U.S. Fish and Wildlife Service

Species Status Assessment Report

Eriogonum tiehmii (Tiehm's buckwheat)

(Photo: James Morefield/Nevada Division of Natural Heritage)

Version 1.0
April 2021
Region 10

ACKNOWLEDGEMENTS

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Funding

The U.S. Fish and Wildlife Service provided funding to Dr. Jacqualine Grant of Southern Utah University to do an eDNA study on *Eriogonum tiehmii*. We thank her for providing expedited research to help inform this Species Status Assessment Report.

SUGGESTED CITATION: U.S. Fish and Wildlife Service. 2021. Species status assessment report for *Eriogonum tiehmii* (Tiehm’s buckwheat), Version 1.0. Department of the Interior California-Great Basin Region. Sacramento, California. April, 2021.

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LIST OF ACRONYMS

ACEC's	Areas of Critical Environmental Concern
Act	United States Endangered Species Act
AUMs	Animal Units Months
BLM	Bureau of Land Management
CBD	Center for Biological Diversity
eDNA	Environmental DNA
FLPMA	Federal Land Policy and Management Act
IPCC	Intergovernmental Panel on Climate Change
NDF	Nevada Division of Forestry
NDNH	Nevada Division of Natural Heritage
NDOW	Nevada Department of Wildlife
NEPA	National Environmental Policy Act
OHV	Off Highway Vehicle
PoO	Plan of Operations
RMPs	Resource Management Plans
Service	United States Fish and Wildlife Service
SSA	Species Status Assessment
UNR	University of Nevada, Reno
WRCC	Western Regional Climate Center

EXECUTIVE SUMMARY

We, the U.S. Fish and Wildlife Service (Service), have developed this Species Status Assessment (SSA) Report in response to a petition (CBD 2019, entire) to list *Eriogonum tiehmii* (Tiehm's buckwheat) under the Endangered Species Act of 1973, as amended (Act). The SSA Report is intended to provide the biological support for determining whether the species meets the definition of either a threatened or an endangered species and if so, provide the biological and ecological information to inform any critical habitat designation. The SSA Report does not represent a decision by us whether or not to list the species under the Act. Instead, this SSA Report provides a review of the best scientific and commercial information available on *E. tiehmii*.

Eriogonum tiehmii was first discovered in 1983 and described in 1985. It is a low growing perennial herb, with blueish gray leaves and pale, yellow flowers that bloom from May to June and turn red with age. Seeds ripen in late-June through mid-July. *Eriogonum tiehmii* is a narrow-ranging endemic known only from one population, comprised of eight subpopulations, in the Rhyolite Ridge area of Silver Peak Range in Esmeralda County, Nevada. It occurs entirely on federal lands managed by the Bureau of Land Management (BLM).

Like most terrestrial plants, *Eriogonum tiehmii* requires soil for physical support and as a source of nutrients and water. Research has found that *E. tiehmii* is a soil specialist as the species is specifically adapted to grow on its preferred soil type. The species is restricted to dry, open, relatively barren slopes with light-colored rocky clay soils derived from an uncommon formation of interbedded claystones, shales, tuffaceous sandstones, and limestones. Vegetation varies from pure stands of *E. tiehmii* to sparse associations with a few other low growing herbs and grass species. *Eriogonum tiehmii* substantially supports the high abundance and diversity of arthropods and pollinators found in the Rhyolite Ridge area.

To evaluate the biological status of *Eriogonum tiehmii* both currently and into the future, we assessed a range of conditions to allow us to consider the species' resiliency, redundancy, and representation. The likelihood of the species' persistence depends upon the number of redundant subpopulations, its resilience to threats, and its distribution (representation). We evaluated how anthropogenic threats such as mineral development, road development and off highway vehicle (OHV) activity, livestock grazing, non-native invasive plant species, and climate change, and natural threats such as herbivory and small population size influence the resiliency, redundancy, and representation of *E. tiehmii* individuals, subpopulations, and overall population. We also evaluated how the effects of climate change have the potential to influence and cumulatively interact with other current and future anthropogenic and natural threats impacting *E. tiehmii*.

Eriogonum tiehmii experienced a recent herbivory event that led to the damage and loss of many individual plants and subpopulations, representing 61 percent of the total population. This was the first documentation of herbivory on the species and its significance depends not only on its frequency and intensity, but whether damaged plants can recover and survive. We also evaluated how this natural threat influenced the resiliency, redundancy, and representation of *E. tiehmii* individuals, subpopulations, and overall population and how it may cumulatively interact with other current and future anthropogenic and natural threats.

The viability of *Eriogonum tiehmii* depends on maintaining multiple redundant and resilient subpopulations over time within the overall population (representation). *Eriogonum tiehmii* is adapted to dry, upland sites, subject only to occasional saturation by rain and snow. Under climate change predictions, we anticipate alteration of precipitation and temperature patterns as models forecast warmer temperatures and slight increases in precipitation. Given our uncertainty regarding the future effects of climate change, as well as other threats, we predict resiliency, redundancy, and representation of *E. tiehmii* under four future scenarios with a timeframe of 40 years. The four future scenarios provide a spectrum of the best available information regarding land management authorizations and land uses, development, existing regulatory mechanisms, and beneficial conservation measures expected to occur during this period. Additionally, 40 years is long enough to capture the temporal range of the available climate model projections; however, beyond that timeframe, the level of uncertainty becomes overwhelming, making future projections unrealistic. These scenarios are:

- Scenario 1 – a continuation of all current BLM land management authorizations and land uses (but no new mining operations authorized) under the intermediate RCP 4.5 climate scenario
- Scenario 2 – approval of the Rhyolite Ridge Lithium-Boron project under the intermediate RCP 4.5 climate scenario
- Scenario 3 – approval of the Rhyolite Ridge Lithium-Boron project under the RCP 8.5 climate scenario
- Scenario 4 – increased herbivory and approval of multiple mining projects under either RCP 4.5 or RCP 8.5 climate scenarios

Under all scenarios, damage and loss from herbivory caused significant declines in population numbers in remaining subpopulations. We anticipate that three of the eight subpopulations would continue to be occupied at some level under three of the scenarios. In 40 years, our analysis shows one scenario (Scenario 1) where resiliency would be similar to current levels. In 40 years for two of our other scenarios (Scenario 2 and 3), we anticipate there would be a significant reduction in resiliency, redundancy, and representation, which would put the species at an increased risk for stochastic and catastrophic events. However, in 40 years for our last scenario (Scenario 4), we anticipate that the species would not persist into the future, becoming extinct in the wild.

1.0 INTRODUCTION

1.1 Purpose of the SSA

This report summarizes the results of a species status assessment (SSA) conducted for the plant *Eriogonum tiehmii* (Tiehm's buckwheat or *E. tiehmii*). The SSA report, the product of conducting an SSA, is a concise review of the species' biology and other factors (both negative and positive) influencing the species, an evaluation of its biological status, and an analysis of the species' potential status under a spectrum of plausible future scenarios. The SSA report is intended to support all functions of the Endangered Species Program, including development of listing rules, recovery plans, and 5-year reviews, should the species warrant listing as an endangered or threatened species under the Endangered Species Act of 1973, as amended (Act). The SSA report is a living document and we may update it periodically as new information becomes available.

The SSA report for *Eriogonum tiehmii* is intended to provide the biological and other support for determining whether the species meets the definition of either a threatened or an endangered species and if so, provide the biological and ecological information to inform any critical habitat designation. The process and this SSA report do not represent a decision by us (the Service) whether or not to list the species under the Act. Instead, this SSA report provides a review of the best scientific and commercial information available on *E. tiehmii*.

1.2 Petition History

On October 7, 2019, we received a letter from the Center for Biological Diversity (CBD; CBD 2019, entire) requesting that *Eriogonum tiehmii* be emergency listed as endangered and critical habitat be designated for this species under the Act. The Act does not provide for a process to petition for emergency listing, therefore we evaluated the letter as a petition under the normal process of determining if it presents substantial scientific or commercial information indicating that the petitioned action may be warranted. The Service issued a 90-day finding on July 22, 2020 (86 FR 44265), stating that the petition presented substantial scientific or commercial information indicating that listing *E. tiehmii* may be warranted.

We received another letter from CBD requesting that we emergency list *Eriogonum tiehmii* on September 17, 2020 after a plant loss event was detected in early September 2020 (see Section 3.1.2). On September 29, 2020, CBD filed a complaint in the U.S. District Court for the District of Nevada alleging that they had submitted emergency petitions for *E. tiehmii* under the Administrative Procedure Act, and the Service had either unreasonably delayed in concluding the petitions, or in the alternative, had arbitrarily and capriciously denied the petitions. On October 8, 2020, we received a Notice of Intent to Sue from CBD, stating that we had missed our deadline of October 7, 2020 under the Act for issuing a 12-month finding for *E. tiehmii*.

The Service responded with a letter to CBD, dated October 27, 2020, listing the ways in which we are monitoring *Eriogonum tiehmii*, coordinating with other agencies and researchers, and moving forward with an expedited 12-month finding timeline. The letter also stated that we considered the immediacy of possible threats to the species and our review of the current situation does not indicate that an emergency situation exists. On October 14, 2020, CBD amended its complaint to add a claim under the Act that the Service had missed the one-year deadline of October 7, 2020 for issuing a 12-month finding for *E. tiehmii*. The litigation remains ongoing.

1.3 State Listing Status

On October 7, 2019, the Nevada Division of Forestry (NDF) was also petitioned by CBD requesting that the state list *Eriogonum tiehmii* as a state protected species under Nevada Administrative Code 527.010. On November 7, 2019, NDF determined the petition submitted by CBD did not include sufficient information because it did not include an economic analysis on listing *E. tiehmii*. However, NDF initiated its own review of the species, and held public meetings on July 15, July 20, and August 21, 2020 to gather public input and comments on adding *E. tiehmii* to the state list of fully protected native flora. NDF has not yet made a decision on their review of the species.

1.4 Methodology

This document draws scientific information from resources such as primary peer-reviewed literature, reports submitted to the Service and other public agencies, species occurrence information and survey data, and expert experience and observations. It is preceded by and draws upon analyses presented in the 90-day finding (86 FR 44265). We have coordinated closely with our partners as we engage in ongoing research and conservation efforts. This assures consideration of the most current scientific and conservation status information.

1.4.1. Analytical Framework

The SSA analytical framework is designed for assessing a species' biological condition and level of viability. Building on the best of our current analytical processes and the latest in conservation biology, this framework integrates analyses that are common to all Act functions, eliminates duplicative and costly processes, and allows us to strategically focus on our core mission of preventing extinction and achieving recovery. The document is temporally structured, generally walking the reader through what is known from past data, how data informs current species' status, and what potential changes to this status may occur in the future based on data and models. The future conditions analysis includes a range of potential conditions the species or its habitat may face and discusses a range of plausible future scenarios if those conditions come to fruition. The range of plausible future scenarios include consideration of the threats most likely to impact the species in the future, including potential cumulative impacts.

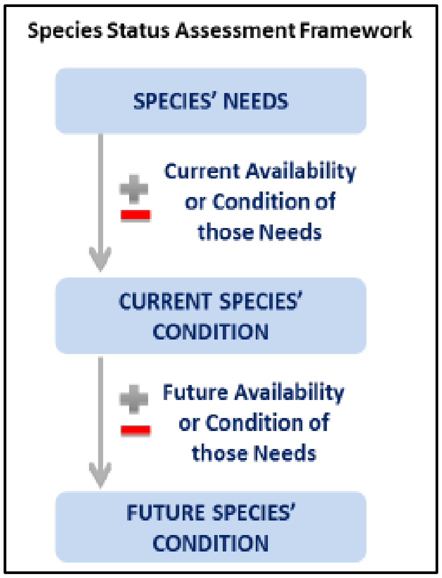

FIGURE 1— The stepwise process for assessing a species' status (Service 2016, entire).

For the purpose of this assessment, we generally define viability as the ability of a species to persist in the wild in its natural ecosystem over time up through and beyond a biologically meaningful timeframe, in this case, 40 years. We chose 40 years based on the best available information regarding land use, development, existing regulatory mechanisms, and beneficial conservation measures expected to occur during this period. Additionally, 40 years is long enough to capture the temporal range of the available climate model projections; however, beyond that timeframe, the level of uncertainty becomes overwhelming, making future projections unrealistic.

Using the SSA Framework (Figure 1), we consider what the species needs to maintain viability by characterizing its status in terms of its resiliency, redundancy, and representation (Wolf *et al.* 2015, entire; Service 2016, entire).

We begin an SSA by describing the species' life history, resource needs, and biological requirements using the principles of resiliency, redundancy, and representation. In general, these three concepts (or analogous ones) apply at the population-level or species-level and are explained that way below for simplicity and clarity. For *Eriogonum tiehmii,* population-level and species-level are synonymous as the species is only known from one population. To avoid confusion, we will use *resiliency* as a population-level term, and *redundancy* and *representation* in reference to individual subpopulations or individual plants of *E. tiehmii* throughout this document.

Resiliency is the ability of a species to withstand stochastic events and normal year-to-year variations in both environmental conditions (*i.e.,* temperature, rainfall, and periodic disturbances such a fires or floods) and demographic conditions (*i.e.,* mortality, fecundity; Redford *et al.* 2011, p. 40). Determined by the size and growth rate of the species population(s), resiliency can be evaluated to gauge the ability of a species to withstand the natural range of favorable and unfavorable conditions.

In many instances, however, data are insufficient or completely lacking regarding a population's size and growth rate. In the absence of such data, it can be reasonable to examine other characteristics that may serve as surrogate indicators of general population health and subsequently, resiliency. Essentially, an assessment of the availability of a species' identified needs (*e.g.,* suitable habitat, resources) may allow us to make assumptions about the potential resiliency of any given population. However, unless there is a documented positive correlation between species needs availability and a population's known demographic condition, the uncertainty regarding such assumptions must be made clear.

Redundancy is the ability of a species to withstand catastrophic events (*i.e.,* natural or anthropogenic stochastic events) that would result in the loss of a substantial component of the species' total overall population. Such a loss could be of one or more populations of a species which is comprised of multiple populations or the catastrophic loss of a substantial number of individuals from a species with only a single population. However, redundancy is not simply a measure of the total number of individuals or populations of a species, but instead must also be evaluated in the context of an assessment of reasonably plausible catastrophic events. For example, a species with numerous small populations does not necessarily translate to a greater ability to withstand catastrophic events if those populations are very close together, and the only reasonably plausible potential catastrophe is one that would affect them all equally. Conversely, a species with only one population, but one which is very large and widely distributed, could well have a high ability to withstand a catastrophic event that would only affect a small percentage of the total overall population. Therefore, our characterization of a species' redundancy takes into consideration both an assessment of the size and distribution of its population(s), and an evaluation of the kinds and likelihood of reasonably plausible catastrophic events to which the species could be exposed.

Representation is the ability of a species to withstand and adapt to long-term changes in environmental conditions (*i.e.*, significant changes outside the range of normal year-to-year variations). The measure of a species' representation may be determined by the breadth of genetic diversity within and among populations, however, in the absence of information on a species' genetic diversity, we may also evaluate a species' known environmental diversity (*i.e.*, the diversity of environmental conditions over which it is known to occur) as an alternative measure of its ability to withstand and adapt to long-term changes.

Using the SSA framework, we consider what the species needs to maintain viability by characterizing the status of *Eriogonum tiehmii* in terms of its resiliency, redundancy, and representation. The species' biology, ecology, and habitat requirements are described in Chapter 2; the current condition of the species' and its habitat are described in Chapter 3, and the future condition of the species' and its habitat are described in Chapter 4. In Chapter 5, we forecast plausible future scenarios for *E. tiehmii* based on the species' biology and current and future threats. As a matter of practicality, the full range of potential future scenarios and the range of potential future conditions for each potential scenario are too large to analyze and describe them individually. Therefore, the chosen scenarios do not include all possible futures, but rather include specific plausible scenarios that represent examples from the continuous spectrum of possible futures.

1.4.2. Legal Framework

Eriogonum tiehmii is located on public lands administered by the BLM. Management of this area is entirely within the jurisdiction of the BLM. Existing regulatory mechanisms and protective measures on Federal land where *E. tiehmii* occurs are described below.

National Environmental Policy Act (NEPA)

All Federal agencies are required to comply with the National Environmental Policy Act of 1970 (as amended; 42 USC §§ 4321 et seq.), which is a procedural statute. Prior to implementation of projects with a Federal nexus, NEPA requires the agency to analyze the project for potential impacts to the human environment, including natural resources. If an Environmental Impact Statement is prepared for an agency action, the agency must provide a full and fair discussion of significant environmental impacts and inform decision makers and the public of reasonable alternatives that would avoid or minimize adverse impacts or enhance the quality of the human environment (40 CFR § 1502.1). The public notice provisions of NEPA provide an opportunity for interested parties to review proposed actions and provide recommendations to the implementing agency. NEPA does not impose substantive environmental obligations on Federal agencies—it merely requires informed agency action.

Federal Land Policy and Management Act of 1976 (FLPMA)

The Federal Land Policy and Management Act (as amended; 43 USC §§ 1701-1785) authorizes BLM to manage public lands under the principles of multiple use and sustained yield. Section

202 of FLMPA directs BLM to prepare resource management plans (RMPs) that establish the basis for actions and approved uses on public lands for specific planning areas (BLM 2005, pp. 1, 14). The Tonopah RMP and associated Record of Decision (BLM 1997, entire) provides a framework to guide management decisions for the 6.1 million ac (2.5 million ha) of land managed by the Tonopah BLM Field Office, including the lands where *Eriogonum tiehmii* occurs.

As described in the Tonopah RMP, habitat for all federally listed threatened or endangered species or Nevada BLM sensitive species will be managed to maintain or increase current species populations. The introduction, reintroduction, or augmentation of Nevada BLM sensitive species may be allowed if in coordination with Nevada Department of Wildlife (NDOW) or the Service, if it is deemed appropriate. Such actions will be considered on a case-by-case basis and will be subject to applicable procedures (BLM 1997, p. 9).

BLM has issued policy guidance to implement its obligations under FLPMA. These include BLM's Integrated Vegetation Management Handbook H-1740-2, which guides BLM's various programs to use an interdisciplinary and collaborative process to plan and implement a set of actions that improve biological diversity and ecosystem function that promote and maintain native plant communities that are resilient to disturbance and invasive species (BLM 2008, p. 2). As well as, BLM's Travel and Transportation Handbook H-8342, which clarifies policies and establishes procedures for implementing travel and transportation planning and management in land use and implementation plans (BLM 2012, pp. 1–4).

Additionally, BLM Manual Section MS-6840, Release 6-125 (BLM 2008, 1–48) provides guidance with respect to sensitive species. *Eriogonum tiehmii* is managed as a BLM sensitive species which are defined as "species that require special management or considerations to avoid potential future listing" (BLM 2008, Glossary, p. 5). Under this policy, BLM initiates proactive conservation measures including programs, plans, and management practices to reduce or eliminate threats affecting the status of the species, or improve the condition of the species' habitat on BLM-administered lands (BLM 2008, Glossary, p. 2).

Mining Law of 1872 (Mining Law)

In the United States, mineral disposal is authorized under an array of statues primarily administered by the BLM, both on federally managed lands as well as other lands where mineral rights have been reserved to the U.S. (so-called split estate lands). The Mining Law of 1872, as amended (30 USC §§ 22–54) authorizes the disposal of minerals that are not otherwise subject to lease or sale. In 1976, FLPMA amended the Mining Law to prevent "unnecessary or undue degradation of the lands." BLM's implementing regulations for governing operations under the Mining Law provide that operators prevent "unnecessary or undue degradation" by adherence to performance standards, reclamation of disturbed areas, and complying with all applicable Federal and state laws related to environmental protection and the protection of cultural resources (see 43 U.S.C. § 3809.415). The performance standards that apply to such mining operations include "[t]he operator shall take such action as may be needed to prevent adverse impacts to threatened or endangered species, and their habitat which may be affected by operations" (43 U.S.C. § 3809.420(b)(7)). BLM's regulations do not, however, require operators to ensure that their mining operations prevent adverse impacts to non-listed species or habitat, including non-listed BLM or state special status or sensitive species or their habitat.

The Mining Law makes “all valuable mineral deposits in lands belonging to the United States... free and open to exploration and purchase...” Accordingly, this statute allows citizens of the U.S. the opportunity to explore for, discover, and purchase certain valuable mineral deposits on Federal lands that are open to mineral entry (BLM 2011, pp. 1–7). Congress, the President, or public land order issued by the Secretary under Section 204 of FLPMA may withdraw lands from the operation of the public lands, including the Mining Law, which would prevent mining in a particular area. However, no areas occupied by *Eriogonum tiehmii* have been withdrawn from mineral entry. On lands subject to the operation of the Mining Law, an operator must submit a notice to BLM of operations 15 calendar days before exploration causing surface disturbance of 5 acres or less (43 C.F.R. § 3809.21(a)). If a listed species is present, a prospective mining operator must submit a Plan of Operations for disturbance greater than casual use (43 CFR § 3809.11(b)(6)).

2.0 SPECIES BACKGROUND

2.1 Species Description

Eriogonum tiehmii is a member of the Polygonaceae (buckwheat family). It is a low growing perennial herb forming a dense compact mat up to 10.8 inches (in; 30 centimeters (cm)) across and 6 in (16 cm) high. Leaves are only at the base of the plant, blueish gray in color, elliptic, and gray tomentose, or hairy, on both surfaces. Tight balls of flowers arise from a leafless, hairy stem (i.e. the inflorescence or flowering stalk). The tepals (i.e., components of the flower that are similar looking and cannot be distinguished into sepals and petals) are light yellow to cream, aging lighter and/or turning red with age. *Eriogonum tiehmii* is the only buckwheat in the subgenus *Eucycla* known to have well defined stalked glands on the outer surfaces of its tepals (Figure 2; Reveal 1985, pp. 277–278; Morefield 1995, pp. 6–7).

FIGURE 2—A. *Eriogonum tiehmii* flowers and B. *Eriogonum tiehmii* stems and leaves (photo credit: James Morefield/Nevada Division of Natural Heritage).

2.2 Taxonomy and Genetics

Eriogonum tiehmii was discovered in 1983 by Arnold Tiehm (Morefield 1995, p. 5) and described by James Reveal in 1985 (pp. 277–278). Within the genus, *E. tiehmii* is placed in the subgenus *Eucycla (*Morefield 1995, p 8; Reveal 2012, pp. 256–261). In Nevada, *E. tiehmii* is morphologically most similar to *E. anemophilum* (West Humboldt buckwheat) and the cream-colored phase of *E. beatleyae* (Beatley's buckwheat). However, the stems of the latter are glandular, not hairy as in *E. tiehmii*, and the involucre (or bracts subtending the flower) of both species are smaller than on *E. tiehmii.*

Grady (2012, entire) examined the molecular phylogenetic patterns of narrow endemism relating to edaphic factors in *Eriogonum*. DNA sequence data (chloroplast and nuclear) were used to reconstruct relationships in *Eriogonum*, with an emphasis on the subgenus *Eucycla.* This study indicates that *Eriogonum tiehmii* is morphologically distinct, geographically isolated, and ecologically specialized (Grady 2012, p. 127). There is a clade composed of three narrowly endemic species – *E. tiehmii, E. soredium* (Frisco buckwheat), and *E. holmgrenii* (Snake Range buckwheat) – that does show some edaphic group similarity, which may point to a lineage of *Eriogonum* that is preferentially adapted to specific substrates (Grady 2012, p. 125).

Grady (2012, entire) used only a single sample of *Eriogonum tiehmii* when conducting his sequencing, not fully allowing the conclusion to be made that *E. tiehmii* is genetically distinct. Consensus trees constructed from Grady's analyses (2012, entire) also indicate a close relationship between *E. tiehmii* and *E. shockleyi* (Shockley's buckwheat), which is widespread and has a history of hybridization with other *Eriogonum* species. Due to this, a genetic analysis was recently conducted to determine the genetic uniqueness of *E. tiehmii* when compared to *E. shockleyi, E. ovalifolium* (cushion buckwheat), and *E. nummulare* (money buckwheat), both which co-occur with *E. tiehmii* (Figure 3; Davis *in litt.* 2019; Ioneer 2020a, p. 20). Results from this study indicate that *E. tiehmii* is genetically distinct, though most similar to *E. shockleyi* (Davis *in litt.* 2019). Research to discern genetic variation within and among subpopulations of *E. tiehmii* is currently being conducted (Wolf 2020, entire). We have carefully reviewed the available taxonomic and genetic information to reach the conclusion that *E. tiehmii* is a valid and recognizable taxon.

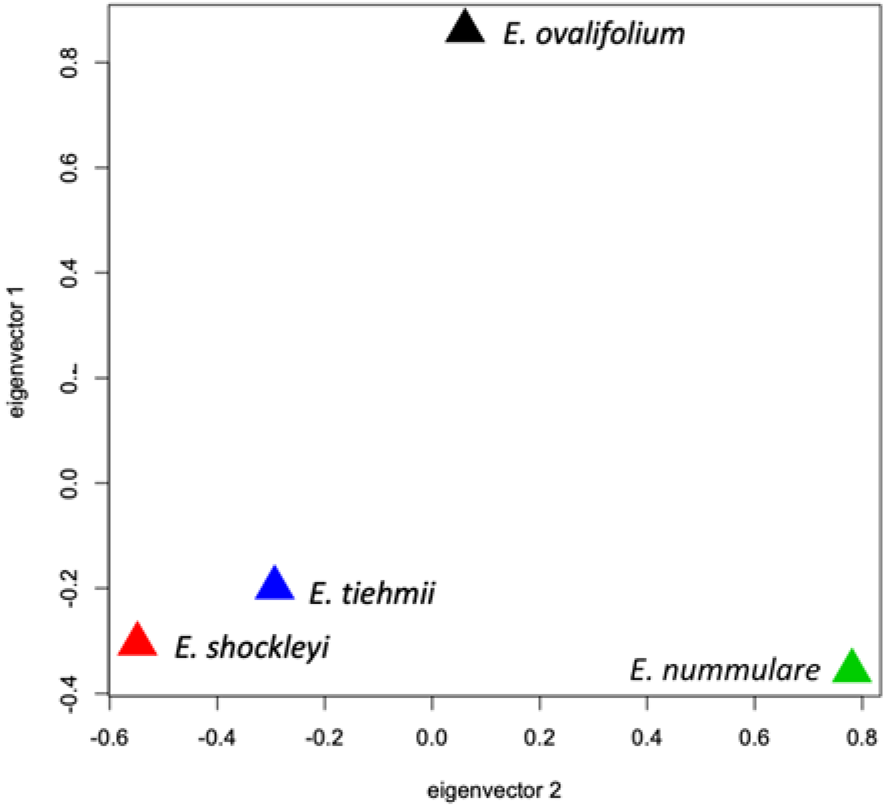

FIGURE 3—Multidimensional scaling of biallelic, single-nucleotide data across four species of *Eriogonum* (Davis *in litt.* 2019).

2.3 Phenology and Life History

The phenology and life history of *Eriogonum tiehmii* have not been comprehensively studied. New leaves are produced in late winter and early spring, flowering occurs from late May to mid-June, and seeds ripen in late-June through mid-July (Ioneer 2020b, p. 4; Morefield 2010, entire; Morefield 2008 entire; Caicco and Edwards 2007, entire; Morefield 1995, p. 14). The flowers turn reddish in color as they age; plants may look reddish and desiccated through the late fall and winter when they are dormant (Ioneer 2020b, p. 4). Timing for flowering and seed production may vary due to year-to-year fluctuations in temperature and precipitation patterns. Low precipitation could entirely prevent reproductive activity in some years (Morefield 1995, p. 14), although under low precipitation conditions in 2020, *E. tiehmii* individuals were able to still produce seed (McClinton *et al.* 2020, p. 24).

The primary seed dispersal agents of *Eriogonum tiehmii* are probably gravity, wind, and water (Morefield 1995, p. 14). Upon maturation of the fruit, seeds are likely to fall to the ground in the immediate vicinity of the parent plant, becoming lodged in the soil surface (Ioneer 2020b, p. 4). The number of seeds produced by individual *E. tiehmii* plants is variable. Research during the 2020 flowering period found that the average density of flowers at subpopulation 6 is 50.57 flower stalks/m^2 producing approximately 455 seeds/m^2. In comparison, at subpopulation 1, the average density of flowers is 5.51 flower stalks/m^2 producing approximately 56 seeds/m^2 (McClinton *et al.* 2020, p. 22). We have no information on the longevity and viability of *E. tiehmii* seed in the soil seed bank (natural storage of seeds within the soil of ecosystems) or what environmental cues are needed to trigger germination. However, many arid plants possess seed dormancy enabling them to delay germination until receiving necessary environmental cues (Pake and Venable 1996, p. 1432–1434, Jurado and Flores 2005, entire).

In May and June 2020, arthropod (includes insects, mites, and spiders) diversity and abundance were surveyed at two *Eriogonum tiehmii* subpopulations (1 and 6, see Figure 4) and two adjacent areas not occupied by the species. Arthropod diversity was distributed across surveyed sites, with each of the four locations containing a substantial proportion (6.25–16 percent) of unique species not found at any other site. Only 11.8–13.5 percent of arthropod species were shared between all four sites at any time (McClinton *et al.* 2020, p. 23). In total, 1,898 specimens from 12 orders, 70 families, and 129 species were found at the two *E. tiehmii* subpopulations. Of those, 79 specimens from 17 families and 47 species occurred only at the *E. tiehmii* subpopulations (McClinton *et al.* 2020, p. 11). Arthropod species diversity was initially highest at the two areas in which *E. tiehmii* does not occur, and decreased at three of the four sites between May and June 2020, but there was a notable increase in diversity (+245 percent) at subpopulation 6 between May and June 2020 (McClinton *et al.* 2020, p. 23). The abundance and diversity of arthropods observed in *E. tiehmii* subpopulations is especially high for a plant community dominated by a single plant species (see Section 2.4).

Eriogonum, in general, are sexual reproducers and insects are the most common pollinators (Gucker and Shaw 2019a, pp. 5–6). Some studies have shown that *Eriogonum* flowers can be pollinated by everything from beeflies and closely related spider predators (the Acroceridea (Cyrtidae)) to specialist pollinators, while other *Eriogonum* species are capable of self-pollination (Moldenke 1976, pp. 20–25). For example, *Eriogonum ovalifolium* var. *vineum* (Cushenbury buckwheat), an endangered buckwheat, is pollinated by flies, as well as sweat bees (Neel and Ellstrand 2003, p. 339). Another endangered buckwheat, *E. ovalifolum* var. *williamsiae* (steamboat buckwheat), is self-compatible, but requires a pollinator to transfer pollen from its stamens to its stigma and is visited by a diverse group of bees, wasps, flies, and butterflies (Archibald *et al.* 2001, p. 612).

Primary pollinator visitors to *Eriogonum tiehmii* include wasps, beetles, and flies (McClinton *et al.* 2020, p. 18). To test if *E. tiehmii* is capable of self-pollination, mesh bags were placed over unopened inflorescences to preclude insect visitors in the beginning of the flowering season in May 2020. In early June 2020, additional bags were placed over previously opened, marked flowers that had the opportunity to be visited by pollinators to compare seed production between open-pollinated and bagged flowers (McClinton *et al.* 2020, p. 22). Results indicate that *E. tiehmii* plants may be able to produce some seed when pollinators are excluded (through wind pollination or selfing), but open pollination significantly increased seed production, averaging 7.3 times as many seeds as bagged inflorescences (McClinton *et al.* 2020, p. 22). Therefore, *E. tiehmii* benefits from pollinator services and needs pollinators to increase seed production.

2.4 Habitat and Ecological Needs

Eriogonum tiehmii occurs between 5,906 and 6,234 feet (ft; 1800 and 1900 meters (m)) in elevation and on all aspects with slopes ranging from 0-50 degrees (Ioneer 2020b, p. 5; Morefield 1995, p. 11). The species occurs on dry, upland sites, subject only to occasional saturation by rain and snow and is not found in association with free surface or subsurface waters

(Morefield 1995, p. 11). Although there is no information on *E. tiehmii's* specific water needs during its various life stages (i.e., dormant seed, seedling, juvenile, adult), it appears to be primarily dependent on occasional precipitation for its moisture supply (Morefield 1995, p. 11). From 1980–2017, long-term average annual precipitation during the growing season (October to September) at Dyer, Nevada (the closest climate center to *E. tiehmii*) was 5.13 in (13.0 cm), with the majority of precipitation received in January and February (Western Regional Climate Center (WRCC) 2020). Thus, we assume that *E. tiehmii* requires annual precipitation that is at or above the 1980–2017 average. There is also no information on the specific temperature tolerances of *E. tiehmii*. However, the species experiences warm, dry summers (average daily maximum 85–95°F (29.4–35 °C)) and cold moist winters (average daily minimum 15–25°F (-9.4– -3.9 °C)); WRCC 2020; Morefield 1995, p. 10), which allows us to assume that it adapted to seasonal temperature changes within these ranges.

Eriogonum tiehmii dominates the sparsely vegetated community in which it occurs resulting in an open plant community with low plant cover and stature (Morefield 1995, p. 12). The vegetation varies from pure stands of *E. tiehmii* to sparse associations with a few other low growing herbs and grass species. The most common associates of *E. tiehmii* are species found in salt desert shrubland communities such as *Atriplex confertifoli*a (shadscale saltbush), *Pleuraphis jamesii* (James' galleta), and *Sporobolus airoides* (alkali sacaton; Morefield 1995, p. 12).

Like most terrestrial plants, *Eriogonum tiehmii* requires soil for physical support and as a source of nutrients and water. *Eriogonum tiehmii* is restricted to dry, open, relatively barren, light-colored rocky clay soils derived from an uncommon formation of interbedded claystones, shales, tuffaceous sandstones, and limestones (Ioneer 2020b, p. 5; Morefield 1995, p. 10). The soils are poor, with little development, lack an A horizon, and are full of broken pieces of the parent bedrock (Ioneer 2020b, p. 5; Morefield 1995, p. 11). Soils are characterized by a variety of textures, and include clay soils, sandy clay loams, sandy loams, and loams (McClinton *et al.* 2020, p. 29). This specialized substrate is called channery soil, which consists of 15 to 35 percent thin, flat fragments of sandstone, shale, slate, limestone, or schist (United States Department of Agriculture (USDA) 2015, p. 7).

Eriogonum tiehmii is distributed on these soils along an outcrop of lithium clay in exposed former lake beds (Ioneer 2020b, p. 5). Soil pH ranges from 7.64 to 8.76 (Ioneer 2020b, p. 6). Initial soil sample analyses demonstrate that boron and carbonates were commonly present at excessive levels and sulfur, calcium, and potassium were commonly present at high levels (Ioneer 2020b, p. 6). Soil pH ranges from 7.64 to 8.76 (Ioneer 2020b, p. 6). Further analyses indicate that soils occupied by *E. tiehmii* have on average extremely low phosphorus, low nitrogen, high boron, and high pH (McClinton *et al.* 2020, p. 35). There were significant differences in soil characteristics between soils occupied and unoccupied by *E. tiehmii*, including potassium, zinc, sulfur, and magnesium, which were on average lower in occupied soils, and boron, silt, bicarbonate, and pH, which were, on average, higher, though there was variation among subpopulations and adjacent, unoccupied sites (McClinton *et al*. 2020, p. 35, 53). For example, boron was higher in *E. tiehmii* subpopulations 1, 2, and 3 than in subpopulations 4, 5, 6, 7, and 8 (Shams *et al.* 2021, p. 5; McClinton *et al*. 2020, p. 30). Taking all soil components into consideration, there is a unique envelope of soil conditions in which *E. tiehmii* thrives that is different from adjacent unoccupied soils.

To further understand *Eriogonum tiehmii* soil requirements, greenhouse propagation experiments were conducted in soils occupied (represented by eight subpopulations; Figure 4) and unoccupied by the species (identified as potential habitat in habitat models (see Section 2.5) and within a distance that could reasonably have been colonized by seed from the eight subpopulations). For *E. tiehmii*, seedlings grown in soils collected from existing habitat (i.e. the eight subpopulations) developed higher overall total biomass than seedlings grown in soils from surrounding unoccupied areas (McClinton *et al.* 2020, p. 36). There was also a strong positive association between emergence and survival in occupied soils (McClinton *et al*. 2020, p. 36). Some unoccupied soils were individually favorable for emergence, survival, or seedling growth, but there were no unoccupied soils that were favorable for all three life history stages of *E. tiehmii*. For example, seedlings emerged and survived in some unoccupied soils at rates comparable to those observed in occupied soils, but biomass in unoccupied soils was lower than in the occupied soils (McClinton *et al*. 2020, p. 36).

Eriogonum tiehmii meets the definition of a soil specialist because it occurs primarily or exclusively on challenging soils that differ from the surrounding soil matrix. Like many other soil specialists, colonization of unoccupied, but suitable habitat by *E. tiehmii* may be limited by dispersal (McClinton *et al.* 2020, p. 37). As described above, *E. tiehmii* seeds likely do not travel far from the parent plant as the species lacks effective animal dispersers. Research into dispersal mechanisms and how habitat connectivity is impacting population dynamics is needed to further understand dispersal and colonization potential.

Thus, for *Eriogonum tiehmii* to maintain its viability, the population or some portion of its subpopulations (Figure 4) must be able to withstand stochastic disturbance. Resource needs that influence the resiliency of the population include soil conditions identified from research (as *E. tiehmii* is adapted to grow on its preferred soil type), abundance of insect pollinators, and availability of direct sunlight. Additionally, secondary resource needs include agents of seed dispersal (gravity, wind, and water) and occasional precipitation for seed germination.

2.5 Range and Geographic Distribution

As described above, *Eriogonum tiehmii* was first discovered in 1983. As of 1994, *E. tiehmii* was only known from its type locality, so field surveys were undertaken to relocate the historical location and find any additional locations of the species. Field surveys located five new locations on approximately 9 acres (ac; 3.6 hectares (ha)), all within 1 mile of the type locality (Morefield 1995, p.1). Population boundaries of *E. tiehmii* were last mapped by Nevada Division of Natural Heritage in 2008–2010, with the most recent surveys for the species conducted in 2019 (Morefield 2008 entire; Morefield 2010, entire; Kuyper 2019, entire). From the 2019 survey effort, the estimated area occupied by the species increased by approximately 14 percent, however, it is unclear if this indicates a true increase in the amount of area occupied by *E.*

tiehmii, because observers and mapping tools used have not been the same among years (Table 1).

In 1994, to fully understand the extent of occupied habitat, thirty-three additional sites covering 301 ac (121.8 ha) that met habitat requirements described above were surveyed without encountering *Eriogonum tiehmii* (Morefield 1995, pp 8–9). Morefield surveyed other areas sporadically between 1995 and 2018 looking for *E. tiehmii* and had similar results (Ioneer 2020b, p. 12). In 2018, a contractor for Ioneer USA Corporation (Ioneer) developed a habitat suitability model to identify potential habitat for *E. tiehmii* within a ten-mile radius of the known population utilizing ArcGIS and remote sensing data (Ioneer 2020b, p.12). The habitat suitability model identified 20 sites, totaling 1,126 ac (455.7 ha), as potential habitat based on soil and geology and an additional 24 sites were identified based on professional knowledge of geology, geomorphology, and soils in the surrounding area (Ioneer 2020b, p.12). Surveys of potential habitat by EM Strategies led to the discovery of two additional small subpopulations, subpopulation 7 and 8, near the already known subpopulations. No new populations of *E. tiehmii* were found within the ten-mile radius of the existing population (Ioneer 2020b, p. 12).

Most written accounts of the geographic range and distribution of *Eriogonum tiehmii* use the terms “site,” “location,” “occurrence” (often, but not always, in reference to Natural Heritage Program Element Occurrence records), “population,” and “subpopulation” interchangeably. Others have aggregated smaller sites into populations according to subjective criteria which have never been explicitly defined. This generates discrepancies among sources with respect to reporting abundance and distribution of the species, with the net result being that different sources (and even different surveys by the same source) are usually not comparable. The tendency to treat each spatially discrete *E. tiehmii* location as a separate population can also suggest more populations than actually exist. In order to define a population, and for the purposes of this SSA Report, we have applied spatial mapping standards devised by NatureServe and its network of Natural Heritage Programs (NatureServe 2004, entire) to aggregate eight known, spatially discrete locations of *E. tiehmii* into one spatially discrete unit, which we herein regard as the “population” of the species (Table 1). We use the term “subpopulation” to reference each of the eight discrete locations within this population. This single population of *E. tiehmii* is found in the Silver Peak Range, west of Rhyolite Ridge in Esmeralda County, Nevada and is restricted to approximately 10 ac (4 (ha) across a three square mile area, located on public lands administered by the BLM (Figure 4; Morefield 1995, p. 8, 13; Kuyper 2019, p. 2).

TABLE 1—Summary of *Eriogonum tiehmii* individuals and occupied habitat

Population	**Subpopulation**	**Estimated Number of Plants**			**Occupied Habitat (acres)**	
		1994[a]	**2008/2010**[b]	**2019**[c]	**2008/2010**	**2019**
1	1	7,000+	15,380	9,240	4.71	4.81
	2	3,000+	4,000	4,541	1.17	1.56
	3	500+	4,000	1,860	0.62	0.63
	4	500+	1,960	8,159	0.58	1.04
	5	15	100	199[d]	0.03	0.04
	6	6,000+	11,100	19,871	1.64	1.88
	7	n/a	n/a	50[d]	n/a	0.004
	8	n/a	n/a	1[d]	n/a	(1 plant)
Total		**17,015+**	**36,540**	**43,921**	**8.75**	**9.97**

[a] Ocular estimate

[b] Method employed: "Estimating Population Size Based on Average Central Density" (Morefield 2008, entire: Morefield 2010, entire)

[c] Method employed: Modified density sampling methodology in BLM technical reference "Sampling Vegetation Attributes" (BLM 1999, Appendix B) and "Measuring and Monitoring Plant Subpopulations" (Elzinga *et al.* 1998)

[d] Direct count

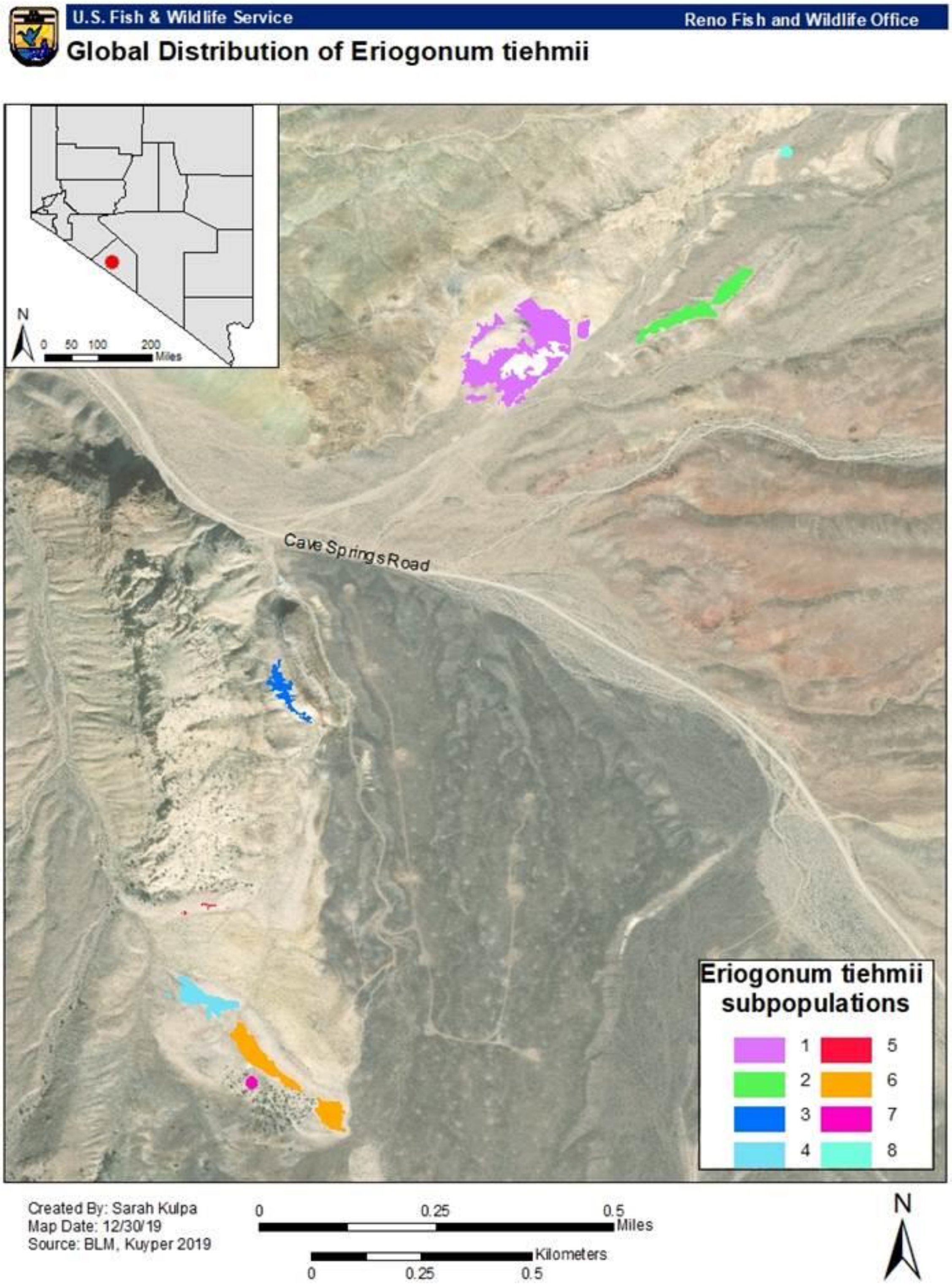

FIGURE 4—Global distribution of *Eriogonum tiehmii*.

2.6 Abundance, Population Trend, and Population Demographics

Reliable estimation of population size or trends in *Eriogonum tiehmii* population dynamics over time is complicated by multiple factors. The estimation of population size (in terms of abundance of individuals) has been conducted by different observers employing a variety of means and levels of survey effort. At one extreme, observations consist of ocular estimates (e.g., subjective, rapid visual estimates); at the other extreme, they consist of meticulous counts of every plant present (Table 1).

Initial surveys for *Eriogonum tiehmii* documented six subpopulations with an estimated total of 17,015 individuals (Table 1; Morefield 1995, p.14, Appendix 1). The Nevada Natural Heritage Program conducted additional surveys for *E. tiehmii* from 2008–2010. Again, no new subpopulations were found, but the extent of the six known subpopulations were refined, re-mapped, and estimated as 36,540 individuals (Table 1; Morefield 2008, entire; Morefield 2010, entire; Kuyper 2019, p.2). A 2019 survey documented eight subpopulations. Two subpopulations were completely surveyed (subpopulations 5, 7) and five subpopulations (subpopulation 1, 2, 3, 4, 6) were sampled with belt transects so that data collection can be repeatable for direct comparisons in the future (Table 1; Kuyper 2019, p. 2; Ioneer 2020b, p. 7). Subpopulation 8 is a single *E. tiehmii* plant (Kuyper 2019, p. 2). Two additional small subpopulations (7 and 8) were found near the already known subpopulations with the total number of plants estimated as 43,921 individuals. While we have confidence in the 2019 estimates of abundance, the survey methods used are too variable to infer population trends over time.

In addition to abundance estimates, the 2019 survey categorized a subsample (1,813 individuals) of *Eriogonum tiehmii* by size based on plant length and width (Table 2; Kuyper 2019, p. 3; Ioneer 2020b, pp. 7–8). Subpopulation 6 had the most individuals in the smallest size class (seedlings, 0-5 cm^2) indicating that this subpopulation is likely experiencing the most recruitment (Table 2; Kuyper 2019, p. 3; Ioneer 2020b, pp. 7–8). These data also indicate that overall, most plants in the population are young (5-80 cm^2), but certain subpopulations —1, 2, and 6 — have the majority of older and larger plants (325-725 cm^2, 725-1260 cm^2, 1260-2000 cm^2, 2000-3000 cm^2, 3000+ cm^2).

TABLE 2—Size classes of *Eriogonum tiehmii* subpopulations

Subpopulation	Size class (basal area cm^2)							
	0-5	**5-80**	**80-325**	**325-725**	**725-1260**	**1260-2000**	**2000-3000**	**3000+**
1	5	77	93	27	4	1	0	1
2	14	96	47	7	1	0	0	0
3	5	20	12	1	1	0	0	0
4	38	149	34	1	0	0	0	0
5	18	141	38	2	0	0	0	0
6	82	576	251	19	1	0	0	0
7	5	33	12	0	0	0	0	0
8	0	0	1	0	0	0	0	0
TOTAL	167	1092	488	57	7	1	0	1

Finally, the 2019 survey recorded the number of inflorescences for a subsample (578 individuals) of *Erigonoum tiehmii* plants in the five subpopulations (1, 2, 3, 5, 7; Kuyper 2019, p. 4; Ioneer 2020b, p. 9). Individual plants were marked with numbered metal coin tags so that they can be monitored over time. Across all subpopulations, 31 to 70 percent of plants were reproductive (flowering) at the time of the survey in May and June (Kuyper 2019, p. 5; Ioneer 2020b, p. 9). Reproductive output (number of inflorescences or flowering stalks) increased with size and was positively correlated with the size of the plant (Kuyper 2019, p. 5; McClinton *et al.* 2020, p. 51). No individuals smaller than ~2.4 in (6 cm) were found with inflorescences while larger *E. tiehmii* individuals (e.g. 100 cm^2) produced ~10–15 inflorescences on average (McClinton *et al.* 2020, p. 51). Development of inflorescences within subpopulation 2 lagged behind the other subpopulations, possibly due to a colder microclimate at its location in a drainage on a north-facing slope (Ioneer 2020b, p. 9). Additionally, plants of similar size in subpopulations 1, 3, and 6 produced a similar number of inflorescences, compared to similar sized individuals in subpopulation 2, that produced, on average, fewer inflorescences (McClinton *et al.* 2020, p. 51).

To develop integrated, structured population models to forecast population trends, field demographic monitoring along the established transects described above were initiated in 2020 (McClinton *et al.* 2020, p. 48). Continued monitoring of demographic rates will provide the size-specific growth and survival rate data needed to parameterize structured population models. The models can be used to estimate and forecast population trajectories, analyze the sensitivity of population growth rate to changes in different demographic rates, and estimate *Eriogonum tiehmii* life history parameters (e.g., lifespan, time to first reproduction, etc.; McClinton *et al.* 2020, p. 52).

3.0 CURRENT CONDITIONS AND STATUS

In this section, we describe the current condition of *Eriogonum tiehmii*. We provide a summary of potential threats affecting the species using the same habitat and demographic factors identified in the Species Background section (Section 2.0). We consider the potential contributions of these threats and how these threats are negatively impacting the species' habitat and demography. We evaluate these threats in the context of (1) any existing regulatory mechanisms (Section 1.4.2) that may reduce impacts to the species or its habitat and (2) other existing efforts to protect or conserve the species (Section 4.2).

3.1 Threats Affecting *Eriogonum tiehmii* and Habitat

In this section, we identify current threats affecting *Eriogonum tiehmii*. We use the term threat to refer to any action or condition that is known to or is reasonably likely to negatively affect individuals of the species. These include actions or conditions that have a direct or indirect impact as well as those that affect individuals through alteration of their habitat or resources. Within the landscape, several threats are, or have the potential to, damage or kill *E. tiehmii* or alter the structure and composition of the habitat conditions favored by this species. These primary threats include: (1) mineral exploration and development, (2) road development and OHV use, (3) livestock grazing, (4) nonnative, invasive plant species, (5) herbivory, and (6) climate change. Climate change may further influence the degree to which these threats, individually or collectively, may affect *E. tiehmii*.

Figure 5 is a conceptual model showing the relationships of the identified threats impacting the species' habitat and life history needs directly or indirectly at the population level, but can also apply at the subpopulation level. While we generally discuss these threats individually, threats can also occur simultaneously, thus additively affecting the resiliency of *E. tiehmii*. Where different individual threats occur at the same time and place, we will describe how they may interact with one another below as well as in the future in Section 4.0 and Section 5.0. Threats may be reduced through the implementation of existing regulatory mechanisms or other conservation efforts that benefit *E. tiehmii* and its habitat. Regulatory mechanisms are summarized in Section 1.4.2 and discussed below throughout the text.

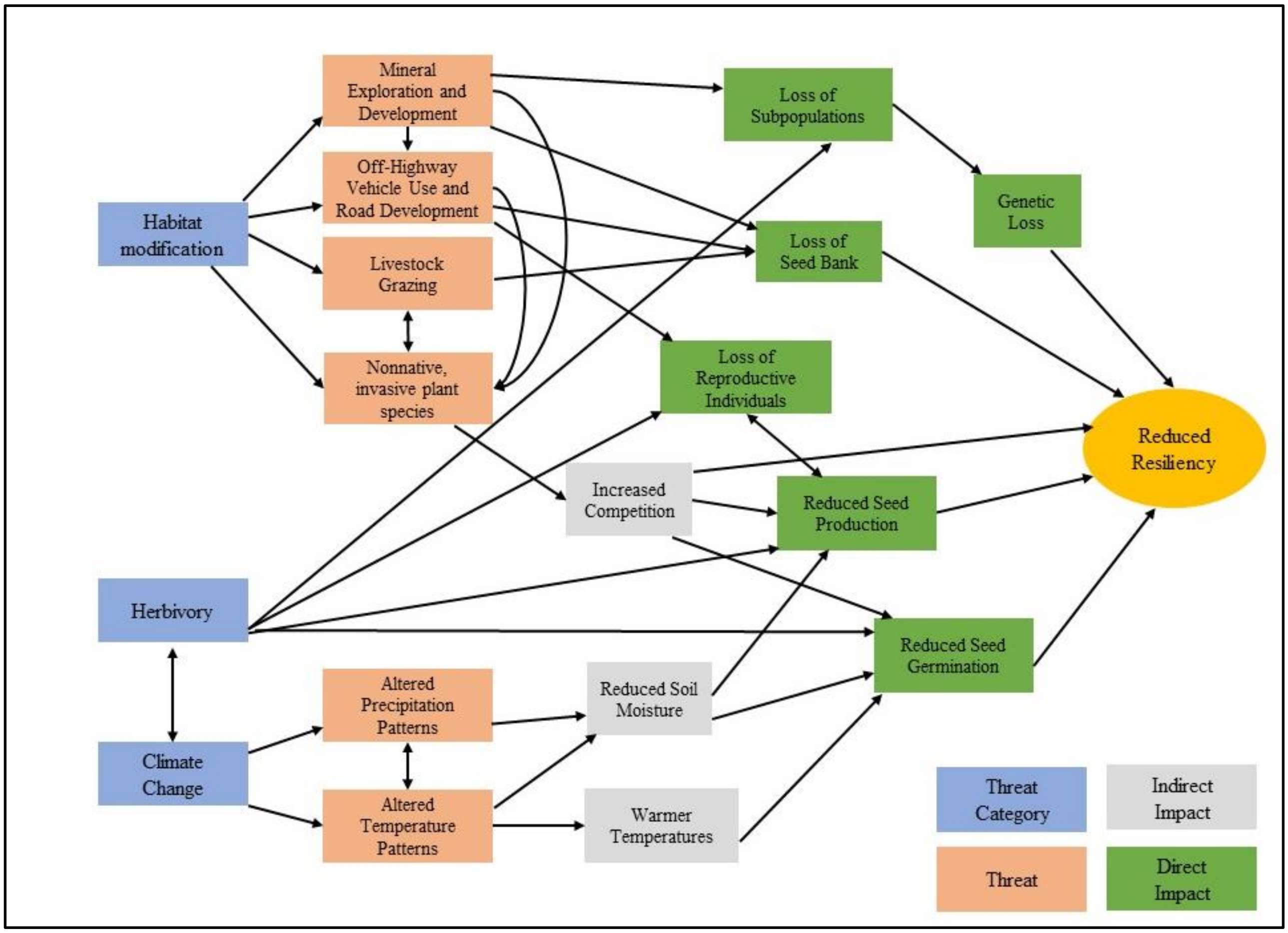

FIGURE 5— Threats affecting the resiliency of *Eriogonum tiehmii*. Connecting lines indicate threat relationships, but not the potential magnitude of the relationships.

3.1.1 Habitat Modification

This broad category includes threats that can physically disturb, damage, or kill *Eriogonum tiehmii* plants or degrade or destroy the habitat required by the species. While most of the threats identified here are associated with human activities, some natural processes such as herbivory (causing damage to or killing individual plants) may also impact the species and is discussed in Section 3.1.2. The habitat modification category also includes several threats that increase the potential for invasive, non-native plant species to be introduced into *E. tiehmii* habitat, thereby increasing competition for resources. While there is evidence of past and on-going habitat modification within the *E. tiehmii* population, there have been no studies of the species' response to these threats at the individual, subpopulation, and/or population level.

Mineral Exploration and Development

As described in Section 1.4.2, The Rhyolite Ridge area, where *Eriogonum tiehmii* occurs, is open to the operation of the Mining Law, which means that mineral exploration and extraction operations under the Mining Law may occur, subject to compliance with BLM's regulations at 43 C.F.R. subparts 3715 and 3809 (BLM 1997, p. 23). Ecological impacts of mineral exploration and extraction operations include loss of biodiversity, waste discharge into surrounding lands, increased emissions, introduction or spread of nonnative, invasive species, and/or habitat degradation, fragmentation, or loss (Sonter *et al.* 2018, pp. 1–4; Murguía *et al.* 2016, entire). Lithium, boron, copper, zinc, and iron, which are in the soils on which *E. tiehmii* grows, are minerals subject to the operation of the Mining Law. Lithium is also included on the Department of Interior's list of minerals (83 FR 23295) deemed critical pursuant to Executive Order 13817 (December 20, 2017. When conducting mining operations on lands open to the operation of the Mining Law, operators are required by FLPMA to prevent "unnecessary or undue degradation," by adherence to performance standards, reclamation of disturbed areas, and complying with all applicable Federal and state laws related to environmental protection and the protection of cultural resources (43 C.F.R. § 3809.415). The performance standards require operators to take such action as may be needed to prevent adverse impacts to threatened or endangered species, and their habitat which may be affected by operations" (43 C.F.R. § 3809.420(b)(7)). By specifying "threatened or endangered species, and their habitat," the BLM's regulations make clear that this performance standard would only apply with respect to listed species or designated critical habitat.

As described in Section 2.2, *Eriogonum tiehmii* was first discovered in 1983. However, mineral exploration in the Rhyolite Ridge area occupied by *E. tiehmii* was occurring prior to the species discovery. In 1962, Stauffer Chemicals was the first company to drill boreholes in the Rhyolite Ridge area and possibly dug and sampled several exploration trenches (Ioneer 2020c, p. 7). Between 1987 and 1992, US Borax drilled a total of 16 holes and excavated and sampled numerous trenches. Gold Summit Corporation acquired US Borax's interests sometime after 2000 (Ioneer 2020c, p. 7). In the 1995 report, Morefield (p. 15) documented that subpopulations 1, 2, 3, 4, and 6 were all impacted by trenches, or mine shafts associated with past mineral exploration, or by surface disturbance associated with the placement of mining claim markers. Morefield (1995, p.15) also noted that subpopulations 1, 2, 3, and 6 cumulatively experienced a loss of about 0.10 ac (0.04 ha) of habitat, but trenches and mine shafts did not appear to be recent because *E. tiehmii* colonized some of the bottoms of trenches as well as the edges of debris piles.

In 2010–2011, the JOGMEC-American Lithium joint venture acquired Gold Summit Corporation's interests and re-sampled the existing trenches and drilled additional exploration holes in the Rhyolite Ridge area (Ioneer 2020c, pp. 7–8). In 2015, Boundary Peak Minerals acquired rights to the Rhyolite Ridge area prior to its transfer to Paradigm Minerals Company, which is now Ioneer (Ioneer 2020c, p. 8). Ioneer drilled additional exploration holes in the Rhyolite Ridge area in 2016 and 2017 (Ioneer 2020c, p. 8). During 2018–2019, Ioneer conducted some surface-disturbing exploration operations and facility condemnation activities in which 3.5 ac (1.4 ha) of surface disturbance occurred in in the Rhyolite Ridge area (Ioneer 2020c, p. 5). Various protection measures for *Eriogonum tiehmii* have been implemented or proposed as part of Ioneer's proposed Rhyolite Ridge Lithium-Boron project, which is described in detail in Section 4.1.1 under Mineral Exploration and Development (Ioneer 2020b, entire).

Road Development and Off-Highway Vehicle Use

Ecological impacts of roads and ground disturbing activities like OHV use include altered hydrology, pollution, sedimentation, silt and dust erosion and deposition, habitat fragmentation, reduced species diversity, and altered landscape patterns (Forman and Alexander 1998, entire; Spellerberg 1998, entire). These effects can exacerbate over time, increasing both the extent of these effects and level of impact to the ecosystem (Forman 2000, pp. 34–35; McGarigal *et al.*

2001, pp 343–345). For example, OHVs can compact soil, crush plants, and provide a means for nonnative plant species to invade otherwise remote, intact habitats (Brooks and Pyke 2001, p.4; Gelbard and Belnap 2003, entire; Brooks and Lair 2005, p. 8).

Road development and OHV use have been noted as a threat to *Eriogonum tiehmii* and can affect individuals, subpopulations, and/or the population (Caicco and Edwards 2007, entire; Donnelly and Fraga 2020b, p. 1; Ioneer 2020b, p. 10). A county road (Cave Springs road) separates subpopulations 1, 2, and 8 from subpopulations 3, 4, 5, 6, and 7 (Figure 4; Ioneer 2020b, p. 10). Subpopulations 1, 2, 5, and 8 are directly adjacent to secondary dirt roads. OHV traffic in the Rhyolite Ridge area is frequently associated with hunting and recreational activities. Impacts to *E. tiehmii* by OHVs that were not within an existing road or trail were documented at subpopulation 1 in 2007, 2019, and 2020(Caicco and Edwards 2007, entire; Donnelly and Fraga 2020b, p. 1; Ioneer 2020b, p. 10).

The BLM Tonopah Field Office does not have a Travel Management Plan, but the Rhyolite Ridge area where *Eriogonum tiehmii* occurs is important bighorn sheep habitat and vehicles are limited to existing roads and trails (BLM 1997, p. 20; A. Bettinger, BLM, pers. comm. 2021). This area is open for new road development for mining or other authorized uses by an authorized officer, but not open to the public to operate OHVs beyond existing roads and trails (A. Bettinger, BLM, pers. comm. 2021). Even though mineral exploration activities have created or improved the roads and trails in the area, mine roads are open to the public despite periodic use (M. Gurtler, BLM, pers. comm. 2021).

Livestock Grazing

Livestock grazing has the potential to result in negative effects to *Eriogonum tiehmii* individuals, subpopulations, and/or the population, depending on factors such as stocking rate and season of use. It is not known if *E. tiehmii* is palatable to livestock, although other species of *Eriogonum* are known to be (Gucker and Shaw 2019a, p. 8; Gucker and Shaw 2019b, p. 8). Regardless, trampling by cattle typically results in broken stems and leaves of plants, and also creates various forms of soil disturbance, including soil compaction. Soil compaction can adversely affect *E. tiehmii* (and other native plant species) due to its potential to alter site hydrology and other microhabitat (including micro-topography) conditions necessary to sustain already-established plants, retain native plant seeds on-site, and encourage seed germination — all of which are pre-requisites for population persistence and recruitment (germination of seed and survival of seedlings; USDA 2001, entire). Livestock use has also been suggested as a contributing factor to the spread of nonnative, invasive plant species (Young *et al*. 1972, entire; Hobbs and Huenneke 1992, p. 329; Loeser *et al.* 2007, pp. 94–95). Additionally, many of the factors that drive wind erosion are greatly affected by soil surface disturbances. Livestock trampling negatively impacts biological and physiological soil crusts and decreases vegetative cover, thereby increasing wind erosion (Field *et al.* 2009, p. 426).

Eriogonum tiehmii occurs in the BLM Silver Peak livestock grazing allotment (BLM 1997, p. 15, Map 17). The Silver Peak Allotment (NV00097) was authorized on 9/09/2020 with a 4-year term that expires on 9/24/2024 (BLM 2021a, entire). There are no grazing exclosures associated with *E. tiehmii* within this BLM allotment; therefore, the species may be exposed to the effects of livestock grazing described in the above paragraph. The Silver Peak Allotment encompasses 281,489 ac (113,915 ha), has a year-round grazing use, and is not divided into pastures, although water points and topography naturally divide the allotment into three different use areas (BLM 2021b, entire; B. Truax, BLM, pers. comm. 2020). Within the allotment, only about 45 percent or 124,152 ac (50,243 ha) are within 2 mi (3.2 km) of stocking water, which is the distance generally accepted as how far cattle will typically travel from water to graze (B. Truax, BLM, pers. comm. 2020; Holechek 1998, p. 12). Cave Spring is the closest water source for cattle in the proximity of *E. tiehmii* and is 1.5 mi (2.4 km) east of the population. There are no other functioning water sources in proximity to *E. tiehmii.* The corral at Cave Spring can be configured to allow livestock access to the east, toward the town of Silver Peak, or to the west, toward the *E. tiehmii* population, through the use of a drift fence and cattle guard (B, Truax, BLM pers. comm. 2021). There are currently 658 active AUMs (animal unit months) and 2,507 temporarily suspended AUMs associated with the Silver Peak allotment due to stocking water range improvements that have fallen out of repair. However, range improvements are in progress and additional AUMs may be returned on this allotment (B. Truax, BLM, pers. comm. 2020). As described in Section 1.4.2, *E. tiehmii* is a BLM sensitive species, however there are no special restrictions or terms and conditions regarding livestock use within the allotment where this species occurs (BLM 2021b, entire).

Nonnative, Invasive Plant Species

Nonnative, invasive species can affect individuals, populations, and ecosystems through competition, change in community composition, and changes in environmental conditions (Willis 2017, p. 60; Simberloff *et al.* 2013, entire). Nonnative, invasive plant species could negatively affect *Eriogonum tiehmii* individuals, subpopulations, and/or the population through competition, displacement, and degradation of the quality and composition of its habitat (Gonzalez *et al.* 2008, entire; Simberloff *et al.* 2013, entire). In addition, most climate change models project conditions conducive to furthering the spread of nonnative invasive plant species (see Sections 3.1.3 and 4.1.3 below; Bradley *et al.* 2010, pp. 312–316).

Surveys of *Eriogonum tiehmii* conducted between 1994 and 2010 did not document any occurrences of nonnative, invasive species in its habitat (Morefield 1995, entire; Caicco and Edwards 2007, entire; Morefield 2008, entire; Morefield 2010, entire). However, *Halogeton glomeratus* (saltlover) has since become established to some degree and is part of the associated plant community in all subpopulations of *E. tiehmii* (CBD 2019, pp. 20–21; Ioneer 2020b, pp. 9–10). In 2019, *H. glomeratus* was observed within and adjacent to disturbed areas and spreading on newly graded roads and well pads from mining exploration activities (CBD 2019, pp. 20–21).

Halogeton glomeratus is not an extremely competitive plant and does not become dominant in undisturbed areas or areas with competing vegetation. However, salt desert shrublands (the plant community in which *Eriogonum tiehmii* occurs) are particularly susceptible to invasion of *H. glomeratus* if ground disturbing activities such as overgrazing, mechanical soil disturbance, and wildfire, which reduces desirable vegetation and increases bare soil, occur in these communities (Padgett *et al.* 2018, p. 182; DiTomaso *et al*. 2013, p. 200). Once established, *H. glomeratus* accumulate salts from the lower soil horizons and salts leach from its dead plant material, which increases topsoil salinity and favors *H. glomeratus* seed germination and establishment

(DiTomaso *et al*. 2013, p. 200). *Halogeton glomeratus* invasion typically follows human disturbance, as it is often found along rights-of-way and in grazing allotments and fallow fields (Duda *et al.* 2003, p. 73).

BLM has Best Management Practices (BMPs) for invasive and nonnative species that focus on the prevention of further spread and/or establishment of these species (BLM 2008, pp. 76–77). BMPs should be considered and applied where applicable to promote healthy, functioning native plant communities, or to meet regulatory requirements. BMPs include inventorying weed infestations, prioritizing treatment areas, minimizing soil disturbance, and cleaning vehicles and equipment (BLM 2008, pp. 76–77). However, incorporation or implementation of BMPs are at the discretion of the authorized BLM officer.

3.1.2 Herbivory

Herbivory on University of Nevada, Reno (UNR) Seedling Transplant Experiment

In 2020, researchers from UNR, under contract with Ioneer, conducted an *Eriogonum tiehmii* transplant study (see Section 2.4 for further discussion of soil properties related to this study). A total of 3,276 seeds were planted in pots at the UNR greenhouse. Overall, 32 percent emerged (1,057 seeds) and of those, 958 were mature enough (>2 leaves) to be transplanted into the wild on April 27–29, 2020. Three unoccupied sites based on habitat suitability models (see Section 2.5) were chosen for transplanting greenhouse grown *E. tiehmii* seedlings. Experiment installation and monitoring are described in greater detail in McClinton *et al.* 2020 (pp. 38–47).

After two months of growth in the wild, 62.2 percent (596 plants) of all *Eriogonum tiehmii* seedlings planted were still present and green. However, monitoring between June 22 and July 6, 2020 detected a major herbivory event in which seedlings were totally excavated or their stems severed, resulting in the loss of almost all transplants (585 plants) (McClinton *et al.* 2020, p. 43). To gain information about herbivore size, test ways to exclude herbivores, and protect the 1 percent of surviving transplants, different sized exclosures were installed on the remaining plants. These exclosures included hamster cages with bars >2.5 cm apart, open-topped metal cones made of 0.6cm mesh, large fine-meshed metal strainers (20cm diameter), small fine-meshed metal strainers (15.9cm diameter), and small fine-meshed plastic strainers (13.3cm diameter) (McClinton *et al.* 2020, p. 40). All plants left uncovered did not survive. Of the plants that had an exclosure installed, 59 percent survived until July 21, 2020, which was the last day of monitoring (McClinton *et al*. 2020, p. 42). Game cameras were installed in July 2020 and deer mice were the most likely culprits of seedling depredation (Service 2020b, entire). Researchers do not expect depredated seedlings to re-sprout (McClinton *et al.* 2020, p. 41).

Herbivory on Natural Population

Surveys of *Eriogonum tiehmii* conducted between 1994 and 2019 did not document any evidence of herbivory on the species (Morefield 1995, entire; Caicco and Edwards 2007, entire; Morefield 2008, entire; Morefield 2010, entire; Kuyper 2019, entire). However, in September 2020, many researchers and members of the public observed wide-scale damage to *E. tiehmii* individuals in all subpopulations (Cunningham and Emmerich 2020, entire; Donnelly 2020, entire; Donnelly and Fraga 2020a, entire; Donnelly and Fraga 2020b, entire; Fraga 2020, entire; Thill and Kuyper 2020, entire; McClinton 2020a, entire; McClinton 2020b, entire; Morrison and Smallwood 2020, entire). In some instances, entire *E. tiehmii* plants were excavated, broken into pieces, and lying beside holes with their taproots severed. In other cases, only portions of *E. tiehmii* plants were dug up and removed, leaving partially intact plants with exposed and stripped roots (Figure 6; Donnelly and Fraga 2020a, entire; McClinton 2020a, entire; McClinton 2020b, entire; Morefield 2020, p. 4). There is disagreement on the cause of damage with some observers claiming it was caused by humans (Cunningham and Emmerich 2020, entire; Donnelly 2020, entire; Donnelly and Fraga 2020a, entire; Fraga 2020, entire; McDade 2020, entire; Moore 2020, entire; Tremer 2020, entire) and others citing small mammals (Boone 2020, entire; Grant 2020, entire; Thill and Kuyper 2020, entire; McClinton 2020a, entire; McClinton 2020b, entire; Morrison and Smallwood 2020, entire).

Field investigations were initiated into the cause of damage by BLM (BLM 2020a, entire), Ioneer (Thill and Kuyper 2020; Morrison and Smallwood 2020, entire), NDOW (West 2020, Nevada Division of Natural Heritage (NDNH; Morefield 2020, entire), and the Service (Service 2020a, entire). Field investigators agree that the damage to *Eriogonum tiehmii* was caused by herbivory, as there was no evidence of tool marks or plant extraction that is consistent with human removal. Two small mammal species were observed on site or by sign (i.e. burrows and mounds) were identified as possibly responsible for the vegetation damage: pocket gophers (*Thomomys* sp.) and white-tailed antelope ground squirrels (*Ammospermophilus leucurus*; Morefield 2020, p. 11; West 2020, p. 3). Field observations were corroborated by environmental DNA (eDNA; *i.e.,* trace DNA found in soil, water, food items, or other substrates with which an organism has interacted) analyses on damaged *E. tiehmii* roots, undamaged control samples of *E. tiehmii* roots, soil tailings adjacent to damaged plants, control soil from undamaged plants, and rodent scat found near damaged plants (Grant 2020, entire).

The eDNA analyses revealed the genetic signatures of a rodent species belonging to tribe Marmotini on damaged *Eriogonum tiehmii* roots. The genetic signatures range from 96.96 to 99.75 percent match with the banked DNA sequence for Harris' antelope ground squirrel (*Ammospermophilus harrisii*) in the GenBank database maintained by the National Institutes of Health (Grant 2020, p. 4). This does not mean that the DNA came from Harris' antelope ground squirrel, as this species does not occur in Nevada. The DNA most likely originated from the Nevada native and locally abundant white-tailed antelope ground squirrel (*A. leucurus*), which does not have a 12S DNA barcode banked in the GenBank or BOLD databases. These two antelope ground squirrels are expected to have extremely similar DNA sequences because they belong to the same genus (Grant 2020, p. 4). Additionally, the same *Ammospermophilus* genetic signatures were also found in soil samples and in the rodent pellets found within the *E. tiehmii* population. The rodent pellets had a 100 percent match for the buckwheat genus, *Eriogonum*, however, a DNA barcode for *E. tiehmii* does not exist in the GenBank or Bold databases, so it was matched with another *Eriogonum* species. No squirrel family (Scuridae) eDNA was found in control samples. These data in combination with the morphological evidence consisting of rodent incisor marks on the roots of damaged plants (Figure 6) strongly support the hypothesis that a diurnal rodent in the genus *Ammospermophilus* was responsible for the damage to *E. tiehmii* (Grant 2020, p. 5).

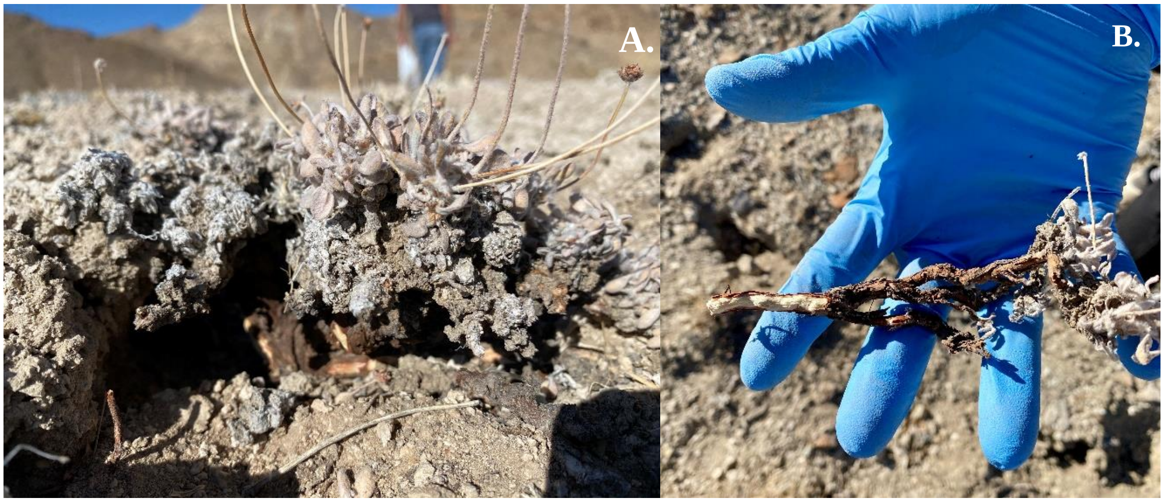

FIGURE 6—A. Partial excavation and stripped roots of an *Eriogonum tiehmii* individual at subpopulation 1. This plant experienced damage, but there are still intact roots securing it in place. B. Severed *E. tiehmii* plant root with incisor marks along its length. Photo credit: Sarah Kulpa/Service.

As described above in Section 2.6, permanent monitoring transects were established in subpopulations 1, 2, 3, 4, and 6 in 2019. Surveys were conducted along these transects in September 2020 to assess damage to *Eriogonum tiehmii* compared to data collected along these transects in 2019 (Thill and Kuyper 2020, entire). Morefield (2020, p. 4–6) assessed damage in all subpopulations except 8, and reported full mortality in subpopulations 5 and 7. Combining this data, 61 percent of *E. tiehmii* individuals were negatively impacted by this herbivory event (18 percent damaged and 43 percent killed; Table 3; Kuyper and Thill 2020, p. 3).

TABLE 3—Estimate of damaged and dead *Eriogonum tiehmii* plants in each subpopulation. Estimates are based on the number of damaged and dead plants in subpopulations within transects, which were extrapolated over the entire area of a subpopulation.

Subpopulation	Estimated number of plants 2019[a]	Estimated number of plants damaged from herbivory	Total percent damaged	Estimated number of plants dead from herbivory	Total percent dead	Total percent of plants damaged or dead
1	9,240	2,156[b]	23	2,978[b]	32	56
2	4,541	883[b]	19	2,710[b]	60	79
3	1,860	368[b]	20	1,258[b]	68	87
4	8,159	1,412[b]	17	3,386[b]	42	59
5	199	n/a		199[c]	100	100
6	19,871	3,092[b]	16	8,439[b]	42	58
7	50	n/a		50[c]	100	100
8	1	no post-herbivory surveys at this subpopulation				
TOTAL	43,921	7,911	18	19,020	43	61

[a] Kuyper 2019
[b] Thill and Kuyper 2020
[c] Morefield 2020

Although we are unable to discern why certain *Eriogonum tiehmii* plants were unharmed, while others were damaged or killed, the following patterns were observed. Younger and smaller *E. tiehmii* plants appeared to be less likely to have experienced damaging or lethal herbivory (Morefield 2020, p. 6; Thill and Kuyper 2020, p. 3). Large mats of *E. tiehmii* (1 foot or more in diameter) were less likely to be damaged, likely due to the extra excavation effort needed to reach the main taproot (Morefield 2020, p. 6). Localized patches of plants in subpopulations 1, 3, and 6 that grow in rockier soil were also less likely to be damaged, again likely due to the extra excavation effort (Morefield 2020, p.6). In subpopulations 4 and 6, higher proportions of intact *E. tiehmii* plants were seen on southwest aspects than on north and east aspects, possibly due to plants on north and east aspects having better water status and being more attractive to herbivores. This may explain the complete lethal herbivory at subpopulations 5 and 7 which occur on north to east aspects (Morefield 2020, p. 7). Other native plant species in and adjacent to the subpopulations of *E. tiehmii* like *Enceliopsis nudicaulis* (Nevada sunray), *Menodora spinescens* (spiny menodora), and *Cylindropuntia echinocarpa* (silver cholla) also experienced excavation and damage (Morefield 2020, p. 8; Service 2020b, p. 2).

The herbivory damage to *Eriogonum tiehmii* is concerning because it is extensive enough to compromise the long-term viability of some of the subpopulations. This was the first-time herbivory was documented on the species; however, this may not be the first time an event like this may has happened. Morefield (2020, p. 12) documented apparent old excavation mounds in subpopulation 1, as well as re-sprouting of heavily damaged plants, which we also observed (Figure 7; Morefield 2020, p. 12; Service 2020a, entire). These herbivory events may be infrequent enough not to have been seen during the previous 35 years since *E. tiehmii* was described, or the individual plants may have recovered before any damage was noticed (Morefield 2020, p. 12). Prior to the past few years, visits to this population were infrequent, happening only every 10–15 years (Morefield 1995, entire; Caicco and Edwards 2007, entire; Morefield 2008, entire; Morefield 2010, entire; Kuyper 2019, entire).

FIGURE 7—Heavily damaged *Eriogonum tiehmii* plant, re-sprouting from damaged roots in subpopulation 4. Photo Credit: Sarah Kulpa/Service.

Another possibility is that a changing climate is leading to temperature increases and changes in moisture availability. Total precipitation was above average in the Rhyolite Ridge area from 2015–2019, ranging from 6.1 to 8.7 in (15.5 to 22 cm) a year (Hegewisch and Abatzoglou 2020a).Whereas, in 2020, total average precipitation for the same area was 2.7 in (6.8 cm); Hegewisch and Abatzoglou 2020b). It is well documented that increases in precipitation are followed by increases in rodent populations (Randel and Clark 2010; entire; Gillespie *et al.* 2008, pp. 78–81; Brown and Ernest 2002, pp. 981–985; Beatley 1976, entire). This sudden shift from above average to below average precipitation may be what impacted the local rodent population at Rhyolite Ridge; a large rodent population could have been seeking water from whatever was available and in this case, it was the shallow taproots of mature *Eriogonum tiehmii* plants (Boone 2020, entire; Morefield 2020, p. 12). See Sections 3.1.3 and 4.1.2 for further details on climate change in the Rhyolite Ridge area.

3.1.3 Climate Change

The terms “climate” and “climate change” are defined by the Intergovernmental Panel on Climate Change (IPCC). The term “climate change” thus refers to a change in the mean or variability of one or more measures of climate (for example, temperature or precipitation) that persists for an extended period of time, whether the change is due to natural variability or human activity (IPCC 2014, pp. 119–120). Results of scientific analyses presented by the IPCC show that anthropogenic greenhouse gas emissions have increased since the pre-industrial era as a result of human activities and are now higher than ever. This has led to unprecedented atmospheric concentrations of greenhouse gases and are “extremely likely” (defined by the IPCC as 95–100 percent likelihood) to be the dominant cause of the observed warming since the mid-20th century (IPCC 2014, pp. 4–10; 40–54).

The implications of climatic changes in the Great Basin depends largely on the interaction of temperature and precipitation. Between 1895 and 2011, temperatures in the Great Basin have increased 1.2° to 2.5°F (0.7° to 1.4°C), with a greater increase in the southern Great Basin (where *Eriogonum tiehmii* occurs) than in the northern Great Basin (Snyder *et al.* 2019, p. 3). Temperatures are increasing more at night than during the day and more in winter than in summer, leading to fewer cold snaps, more heatwaves, fewer frosty days and nights, less snow, and earlier snowmelt (Snyder *et al.* 2019, p. 3; Padgett *et al.* 2018, p. 167; Abatzoglou and Kolden 2013, entire; Knowles *et al.* 2006, p. 4557; Mote *et al.* 2005, entire; Stewart *et al.* 2005, p. 1152).

For native plants, like *Eriogonum tiehmii*, the impacts will be largely determined by the spatial availability of soil water and timing of plant-available soil water. Soil water availability is affected by warming temperatures, which can lead to drought and soil water deficits (Snyder *et al.* 2019, p.2; Padgett *et al.* 2018, p. 167; Loik *et al.* 2004, entire). To generate temperate changes specific to the area where *E. tiehmii* occurs, Climate Mapper was used to visualize recent climate and hydroclimatic data as well as seasonal climate forecasts and longer-term climate projections (Hegewisch and Abatzoglou 2020c; Hegewisch and Abatzoglou 2020d).

Two indicators of temperature are important for evaluating trends in climate change, the increase in mean temperature and the increase in maximum temperature. For the Rhyolite Ridge area of the Great Basin where *Erigonum tiehmii* occurs, the 41-year trend provided by Climate Mapper indicates an increase in mean temperature during the growing season (October to September) of approximately 0.8°F/decade (0.4°C/decade; Hegewisch and Abatzoglou 2020c). The mean temperature during summer months (June – September) has increased by 1.2°F/decade (0.7°C/decade; Hegewisch and Abatzoglou 2020c). Similarly, the maximum temperature 41-year trend for the Rhyolite Ridge area during the growing season (October to September) shows an increase of 0.5°F/decade (0.3°C/decade; Hegewisch and Abatzoglou 2020c).

As described above in Section 3.1.2, temperature increases and changes in moisture availability may have been drivers behind the recent herbivory event. Thus, effects associated with global climate change may already be manifesting and impacting *Eriogonum tiehmii*. The implications of this and future climate change projections are discussed further in Section 4.1.2.

3.1.4 Small Population Size

Rare plant species, like *Eriogonum tiehmii*, that have restricted ranges, specialized habitat requirements, and limited recruitment and dispersal, have a higher risk of extinction due to demographic uncertainty and random environmental events (Shaffer 1987, pp. 69–75; Lande 1993, pp. 911–927; Hawkins *et al.* 2008, pp. 41–42; Caicco 2012, pp. 93–94; Kaye *et al.* 2019, p. 2). Generally, the extinction probability of a population increases as population size decreases, with small populations having a greater risk of extirpation and extinction (Kaye *et al.* 2019, p. 2). The risks to small plant populations, like *E. tiehmii*, include losses in reproductive individuals, declines in seed production and viability, loss of pollinators, loss of genetic diversity, and Allee effects (Willis 2017, pp. 74–77; Berec *et al.* 2007, entire; Eisto *et al.* 2000, pp. 1418–1420).

3.1.5 Disease

Morefield 1995 (p. 15) documented that several *Eriogonum tiehmii* plants at subpopulation 6 had abnormally large leaves, and a few others had yellow edges on the leaves, both appearing to be caused from fungal infections. No fruiting bodies were seen, so it was not possible to collect and identify the pathogens (Morefield 1995, p. 15). There is no documentation of fungal infections from more recent surveys (Caicco and Edwards 2007, entire; Morefield 2008, entire; Morefield 2010, entire; Ioneer 2020b, entire) and there is little to suggest that impacts from fungal infections are likely to occur.

3.1.6 Overutilization (unauthorized collecting)

There is no evidence of unauthorized collection of *Eriogonum tiehmii.*

3.2 Conservation Measures and Regulatory Mechanisms

BLM

As described in Section 1.4.2, *Eriogonum tiehmii* is a BLM sensitive species (BLM 2008, pp. 1–48). The stated objective for sensitive species is to initiate proactive conservation measures that reduce or eliminate threats to minimize the likelihood of and need for listing the species under the Act (BLM 2008, entire). However, BLM's regulations do not allow the agency to require conservation measures for sensitive species as a condition of exploring for or developing minerals subject to disposal under the Mining Law. Rather, the BLM's regulations require operators to avoid adverse effects to species listed as threatened or endangered and critical habitat (43 CFR § 3809.420(b)(7)). Additionally, no areas occupied by *E. tiehmii* have been withdrawn from mineral entry. Because the lands in the Rhyolite Ridge remain open to the operation of the Mining Law, and because miners are not required to obtain prior approval from BLM before they stake or "locate" a mining claim, the BLM has no ability to prevent any surface impacts related to the placement of mining claim monuments. Only areas that have been "withdrawn" to mineral entry by Congress, or public land order are truly closed to mineral entry.

Mining and mineral exploration operations have created or improved the roads and trails in the Rhyolite Ridge area, allowing easier and greater access for vehicles and OHVs. The BLM Tonopah Field Office does not have a Travel Management Plan, but the Rhyolite Ridge area where *Eriogonum tiehmii* occurs is important bighorn sheep habitat and vehicles are limited to existing roads and trails (BLM 1997, p. 20; A. Bettinger, BLM, pers. comm. 2021). This area is open for new road development for mining or other authorized uses by an authorized officer, but not open to the public to operate OHVs beyond existing roads and trails (A. Bettinger, BLM, pers. comm. 2021). Mine roads are not open to the public for recreational activities despite periodic use (M. Gurtler, BLM, pers. comm. 2021).

Grazing in the Rhyolite Ridge area is regulated under FLPMA. Under FLPMA, BLM has the ability to establish and implement special management areas such as ACECs to reduce or eliminate actions that adversely affect sensitive species, such as *Eriogonum tiehmii*. Although *E. tiehmii* is a BLM sensitive species, there are no special restrictions or terms and conditions regarding livestock use within the Silver Peak allotment where this species occurs. Any grazing permit on federal lands obligates BLM to evaluate how it will affect a species listed as threatened or endangered and/or its critical habitat and consult with the Service on how grazing activities should be conducted, changed, or curtailed to ensure they do not jeopardize the listed species. However, BLM’s regulations do not require the same evaluation of sensitive species.

BLM has Best Management Practices (BMPs) for invasive and nonnative species that focus on the prevention of further spread and/or establishment of these species (BLM 2008, pp. 76–77). BMPs should be considered and applied where applicable to promote healthy, functioning native plant communities, or to meet regulatory requirements. BMPs include inventorying weed infestations, prioritizing treatment areas, minimizing soil disturbance, and cleaning vehicles and equipment (BLM 2008, pp. 76–77). However, incorporation or implementation of BMPs is at the discretion of an authorized BLM officer.

In response to the recent herbivory event on *Eriogonum tiehmii* subpopulations, BLM has been monitoring the species biweekly. Photo plots were established near undamaged plants in subpopulations 1, 3, and 6 to help determine whether herbivory is continuing (B. Crosby, BLM, pers. comms. 2020a; B. Crosby, BLM, pers. comms. 2020b). Ocular estimates from the photo plots indicate that herbivory is not ongoing (Crosby 2020b, p. 1). Game cameras that were installed by BLM when damage to the species was first reported were removed in mid-November, but may be reinstalled if deemed necessary (Crosby 2020a, p. 1).

Ioneer

As described above in Section 2.5, Ioneer funded the development of a habitat suitability model to identify additional potential habitat for *Eriogonum tiehmii* through field surveys (Ioneer 2020b, p. 12). In addition, a demographic monitoring program was initiated in 2019 to detect and document trends in population size, acres inhabited, size class distribution, and cover with permanent monitoring transects established in subpopulations 1, 2, 3, 4, and 6 (Ioneer 2020b, p. 16). Ioneer also funded collection of *E. tiehmii* seed in 2019 (Ioneer 2020b, pp. 13-14). Some of this seed was used by UNR for a propagation trial and transplant study, which is described in Section 3.1.2 (Ioneer 2020b, p. 14). The remainder of this seed is in long-term storage at Rae Selling Berry Seed Bank at Portland State University (Ioneer 2020b, p. 13).

3.3 Summary of Current Condition

Data sufficient to directly assess the resiliency of the *Eriogonum tiehmii* population are sparse, as research and monitoring to better understand the species are still in their infancy (Grant 2020, entire; Ioneer 2020b, pp. 11–18; McClinton *et al.* 2020, entire; Service 2020b, entire). As a result, information is not known about subpopulation connectivity and dispersal (i.e., gene-flow) and recruitment and/or seedling establishment as there are no data yet to indicate any kind of trend. Furthermore, research to understand the mechanisms controlling changes in the abundance of *E. tiehmii* individuals through the monitoring of demographic rates has only just begun.

Globally, *Eriogonum tiehmii* is known from eight subpopulations that make up a single population. Additionally, as discussed in Section 2.5, surveys to detect additional populations of *E. tiehmii* have failed. *Eriogonum tiehmii* substantially contributes to supporting the high abundance and diversity of arthropods and pollinators found in the Rhyolite Ridge area (as described in Section 2.3). Research has identified a set of soil conditions that are a requirement for the growth of *E. tiehmii* as the species is specifically adapted to grow on its preferred soil type (as described in Section 2.4).

Eriogonum tiehmii occurs on 10 ac (4 ha) entirely on Federal lands with sparse associations of other plant species (Section 2.4). Rare plant species, like *E. tiehmii*, that have restricted ranges, specialized habitat requirements, and limited recruitment and dispersal, have a higher risk of extinction due to demographic uncertainty and random environmental events. Current primary threats to the species that we are carrying forward in this analysis include mineral exploration and development, road development and OHV use, livestock grazing, nonnative, invasive plant species, herbivory, and climate change. Many of the threats affecting the species have the potential to work in combination. For example, mineral exploration, road development and OHV use, and livestock grazing can introduce non-native, invasive plant species which in turn can directly compete with and displace *E. tiehmii* within its habitat.

As described above in Section 3.1.2, the native *Eriogonum tiehmii* population and a seedling transplant experiment experienced detrimental herbivory in 2020. Almost all transplants were lost to herbivores in a two-week period, while all native subpopulations experienced greater than 50 percent damage or loss of individual plants, with subpopulations 5 and 7 experiencing total mortality. This was the first documentation of herbivory on the species. Herbivore pressure precluded seedling survival in experimental plots, while in the native population, its significance depends not only on its frequency and intensity, but whether damaged plants can recover and survive. Within the native population, we are uncertain if the species' is redundant enough to recover from this damage and loss. Further studies and monitoring need to be conducted to determine if management to reduce herbivory is necessary to maintain *E. tiehmii* individuals and subpopulations, or if it was just a random catastrophic event that is not likely to occur on a regular basis.

4.0 FUTURE CONDITIONS AND STATUS

In this section, we assess future threats affecting *Eriogonum tiehmii*. Utilizing the information and evaluations in the Current Conditions section (Section 3.0), we consider the potential contributions of threats in the future, and correspondingly, how those threats may negatively impact the species' habitat and demography. We evaluate these threats in the context of (1) any existing regulatory mechanisms (Section 1.4.2) that may reduce impacts to the species or its habitat and (2) other existing efforts to protect or conserve the species (Section 4.2).

4.1 Threats Affecting *Eriogonum tiehmii* and Habitat

In this section, we assess future threats that may affect *Eriogonum tiehmii*. For *E. tiehmii*, a proposed mining operation has the potential to impact a significant number of individuals and its habitat. Future changes in the global climate also have the potential to collectively affect current and future threats that already are or may affect the species, which we describe below as well as in Section 5.0.

While we generally discuss these threats individually, threats can occur simultaneously, thus additively affecting the resiliency of *Eriogonum tiehmii*. Where different individual threats occur at the same time and place, we will describe how they may interact with one another below as well as in Section 5.0. Threats may be reduced through the implementation of existing regulatory mechanisms or other conservation efforts that benefit *E. tiehmii* and its habitat. Regulatory mechanisms are summarized in Section 1.4.2 and discussed below throughout the text.

4.1.1 Habitat Modification

This broad category includes threats that can physically disturb, damage, or kill *Eriogonum tiehmii* plants or degrade or destroy the habitat required by the species. The future threats identified here are associated with human activities. The habitat modification category also includes several threats that increase the potential for invasive, non-native plant species to be introduced into *E. tiehmii* habitat, thereby increasing competition for resources. While there is evidence of past and on-going habitat modification within the *E. tiehmii* population, as described above in Section 3.1.1, there have been no studies of the species' response to these threats at the individual, subpopulation, or population level.

Mineral Exploration and Development

As described above in Section 3.1.1, the Rhyolite Ridge area, where *Eriogonum tiehmii* occurs, has a history of mineral exploration and development (BLM 1997, p. 23). Lithium, boron, copper, zinc, and iron, which are in the soils on which *E. tiehmii* grows, are minerals subject to disposal under the Mining Law. Trenches and mine shafts associated with mineral exploration and development have already impacted subpopulations 1, 2, 3, 4, and 6, resulting in the loss of the *E. tiehmii* habitat. Future mineral exploration and development would be expected to result in similar or more detrimental impacts to the species. As described in 1.4.2, the lands on which *E. tiehmii* grows are subject to the operation of the Mining Law. Therefore, under BLM's regulations, operators may explore and cause a surface disturbance of up to 5 acres after an operator gives notice to BLM and waits 15 days (43 C.F.R. § 3809.21(a)). By contrast, if a listed species or designated critical habitat is present, an operator must submit a mining plan of operations and obtain BLM approval for any surface disturbance greater than casual use (43 CFR § 3809.11(b)(6)).

An operator may submit a Plan of Operations to BLM for the lands where *Eriogonum tiehmii* grows at any time. For example, in May 2020, Ioneer submitted a Plan of Operations (PoO) to BLM for the proposed Rhyolite Ridge Lithium-Boron project (Ioneer 2020c, entire). BLM is currently processing the proposed PoO, including analyzing the environmental impacts of approving the project under the National Environmental Policy Act (NEPA; BLM 2020b, entire). As described in the proposed PoO, surface disturbance would include construction and operation of a quarry, processing plant, overburden storage facility, spent ore storage facility, and access roads. As proposed, the quarry would be 213 ac (86.2 ha) and lithium-clay and lithium-boron ore resources would be extracted using conventional excavators. Overburden rock and ore would be transported from the quarry using haul trucks with the ore directed to the processing plant and the overburden to a rock storage area (Ioneer 2020c, p. 11). In total, approximately 932 ac (377.2 ha) of BLM-administered public lands would be disturbed by the proposed project (Ioneer 2020c, p. 5). If approved as proposed, construction of the processing plant would take approximately two years, and ore extraction and processing would occur over an approximate four to five-year period (Ioneer 2020c, p. 6). As proposed, dewatering wells at the quarry would cease operation at the end of operations and a terminal lake would develop in the quarry (Ioneer 2020c, p. 18).

Ioneer's proposed project entirely encompasses the single population of *Eriogonum tiehmii*. The proposed quarry would directly impact subpopulations 4, 5, 6, and 7 (Ioneer 2020b, p. 11). 43 percent of the *E. tiehmii* population was killed from the herbivory event, with an additional 18 percent of the population damaged. The project, as proposed, would cumulatively disturb and remove an additional 27 percent of the *E. tiehmii* population (between 11,701–16,205 of the remaining plants depending on whether damaged plants recover from herbivory) and 30 percent of its total habitat (2.96 ac (1.2 ha); Table 4; Ioneer 2020b, Figure 4, p. 29). At the end of the project, areas previously occupied by *E. tiehmii* (subpopulations 4, 5, 6 and 7) would be underwater within the boundaries of a terminal quarry lake (Ioneer 2020c, pp. 71–72).

TABLE 4—Cumulative impacts of herbivory and the proposed Rhyolite Ridge Lithium-Boron project on *Eriogonum tiehmii.*

Subpopulation	**Estimated number of plants 2019**[a]	**Estimated number of plants damaged from herbivory**	**Estimated number of plants dead from herbivory**	**Estimated number of remaining, intact plants post-herbivory and proposed mine**
1	9,240	2,156[b]	2,978[b]	4,106[d]
2	4,541	883[b]	2,710[b]	948[d]
3	1,860	368[b]	1,258[b]	234[d]
4	8,159	1,412[b]	3,386[b]	subpopulations impacted by the proposed mine
5	199	n/a	199[c]	
6	19,871	3,092[b]	8,439[b]	
7	50	n/a	50[c]	
8	1	No post-herbivory surveys		1
TOTAL	43,921	7,911	19,020	5,289

[a] Kuyper 2019

[b] Thill and Kuyper 2020

[c] Morefield 2020

[d] These numbers were calculated subtracting the estimated number of plants from those damaged or killed by herbivory. These numbers represent the intact plants within subpopulations that would not be impacted from the proposed mine.

To minimize potential impacts to *Eriogonm tiehmii*, Ioneer's proposed PoO includes various protection measures for the species (Ioneer 2020b, entire). Subpopulations 1, 2, 3, and 8 (5,289 plants) would be avoided and left undisturbed, with fencing maintained for the life of the project and signage placed around subpopulations 1 and 2 (Ioneer 2020b, p. 11). Seed from *E. tiehmii* was collected in 2019 and more seed collection is planned in the future for long-term storage and experimental use (Ioneer 2020b, pp. 13-14). Some of the seed was used at the University of Nevada, Reno for a plant/soil relationship, propagation trial, and transplant study to evaluate the possibility of planting *E. tiehmii* seedlings into unoccupied, potential habitat (described in more detail in Section 3.1.2; Ioneer 2020b, p. 14). Ioneer would also remove and salvage all remaining plants in subpopulations 4, 5, 6, and 7 (between 11,701–16,205 plants depending on if damaged plants recover from herbivory) and translocate them to another location (Ioneer 2020b, p. 15). Finally, a demographic monitoring program (described in Section 2.6) was initiated to detect and document trends in population size, acres inhabited, size class distribution, and cover with permanent monitoring transects established in subpopulations 1, 2, 3, 4, and 6 (Ioneer 2020b, p. 16; McClinton *et al.* 2020, pp. 48–52). However, these operator-committed conservation measures are specific to this proposal and would not necessarily be included with other potential projects in the Rhyolite Ridge area in the future. See Section 4.2 for a more detailed discussion of conservation measures for impacts related to mineral exploration and development.

Road Development and Off-Highway Vehicle Use

As described above in Section 3.1.1, ecological impacts of roads and ground disturbing activities like OHV use include altered hydrology, pollution, sedimentation, silt and dust erosion and deposition, habitat fragmentation, reduced species diversity, and altered landscape patterns (Forman and Alexander 1998, entire; Spellerberg 1998, entire). Ioneer's proposed Rhyolite Ridge Lithium-Boron project would construct and maintain service and haul roads within the Rhyolite Ridge area. Service roads (20 feet wide) would be constructed to move equipment and supplies to support various components of the proposed project, as well as to provide for light vehicle traffic (Ioneer 2020b, p. 43). Haul roads (maximum of 150 feet wide) would be constructed and maintained on a routine basis to ensure safe, efficient haulage operations and to minimize dust and diesel emissions to allow haul trucks to transport ore, overburden, and spent ore between the quarry, processing plant, overburden storage facility, and spent ore storage facility (Ioneer 2020b, p. 43). Cave Springs Road (as seen on Figure 4) is currently maintained by Esmeralda County and bisects the *Eriogonum tiehmii* subpopulations. Realignment of this road is proposed to accommodate haul roads. It is assumed that the rerouted road would be transferred to the county at closure, as an amendment to the county's existing right-of-way with BLM (Ioneer 2020b, p. 44). The expected amount of truck traffic associated with providing needed materials and supplies and product transport for the proposed project is anticipated to be 100 round trips per day, 365 days per year (Ioneer 2020b, p. 7).

Dust deposition, often a result of vehicle traffic on roads, negatively affects the physiological processes of plants including photosynthesis, reproduction, transpiration, water use efficiency, leaf hydraulic conductance, and stomatal disruption that impedes the ability of the stomata to open and close effectively (Hirano *et al.*1995, pp. 257–260; Vardaka *et al.* 1995, pp. 415–418; Wijayratne *et al.* 2009, pp. 84-87; Lewis 2013, pp. 56–79; Sett 2017, entire). The distance that dust travels depends on particle size, air turbulence, height, and roughness of the surrounding vegetation. Lighter particles such as small-particle clay (less than 0.002 millimeters (mm)) travel farther than heavier particles such as silt (0.05–0.002 mm) and sand (2.0–0.05 mm; USDA 1987, p.5). Dust particles can travel large distances, especially in sparsely vegetated areas, like *Eriogonum tiehmii* habitat, compared to heavily vegetated or forested areas (Grantz *et al.* 2003, p. 215; Field *et al.* 2009, pp. 425–426). Physiological disruption to *E. tiehmii* individuals from dust generated from vehicular traffic associated with the Rhyolite Ridge Lithium-Boron project would likely negatively affect the overall health and physiological processes of the population.

OHV impacts have already been documented in subpopulation 1 (Caicco and Edwards 2007, entire; Donnelly and Fraga 2020b, p. 1; Ioneer 2020b, p. 10) and can kill or damage individual plants and modify habitat through fragmentation and soil compaction. Mining and mineral exploration activities that grade, improve, and widen roads in the Rhyolite Ridge area may allow easier and greater access for OHVs and recreational use. Additionally, road development and increased vehicle traffic associated with the mine may create conditions that further favor the establishment of nonnative, invasive species within *Eriogonum tiehmii* habitat. The BLM Tonopah Field Office does not have a Travel Management Plan, but the Rhyolite Ridge area is important bighorn sheep habitat and vehicles are limited to existing roads and trails (BLM 1997, p. 20; A. Bettinger, BLM, pers. comm. 2021). However, this area is open for new road development for mining or other authorized uses by an authorized officer, but not open to the public to operate OHVs beyond existing roads and trails (A. Bettinger, BLM, pers. comm. 2021). Mine roads are not open to the public for recreational activities despite periodic use (M. Gurtler, BLM, pers. comm. 2021).

Livestock Grazing

As discussed above in Section 3.1.1, livestock grazing has the potential to result in negative impacts to *Eriogonum tiehmii* individuals, subpopulations, and/or the population, depending on factors such as stocking rate and season of use. It is not known if *E. tiehmii* is palatable to livestock, although other species of *Eriogonum* are known to be (Gucker and Shaw 2019 a, p. 8; Gucker and Shaw 2019b, p. 8). Regardless, trampling by cattle typically results in broken stems and leaves of plants, and also creates various forms of soil disturbance, including soil compaction.

The Silver Peak Allotment (NV00097) was authorized on 9/09/2020 with a 4-year term that expires on 9/24/2024 (BLM 2021a, entire). Upon expiration, the BLM will consider reauthorization and/or changing the number of active AUMs. As mentioned previously, there are currently 658 active AUMs (animal unit months) and 2,507 temporarily suspended AUMs associated with the Silver Peak allotment due to stocking water range improvements that have fallen out of repair. However, range improvements are in progress and additional AUMs may be returned on this allotment (B. Truax, BLM, pers. comm. 2020). Although some *Eriogonum tiehmii* individuals may be impacted by this threat, current grazing damage to *E. tiehmii* has not been observed. However, grazing impacts could potentially increase in the future if additional AUMs are returned to this allotment.

Nonnative, Invasive Plant Species

As discussed above in Section 3.1.1, nonnative, invasive plant species could negatively affect *Eriogonum tiehmii* individuals, subpopulations, and/or the population through competition, displacement, and degradation of the quality and composition of its habitat. *Halogeton glomeratus* was recently observed within and adjacent to disturbed areas and is spreading on newly graded roads and well pads from mining exploration activities (CBD 2019, pp. 20–21). *Halogeton glomeratus* invasion typically follows human disturbance, as it is often found along rights-of-way and in grazing allotments and fallow fields (Duda *et al.* 2003, p. 73).

As discussed above, Ioneer’s Rhyolite Ridge Lithium-Boron project proposes to construct and operate a quarry, processing plant, overburden storage facility, spent ore storage facility, and access roads (Ioneer 2020c, p. 11). If the project is approved, and these ground disturbing activities occur, there is a potential for increase in spread of nonnative, invasive plant species.

However, this possible increase is not certain and depends on approval of the proposed project. Under NEPA, BLM has the discretion to analyze best management practices to help reduce the likelihood that nonnative, invasive plant species are introduced and spread in *Eriogonum tiehmii* habitat.

4.1.2 Herbivory

Eriogonum tiehmii experienced a recent herbivory event that was extensive enough to compromise the long-term viability of individuals, subpopulations, and the overall population. All subpopulations experienced greater than 50 percent damage or loss of individual plants with subpopulations 5 and 7 experiencing total mortality. This was the first documentation of herbivory on the species. The significance of this herbivory event depends not only on its frequency and intensity, but whether damaged plants can recover and survive.

As described above in Section 3.1.2, we are unable to discern why this occurred. One possibility is that climate changes are causing temperature increases and changes in moisture availability. Total precipitation was above average in the Rhyolite Ridge area from 2015–2019, whereas in 2020, it was significantly below average. It is well documented that increases in precipitation are followed by increases in rodent populations (Randel and Clark 2010; entire; Gillespie *et al.* 2008, pp. 78–81; Brown and Ernest 2002, pp. 981–985; Beatley 1976, entire). This sudden shift from above average to below average precipitation may be what impacted the local rodent population at Rhyolite Ridge; a large rodent population was seeking water from whatever was available and in this case, it was the shallow taproots of mature *Eriogonum tiehmii* plants (Boone 2020, entire; Morefield 2020, p. 12). If herbivory was driven by a water stressed rodent population, future alteration of temperature and precipitation patterns may create climate conditions for this to happen again, resulting in further damage or loss of *E. tiehmii* individuals.

4.1.3 Climate Change

As described above in Section 3.1.3, the term climate change refers to a change in the mean or variability of one or more measures of climate (IPCC 2014, pp. 119–120). Scientists use a variety of climate models, which include consideration of natural processes and variability, as well as various scenarios of potential levels and timing of greenhouse gas emissions, to evaluate the causes of changes already observed and to project future changes in temperature and other climate conditions. Model results yield very similar projections of average global warming until about 2030, and thereafter the magnitude and rate of warming vary through the end of the century depending on the assumptions about population levels, emissions of greenhouse gases, and other factors that influence climate change. Thus, absent extremely rapid stabilization of greenhouse gases at a global level, there is strong scientific support for projections that warming will continue through the 21st century, and that the magnitude and rate of change will be influenced substantially by human actions regarding greenhouse gas emissions (IPCC 2014; entire).

Global-scale climate projections are informative, and often the best scientific information available for some geographical locations. However, projected changes in climate and related impacts can vary substantially across and within different regions of the world (IPCC 2014; entire) and within the United States (Melillo *et al.* 2014, entire). Therefore, we use “downscaled” projections when they are available and have been developed through appropriate scientific procedures, because such projections provide higher resolution information that is more relevant to spatial scales used for analyses of a given species (for additional discussion on downscaling, see Glick *et al.* 2011, pp. 58–61).

Various changes in climate may have direct or indirect impacts on a species. These may be positive, neutral, or negative, and they may change over time, depending on the species and other relevant considerations, such as the interaction of climate with other variables such as habitat fragmentation (Bertelsmeier *et al.* 2013, entire; Chen *et al.* 2011, entire; Parmesan and Yohe 2003, entire). However, continued high emissions would lead to mostly negative impacts for biodiversity and ecosystem services (IPCC 2018, pp. 9–12; IPCC 2014, pp. 40–54).

Rapidly changing global surface temperature and precipitation patterns are altering local environmental conditions where plants grows (Willis 2017, pp. 44–59; IPCC 2014, p.13). Large-scale patterns of changing plant distributions, flowering times, and novel community assemblages, in response to rising temperatures and changing rainfall patterns, are now apparent in many vegetation biomes (Willis 2017, p. 44). Many plant species are predicted to respond to climate change by shifting their ranges (Chen *et al.* 2011, entire; Lenoir *et al.* 2008, entire), however plant species that are unable to adapt to rapidly changing conditions or migrate to new areas may be extirpated in parts of their ranges or, in extreme cases, go extinct (Willis 2017, p. 44; IPCC 2014, p. 13).

The implications of climatic changes in the Great Basin depends largely on the interaction of temperature and precipitation. As described above in Section 3.1.3, temperatures in the Great Basin have increased over the past 100 years. Although these observed trends provide information as to how climate has changed in the past, climate models can be used to simulate and develop future climate projections.

Hegewisch and Abatzoglou (2020d) provided graphs of future climate projections from 20 downscaled global climate models under low (RCP 4.5) and high (RCP 8.5) greenhouse gas emission scenarios until 2099. Simulations using these downscaling methods from multiple models project mean average temperature during December, January, and February for the Rhyolite Ridge area to increase by 2.3°F (1.3°C) by 2060 and 3.4°F (1.9°C) by 2099 under low emission scenarios (RCP 4.5). Under high emission scenarios (RCP 8.5), mean average temperatures during winter months increase by 3.6°F (2°C) by 2060 and 7.1°F (3.9°C) by 2099. Likewise, these models project maximum average temperatures during June, July, and August for the Rhyolite Ridge area to increase by 2.9°F (1.6°C) by 2060 and 4.1°F (2.3°C) by 2099 under low emission scenarios (RCP 4.5). Under high emission scenarios (RCP 8.5), maximum average temperatures during summer months increased by 4.6°F (2.6°C) by 2060 and 8.9°F (4.9°C) by 2099 (Hegewisch and Abatzoglou 2020d).

Additionally, simulations using these downscaling methods from multiple models project annual precipitation for the Rhyolite Ridge area to increase by 0.4 in (10.16 mm (milometers)) by 2060 and 0.6 in (15.24 mm) by 2099 under low emission scenarios (RCP 4.5). Under high emission scenarios (RCP 8.5), annual precipitation increases by 0.3 in (7.62 mm) by 2060 and 0.7 in (17.78 mm) by 2099 (Hegewisch and Abatzoglou 2020d). As described above in Section 3.1.2, total precipitation was above average in the Rhyolite Ridge area from 2015–2019, ranging from

6.1 to 8.7 in (15.5 to 22 cm) a year (Hegewisch and Abatzoglou 2020a).Whereas, in 2020, total average precipitation for the same area was 2.7 in (6.8 cm; Hegewisch and Abatzoglou 2020b).

As discussed above in Section 2.4, *Eriogonum tiehmii* is adapted to dry, upland sites, subject only to occasional saturation by rain and snow. Increasing temperature can affect precipitation patterns. The fraction of winter precipitation (November–March) that falls as snow versus rain is declining in the western United States (Palmquist *et al.* 2016, pp. 13-16). Shifts from snow to rain when temperatures are cold enough to limit water losses from plant transpiration, and soils that are not frozen may have minimal impact on deep soil water storage. If rainfall replaces snow and temperatures are increased enough to thaw soils to stimulate plant growth and physiological activity earlier in the year, this would result in less deep soil water recharge (i.e., less soil water infiltration and more evaporation) and potential changes in plant community composition (Huxman *et al.* 2005, entire).

Fire is a naturally occurring phenomenon that impacts the distribution and structure of vegetation (Willis 2017, p. 52). However, due to increasing temperatures and reductions in precipitation, the severity and frequency of wildfires is likely to increase (Snyder *et al.* 2019, p. 8; Comer *et al.* 2013, pp. 130–135; Chambers and Wisdom 2009, pp. 709–710). While the Great Basin is extremely prone to fires, with 14 million ac (5.6 million ha) burning in the last 20 years, there are no reported accounts of fire within *Eriogonum tiehmii* habitat or in the surrounding Rhyolite Ridge area (BLM 2020c, entire). We currently do not have any data to suggest what level of effect wildfire could have on *E. tiehmii*, however, it could result in habitat loss, habitat fragmentation, and/or remove *E. tiehmii* individuals.

The direct, long term impact from climate change to *Eriogonum tiehmii* is yet to be determined. The timing of phenological events, such as flowering, are often related to environmental variables such as temperature. Large scale patterns of changing plant distributions, flowering times, and novel community assemblages in response to rising temperatures and changing rainfall patterns are apparent in many vegetation biomes (Munson and Long 2017, entire; Willis 2017, pp. 44– 49; Hawkins *et al.* 2008, entire; Burgess *et al.* 2007, entire; Parmesan 2006, entire). However, we do not know if or how climate change may alter the phenology of *E. tiehmii* or cause changes in pollinator behavior.

Under climate change predictions, we anticipate alteration of precipitation and temperature patterns as models forecast warmer temperatures and slight increases in precipitation. The timing and type of precipitation received (snow vs. rain) may impact plant transpiration and the soil water recharge needed by *Eriogonum tiehmii*. Additionally, variability in interannual precipitation combined with increasing temperatures, as recently seen from 2015–2020, may make conditions less suitable for *E. tiehmii* by bolstering local herbivore populations. High herbivore abundance combined with high temperatures and drought may have contributed to the large herbivore impacts in 2020 at both the transplant experiment and native population. Thus, climate change may exacerbate impacts from other threats currently affecting this species and its habitat.

4.1.4 Small Population Size

As described above in Section 3.1.4, rare plant species, like *Eriogonum tiehmii*, that have restricted ranges, specialized habitat requirements, and limited recruitment and dispersal, have a higher risk of extinction due to demographic uncertainty and random environmental or catastrophic events (Shaffer 1987, pp. 69–75; Lande 1993, pp. 911–927; Hawkins *et al.* 2008, pp. 41–42; Caicco 2012, pp. 93–94; Kaye *et al.* 2019, p. 2). As discussed in Section 3.1.2, a recent herbivory event occurred and negatively impacted the species. In the future, the population of *E. tiehmii* would remain small and would continue to be more susceptible to random environmental events that may negatively affect small populations. However, because we do not fully understand the cause of the recent catastrophic event, it is not clear whether or to what extent events such as these would continue to manifest themselves on *E. tiehmii.*

Additionally, habitat fragmentation can pose specific threats to a species through genetic factors such as increases in genetic drift and inbreeding, together with a potential reduction in gene flow from neighboring individuals or subpopulations (Jump and Peñuelas 2005, p. 1015–1016). The effects of habitat fragmentation from the proposed Rhyolite Ridge Lithium-Boron project on *Eriogonum tiehmii* may be compounded by the inherently poor dispersal of the species and specific soil requirements as described in Sections 2.4 and 2.5. Habitat fragmentation can amplify the effects of climate change that may result in altered *E. tiehmii* phenology and pollinator behavior by reducing individual fitness and lead to an increased risk of population extinction.

4.1.5 Disease

As described above, Morefield 1995 (p. 15) documented that several *Eriogonum tiehmii* plants at subpopulation 6 had fungal infections on their leaves. There is no documentation of fungal infections from more recent surveys (Caicco and Edwards 2007, entire; Morefield 2008, entire; Morefield 2010, entire; Ioneer 2020b, entire) and there is little to suggest that future impacts from fungal infections are likely to occur.

4.1.6 Overutilization (over collecting)

There is nothing to suggest that unauthorized collection will have an impact on *Eriogonum tiehmii* in the future.

4.2 Conservation Measures and Regulatory Mechanisms

BLM

As described in Section 4.1.2, *Eriogonum tiehmii* is a BLM sensitive species. However, as described in Section 3.2, BLM’s surface management regulations for operations under the Mining law do not provide BLM with the authority to impose conservation measures or condition mineral exploration and development on compliance with conservation measures unless the species or critical habitat is listed under the Act. In some circumstances, some operators would include commitments to undertake voluntary protection or conservation measures as part of their proposed mining operations, as Ioneer has done in its proposed mine plan (see Section 4.1.1 and below). However, other operators and other mineral exploration or development projects might not agree to apply conservation measures at all. Additionally, so long as these lands remain open to the operation of the Mining Law, surface impacts associated with monumenting mining claims would continue to occur, as could surface disturbance of up to five acres, provided an operator gave the BLM a Notice and waited 15 days.

The BLM Tonopah Field Office does not have a Travel Management Plan, but the Rhyolite Ridge area is important bighorn sheep habitat and vehicles are limited to existing roads and trails (BLM 1997, p. 20; A. Bettinger, BLM, pers. comm. 2021). The Rhyolite Ridge area is open for new road development for mining or other authorized uses by the authorized officer, but not open to the public to operate OHVs beyond existing roads and trails (A. Bettinger, BLM, pers. comm. 2021). Mine roads are not open to the public for recreational activities despite periodic use (M. Gurtler, BLM, pers. comm. 2021). However, road improvements associated with mining operations may allow easier and greater access for recreational vehicles and OHVs.

Ioneer

As part of the proposed Rhyolite Ridge Lithium-Boron project, Ioneer is developing a Conservation Plan for *Erigonum tiehmii* to protect and preserve the continued viability of the species on a long-term basis. Currently, only a Table of Contents has been drafted (Ioneer 2020d, entire).

Various protection measures for the *Eriogonum tiehmii* have been implemented or proposed as part of the proposed Rhyolite Ridge Lithium-Boron project. These include:

- Avoiding subpopulations 1, 2, 3, and 8 (5, 289 plants; Ioneer 2020b, p. 11);
- Fencing and placing signage around subpopulations 1 and 2 (Ioneer 2020b, p. 11);
- Collecting seed for long-term storage and experimental use (Ioneer 2020b, pp. 13-14). Some seed was already collected in 2019 and used at UNR for a plant/soil relationship, propagation trial, and transplant study to evaluate the possibility of planting *E. tiehmii* seedlings into unoccupied, potential habitat (described in more detail in Section 3.1.2; Ioneer 2020b, p. 14);
- Removing and salvaging all remaining plants in subpopulations 4, 5, 6, and 7 (between 16,205 – 11,701 plants depending on if damaged plants recover from herbivory) and translocate them to another location (Ioneer 2020b, p. 15); and
- Initiating a demographic monitoring program (described in Section 2.6) to detect and document trends in population size, acres inhabited, size class distribution, and cover with permanent monitoring transects established in subpopulations 1, 2, 3, 4, and 6 (Ioneer 2020b, p. 16; McClinton *et al.* 2020, pp. 48–52).

However, the proposed project may or may not be permitted by BLM, thus mining would not occur, and these protection measures may or may not be fully implemented.

4.3 Summary of Future Conditions

Similar to current conditions, future conditions and the impacts on *Eriogonum tiehmii* would continue to hinge on the species small range, distribution, and abundance. Many of the threats affecting the species under these conditions may continue to affect the species individually and also have the potential to work in combination. For example, mine and road development and OHV use, and livestock grazing can introduce non-native, invasive plant species which in turn can directly compete with and displace *E. tiehmii* within its habitat. New and improved roads also allow easier and greater access for recreational vehicles and OHVs. OHV impacts have already been documented in subpopulation 1 and can kill or damage individual plants and modify habitat through fragmentation and soil compaction. Dust generated from increased vehicle traffic may negatively affect the overall health and physiological processes of subpopulations and habitat that would not be directly impacted and removed by the proposed mining activity.

Cumulative impacts from herbivory (described in Section 3.1.2) and the proposed Rhyolite Ridge Lithium-Boron project (if permitted by BLM) would reduce the total *Eriogonum tiehmii* population by 70 to 88 percent, or from 43,921 individuals to roughly 5,289–8,696 individuals, as we do not know yet if the damaged plants will be able to recover and survive. Ioneer is proposing to remove and salvage all remaining plants in subpopulations 4, 5, 6, and 7 (between 11,701–16,205 plants depending on if damaged plants recover from herbivory) and translocate them to another location. However, with research indicating that *E. tiehmii* is a soil specialist and that adjacent, unoccupied sites were not suitable for all early life history stages, herbivore impacts on transplanted seedlings, and lack of testing and multi-year monitoring on the feasibility of transplanting the species, we are uncertain of its success.

Based on information Section 2.0, there is strong evidence that subpopulation 6 may be the most resilient of the eight *Eriogonum tiehmii* subpopulations. Subpopulation 6 has the most individuals, produces a higher average density of flowers, correlating to a higher seed output, supports high pollinator diversity, and supports a variety of size classes, including having the most individuals in the smallest size class indicating that this subpopulation is likely experiencing the most recruitment. Loss of this subpopulation may have an immense impact on the overall resiliency and continued viability of the species, beyond just the numeric loss of redundancy and representation.

Rare plant species, like *Eriogonum tiehmii*, that have restricted ranges, specialized habitat requirements, and limited recruitment and dispersal, have a higher risk of extinction due to demographic uncertainty and random environmental events. Additionally, habitat fragmentation poses specific threats to species through genetic factors such as increases in genetic drift and inbreeding, together with a potential reduction in gene flow from neighboring individuals or subpopulations (Jump and Peñuelas 2005, p. 1015–1016). The effects of habitat fragmentation from the proposed Rhyolite Ridge Lithium-Boron project on *E. tiehmii* may be compounded by the inherently poor dispersal of the species and specific soil requirements as described in Sections 2.4 and 2.5. Habitat fragmentation can amplify the effects of climate change that may result in altered *E. tiehmii* phenology and pollinator behavior by reducing individual fitness and lead to an increased risk of population extinction. Research to determine the level of genetic variation within and among *E. tiehmii* subpopulations is in progress (see Section 2.2).

The effects of future climate change have the potential to influence and add to many of the other threats already impacting *Eriogonum tiehmii*. For example, if the herbivory event was driven by water stressed rodent populations, future alteration of temperature and variability in precipitation patterns may create climatic conditions for this to happen again. Due to modeled changes in future climate, damage and loss from the catastrophic herbivory event, and the anticipated removal of additional subpopulations and habitat for the proposed Rhyolite Ridge Lithium-Boron project, we expect the future resiliency, redundancy and representation of *E. tiehmii* to be reduced based on the potential future threats we have analyzed.

The severity or likelihood of these potential future impacts are unknown at this time. In the next section, we examine the possibilities in greater detail.

5.0 FUTURE SCENARIO CONSIDERATIONS

In the preceding sections, we identify possible threats that could potentially impact *Eriogonum tiehmii* and we assessed them under current conditions (Section 3.0) and future conditions (Section 4.0). We examine four plausible scenarios to give the reader an idea of the breadth of possible future outcomes for the viability of *E. tiehmii*. For these scenarios, we project out 40 years. We chose 40 years based on the best available information regarding land management authorizations and land uses, development, existing regulatory mechanisms, and beneficial conservation measures expected to occur during this period. Additionally, 40 years is long enough to capture the temporal range of the available climate model projections; however, beyond that timeframe, the level of uncertainty becomes overwhelming, making future projections unrealistic.

5.1 Scenario 1

Under this scenario, we take the existing current BLM land management authorizations and land uses and project them forward into the future 40 years. We assume that habitat modifying threats such as mineral exploration and development, road development and OHV use, livestock grazing, and nonnative, invasive plant species do not increase or alter *Eriogonum tiehmii* habitat more than current levels. We assume that mean average temperature during December, January, and February for the Rhyolite Ridge area to increase by 2.3°F (1.3°C) by 2060 under low emission scenarios (RCP 4.5). Likewise, these models project maximum average temperatures during June, July, and August for the Rhyolite Ridge area to increase by 2.9°F (1.6°C) by 2060 under low emission scenarios (RCP 4.5). Annual precipitation for the Rhyolite Ridge area is projected to increase by 0.4 in (10.16 mm) by 2060 under low emission scenarios (RCP 4.5). We assume the slight increase in precipitation to buffer evaporative demand (*i.e.,* soil water availability) and that these increases in temperature would not affect the physiology and continued viability of *E. tiehmii.* Finally, we assume that herbivory on *E. tiehmii* was a one-time, catastrophic event.

Resiliency

Under this scenario, we anticipate the *Eriogonum tiehmii* population would continue to be present and recover from herbivory damage. There would be continuation of current BLM land management authorizations and land uses, and no new mining operations would be authorized. However, the smaller subpopulations (5 and 7) that were lost due to herbivory may no longer exist. We expect the resiliency of the larger subpopulations to be at least as good as they are currently such that each of the larger subpopulations retains their ability to withstand stochastic events.

Redundancy

Under this scenario, the redundancy of the population has been reduced from rodent herbivory. The *Eriogonum tiehmii* population is still persistent, even though smaller subpopulations have become extirpated. We expect redundancy to continue to be low, which is typical of a narrow endemic species.

Representation

Under this scenario, we expect *Eriogonum tiehmii* individuals would continue to be present throughout its narrow range as a result of the continuation of current BLM land management authorizations and land uses, no new mining operations being authorized, and climatic conditions largely remaining the same. We expect similar levels of representation to what the species currently has (*i.e.,* low representation).

Summary of Scenario 1

Damage and loss from herbivory caused significant declines in population numbers in all remaining subpopulations. However, we expect that *Eriogonum tiehmii* would continue to persist throughout its narrow range. Subpopulations 5 and 7 experienced total mortality due to herbivory and may never recover due to their inability to recover from the soil seed bank. Slight increases in precipitation would buffer evaporative demand (*i.e.,* soil water availability) and increases in temperature would not affect the physiology and continued viability of *E. tiehmii*. The species would be able to adapt to these changing climate conditions because there are not any additional anthropogenic or herbivore pressures impacting the species.

5.2 Scenario 2

Under this scenario, we take the existing conditions and project them forward into the future 40 years, assuming BLM approves a mining project of a size and scope similar to the Rhyolite Ridge Lithium-Boron project. If approved, the mine would start construction and extraction within this 40-year time period. We assume that the proposed translocation (salvage) of *Eriogonum tiehmii* is ultimately unsuccessful due to the specific habitat requirements of the species. We also assume that road development and OHV use, and nonnative, invasive plant species increase within the Rhyolite Ridge area. We assume that livestock grazing would continue impacts at its current level. We assume that mean average temperature during December, January, and February for the Rhyolite Ridge area would increase by 2.3°F (1.3°C) by 2060 under low emission scenarios (RCP 4.5). Likewise, these models project maximum average temperatures during June, July, and August for the Rhyolite Ridge area to increase by 2.9°F (1.6°C) by 2060 under low emission scenarios (RCP 4.5). Annual precipitation for the Rhyolite Ridge area is projected to increase by 0.4 in (10.16 mm) by 2060 under low emission scenarios (RCP 4.5). The timing and type of precipitation received (snow vs. rain) may impact plant transpiration and the soil water recharge needed by *Eriogonum tiehmii*. Thus, the modeled higher temperatures could lead to drought and soil water deficits impacting the physiology and reproduction of *E. tiehmii.* However, this affect may be buffered to some extent by a slight increase in precipitation. Finally, we assume that the herbivory event was not a one-time catastrophic event, but instead driven by a water stressed rodent population. Increases in temperature and fluctuations in precipitation patterns may create climatic conditions for this to occur more frequently.

Resiliency

Under this scenario, we anticipate that the number of *Eriogonum tiehmii* individuals occupying subpopulations would decrease in abundance due to herbivory, mine development, increased periods of drought, increases in temperature, and land management activities that are not providing protection to the species. Subpopulations 4, 5, 6, and 7 would be extirpated which would impact the ability of the remaining subpopulations and overall population to withstand stochastic events and variations in environmental and demographic conditions. We anticipate a decrease in *E. tiehmii* genetic diversity, recruitment and seedling establishment due to the loss of occupied habitat and subpopulations.

Redundancy

Under this scenario, only subpopulations 1, 2, and 3 remain, subpopulation 8 is extirpated because it is only 1 plant, and the overall population is 5,000 plants or less. We anticipate a decrease in *Eriogonum tiehmii* genetic diversity, recruitment and seedling establishment due to the loss of occupied habitat and subpopulations. We anticipate significant declines in abundance as a result of deteriorating habitat and environmental conditions. The ability of the species to withstand anthropogenic or natural catastrophic events would be reduced.

Representation

Under this scenario, we expect a significant reduction the number of *Eriogonum tiehmii* individuals and loss of occupied habitat and entire subpopulations due to herbivory and mining. Remaining *E. tiehmii* plants may not be able to withstand and adapt to increased temperatures that are causing more frequent periods of drought. The slight increase in precipitation is irrelevant due to an increase in evaporative demand (*i.e.*, lower soil moisture availability) due to increases in temperatures. The species would struggle to adapt to changing climate conditions because of anthropogenic and herbivore pressures.

Summary of Scenario 2

Damage and loss from herbivory caused significant declines in population numbers in all subpopulations. Removal of additional *Eriogonum tiehmii* plants and 30 percent of the species habitat further reduces the species population size and range. We expect that subpopulations 1, 2, and 3 would continue to be occupied, but declining. Subpopulation 8 is 1 plant and would likely be extirpated. Based on information Section 2.0, there is strong evidence that subpopulation 6 may be the most resilient of the eight *E. tiehmii* subpopulations. Loss of subpopulation 6 may have an immense impact on the overall resiliency and continued viability of the species, beyond just the numeric loss of redundancy and representation. The timing and type of precipitation received (snow vs. rain) would impact plant transpiration and the soil water recharge needed by *E. tiehmii*. We anticipate significant declines in population size due to increased periods of drought from increased temperatures that may result in reduced recruitment and seedling establishment and decrease the species' ability to withstand stochastic and catastrophic events (like herbivory) and adapt to future change.

5.3 Scenario 3

Under this scenario, we take the existing conditions and project them forward into the future 40 years, assuming BLM approves a mining project of a size and scope similar to the Rhyolite Ridge Lithium-Boron project. If approved, the mine would start construction and extraction within this 40-year time period. We assume that the proposed translocation (salvage) of *Eriogonum tiehmii* is ultimately unsuccessful due to the specific habitat requirements of the species. We also assume that road development and OHV use, and nonnative, invasive plant species increase within the Rhyolite Ridge area. We assume that livestock grazing would continue impacts at its current level. We assume that mean average temperature during December, January, and February for the Rhyolite Ridge area would increase by 3.6°F (2°C) by 2060 under high emission scenarios (RCP 8.5). Likewise, these models project maximum average temperatures during June, July, and August for the Rhyolite Ridge area to increase by 4.6°F (2.6°C) by 2060 under high emission scenarios (RCP 8.5). Annual precipitation for the Rhyolite Ridge area is projected to increase by 0.3 in (7.62 mm) by 2060 under high emission scenarios (RCP 8.5). The timing and type of precipitation received (snow vs. rain) may impact plant transpiration and the soil water recharge needed by *E. tiehmii*. Thus, the modeled higher temperatures could lead to drought and soil water deficits impacting the physiology and reproduction of *E. tiehmii.* However, this affect may be buffered to some extent by a slight increase in precipitation. Finally, we assume that the herbivory event was not a one-time catastrophic event, but instead driven by a water stressed rodent population. Increases in temperature and fluctuations in precipitation patterns may create climatic conditions for this to occur more frequently.

Resiliency

Under this scenario, we anticipate that the number of *Eriogonum tiehmii* individuals occupying subpopulations would decrease in abundance due to herbivory, mine development, increased periods of drought, increases in temperature, and land management activities that are not providing protection to the species. Subpopulations 4, 5, 6, and 7 would be extirpated which would impact the ability of the remaining subpopulations and overall population to withstand stochastic events and variations in environmental and demographic conditions. We anticipate a decrease in *E. tiehmii* genetic diversity, recruitment and seedling establishment due to the loss of occupied habitat and subpopulations.

Redundancy

Under this scenario, only subpopulations 1, 2, and 3 remain, subpopulation 8 is extirpated because it is only 1 plant, and the overall population is 5,000 plants or less. We anticipate significant declines in abundance as a result of deteriorating habitat and environmental conditions. The ability of the species to withstand anthropogenic or natural catastrophic events would be reduced.

Representation

Under this scenario, we expect a significant reduction the number of *Eriogonum tiehmii* individuals and loss of occupied habitat and entire subpopulations due to herbivory and mining. Remaining *E. tiehmii* plants may not be able to withstand and adapt to increased temperatures that are causing more frequent periods of drought. The slight increase in precipitation is irrelevant due to an increase in evaporative demand (*i.e.*, lower soil moisture availability) due to increases in temperatures. The species would struggle to adapt to changing climate conditions because of anthropogenic and herbivore pressures.

Summary of Scenario 3

Damage and loss from herbivory caused significant declines in population numbers in all subpopulations. Removal of additional *Eriogonum tiehmii* plants and 30 percent of the species habitat further reduces the species population size and range. We expect that subpopulations 1, 2, and 3 would continue to be occupied, but declining. Subpopulation 8 is 1 plant and would likely be extirpated. Based on information Section 2.0, there is strong evidence that subpopulation 6 may be the most resilient of the eight *E. tiehmii* subpopulations. Loss of subpopulation 6 may have an immense impact on the overall resiliency and continued viability of the species, beyond just the numeric loss of redundancy and representation. The timing and type of precipitation received (snow vs. rain) would impact plant transpiration and the soil water recharge needed by *E. tiehmii.* We anticipate significant declines in population size due to increased periods of drought from increased temperatures that may result in reduced recruitment and seedling establishment and decrease the species' ability to withstand stochastic and catastrophic events (like herbivory) and adapt to future change.

5.4 Scenario 4

Under this scenario, we take the existing conditions and project them forward into the future 40 years, assuming BLM approves a mining project or multiple mining projects of a size and scope larger than the Rhyolite Ridge Lithium-Boron project. We assume that any protection measures, such as the proposed translocation (salvage), are ultimately unsuccessful due to the specific habitat requirements of the species for carrying out its basic life history processes of establishment, reproduction, and dispersal. We also assume that road development and OHV use, and nonnative, invasive plant species increase within the Rhyolite Ridge area. Increased dust from increased vehicular traffic negatively affect the overall health and physiological processes of *Eriogonum tiehmii.* Future climate scenarios under both low (RCP 4.5) or high (RCP 8.5) emission scenarios project increases in mean average temperatures and maximum average summer temperatures by 2060, as well as a slight increase in precipitation. However, timing and type of precipitation received (snow vs. rain) may impact plant transpiration and the soil water recharge needed by *E. tiehmii*. Thus, the modeled higher temperatures could lead to drought and soil water deficits impacting the physiology and reproduction of *E. tiehmii.* However, this effect may be buffered to some extent by a slight increase in precipitation. Finally, we assume that the herbivory event was not a one-time catastrophic event, but instead driven by a water stressed rodent population. Herbivores will continue to negatively impact the natural population as well as any seedings, transplant, and/or translocation (salvage) experimental studies. Projected increases in temperature and fluctuations in precipitation patterns may create climatic conditions for herbivory to occur more frequently.

Resiliency

Under this scenario, we anticipate that *Eriogonum tiehmii* individuals occupying all subpopulations would decrease in abundance due to a combination of herbivory, mine development, increased periods of drought, increases in temperature, and lack of regulatory mechanisms in place to provide protection to the species. Subpopulations 4, 5, 6, and 7 would be extirpated from the Rhyolite Ridge Lithium-Boron project, and subsequent mining activity would impact subpopulations 1, 2, 3, and 8. These impacts to occupied habitats combined with mining, repeated herbivory, and increases in vehicle traffic and dust deposition would result in the species becoming extinct in the wild.

Redundancy

Under this scenario, all subpopulations become extinct in the wild due to significant declines in abundance as a result of deteriorating habitat and environmental conditions that negatively impact the ability of the species to withstand anthropogenic or natural catastrophic events.

Representation

Under this scenario, we expect the *Eriogonum tiehmii* population to become extinct in the wild due to the loss of occupied habitat, subpopulations, and individuals due to the cumulative impacts of herbivory and mining, as well as a lack of regulatory mechanisms in place to provide protection to the species. The species would be unable to adapt to changing climate conditions because of the intensity of anthropogenic and herbivore pressures.

Summary of Scenario 4

Eriogonum tiehmii would become extinct in the wild in the 40-year period due to cumulative threats that would continue at increased rates, with mining and continued herbivory having the greatest impacts on viability of the species and its habitat.

5.5 Uncertainties Relating to Future Conditions

Uncertainties remain regarding how *Eriogonum tiehmii* would respond in a changing climate, how climate may change, and how future management authorizations and uses may change within the Rhyolite Ridge area and surrounding BLM managed lands, and what, if any, regulatory changes may occur. We do not know how many subpopulations are needed to provide sufficient redundancy and representation of the species. Best available research indicates that *E. tiehmii* is a soil specialist and that adjacent, unoccupied sites were not suitable for all early life history stages. Herbivores negatively impacted transplanted seedlings and there is a lack of testing and multi-year monitoring on the feasibility of transplanting *E. tiehmii* seedlings to unoccupied sites. Further research, long-term monitoring, and installation of herbivory exclosures during seedling planting is needed to determine if seedlings can establish a self-sustaining population.

We lack data on dispersal mechanisms and how habitat connectivity is impacting *Eriogonum tiehmii* subpopulation and population dynamics. We are uncertain what recruitment and seedling establishment would look like in the future. We are uncertain what environmental factors aligned to trigger the catastrophic herbivory event and if this can or would happen again. In addition, we are also uncertain which environmental factors would affect *E. tiehmii* more; for example, an increase in evaporative demand may lead to further reductions in resilience, even with slightly increased precipitation levels. We have presented scenarios that represent this range of uncertainty.

5.6 Summary of Future Condition Scenarios

In summary, we anticipate subpopulations 1, 2, and 3 to continue to be occupied at some level under three of the scenarios (Scenario 1, 2, and 3) described above. By 2060, our analysis shows one scenario (Scenario 1) where resiliency would be similar to current levels. For two of our other scenarios (Scenario 2 and 3) by the year 2060, we anticipate there would be a significant reduction in resiliency, redundancy, and representation, which would put the species at an increased risk for stochastic and catastrophic events. However, by 2060 for our last scenario (Scenario 4), we anticipate that the species would not persist into the future, becoming extinct in the wild. Under all scenarios, damage and loss from herbivory caused significant declines in population numbers in all remaining subpopulations. Under three scenarios (Scenario 2, 3, and 4), cumulative threats from herbivory and mining have the greatest impact on viability of the species and its habitat.

Under Scenario 1, we expect that *Eriogonum tiehmii* would continue to persist throughout its narrow range. Subpopulations 5 and 7 experienced total mortality due to herbivory and may never recover due to their inability to recover from the soil seed bank. Slight increases in precipitation would buffer evaporative demand (i.e. soil water availability) and increases in temperature would not affect the physiology and continued viability of *E. tiehmii*. The species would be able to adapt to these changing climate conditions because there are not any additional anthropogenic or herbivore pressures impacting the species.

Under Scenarios 2 and 3, removal of additional *Eriogonum tiehmii* plants and 30 percent of the species habitat further reduces the species population size and range. We expect that subpopulations 1, 2, and 3 would continue to be occupied, but declining. Subpopulation 8 is 1 plant and would likely be extirpated. Based on information Section 2.0, there is strong evidence that subpopulation 6 may be the most resilient of the eight *E. tiehmii* subpopulations. Loss of subpopulation 6 may have an immense impact on the overall resiliency and continued viability of the species, beyond just the numeric loss of redundancy and representation. The timing and type of precipitation received (snow vs. rain) would impact plant transpiration and the soil water recharge needed by *E. tiehmii.* We anticipate significant declines in population size due to increased periods of drought from increased temperatures that may result in reduced recruitment and seedling establishment and decrease the species' ability to withstand stochastic and catastrophic events (like herbivory) and adapt to future change.

Under Scenario 4, *Eriogonum tiehmii* would not persist into the future, becoming extinct in the wild due to cumulative threats that would continue at increased rates, with mining and continued herbivory having the greatest impacts on viability of the species and its habitat.

We do not know the size and scale of future mining operations in the Rhyolite Ridge area, though we can make assumptions based on the size and scope of the proposed Rhyolite Ridge Lithium-Boron project. We do not yet know if *Eriogonum tiehmii* can sustain widespread damage from herbivory (i.e., re-sprout from damaged roots.) We do not yet know if *E. tiehmii* seedling transplants (grown in a greenhouse) or translocation of adult individuals (*i.e.,* salvage; dug up and moved) can survive and establish self-sustaining subpopulations. Viable seed in the soil seed bank can act as a buffer during periods of prolonged drought, however, we do not know the longevity or viability of seed in the soil seed bank or what environmental cues are needed to trigger germination. Because there is only one population of *E. tiehmii*, this species is already at risk of catastrophic events and may have low adaptability to changing conditions.

6.0 OVERALL SYNTHESIS

Eriogonum tiehmii is a low growing perennial herb, with blueish gray leaves and pale, yellow flowers that bloom from May to June and turn red with age. The historic and current range of the species is the Silver Peak Range of Esmeralda County, Nevada, where it is known from one population in the Rhyolite Ridge area that is entirely on federal land. As discussed in Section 2.5, surveys to detect additional populations of *E. tiehmii* have failed. *Eriogonum tiehmii* substantially contributes to supporting the high abundance and diversity of arthropods and pollinators found in the Rhyolite Ridge area (as described in Section 2.3). Research has identified a set of soil conditions that are a requirement for the growth of *E. tiehmii* as the species is specifically adapted to grow on its preferred soil type (as described in Section 2.4).

As described in Section 3.1.2, the native *Eriogonum tiehmii* population and a seedling transplant experiment experienced detrimental herbivory in 2020. Almost all transplants were lost to herbivores in a two-week period, while all native subpopulations experienced greater than 50 percent damage or loss of individual plants, with subpopulations 5 and 7 experiencing total mortality. This was the first documentation of herbivory on the species. Herbivore pressure precluded seedling survival in experimental plots, while in the native population, its significance depends not only on its frequency and intensity, but whether damaged plants can recover and survive. Within the native population, we are uncertain if the species' is redundant enough to recover from this damage and loss. Further studies and monitoring need to be conducted to determine if management to reduce herbivory is necessary to maintain *E. tiehmii* individuals and subpopulations, or if it was just a random catastrophic event that is not likely to occur on a regular basis.

The specialized soils on which *Eriogonum tiehmii* occurs are high in lithium and boron, making this once remote location that is home to this species now of high interest for mineral development. Mineral exploration has already impacted *E. tiehmii* habitat by contributing to the spread of *Halogeton glomeratus*, a nonnative, invasive plant species, within all subpopulations of the species. The proposed Rhyolite Ridge Lithium-Boron project, if approved, would result in the loss of habitat and subpopulations, even with the voluntary protection measures included in the operator's proposal. Cumulative impacts from herbivory and the proposed Rhyolite Ridge Lithium-Boron project would reduce the total *E. tiehmii* population by 70 to 88 percent, or from 43,921 individuals to roughly 5,289–8,696 individuals, as we do not know yet if the plants damaged from herbivory would be able to recover and survive.

Ioneer is proposing to remove and salvage all remaining plants in subpopulations 4, 5, 6, and 7 (between 11,701–16,205 plants depending on if damaged plants recover from herbivory) and transplant them to another location. However, with research indicating that *Eriogonum tiehmii* is a soil specialist and that adjacent, unoccupied sites are not suitable for all early life history stages, herbivore impacts on transplanted seedlings, and lack of testing and multi-year monitoring on the feasibility of transplanting the species, we are uncertain of its success. Thus, the impact to *E. tiehmii* would be permanent and irreversible due to the loss of subpopulations and habitat because once mining is complete, the formerly occupied area would be underwater within the boundaries of a terminal quarry lake. Elimination of these subpopulations may remove corridors for pollinator movement, seed dispersal, and population expansion. Loss of subpopulation 6 may have an immense impact on the overall resiliency and continued viability of the species, beyond just the numeric loss of redundancy and representation, as there is strong evidence, as described in Section 2.0, that subpopulation 6 is the most resilient of the eight *E. tiehmii* subpopulations.

Road development and vehicle traffic associated with the proposed mine may create conditions that further favor the establishment of nonnative, invasive species within *Eriogonum tiehmii* habitat. Road improvements also allow easier and greater access for recreational vehicles and OHVs. OHV impacts have already been documented in subpopulation 1 and can kill or damage individual plants and modify habitat through fragmentation and soil compaction. Dust generated from increased vehicle traffic may negatively affect the overall health and physiological processes of subpopulations and habitat that would not be removed by the proposed mining activity.

Livestock grazing occurs within the *Eriogonum tiehmii* population as part of the BLM’s Silver Peak allotment. Livestock grazing may result in direct impacts to individual *E. tiehmii* plants due to trampling of vegetation and soil disturbance (compaction) in ways that can render habitat no longer suitable to established plants, while also discouraging population recruitment (by discouraging seed retention, seed germination, and seedling survival). Patterns of soil disturbance associated with grazing also can create conditions conducive to the invasion of nonnative plant species.

Eriogonum tiehmii is adapted to dry, upland sites, subject only to occasional saturation by rain and snow. Under climate change predictions, we anticipate alteration of precipitation and temperature patterns as models forecast warmer temperatures and slight increases in precipitation. The timing and type of precipitation received (snow vs. rain) may impact plant transpiration and the soil water recharge needed by *E. tiehmii*. Additionally, variability in interannual precipitation combined with increasing temperatures, as recently seen from 2015–2020, may make conditions less suitable for *E. tiehmii* by bolstering local herbivore populations. High herbivore abundance combined with high temperatures and drought may have contributed to the large herbivore impacts in 2020 in both the transplant experiment and native population. Thus, climate change may exacerbate impacts from other threats currently affecting this species and its habitat.

Under three Future Condition Scenarios, we anticipate subpopulations 1, 2, and 3 to continue to be occupied at some level. In 40 years, our analysis shows one scenario (Scenario 1) where resiliency would be similar to current levels. Our analysis shows two scenarios (Scenario 2 and 3), where there would be a significant reduction in resiliency, redundancy, and representation, which would put the species at an increased risk for stochastic and catastrophic events. However, under our fourth scenario (Scenario 4), our analysis shows that the species would become extinct in the wild. Under all scenarios, damage and loss from herbivory cause significant declines in population numbers in all remaining subpopulations. Under three scenarios (Scenario 2, 3, and 4), cumulative threats from herbivory and mining have the greatest impact on viability of the species and its habitat. Viable seed in the soil seed bank may act as a buffer to random stochastic events or prolonged drought, however, we do not know the longevity or viability of seed in the soil seed bank or what environmental cues are needed to trigger germination. Because there is only one population of *Eriogonum tiehmii*, it is already at risk of catastrophic events that may be compounded by cumulative effects from anthropogenic and natural threats. Thus, due to the restricted range and specialized habitat requirements, *E. tiehmii* is vulnerable to current and future threats that affect both the species and its habitat at the individual, subpopulation, and population level.

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