2021 Population Census of *Eriogonum tiehmii* (Tiehm's buckwheat) in the Polygonaceae

Cover photos: Top right: Tiehm's buckwheat in flower; top left: Tiehm's buckwheat leaves; bottom center: subpopulation 6 in flower in 2020. Photos by Patrick Donnelly.

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Introduction

Tiehm's buckwheat (*Eriogonum tiehmii* Reveal) is a narrowly endemic perennial herb in the buckwheat family (Polygonaceae) that blooms between May and June (Fig. 1). Its global range is restricted to a single location, inhabiting 10 acres that are spread across 3 square miles in the Rhyolite Ridge area of the Silver Peak Range in Esmeralda County, Nevada (Morefield 1995). This species is considered a soil-specialist and occurs in habitat consisting of open, sparsely vegetated slopes, between 5,906 and 6,234 feet in elevation, on highly mineralized clay rich soils (McClinton et al. 2020, USFWS 2021, Fig. 2). It is ranked as a G1/S1 (critically imperiled) by the Nevada Division of Natural Heritage, and is listed as "sensitive" by the Bureau of Land Management (BLM). Based on information presented in their 12-month finding in response to a petition submitted by the Center for Biological Diversity, the U.S. Fish and Wildlife Service found that protection of Tiehm's buckwheat under the federal Endangered Species Act is warranted (USFWS 2021). The species is currently at risk of extinction due to a proposed boron-lithium mine. The project area of the mine encompasses the entire range of Tiehm's buckwheat, and if implemented, the first phase of the project would impact over 50% of the known global population, causing extirpation of subpopulations 4, 5, 6, and 7 (EM Strategies 2020, USFWS 2021; Fig. 2).

Figure 1. *Eriogonum tiehmii* (Tiehm's buckwheat) in flower. Photo taken on May 31, 2019.

In September 2020 an unprecedented event caused severe damage and population decline to Tiehm's buckwheat across the entire range of the species (McClinton et al. 2020, Donnelly and Fraga 2020a). The observed damage was highly variable in nature and included total plant mortality, plants that were partially dug up with roots exposed, and above-ground portion of the plants detached from their roots with roots remaining in the ground (Fig 3). Investigations into the cause of the mortality and

damage occurred one to four weeks after the initial discovery (Grant 2020, Morefield 2020, West 2020), therefore evidence substantiating the cause of damage may have been obscured or altered during that time. Multiple hypotheses for the damage and mortality have been proposed, including intentional damage by humans, and herbivory by small mammals (i.e. ground squirrels and pocket gophers); however, evidence gathered to date is inconclusive (Donnelly and Fraga 2020a, Grant 2020, Morefield 2020, West 2020). All investigators who examined the site agree that the damage was severe and significant (Donnelly and Fraga 2020, Grant 2020, Morefield 2020, West 2020). Initial estimates indicate that approximately 60% of the known global population may have experienced damage or mortality (Fraga 2020, Morefield 2020, Table 1).

Botanists from the California Botanic Garden conducted a total census of the only known global population of Tiehm's buckwheat between June 7 and 9, 2021, in order to assess its current status. A summary of the census results, including methods, discussion, and recommendations for future monitoring is provided.

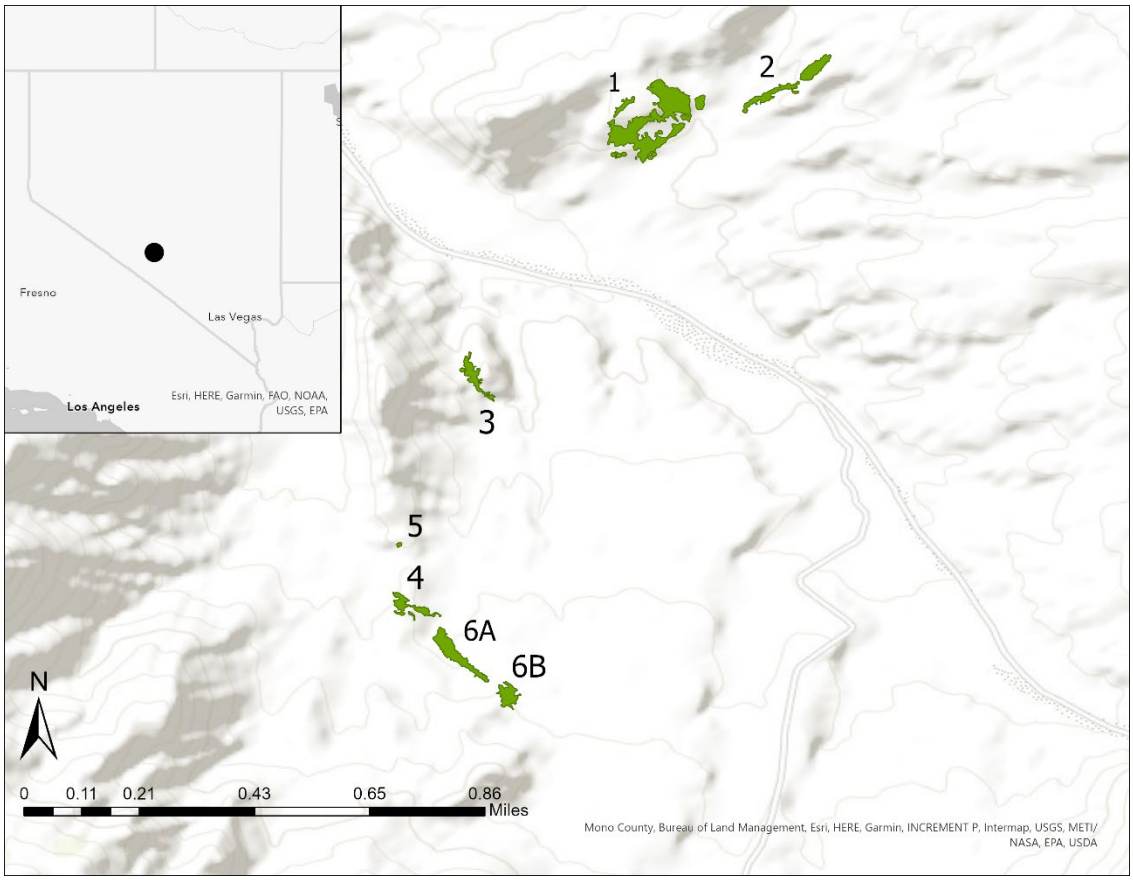

Figure 2. Map of Tiehm's buckwheat populations.

Figure 3. Photographs showing damaged plant in January 16, 2021 and the same plant recovering from damage and re-sprouting on May 7, 2021.

Figure 4. Stem tissue of Tiehm's buckwheat showing three stem segments that are separated by at least 5 cm and were counted as separate individuals per the protocol outlined by EM Strategies in 2019.

Methods

The CalBG survey took place on June 7, 8, and 9, 2021 across all known subpopulations of Tiehm's buckwheat (except for subpopulation 8; Fig. 2). The CalBG survey team was led by Naomi Fraga (Director of Conservation Programs) and included the following team members: Kala Barron (Restoration Technician), Carson Barry (Conservation Intern), Joy England (Rare Plant Botanist), and Kim Schaefer (Seed Conservation Technician).

Each team member was assigned discrete areas to survey within each subpopulation. A pdf map containing polygons for each subpopulation was loaded into the Avenza app to delineate survey areas across the known range of the species. Meter tape was used to divide each polygon into discrete survey areas. Within a survey area, a combination of meter tape and pin flags were used to systematically survey the entire area. In areas of high density, a meter tape was laid down to create a 1-meter-wide belt transect that was walked slowly to count all plants. The number of plants observed was recorded onto a field form, and the data was combined once surveys were complete. During surveys we attempted to count damaged plants that were recovering, separately from undamaged plants, however this was too difficult to assess. Therefore, we only report the total number of living plants observed within each subpopulation. In order to be consistent with prior methods, we defined the unit of an "individual" as being a group of stem tissue that had less than 5 cm of space between living tissue (EM Strategies 2020; Fig. 4). Due to damage that occurred to above ground stem tissue, plants that may have been counted as one individual in 2019 could have been counted as multiple individuals in 2021. Due to time constraints, plant size and reproductive status were not recorded.

Results

Census results

We counted a total of 15,757 living individuals across all subpopulations in the 2021 survey (Table 1). A high proportion of plants appeared to be recovering from damage, especially in subpopulation 1, 2 and 4, although the approximate number of plants recovering from damage was too difficult to determine. Subpopulation 6 is the largest subpopulation with 7,787 individuals counted. Subpopulation 5 and 7 were

presumed to be extirpated in 2020, but three individuals and 14 individuals respectively were found re-sprouting from roots. Subpopulation 4 appears to be the most severely impacted, with only 649 individuals remaining. Subpopulation 3 had the most limited damage with an estimated 37% population decline. We estimated that all subpopulations, except for subpopulation 3 were reduced by 50% or more (Table1).

Herbivory in 2021

On a routine population visit on May 7, 2021 Fraga and Patrick Donnelly (Center for Biological Diversity) observed one clipped inflorescence in subpopulation 1 (Fig. 5). We did not observe wide scale herbivory of inflorescences during the 2021 census or on any other visits in 2021. There has been no observed wide scale damage to plants similar to what occurred in 2020 as of July 16, 2021, when Patrick Donnelly last visited the site (Personal communication, July 16, 2021).

Figure 5. Clipped inflorescence. Photo taken May 7, 2021.

Table 1. Estimate of Tiehm's buckwheat subpopulations. Estimate of the number of plants in 2019 (EM Strategies 2020), damaged and dead plants in 2020 (USFWS 2021), and estimates based on the current census.

Sub-population	Estimated number of plants (2019)	Estimated plants damaged or dead (2020)	% estimated dead or damaged (2020)	2021 census	Difference between 2019 and 2021 census	% change 2019 to 2021
1	9,240	5,134	56%	4,420	4,820	52%
2	4,541	3,593	79%	1,719	2,822	62%
3	1,860	1,626	87%	1,165	695	37%
4	8159	4,798	59%	649	7,510	92%
5	199	199	100%	3	196	98%
6	19,871	11,531	58%	7,787	12,084	61%
7	50	50	100%	14	36	72%
8	1	Not censused post damage in 2020 or 2021				
Total	43,921	26,931	61%	15,757	28,163	64%

Off Highway Vehicle (OHV) Damage

We observed extensive OHV tracks at subpopulation 1, 4 and 6 during the census (Fig 6). At subpopulation 6B we observed a plant that was re-sprouting from the 2020 damage, but was subsequently broken off from its roots by OHV traffic (Fig. 7).

Figure 6. Off Hwy Vehicle tracks at the top of the ridge at subpopulation 1.

Figure 7. Plant damaged and severed from its root from OHV damage.

Discussion

The 2019 estimates of the total number of individuals in subpopulations 4 and 6 were likely over estimates as indicated by the 2021 census. Based on the 2020 assessment of damage (USFWS 2020), there should have been approximately 3,300 undamaged plants remaining in subpopulation 4 and approximately 8,300 undamaged plants remaining in subpopulation 6 (Morefield 2020). We counted only 649 total plants

in subpopulation 4 which is five times less than the total estimate of undamaged plants that were estimated to be remaining. We counted 7,787 total plants in subpopulation 6 which included damaged and undamaged plants; this is less than the estimate of undamaged plants that were estimated to have been remaining (Morefield 2020, USFWS 2020).

Potential issues with the reliability of the subpopulation estimates have been mentioned in prior reports. EM Strategies (2020) noted that “Constraints to obtaining accurate estimates include the patchy nature of the subpopulations, and the difficulty of determining what constitutes an individual plant in high density areas.” McClinton et al. (2020) did not extrapolate the total population size from the 2020 transect counts, but noted that “errors due to plants that are missed or small variation in transect tape placement could account for internal variability” and that establishment of demography plots (e.g. tagged plants) in subpopulations 4 and 6B would help to determine the cause of variation in counts between years, and may reduce observation uncertainty.

In 2021, southwestern Nevada experienced exceptional drought conditions (U.S. drought monitor 2021) with only 89.98 mm of precipitation estimated through interpolated weather data by the PRISM climate group at the Tiehm’s buckwheat population (37.8112, -117.8611) for the water year (October to September) at 4 km resolution (Prism 2021; Fig. 9). The exceptional drought conditions experienced in 2021 are similar to drought conditions experienced in 2020 with 108.78 mm of total precipitation that was estimated for the water year based on PRISM models at the Tiehm’s buckwheat population in 2020. It is important to note that data downloaded from PRISM that are one to six months old are considered provisional (PRISM 2021).

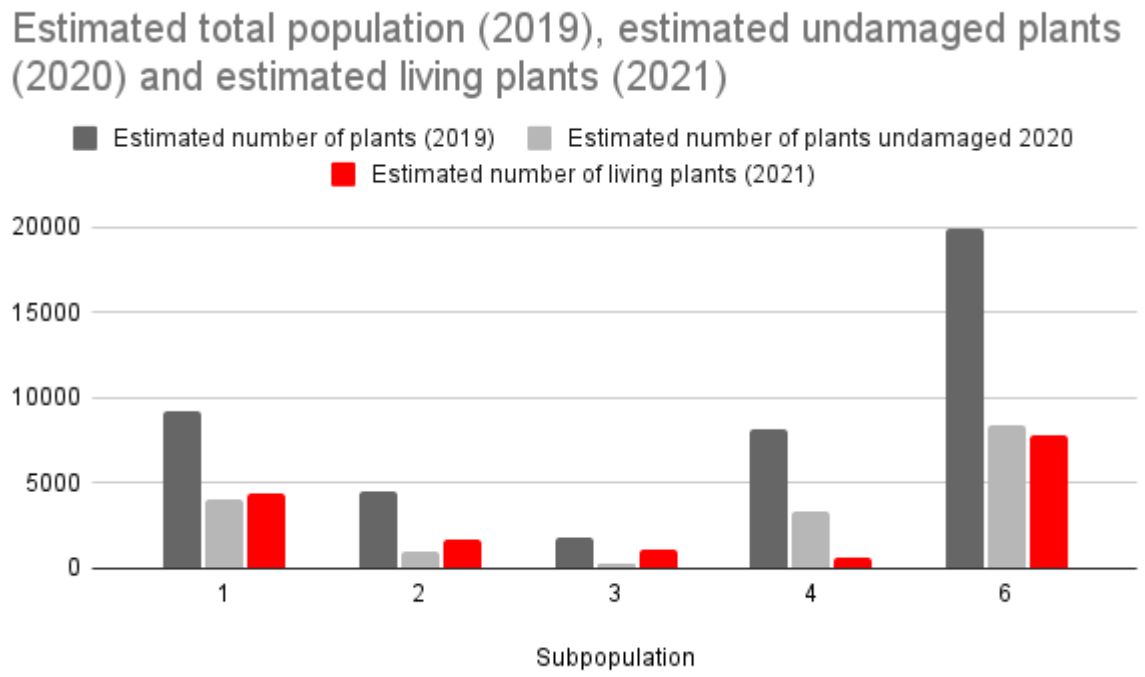

Figure 8. Bar graph showing 2019 Tiehm's buckwheat subpopulation estimates (dark gray), 2020 estimation of undamaged plants (light gray), and 2021 total census (red). Subpopulations 5 and 7 are not included due to scale.

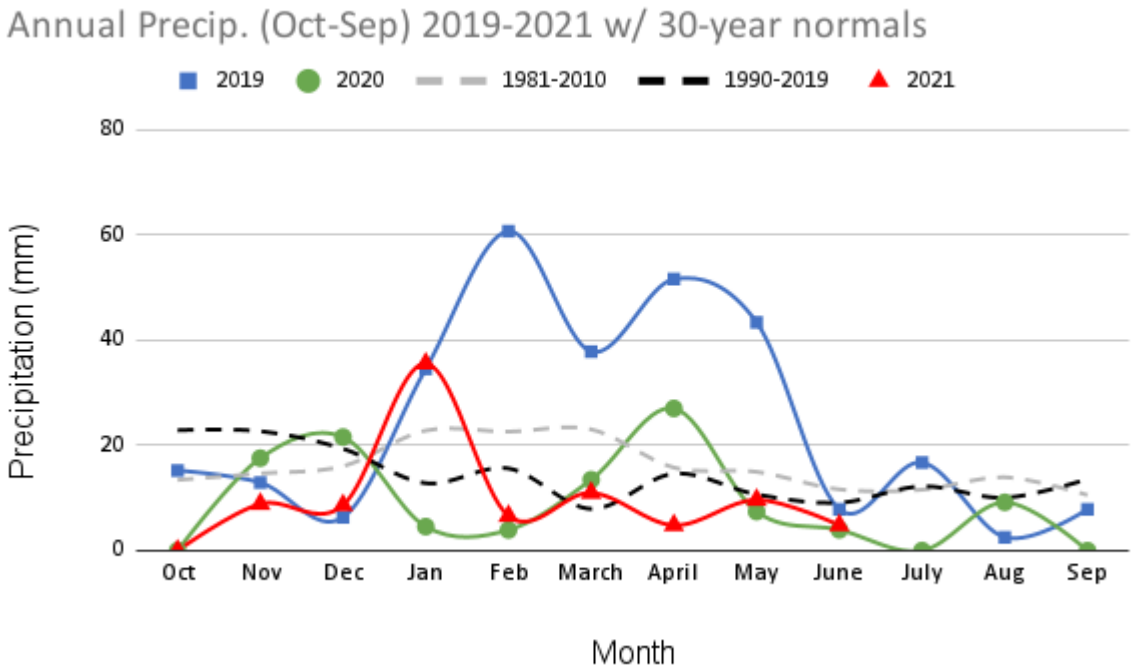

Figure 9. Annual precipitation downloaded and interpolated from PRISM (2021) for 2019-2021, including 30-year normal for 1981-2010 and 1990-2019.

Recommendations

Monitoring recommendations

Continued monitoring is needed to assess plant recovery following the 2020 damage, especially due to exceptional drought conditions, and additional damage to plants from recurring OHV trespass. Given the significant decline at subpopulation 4, we recommend that future counts use a total census method at this subpopulation, including tagging plants to establish demographic data to track individuals through time. We also recommend setting up demography plots in subpopulation 6B, as was recommended by McClinton at al. (2020).

Restoration recommendations

Given the significant population decline and loss of individuals we recommend experimental out-plantings within known subpopulations. Experimental out-plantings have taken place in non-occupied locations; these experiments could potentially inform restoration within known populations. Conducting restoration experiments to restore and enhance known populations will aid in future recovery efforts of this species. Seed sourcing for these experiments should be informed by population genomics studies that are currently ongoing at the University of Alabama at Huntsville. Additionally, to protect the loss of genetic diversity against future catastrophic events, a robust conservation seed collection should be established at a reliable seed repository. The collection should be stored by keeping maternal lines separate and tracked by subpopulation, with a backup collection stored at the National Laboratory for Genetic Resources Preservation in Fort Collins, Co.

Recommendations to protect against OHV damage

Monthly visits by Patrick Donnelly and Fraga have revealed Off highway vehicle (OHV) trespass is occurring on a regular basis (Donnelly and Fraga 2020b). During monitoring we observed fresh OHV tracks at subpopulations 1, 4 and 6. A plant that was re-sprouting from damage that occurred in 2020 was severed from its root, causing mortality. The mining exploration by Ioneer has increased vehicle access to subpopulations 4, 5, and 6, increasing activity and trespass into occupied habitat. OHV activity may cause soil compaction, damage plants, alter habitat quality, and introduce

invasive plants (Switalski 2018). We recommend erecting a fence to protect populations and prevent vehicle incursion. In order to facilitate recovery, future OHV trespass within occupied habitat should be prevented.

Acknowledgement

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