WASHINGTON NATURAL HERITAGE PROGRAM

Updated monitoring methods and recent population trends for *Hackelia venusta*

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ON THE COVER: *Hackelia venusta* blooms in Tumwater Canyon. Photo by Jesse E. D. Miller.

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Introduction

Showy stickseed or *Hackelia venusta* (Piper) St. John (Boraginaceae) is a perennial herb with typically white flowers that are borne on multiple stems. A narrow endemic of the Wenatchee mountains, *H. venusta* grows at a single location in Tumwater Canyon near Leavenworth, Washington, USA. *H. venusta* was originally collected in 1920 by J. C. Otis, and was described as *Lappula venusta* in 1924 by Charles V. Piper (Gamon 1997). It was subsequently placed in *Hackelia* and included in a revision of the genus by Gentry and Carr (1976, as cited in Gamon 1997). At one time, *H. venusta* was also believed to occur at several locations in the Alpine Lakes Wilderness, but these populations are now considered a separate species, *Hackelia taylori*, which is distinguished by its deep blue flowers and is also quite rare.

The typical habitat of *Hackelia venusta* is granitic sand on steep, unstable slopes in areas with low vegetation cover (Gibble 2015). Since the 1980s, population estimates in the Tumwater Canyon site have varied from as many as ~1000 plants to as few as 140 plants (in 1995), with a variable but overall declining trend. Competing vegetation may pose a threat to *H. venusta* (Gibble 2015). Disturbance associated with recreation, road construction and the use of de-icing chemicals may also pose a threat to the species (Fertig 2021). Fire suppression may also threaten *H. venusta*, since wildfire may remove competing vegetation while having relatively little effect on barren areas where *H. venusta* occurs. *H. venusta* was listed as a federally endangered species in 2002 (US Fish and Wildlife Service 2002).

Assessing population trends over time is critical for planning conservation and management practices for *Hackelia venusta*. The Washington Natural Heritage Program has monitored *H. venusta* since it was included on the first state rare plant list in 1981 (Florence Caplow, unpublished letter). Monitoring *H. venusta* is challenging because it is difficult to see plants without disturbing the unstable soils around them. For over a decade, WNHP tracked *H. venusta* populations in polygons originally mapped by Joe Arnett (Arnett 2011). However, the Arnett plots proved challenging for other observers to reliably relocate, and their size required walking among the sensitive plants, potentially damaging these rare plants.

Here, we describe a new monitoring protocol for *Hackelia venusta* that is informed by the lessons we have learned from over four decades of monitoring this species. Recognizing that monitoring the total size of the entire population is very difficult because of the challenges of moving around the steep and slide-prone site, we focus instead on a protocol that should allow us to detect population trends without sampling all plants in the population. This new monitoring protocol is likely to increase reproducibility and reduce potential disturbance to the plants and their habitat caused by surveyors. In addition to describing the new protocol, we also analyze trends in *H. venusta* abundance since 2010.

Methods

Developing updated monitoring protocol

We developed a new monitoring protocol for *Hackelia venusta* using permanent plots and photo points that are dispersed throughout the existing population and adjacent suitable habitat (Figure 1). These locations were demarcated using aluminum tags that were either nailed to trees or affixed to rebar in the ground. The sampling locations were placed in roughly a grid pattern, to the extent that the terrain allowed. At each location, we counted the number of vegetative and reproductive *H. venusta* plants within a 10 m radius of the marker, in either a 180-degree hemispheric plot, or a 360-degree circular plot. The 10 m distance was selected so that all plants in a plot could be observed from outside the plot to reduce trampling disturbance. We also recorded the number of seedlings that could be seen from a fixed position near the marker as a separate count.

< Figure 1 is redacted; please contact the Washington Natural Heritage Program if you need an unredacted version of this report.>

Figure 1. Map of Arnett plots (blue polygons) and new point-count monitoring plots (red polygons) at the only wild population of *Hackelia venusta* in Tumwater Canyon in Chelan County, Washington, USA.

We installed the circular or hemispheric plots at 25 points in the core population area as well as to the south where additional clusters of plants occurred (Figure 1). Some plots were located in areas of suitable habitat that did not currently contain plants for the purpose of assessing how the spatial distribution of the plants changes over time. All plots were censused for *H. venusta*, and we took photographs of each plot from its associated marker. 21 of the new plots were established and censused in 2022; another four plots were established and censused in 2023, and the other 21 plots were censused again in 2023.

Analysis of population trends

To analyze recent trends in *Hackelia venusta* abundance, we selected Arnett plots that had been visited at least once from 2009-2011 and again from 2020-2022. If a plot was visited more than once during the first or second three-year period, we averaged the values within the three-year period so that we could analyze a single starting and ending value for each plot. To analyze whether abundance changed over time, we used a linear mixed model with number of plants as the dependent variable, time point as the fixed effect, and plot as a random effect. The analysis was performed using the lme4 package (Bates et al. 2015) in R 4.3.1 (R Core Team 2023). The new monitoring plots were not used in this analysis, since only two years of data are available, and because they are not directly comparable to the Arnett plots.

Results and Discussion

Updated monitoring protocol results

In the first visit to the 21 new monitoring plots in 2022, we encountered a total of 100 plants, including 85 reproductive plants and 15 vegetative plants. Within each plot, the number of plants ranged from one to 28, with a median of four plants. In the 25 monitoring plots visited in 2023, we encountered a total of 128 plants, including 111 reproductive and 17 vegetative plants. The median number of plants per plot was 3.5 and counts ranged from zero to 22. A comprehensive description of the new protocol and plot locations will be included in a forthcoming report from the Washington Rare Plant Care and Conservation Program.

Analysis of population trends

The average number of plants per Arnett plot decreased by 23% over the eleven-year period we analyzed, from 17.8 plants in 2009-2011 to 12.4 plants in 2020-2022 (Figure 2). This represented a significant decrease (P=0.03).

Discussion

Decreasing population trends highlight that *Hackelia venusta* remains vulnerable to extinction. Considering that *H. venusta* is a single-site endemic with a small population that fluctuates greatly, it seems possible that demographic stochasticity alone could reduce the population below a sustainable point. Current outplanting efforts remain critical to the long-term viability of this plant.

The new monitoring plots described here should help facilitate relatively precise, long-term monitoring of *Hackelia venusta* while minimizing disturbance to their sensitive habitat. While the new plots cover less area than the previously used Arnett plots, they confer several advantages over the previous method. The new plots will reduce disturbance to the plants because they are small enough that surveyors do not need to walk through the plots. This represents a significant improvement over the previous method because the soils at the site are highly prone to erosion when walked upon, and surveying the Arnett plots had the potential to cause substantial disturbance to *H. venusta* plants. The smaller size of the new plots allows all individual plants to be seen from a single vantage, which probably increases accuracy of monitoring. The new plots were also placed in areas both with and without existing *H. venusta* plants, so they may capture the colonization of new areas if *H. venusta* populations occur in a shifting mosaic pattern. In contrast, the Arnett plots were only established in areas where *H. venusta* had been detected, meaning that they might exaggerate population declines under a shifting mosaic-type population dynamic. Finally, the smaller size of the new plots means that they could be utilized in future efforts to study the demography of *H. venusta*. Because the new plots confer these advantages over the Arnett plots, we recommend using the new plots as the basis of future monitoring efforts.

The causes of the decrease in *Hackelia venusta* abundance that we document over the last decade of monitoring are not fully understood. This decrease may be caused by known threats to the species, such as fire suppression. Pollinator limitation could also be a factor limiting reproduction, and further research should explore pollination ecology of *H. venusta*. The pollinators of *H. venusta* are not well documented. Its flower morphology seems consistent with a possible nocturnal pollinator. The declining trend could also be explained by demographic stochasticity alone or in combination with other factors.

A demographic monitoring study that tracks individual plants could yield insights into population dynamics and help address critical questions underpinning the conservation of *Hackelia venusta*. For example, seedling survival data could be used to perform a population viability assessment. A demographic study could also elucidate whether prolonged dormancy occurs in *H. venusta*. Demographic studies have not been implemented to date because the sensitive nature of the habitat makes it difficult to approach plants without causing erosion and potentially damaging plants. However, because this is a major research need considering the imperiled status of *H. venusta*, creative approaches such as using drones should be considered for performing demographic monitoring without damaging the population.

Drone-based monitoring and research for *Hackelia venusta* could be worth exploring further, given the unique challenges of monitoring this species on foot (e.g., difficult terrain for travel and erosive soils). Exploratory pilot studies would be needed before drone-based monitoring or demographic studies could be implemented. It is currently unknown how effectively a drone could differentiate *H. venusta* from co-occurring herbaceous plants. Also, if regulations require the drone to operate within the line of sight of the operator, this could make drone research in this wooded area challenging. However, if these potential challenges can be circumvented, a drone-based approach could provide a faster and easier method for monitoring plots and demography. Drones could potentially be used to sample the new monitoring plots we describe above, and might also be useful for addressing additional research needs. For example, a drone-based approach could thoroughly survey the steep terrain beyond the known extent of the *H. venusta* population, and might lead to the discovery of additional *H. venusta* plants. Drones could also be potentially deployed in future demographic studies of *H. venusta*.

Developing precise estimates of *Hackelia venusta*'s abundance remains challenging. Complete counts of the wild population have rarely been performed, in part because the terrain is steep and unstable. Long-term trends are difficult to establish based on existing plot-based data because different subsets of the plots have historically been visited in most monitoring years. We believe that the data presented here represent the most comprehensive possible trend analysis for the time period since 2009, but it is difficult to compare these monitoring years with monitoring data prior to 2009. Despite this uncertainty, there is no question that *H. venusta* remains one of the most vulnerable plant taxa in Washington.

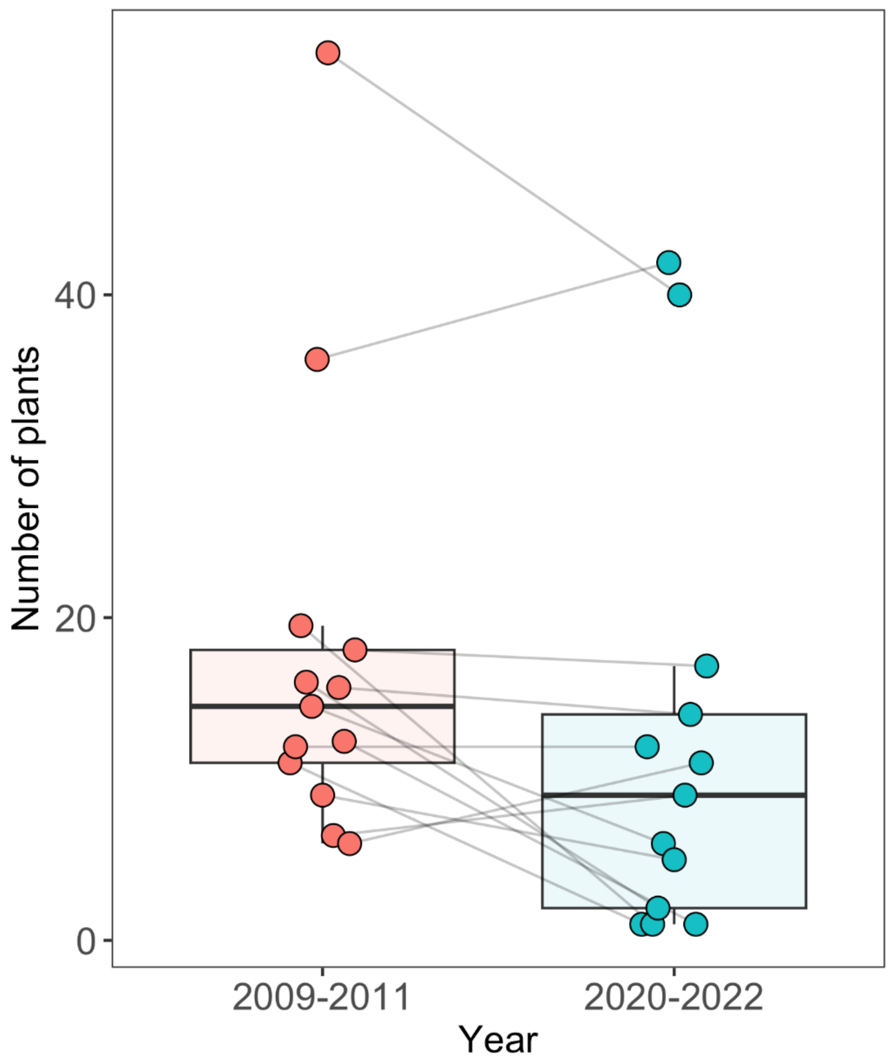

Figure 2. Population trends for *Hackelia venusta* from 2009-2011 to 2020-2022. Red points represent Arnett study plots during the first time period, and blue points represent the same plots during the second time period.

Literature Cited

Arnett, J. 2011. *Hackelia venusta* (showy stickseed). Monitoring and Inventory, 1968-2011. Prepared for the U.S. Fish and Wildlife Service. Natural Heritage Report 2011-03., Washington Natural Heritage Program, Department of Natural Resources, Olympia.

Bates, D., M. Mächler, B. Bolker, and S. Walker. 2015. Fitting Linear Mixed-Effects Models Using lme4. Journal of Statistical Software 67:1–48.

Fertig, Walter. 2021. Status of Federally Listed Plant Taxa in Washington State. Natural Heritage Program Report 2021-01. Washington Natural Heritage Program, WA Department of Natural Resources, Olympia, WA.

Gamon, J. G. 1997. Report on the status of *Hackelia venusta* (Piper) St. John. Washington Natural Heritage Program, WA Department of Natural Resources, Olympia, WA.

Gentry, J. L., and R. L. Carr. 1976. A revision of the genus *Hackelia* (Boraginaceae) in North America, North of Mexico. Memoirs of the New York Botanical Garden 26:121–227.

Gibble, W. 2015. *Hackelia venusta* (showy stickseed) Recovery Project. Report prepared for the US Fish and Wildlife Service Region 1. Rare Plant Care and Conservation. University of Washington Botanic Gardens.

R Core Team. 2023. R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna, Austria.

US Fish and Wildife Service, U. S. 2002. Endangered and threatened wildlife and plants: determination of endangered status for the Washington plant *Hackelia venusta* (showy stickseed. Federal Register 67:5515–5525.

Appendix A: *Monitoring data*

Table A1. Hackelia venusta abundance (number of plants) as estimated in Arnett plots, 2004-2022

Subarea	Description	USFWS et al 2004	Arnett 2009	Arnett 2010	Arnett 2011	Arnett 2012	Arnett 2014	Gibble 2020	Gibble 2021	Gibble 2022	Notes
A	Cliffs at roadside across from pulloff	300-500*	12	10					1		
B	Center of core, adjacent to road (up to sandy area below PSME)	(inc in G)	21	3						12	
C	Vicinity of large maple adjacent to road	(inc in G)	11	28						1	
D	Downslope of two logs in core center (from CEVE to CEVE	(inc in G)	15	17						2	
	Between two logs in core center (incl PSME)	(inc in G)	14	15						6	
F	Above two logs in core center, up to cliff	(inc in G)	11	14							
G	Draw above upper ends of two logs	300-500*	29	43				47		37	2022 count might include some of F
H	Upslope of G draw, north portion	(inc in G)	10	8						5	
I	Upslope of G draw, central portion	(inc in G)	43	67						40	
J	Upslope of G draw, south portion	(inc in G)	12	0							(not sure where this is, description sounds like it is area I)
SE of J	in gully south of core, under PIPO and on outcroppings just upslope of 2015 plot 3							24	9	16	2021 count only in gully above PIPO, not around base of tree. I think Arnett was aware of these, maybe as part of J
K	Uppermost portion of core population	(inc in G)	6	13							
New area	ESE of K, at top of gully south of core									18	

Subarea	Description	USFWS et al 2004	Arnett 2009	Arnett 2010	Arnett 2011	Arnett 2012	Arnett 2014	Gibble 2020	Gibble 2021	Gibble 2022	Notes
I, part K?	Above G gully and W 2019 overlook plot (#8)							58			
NE of K	In gully south of core, upslope of 2019 Upper Gully plot (#9)							25			as far as I know, Arnett never counted this group
L	South of two logs, below cliffs	(inc in G)	10	3					9	9	
M	North of core, above cliffs	6	15	0							
near N, P	on north side of sandy slope at base of outcropping and under trees, north of P									13	Not sure if Arnett was aware of these plants, just upslope of road but not visible from road
N	Cliffs along road south of core	80	18	18	11				17	11	
O	At tree base, between the road and river	18	12	19	6				1		
P	edge of gully to south of core	40									Is P actually near Plot 3, or gully that south of J?
Q	under large PSME south of gully	27									Or is Q actually just north of N?
P or Q	Downslope from 2015 plot 4 (Sambucus), under PSME (2012 transect)							17		21	
R	in gully south of E-W band of cliffs	35			6				11		
S	upper portion of E-W band of cliffs	6			18				17		
T	2011 sample points 7-9, band of cliffs above The Alps	60			7						
U	2011 sample point 10	(w/T)			6						
V	2011 sample points 11 & 12	(w/T)			6						
TOTAL*		**672**	**239**	**258**	**60**	**477**		**171**	**65**	**191**	

*Note that totals represent the total of whatever plots were monitored in a given year, and do not represent the total abundance of the wild population. Totals are not directly comparable year-to-year since different plots were monitored each year.