounded by a berm. Sometimes listed as pond 1B.	Shallow pond threatened by drying, some <i>Typha latifolia</i> and <i>Phalaris arundinacea</i> present
<b>USFWS</b>							
Turnbull Pond 21B (#30)	Spokane	Turnbull NWR	Columbia Plateau	2009	BC-Good/Fair	Pond with much dead, fallen wood and murky water. <i>Populus tremuloides</i> on shoreline.	Some <i>Phalaris arundinacea</i> present, algae covering plants
Turnbull Pond 31 (#31)	Spokane	Turnbull NWR	Columbia Plateau	2008	B-Good	Deep pond with open water in center, steep banks with rock outcrops. Numerous downed logs, pine savannah upland	<i>Phalaris arundinacea</i> and <i>Juncus</i> spp. present and decomposing in wetland
Turnbull Pond 29 (#32)	Spokane	Turnbull NWR	Columbia Plateau	2007	BC-Good/Fair	Open water with decomposing vegetation and downed logs, moderately dense shrubs lining pond	<i>Phalaris arundinacea</i> and <i>Carex</i> spp lining pond and decomposing
Turnbull Pond 12 (#33)	Spokane	Turnbull NWR	Columbia Plateau	2007	C-Fair	Small, densely vegetated pond tucked in between two low, rocky rises. Open pine savannah uplands with shrubby patches near wetlands.	Dense <i>Phalaris arundinacea</i> , <i>Typha latifolia</i> , <i>Juncus</i> spp. lining pond and decomposing in wetland, ditch draining wetland. Algal blooms. Road/trail immediately adjacent to part of pond. Herbivory by waterfowl
Turnbull Pond 1A (#34)	Spokane	Turnbull NWR	Columbia Plateau	1993	D-Poor	Pond lined with shrubs, no woody debris in pond	Shrubby shoreline, some <i>Phalaris arundinacea</i> , very small population, possible grazing
Turnbull Pond 112 (#35)	Spokane	Turnbull NWR	Columbia Plateau	1993	D-Poor	Plants only at S end of <i>Salix</i> clump where water is over 2 ft deep.	Very small population, sparse <i>Scirpus</i> spp., <i>Phalaris arundinacea</i> covering shore, shallow pond
Turnbull Pond 96 (#36)	Spokane	Turnbull NWR	Columbia Plateau	2007	B-Good	Shallow, open water pond with lots of logs and debris. Moderate shrub cover on shrubline, basalt outcrops and steep banks.	Sparse <i>Phalaris arundinacea</i> , moderately dense shrubs along shoreline, herbivory and heavy browsing, dirt road near pond
Turnbull Pond 107 (#38)	Spokane	Turnbull NWR	Columbia Plateau	2009	BC-Good/Fair	Large wetland with some suitable habitat sections, dense algal growth	Some emergent <i>Scirpus</i> spp. and <i>Juncus</i> spp., dense algal blooms.

							Phalaris arundinacea present in general area
Turnbull Pond 13 (#54)	Spokane	Turnbull NWR	Columbia Plateau	2008	C-Fair	Pond is like a "figure 8" with two segments connected by narrow neck and is surrounded by steep rock slopes	Very small pond at risk of drying, small population, some <i>Phalaris arundinacea</i>
Turnbull Pond 82 (#55)	Spokane	Turnbull NWR	Columbia Plateau	2008	F-Failed	Pond deep in center but very shallow and vegetated near shore. Occasional side channels. Pond drying out.	Water depth not suitable, <i>Phalaris arundinacea</i> and <i>Schoenoplectus acutus</i> lining pond, channels made by ungulates
<b>USFWS</b>							
Turnbull Pond 63 (#56)	Spokane	Turnbull NWR	Columbia Plateau	1993	F-Failed	Water very deep at culvert and in center area of pond, surrounded by <i>Populus tremuloides</i> . Prescribed burning occurring in grassy uplands.	Road crossing with culvert adjacent, dense <i>Phalaris arundinacea</i> and <i>Schoenoplectus acutus</i>
Turnbull Pond 32 (#57)	Spokane	Turnbull NWR	Columbia Plateau	2021	B-Good	Open water with floating logs and decaying debris. Shoreline is dominated by rocks, <i>Pinus ponderosa</i> , and some <i>Populus tremuloides</i> . Plants found in patches of open water among vegetation.	Very dense <i>Phalaris arundinacea</i> , burweed, bulrush and decomposition
Turnbull Pond 120 (#58)	Spokane	Turnbull NWR	Columbia Plateau	2009	BC-Good/Fair	Small pond with mostly open water, shore lined with <i>Populus tremuloides</i> . Open pine savannah upland. Low disturbance.	Areas of dense <i>Phalaris arundinacea</i> and <i>Scirpus</i> spp.
Turnbull Pond 139 (#59)	Spokane	Turnbull NWR	Columbia Plateau	2009	C-Fair	Few notes, appears to be a very shallow pond	Very small pond and population, heavy <i>Populus tremuloides</i> cover on shoreline
Turnbull Pond 117 (#60)	Spokane	Turnbull NWR	Columbia Plateau	2009	BC-Good/Fair	Plants found among dead wood where <i>Phalaris arundinacea</i> is sparse, <i>Populus tremuloides</i> around shoreline	Some <i>Phalaris arundinacea</i>
Turnbull Pond 18 (#61)	Spokane	Turnbull NWR	Columbia Plateau	2008	C-Fair	Open pond with woody debris, shore dominated by deciduous trees/shrubs and pine, large areas of exposed water	<i>Phalaris arundinacea</i> dense in places and decomposing in wetland, shrubs surrounding shoreline, algae, herbivory by waterfowl
Turnbull Pond 149 (#62)	Spokane	Turnbull NWR	Columbia Plateau	1998	BC-Good/Fair	Isolated pond among open pine forest along a flat-topped ridge, connecting to outlet stream. Clear, open water surrounded by basalt cliffs, very shallow in parts. Shoreline moderately shrubby.	Past grazing, logging, some <i>Phalaris arundinacea</i> , disturbed uplands

Turnbull Pond 150 (#63)	Spokane	Turnbull NWR	Columbia Plateau	2008	C-Fair	Pond with little to no open water	Unknown
NW of Campbell Lake (#65)	Spokane	Turnbull NWR	Columbia Plateau	1997	E-Extant	Large sylvan pool in channeled scablands. Water normally drying by midsummer. Surrounding area composed of mixed grasses/ Pine woodlands.	Very small population
N of S Luke Rd (#69)	Spokane	Turnbull NWR	Columbia Plateau	2012	BC-Good/Fair	Pond with deep center, lined with deciduous cover. Plants for growing around dead wood from Salix spp.	Abundant Phalaris, dense algae, some Schoenoplectus acutus and Typha latifolia, Salix spp. covering much of shoreline
<b>Private/Unknown</b>							
Cheney-Spangle Rd (#3)	Spokane	Private (DNR Registry)	Columbia Plateau	1986	B-Good	Small, shallow pond (ca. 100 X 40 meters) lined by <i>Pinus ponderosa</i> and <i>Populus tremuloides</i>	Very small and fairly shallow pond at risk of drying, past grazing, <i>Phalaris arundinacea</i> present
Curtis Rd (#4)	Spokane	Unknown	Columbia Plateau	1987	B-Good	Vernal pond (currently 30 X 50 meters) surrounded by <i>Pinus ponderosa</i> with a few scattered <i>Populus tremuloides</i>	<i>Phalaris arundinacea</i> around entire wetland, grazing, logging, very small and shallow wetland subject to drying
Bretz Pothole (#5)	Spokane	Private (DNR Registry)	Columbia Plateau	1990	BC-Good/Fair	Small and shallow pond surrounded by <i>Pinus ponderosa</i> and <i>Populus tremuloides</i> . Lots of detritus and litter on the bottom. Pond may have since dried out or been developed through.	Residential development and driveway immediately adjacent, <i>Phalaris</i> present
Cameron Rd (#6)	Spokane	Unknown	Columbia Plateau	1987	CD-Fair/Poor	1 acre pond with a shoreline of <i>Populus tremuloides</i> and <i>Pinus ponderosa</i>	Pond dissected by road, <i>Phalaris arundinacea</i> dominating, residential structures close to pond edge, dirt road bisecting occurrence
Jennings Rd (#7)	Spokane	Private	Columbia Plateau	1987	C-Fair	2 acre, shallow pond lined by <i>Populus tremuloides</i> and <i>Pinus ponderosa</i>	Grazing, <i>Phalaris arundinacea</i> and <i>Scirpus</i> spp. dominant
Cross Tracks 1 (#8)	Spokane	Private	Columbia Plateau	1987	BC-Good/Fair	Small pond on top of "basalt table", 20 X 30 meters in size, 2-3 ft. deep in center. Uplands degraded by grazing	Very small and fairly shallow pond at risk of drying, past heavy grazing, logging, <i>Phalaris arundinacea</i> present
Cross Tracks 2 (#9)	Spokane	Unknown	Columbia Plateau	1987	BC-Good/Fair	Two connected ponds in hourglass shape, surrounded by <i>Pinus ponderosa</i> and <i>Populus tremuloides</i>	Past grazing, <i>Phalaris arundinacea</i> present
Cross Tracks 3 (#10)	Spokane	Private	Columbia Plateau	1987	C-Fair	Small pond on top of "basalt table", part of a large pond system, opening in	ORV trails through wetland, fair amount of <i>Scirpus</i> spp. and <i>Phalaris arundinacea</i> .

						middle among <i>Scirpus</i> spp. and <i>Phalaris arundinacea</i> .	
E of Kepple Lake (#12)	Spokane	Unknown	Columbia Plateau	1987	BC-Good/Fair	Two ponds connected by a drainage ditch which controls water inflows	Moderately heavy grazing, logging along shore, drainage ditch present, dominated by <i>Scirpus</i> and <i>Phalaris</i>
Lily Pond (#15)	Spokane	Unknown	Columbia Plateau	1987	BC-Good/Fair	Small, deep, basalt rimmed pond surrounded by degraded uplands with <i>Pinus ponderosa</i> and <i>Populus tremuloides</i> . Fairly open water.	Small amount of <i>Phalaris</i> , grazing in adjacent lands, railroad tracks in close proximity
Anderson Rd (#16)	Spokane	Unknown	Columbia Plateau	1987	C-Fair	Plants scattered mostly in NE part of pond, railroads and buildings in close proximity to pond, degraded uplands	Grazing, nearby logging, some <i>Phalaris</i>

**Table 2. Overall trends of *Howellia aquatilis* occurrences grouped by land management agency.**

Occurrences in red were selected for continued post-delisting monitoring using an expanded protocol starting in 2022 (U.S. Fish and Wildlife Service, 2020). Long-term changes ( $\Delta$ ) were calculated by taking the difference between the last observation's count data and the first observation's count data, regardless of year. Long-term averages are the average of all collected count data by occurrence. 10-year averages and changes ( $\Delta$ ) were calculated only for data collected between 2011 and 2021. PHAR3 abundance is a categorical estimate of the abundance of the exotic graminoid *Phalaris arundinacea* derived from abundances described in field notes per post-delisting monitoring protocols. NA values indicate no data or no quantitative data available (qualitative/descriptive estimate only). 0 values indicate that a survey was conducted but no plants were found. Data from occurrences on private lands or lands with unknown ownership should be interpreted with extra caution as many of these occurrences have never been revisited and counts were typically recorded as broad estimates in these early survey years.

<b>Occurrence</b>											
<b>BLM</b>	<b>Ecoregion</b>	<b>First Visit</b>	<b>Last Visit</b>	<b>Last Pop Estimate</b>	<b>Min Pop</b>	<b>Max Pop</b>	<b>Long-term Avg</b>	<b>10 Year Avg</b>	<b>Long-term <math>\Delta</math></b>	<b>10-Year <math>\Delta</math></b>	<b>PHAR3 Abund.</b>
W of Hog Lake (#37)	Columbia Plateau	1993	2012	50	0	50	14	50	0	0	Moderate
<b>DNR/DFW</b>	<b>Ecoregion</b>	<b>First Visit</b>	<b>Last Visit</b>	<b>Last Pop Estimate</b>	<b>Min Pop</b>	<b>Max Pop</b>	<b>Long-term Avg</b>	<b>10 Year Avg</b>	<b>Long-term <math>\Delta</math></b>	<b>10-Year <math>\Delta</math></b>	<b>PHAR3 Abund.</b>
Dishman Hills (#1)	Columbia Plateau	1978	2019	187	50	217	158	119	30	-137	Low
Powder Factory (#64)	Puget Trough	1995	2008	"few"	NA	NA	NA	NA	NA	NA	Moderate
Smythe Rd N (#67)	Columbia Plateau	1999	2011	102	102	1400	557	102	-1298	NA	High
Burnett Rd (#68)	Columbia Plateau	1999	2013	0	0	2005	977	0	-2005	NA	Moderate

<b>USDOD</b>	<b>Ecoregion</b>	<b>First Visit</b>	<b>Last Visit</b>	<b>Last Pop Estimate</b>	<b>Min Pop</b>	<b>Max Pop</b>	<b>Long-term Avg</b>	<b>10 Year Avg</b>	<b>Long-term Δ</b>	<b>10-Year Δ</b>	<b>PHAR3 Abund.</b>
Foot Lake (#39)	Puget Trough	1994	2020	400	135	516	326	350	62	265	High
S of Bentsen (#40)	Puget Trough	1994	2015	0	0	4	2	0	-4	NA	None
Bentsen (#41)	Puget Trough	1994	2015	5	0	5	3	5	5	NA	None
Binocular Pond (#42)	Puget Trough	1996	2015	7	7	90	49	7	-83	NA	High
Shaver Kettle (#43)	Puget Trough	1996	2020	1075	200	1075	652	765	275	875	Moderate
Trench Wetland (#44)	Puget Trough	1996	2020	990	20	990	374	525	970	710	None
NE Chambers Satellite (#45)	Puget Trough	1996	2015	52	0	52	26	52	52	NA	High
N Chambers Pond (#46)	Puget Trough	1996	2015	145	145	706	426	145	-561	NA	Low
W Shaver Pond (#47)	Puget Trough	1996	2020	610	173	804	461	447	-194	437	Low
Crone Marsh (#48)	Puget Trough	1995	2020	950	576	1773	1121	944	-50	-355	Low
Joseph Marsh (#49)	Puget Trough	1995	2020	500	202	1780	692	394	0	298	Low
Middle East Chambers (#50)	Puget Trough	1996	2015	0	0	53	27	0	-53	NA	Moderate
Dailman Lake (#51)	Puget Trough	1997	2015	8	8	500	140	8	-492	NA	Moderate
Hamilton Lake (#52)	Puget Trough	1997	2015	16	4	16	11	16	12	NA	Moderate

<b>USDOD</b>	<b>Ecoregion</b>	<b>First Visit</b>	<b>Last Visit</b>	<b>Last Pop Estimate</b>	<b>Min Pop</b>	<b>Max Pop</b>	<b>Long-term Avg</b>	<b>10 Year Avg</b>	<b>Long-term Δ</b>	<b>10-Year Δ</b>	<b>PHAR3 Abund.</b>
Chambers East (#53)	Puget Trough	1997	2020	445	91	445	187	307	354	276	Moderate
Willow Kettle (#66)	Puget Trough	1998	2020	438	40	438	143	186	358	358	Moderate
Combs (#70)	Puget Trough	2015	2015	120	120	120	120	120	NA	NA	None
Lynch (#71)	Puget Trough	2015	2020	2000	400	2000	909	962	1515	1515	Low
Roy (#72)	Puget Trough	2015	2020	0	0	11	3	4	-11	-11	None
Ressa (#73)	Puget Trough	2015	2015	3	3	3	3	3	NA	NA	None
Shaver Puddle (#74)	Puget Trough	2000	2020	1	1	110	39	15	-109	-29	None
<b>USFWS</b>	<b>Ecoregion</b>	<b>First Visit</b>	<b>Last Visit</b>	<b>Last Pop Estimate</b>	<b>Min Pop</b>	<b>Max Pop</b>	<b>Long-term Avg</b>	<b>10 Year Avg</b>	<b>Long-term Δ</b>	<b>10-Year Δ</b>	<b>PHAR3 Abund.</b>
Blackwater Island RNA (#2)	Puget Trough	1980	2018	500	500	500	500	500	NA	NA	Moderate
Turnbull Pond 76 (#11)	Columbia Plateau	1987	2007	500	0	500	259	NA	490	NA	Moderate
E of Campbell Lake (#13)	Columbia Plateau	1987	2008	6	6	6	6	NA	NA	NA	High
Squirrel View (#14)	Columbia Plateau	1987	2021	5	5	105	36	5	-11	NA	Moderate
N of W Tritt Lake (#17)	Columbia Plateau	1990	2012	0	0	0	0	0	0	NA	Moderate

USFWS	Ecoregion	First Visit	Last Visit	Last Pop Estimate	Min Pop	Max Pop	Long-term Avg	10 Year Avg	Long-term Δ	10-Year Δ	PHAR3 Abund.
Turnbull Pond 10 (#18)	Columbia Plateau	1990	2007	90	0	181	86	NA	88	NA	High
S of W Blackhorse Lake (#19)	Columbia Plateau	1990	2010	2	0	2	1	NA	2	NA	Moderate
Turnbull Pond 85 (#20)	Columbia Plateau	1993	2009	0	0	57	20	NA	-3	NA	High
Turnbull Pond 21A (#21)	Columbia Plateau	1993	2009	2	0	2	1	NA	1	NA	Moderate
Turnbull Pond 77 (#22)	Columbia Plateau	1993	2007	1	0	1	1	NA	1	NA	Moderate
Turnbull Pond 72 (#23)	Columbia Plateau	1993	2010	240	2	240	121	NA	238	NA	Moderate
Turnbull Pond 55 (#24)	Columbia Plateau	1993	2008	10	2	150	54	NA	8	NA	Moderate
Turnbull Pond 39 (#25)	Columbia Plateau	1993	2008	23	3	23	13	NA	20	NA	Moderate
Turnbull Pond 21C (#26)	Columbia Plateau	1993	2009	200	1	200	101	NA	199	NA	Moderate
Turnbull Pond 61 (#28)	Columbia Plateau	1993	2007	250	5	250	90	NA	245	NA	High
Turnbull Pond 18 (#29)	Columbia Plateau	1993	2008	3	1	3	2	NA	2	NA	Low
Turnbull Pond 21B (#30)	Columbia Plateau	1993	2009	0	0	4	2	NA	-4	NA	Moderate
Turnbull Pond 31 (#31)	Columbia Plateau	1993	2008	297	0	297	75	NA	294	297	Low
Turnbull Pond 29 (#32)	Columbia Plateau	1993	2021	0	0	50	17	0	-50	-15	High



USFWS	Ecoregion	First Visit	Last Visit	Last Pop Estimate	Min Pop	Max Pop	Long-term Avg	10 Year Avg	Long-term $\Delta$	10-Year $\Delta$	PHAR3 Abund.
Turnbull Pond 12 (#33)	Columbia Plateau	1993	2007	55	0	55	28	NA	55	NA	High
Turnbull Pond 1A (#34)	Columbia Plateau	1993	2012	0	0	1	0	0	-1	0	Moderate
Turnbull Pond 112 (#35)	Columbia Plateau	1993	2011	0	0	3	2	0	-3	NA	Moderate
Turnbull Pond 96 (#36)	Columbia Plateau	1993	2007	110	0	110	32	NA	106	NA	Low
Turnbull Pond 107 (#38)	Columbia Plateau	1993	2009	30	2	30	16	NA	28	NA	Moderate
Turnbull Pond 13 (#54)	Columbia Plateau	1993	2008	34	0	34	14	NA	25	34	Low
Turnbull Pond 82 (#55)	Columbia Plateau	1993	2021	0	0	25	9	0	-1	-25	Moderate
Turnbull Pond 63 (#56)	Columbia Plateau	1993	2012	0	0	3	1	0	-3	0	Moderate
Turnbull Pond 32 (#57)	Columbia Plateau	1993	2021	1000	0	1000	208	NA	999	1000	High
Turnbull Pond 120 (#58)	Columbia Plateau	1993	2021	0	0	100	53	0	-100	NA	High
Turnbull Pond 139 (#59)	Columbia Plateau	1993	2009	9	1	9	5	NA	8	NA	Low
Turnbull Pond 117 (#60)	Columbia Plateau	1993	2009	1	1	3	2	NA	-2	NA	Low
Turnbull Pond 18 (#61)	Columbia Plateau	1993	2008	48	0	48	12	NA	45	48	High
Turnbull Pond 149 (#62)	Columbia Plateau	1996	1998	200	0	200	104	NA	89	NA	Low

<b>USFWS</b>	<b>Ecoregion</b>	<b>First Visit</b>	<b>Last Visit</b>	<b>Last Pop Estimate</b>	<b>Min Pop</b>	<b>Max Pop</b>	<b>Long-term Avg</b>	<b>10 Year Avg</b>	<b>Long-term Δ</b>	<b>10-Year Δ</b>	<b>PHAR3 Abund.</b>
Turnbull Pond 150 (#63)	Columbia Plateau	1996	2008	76	76	76	76	NA	NA	NA	None
NW of Campbell Lake (#65)	Columbia Plateau	1997	1997	7	7	7	7	NA	NA	NA	None
N of S Luke Rd (#69)	Columbia Plateau	2012	2012	80	80	80	80	80	NA	NA	High
<b>Private/Unknown</b>	<b>Ecoregion</b>	<b>First Visit</b>	<b>Last Visit</b>	<b>Last Pop Estimate</b>	<b>Min Pop</b>	<b>Max Pop</b>	<b>Long-term Avg</b>	<b>10 Year Avg</b>	<b>Long-term Δ</b>	<b>10-Year Δ</b>	<b>PHAR3 Abund.</b>
Cheney-Spangle Rd (#3)	Columbia Plateau	1986	1986	1000	1000	1000	1000	NA	NA	NA	Low
Curtis Rd (#4)	Columbia Plateau	1987	1987	700	700	700	700	NA	NA	NA	High
Bretz Pothole (#5)	Columbia Plateau	1986	1992	0	0	1000	333	NA	-1000	NA	Low
Cameron Rd (#6)	Columbia Plateau	1987	1987	"observed"	0	0	NA	NA	NA	NA	High
Jennings Rd (#7)	Columbia Plateau	1987	1987	"observed"	0	0	NA	NA	NA	NA	High
Cross Tracks 1 (#8)	Columbia Plateau	1987	1987	"small pop"	0	0	NA	NA	NA	NA	Moderate
Cross Tracks 2 (#9)	Columbia Plateau	1987	1987	"observed"	0	0	NA	NA	NA	NA	Moderate
Cross Tracks 3 (#10)	Columbia Plateau	1987	1987	"few"	0	0	NA	NA	NA	NA	Moderate
E of Kepple Lake (#12)	Columbia Plateau	1987	1987	"observed"	0	0	NA	NA	NA	NA	High

<b>Private/Unknown</b>	<b>Ecoregion</b>	<b>First Visit</b>	<b>Last Visit</b>	<b>Last Pop Estimate</b>	<b>Min Pop</b>	<b>Max Pop</b>	<b>Long-term Avg</b>	<b>10 Year Avg</b>	<b>Long-term <math>\Delta</math></b>	<b>10-Year<math>\Delta</math></b>	<b>PHAR3 Abund.</b>
Lily Pond (#15)	Columbia Plateau	1987	1987	"small pop"	0	0	NA	NA	NA	NA	Low
Anderson Rd (#16)	Columbia Plateau	1987	1987	"scattered"	0	0	NA	NA	NA	NA	Moderate

**Table 3. Full data set of counts and qualitatively estimated numbers of *Howellia aquatilis* individuals across all known extant occurrences surveyed between 1978 and 2021.** \*Denotes incomplete surveys where less than 90% of a pond associated with an element occurrence was searched per field notes. Occurrences in red were selected for continued post-delisting monitoring using an expanded protocol starting in 2022 (U.S. Fish and Wildlife Service, 2020). 0 values indicate that a survey was conducted but no plants were found. Empty cells indicate that no survey was conducted that year for a given occurrence. Obs=Observed, Locs=locations

1978-2000																
Occurrence	Survey Year															
BLM	1978	1980	1983	1986	1987	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
W of Hog Lake (#37)									50		10-20	9	Obs	2 locs	3	Obs
DNR/DFW	1978	1980	1983	1986	1987	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Dishman Hills (#1)	Obs		2x15 m area													
Powder Factory (#64)											small, scattered					
Smythe Rd N (#67)															1260-1860+	
Burnett Rd (#68)															2005	
USDOD	1978	1980	1983	1986	1987	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Foot Lake (#39)										few*		3 locs	3 locs	338		
S of Bentsen (#40)										5x2 m area				4		
Bentsen (#41)										large pop				not found		
Binocular Pond (#42)												few	numerous	90		

1978-2000																
USDOD	1978	1980	1983	1986	1987	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Shaver Kettle (#43)												healthy pop		800		
Trench Wetland (#44)												scattered-dense		20		
NE Chambers Satellite (#45)												Obs		not found		
N Chambers Pond (#46)												floating fragments	entire shore	706		
W Shaver Pond (#47)												Obs	numerous	804		
Crone Marsh (#48)											2 areas	4 areas	scattered-abund	1000+		
Joseph Marsh (#49)											50 m area	scattered-dense			500	
Middle East Chambers (#50)												Obs		53		
Dailman Lake (#51)													100s	39		
Hamilton Lake (#52)													4	13		
Chambers East (#53)													few	91		
Willow Kettle (#66)														multiple groups		
Combs (#70)																
Lynch (#71)																
Roy (#72)																
Ressa (#73)																

1978-2000																
USDOD	1978	1980	1983	1986	1987	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Shaver Puddle (#74)																80-140
USFWS	1978	1980	1983	1986	1987	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Blackwater Island RNA (#2)		30 x 30 ft area						Obs								
Turnbull Pond 76 (#11)					Obs	Obs			10+			402	not found*			
E of Campbell Lake (#13)					little	Obs										
Squirrel View (#14)					scattered							16				
N of W Tritt Lake (#17)						very little										
Turnbull Pond 10 (#18)						scattered			2*			156	not found*			
S of W Blackhorse Lake (#19)						fair pop							not found*			
Turnbull Pond 85 (#20)									3 fragments *			57	not found*			
Turnbull Pond 21A (#21)									1*			Obs	not found*			
Turnbull Pond 77 (#22)									Obs				not found*			
Turnbull Pond 72 (#23)									2							
Turnbull Pond 55 (#24)									2			150				

Turnbull Pond 39 (#25)									3							
<b>1978-2000</b>																
<b>USFWS</b>	1978	1980	1983	1986	1987	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Turnbull Pond 21C (#26)									1							
Turnbull Pond 61 (#28)									5			46	50-75*			
Turnbull Pond 18 (#29)									1*							
Turnbull Pond 21B (#30)									2-5							
Turnbull Pond 31 (#31)									3+				not found*			
Turnbull Pond 29 (#32)									50+			18	2			
Turnbull Pond 12 (#33)									numerous				not found*			
Turnbull Pond 1A (#34)									1							
Turnbull Pond 112 (#35)									3							
Turnbull Pond 96 (#36)									4 clumps			15	not found*			
Turnbull Pond 107 (#38)									2			30				
Turnbull Pond 13 (#54)									9							
Turnbull Pond 82 (#55)									1*							
Turnbull Pond 63 (#56)									3*				not found			

Turnbull Pond 32 (#57)									1			39	not found			
<b>1978-2000</b>																
<b>USFWS</b>	1978	1980	1983	1986	1987	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Turnbull Pond 120 (#58)									100+			98	10-20			
Turnbull Pond 139 (#59)									1*			9				
Turnbull Pond 117 (#60)									3			1				
Turnbull Pond 18 (#61)									3			10	1			
Turnbull Pond 149 (#62)												111	not found	200*		
Turnbull Pond 150 (#63)												76				
NW of Campbell Lake (#65)													7			
N of S Luke Rd (#69)																
<b>Private/ Unknown</b>	1978	1980	1983	1986	1987	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Cheney-Spangle Rd (#3)				100s- 1000s												
Curtis Rd (#4)					several 100											
Bretz Pothole (#5)				100s- 1000s		Obs	not found	not found								
Cameron Rd (#6)					Obs											
Jennings Rd (#7)					Obs											



Cross Tracks 1 (#8)					small pop													
<b>1978-2000</b>																		
<b>Private/ Unknown</b>	1978	1980	1983	1986	1987	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000		
Cross Tracks 2 (#9)					Obs													
Cross Tracks 3 (#10)					few													
E of Kepple Lake (#12)					Obs													
Lily Pond (#15)					small pop													
Anderson Rd (#16)					scattered													

<b>2001-2021</b>																		
<b>Occurrence</b>	<b>Survey Year</b>																	
<b>BLM</b>	2001	2002	2003	2004	2005	2007	2008	2009	2010	2011	2012	2013	2014	2015	2018	2019	2020	2021
<b>W of Hog Lake (#37)</b>	2+	not found	not found	Obs	not found	E side of pond	E side of pond	5 locs, abundant	several patches	several patches	50*							
<b>DNR/DFW</b>	2001	2002	2003	2004	2005	2007	2008	2009	2010	2011	2012	2013	2014	2015	2018	2019	2020	2021
<b>Dishman Hills (#1)</b>		217								50						187*		
<b>Powder Factory (#64)</b>							few											
<b>Smythe Rd N (#67)</b>										85-120								

Burnett Rd (#68)									926	not found*		dense						
<b>2001-2021</b>																		
<b>USDOD</b>	2001	2002	2003	2004	2005	2007	2008	2009	2010	2011	2012	2013	2014	2015	2018	2019	2020	2021
Foot Lake (#39)														120-150	516		300-500	
S of Bentsen (#40)														not found				
Bentsen (#41)														5				
Binocular Pond (#42)														7				
Shaver Kettle (#43)														200	805-1235		1050-1100	
Trench Wetland (#44)														230-330	255-355		870-1110	
NE Chambers Satellite (#45)														52				
N Chambers Pond (#46)														107-182				
<b>USDOD</b>	2001	2002	2003	2004	2005	2007	2008	2009	2010	2011	2012	2013	2014	2015	2018	2019	2020	2021
W Shaver Pond (#47)														148-198	558		610	
Crone Marsh (#48)														1305	501-651		950	
Joseph Marsh (#49)														202	455-505		450-550	
Middle East Chambers (#50)														not found				

Dailman Lake (#51)														8				
<b>2001-2021</b>																		
<b>USDOD</b>	2001	2002	2003	2004	2005	2007	2008	2009	2010	2011	2012	2013	2014	2015	2018	2019	2020	2021
Hamilton Lake (#52)														16				
Chambers East (#53)														144-194	5 patches		330-560	
Willow Kettle (#66)														80	<50		315-560	
Combs (#70)														120				
Lynch (#71)														485	>400		2000+	
Roy (#72)														11	not found		not found	
Ressa (#73)														3				
Shaver Puddle (#74)														30	14		1	
<b>USFWS</b>	2001	2002	2003	2004	2005	2007	2008	2009	2010	2011	2012	2013	2014	2015	2018	2019	2020	2021
Blackwater Island RNA (#2)							3 locs	Obs					500+		all 4 ponds			
Turnbull Pond 76 (#11)						100s												
<b>USFWS</b>	2001	2002	2003	2004	2005	2007	2008	2009	2010	2011	2012	2013	2014	2015	2018	2019	2020	2021
E of Campbell Lake (#13)							6											
Squirrel View (#14)							105+											5

N of W Tritt Lake (#17)							not found	not found*	not found*		not found							
<b>2001-2021</b>																		
<b>USDOD</b>	2001	2002	2003	2004	2005	2007	2008	2009	2010	2011	2012	2013	2014	2015	2018	2019	2020	2021
Turnbull Pond 10 (#18)						60-120												
S of W Blackhorse Lake (#19)							2 small clusters	not found*	2 small clusters*									
Turnbull Pond 85 (#20)								many fragments										
Turnbull Pond 21A (#21)								2*										
Turnbull Pond 77 (#22)						1												
Turnbull Pond 72 (#23)									240+									
Turnbull Pond 55 (#24)							10+*											
Turnbull Pond 39 (#25)							23											
Turnbull Pond 21C (#26)						200+		Obs										
Turnbull Pond 61 (#28)						250+												

Turnbull Pond 18 (#29)							1-3												
<b>2001-2021</b>																			
<b>USFWS</b>	2001	2002	2003	2004	2005	2007	2008	2009	2010	2011	2012	2013	2014	2015	2018	2019	2020	2021	
Turnbull Pond 21B (#30)						not found *		Obs											
Turnbull Pond 31 (#31)						not found *	297												
Turnbull Pond 29 (#32)						15												not found	
Turnbull Pond 12 (#33)						40-70													
Turnbull Pond 1A (#34)									not found	not found	not found								
Turnbull Pond 112 (#35)										not found									
Turnbull Pond 96 (#36)						110+													
Turnbull Pond 107 (#38)								evenly scattered											
Turnbull Pond 13 (#54)						not found *	32-35												

Turnbull Pond 82 (#55)							25+												not found
<b>2001-2021</b>																			
<b>USFWS</b>	2001	2002	2003	2004	2005	2007	2008	2009	2010	2011	2012	2013	2014	2015	2018	2019	2020	2021	
Turnbull Pond 63 (#56)							not found	not found*			not found								"low" pop
Turnbull Pond 120 (#58)								entire perimeter											not found
Turnbull Pond 139 (#59)								1x2 m area											
Turnbull Pond 117 (#60)								Obs											
Turnbull Pond 18 (#61)						not found *	48												
Turnbull Pond 149 (#62)																			
Turnbull Pond 150 (#63)						throughout pond"													
NW of Campbell Lake (#65)																			
N of S Luke Rd (#69)											<100*								
<b>Private/Unk</b>	2001	2002	2003	2004	2005	2007	2008	2009	2010	2011	2012	2013	2014	2015	2018	2019	2020	2021	
Cheney-Spangle Rd (#3)																			

Curtis Rd (#4)																			
<b>2001-2021</b>																			
<b>Private/Unk</b>	2001	2002	2003	2004	2005	2007	2008	2009	2010	2011	2012	2013	2014	2015	2018	2019	2020	2021	
Bretz Pothole (#5)																			
Cameron Rd (#6)																			
Jennings Rd (#7)																			
Cross Tracks 1 (#8)																			
Cross Tracks 2 (#9)																			
Cross Tracks 3 (#10)																			
E of Kepple Lake (#12)																			
Lily Pond (#15)																			
Anderson Rd (#16)																			