Conservation Research in the Leslie Gulch ACEC
Population monitoring for *Trifolium owyheense* and seed bank dynamics in *Senecio ertterae*

First-year report
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PREFACE

This report is the result of a cooperative Challenge Cost Share project between the Institute for Applied Ecology (IAE) and a federal agency. IAE is a non-profit organization dedicated to natural resource conservation, research, and education. Our aim is to provide a service to public and private agencies and individuals by developing and communicating information on ecosystems, species, and effective management strategies and by conducting research, monitoring, and experiments. IAE offers educational opportunities through 3-4 month internships. Our current activities are concentrated on rare and endangered plants and invasive species.

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Cover photographs: *Trifolium owyheense* (top) and *Senecio ertterae* (bottom) (photos by Steven Gisler).

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INTRODUCTION

Designated as an Area of Critical Environmental Concern (ACEC) in 1983, the Leslie Gulch ACEC contains 11,653 acres of deep, spectacularly eroded canyons in a remote corner of the Owyhee Uplands of Malheur County, Oregon (Figure 1). The ACEC is owned and managed by the Vale District Bureau of Land Management (BLM), which is responsible for protecting the area's unique plant, wildlife, scenic, and recreational values. Resulting from its geographic isolation and exposed volcanic soils, Leslie Gulch provides habitat for a diverse and highly specialized community of native plants, many of which are extremely scarce and known from few or no other places in the world (Grimes 1984). The current two-part project was designed to improve our knowledge and management of two rare and poorly understood Leslie Gulch plant species, *Trifolium owyheense* (Owyhee clover) and *Senecio ertterae* (Ertter's senecio).

Figure 1. Photograph of the Leslie Gulch ACEC.

SPECIES INFORMATION AND STATUS

Trifolium owyheense

Trifolium owyheense (upper cover photo) is a rare member of the pea family (Fabaceae) known only from Leslie Gulch and neighboring uplands in eastern Malheur County and adjacent Idaho. Due to the small number of its extant populations and threats posed by livestock grazing, invasive weeds, off-road vehicles, and potential mineral development, *T. owyheense* has been listed as Endangered by the State of Oregon and a Species of Concern by the U.S. Fish and Wildlife Service.

Trifolium owyheense is a perennial herb with glaucus stems, leaves bearing three leathery leaflets with light-colored chevron patterns (a characteristic shared with many clovers), large flowering heads composed of deep red/pink flowers, stiff involucral bracts, and small spotted fruits (pods) containing 2-3 seeds. *Trifolium owyheense* superficially resembles *T. macrocephalum*, a more common and widespread clover with similarly large and showy inflorescences. However, the latter is readily distinguishable from *T. owyheense* and most other clovers by its leaves, which typically exhibit five to six leaflets rather than three.

Trifolium owyheense is usually found on barren slopes and mounds composed of talus and loose, coarse-grained, crumbly soils derived from rhyolitic ash parent material. Surrounding plant communities are generally dominated by sparse sagebrush, juniper, and bunchgrasses. Direct associates often include: *Agropyron spicatum*, *Astragalus sterilis*, *Bromus tectorum*, *Eriogonum novonudum*, *E. vimineum*, *Mimulus cusickii*, *Phacelia lutea*, *P. hastata*, *Senecio ertterae*, and *Mentzelia packardiae*. Previous research by Gisler and Meinke (ODA 2001) indicates that *T. owyheense* is sexually self-compatible and capable of seed production in the absence of pollinators, though the species attracts numerous bumblebees and other insect visitors.

<u>Senecio ertterae</u>

Senecio ertterae (lower cover photo and Figure 2) is a rare member of the aster family (Asteraceae) endemic to Leslie Gulch and several neighboring side canyons. Sharing the aforementioned threats with *Trifolium owyheense*, *S. ertterae* has been listed as a Species of Concern by the U. S. Fish and Wildlife Service. It was previously listed as Threatened by the State of Oregon, but was subsequently de-listed following designation of ACEC status for Leslie Gulch, a conservation action believed by the Oregon Department of Agriculture to warrant removal of protective status (Kaye 2000).

Senecio ertterae is an herbaceous, tap-rooted annual plant with succulent glaucus leaves and golden yellow flowers, each with 8-10 “petals,” or rays. An extremely late bloomer, *S. ertterae* typically flowers in late August to middle September, well after most other associated species in this arid habitat have completed flowering. Although small individuals often produce fewer than 20 flowers, large plants can exhibit a candelabra branching pattern yielding hundreds of flowering heads (Figure 2). Kaye

Figure 2. Photograph showing ashy *Senecio ertterae* soils and the candelabra branching habit of large individuals.

(1989) estimated average reproductive capacity for this species at 500 seeds/plant. Although the breeding system of this species has not been investigated, its brightly colored flowers attract a wealth of insect visitors, including skippers, sphinx moths, and other lepidopterans, as well as bumblebees, smaller solitary bees (i.e., Halictidae and Megachilidae), bee flies, and syrphid flies.

Senecio ertterae frequently occurs with, or near, *Trifolium owyheense*, and shares the latter species' affinity for dry, sparsely vegetated, ashy talus slopes and crumbly mounds (Figure 2). Associated species are the same as those listed above for *T. owyheense*. According to Kaye (2000), *S. ertterae* may depend on disturbance and erosion for maintenance of suitable open habitat; individuals have been observed on gravel recently disturbed by erosion and run-off, along old cattle trails, and in soil disturbed by road maintenance equipment.

PROJECT DESCRIPTION AND OBJECTIVES

The objective of the current project is to provide Vale District BLM with information needed to make biologically informed management decisions for the Leslie Gulch ACEC and its sensitive botanical resources. Specifically, this two-part project is designed to 1) develop and implement a long-term population monitoring plan for *Trifolium owyheense*, and 2) perform seed bank research for *Senecio ertterae*.

Population monitoring for Trifolium owyheense

Population monitoring will provide much-needed data on baseline demographic conditions and long-term population trends for *T. owyheense*, thereby supplying a useful reference for assessing the status of this rare species (i.e., are populations stable, increasing, or decreasing over time?), measuring the levels and impacts of herbivory, and evaluating effects of habitat changes caused by natural forces and prescribed management actions.

The specific goals of first-year (2004) work for *T. owyheense* are four-fold: 1) re-locate known populations within the ACEC, 2) survey priority areas identified by the Vale District Botanist for new populations, 3) record GPS waypoints at all populations encountered and perform on-site evaluations for monitoring suitability, and 4) utilize habitat and life-history observations to develop a population monitoring plan for the species. Plot set-up and implementation of the monitoring plan is scheduled to commence in spring of 2005.

Seed bank research for Senecio ertterae

Because *Senecio ertterae* is an annual plant, with few or no individuals surviving and reproducing more than one year, the viability and dynamics of its populations depend entirely on the production of seeds and the recruitment of new individuals from a soil seed bank. Therefore, even a basic understanding of this rare species requires an understanding of what happens to its seeds over time. Research into the seed bank dynamics of *S. ertterae* will help advance this understanding by providing information on: annual fluctuations and long-term trends in seed production and seedling recruitment, the size of *S. ertterae*'s soil seed bank, levels of seed viability and germination requirements, the rate of viability decline among seeds remaining buried in the soil over time, and the relative demographic contributions of current-year and past-year seed crops. In short, this research will help us understand population dynamics in this species and predict the response of its populations to climatic conditions, environmental disturbances, and management actions that affect seed production.

The specific goals of first-year (2004) work for *S. ertterae* are to: 1) develop a seed bank research plan, 2) visit known *S. ertterae* populations within the ACEC and select appropriate research sites, 3) set-up research plots, including establishment of seed burial and seed exclosure plots (discussed below), 4) collect first-year seed production data, 5) collect seeds for viability and germination tests in the lab, and 6) collect and process soil samples to estimate seed persistence in the soil seed bank. The research plots set up in 2004 will provide the framework for data collection in 2005 and future years. Seed burial packets will require excavation for a minimum of 4 years, beginning in 2005 (see Methods, below).

METHODS

Population monitoring for Trifolium owyheense

IAE staff performed surveys for *Trifolium owyheense* within the Leslie Gulch ACEC on May 17-20, 2004. At this time lower-elevation populations had already completed flowering and were producing fruits, whereas higher-elevation populations above 5,000 ft. (i.e., Grassy Ridge) still exhibited a few open flowers. Using topographic maps provided by BLM we surveyed approximately 960 acres, resulting in the re-location of 11 previously documented populations and the discovery of 4 additional populations not identified on BLM maps. The survey acreage was distributed among four high priority search areas harboring known populations within the ACEC: Slocum Creek, Lower Leslie Gulch (north of the Slocum Creek parking area), Dago Gulch, and Grassy Ridge. Figure 3 shows a topographic map of all populations visited in 2004, including the 4 newly discovered populations (identified as #s 4, 7, 8, and 12). Figures 4, 5, and 6 show larger scale maps of survey areas and population locations.

Figure 3 is not included in the web-page version of this report.

Figure 4 is not included in the web-page version of this report.

Figure 5 is not included in the web-page version of this report.

Figure 6 is not included in the web-page version of this report.

Once *Trifolium owyheense* populations were located we evaluated their suitability for demographic monitoring. Populations occurring on very fragile, steep, crumbly slopes were generally deemed unsuitable for monitoring since this activity could cause long-lasting damage to the sensitive, highly erodible habitat. Low suitability rankings were also assigned to very small populations, sites with a predominance of exposed bedrock (which would hinder installation of permanent plot marker posts), and sites readily visible from the Leslie Gulch road (which might attract vandalism to monitoring plots).

To facilitate relocation of populations for monitoring in 2005 and later years, we created topographic maps of all sites with labeled access routes from obvious landmarks and prepared narrative directions to each site accompanied by site photographs and decimal degree GPS waypoints (these are presented in Appendix A). Variables considered in the development of monitoring protocols for *T. owyheense* included the distribution and density of plants within populations, the presence of discernable and biologically meaningful life-history stages in the species (i.e., identifiable size/age/reproductive categories), and the ability to distinguish individual plants from one another, especially within large clusters of leaves. To determine the latter and assess the degree of subterranean spread/clonal growth in the species (which could complicate the identification of individuals), we carefully excavated clusters of leaves in several populations to reveal their underground root system(s).

<u>Seed bank research for Senecio ertterae</u>

IAE staff performed surveys, seed collecting, plot set-up, and data collection for *Senecio ertterae* within the Leslie Gulch ACEC on August 30-September 2, 2004. At this time plants were in peak flower, with some immature flowers (approximately 15 percent) still enclosed within buds and only a few flowers (<1 percent) that had developed into mature seed heads. This phenological timing was ideal for the project, insofar that the bright flowers facilitated easy detection of populations and the lack of seed heads allowed us to perform research tasks needing to take place prior to seed dispersal (described below). However, the early stage of floral development slowed our seed collecting efforts considerably due to the paucity of mature seed heads.

Using topographic maps provided by BLM we re-located known *Senecio ertterae* populations and evaluated their suitability for research plot establishment. Two large *S. ertterae* patches were eventually selected as research sites due to their large size, homogeneous habitat, accessibility, and limited visibility from the main Leslie Gulch road; the latter factor was considered important to reduce the potential for plot vandalism. The two research sites are situated on adjacent talus slopes, separated by approximately 100 meters, and are located (*plot location information not included on the web-page version of this report*) (Figure 7). Following selection of the two *S. ertterae* sites, research plots were set up to investigate seed bank dynamics in the species (see Appendix B for plot diagrams and layout information).

The following pages break our seed bank research down into its individual components, each of which addresses a particular stage of seed fate within the *Senecio ertterae* life cycle. See Figure 8 for a diagrammatic representation of our research plan in this biological context.

Figure 7 is not included in the web-page version of this report.

Seed production
Our first task within research plots was to quantify total seed production levels, or the amount of seed bank input, for 2004. Because the two *S. ertterae* patches are so big and densely populated, we estimated seed production using a sub-sampling approach. Sub-sampling was performed by establishing four steel rebar corner posts around each plot and then counting the number of plants and flowers along randomly selected transects. 10 transects were sampled at each site, each measuring 0.5 meters wide and spanning the length of the plot. All plants within 0.5 meters of each transect had their flowers counted. As shown in Appendix B, Plot 1 is 16 m x 16 m, so the 10 transects represent a 32 percent sample of the entire plot. Plot 2 (Appendix B) is 20 m x 10 m, so the 10 transects represent a 50 percent sample of the entire plot. New transects will be randomly sampled every year to provide data on annual seed production levels within each plot. To estimate total seed production within the plots we will multiply the mean number of viable seeds produced by each flowering head (using a random sample of 30 seed heads) by the total number of flowering heads within each plot. Viability tests, described below, will be performed in winter of 2004 to arrive at an estimate of total viable seed production.

Seed viability and germination
Levels of seed viability in *Senecio ertterae* will be determined by subjecting seeds to two kinds of tests, scheduled for implementation in winter of 2004. First, seed viability will be tested using a standard Tz test in the lab, whereby seeds are soaked for 24 hr in a solution of Tetrazolium chloride and then visually inspected for red staining. This staining is indicative of actively respiring seeds, whereas non-stained seeds are not respiring and considered non-viable. Secondly, to determine if results of Tz tests mirror actual seed germinability, we will also test germination in the lab. For these tests, we will use whichever seed germination protocol proves most successful during seed germination trials (see below).

To investigate seed germination requirements in *Senecio ertterae*, we will perform a replicated, factorial experiment whereby seeds will be subjected to 12 germination treatments. These treatments will include 6 levels of cold stratification at 5°C (no cold stratification, and cold stratification for 2, 4, 6, 8 and 12 weeks), combined with two levels of light exposure (light vs. dark). The light treatment will provide seeds with regulated 12 hr photoperiods, whereas the dark treatment will maintain seeds in darkness by wrapping germination trays in aluminum foil. All seeds will be rinsed with a 3 percent hydrogen peroxide solution to inhibit the growth of mold in the germination trays. Germination trials will require a total of 2000 seeds, with each treatment assigned 200 seeds (each seed representing a single experimental replicate). All seeds will be obtained from a mixed, bulk-collected seed sample, collected August 30-September 2, 2004, to remove potential maternal effects from germination data. Results from seed viability tests and germination trials will be reported in the 2005 report.

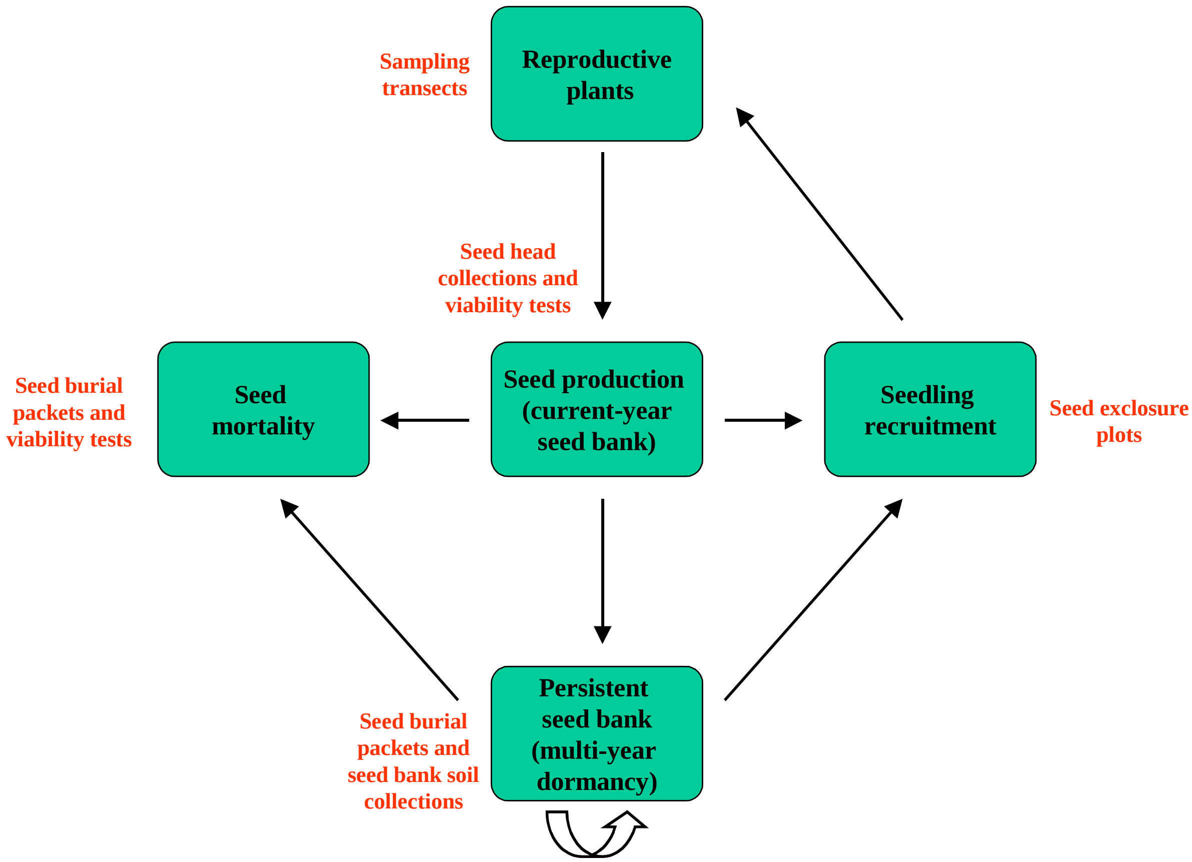

Figure 8. Flow diagram of the *Senecio ertterae* life cycle, and the research activities (in red) being conducted to measure the fate of seeds at each stage.

Seed bank size
Fundamental to understanding seed bank dynamics is a knowledge of the actual size of the soil seed bank, including the portion of the seed bank that persists and remains viable for multiple-years. This is the fraction of the seed bank that will restore populations if current-year seed crops fail due to grazing, unfavorable climate, pests and diseases, or other factors. To investigate this, we collected 30 soil core samples from each of the two research plots. Three soil samples were randomly collected and pooled from each of the 10 transects used for seed production sub-sampling at each plot. Soil samples were collected by inserting a cylindrical metal bulb planter approximately 10 cm into the soil (Figure 9), sliding a trowel underneath the planter opening to trap the core sample inside, and then transferring the sample from the planter into sealed plastic bags. These soil samples were returned to the lab where we propose to separate *S. ertterae* seeds using sieves to filter larger and finer soil particles, followed by a floating procedure to separate light organic material from heavier mineral content. This kind of intensive screening will be necessary because *Senecio ertterae* seeds are very small and grey, rendering them extremely difficult to distinguish from other small, grey, ash and soil particles. Once we measure the viable seed content from the known volume of soil samples, we will then be able to estimate the size of the persistent seed bank for the entire research plot.


Figure 9. Photograph showing collection of soil core samples within *S. ertterae* research plots.

Recruitment from the persistent seed bank
In addition to knowing the size of the persistent soil seed bank, discussed above, it is also important to understand how much seedling recruitment results from the persistent soil seed bank, in contrast to recruitment resulting from the current year's seed crop. In other words, we want to find out and contrast how many plants in a population come from the seeds of last year's generation and how many come from seeds of ancestral generations that have persisted more than one year in the soil. Along with seed bank size measurements, discussed above, this information will help predict the resiliency of populations to disturbances and climatic conditions that might reduce or eliminate seed production for one or more years.

To address this issue we established plots that exclude all current-year seeds, so any seedling recruitment the following year will be attributable to seeds from past generations retained within the persistent seed bank. Meanwhile, the difference in recruitment within and outside seed exclosure plots provides an estimate of seedling recruitment from current-year seeds. As such, the seed exclosure plots answer two questions at the same time. To create these seed exclusion plots we randomly selected one location along each of the 10 population sub-sampling transects (described above) at each site, and at each location we pinned down a 0.5 m x 0.5 m square of lightweight insect barrier fabric (Figure 10). This durable, UV-resistant fabric is permeable to air and water, but does not allow seeds through its tightly woven polyethylene mesh. It is hoped these fabric seed exclosure plots, with their bright white color, will survive potential disturbance from deer and human visitors to the area. If these seed exclosure plots prove successful, new plots should be established every year to obtain annual data on seedling recruitment from the persistent seed bank. The difference between seedling recruitment within and without seed exclusion plots provides an estimate of the fraction of population recruitment gained from the First-year data from these plots will be available in spring of 2005.

Figure 10. Photograph showing seed exclusion fabric placed within *S. ertterae* research plots.

Seed longevity in the seed bank

The final research task we are performing at the *Senecio ertterae* research plots is to investigate the longevity of seeds buried in the soil. This information is important because it can help us understand how long seeds persist in seed banks and how well populations might rebound from prolonged periods of drought, grazing, or other factors that reduce or eliminate seed production for multiple years. In such cases, population rebound will hinge on recruitment from a persistent seed bank. To address this question, we placed *S. ertterae* seeds into packets and buried them in the soil at each research plot (Figure 11) (see Appendix B for packet burial locations at each plot). Packets were constructed from the same permeable synthetic fabric that was used for seed exclusion plots, thus allowing seeds to experience normal environmental fluctuations in temperature, humidity, soil moisture, fungal pathogens, etc. Seed packets (75 seeds per packet) are buried in groups of 4 at 15 locations within the research plots. Each of the 15 locations is marked by a steel rebar post. One packet from each of the 15 groups will be excavated and subjected to seed viability tests each year for four years (or perhaps some combination of alternating years, depending upon initial results), beginning in 2005. As such, each year of seed packet excavation will provide 15 replicates of seed viability data. Viability tests will be performed using Tz or germination trials, as described above.

Figure 11. Photograph showing *S. ertterae* seed burial packets.

RESULTS AND DISCUSSION

Population monitoring for Trifolium owyheense

After visiting and evaluating 15 *Trifolium owyheense* populations within the Leslie Gulch ACEC, we determined that 6 populations were best suited for establishment of permanent monitoring plots. The remaining 9 populations occur on extremely fragile, steep, crumbly substrates and would probably suffer long-term damage from annual monitoring activities. Some of these populations also had a high occurrence of exposed bedrock that would hinder plot construction. The following populations (corresponding to site identification numbers in Figures 3-6 and Appendix A) are recommended for monitoring within the Leslie Gulch ACEC: #1, #2, #5, #6, #9, and #14. These monitoring sites span a variety of population sizes, substrate types, aspects, elevations, herbivory pressures, and geographic areas. As such, they provide a wide representation of environmental amplitude within the ACEC. Descriptions of individual monitoring sites, along with mapped access routes and site photographs, are provided in Appendix A.

Observations made during *Trifolium owyheense* site visits indicate several important biological factors influencing the design of demographic monitoring protocols. First, although the number of flowering individuals within *T. owyheense* populations is often not great, population sizes frequently become enormous when non-flowering plants are also taken into account. For example, several populations contained tens of thousands (and in one case *hundreds* of thousands) of leaves in 2004. Because the large size of these populations renders complete censusing of plants impractical, a sub-sampling approach is recommended whereby narrow (0.25-0.5m-wide), linear transects are randomly established across occupied habitat to monitor each population. The number and length of transects at each site will vary depending on site-specific habitat constraints and the amount of population variability. Especially within large populations, first-year (2005) pilot data may be needed to calculate sampling errors and refine sampling procedures. Transect locations at each site will be marked with steel rebar posts and numbered metal tags to facilitate accurate plot re-location and consistent sampling between years.

Another important factor influencing the design of monitoring protocols for *T. owyheense* is the ability to distinguish individual plants. For species occurring as recognizably discrete individuals it is possible to map and/or mark individual plants and follow their fates (i.e., recruitment, growth, reproduction, dormancy, and death) over time. However, our observations show this individualistic monitoring approach will not be appropriate, or possible, for *T. owyheense* because it often occurs as carpets of low-growing leaves with indecipherable numbers of individuals (Figure 12). Because the underground connections of these leaves are obscured by soil, there is no way to know which leaves correspond to which individuals, nor how many individuals are present. For instance, at several populations we excavated what we thought were single individuals, only to find that they were in fact comprised of several taprooted individuals with variable numbers of leaves (Figure 13). As such, there is no way to predict how many individuals comprise leaf clusters, much less entire populations. To avoid the problems posed by this constraint, it is recommended that leaf and inflorescence counts be used as the units for population monitoring, rather than numbers of individuals *per se*. IAE has employed this same counting approach to monitor populations of the endangered Kincaid's lupine (*Lupinus sulphureus* ssp. *kincaidii*) in the Willamette Valley, which has a rhizomatous/asexual growth habit that similarly prevents reliable distinction of individual plants. If needed, the number of individuals present within populations could be estimated on an annual (or less frequent) basis by excavating a random subsample of leaf clusters and counting the number of corresponding taproots. Then, the total number of leaves in the population (estimated using sampling transects) could be multiplied by this sub-sampled root : leaf ratio to arrive at an estimate of total individuals present in the population.

Figure 12. Photograph showing dense carpets of *T. owyheense* leaves.

Figure 13. Closely spaced *T. owyheense* leaves often arise from separate taproots, rendering distinction of individuals impossible based solely on above-ground observations.

The difficulty in recognizing individual plants has repercussions on another facet of demographic monitoring, the definition of biologically meaningful life history categories. Because individual plants usually cannot be distinguished and counted using above-ground parts (i.e., leaves and stems), it is consequently impossible to collect data on size and/or age-based attributes that correspond with individuals. As such, the only reliable unit of data is restricted to the number of leaves and flowering heads. However, it is possible to divide leaves and flowering stems into grazed and non-grazed subcategories to assess levels of herbivory.

Herbivory takes place at many *Trifolium owyheense* populations within the ACEC, evidenced by a high frequency of stem clipping. Based upon circumstantial fecal evidence, this herbivory appears attributable to rabbits, deer, horses, and cows (Figures 14 and 15).

Figure 14. Photograph showing *T. owyheense* leaves emerging through horse feces.

Figure 15. Photograph showing grazed *T. owyheense* stem (indicated by red arrow) growing through deer feces.

Given the potentially profound impact of herbivory on flowering and sexual reproduction, it is recommended that population monitoring be accompanied by a herbivory study. Here, a random subset of locations along demographic monitoring transects could be covered with small (0.5 m x 0.5 m) wire mesh herbivory exclosure cages. Comparisons of leaf and inflorescence counts within and outside cages would then provide useful data on the impacts of grazing on fecundity and recruitment.

Senecio ertterae

Seed production

Randomly sampled *Senecio ertterae* seed heads yielded a mean 43.6 (SE 1.6) seeds per head in 2004, of which a mean 31.9 (SE 2.0) appeared plump and viable. Remaining seeds were shriveled and assumed to represent either aborted seeds or unfertilized ovules. Based upon these data, we can estimate the total number of filled (containing embryos) seeds produced by the *Senecio ertterae* populations encompassed within the two research plots established in 2004. Using the sub-sampling procedure described in Methods, above, Plot 1 contained an estimated 53,590.4 (SE 182.8) flowers among an estimated 4,716.9 (SE 44.06) individuals, resulting in an estimated 1,709,533.8 filled seeds for the entire plot. Plot 2 contained an estimated 81,212 (SE 322.0) flowers among an estimated 1,474 (SE 9.35) individuals, resulting in an estimated 2,590,662.8 (SE) filled seeds for the entire plot. Once actual seed viability levels are determined through testing in the lab (see Methods, above), we will be able to estimate the total input of viable, rather than simply filled, seeds into the seed bank in 2004. Plot sampling scheduled for 2005 and later years will allow us to identify the magnitude of variability, and any trends, in seed production over time.

Seed viability and germination

Seed viability tests and germination trials (see Methods, above) will be performed in winter of 2004. Forthcoming results of this research will be documented in the 2005 report.

Seed bank size

Separation and counting of *Senecio ertterae* seeds from soil samples (see Methods, above) will take place in winter of 2004. Forthcoming results of this research will be documented in the 2005 report.

Recruitment from the seed bank

Data from seedling recruitment plots established in 2004 (see Methods, above) will not be available until spring of 2005. First-year results will be documented in the 2005 report.

Seed longevity in the seed bank

Seed viability data from seed bags buried in 2004 (see Methods, above) will not be available until summer of 2005. First-year results will be documented in the 2005 report.

SUMMARY AND CONCLUSIONS

Population monitoring for Trifolium owyheense

Habitat surveys conducted in 2004 resulted in the re-location of 11 known *T. owyheense* populations and the discovery of 4 new populations. After evaluating these populations, six were selected as suitable locations for establishment of monitoring plots in 2005. Most populations are very large, due to prolific non-flowering plants (often forming dense carpets of leaves), so random transects will be established to sub-sample and monitor the populations. We excavated *T. owyheense* root systems at several populations, demonstrating that the species is taprooted, and that the number of individual plants in an area cannot be accurately predicted by observation of above-ground leaves and stems, even among small leaf clusters. Given this constraint, monitoring will rely on leaf and inflorescence counts rather counts of individual plants. If needed, a sub-sample of individuals can be excavated at each population to estimate numbers of individuals based upon leaf counts. Herbivory is evident at most *T. owyheense* populations; based upon fecal evidence around grazed plants, this may be caused by a mixture of deer, rabbits, horses, and cows. A herbivory study using small (0.5 x 0.5 m), randomly placed exclosures is recommended to accompany the monitoring project. Set-up of monitoring plots and collection of first-year data will commence in spring of 2005. Continued monitoring will eventually provide insight into long-term population trends and help track the response of populations to natural and prescribed habitat alterations.

Seed bank research for Senecio ertterae

Two *Senecio ertterae* research plots were established for the seed bank study. Permanent corner posts were installed and sampling transects were used to estimate population size, flower production, and seed set. Soil samples were collected to quantify seed persistence in the soil, and fabric seed exclosure plots were established to determine (in 2005) the relative contributions of current-year and past-year seed crops to population recruitment. Fabric seed packets were also buried within research plots to investigate seed longevity in the soil. Excavation of these packets will begin in 2005 and take place annually for at least 4 years. Lastly, seeds were collected and returned to the lab to carry out seed viability tests and germination trials, with forthcoming results to be reported in next year's 2005 report. As seed collecting and plot monitoring continues in future years we will begin to understand the population dynamics of this rare species and predict its response to natural forces and prescribed management actions that influence population size and seed production.

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Appendices of population locations and plot layout diagrams are not included in the web-page version of this report.