Species Status Assessment Report for

Canelo Hills ladies' tresses
Spiranthes delitescens

Photo by Andrew Salywon, Desert Botanical Garden, July 2016, with permission

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This document is dedicated to the memory of Ronald A. Coleman, lifelong botanist and author of books on Arizona, California, and New Mexico orchids. Ron's contributions to our understanding of Spiranthes delitescens *include documented site visits over many decades. Ron will be missed by the botanical community.*

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EXECUTIVE SUMMARY

This species status assessment (SSA) reports the results of comprehensive status review for Canelo Hills ladies' tresses (*Spiranthes delitescens*; CHLT) through an analytical approach assessing the species needs, current status, and future status of a species using the best available information, and provides a thorough account of the species' overall viability. For the purpose of this assessment, we generally define viability as the ability of CHLT to sustain populations in natural systems over time. The SSA Framework uses the conservation biology principles of resiliency, redundancy, and representation (collectively known as the "3Rs") as a lens to evaluate the current and future condition of the species.

Canelo Hills ladies' tresses is a member of the Orchidaceae, or orchid family. The species occurs in ciénega habitats where soils are finely grained, highly organic, and seasonally or perennially saturated, yet scouring floods are uncommon. The species is known to have historically occurred in four separate populations in southern Arizona that are located on the Babocomari Ranch (Babocomari), Canelo Hills Preserve subpopulation plus the Forest Service subpopulation (collectively, Canelo Hills), San Rafael Ranch (San Rafael Valley), and a private ranch at Turkey Creek (Turkey Creek). Canelo Hills ladies' tresses plants were last seen at the Canelo Hills Population when five individuals were found in 2002, at the Turkey Creek Population in 2019 when three individuals were found, at the San Rafael Valley Population in 2006 when CHLT plants were reported as present, and at the Babocomari Population in 2008 when CHLT plants were reported as present.

Canelo Hills ladies' tresses needs multiple resilient populations. Resilient populations are those able to withstand stochastic events arising from spatially and temporally random factors, and that are distributed widely across its range, to maintain its persistence into the future and to avoid extinction. Several factors influence the resiliency of a population in response to stochastic events. These factors are:

- Abundance – populations large enough that local stochastic events do not eliminate all individuals, allowing the overall population to recover from any one event
- Subpopulations – multiple subpopulations per population so that local stochastic events do not eliminate the entire population
- Recruitment – the number of seedlings exceeds the number of dead or dying individuals
- Mycorrhizal symbiont – required for germination, seedling survival, and root survival
- Saturated organic soils in ciénegas – seasonally or perennially saturated soils for seedling development, growth, and flowering
- Groundwater and winter precipitation – winter precipitation for aquifer recharge, creation of flowing rivulets, and mobilization of accumulated litter to expose bare soil

- Summer precipitation – summer precipitation for plant growth from low severity storm events that do not initiate flooding
- Light to moderate disturbance and competition reduction – sufficient to maintain full sun
- Presence of pollinators – sufficient to ensure seed production, as the species does not reproduce vegetatively

To assess the population resiliency levels for the current condition, we used all but the population and habitat factors of recruitment, mycorrhizae symbiont, and presence of pollinators because we have no information on the abundance of these factors in any of the four populations. We also used only the winter precipitation for current condition because winter precipitation is essential for ciénega recharge and therefore essential for CHLT habitat. We assessed both summer and winter precipitation changes in future scenarios as we anticipate summer drought and increased flooding potential to also impact individual CHLT in future scenarios. For each of the seven population and habitat factors, we developed condition categories (High, Moderate, Low, and Functionally Extirpated) to assess the condition of each factor for each population, in order to determine overall population resiliency. Tables ES-1 and ES-2 provide our assessment of the current and future conditions of CHLT populations. To assess current condition of the species, we also considered representation and redundancy. Representation is the ability to adapt to changing environmental conditions as measured by the breadth of genetic or environmental diversity within and among populations. Redundancy is the ability of a species to withstand catastrophic events, measured by the number of populations, their resiliency, and their distribution and connectivity. Genetic analysis of this species has not been conducted within or among populations. However, populations are separated by distances of 2.5 kilometers (km) to 20.6 km (1.6 to 12.8 miles [mi]) apart, making cross-pollination highly unlikely outside of the Canelo Hills and Turkey Creek Populations. Currently, we know of 4 populations, all within a 31.7 km by 3 km (19.7 by 1.9 mi) area of Santa Cruz and Cochise Counties, Arizona.

To evaluate the biological status of the CHLT into the future, we assessed a range of conditions over 25 and 50 years to allow us to consider the species' resiliency, redundancy, and representation. Our analysis of the past, current, and future influences on what CHLT needs for long-term viability revealed that there are a number of threats to this species. Threats that play a large role in the future viability of CHLT include:

1) Loss or Reduction of Ciénega Habitat – historical intensive grazing of domestic stock, historical removal of beaver from regional streams and rivers, agricultural re-contouring and aquifer depletion, drought and climate change, evapotranspiration, and alteration of fire regimes, including native woody species and nonnative invasion have historically reduced, and in some instances, continue to reduce CHLT habitat and stress CHLT individuals.
2) Pollinator Decline – the primary pollinator of CHLT is a bee considered to be in serious decline; this has the potential to impact reproduction and genetic variability.
3) Herbivory – while grazing outside of the flowering and fruiting season can be beneficial to the species, herbivory or predation by vertebrates and invertebrates during the flowering and fruiting season can reduce reproduction and genetic diversity.
4) Small Population Size and Lack of Connectivity / Individual Effects - Small populations are less able to recover from losses caused by random environmental changes. Individual effects such as herbivory, predation, or illegal collection can have large population-level

impacts on all four populations, as each are believed to currently contain fewer than 50 individuals.

If populations lose resiliency, they are more vulnerable to extirpation, with resulting losses in representation and redundancy. Given our uncertainty regarding the future of available water within populations, we have forecasted CHLT population condition in terms of resiliency, redundancy, and representation under four future plausible scenarios (Table ES–1 and 2).

Under scenario 1 – Continuation – We would expect the viability of CHLT to be characterized by a loss of resiliency, representation, and redundancy at the level that is currently occurring. At the 25-year time step, no populations would be in High or Moderate condition and four populations (100 percent) would be in Low condition and more susceptible to loss. Within Scenario 1 we assume impacts from drought, climate change, and other threats continue as in the near past. Seed is collected for conservation purposes. We think this is highly likely to occur within the 25-year time step with decreasing likelihood at future time steps. This expectation is based on climate change projections portraying emissions increases, resulting in increased impacts to the species. At the 50-year time step, all four populations remain in Low condition, but all threats increase slightly, thus reducing total scores within the Low category. We feel the continuation of this scenario in the near term is highly likely, but is reduced to somewhat likely in the longer term, as threats increase.

Under scenario 2 – Conservation – We would expect the viability of CHLT to be characterized by higher levels of resiliency, representation, and redundancy than it exhibits under the current condition. With the great increase in conservation measures aimed at restoring CHLT and its wetland habitat, at the 25 and 50-year time steps, three populations increase in condition to Moderate condition and one population increases to High condition. Within Scenario 2, the following risks are reduced greatly: water withdrawal, wildfire, flooding, illegal collection, trampling, herbivory, and predation. Climate change and drought continue at current levels and do not get worse due to carbon emissions reductions globally. Conservation measures are also completed to reduce risks, including: sites are monitored with additional plants located, sites are augmented, or new sites are established; seeds and mycorrhizae are preserved; upland forests are thinned; and land restoration occurs to improve or remove diversions and headcuts; nonnative competitors are controlled and native communities enhanced, invading upland woody plants are removed, and water conservation actions and conservation easements are put into place, etc. In addition, at the Canelo Hills Population, regular light to moderate disturbance is reintroduced. Because climate change impacts are projected to increase and it will take a concerted effort to realize these conservation measures, we think this Scenario is unlikely in the near term, but somewhat likely in the long term.

Under scenario 3 – Moderate Increase in Effects – We would expect the viability of CHLT to be characterized by lower levels of resiliency, representation, and redundancy than it has in the Continuation scenario. At both the 25 and 50-year time steps, no populations would be in High or Moderate condition. At the 25-year time step, three populations remain in Low condition and one becomes functionally extirpated. At the 50-year time step, two populations (50 percent) would be in Low condition, and two populations (50 percent) would be functionally extirpated. Within Scenario 3, we assume increased confidence in climate change impacts based on IPCC projections, in which they state high confidence in emissions scenario RCP4.5 being exceeded. Under this scenario, water flow reduction due to groundwater withdrawal, woody plant invasion, evapotranspiration, and drought continues to reduce ciénega habitat for this species. Risk of catastrophic wildfire is high due to dry conditions, invasion of nonnatives in the uplands, and increased risk of fire starts from illegal activity, recreation, and natural causes. Illegal collection, trampling, herbivory, predation, and other impacts continue at current or increased levels. Light to moderate disturbance is not returned to the Canelo Hills Population. Based on IPCC's and viticulture increase projections, we think that in the short term this scenario is somewhat likely and in the long term, this is moderately likely.

Under scenario 4 – Major Increase in Effects – We would expect the viability of CHLT to be characterized by lower levels of resiliency, representation, and redundancy than under the Moderate Increase in Effects scenario. At both the 25 and 50-year time steps, no populations would be in High or Moderate condition, one population (25 percent) would be in Low condition, and three (75 percent) would be functionally extirpated. Water flow reduction due to groundwater withdrawal, woody plant invasion, and drought increases further, continuing to reduce ciénega habitat for this species. Risk of catastrophic wildfire is high due to dry conditions, invasion of nonnatives in the uplands, and increased risk of fire starts from illegal activity, recreation, and natural causes. Illegal collection, trampling, herbivory, predation, and other impacts also continue at current or increased levels. Light to moderate disturbance is not returned to the Canelo Hills Population. For Scenario 4, the IPCC confidence is low that emissions scenario RCP8.5 will occur, therefore the likelihood of Scenario 4 occurring is somewhat likely in the short term and moderately likely in the long term. However, the IPCC is confident that the emissions will fall within the RCP4.5 and RCP8.5 range.

Table ES-1. Summary results of Canelo Hills ladies' tresses (*Spiranthes delitescens*) population condition classes forecasted from four future scenarios at the 25 and 50-year time steps.

	High	**Moderate**	**Low**	**Functionally Extirpated**
Current	0	2	2	0
25-year	-	-	-	-
Scenario 1 - Continuing	0	0	4	0
Scenario 2 - Conservation	1	3	0	0
Scenario 3 - Moderate Increase in Effects	0	0	3	1
Scenario 4 - Major Increase in Effects	0	0	1	3
50-year	-	-	-	-
Scenario 1 - Continuing	0	0	4	0
Scenario 2 - Conservation	1	3	0	0
Scenario 3 - Moderate Increase in Effects	0	0	2	2
Scenario 4 - Major Increase in Effects	0	0	1	3

While we have data to inform us of the threats that are likely to impact CHLT populations in the future, and we understand how the these threats can impact CHLT, there is uncertainty regarding the exact risk of the threats to each population because of limitations of the data, such as where and when each threat will occur in the future and exactly which populations will be impacted.

Consequently, we made the following assumptions about threats to the ciénegas supporting populations:

- All four populations have equal likelihood of continued drought, including decreased winter precipitation;
- Each of the four populations are equally likely to be impacted by cross border violators (e.g., wildfire starts) due to all populations being within 34 km of the U.S.-Mexico border.
- Nonnative and native invasive plants that can outcompete CHLT are equally likely to occur at all four populations, however dogbane (*Apocynum cannabinum*) is currently known only from the Canelo Hills Population;
- Because fires have occurred in proximity to all four populations within the past decade, we assume all of the populations have an equal chance of fire from lightning ignition, nonnative fuels, recreation, or cross border violator presence;

We examined the resiliency, representation, and redundancy of CHLT under each of four plausible scenarios (Table ES–2). The time step for each scenario was based on its likelihood of occurrence. Resiliency of CHLT populations depends on future availability of mycorrhizal symbionts (though this factor was not analyzed due to lack of information), saturated organic soils in ciénegas, groundwater and winter precipitation, summer precipitation, light to moderate disturbance, and presence of pollinators (though this factor was not analyzed, again, due to lack of information). We expect the four CHLT populations to experience changes to these aspects of their habitat in different ways under the different scenarios. We projected the likelihood of each scenario based on the events that would occur under each scenario (Table ES–3). Table ES–4 provides our understanding of the needs of populations and the species, as well as the assessment of the current and future conditions of CHLT populations.

Table ES-2. Canelo Hills ladies' tresses (*Spiranthes delitescens*) population condition classes and scores forecasted under each scenario at 25 and 50-year time steps. FE = functionally extirpated.

Population	**Continuation - 25 years**	**Continuation - 50 years**	**Conservation – 25 years**	**Moderate Increase - 25 years**	**Moderate Increase - 50 years**	**Major Increase 25 - years**	**Major Increase - 50 years**
Babocomari	Low (0.85)	Low (0.75)	Moderate (2.05)	Low (0.6)	Low (0.5)	FE (0.4)	FE (0.35)
Canelo Hills	Low (0.6)	Low (0.5)	Moderate (1.85)	FE (0.35)	FE (0.25)	FE (0.15)	FE (0.05)
San Rafael Valley	Low (0.8)	Low (0.7)	Moderate (1.95)	Low (0.55)	FE (0.45)	FE (0.35)	FE (0.25)

Population	Continuation - 25 years	Continuation - 50 years	Conservation – 25 years	Moderate Increase - 25 years	Moderate Increase - 50 years	Major Increase 25 - years	Major Increase - 50 years
Turkey Creek	Low (1.4)	Low (1.3)	High (2.55)	Low (1.15)	Low (1.05)	Low (0.95)	Low (0.85)

Table ES–3. Highly likely = we are greater than 90 percent sure that this scenario will occur; Moderately likely = we are 70–90 percent sure that this scenario will occur; Somewhat likely = we are 50–70 percent sure that this scenario will occur; Unlikely= we are less than 50 percent sure that this scenario will occur.

Likelihood of Scenario Occurring	Current Condition	Scenario 1 – Continuation	Scenario 2 – Conservation	Scenario 3 – Moderate increase in effects	Scenario 4 – Major increase in effects
25 years	n/a	Highly likely	Unlikely	Somewhat likely	Somewhat likely
50 years	n/a	Somewhat likely	Somewhat likely	Moderately likely	Moderately likely

Table ES-4. Species Status Assessment summary for Canelo Hills ladies' tresses (*Spiranthes delitescens*).

3Rs	Needs	Current Condition	Future Condition (Viability) Projections based on future scenarios in 25 and 50 years:

Resiliency: Population (Large populations or habitat with good condition able to withstand stochastic events)	• High abundance populations.
	• Multiple subpopulations within each population.
	• Multiple groupings within subpopulations.
	• Recruitment exceeding mortality.
	• Mycorrhizal symbionts.
	• Saturated organic soils in ciénega.
	• Groundwater and winter precipitation.
		• 4 populations thought to be extant within 4 southern AZ ciénegas.
		• 3 of the 4 populations with no recent above ground sightings, but presumed extant (underground or undetectable aboveground) with small numbers.
		• Population status:
		  • 0 high resiliency
		  • 2 moderate resiliency
		  • 2 low resiliency
			In each scenario, all populations likely will lose some individuals to a variety of threats including groundwater withdrawal, drought, and wildfire.
			• At both the 25 and 50-year time step there are 4 populations (100 percent) in Low condition. Populations at the 50-year time step are slightly less resilient than those same populations at the 25-year time step.

3Rs	Needs	Current Condition	Future Condition (Viability) Projections based on future scenarios in 25 and 50 years:
	• Light to moderate disturbance. • Summer precipitation. • Presence of pollinators.		
Representation: Species (Genetic and ecological diversity to maintain adaptive potential)	• Genetic variation within and between populations important to maintain adaptive potential. • Distribution of populations such that the range of environmental conditions is represented.	• Total of 4 populations. • Genetic variation within and between populations is unknown though presumed low due to similarity of habitat, including elevation range.	• Losses in individuals. • Reduced genetic diversity due to contraction in size of populations and loss of unique alleles. • Reduced genetic diversity due to functional extirpations of multiple populations in the future.
Redundancy: Species (Number, distribution, and connectivity of populations to withstand catastrophic events)	• A large number of populations distributed across the range of the species.	• Historically 4 populations in 4 ciénegas. • Currently 4 populations in 4 ciénegas. • Ciénegas isolated; 2.5 km to 20.6 km (1.6 to 12.8 mi) apart. • 3 of 4 populations not located above ground in a decade or more. • 1 population with 2 subpopulations. • 3 populations with 1 subpopulation. • Ciénega size ranges from 7 ha (17 ac) to 61 ha (151 ac). • Total Ciénega area 97 ha (240 ac).	• Subpopulations lost. • Populations functionally extirpated. • Populations become more isolated due to functional extirpation.

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CHAPTER 1. INTRODUCTION

Canelo Hills ladies' tresses (*Spiranthes delitescens* Sheviak; herein CHLT) is a member of the Orchidaceae or orchid family. The species occurs in ciénega habitats in southern Arizona where soils are finely grained, highly organic, and seasonally or perennially saturated, yet scouring floods are uncommon (Harlow 2015, p. 18; Hendrickson and Minckley 1984, pp. 133, 162). Canelo Hills ladies' tresses has a limited distribution and is known to have historically occurred in four separate populations in Santa Cruz and Cochise Counties that are located on the Babocomari Ranch (Babocomari), Canelo Hills Preserve subpopulation plus the Forest Service subpopulation (collectively, Canelo Hills), San Rafael Ranch (San Rafael Valley), and a private ranch at Turkey Creek (Turkey Creek).

On January 6, 1997, the U.S. Fish and Wildlife Service (USFWS) listed CHLT as an endangered species under the Endangered Species Act of 1973, as amended (Act) as a result of ciénega degradation and loss, collection of plants, competition with nonnative species, and vulnerability to catastrophic environmental events (62 FR 665). Due to the threat of collection, critical habitat was not designated for this species as the publication of critical habitat descriptions and maps would make CHLT more vulnerable to collection and increase enforcement problems. The recovery priority number for CHLT is 2c, meaning it is a full species with a high degree of threat.

1.1 Species Status Assessment Framework

The Species Status Assessment (SSA) framework (USFWS 2015, entire) is an analytical tool used to provide an in-depth review of a species' biology and threats, evaluate its biological status, and assess the resources and conditions needed to maintain long-term viability (ability of a species to sustain populations in natural systems over time). Using the SSA framework (Figure 1.1), we consider what a species needs to maintain viability by characterizing its status in terms of resiliency, redundancy, and representation (Wolf *et al*. 2015, entire). The result is an SSA report that characterizes the species' viability based on the best scientific understanding of current and future abundance and distribution within the species' ecological settings. The intent is for the SSA report to be easily updated as new information becomes available and to support all functions of the USFWS' Endangered Species Program from candidate assessment, to listing, to consultations, to recovery. As such, the SSA report will be a living document upon which other documents, such as listing rules, recovery plans, and 5–year status reviews, are based.

Based upon the best available information, this SSA report for CHLT provides a thorough review of the biology and natural history, demographic risks, threats, limiting factors, and conservation measures in the context of determining the viability of the species. The information contained in this SSA report will provide the basis for a recovery strategy and support the development of a streamlined recovery plan that complies with the Service's Recovery Planning and Implementation Guide (2016). For the purposes of this SSA, we are analyzing impacts to known CHLT populations, which we define as individual plants occurring within the same watercourse (i.e., ciénega) and within the distance pollinators can travel.

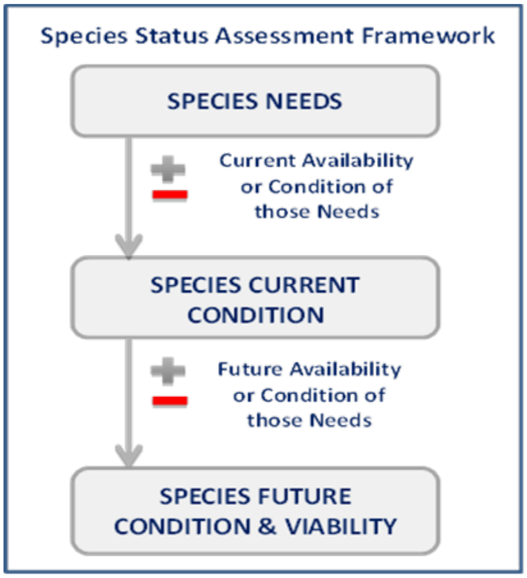


Figure 1.1. Species Status Assessment framework.

- **Resiliency** describes the ability of populations to withstand stochastic events (arising from random factors). We can measure resiliency based on metrics of population health; for example, germination versus death rates and population size. Highly resilient populations are better able to withstand disturbances such as random fluctuations in germination rates (demographic stochasticity), variations in rainfall (environmental stochasticity), or the impacts of anthropogenic activities.

- **Representation** describes the ability of a species to adapt to changing environmental conditions. Representation can be measured by the breadth of genetic or environmental diversity within and among populations and gauges the probability that a species is capable of adapting to environmental changes. The more representation, or diversity, a species has, the more it is capable of adapting to changes (natural or human caused) in its environment. In the absence of species-specific genetic and ecological diversity information, we evaluate representation based on the extent and variability of habitat characteristics across the geographical range.

- **Redundancy** describes the ability of a species to withstand catastrophic events. Measured by the number of populations, their resiliency, and their distribution (and connectivity), redundancy gauges the probability that the species has a margin of safety to withstand or can bounce back from catastrophic events (such as a rare destructive natural event or episode involving many populations; for example, wildfire or flooding).

The format for this SSA report includes: (1) the life history, biology, and resource needs of individuals (Chapter 2); (2) The historical and current distribution of CHLT, and population and species needs (Chapter 3); (3) threats that affect the species' viability (Chapter 4); (4) current condition of the species, including descriptions of each population, and a framework for determining the distribution of resilient populations across its range (Chapter 5); and (5) a description of species viability in terms of resiliency, redundancy, and representation (Chapter 6).

CHAPTER 2. INDIVIDUAL NEEDS – LIFE HISTORY AND BIOLOGY

In this chapter we provide the species' basic biological information including taxonomic history, genetics, morphological description, and known life history traits. We then outline the resource needs of CHLT individuals. Here we report those aspects of the life history of CHLT that are important to our analysis in determining the viability of the species using resiliency, representation, and redundancy.

2.1 Taxonomy and Genetic Diversity

Canelo Hills ladies' tresses was first presumed to be *Spiranthes graminea* (no common name), a flowering plant of the orchid family (Orchidaceae) previously known from Mexico (Sheviak 1990, pp. 213-214). Through study of herbarium specimens and live plants both in the field and under cultivation, the plants located in Arizona were determined to be a distinct species and as a result described and named *S. delitescens*, due to unique morphological and cytological characteristics (Sheviak 1990, p. 214). For example, the pubescence (fine layer of hair) of CHLT is unusual, with trichomes (hairs) tapering toward the apices (Sheviak 1990, p. 218). In addition, CHLT chromosome number was determined to be 2n=74, hence it appears to be an amphiploid (a plant originating from hybridization) between unknown species of n = 15 and n = 22 lineages. The evolutionary distinctness of the species was confirmed with DNA sequence data in 2007 (Dueck and Cameron 2007, p. 194) and the most recent taxonomic key to distinguish it from other species in the genus can be found in Sheviak and Brown (2019, p. 544).

2.2 Morphology

Canelo Hills ladies' tresses is an erect, slender, orchid with linear-lanceolate (narrow, tapering to a point), grass-like leaves growing both basally (at the base of the plant) and on the stem (Figure 2.1). Leaves are up to 18 centimeters (cm; 7.09 inches [in]) long by 1.5 cm (0.59 in) wide, being gradually reduced upward to sheathing bracts (leaves below flowers) 9 to 17 millimeters (mm; 0.35 in to 0.67 in) long (Sheviak 1990, p. 216). Roots are tuberously thickened (fleshy oblong or rounded thickening), about 5 mm (0.2 in) in diameter (Sheviak 1990, p. 216). The flower stalk ranges in height from 24 to 47.5 cm with white flowers arranged in a spiral, with 3 flowers per cycle of spiral at the top of the spike (Sheviak 1990, p. 216; Figure 2.2). Flowers are characterized by a pronounced ventrally-directed curve such that, in lateral view, the base appears ascending but the apex is horizontal or somewhat nodding, hence distinguishing the species from Ute ladies' tresses (*S. diluvialis*, *S. graminea*, and *S. nebulorum* (no common name; Sheviak 1990, p. 217). The flowering period for this species is from July to early August during the monsoon rainy season.

Canelo Hills ladies' tresses is a geophyte (plants whose nutrient storage structures occur belowground). Many geophytes have the ability to go dormant for multiple years, so long as the metabolic needs of the plants are met during this time (Reintal *et al*. 2010, p. 116). When plants are dormant, there is a lack of aboveground sprout development and therefore a lack of photosynthesis and sexual reproduction (Shefferson *et al*. 2005, p. 3099). Geophyte dormancy may correlate to climatic variables, often occurring in times of stress, such as prolonged drought, and remain underground until aboveground conditions improve (Shefferson *et al*. 2005, p. 3099;

Reintal *et al*. 2010, p. 112). Prolonged dormancy is most common in dry or seasonally dry habitats, though it may also occur in mesic habitats; species dependent on high light levels are also more prone to dormancy (Reintal *et al*. 2010, p. 116). The dormancy potential in CHLT contributes to our lack of documentation of individuals and understanding of population size and occurrence.

Figure 2.1. Canelo Hills ladies' tresses (*Spiranthes delitescens*) basal and cauline (stem) leaves. Photo by Andrew Salywon, July, 2016, with permission.

Figure 2.2. Canelo Hills ladies' tresses (*Spiranthes delitescens*) capsule formation. Photo by A. Salywon, July, 2016, with permission.

2.3 Phenology (Seasonal Changes) and Reproduction

The seeds of orchids, including CHLT, are very small with no endosperm (food store of a seed), thus requiring nutrients for germination from mycorrhizal symbionts (relationship between a fungus and the roots (or seeds) of plants). Although thousands of seeds are produced by individuals, a relatively small number of seedlings emerge (McCormick and Jacquemyn 2014, p. 393; Rasmussen and Whigham 1998, p. 50). When seeds germinate, the embryo enlarges to form a protocorm (intermediate structures with no leaves or roots). The protocorms become green and accumulate carbohydrate reserves through photosynthesis. When enough reserves are attained, a shoot and root are formed. Plants may remain in a dormant, subterranean state or remain vegetative (non-flowering) for more than one year and in some orchids, the underground stage may last much of their lives. Prolonged dormancy is tied to highly developed mycorrhizal associations and fluctuations in the physical state of orchids (e.g., dormant, growing, flowering) may be related to climatic and edaphic factors impacting pH, temperature, and moisture requirements of the mycorrhizae – orchid association (McCormick and Jacquemyn 2014, p. 396; Reintal *et al*. 2010, pp. 112, 116; Sheviak 1974, p. 17).

Aboveground vegetative growth of CHLT begins in late spring (McClaran 1996, p. 166). A flowering stalk is produced in July and August, with seed being produced in capsules approximately three weeks after flowers form, typically in late August (Gori 1994, p. 1). Seed viability is unknown and should be studied. Plants die back in September or October, overwintering belowground (Gori 1994, p. 1). Plants that flower one year can become dormant, vegetative, or reproductive the next year (Newman 1991, p. 5; McClaran and Sundt 1992, p. 300). Antlfiner and Wendel (1997, p. 779) in their study of nodding ladies' tresses (*S. cernua*), noted the reproductive structures of this orchid are photosynthetic, accounting for almost half of their own carbon requirements; the rest coming from stored carbohydrates. Larger nodding ladies' tresses plants have greater reserves and greater ability to produce flowers, and consecutive flowering only occurs if there is sufficient carbon reserve to support flowering, otherwise plants remain in a vegetative state until they regain reserves (Antlfiner and Wendel 1997, p. 779). The same is presumed to be true for CHLT. The life cycle of CHLT is shown in Figure 2.3.

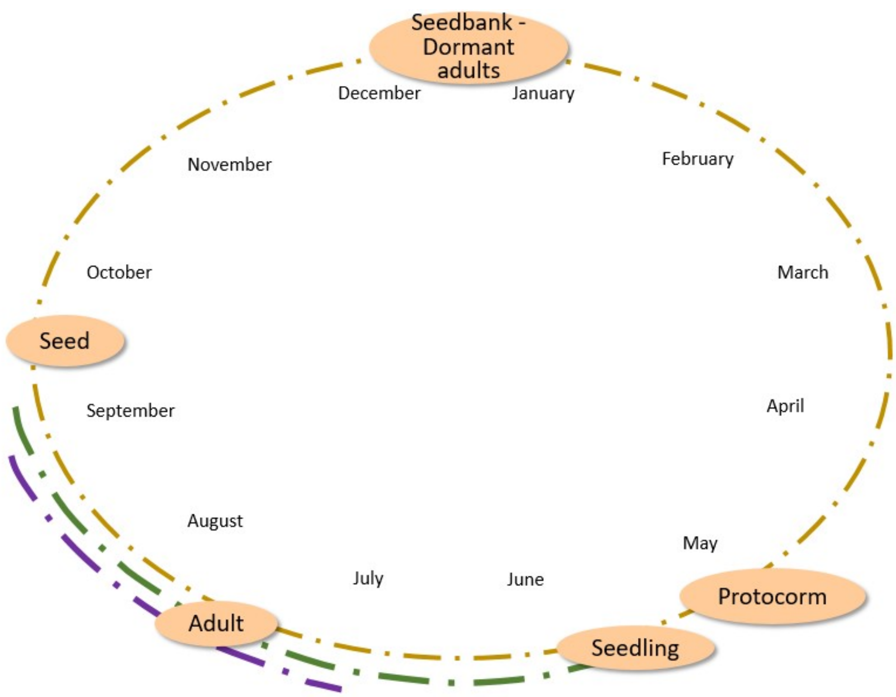


Figure 2.3. The Canelo Hills ladies' tresses (*Spiranthes delitescens*) life cycle. Gold line indicates underground stage, green line indicates above ground stage, and purple line indicates flowering stage.

In general, *Spiranthes* species can produce seed through insect pollination, self-pollination, unfertilized ovules, or by some combination of these three (Argue 2012, p. 19). Species that produce odors, such as CHLT, do so to attract pollinators for sexual reproduction (Argue 2012, p. 32). It is unknown if CHLT is able to self-pollinate or produce seed from unfertilized ovules. The primary pollinators of *Spiranthes* species are medium to large, long-tongued bees, especially of the genus *Bombus* (bumblebees; Argue 2012, p. 34). These bees are able to reach the nectar at the base of the floral tube. Gori (1994, p. 1) reported that bumblebees appear to be the primary pollinator of CHLT. The limited number of flowering plants found in any of the four CHLT populations in recent years inhibits cross-pollination and could result in reduced seed production (Gori 1994, p. 4). Although many *Bombus* species can travel long distances (up to 2.8 km; Zurbuchen *et al*. 2010, p. 672), CHLT populations are separated by 2.5 km to 20.6 km (1.6 to 12.8 mi), making cross-pollination unlikely outside of the Canelo Hills / Turkey Creek Populations.

As in all orchids, the tiny dust-like seeds of CHLT are well suited for dispersal by wind. It is suspected that most seed falls within a few meters of the mother plants, while a small portion may be carried many kilometers away by wind (Dressler 1981, p. 12). Despite the large quantities of seed produced by orchids, most seed fails to germinate (Arditti 1965, p. 76). Seed germination and establishment require not only seed to land in suitable habitat, but also a fungal association that provides nourishment for sometimes years before aboveground growth is produced and photosynthesis begins (Argue 2012, p. 43). It is unknown how long CHLT seed remains viable.

2.4 Lifespan

The lifespan of orchids, in general, ranges widely and may extend for many decades (Zhang *et al*. 2018, p. 197; McClaran 1996, p. 167). Most orchids have a long juvenile period, slow growth rate, and reduced photosynthetic capacity (Zhang *et al*. 2018, p. 196; Rasmussen and Whigham 1998, p. 50). McClaran suggested a lifespan of three to four years for CHLT, however his study period was eight years and plants may have gone dormant during this period, and CHLT plants in the four locations of his study have since been found periodically over several decades (Table 2.1). Hicks (pers. comm. January 21, 2020) noted that individuals at one of the populations were tracked by the landowner over many years and he believes CHLT is potentially very long-lived, perhaps up to a century. Similarly, Gori (1994, p. 11) noted that CHLT may live symbiotically with mycorrhizae underground from 1-15 years, and live aboveground vegetatively, reproductively, and may return to an underground state; hence making the lifespan of this orchid perhaps many decades. Coleman was able to maintain a CHLT individual in a pot for approximately 15 years with no signs of diminishing (Hicks, pers. comm. July 11, 2021). Gori (1994, p. 11) also notes that environmental stress, such as reduced water availability, can lead to mortality at any portion of the life cycle. In recent years, no plants have been located in repeated surveys of the Canelo Hills (2010-2015, 2019), Babocomari (2015, 2019), or San Rafael Valley Populations (2015, 2019). Despite no recent positive surveys in three ciénegas, due to the longevity in dormant state of other *Spiranthes* species, we presume all populations and subpopulations are extant.

Table 2.1. Record of Canelo Hills ladies' tresses (*Spiranthes delitescens*) observation at the four Arizona populations; it is unknown if the same individuals were seen during repeat visits. TNC = The Nature Conservancy; Coronado National Forest (NF); the remaining locations occur on private ranch lands. In addition, in recent years, no plants have been located in repeated surveys of the Canelo Hills (2010-2016, 2019), Babocomari (2015, 2016, 2019), or San Rafael Valley (2015, 2019) populations.

Population	Subpopulation	Year of Observation
Babocomari	**none**	1969, 1981, 1998, 2008
Canelo Hills	**TNC**	1968, 1969, 1970, 1971, 1978-1999, 2002
Canelo Hills	**Coronado NF**	1996
San Rafael Valley	**none**	1980, <1990, 1995, 1999, 2006
Turkey Creek	**none**	1968, 1982, 1987, 1988, 1989, 1990, <1992, 1992, 1995, 1996, 2001, 2004, 2006, 2016, 2019

2.5 Resource Needs of Individuals

2.5.1 Ciénegas

Canelo Hills ladies' tresses is found in finely grained, highly organic, and seasonally or perennially saturated soils in ciénegas at elevations ranging from 1,433 to 1,524 meters (m) (4,700-5,000 feet (ft)). The term ciénega is defined differently by various authors (e.g., NatureServe 2019, entire; Stromberg 1993, p. 2; Hendrickson and Minckley 1984, p. 131). While the term ciénega has been used to describe various aquatic systems, NatureServe (2019, entire) applies the term to North American Warm Desert, freshwater spring-fed wetlands, with potential saline margins (from high evaporation), occurring below 2,000 m elevation. Hendrickson and Minckley (1984, pp. 131, 133-134) apply the term to mid-elevation (1,000-2,000 m) freshwater wetlands associated with perennial springs and headwater streams, with permanently saturated, highly organic, reducing soils located in semidesert grassland or Madrean evergreen woodland. Stromberg (1993, p. 2) suggests ciénegas are a wetland type found throughout the southwest that include warm-temperate riverine marshlands of southern Arizona semidesert grasslands at elevations between 1,100 and 1,500 m (3,609 and 4,921 ft).

Most ciénegas are associated with springs (complex ecosystems in which groundwater reaches the earth's surface; Stevens and Meretsky 2008, p. 3) and are low gradient wetlands that serve to slow water and trap organic materials and nutrients (Figure 2.4; Sivinski and Tonne 2011, p. 1; Hendrickson and Minckley 1984, pp. 133-134). Ciénegas are often found in the upper reaches of small drainages or above river channels in a variety of surrounding vegetation communities, and thus are largely protected from scouring floods (Sivinski and Tonne 2011, p. 2; Figure 2.7). Dominant vegetation in ciénegas include grasses, sedges (*Carex* spp.), flatsedges (*Cyperus* spp.), and spikerush (*Eleocharis* spp.; Stromberg *et al*. 2017, p. 8; Harlow 2015, p. 18; Hendrickson and Minckley 1984, p. 136). Ciénega vegetation either decomposes annually or forms a matt of decaying matter of varying thickness as above-ground mass dies. This leads to layers of organic peats and fine-textured silts that are trapped during occasional flood flows. In southern Arizona, CHLT is known from just four ciénegas. Recent studies of ciénegas throughout the southwest indicate many are no longer functioning (Figure 2.5).

Figure 2.4. Example of a ciénega in southern AZ. U.S. Fish and Wildlife Service file photo.

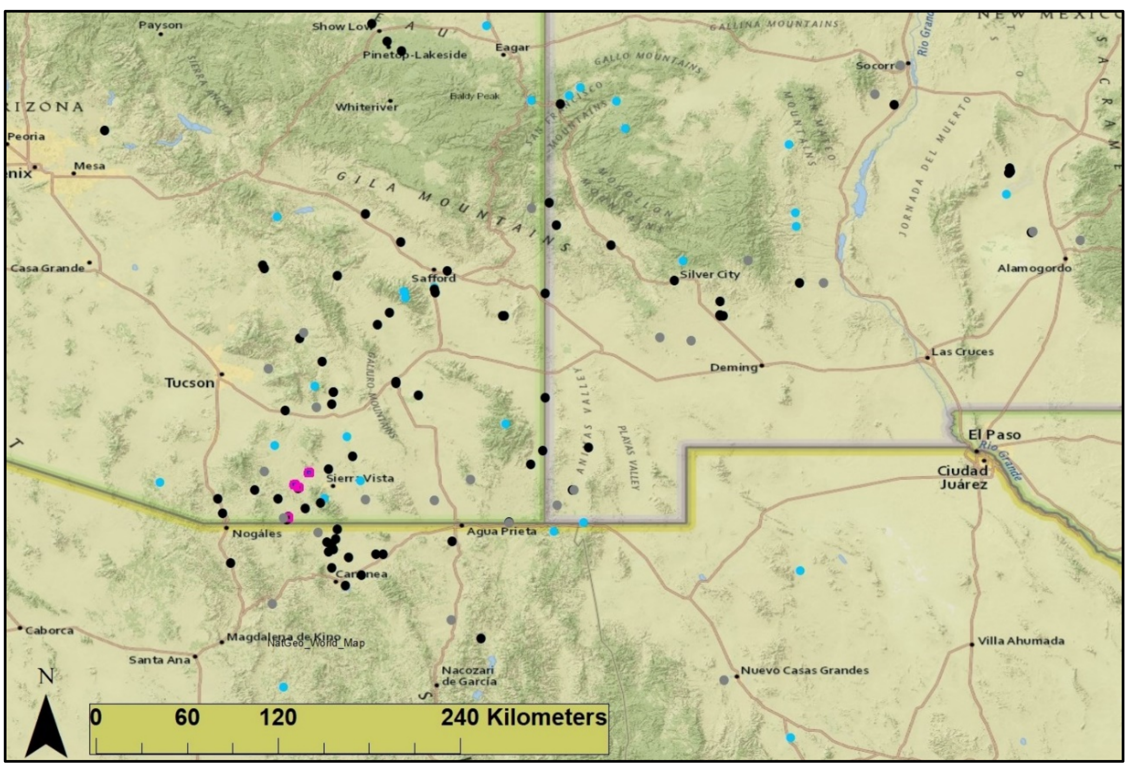


Figure 2.5. Ciénegas containing Canelo Hills ladies' tresses (*Spiranthes delitescens*) (pink), among dead and degraded (black), restorable (gray), and healthy or unknown status (blue) ciénegas in the southwest region occurring between 1,421 and 1,529 meters in elevation.

2.5.2 Mycorrhizae Symbiont

It is thought that all orchid species, including CHLT, have an association with mycorrhizae at some point in their life cycle (IUCN/SSC Orchid Specialist Group 1996, p. 111; McClaran and Sundt 1992). Mycorrhizae help with quick absorption of nutrients and provide carbohydrates that many orchids rely on throughout their entire life cycle (Zhang *et al*. 2018, p. 296). Most orchid seeds will not germinate unless they have been infected by an appropriate fungus (Moore 2019, entire). Although orchid species usually develop chlorophyll in their adult stage, most still have mycorrhizal associations and gain nitrogen, phosphorus, and possibly carbon from the mycorrhizae (Moore 2019, entire). Mycorrhizae are adapted to specific substrate chemistry and conditions, therefore, associated orchids are also limited by theses specific substrate conditions (IUCN/SSC Orchid Specialist Group 1996, p. 1). It is assumed that for CHLT to germinate, grow, and reproduce, not only the appropriate substrate, water, light, and other requirements must be met, but the correct mycorrhizal symbiont must be present at the site. The only available information on mycorrhizal associations with CHLT is the collection of pelotons (hyphae coils that increase the interfacial surface area between orchid and fungus) from one population in 2016, indicating the appropriate fungus was present at this site (Salywon pers. comm. September 1, 2016). Mycorrhizae were unable to be grown in laboratory conditions from these pelotons, however (O'Neill pers. comm. October 3, 2019).

2.5.3 Saturated Organic Soils in Ciénegas


Figure 2.6. Saturated soil of a ciénega. Photo credit Thomas A. Minckley September 2008.

Canelo Hills ladies' tresses requires finely grained, highly organic, and seasonally or perennially saturated soils in ciénegas (Figure 2.6). In a recent study by Stromberg *et al*. (2017, p. 8), CHLT plants were located in soils that varied from moist to saturated with standing water. They found a statistical correlation between the presence of CHLT and wet winters and stream flow with depth to water being closest to the surface in winter, and deepest in the summer (Stromberg *et al*. 2017, pp. 8-9). This correlation did not continue in 2019 following a wet 2018-2019 winter. In the summer of 2019, three individuals were found at Turkey Creek and no plants were found at the other three ciénegas.

In 1970, it was said that the ciénega at Canelo Hills was one of the best remaining oases known in southern Arizona and is formed by hillside springs (Artz 1970, p. 1). Depth to water has increased at the Canelo Hills since first measured in 1989; depth to water is shallowest nearest the springhead (Stromberg *et al*. 2017, pp. 8-10). In 2015 through 2016, gravimetric water content at the ciénegas at Canelo Hills and Babocomari was measured, averaging 74±7 and 70±6 for surface soils and 68±7 and 69±6 for deeper soils (Stromberg *et al*. 2017, p. 12). These measures were not available for the ciénegas where the other two CHLT populations are located.

Ciénega vegetation may decompose annually, leading to the layers of organic peats and fine-textured silts that are trapped during occasional flood flows. The total organic carbon at the ciénegas at Canelo Hills and Babocomari were both 25±2 percent in the surface soils and 20-22±2 in the deeper soils, respectively (Stromberg *et al*. 2017, pp. 11-12). These measures were not available for the other two CHLT populations.

2.5.4 Groundwater and Winter Precipitation

Drought stress can lead to mortality of CHLT at any portion of its life cycle (Gori 1994, p. 11). Ciénegas have water tables at or near the ground surface (Norman *et al*. 2019, p. 4) and are, therefore, maintained by the discharge of groundwater from relatively shallow aquifers. These groundwater aquifers, in turn, are typically recharged by infiltration of precipitation, at both a regional scale and within ephemeral streams along mountain fronts (Pool 2005, p.1). Winter precipitation dominates as an overall recharge source because the duration of precipitation produced by frontal storms is typically longer and evaporation and transpiration rates are lower during winter months (Stromberg *et al.* 2015, p. 5; Guido 2008, p. 4; Wahi *et al*. 2008, pp. 420-421; Pool 2005, p. 3;). Summer precipitation is produced primarily by monsoonal thunderstorms that can be of greater intensity than winter frontal storms, but generally are of short duration and produce little runoff and streamflow infiltration because the storms are localized and evaporation and transpiration rates are high. Infiltration of summer streamflow, however, can be an important source of recharge in some locations due to variable interannual precipitation, hydrology, and/or lithology (Eastoe and Wright 2019, p. 17; Baillie *et al*. 2007, pp. 10-11). In a study of southern Arizona ciénegas, including two ciénegas which support CHLT, Brunelle *et al*. (2018, p. 1) found that winter and subsequent spring precipitation is important for groundwater recharge. Stromberg *et al*. (2017, p. 7) found a significant correlation between winter stream flow and the presence of CHLT at Canelo Hills Population. Similarly, Davis (1993, p. 64) found an association between precipitation and water levels at the Canelo Hills Population, but also noted the importance of groundwater from a spring in maintaining wetland saturation.

2.5.5 Disturbance and Competition Reduction

Despite being typically long-lived species, ideal habitat for orchids may be short-lived, leading to the irregular above-ground appearance of many orchids (IUCN/SSC Orchid Specialist Group 1996, p.15). Many species of orchid require periodic low to medium levels of disturbance to remove competing vegetation and maintain light levels needed for germination and growth, or increase available nutrients required for flowering and seed development (IUCN/SSC Orchid Specialist Group 1996, pp.15, 20). For example, Navasota ladies' tresses (*S. parksii*) has been found in disturbed areas with thin leaf litter (Wonkka 2010, p. 11) and both Navasota and nodding ladies' tresses increased in the number of flowering individuals following disturbance treatments (Bruton 2014, p. 32). Arft (1995, p. 99) suggests natural disturbance and recolonization may be essential to *S. diluvialis* survival. Similarly, when density of competing vegetation is reduced, CHLT has been shown to increase (McClaran 1996, p. 163; Gori 1994, p.

3). Gori (1994, p. 11) noted that the absence of disturbance to surrounding vegetation may stress this species, resulting in decreased reproduction, increased time in the underground life stage, and mortality at all life stages. Likewise, Harlow (2015, p. 28) indicates that dense vegetation surrounding CHLT is a threat to the survival of the plants.

As an example, one individual CHLT was found in the middle of the footpath at the Canelo Hills Population in the early 1990s, illustrating the requirement of some disturbance to maintain light for the species (Gori and Fishbein 1991, p. 4). Further, a field collected plant which had been in a pot for more than one year and which had no above-ground growth began to grow after soil and associated plants in the pot were removed (Desert Botanical Garden 1993, p. 95). Management of orchids must incorporate disturbances to maintain appropriate habitat, but this is often complex and requires observation and research to determine the timing and degree of disturbance required (IUCN/SSC Orchid Specialist Group 1996, p. 123).

Many ciénega plants require full sun and open growing conditions. This historical condition was created by disturbances that removed or reduced both understory competing herbaceous and graminoids species and overstory trees. There were two main sources of disturbance in ciénegas that most likely helped maintain open canopies and reduce direct competition; these were low levels of grazing and low severity fire.

Low Levels of Grazing

Historically, incompatible grazing levels led to the destruction and modification of many ciénegas through increases in barren soil, erosion, headcutting (erosional feature in a stream which contributes to lowering the water table of the surrounding system), and increased frequency or intensity of destructive floods. Currently however, low levels of herbivory and ground disturbance, or alternatively mowing, may decrease competing understory vegetation, thus creating appropriate conditions for CHLT establishment and survival (Harlow 2015, p. 22). Grazing at the Turkey Creek Population may account for the greater number of CHLT present in recent decades, as compared with nearby, ungrazed, Canelo Hills Population (McClaran 1996, p. 168; McClaran and Sundt 1992, p. 302). However, both the Babocomari and the San Rafael Valley Populations have maintained periodic grazing at low to medium levels for over one hundred years, and CHLT have not been located in either location since the mid-2000s. Grazing by large ungulates was an important feature of the southeastern Arizona landscape in the Pleistocene Epoch (ended 11,700 years ago) and again in the past roughly 400 years; in between these times, other disturbance, such as fire, likely maintained open spaces within ciénega vegetation (Gori and Fishbein 1991, p. 2).

Fire

Many species of plants, including many orchids, are adapted to fire in the ecosystem. Fire releases nutrients, promotes light penetration by the removal of dead or decaying organic matter, removes woody plant starts, and creates patches of bare ground available for colonization (Cole and Cole 2015, p. 35; IUCN/SSC Orchid Specialist Group 1996, p. 19). In southern Arizona ciénegas, historical fire regimes were highly correlated to precipitation patterns, with fire frequency increasing following wet winters and fine fuel accumulation (Brunelle *et al*. 2018, p. 12). Prehistoric peoples may have burned, perhaps seasonally, the dense growth of ciénegas and drainages to clear water delivery systems for villages and increase nutrients and open space for growing crops such as corn (Villarreal et al 2020, p. 14; Fish 2006, p. 67; Davis *et al*. 2002, p. 393; Hendrickson and Minckley 1984, pp. 142, 161). In addition, there is also documentation of both deliberate and accidental burning of valley vegetation by European settlers (Davis *et al*. 2002, p. 410).

Historically, fire in ciénegas was frequent enough to exclude most woody plants, as well as suppress the abundance of native wetland dominants such as bulrush (*Scirpus* sp.) and remove plant litter (Figure 2.7; Davis *et al*. 2002, p. 393; Baker *et al*. 1998, p. 5; Fonseca 1998, p. 114). Fire in ciénegas is influenced greatly by fire in surrounding vegetation communities. The San Rafael Valley and the Babocomari Populations are surrounded by Semidesert and Plains Grasslands; the Canelo Hills and the Turkey Creek Populations are surrounded by Madrean Evergreen Woodland (Figure 2.8). The Semidesert and Plains Grasslands and Madrean Evergreen Woodlands of southern Arizona historically had large-scale low severity fire roughly every 10 to 20 years and following periods of adequate moisture (Fryer and Luensmann 2012, entire; McDonald and McPherson 2011, p. 385; Swetnam *et al*. 2010, p. 1; Brooks and Pyke 2002, p. 6; McPherson and Weltzin 2000, p. 5).

Due to a variety of human activities in the landscape (e.g., excessive livestock grazing, fuelwood cutting, nonnative introduction and expansion, and fire suppression starting around the turn of the last century through the mid–1900s), today grasslands and woodlands have high fuel loads, and high severity fires are becoming increasingly more common (FireScape, 2016, entire; Swetnam *et al.* 2010, p. 11; Crimmins and Comrie 2004, p. 464; Anable *et al*. 1992, pp. 186-187). Swetnam *et al.* (2010, p. 15) note that there is no evidence that such large stand-replacing fires occurred historically in southern Arizona; for example, fire-scar studies have revealed that only low intensity surface fire regimes persisted for the past three to five centuries. Similarly, Villarreal et al (2020, p. 15) note that historically, frequent low-intensity fires were relatively common in the warm, dry environments that support grasslands in the region. They also note that southern Arizona plant communities are now subject to increased fire frequency and severity due to historical and current land uses and increases in nonnative plants and ignition sources (p. 13).

In other orchid species, it has been documented that flowering and seed production can be a significant drain on orchid resources, therefore additional nutrients gained from low to moderate severity burning may aid plants with reproduction (IUCN/SSC Orchid Specialist Group 1996, p. 20). Fire one year may lead to increased growth and flowering the following year (IUCN/SSC Orchid Specialist Group 1996, p. 20). While fire is an important disturbance mechanism in other wetland habitats, it is also believed to be historically important at the Canelo Hills Population (Gori and Fishbein 1991, p. 1). At the Canelo Hills Population it was a concern that too hot of a fire could kill the underground structure of CHLT, thus an early season (April) prescription fire was prescribed Ciénega (Dewey 1983, p. 1). Here, following both the prescription and wild fires, CHLT increased in the number plants, sometimes for several years post fire (Figure 2.9). Note however, that following the Ryan wildfire in 2002, which burned at higher severity than the prescription burns, CHLT was seen in small numbers and for a single year following the burn. No CHLT plants have been seen at this location since that time, despite numerous years of survey.

Alternatively, high frequency or high severity burns may have negative impacts of CHLT. In 1991, the dominant plants listed at the Canelo Hills Population were tall grasses, sedges, and rushes (e.g., beaked spikerush [*Eleocharis rostellata*], Kentucky bluegrass [*Poa pratensis*], sedges, and aparejograss [*Muhlenbergia utilis*]; Gori and Fishbein 1991, pp. 2-3). They noted dogbane (*Apocynum suksdorfii* and *A. cannabinum*) was patchy in the ciénega, likely from past grazing and trampling by cattle followed by clonal growth (Gori and Fishbein 1991,p. 5). In their 1993 report, Fishbein and Gori noted that with high burn frequency, there was an increasing cover of dogbane and other native plants at the Canelo Hills Population. In 2015, Crawford and Calhoun noted a near monoculture of dogbane at the Canelo Hills Population with fewer understory plants due to increased competition (Figure 2.10), and no CHLT were found. Similarly, in 2019, Turner noted much of the area was completely dominated by dogbane (Turner pers. comm. Aug 19, 2019). Between 1989 and 2015, Stromberg *et al*. (2017, p. 8) noted an increase in clonal perennial species (e.g., dogbane) at the Canelo Hills Population site and a decrease in disturbance adapted annual plants (Stromberg *et al*. 2017, p. 8).

Figure 2.7. Example of woody plant invasion into Canelo Hills ladies' tresses (*Spiranthes delitescens*) habitat. Photo by Andrew Salywon 2016.

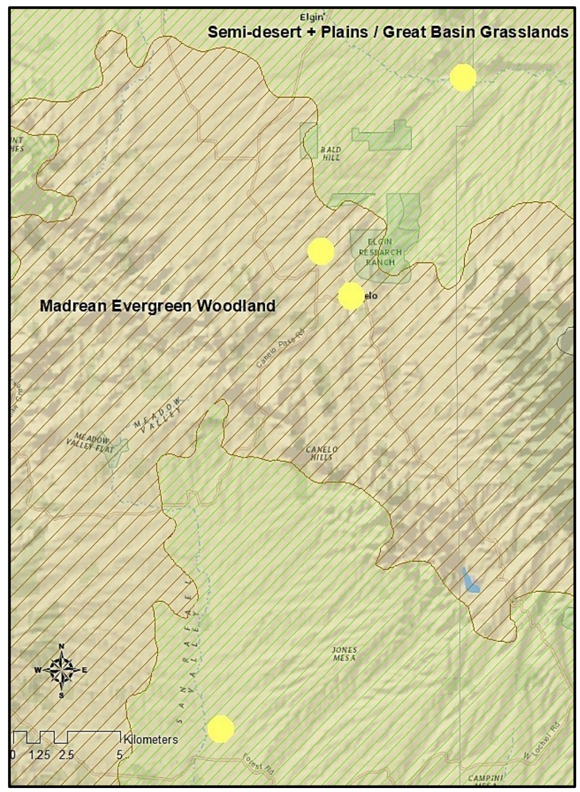


Figure 2.8. The location of the four Canelo Hills ladies' tresses (*Spiranthes delitescens*) populations in relation to the surrounding vegetation communities. Babocomari (top right) and San Rafael Valley (bottom left) Ciénegas are in Semi-desert and Plains / Great Basin Grasslands. Canelo Hills and Turkey Creek are in Madrean Evergreen Woodlands.

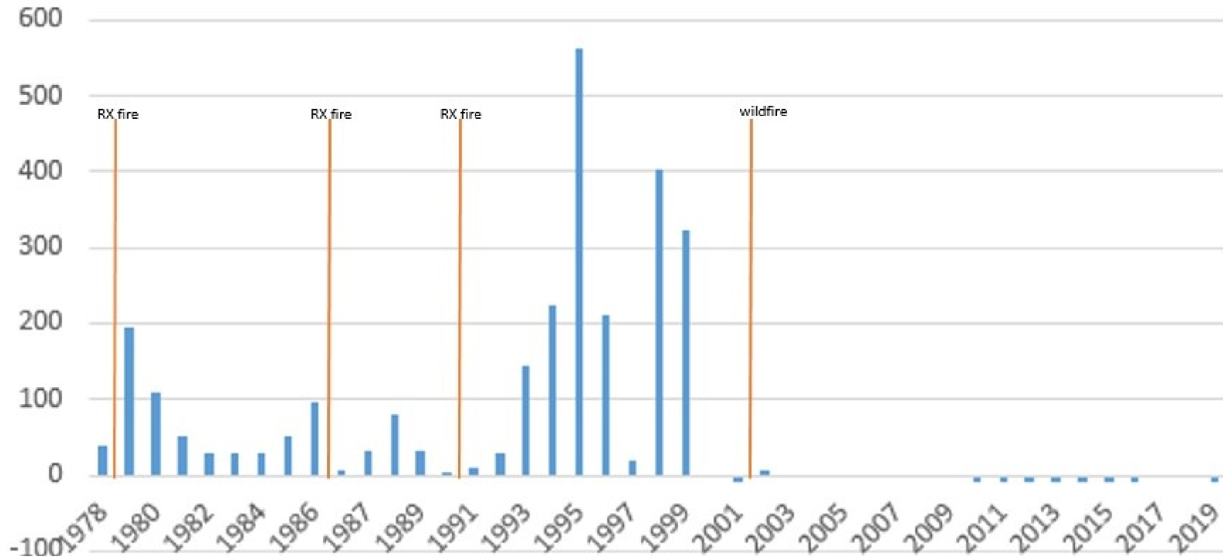


Figure 2.9. Number of Canelo Hills ladies' tresses (*Spiranthes delitescens*) plants found during surveys at Canelo Hills Ciénega TNC Subpopulation between 1978 and 2019. Negative numbers represent searches with no plants located. Orange lines indicate fires that burned through the orchid patch.

2.5.6 Presence of Pollinators

Cross-pollination and gene flow in CHLT is thought to require the presence of pollinators, though self-fertilization may be possible based on fruit set (Hicks, pers. comm. July 11, 2021). The primary pollinator of CHLT are medium to large, long-tongued bumblebees (*Bombus* spp.) (Gori 1994, p. 1). Zurbuchen *et al*. (2010, p. 672) reported foraging distance of *Bombus* sp. from 16 scientific studies, with the average distance being approximately 960 m. The primary pollinator of CHLT is most likely Sonoran bumblebee (*B. sonorus*; Buchmann pers. comm. October 4, 2019). Most *Bombus* spp., including the Sonoran bumblebee, nest underground in abandoned rodent burrows or similar cavities and are generalist foragers, visiting a variety of flowering plants (Texas Parks and Wildlife 2019a, entire; USFS 2019, entire). The distribution of the Sonoran bumblebee is centered in Mexico and goes into the southern portions of California, Arizona, New Mexico, and Texas (Warriner 2012, p. 444), but are thought to be in decline throughout their range (The Committee on the Status of Pollinators in North America 2007, p. 289).

Figure 2.10. Site visit to Canelo Hills to look for Canelo Hills ladies' tresses (*Spiranthes* delitescens) on July 31, 2015 revealed a near monoculture of dogbane (*Apocynum cannabinum*) in some of the ciénega area. U.S. Fish and Wildlife Service file photo.

2.6 Summary

In summary, CHLT is a small, long-lived, terrestrial orchid that occurs in four known populations in southern Arizona. Two populations were first discovered in 1968 at Canelo Hills and Turkey Creek, and two additional populations discovered in 1969 and 1980 at Babocomari and in the San Rafael Valley, respectively. All four populations have been monitored periodically. The largest number of plants seen in any population was 731, in 1999 at the San Rafael Valley Population; the smallest number of plants found was 3, in 2019 in the Turkey Creek Population. The species requires saturated organic soils in ciénegas, an appropriate mycorrhizal symbiont, groundwater and precipitation, disturbance to remove competition with native and nonnative plant associates, and suitable pollinator presence.

CHAPTER 3 – POPULATION AND SPECIES NEEDS

In this chapter we consider the probable historical distribution of CHLT, its current distribution, and what the species needs for viability. We first review the historical and current information on the range, distribution, and ecology of the species. We next review the conceptual needs of the species, including population resiliency, and species redundancy and representation to support viability of CHLT and reduce the likelihood of extinction.

3.1 Historical and Current Range, Distribution, and Abundance

We do not have information regarding historical populations of CHLT, however it is likely that the species was distributed throughout multiple ciénegas in southern Arizona. There have been many changes in the southeastern Arizona landscape since the 1890s with intensive cattle grazing, water development, nonnative plant invasion, and altered fire regimes, among others (e.g., Anable *et al*. 1992, pp. 186-187; Bahre 1991, entire; Hendrickson and Minckley 1984, entire). Ciénega habitat has been reduced from a widespread distribution historically to small remnants scattered throughout the region today, with approximately 56 percent of known ciénegas either dead or severely compromised and more than 95 percent of the historical area of ciénegas now dry due to loss or shrinkage of wetted area (Cole and Cole 2015, p. 36). It is possible that these impacts reduced a more widespread historical range of CHLT, or the number of populations, but we have no specific information indicating this. The current range of CHLT includes populations in four ciénegas in southern Arizona, three of which are in Santa Cruz County and the fourth in Cochise County (Figure 3.1). The populations range in elevation from 1,402 to 1,508 m (4,600 to 4950 ft), and the total ciénega size for each population is small: Babocomari is approximately 61 hectares (ha; 151 acres (ac)), Canelo Hills (including both subpopulations) is approximately 10 ha (24 ac), San Rafael Valley is approximately 7 ha (17 ac), and Turkey Creek is approximately 19 ha (48 ac).

Many orchids are locally distributed and generally rare (Zhang *et al*. 2018, p. 196). Sheviak (1984, p. 9) noted that for the Ute ladies' tresses, the discontinuous distribution reflects a lack of suitable, moist habitat in an arid region. Similarly, the restricted distribution of CHLT in southern Arizona suggests either limited dispersal, limited ciénega habitat, or both. The four populations of CHLT in southern Arizona are spread across an area approximately 32 km x 3 km (19.9 mi x 1.8 mi). There is one other *Spiranthes* species known to occur in Arizona, hooded ladies' tresses (*S. romanzoffiana*) which is a widespread species of wetted habitat in much of the western United States and Canada with distribution in Arizona in Apache, Coconino, and Graham Counties. This species does not overlap with CHLT (Figure 3.2).

Most of the ciénegas in the southwestern United States and northern Mexico have been visited with plants therein accounted for (e.g., Sivinski and Tonne 2011, entire; McLaughlin 2006, entire; Van Devender and Reina 2005, entire; and Hendrickson and Minckley 1984, entire). No additional locations are known to support CHLT in Arizona or Mexico, and it is unlikely that any large populations remain unaccounted for. We consider all four populations extant, despite negative surveys in recent years. We make this assumption because the plant is difficult to locate above ground among understory vegetation and impossible to detect underground in its vegetative state, which may last many years.

Figure 3.1. Distribution of Canelo Hills ladies' tresses (*Spiranthes delitescens*) in Santa Cruz and Cochise Counties, southern Arizona (yellow dots). All four populations occur on private lands, with four individuals in a separate subpopulation at the Canelo Hills Population historically found on Coronado National Forest land.

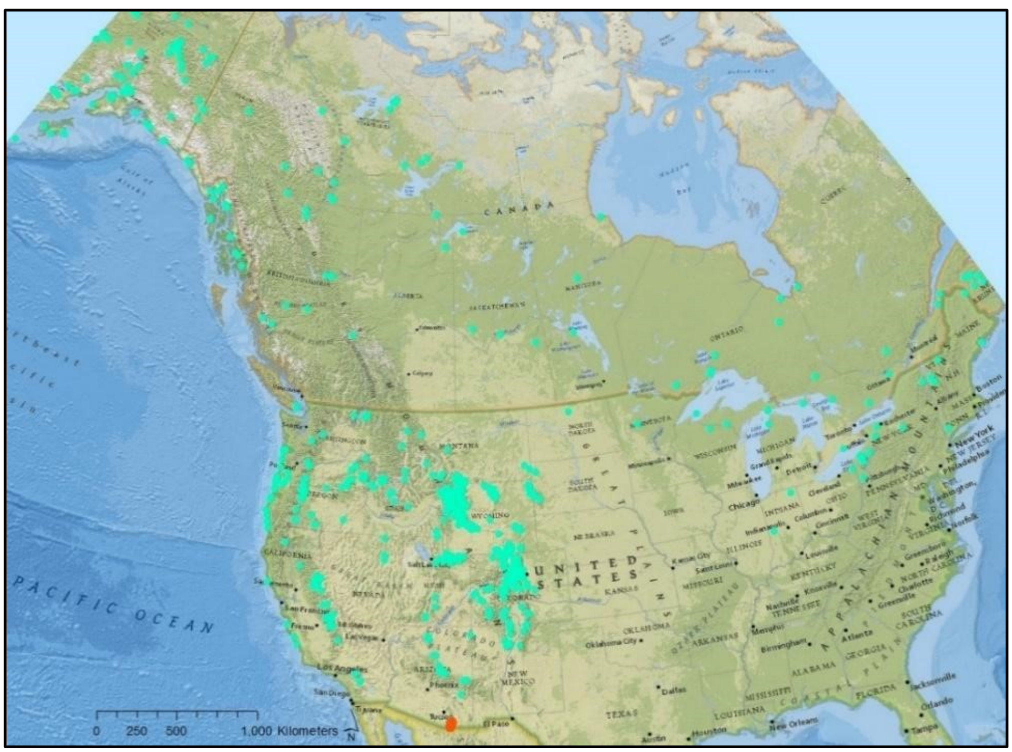


Figure 3.2. Range of hooded ladies' tresses (*Spiranthes romanzoffiana*) (green) in relation to the range of Canelo Hills ladies' tresses (*Spiranthes delitescens*) (orange).

Population numbers have varied widely between years and between populations (Table 3.1). At Babocomari, individual plant counts were never made. At Canelo Hills, the population has ranged from a low of 1 individual in 1990 to a high of 564 in 1995 (Gori and Backer 1999, p. 2; Newman 1991, p. 6). In the San Rafael Valley, counts were made twice, in 1980 when 18 individuals were found, and again in 1999, when 731 flowering plants were counted (Harlow 2015, p. 18; Gori and Backer 1999, p. 2). At Turkey Creek, the smallest number recorded was in 2019 when 3 plants were found and the largest number was in 1990 when 85 individuals were counted (HDMS, entire).

Table 3.1. Survey results from site visits at the four known Canelo Hills ladies' tresses (*Spiranthes delitescens*) populations (a – Babocomari; b- Canelo Hills, c) San Rafael Valley, and d) Turkey Creek). In some instances the number of individuals observed was not recorded. The largest population reported for each location is highlighted in bold.

a) Babocomari Population

Date	Number of Plants	Citation
1969	present	Letter from Paul S. Martin
1970	0	Letter from Paul S. Martin
7/25/1981	present	Herbarium specimen: R. Bailowitz
August 1987	0	Sundt and McClaran 1988, p. 4
1988	0	Sundt and McClaran 1988, p. 4
1998	present	Coleman Database
2008	present	labeled photograph in USFWS files
7/6/2015	0	Stromberg *et al*. 2017, p. 5
7/26/2016	0	Stromberg *et al*. 2017, p. 5
8/3/2019	0	Ben Brophy pers. comm. 8/6/2019

b) Canelo Hills Population - TNC Subpopulation

Date	Number of Plants	Citation
7/7/1968	present	Herbarium specimen: P.S. Martin
7/10/1968	present	Herbarium specimen: P.S. Martin
8/27/1969	present	Herbarium specimen: P.S. Martin
August 1970	10	Davis 1970, entire
1971	present	HDMS EO 9260
1978	40	Gori 1994, p. 12; Newman 1991, p. 5; Lamma 1982, p. 2
1979 post-burn	196	McClaran 1996, p. 163; Gori 1994, p. 12; McClaran and Sundt 1992, p. 299; Newman 1991, p. 5; Lamma 1982, p. 1
7/26/1980	present	Gori 1994, p. 12
8/1/1980	118	Lamma 1982, p. 2
8/3/1980	scattered	HDMS EO 9260
9/1/1980	scattered	HDMS EO 9260
7/27/1981	present	HDMS EO 9260
8/1/1981	56	Gori 1994, p. 12, Lamma 1982, p. 1

Date	Number of Plants	Citation
7/29/1982	present	HDMS EO 9260
8/6/1982	26, 3	Gori 1994, p. 12; Newman 1991, p. 5, Lamma 1982. p.2
1983	40	McClaran 1996, p. 165; McClaran and Sundt 1992, p. 300
1984	30	Newman 1991, p. 5
1985	50	McClaran 1996, p. 165; Gori 1994, p. 12
1986-pre burn	97	Gori 1994, p. 3
1986-post burn	8	McClaran 1996, p. 164; McClaran and Sundt 1992, p. 299
1987	32	McClaran 1996, p. 169; Gori 1994, p. 12; McClaran and Sundt 1992, p. 301
9-13-1987	66	HDMS EO 9260
8/21/1988	80	Newman, 1991, p. 5
1989	31	McClaran 1996, p. 169; Gori 1994, p. 12; McClaran and Sundt 1992, p. 301
1990	1	Newman 1991, p. 6
1991	10	Gori 1994, p. 12
1992	30	Gori 1994, p. 12
1993	115	Gori pers. comm. June 12,1998
1994	206	Gori pers. comm. June 12,1998
1995	521	Gori pers. comm. June 12,1998
7/22/1995	present	HDMS EO 9260
1996	182	HDMS EO 9260, Gori pers. comm. June 12,1998
1997	19	Gori and Backer 1999, p. 2, Gori pers. comm. June 12,1998
1998	402	Gori and Backer 1999, p. 2
7/10/1999	present	HDMS EO 9260
1999	322	Gori and Backer 1999, p. 1
2001	0	Aaron Hicks pers. comm. January 21, 2020
2002-post Ryan Fire	5	Ron Coleman pers. comm. 7/8/2015
2010-2014	0	Jeffrey Miller pers. comm. 7/25/2015
7/27/2015	0	HDMS EO 9260
7/26/2016	0	Stromberg *et al*. 2017, p. 5
8/12/2019	0	Dale Turner site visit pers. comm. 8/19/2019

Canelo Hills Population - Coronado NF Subpopulation

Date	Number of Plants	Citation
1996	**4**	TNC 1996, p. 1
2015	0	Stromberg *et al*. 2017, p. 5
2019	0	Dale Turner pers. comm. 8/19/2019

c) San Rafael Valley Population

Date	Number of Plants	Citation
7/26/1980	18	Herbarium specimen: L.J. Toolin
<1990	abundant	Sheviak 1990, p. 230
8/20/1995	present	Coleman database
1999	**731**	Harlow 2015, p. 18; Gori and Backer 1999, p. 2
7/6/2006	present	Ross Humphreys pers. comm. 11/18/2013
2014	0	Harlow 2015, p. 18
7/31/2015	0	Crawford pers. comm. 8/3/2015
7/1/2019	0	Ross Humphreys pers. comm. 8/19/2019

d) Turkey Creek Population

Date	Number of Plants	Citation
1968	present	Lindsey 1999, p. 41
1981	0	D Koppinger, note attached to 01/12/82 letter from F Gehlbach to Terry Johnson
7/29/1982	56	Herbarium specimen: Toolin and Reichenbacher; Lamma 1982, p. 1
8/20/1982	Over 50	HDMS EO 7211
1987	18	McClaran 1996, p. 169
1988	20	McClaran 1996, p. 169
1989	18	McClaran 1996, p. 169
1990	Extensive	Sheviak 1990, p. 230
<1992	**85**	Herbarium specimen: Liz Ecker
8/19/1992	20	Herbarium specimen: Liz Ecker
7/22/1995	8	HDMS EO 7211
1996	8	Ron Coleman pers. comm. 2/5/2016
2001	12	Ron Coleman pers. comm. 2/5/2016 Aaron Hicks pers. comm. 1-21-2020
2004	<12	Ron Coleman pers. comm. 2/5/2016
2006	lots	Aaron Hicks pers. comm. 1-21-2020
8/18/2015	0	HDMS EO 7211
7-26-2016	12	HDMS EO 7211
8-17-2016	21	HDMS EO 7211
2019	3	HDMS EO 7211

3.2 Needs of Canelo Hills ladies' tresses

As discussed in Chapter 1, for the purpose of this assessment, we define **viability** as the ability of the species to sustain populations in the wild over time. Using the SSA framework, we describe the species' viability by characterizing the status of the species in terms of **resiliency**, **redundancy**, and **representation**. In this section we analyze what the species needs in terms of population resiliency and species representation and redundancy.

3.2.1 Population Resiliency

For CHLT to maintain viability, its populations must be able to withstand environmental stochasticity (normal, year-to-year variations in environmental conditions such as temperature, rainfall), periodic disturbances within the normal range of variation (fire, floods, storms), and demographic stochasticity (normal variation in demographic rates such as mortality and fecundity) (Redford *et al*. 2011, p. 40). In other words, resiliency is the ability to sustain populations through the natural range of favorable and unfavorable conditions. We can best gauge resiliency by evaluating population level characteristics such as: demography (abundance and the components of population growth rate -- survival, reproduction, and migration), genetic health (effective population size and heterozygosity), connectivity (gene flow and population rescue), and habitat quantity, quality, configuration, and heterogeneity. Also, for species prone to spatial synchrony (regionally correlated fluctuations among populations), distance between populations and degree of spatial heterogeneity (diversity of habitat types or microclimates) are also important considerations. Resilient CHLT populations must be large enough that stochastic events do not eliminate the entire population. In addition, recruitment must exceed mortality. Dispersal within and between populations enable the population to recover from disturbance events and maintain or increase genetic diversity.

Environmentally stochastic events that have the potential to affect CHLT population resiliency include drought and climate change, which can reduce groundwater availability and impact growth and development of the species. Habitat elements that increase resiliency to these events include healthy wetland characteristics (e.g., water storage, aquifer recharge, sediment trapping, streambank building, flow energy dissipation, vegetation community with root structure to prevent erosion, etc.) and adequate precipitation. In addition, a number of demographic factors influence the resiliency of CHLT populations. Small population size decreases CHLT population resiliency, as all threats are exacerbated in populations with only a small number of individuals. Area of occupied habitat, abundance, and recruitment thus all affect population resiliency. The interaction of these demographic factors and habitat elements are shown in Figure 3.3.

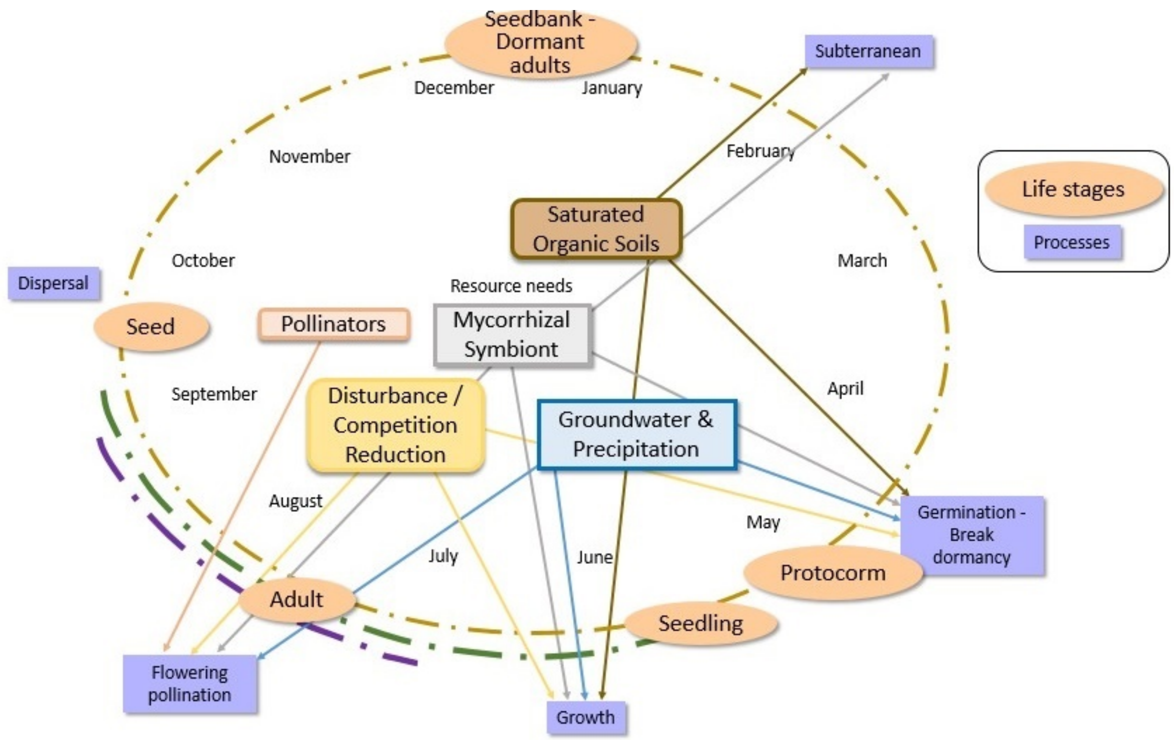


Figure 3.3. Life history of Canelo Hills ladies' tresses (*Spiranthes delitescens*) including life stages, processes, and resource needs. Gold line =underground, green line = above ground, and purple line =flowering.

3.2.2. Species Representation

Representation is the ability of a species to adapt to both near-term and long-term changes in its physical (climate conditions, habitat conditions, habitat structure, etc.) and biological (pathogens, competitors, predators, etc.) environments. This ability to adapt to new environments, referred to as adaptive capacity, is essential for viability as species need to continually adapt to their continuously changing environments (Nicotra *et al*. 2015, p. 1269). Species adapt to novel changes in their environment by either relocating to new, suitable environments, or by altering their physical or behavioral traits (phenotypes) to match the new environmental conditions through either plasticity or genetic change (Beever *et al*. 2016, p. 132; Nicotra *et al*. 2015, p. 1270). The latter (evolution) occurs via the evolutionary processes of natural selection, gene flow, mutations, and genetic drift (Crandall *et al*. 2000, p. 290-291; Sgro *et al*. 2011, p. 327; Zackay 2007, p. 1). We can best gauge representation by examining the breadth of genetic, phenotypic, and ecological diversity found within a species and its ability to disperse and colonize new areas. In assessing the breadth of variation, it is important to consider both larger-scale variation (such as morphological, behavioral, or life history differences which might exist across the range and environmental or ecological variation across the range), and smaller-scale variation (which might include measures of interpopulation genetic diversity). In assessing the dispersal ability, it is important to evaluate the ability and likelihood of the species to track suitable habitat and climate over time. Lastly, to evaluate the evolutionary processes that contribute to and maintain adaptive capacity, it is important to assess natural levels and patterns of gene flow, degree of ecological diversity occupied, and effective population size.

There are currently known to be four CHLT populations within 97 ha (240 ac) total area. The species occupies similar habitats (soils, light, water, elevation, and associated species) in all four locations, therefore there is little ecological diversity among populations. Genetic analysis of this species has not been conducted within or among populations. However, populations are widely separated (2.5 km to 20.6 km [1.6 to 12.8 mi] apart) over a roughly 31.7 km by 3 km [19.7 by 1.9 mi] area), making cross-pollination, and thus gene flow among populations, unlikely. In addition, most of the populations contain small numbers of individuals, therefore we assume that genetic variability within populations is low.

Because we do not know the status of underground plants at any of the CHLT populations, and only one population has been verified to have aboveground growth in recent years (Turkey Creek Population) with a small number of plants found, it is likely that there has been a loss of genetic diversity within populations, but potentially greater genetic diversity among populations. As such, maintaining representation in the form of genetic diversity across multiple populations may be important to the capacity of CHLT to adapt to future environmental change.

3.2.3 Species Redundancy

Canelo Hills ladies' tresses needs to have multiple resilient populations distributed throughout its range to be able to withstand catastrophes. Catastrophes are stochastic events that are expected to lead to population collapse regardless of population heath and for which adaptation is unlikely (Mangal and Tier 1993, p. 1083). Redundancy is best gauged by analyzing the number and distribution of populations relative to the scale of anticipated species-relevant catastrophic events. The more populations, and the wider the distribution of those populations, the more redundancy the species will exhibit. Redundancy reduces the risk that a large portion of the species' range will be negatively affected by a catastrophic natural or anthropogenic event at a given point in time. Species that are well distributed across their historical ranges are considered less susceptible to extinction and more likely to be viable than species confined to small portions of their ranges (Carroll *et al*. 2010, entire).

Of the four CHLT populations, three consist of a single subpopulation (Babocomari, San Rafael Valley, and Turkey Creek). The Canelo Hills Population consists of two subpopulations, one on TNC lands and one with the Coronado National Forest. There is little connectivity potential among the four ciénegas (separated from roughly 2.5 km to 20.6 km (1.6 to 12.8 mi) apart); therefore, a localized threat such as dewatering from agricultural withdrawal or a high severity wildfire would impact only those populations near the activity. However, regional drought or invasion of woody species could affect many populations throughout the plant's range. At a minimum, we likely need to retain population redundancy across the species' range to minimize impacts from catastrophic events. Ideally, redundancy for this species needs to be increased.

3.3 Summary

In summary, CHLT occurs in four ciénegas of southeastern Arizona, likely a much-reduced distribution from historical, as ciénega habitat has changed from a widespread distribution to small remnants scattered throughout the region today. For CHLT to maintain viability, its populations must be large enough, and include multiple subpopulations, such that stochastic events do not eliminate the entire population. In addition, recruitment must exceed mortality. The primary needs of the species include having the appropriate mycorrhizal symbiont available in the habitat; having saturated organic soils in ciénegas, and groundwater and winter precipitation to maintain ciénegas habitat; have light to moderate disturbance to reduce understory competition; and have suitable pollinators for genetic exchange and seed production.

CHAPTER 4 –THREATS ON VIABILITY

In this chapter, we evaluate the past, current, and future threats (i.e., negative changes in the resources needed by CHLT) that affect the viability of CHLT (Figure 4.1). Current and potential future threats, along with current and future expected distribution and abundance, determine viability and, therefore, vulnerability to extinction. We organized these threats around themes and discuss the sources of those threats. The primary threats of CHLT are 1) loss of ciénega habitat, 2) pollinator decline, 3) herbivory and predation, and 4) small population size and lack of connectivity. These threats are complex and are discussed in detail below and shown in Figure 4.1.

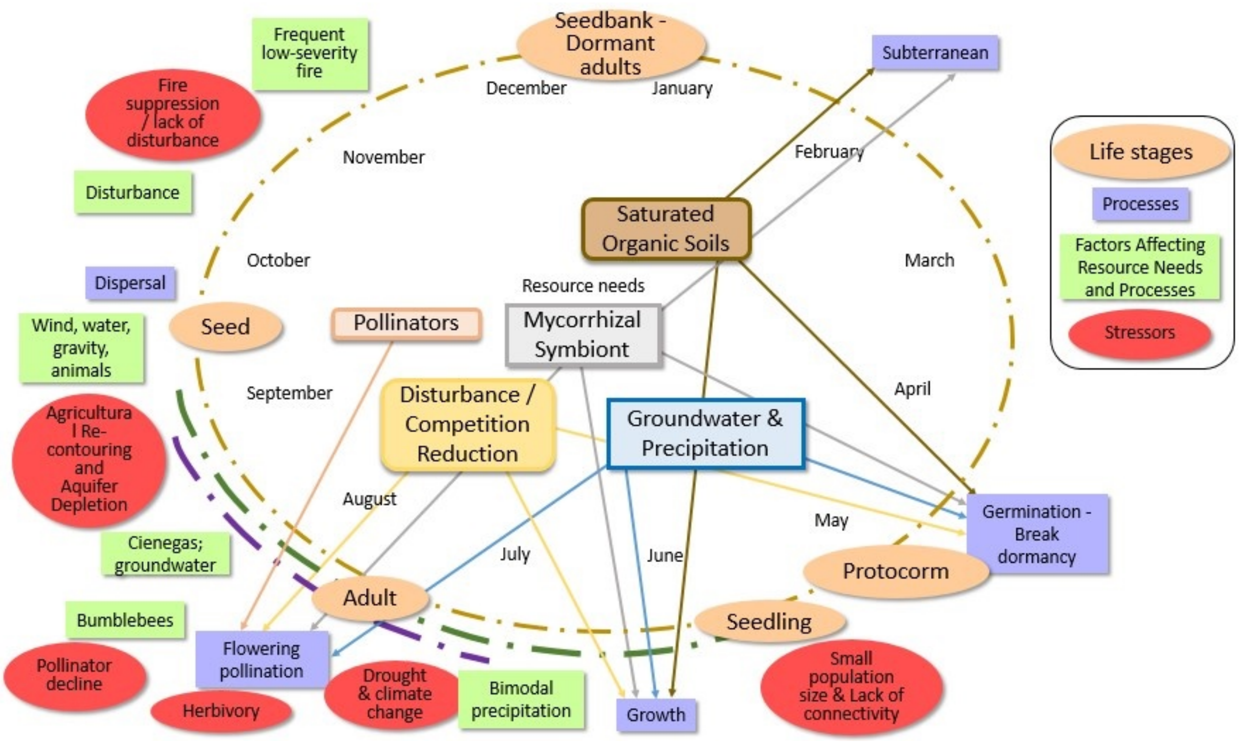


Figure 4.1. Life history of Canelo Hills ladies' tresses (*Spiranthes delitescens*) including life stages, processes, resource needs, factors affecting resource needs and threats. Gold line indicates underground stage, green line indicates above ground stage, and purple line indicates flowering stage.

4.1 Loss or Reduction of Ciénega Habitat

Functional ciénegas were much more common prior to the late 1800s, as evidenced by pollen and fire records, General Land Office survey notes, and early trapper and settler diaries (Brunelle *et al*. 2018, p. 2; Cole and Cole 2015, p. 36; Fonseca 1998, p. 111; Hendrickson and Minckley 1984, p. 131). Estimates of historical ciénega abundance in the International Four Corners Region of the Southwest (Arizona, Sonora, New Mexico, and Chihuahua) vary from hundreds to thousands of ciénegas (Cole and Cole 2015, p. 36). Many of these ciénegas retain some ecological function or are restorable, while others are so compromised that there is no prospect for their restoration (Cole and Cole 2015, p. 36; Sivinski 2018, p. 4). In a study of 60 ciénegas of the Apache Highlands ecoregion (Arizona, New Mexico, and Sonora Mexico), 46 were extant, the others were dry or so altered they have lost their ecological function and no longer provide services such as water purification, flood control, nutrient cycling, etc. (Minckley *et al*. 2013, p. 218). Cole and Cole (2015, p. 36) note there are currently 155 identified ciénegas existing in the international four corners region of Arizona, Sonora, New Mexico, and Sonora. Of these 155 ciénegas, 87 (56 percent) are either dead or so severely compromised that there is no prospect for their restoration (Figure 4.2). Sivinksi (2019, p. 14) defines "dead ciénegas" as historical ciénegas that no longer have groundwater at or near the ground surface and likely have water tables so severely depleted that restoration, given today's techniques and economics, is not feasible. In addition to the reduced abundance of ciénegas in the International Four Corners Region, the remaining ciénegas are greatly reduced in size and due to many being severely incised, are more like creeks than marshes (Cole and Cole 2015, p. 36). Greater than 95 percent of the historical area of ciénegas is now dry (Cole and Cole 2015, p. 36).

Based on the information available for ciénega abundance, it is highly likely that additional populations of CHLT occurred at some of these historical ciénegas that have since lost their ecological function due to physical alteration (Figure 4.2). We also assume that if historical populations existed, they would have occurred closer to one another, been more connected (through pollination), and contained higher abundances of plants than they are currently.

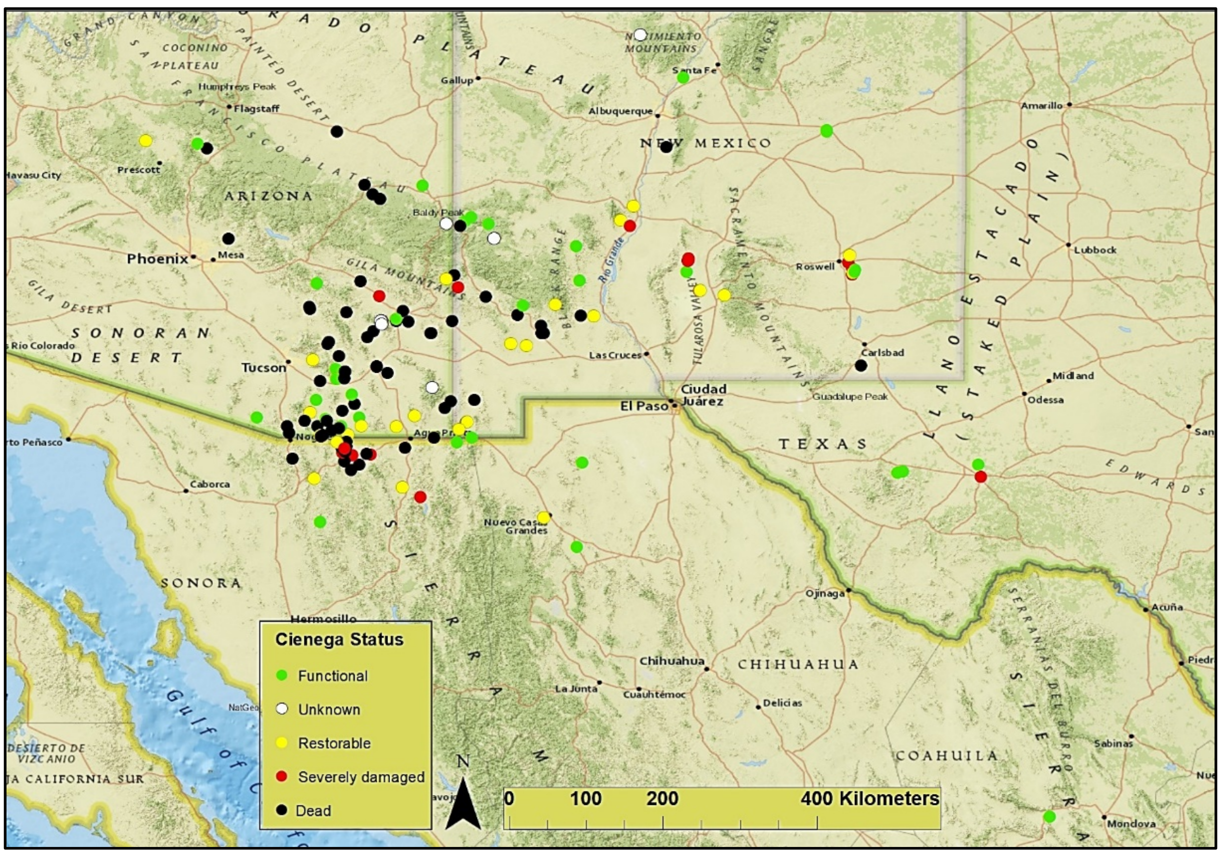


Figure 4.2. Historical ciénega locations and conditions in the international four corners region; Map recreated from data provided by Dean Hendrickson.

The primary factors that led to the loss or reduction of ciénega habitat in the southwest include: a) historical intensive grazing of domestic livestock, b) the historical removal of beaver (*Castor canadensis*) from regional streams and rivers, c) agricultural re-contouring and aquifer depletion, d) drought and climate change, and e) alteration of fire regimes including woody species and nonnative invasion. These factors are discussed below.

4.1.1 Historical Intensive Grazing of Domestic Livestock

Historical livestock grazing at incompatible stocking levels had detrimental impacts to ciénegas in the form of erosion, headcutting (Figure 4.3), increased frequency or intensity of destructive floods, movement of nonnative plants, and other undesirable effects (Cole and Cole 2015, p. 32; Harlow 2015, p. 21; McLaughlin, 2004, p. 128; Hendrickson and Minckley 1984, p. 138). Prior to the 1500s, indigenous people, who saw the ciénegas as sacred, occupied the range of the CHLT and did not have domesticated livestock. By the 1500s, European and other settlers arrived and began raising livestock in the area. By the 1700's Spanish cattlemen had ranches in the Santa Cruz and San Pedro River Valleys. There are records of roughly 100,000 head of cattle in the San Pedro Valley of Arizona by 1694 and over 1,500,000 head of cattle in Arizona by 1891 (Allen 1989, p. 11). In 1854, Bartlett claimed the herds around Babocomari Ranch numbered no fewer than 40,000 cattle, as well as many horses and mules (Hastings and Turner 1984, p. 148).

Figure 4.3. Example of a headcut in southern Arizona. Photo with permission of Jeff Simms, 2016.

Sheep were introduced into the southwestern United States in 1598 and by 1700s, there were great flocks of sheep in southeastern Arizona (Haskett 1936, pp. 4, 7). In 1878, Hinton mentioned there were 7,000 sheep grazing in the area of the Babocomari Ranch (Hastings and Turner 1984, p. 148). By the late 1800s, excessive livestock levels coupled with two years of drought resulted in livestock mortality of fifty to seventy five percent (Allen 1989, p. 13; Hendrickson and Minckley 1984, p. 138). Hendrickson and Minckley (1984, p. 149) estimated that prior to the drought, the combined areas of Cochise, Graham, Pima, and Santa Cruz Counties averaged more than 377,000 cattle. In comparison between 1977 and 1981, they estimate just over 180,000 cattle graze this same area. In summary, by the late 1800s, livestock were present in so great of number as to severely degrade ciénegas, lowering the vigor of native grass plants, increasing the presence of barren soil and erosion, increasing the frequency of destructive flooding, and leading to arroyo cutting (Cole and Cole 2015, p. 32; Minckley *et al*. 2013, p. 214; Allen 1989, p. 13; Hendrickson and Minckley 1984, p. 138). Following excessive stocking and two years of drought, livestock numbers plummeted.

In the 1950s, the Canelo Hills Quarter Horse Ranch in the Canelo Hills area, was sold and the land was subsequently utilized for cattle grazing. This property was grazed by cattle between 1957 and 1969 and then was reverted to horse pasturing (Barstad 1981, p. 29). The nearby Huston (or Triangle M) Ranch was grazed by cattle since before 1977, when it changed ownership to another cattle rancher. This property was heavily altered by irrigation, seeded, dammed, diked, pastured, etc. (Barstad 1981, p. 29). A third nearby ranch, the Z Triangle, was grazed between 1951 and 1977, when it shifted to horse pasturing. The bottomland area was used for raising crops and the stream channel was altered with earth dikes. Between 1977 and 1980, 44.5 ha (110 ac) of this land was sold to the Nature Conservancy and made into the Canelo Hills Ciénega Preserve, with all grazing halted. Another nearby property was also sold to The Nature Conservancy in 1969 following cattle grazing since at least the 1930s (Barstad 1981, p. 32). Headcuts on the property from previous land management practices were reduced by constructing a cement dam. Just downstream from these areas is a U.S. Forest Service grazing allotment that was grazed by cattle prior to 1978 when it was changed to a three to five year grazing recovery study. The nearby Research Ranch was grazed until 1969 when it was removed from grazing for research and protection.

4.1.2 Historical Removal of Beaver from Regional Streams and Rivers

Beaver are important species in structuring wetland plant communities. They inhibit woody plant regeneration, increase sedimentation and areas of ponded water, assist in nutrient cycling, increase water storage, raise the local water table, and potentially supplement low stream flows during dry seasons (Gibson and Olden 2014, p. 393). In the 1820's, trappers reported beaver to be abundant in southcentral Arizona (Gibson and Olden 2014, p. 394; Hendrickson and Minckley 1984, pp. 158-159; Davis 1984, p. 169). In an effort to drain wetlands for agricultural production and to reduce mosquito-borne disease, beaver were drastically reduced or extirpated throughout North America by the early 1900s (Gibson and Olden 2014, pp. 394-395). Following beaver removal by trappers and by way of nuisance management, and in combination with a variety of other land use changes, there was greater erosion, channel cutting, and reduced availability of water in these ciénegas (Gibson and Olden 2014, p. 395; Fonseca 1998, p. 113).

4.1.3 Agricultural Re-contouring and Aquifer Depletion

The ciénega habitats of southeastern Arizona overlap with grassland and woodland communities and are within a short distance of conifer forests and deserts. This closeness to both water for drinking and agriculture, and year-round food resources from nearby plant communities, made the area attractive to prehistoric peoples (Huckell 1995, p. 25). Indeed, by 1500-1000 BC, mixed farming and foraging subsistence was present in southeastern Arizona, with maize, and possibly beans and squash grown in floodplains (Huckell 1995, pp. 97, 119-121, 137). There is no evidence of irrigation use by these peoples, though simple ditch systems may have been used (Huckell 1995, p. 124).

Landscapes of southeastern Arizona prior to the 1800's are in stark contrast to current landscape conditions (Huckell 1995, p. 19). Historical accounts depict broad valleys, shallow perennial streams and ponded waters, and lush vegetation (Huckell 1995, p. 21). Since 1870, however, wetlands in southeastern Arizona have much decreased in surface flow, have deeply entrenched channels in parts, and support many nonnative plants (Bahre 1991, pp, 176-177). Settlers have diverted, dammed, and channeled surface waters, and pumped groundwater for agricultural, mining, disease control, and other purposes (Figure 4.4; Sivinski 2018, p. 6; Cole and Cole 2015, p. 32; Gibson and Olden 2014, p. 395; Guido 2008, p. 2; Hendrickson and Minckley 1984, p. 144). Since the 1940s, technology has enabled deeper wells to be drilled with more powerful pumps (Naeser and St John 1998, p. 187).

Figure 4.4. Example of re-contouring land in southeastern Arizona. Photo credit Andrew Salywon 2016.

Much of the historical damage to lands continues to create problems on the lands today. For example, in an area near the Canelo Hills Population, legacy gullies that were plugged with berms and redirected, now have significant effect on alluvial storage of water (Stream Dynamics 2016, p. 2). Using a Google Earth time slider, Stream Dynamics determined one gully that did not exist in 1992, was over 500 feet long in 2016; this also increases downstream flooding and decreases persistent base flow (Figure 4.5; Stream Dynamics 2016, p. 2). Indeed, prior to the 1890s, floods were common, but they spread over the broad grassy valley bottoms. Once the landscape was altered with ditches, levees, wagon roads, railroad embankments, etc., and downcutting began, the frequency and severity of flooding increased (Hastings 1959, p. 63).

Figure 4.5. Example of a headcut near Canelo Hills Population that, in 2016, was over 500 feet long. Photo by Andrew Salywon, 2016.

Groundwater pumping continues in many portions of this area, including the Sonoita Valley, where numerous small vineyards have become established since the 1980s, occupying over 81 ha (200 ac) and producing tens of thousands of gallons of wine annually (ADWR 2019, entire; Sonoita and Elgin Chamber of Commerce 2019, entire). Naeser and St. John (1998, p. 192 report that in this region in general each acre of grapes is irrigated with 3 to 6 inches of water per year. At 200 acres of grapes that is up to 100 acre-foot of water used annually on grape production. Similarly, more than 75 percent of the agricultural water supply in the nearby Upper San Pedro Basin is groundwater derived (ADWR 2019, entire). The population of this region continues to grow, along with demand for groundwater (ADWR 2019, entire; Naeser and St. John 1998, p. 187).

4.1.4 Drought and Climate Change

Over the next century, the conservation of rare plants will need to consider not only the effect of climate change on species and ecosystems, but also on understanding how other factors interact with climate change to influence species viability (Souther and McGraw 2014, p. 1463). Climate change is an important consideration in the analysis of the future threats to CHLT because of the direct impact to the plant, as well as the dewatering of its rare habitat. Not only does climate affect plants directly, it has been shown that climate coupled with other threats can have a cumulative impact resulting in greater than anticipated decline in rare species. For example, Souther and McGraw (2014, p. 1472) performed projections of viability for a rare northeastern plant with increase in temperature over the next 70 years, with stress from illegal collection of the plant and with the two threats combined. They found the extinction risk was 65 percent for the combined threats, but just 6 percent and 8 percent for these two threats independently.

Continued greenhouse gas emissions at or above current rates will cause further warming with broad implications for living organisms across the planet and the habitat on which they depend (Intergovernmental Panel on Climate Change (IPCC) 2014, p. 8). Climate models indicate that the transition to a more arid climate is already underway and predict that in this century the arid regions of the southwestern U.S. will become drier (i.e., decreased precipitation) and warmer (i.e., increased surface temperatures), and have fewer frost days, decreased snow pack, increased frequency of extreme weather events (heat waves, droughts, and floods), declines in river flow and soil moisture, and greater water demand by plants, animals and humans (Garfin *et al*. 2013, pp. 5-6; Archer and Predick 2008, p. 23). Increasing dryness in the southwestern U.S. and northern Mexico is predicted to occur as early as 2021-2040 (Seager *et al*. 2007, p. 1181). Analyses of the southwestern U.S. using Coupled Model Intercomparison Project Phase 3 models, show consistent projections of drying, primarily due to a decrease in winter precipitation (Collins *et al*. 2013, p. 1080).

When temperatures rise, as has been occurring in recent decades and as is projected to continue into the future, transpiration rates also increase. Transpiration is evaporation of water from plant leaves. Higher temperatures cause stoma (the plant cells which control the openings) to open allowing water to be released to the atmosphere (United States Geological Survey 2017, entire). Transpiration accounts for about ten percent of the moisture in the atmosphere, with the rest coming primarily from evaporation from water bodies. Both CHLT and its associated species may be impacted by higher evapotranspiration rates.

Climate change over the 21st century is additionally projected to reduce renewable surface water and groundwater resources in most dry subtropical regions (IPCC 2014, p. 69). For rivers sustained by rainfall runoff and regional groundwater inflow, regional warming is causing evaporation rates to increase and stream recharge rates to decrease, and thus producing declines in stream base flows and water tables (Stromberg *et al.* 2015, p. 4). Canelo Hills ladies' tresses occurs within two watersheds in southern Arizona, the San Pedro basin and the Santa Cruz River basin, both are largely recharged by intermittent rainfall-driven stream flow events (Serrat-Capdevila *et al.* 2007, p. 52; Erwin 2007, pp. 23-25, 38). Serrat-Capdevila *et al*. 2007 (entire) modeled the effects of four climate change scenarios on the hydrology of the San Pedro River basin, with groundwater extraction maintained equal to the rate at the time of the study. Results indicate that over the next 100 years, groundwater recharge in the San Pedro River basin will decrease 17-30 percent, depending on the climate scenario considered (Serrat-Capdevila *et al*. 2007, p. 63) and average annual base flow will be half the base flow in 2000. As the area gets drier, the San Pedro aquifer groundwater overdraft will become more severe as recharge declines and groundwater pumping increases (Meixner *et al*. 2016, p. 135). Similarly, Shamir *et al*. (2015, entire) studied climate change projections of precipitation for the Upper Santa Cruz River using eight climate change scenarios, and concluded there would be increased variability and uncertainty in winter and summer precipitation and recharge in this arid region.

In summary, the future effects of global climate change and drought on CHLT have been and likely will continue to be great. Decreases in precipitation in summer impact plant growth and decreases in winter precipitation reduce ciénega recharge. More severe weather during the summer equate to a higher probability of severe flooding events. Dryer conditions, coupled with increases in nonnative grasses and higher fire starts equate to more frequent and severe fire events (see next section). And lastly, dryer conditions result in higher levels of evapotranspiration and water loss from CHLT habitat. We will continue to assess the potential threats of climate change and drought as additional scientific information becomes available.

4.1.5 Alteration of Fire Regimes

The desert grasslands and woodlands of southern Arizona historically had large-scale low severity fire roughly every 10 to 20 years and following periods of adequate moisture (McPherson and Weltzin 2000, p. 5; Brooks and Pyke 2002, p. 6; McDonald and McPherson 2011, p. 385; Fryer and Luensmann 2012, entire). Burning was frequent enough to remove woody plants (e.g., hackberry [*Celtis*], cottonwood [*Populus*], ash [*Fraxinus*], and willow [*Salix*]) from the wetlands and suppress the abundance of native rhizomatous plants (plants with a stem situated either at the soil surface or underground that contains nodes from which roots and shoots originate) such as bulrush (Davis *et al*. 2002, p. 393; Baker *et al*. 1998, p. 5; Fonseca 1998, p. 114). The occurrence of these wildfires declined after 1882, likely due to high intensity livestock grazing and the resulting lack of understory vegetation to carry fire (Bahre 1985, p. 190; Leopold 1924, p. 3). In addition, early Anglo settlers of the area advocated active fire suppression (Bahre 1985, p. 194). Indeed, Leopold (1924, p. 6) indicated that livestock grazing was used to reduce fire hazards at the turn of the century.

Fires today are more frequent and severe due to the unnaturally dense and evenly spaced canopies of nonnative plants, drought conditions, and more frequent anthropogenic fire starts, such as from cross-border violators (Anable *et al*. 1992, p. 186; D'Antonio and Vitousek 1992, p. 75; Williams and Baruch 2000, p. 128; Crimmins and Comrie 2004, p. 464; Emerson 2010, pp. 15, 17). Nonnative grasses have higher seed output and large seed banks, earlier green-up in the spring, and greater biomass production than native grasses; all of these characteristics help to perpetuate a grass-fire cycle (e.g., D'Antonio and Vitousek 1992, p. 73; Zouhar *et al*. 2008, pp. 17, 21; Steidl *et al*. 2013, p. 529). While ciénegas are in the headwaters and historically did not have scouring floods, flooding, erosion, and sedimentation are all possible in ciénegas today due to surrounding vegetation communities, often infested with nonnative plants, burning with more frequency and intensity.

In addition to nonnative plants in the surrounding uplands, modern ciénegas may include less diversity of native understory species adapted to disturbance. Modern ciénegas may have an increase in native woody, clonal, and nonnative plants, such as that seen in at the Canelo Hills Population (Stromberg *et al*. 2017, p. 10). As water levels in ciénegas decrease and as $C0_2$

increases, woody plants invade if there is no disturbance to prevent invasion (Huxman and Scott 2007, p. 1). These woody plants also alter streamflow through increased evapotranspiration. Invasive non-native plants are of concern because they often quickly colonize an area and aggressively compete with native species for sunlight, water, and nutrients. Commonly associated invasive non-native species in CHLT habitat include Johnson grass (*Sorghum halepense*), foxtail (*Hordeum jubatum*), Bermuda grass(*Cynodon dactylon*), and watercress (*Nasturtium officinale*) (Harlow 2015, p. 22; Gori 1993, p. 1; Lamma 1982, p. 1).

Canelo Hills ladies' tresses evolved with frequent, low severity fires, which remove fine fuels thus benefitting the species in a number of ways (e.g., increase in nitrogen, reduced competition). However, high severity fires may be detrimental to the species and its habitat. For example, indirect impact of high severity fire may include hydrophobic (repels water) soil, increased runoff of floodwaters, post-fire flooding, deposition of debris and sediment originating in the burned area, erosion, changes in vegetation community composition and structure, increased presence of nonnative plants, and alterations in the hydrologic and nutrient cycles (Stephens *et al*. 2013, p. 42; Hart *et al*. 2005, p. 167; Smithwick *et al*. 2005, p. 165; Crawford *et al*. 2001, p. 265; Griffis *et al*. 2000, p. 243). In many locations in southern Arizona in recent decades, repeat fires, often with high severity, have occurred within short periods of time. Figure 4.6. shows the perimeter of 11 fires that burned near CHLT populations between 2002 and 2017 (USGS 2018, entire). Severity of burn within the Canelo Hills and Babocomari Populations are shown in Figures 4.7 and 4.8. This fire burned largely at moderate to high severity. Although we do not know effects of high severity fire on CHLT, we do know that immediately after the Ryan Fire of 2002, five individuals were found at Canelo Hills Population and no CHLT have been seen aboveground in any year since this burn.

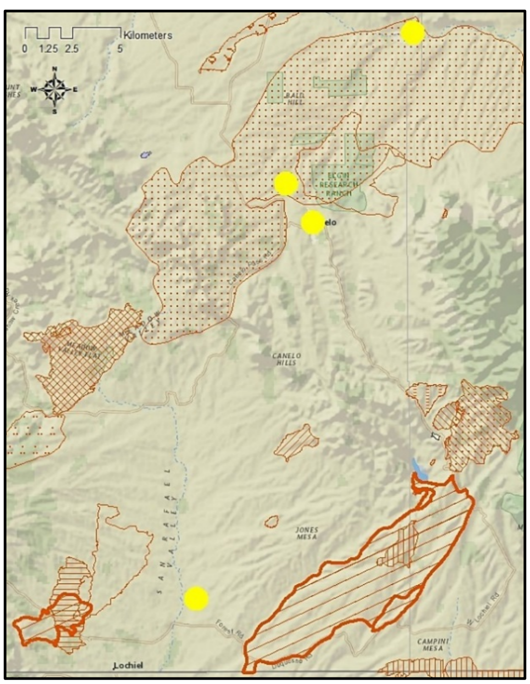


Figure 4.6. Location of 11 wildfires that burned near populations of CHLT between 2002 and 2017, as represented by different fill patterns.

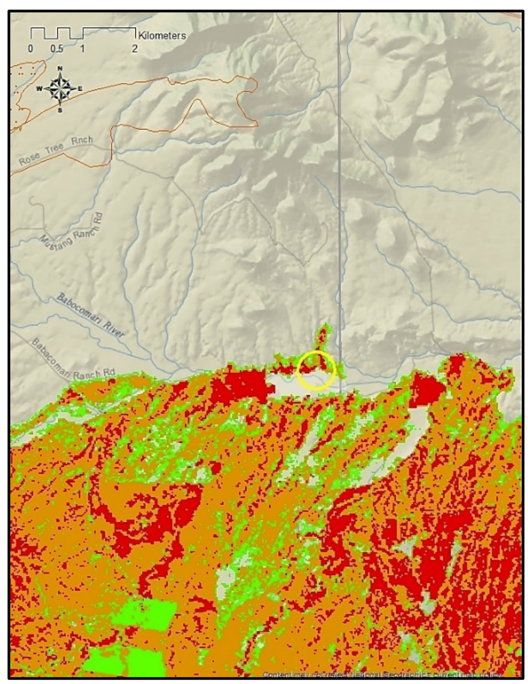


Figure 4.7. Fire severity map of the Babocomari Population and the 2002 Ryan Fire. Light green represents low severity, orange is moderate severity fire, and red is high severity fire.

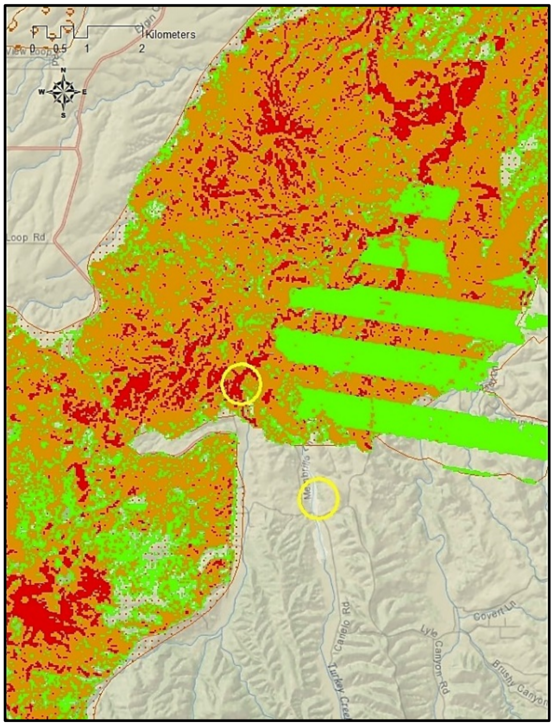


Figure 4.8. Fire severity map of Canelo Hills and Turkey Creek Populations and the 2002 Ryan Fire. Light green represents low severity, orange is moderate severity fire, and red is high severity fire. Light green strips represent fuel treatment areas.

4.2 Pollinator Decline

As previously described in Chapter 2, the primary pollinators of *Spiranthes* species are medium to large, long-tongued bees, especially of the genus *Bombus* (bumblebees; Argue 2012, p. 34; Gori 1994, p. 1) and most likely Sonoran bumblebees (Buchmann pers. comm. October 4, 2019). The number of Sonoran bumblebees varies by year, depending upon host plants whose bloom depends on rainfall (Bugguide 2019, entire). The Committee on the Status of Pollinators in North America (2007, p. 289) recognizes the Sonoran bumblebee as a bee species in decline in North America. Texas Parks and Wildlife (2019b, entire) considers *B. sonorou*s as a species of greatest conservation need (species of greatest conservation need, Accessed October 9, 2019). Cameron *et al*. (2012, p. 666) indicated that it is possible that the Sonoran bumblebee may be at risk of decline and deserves monitoring. Further, low availability of pollen and nectar resources (*e.g*., few flowering CHLT) for *Bombus* colonies can result in reduced CHLT seed production (Gori 1994, p. 4).

4.3 Small Population Size and Lack of Connectivity

Small, reproductively isolated populations are susceptible to the loss of genetic diversity, genetic drift, and inbreeding. The loss of genetic diversity may reduce the ability of a species or population to resist pathogens and parasites, to adapt to changing environmental conditions, or to colonize new habitats. Conversely, populations that pass through a “genetic bottleneck” may subsequently benefit through the elimination of harmful alleles. Nevertheless, the net result of loss of the genetic diversity is likely to be a loss of fitness and lower chance of survival of populations and of the species. Genetic drift is a change in the frequencies of alleles in a population over time. Genetic drift can arise from random differences in founder populations and the random loss of rare alleles in small isolated populations. Genetic drift may have a neutral effect on fitness, but is also a cause of the loss of genetic diversity in small populations. Genetic drift may also result in the adaptation of an isolated population to the climates and soils of specific sites, leading to the development of distinct ecotypes and to speciation. Inbreeding depression is the loss of fitness among offspring of closely related individuals. While most animal species are susceptible to inbreeding depression, plant species vary greatly in response to inbreeding.

Small populations are less resilient to losses caused by random environmental changes (Shaffer and Stein 2000, pp. 308–310), such as fluctuations in reproduction (demographic stochasticity), variations in precipitation (environmental stochasticity), or changes in the frequency or severity of disturbance. Similarly, the individual effects of competition, herbivory, predation, border activity, illegal collection, erosion, or other threats could have greater impact on very small populations. Of the four known CHLT populations, three have not been found in recent decades, however, due to the nature of this species and its ability to persist for long periods of time underground, we assume all four populations are extant, but may have few individuals. We assume all populations are small because the largest population ever recorded contained 731 individuals and the most recent number of plants found at the one population where plants were documented was three individuals. We do not know to what extent inbreeding has reduced fitness of any CHLT population, however, given the small size of all populations and the distance between populations, impacts from the threats listed in the above sections are exacerbated due to small population size and individual effects. Examples of individual effects on small populations include herbivory, predation, and illegal collection, which are discussed below.

Herbivory

Invertebrate herbivory has been documented on CHLT at the Canelo Hills and Turkey Creek Populations (Gori 1994, p. 6; Sundt and McClaran 1988, p. I-3. Gori (1994, p. 6) noted that grasshoppers were consuming leaves, stalks, and capsules of this species. In 1998, The Nature Conservancy reported the highest grasshopper herbivory levels recorded in their CHLT monitoring plots, with 76.7 percent of flower stalks impacted by herbivory. The number of plants with herbivory observed in their three monitoring plots between 1993 and 1998 can be found in Table 4.1. We are aware of no observations of herbivory recorded at Babocomari or the San Rafael Valley Populations. Seed predation may occur in any population and could greatly impact a years seed crop, though this has not been reported.

Table 4.1. Number of Canelo Hills ladies' tresses (*Spiranthes delitescens*) individuals in monitoring plots at the Canelo Hills Population between 1993 and 1998. Data derived from The Nature Conservancy 1998, p. 2.

Year	Number Plants with flower stalks	Number of flower stalks impacted by grasshopper herbivory	Percent of flower stalks impacted by grasshopper herbivory
1998	60	46	76.7
1997	1	0	0
1996	42	7	16.7
1995	99	29	29.3

Year	Number Plants with flower stalks	Number of flower stalks impacted by grasshopper herbivory	Percent of flower stalks impacted by grasshopper herbivory
1994	76	50	65.8
1993	67	28	41.8

Although we are not aware of any documentation of vertebrate herbivory on this species, CHLT is a highly palatable plant and, like other *Spiranthes* species, may be preferentially grazed by ungulates, lagomorphs, rodents, and insects (Nally 2016, p. 31; USFWS 2009, p. 33; USFWS 1992, p. 2051). Harlow (2015, pp. 21, 25) noted that livestock grazing may occur on CHLT and could be detrimental during times of prolonged drought, when other preferred plants are scarce. While grazing during the non-flowering season benefits the species, Gori (1994, pp. 6-7) emphasizes the need for grazing to be outside of the months of June through August, when flowering stalks are present, as herbivory of flowers and seed capsules could reduce reproduction and genetic exchange.

Illegal Collection

Illegal collection of CHLT has not been documented; however, collection pressure from rare plant or orchid enthusiasts has been reported as a threat (Harlow 2015, p. 18; Gori 1994, p. 6). This species is so rare, that if location information were made public, it is possible that collection of the few remaining individuals could severely impact this plant at the species level.

4.4 Summary

Our analysis of threats to CHLT revealed that there are a number of historical and ongoing threats to this species. The primary ongoing threats to CHLT are 1) loss of ciénega habitat from drought and aquifer depletion, 2) pollinator decline, 3) herbivory and predation, and 4) small population size and lack of connectivity. The loss of ciénega habitat is a complicated threat encompassing many aspects of both historical and current events that impact the species and its habitat. These include: intensive historical grazing of domestic livestock, removal of beaver from regional streams and rivers, agricultural re-contouring and aquifer depletion, drought and climate change, and alternation of fire regimes. In addition to the reduced abundance of ciénegas, the remaining ciénegas are greatly reduced in size and due to many being severely incised, they are more like creeks than marshes (Cole and Cole 2015, p. 36). Greater than 95 percent of the historical area of ciénegas is now dry due to ciénega loss or shrinkage of wetted area (Cole and Cole 2015, p. 36).

CHAPTER 5 – CURRENT CONDITIONS

In this chapter, we present information on the demographic and habitat factors we used to evaluate the current condition of CHLT, and how they influence the species' viability in terms of its resiliency, redundancy, and representation.

5.1 Introduction

The best available information on the current condition of the species indicates that in 2019, there were three aboveground individual CHLT within a single population and unknown numbers of underground individuals at this and three additional populations. To date, conservation efforts include periodic monitoring, removal of encroaching trees at one location, and seed collection from a second location. Historical data was collected sporadically within the four populations, but some correlation can be made between declines in aboveground plants and drought, groundwater reduction, increases in competition, and increased severity of fires. Table 5.1 indicates the number of populations and aboveground individuals recorded from throughout the range of CHLT.

Table 5.1. Canelo Hills ladies' tresses (*Spiranthes delitescens*) populations and greatest number of individuals recorded at each. The term "present" means the plant was found, but no counts were made.

Population	Populations / Subpopulations with >60 individuals historically	Least number of individuals recorded	Greatest number of individuals recorded
Babocomari	0	present	present
Canelo Hills TNC	1	5	564
Canelo Hills FS	0	2	4
San Rafael Valley	1	present	731
Turkey Creek	0	3	56
Total	2	10+	1,355+

5.2. Populations

Unless otherwise noted, information within this section comes from the Arizona Heritage Database Management System (Natural Heritage Program that is part of a global network of over 80 programs and data centers). Most historical data comes from herbarium collection information; data that is more recent is largely from surveys for CHLT led by the Desert Botanical Garden, The Nature Conservancy, and the USFWS. In the survey data tables in this section: the term 'present' means plants were found, but no population count was made. We have limited information on the microhabitat variables at each of the CHLT populations. What information we do have is presented below.

5.2.1 Babocomari Population

Canelo Hills ladies' tresses occurs in the Babocomari Population on private land (Figure 5.2). The ciénega at the Babocomari Population is in the headwater reaches of the Babocomari River, a tributary of the San Pedro River. The ciénega possesses dense understory cover, predominantly of rhizomatous or stoloniferous (a creeping horizontal plant stem) graminoids (plant with a grass-like morphology) and forbs (non-woody plants) such as common spikerush (*Eleocharis palustris*), Baltic rush (*Juncus balticus*), and Yerba mansa (*Anemopsis californica*; Stromberg *et al*. 2017, pp. 11 and 25). Soil organic matter in this ciénega was found to be 25±2 percent in both the top 10 cm and in soils up to 20 cm in depth (25±2 percent). In 1981, the site was considered to be "marshy" (Bailowitz, herbarium specimen).

The Bobacomari Population was first documented in 1981, and then observed again in 1998 and 2008. Though the number of plants was not recorded at this site in any year, in 2008 it was said to be "abundant" (Stromberg *et al*. 2017, p. 8). There have been additional surveys for the plant at this location in 2015, 2016, and 2019, but no CHLT were located. We assume there are a small number of individuals in the Babocomari Population either obscured by dense vegetation or that remain dormant underground.

Agricultural practices began on the land encompassing the Babocomari Population by the late 1600's (Babocomari Ranch History 2019, entire), and livestock grazing on this land has occurred ever since. To help combat damage to the land from historical unsustainable livestock grazing levels, the owners who purchased the land in 1935 began range management conservation practices that are continued today by their descendants. Currently, we are unaware of the grazing regime or the number of cattle present annually at the Babocomari Ranch Population or of specific land management practices such as invasive plants management.

Figure 5.1. Babocomari Canelo Hills ladies' tresses (*Spiranthes delitescens*) Population and general area.

5.2.2 Canelo Hills Population

The first documentation of CHLT from Canelo Hills Population area is the 1968 collection by Paul S. Martin. However, Artz (1970, entire) indicates that in 1938, CHLT were found at the Canelo Hills Population in great profusion, and had been sighted three times previous to 1938 though in small numbers. It is not known if these supposed sightings prior to 1938 were all at the Canelo Hills Population or among the other known populations.

The Canelo Hills Population occurs on O'Donnell Creek, which joins Turkey Creek 5 km from the confluence with the Babocomari River. Between 1989 and 2015, notable changes occurred in the vegetation community of this ciénega: there has been an increase in woody (e.g., Bonpland willow [*Salix bonplondiana*], golden current [*Ribes aureum*], alligator juniper [*Juniperus deppeana*], Arizona walnut [*Juglans major*], and Arizona grape [*Vitis arizonica*]) and clonal perennial plants (e.g., dogbane) and a decrease in annual species (Stromberg *et al.* 2017, p. 10). Soil organic matter in this ciénega was found to be 25±2 percent in both the top 10 cm and 20±2 percent in soils up to 20 cm in depth (Stromberg *et al*. 2017, p. 11).

The lands surrounding the Canelo Hills Population have a history of domestic livestock grazing since the 1880s. In 1969, TNC purchased 165 acres and created a preserve to protect and restore native aquatic and wetland species, along with adjacent riparian communities and the surrounding upland communities. All livestock use on the new preserve was stopped, while nearby lands, both private and public, continue grazing. Headcuts on the preserve and nearby lands, likely caused by previous land management practices, were controlled by concrete dams and other management actions. Management by TNC has included introduction of prescribed fire, nonnative plant removal, and supporting applied and academic research on species ecology and restoration techniques.

<u>TNC and FS Subpopulations</u>

There are two subpopulations of CHLT within the Canelo Hills Population, one on FS land (Coronado NF Subpopulation) and the other within the Canelo Hills Population TNC Subpopulation. These subpopulations were separated by roughly 800 meters of riparian corridor; a distance that enabled pollination between the two groups of plants. The TNC Subpopulation has the longest history of monitoring of any CHLT location, with documentation of plants 27 times between 1968 and 2002. At the last time CHLT plants were seen here in 2002, 5 individuals were recorded. Canelo Hills ladies' tresses plants were not detected during seven surveys of the subpopulation between 2010 and 2019. In 1996, four CHLT plants were documented on adjacent Coronado National Forest lands (TNC 1996, p. 1). These plants were enclosed in a larger livestock exclosure fence in 1998 and remain in this enclosure as of 2021 (Heitholt pers. comm. April 21, 2021). Canelo Hills ladies' tresses plants were not detected during surveys of the Coronado NF Subpopulation area in 2015 or 2019. It is reasonable to assume there are a small number of individuals in the Canelo Hills Population, either obscured by dense vegetation or that remain dormant underground.

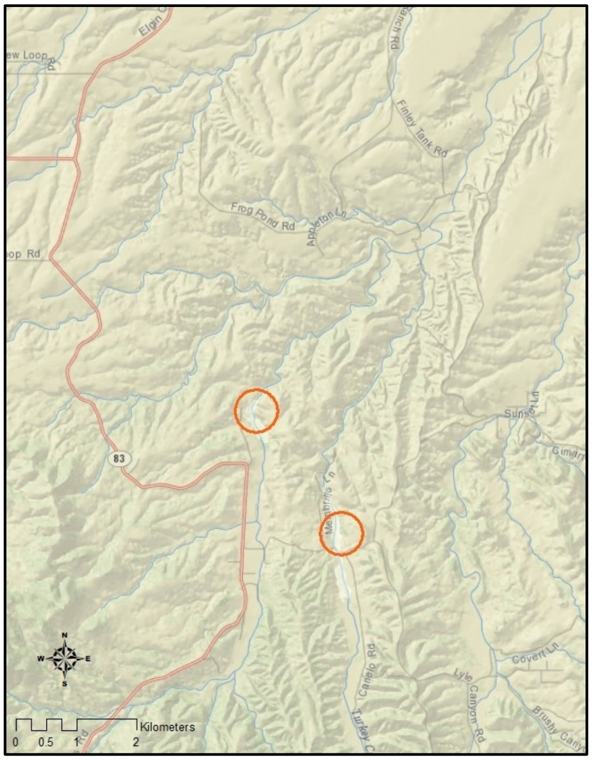


Figure 5.2. Canelo Hills and Turkey Creek Canelo Hills ladies' tresses (*Spiranthes delitescens*) Populations.

5.2.3 Turkey Creek Population

The Turkey Creek Population occurs on private land along Turkey Creek, which runs parallel with O'Donnell Creek; joining it 5 km from the confluence with the Babocomari River. The Turkey Creek Population has been documented 14 times between 1968 and 2019. The last time CHLT plants were seen here was in 2019, when 3 individuals were recorded. In 2016, it was noted that understory vegetation at this site was more sparse than other CHLT populations and included rhizomatous graminoids such as spikerush, stoloniferous forbs such as California loosestrife (*Lythrum californicum*), perennials and annuals.

The Turkey Creek Population has a history of domestic livestock grazing since the 1880s, which continues to this day, and the land has been owned by a single family for over 100 years. As with the Babocomari Population, we are unaware of the grazing regime or the number of cattle present annually at the Turkey Creek Population or of specific land management practices such as invasive plants management.

5.2.4 San Rafael Valley

The San Rafael Valley Population is located on private land in a ciénega in the headwaters of the upper Santa Cruz River. It was first documented in 1980, and then again observed in 1995, 1999, and 2006. Canelo Hills ladies' tresses plants were not detected during surveys of the San Rafael Valley Population in 2015 or 2019. Individual plant counts have never been made for this population.

The San Rafael Valley has been grazed continuously since 1823 as a cow/calf cattle ranch (Harlow 2015, p. 3). Since 2000, the lands surrounding the ciénega have been grazed at sustainable levels, and the property owner has added new water sources, and implemented deferred grazing in riparian pastures during April to November annually (Harlow 2015, p. 3). The ciénega where CHLT occurs is grazed one to two weeks at a time for a total of four to six weeks in any year; in some years the pasture is not grazed (Harlow 2010, p. 13).

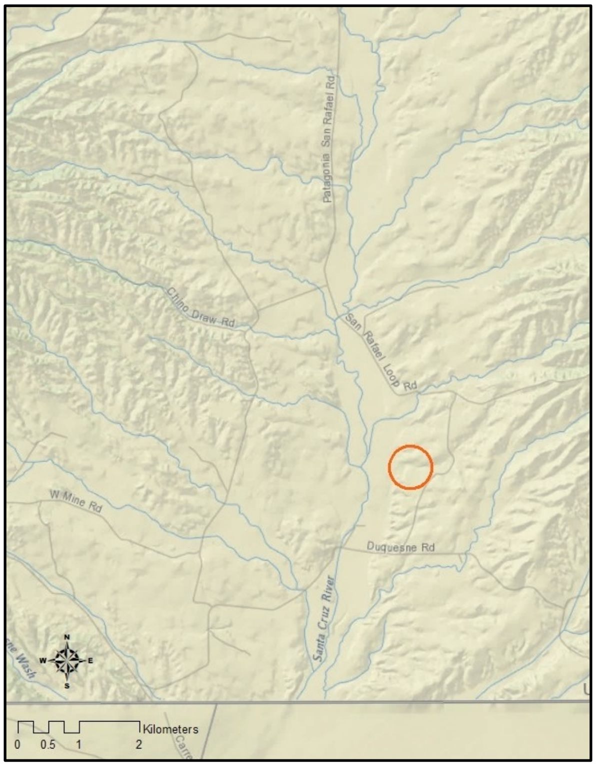


Figure 5.3. San Rafael Valley Canelo Hills ladies' tresses (*Spiranthes* delitescens) Population.

5.3. Current Population Resiliency

There are multiple factors that can affect the resiliency of CHLT populations. These include demographic factors such as abundance, the number of subpopulations, and recruitment; as well as habitat factors such as saturated soils, precipitation and groundwater recharge, level of disturbance, competition, mycorhizal symbionts, and pollinator presence. For our analysis of population resiliency, we focused on those factors for which we have sufficient data to assess population-level influences on the current condition of CHLT populations.

5.3.1 Demographic Factors

<u>Abundance</u>
For populations of CHLT to be resilient, abundance should be large enough that local stochastic events do not eliminate all individuals, allowing the overall population to recover from any one event. A greater number of individuals in a population increases the chance that a portion of the population will survive. For rare plants, a minimum population size of 100 is suggested to prevent inbreeding depression and more than 1,000 individuals may be required to maintain evolutionary potential (Maschinski and Albrecht 2017, p. 392; Jameison and Allendorf 2012, p.

580). One thousand individuals is also the cutoff used by Nature Serve to differentiate between critically imperiled and imperiled species (NatureServe 2019, entire).

The survey data available for CHLT includes the total number of flowering, and sometimes, non-flowering plants from each of the four populations sporadically over time. Plant numbers fluctuate annually pending competition, groundwater availability, and other factors. The greatest population size recorded since the species was first detected in 1968 was 731 individuals in the San Rafael Valley in 1999. The two highest population counts for any location were 731 and 564 individuals; the average of these is 648. We therefore use 650 individuals as our cut off for the abundance of CHLT to be in a high resiliency category. Because 100 individuals is a minimum for preventing inbreeding depression, we use this number as our cutoff for abundance to be in a Moderate resiliency category, making anything under 100 individuals in a Low resiliency category.

Number of Subpopulations

For populations of CHLT to be resilient, they also need multiple subpopulations per population so that local stochastic events do not eliminate the entire population, allowing the population to recover through seed dispersal from other subpopulations within the population. Subpopulations within a population are close enough to one another to support pollen exchange between individuals and groups of plants (separated by less than the distance the primary pollinator can travel, in this case, we assume approximately 960 meters). It is possible that some threats may impact some subpopulations but not others. The necessary number of subpopulations per population is unknown; however, estimations can be attained from available data. It is very likely that interconnected ciénega systems could have supported multiple CHLT subpopulations historically (For example, the existence of two subpopulations within the Canelo Hills Population). Similarly, Ute ladies' tresses and Navasota ladies' tresses are known to occur at multiple subpopulations within populations (USFWS 2018, p. 4; USFWS, 2009, p. 2). We, therefore, consider populations with three or more subpopulations to have high resilience, those with two subpopulations to have moderate resilience, and those with a single subpopulation to have low resilience.

Recruitment

Resilient *S. delitescens* populations must be present aboveground, produce and disperse seeds, establish seedlings that survive, and maintain mature reproductive individuals in the population. Presence of individuals aboveground allow for recharging nutrient and carbon storage, as well as, provide the possibility of recruitment. Current population size and abundance reflects previous influences on the population and habitat, while reproduction and recruitment reflect population trends that may be stable, increasing or decreasing in the future. Because there is no data available regarding seed production, seedling development, or seedling establishment in the wild, this element is not rated in our analysis.

5.3.2 Habitat Factors

Habitat parameters needed for resilient CHLT populations include: finely grained, highly organic, and seasonally or perennially saturated soils; bimodal precipitation with winter snow and rain, and summer monsoon rain; open ciénegas with full sun and disturbance to reduce competition; suitable mycorrhizae, and the presence of pollinators for cross pollination and increased genetic diversity. Habitats with appropriate levels of these parameters are considered to contribute to resiliency, while those habitats with levels outside of the appropriate ranges are considered to provide less resiliency. Habitat in Low condition is more susceptible to loss from a single stochastic event such as groundwater withdrawal or drought.

Saturated Organic Soils in Ciénegas

Resilient CHLT populations need fine grained, highly organic, and seasonally or perennially saturated soils. Canelo Hills ladies' tresses need this source of stability, nutrients, and water for all aspects of its lifecycle including germination, growth, and reproduction. One observation of the species occurring adjacent to a hillside seep with ample moisture, indicated excessive growth habit of the plants (up to a man's waist; Hicks pers. comm. January 21, 2020). Because CHLT relies on seasonally or perennially saturated soils, we consider ciénegas with perennial standing water to be in High condition, those with intermittent standing water to be in Moderate condition, and those with only moist soils to be in Low condition. Ciénegas that no longer have appropriate soil moisture levels are not habitat for CHLT.

Precipitation and Groundwater Recharge

Resilient CHLT populations need adequate winter precipitation and summer monsoons for groundwater recharge, maintaining saturated soils, mycorrhizae health, and CHLT growth and flowering. In addition, the age of the groundwater is important to determine how much recharge is coming from precipitation and how much may be much older water from aquifers, this has implications for management of land uses that extract groundwater. The minimum amount of precipitation needed for individual survival is unknown, however, aboveground growth and flowering of CHLT is reduced during periods of water stress (Gori, pers. comm. February 2, 2016; Gori and Backer 1999, p. 1; McClaran 1996, p. 162-163; Gori 1994, p. 3). Precipitation within southern Arizona is bimodal with winter snow and rain, and summer monsoon rain. We assume that deviation from the timing and amount of precipitation would impact the resiliency of a population, because soil moisture would be impacted. This would lead to increased desiccation; decreased growth; alterations in the timing or amount of flowering, which may result in pollinators not being present during flowering; lack of flowering; and decreased recruitment.

Current winter precipitation was quantified using Western Region Climate Center total precipitation for the months of October-March (deemed most important for CHLT groundwater recharge). To determine the high and low thresholds for winter precipitation, we took the highest and lowest recorded winter precipitation in the most recent complete year of record for six weather stations nearest the CHLT populations (Canelo 1NW, Fort Huachuca, Nogales, Patagonia, San Rafael Ranch, and Sierra Vista). The high was 32.2 cm (12.68 in) of winter precipitation at Canelo 1 NW and the low was 4.67 cm (1.84 in) at Sierra Vista. To determine the moderate winter precipitation ranking, we took the average winter precipitation across the periods of record for the six weather stations (14.22 cm [5.6 inches]). Therefore, using this information, we rated populations with up to 12.7 cm (5 in) of precipitation during the winter months as Low, populations with 12.75 to 30.5 cm (5.1 to 12 in) of precipitation as Moderate, and over 30.55 cm (12 in) as High.

Level of Disturbance and Competition Reduction

Historically, ciénegas burned at low severity and were lightly grazed by native mammals with regularity (e.g., medium levels of disturbance that cleared understory vegetation and thick duff layers which accumulate annually, but without the level of disturbance that encourages nonnative plant invasion or erosion). Because most ciénegas are located near headwaters, scouring floods are not common. Canelo Hills ladies' tresses requires open areas free of overstory shading, and frequent low severity fire and high water tables help maintain this open setting. In the absence of other forms of disturbance (e.g., fire), it is also possible that selective, well-managed livestock grazing could create habitat disturbance and open sun conditions favoring CHLT. Because of the CHLT need for some disturbance, we consider populations with regular (every 1-4 years) medium levels of disturbance to be in High condition, those with irregular medium levels of disturbance (every 5-10 years) to be in Moderate condition, and those with medium levels of disturbance in periods greater than 10 years apart or at any frequency with high severity disturbance (e.g., a high severity fire, intense flooding, or intense grazing, such that nonnatives could invade or erosion occur) to be in Low condition.

Mycorrhizal Symbiont

The sybiotic relationship between a fungus and the roots (or seeds) of plants can aid the infected plant in the uptake of water and nutrients, as well as provide disease and herbivory resistance. All orchid species utilize mychorrhizae at all stages of their life cycle, even when the plant is aboveground and photosynthesizing, as isotope studies have shown that most orchids get carbon from both photosynthesis and mycorrhiza (Whigham pers. comm. October 7, 2019). Hicks notes that *Cypirpedium* spp. have no identified mycorrhizae, however. Regardless, not only must the correct mycorrhizae be present at the site to infect *S. delitescens*, the mycorrhizae must have suitable organic matter and moisture to occur in abundance (Whigham pers. comm. October 7, 2019). Because information on mycorrhizae within the four populations is largely absent from the literature, this element is not rated in our analysis.

Pollinator Presence

Canelo Hills ladies' tresses requires pollinators for pollen transfer within and between plants. The primary pollinator of the species is thought to be the Sonoran bumblebee (Buchmann pers. comm. Oct 4, 2019; Gori 1994, p. 2). Because the species requires pollinators and is unable to reproduce vegetatively, small, scattered populations are at greater risk of extirpation through lack of reproduction. The physical clustering of numerous plants in close proximity is probably necessary for effective genetic mixing and seed production, though this has not been studied in this species. The availability of pollinators of this species is largely absent from the literature, and therefore this element is not rated in our analysis.

5.3.3 Population Resiliency Categories

In this section, we describe our methodology for assessing the resiliency of each CHLT population. We first define our understanding of what the various condition categories (i.e., High, Moderate, Low, and Extirpated; Table 5.2) are for each analysis factor. To analyze population resiliency levels, we used the following factors: abundance; number of subpopulations; saturated organic soils, winter precipitation, and frequency of low to medium levels of disturbance. Some factors rely on qualitative metrics while with others, where more data is available, we were able to develop quantitative metrics. We assigned a numerical value to the condition categories, High=3, Moderate=2, Low=1, and Extirpated =0, so we could calculate an overall score.

For some populations the specific information was not available; however, using our best professional judgement we made assumptions to complete our analysis based on what we do know about this species and similar species, habitat conditions, and the data reported. Systematic, regular surveys have not been conducted throughout the full range of this species. Survey information within and among populations varies in timing, data collected, and surveyor.

Table 5.2. Condition categories for demographic and habitat factors used to evaluate Canelo Hills ladies' tresses (*Spiranthes delitescens*) population resiliency.

Condition Categories	Demographic Factors		Habitat Factors		
	Number of Subpopulations	**Abundance**	**Saturated Organic Soils Ciénega**	**Winter (Oct-Mar) Precipitation**	**Frequency and Intensity of Disturbance**
High (3)	Three or more subpopulations of plants exist within the population.	Number of flowering plants in each population is > 550 individuals.	Ciénega with year-round standing water.	More than 12 inches of winter rain on average during the past 5 years as recorded at the nearest weather station.	Light to medium disturbance on a regular basis (every 2-4 years)
Moderate (2)	Two subpopulations of plants exist within the population.	Number of flowering plants in each population is 100 to 550 individuals.	Ciénega with standing water at some point in year.	Between 6.1 and 12 inches of winter rain on average during the past 5 years as recorded at the nearest weather station.	Light to medium disturbance on an irregular basis (every 5-10 years)
Low (1)	The population is composed of a single subpopulation.	Number of flowering plants in each population is < 100 individuals.	Ciénega with moist soils.	6 or fewer inches of winter rain on average during the past 5 years as recorded at the nearest	No light to medium disturbance in over 10 years

Condition Categories	Demographic Factors		Habitat Factors		
	Number of Subpopulations	**Abundance**	**Saturated Organic Soils Ciénega**	**Winter (Oct-Mar) Precipitation**	**Frequency and Intensity of Disturbance**
				weather station.	
Functionally Extirpated (0)	No subpopulations.	No individuals are found during surveys in appropriate microhabitat in excess of 30 years	Ciénega has dried; no suitable habitat remains	Drought situation	Disturbance is too infrequent to remove competing vegetation, or heavy and frequent such that it impedes survival and reproduction.

We averaged all the condition category scores for each population to determine the overall resiliency score. To provide context for this score, we established an overall resiliency scale from 0 to 3 to communicate our understanding of the overall condition of each population (Table 5.3). To determine the overall resiliency scale we first determined the highest score attainable (3) and the lowest score attainable (0). Within this range, we established four overall resiliency levels based on the number of population and habitat factors in the condition categories as shown in Table 5.3. Appendix 1 provides the ranking of each population and habitat factor for current condition.

Table 5.3. Overall resiliency scale with scoring.

Scale	Scoring Range
Functionally Extirpated	0–0.48
Low	0.5–1.49
Moderate	1.5–2.49
High	2.5–3

The current resiliency of the four known CHLT populations are provided in Table 5.4 below and are based on condition categories in Table 5.2. As only the Canelo Hills Population has more than a single subpopulation, it was the only population to score above a 1 in this category. Populations with 1-50 individuals at last sighting were given a score of 0.5, unless the population has been seen aboveground in the past ten years, then it was given a score of 1, as in the case with the Turkey Creek Population. Winter precipitation data for the Babocomari, Canelo Hills, and Turkey Creek Populations were based on the Canelo Weather Station data. Winter precipitation for the San Rafael Valley Population used a combination of San Rafael Ranch Weather Station and Canelo Weather Station data.

Table 5.4. Current resiliency of the four known Canelo Hills ladies' tresses (*Spiranthes delitescens*) populations in the United States.

Population	**Subpopulation**	**Abundance**	**Saturated Organic Soils**	**Winter Precipitation**	**Disturbance / Competition Reduction**	**Current Condition**
Babocomari	1	0.5	2	2	2	**Moderate (1.5)**
Canelo Hills	2	0.5	1	2	1	**Low (1.3)**
San Rafael Valley	1	0.5	2	1.5	2	**Low (1.4)**
Turkey Creek	1	1	3	2	3	**Moderate (2.0)**

Figure 5.4 depicts the species' current condition across the species' range. The Babocamari and Turkey Creek Populations are in Moderate condition and the Canelo Hills and San Rafael Valley Populations are in Low condition. There are no populations in High condition. The Canelo Hills Population has the lowest overall condition score (1.3), closely followed by the San Rafael Valley Population (1.4) and the Babocomari Population (1.5). The Turkey Creek Population has the highest overall condition score (2.0).

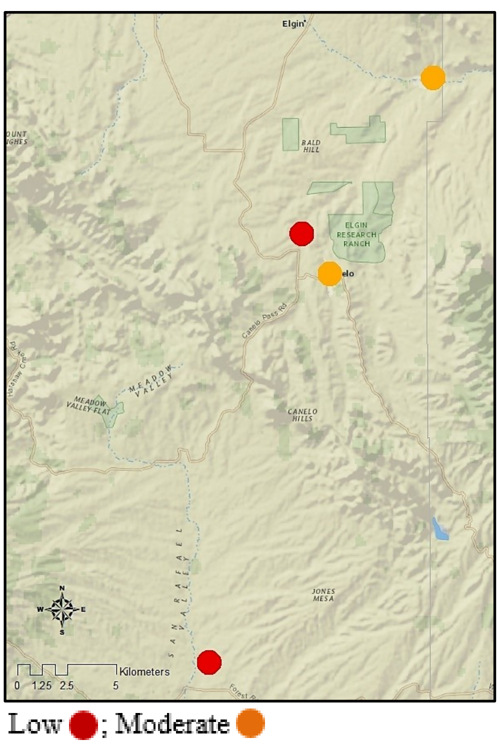


Figure 5.4. Current condition of Canelo Hills ladies' tresses (*Spiranthes delitescens*) populations in the United States.

5.4 Current Species Representation

All four populations of CHLT have the same resource needs, occur within similar habitats, and occupy comparable elevations, indicating that the species lacks ecological diversity. Genetic studies have not been conducted within or among these four populations of however, we consider the species to have some representation in the form of potential genetic exchange, at least between the Canelo Hills and the Turkey Creek Populations, due to their geographic closeness. Populations that are more geographically isolated, such as the Babocomari and San Rafael Valley Populations (separated by over 30 km [19 mi]) may not be as genetically diverse because pollination or transport of seeds between populations may be very limited. Overall, we consider CHLT to lack species representation and we do not expect great localized adaptation within any population.

5.5 Current Species Redundancy

There are currently four CHLT populations distributed across the range of the species, three of which contain a single subpopulation, and one containing two subpopulations. These populations are naturally fragmented in the landscape, so re-establishment through adjacent populations following catastrophic events is unlikely. All four populations currently are believed to contain fewer than 100 individuals and only one population has been recorded above ground in more than a decade. The habitat of all four populations appears to be contracting in size due to drying of habitat and presence of competitive native and nonnative understory plants.

CHAPTER 6 – VIABILITY

In previous chapters we have considered what CHLT needs for viability, the threats that are influencing species viability, and the current condition of all populations. We now consider what the species' future conditions are likely to be by varying the factors from Chapter 5 under four scenarios across a 25-year and a 50-year time step to capture a plausible range of future conditions

6.1 Introduction

Each CHLT population faces a variety of threats at varying levels of risk into the future from natural and anthropogenic threats, including the following:

- loss of wetted habitat from groundwater withdrawal, diversions, evapotranspiration, and drought;
- loss of seedlings, adults, and reproduction from current and future drought;
- loss of sun and space from encroachment of drought tolerant trees, as well as, invasion of dense native and nonnative understory plants;
- high severity wildfires ignited from recreationist, cross border violators, and lightning;
- erosion, sedimentation, and burial from post-wildfire runoff;
- loss of flowers and seed production from trampling or herbivory of wildlife and livestock; or herbivory and predation by insects
- higher frequency or severity of flooding events from current and future climate change with less summer precipitation available for growth and flowering; and
- illegal collection.

Climate change has already begun to affect the regions of Arizona where CHLT occurs, resulting in higher air temperatures, increased evapotranspiration, and changing precipitation patterns, such that water levels range-wide have already reached historical lows (CLIMAS 2021, entire; CLIMAS 2014, entire). These low water levels put the populations at elevated risk of habitat loss due to the reduction of soil moisture. As all four CHLT populations contain low numbers of individuals, with low to moderate resiliency, a single stochastic event such as a high severity wildfire or long-term drought could eliminate an entire population. These impacts are heightened at the species level because the isolation of the populations prohibits natural recolonization among populations. Smaller populations are also more vulnerable to smaller threats such as high competition, erosion, sedimentation, herbivory, predation, and illegal collection. If populations lose resiliency, they are more vulnerable to extirpation, with resulting losses in representation and redundancy.

6.2 Scenarios Assessment

Because we have significant uncertainty regarding: (1) to what degree climate will change in the future, which in turn will have an effect on rainfall and severity of future periods of drought and flooding; (2) the amount of water withdrawal and water diversion that will occur in the future; (3) whether nonnative plants will be aggressively removed or allowed to spread or if native drought tolerant, woody, or rhizomatous plants will be reduced; (4) whether upland forests will be managed for wildfire prevention and more natural low severity fires, or if larger more severe fires will burn; and 5) whether individual effects will impact large portions of these small populations, we have forecast what CHLT may have in terms of resiliency, redundancy, and representation under four plausible future scenarios. These future scenarios forecast the viability of CHLT over the next 25 and 50 years (2046-2071). We chose a 25 year interval as the basis of our evaluation time-step as this is the average number of years between the two longest periods when plants were not seen in two separate populations (Babocomari and Turkey Creek; refer to Table 3.1); and a 50 year interval as the second evaluation time-step because this is within the range of available hydrological and climate change model forecasts, and it represents two of the longest periods of underground existence documented for CHLT.

While we have data to inform us of the threats that are likely to impact CHLT populations in the future, and we understand how these threats can impact CHLT, there is uncertainty regarding the exact risk of the threats to each population because of limitations of the data, such as where and when each threat will occur in the future and exactly which populations will be impacted. Consequently, we made the following assumptions about threats to the ciénegas supporting populations:

- All four populations have equal likelihood of continued drought, increased flooding potential, and decreased winter precipitation; and
- Each of the four CHLT populations are equally likely to be impacted by anthropogenic wildfire starts (originating from cross border violators) due to all populations being within 34 km of the U.S.- Mexico border;
- Nonnative and native invasive plants that can outcompete CHLT are equally likely to occur at all four populations, however dogbane is currently known only from the Canelo Hills Population;
- Because fires have occurred in proximity to all four populations within the past decade, we assume all of the populations have an equal chance of fire from lightning ignition, nonnative fuels, and recreation.

We developed four scenarios incorporating the most significant threats on the species that are ongoing or will occur in the future. For each scenario, we describe the level of impact from the identified threats that would occur in each population. All of the scenarios involve some degree of uncertainty; however, they present a range of realistic and plausible future conditions. Table 6.1 below summarizes the four scenarios. All scenarios consider available water loss due to groundwater withdrawal, dewatering, diversion, evapotranspiration, and drought; reduced growth and reproduction due to drought (primarily from reduction in summer rain); increased competition / lack of disturbance, increased probability of intense flooding events, and, high severity wildfire, erosion, sedimentation, and burial. In addition, effects on individual plants from additional threats are assessed, including trampling, herbivory, predation, and illegal collection. Small populations are assumed to be less resilient to these individual effects. The Continuation scenario evaluates the condition of CHLT if there is no change in threats to the populations relative to what exists today. The Conservation scenario takes into account realistically possible additional protective measures to decrease threats to the populations. The Moderate increase in effects scenario is an increase in the threats to populations with changes in climate as projected at a moderate (between RCP4.5 and RCP8.5) emissions scenario along with increases in other threats, as detailed below. The Major increase in effects scenario is a further increase in threats to populations, with changes in climate projected at a higher (RCP8.5) emissions scenario, and with additional increases in other threats, as detailed below.

Table 6.1 Impact categories. *Available water includes precipitation, soil moisture, humidity, surface water, aquifer recharge, reduction in riparian and invasive woody vegetation, and increased number of days without water.

Threats	**Water Reduction**	**Increased Competition**	**Altered Fire Regime**	**Climate**	**Individual Effects**	**Conservation**
Threat or actions described	Water withdrawal; Water diversion; Decreased winter precipitation (for groundwater recharge); Increased upland vegetation invasion and evapotranspiration	Nonnative plants; Native drought tolerant plants; Native rhizomatous plants	Increased fire starts; Increased litter in uplands; Increased fire severity and frequency	Increased flooding; Decreased summer precipitation (for growth and flowering)	Trampling; Herbivory; Predation; Illegal collection	Conservation actions implemented
Scenario 1 Continuation	Water reduction occurs at the same rate.	Competition from native and nonnative plants occurs at same rate as the last 10 years.	Number or severity of wildfires annually increases at the same rate as the last 10 years. RCP4.5 emissions scenario.	Number or severity of flooding and drought events continue at the same rate as the past 10 years. RCP4.5 emissions scenario.	Applied to populations <50 individuals.	No new individuals; subpopulations or populations found; no augmentation of existing populations; seed preservation occurs; no control of nonnatives; forest may be thinned. RCP4.5 emissions scenario.
Scenario 2 Conservation	Number of water reducing activities does not increase from current condition. Available water remains stable or increases from landscape	Competition from native and nonnative plants is reduced due to management actions.	Number or severity of wildfires does not increase and may decrease from current rate due to	Number or severity of flooding and drought events do not increase past current RCP4.5	Applied to populations <50 individuals.	Sites revisited and additional plants are located, sites are augmented, or new sites are established, additional seed preservation

Threats	Water Reduction	Increased Competition	Altered Fire Regime	Climate	Individual Effects	Conservation
	restoration activities.		thinning in the uplands and nonnative control. RCP4.5 emissions scenario.	emissions scenario.		occurs, nonnatives controlled, forest thinned, water conservation measures in place, RCP4.5 emissions scenario.
Scenario 3 Moderate Increase in Effects	Number of water reducing activities increases from current condition. Available water is reduced. Between RCP4.5 and RCP8.5 emissions scenario.	Competition from native and nonnative plants increases.	Number or severity of wildfires annually increases at a higher rate as the last 10 years. Beween RCP4.5 and RCP8.5 emissions scenario.	Number and severity of flooding and drought events increases over the rate of the past 10 years. Between RCP4.5 and RCP8.5 emissions scenario.	Applied to populations <50 individuals.	No new individuals, subpopulations, or populations found, and no augmentation of existing populations, nonnatives controlled, and forest may be thinned. Between RCP4.5 and RCP8.5 emissions scenario.
Scenario 4 Major Increase in Effects	Number of water reducing activities increases from moderate levels. Available water is reduced per RCP8.5 emissions scenario.	Competition from native and nonnative plants increases above moderate levels.	Number or severity of wildfires annually increases above medium levels. RCP8.5 emissions scenario.	Number and severity of flooding and drought events increases above moderate levels. RCP8.5 emissions scenario.	Applied to populations <50 individuals.	No new individuals, subpopulations or populations found, and no augmentation of existing populations, nonnatives controlled, and forest may be thinned. RCP8.5 emissions scenario.

6.2.1 Drought and Climate Change Assumptions

Emission projections

In section 4.1, we discussed the potential effects of drought and warming caused by climate change on CHLT. In this section, we briefly explain the upper and lower climate change trajectories considered in the future scenarios for the species.

The most recent Synthesis Report of the Intergovernmental Panel on Climate Change (IPCC) describes four alternative trajectories for carbon dioxide emissions and the resulting atmospheric concentrations from the year 2000 to 2100 (IPCC 2014, pp. 9, 22, 57). For the purposes of our analysis, we chose two of the Representative Concentration Pathways (RCP) included in the IPCC Synthesis Report; one intermediate scenario (RCP4.5) and scenario with very high greenhouse gas emission (RCP8.5) (IPCC 2014, p. 8).

Canelo Hills ladies' tresses future scenarios 1-2 (Continuation and Conservation), assume an RCP4.5 emissions trajectory, a medium stabilization scenario where CO_2 emissions continue to increase through mid-21st century, but then decline and atmospheric carbon dioxide concentrations are between 580 and 720 ppm CO2 from 2050 to 2100, representing an approximate +2.5 ºC temperature change relative to 1861-80 (IPCC 2014, p. 9, Figure SPM.5). Canelo Hills ladies' tresses future scenario 3 (Moderate Increase in Effects) assumes a range between the RCP4.5 and RCP8.5. Canelo Hills ladies' tresses future scenario 4 (Major Increase in Effects) assumes an RCP8.5 emissions trajectory, where atmospheric carbon dioxide concentrations are above 1,000 ppm CO_2 between 2050 and 2100, representing an approximate +4.5 ºC temperature change relative to 1861-80 (IPCC 2014, p. 9, Figure SPM.5). The 2014 IPCC Synthesis Report projects global temperature change to 2100 (IPCC 2014, p. 8). A recent study suggests that, because of uncertainty in long-run economic growth rates, there is "a greater than 35 percent probability that emissions concentrations will exceed those assumed in the most severe of the available climate change scenarios (RCP8.5)" by 2100. As of February 2021, the global mean CO2 concentration was 415.88ppm (National Oceanic and Atmospheric Administration 2021: entire).

For both RCP4.5 and RCP8.5, global mean surface temperature change for the end of the 21^{st} century (2081-2100) is projected to likely exceed 1.5ºC, relative to 1850-1900 (IPCC 2014, p. 60). Under RCP8.5, global mean surface temperature change is projected likely to exceed 2.0ºC by 2100, perhaps as high as 4.8 ºC, relative to 1850-1900 (IPCC 2014, p. 60). Global mean surface temperature for the mid-century (2046-2065) is projected to increase under RCP4.5 and RCP8.5, but projections are lower than those for the end of the century (IPCC 2014, p. 60). It is virtually certain that there will be more frequent hot and fewer cold temperature extremes over most land areas on daily and seasonal timescales, as global mean surface temperature increases (IPCC 2014, p. 58). In many mid-latitude and subtropical dry regions, mean precipitation will likely decrease, under the RCP8.5 scenario (IPCC 2014, p.60).

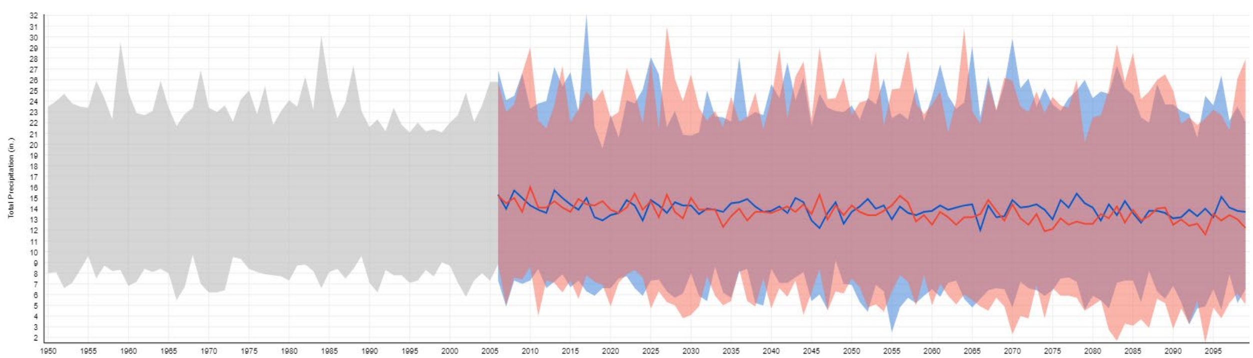
Climate change over the 21st century is additionally projected to reduce renewable surface water and groundwater resources in most dry subtropical regions (IPCC 2014, p. 69). In presently dry regions, the frequency of droughts will likely increase by the end of the 21st century under RCP8.5 regions (IPCC 2014, p. 69). Because of the influence of temperature on water, including evapotranspiration, climate change is expected to result in drier soils with less runoff (USGCRP 2017, pp. 232). Future human demand for water resources, due to human population growth and limitations of existing supply, is expected to interact with climate effects and exacerbate the effects of drought on water resources in Arizona.

Flooding and Changes in Winter Precipitation

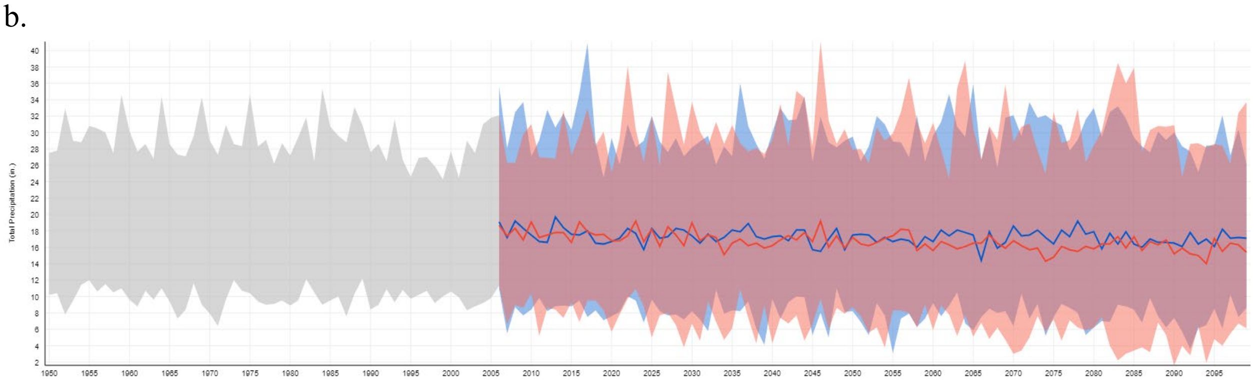
To assess impacts from climate change, we focused on projected changes in precipitation (winter precipitation) and extreme events (flooding). Because of the importance of water to this species, deductions in future scenarios are taken in both climate (summer precipitation for growth and reproduction) and water reduction categories (winter precipitation for groundwater recharge of the ciénega).

Total precipitation projections under the RCP4.5 and RCP8.5 scenarios for Cochise and Santa Cruz Counties are shown in Figure 6.1a and b, respectively. Note the increase in frequency and amplitude of both higher and lower spikes in the two future scenarios. Graphs were created using the Climate Explorer Toolkit.

a.



b.



Figures 6.1a and b. Past, present, and projected precipitation for Cochise and Santa Cruz Counties, Arizona under the RCP4.5 (blue) and RCP8.5 scenarios.

Flooding - Based on climate change data and modeling, it is likely that the severity of storm events will increase, resulting in more runoff, more severe and more common flooding events, and more erosion and sedimentation affecting populations, especially following wildfire events in the uplands. An increase in the flood frequency or intensity could result in an increase in the number of plants dislodged or buried. Within three CHLT populations there are concrete retention structures or roads protecting ciénega habitat from the upstream migration of headcuts (Gori 1994, p. 6). Within the San Rafael Valley Population, CHLT individuals are outside of the active floodplain of the Santa Cruz River, but continued downcutting of the Santa Cruz River could increase flow gradients from the spring to the river or initiate erosion in the spring channel resulting in water tables declines where CHLT grow (Gori 1994, p. 6).

For Future Scenario 1 (Continuation) we assumed an RCP4.5 trajectory and anticipate additional higher intensity precipitation events and greater probability of wildfire in the uplands leading to potential erosion and sedimentation events within inhabited ciénega. For Future Scenario 2 (Conservation), we assume an RCP4.5 trajectory and anticipate that land management activities will occur to the extent that will minimize impacts from flooding events, fire severity will be reduced with the management of upland nonnative grasses, native understory diversity will be enhanced, conservation easements will be attained, water savings and enhancement work is occurring, and hydrological and geomorphological restoration work is completed. For Future Scenario 3 (Moderate Increase in Effects), we anticipate a slightly greater probability of higher intensity precipitation and wildfire events occurring than in Scenario 1 (e.g., between RCP4.5 and RCP8.5 scenarios). For Future Scenario 4 (Major Increase in Effects) we assume an RCP8.5 trajectory and anticipate a slightly greater probability of higher intensity precipitation and more severe and frequent wildfire events occurring than in Scenario 3. In addition, increased dryness, hotter temperatures, and increased evapotranspiration will occur between each future scenario.

Winter Precipitation - Precipitation determinations were made based on Western Region Climate Center Total precipitation for the months of October-March (deemed most important for groundwater recharge). To determine the High and Low thresholds for winter precipitation, we took the highest and lowest recorded winter precipitation in the most recent complete year of record for six weather stations nearest the CHLT populations (Canelo 1NW in 2010, Fort Huachuca in 1981, Nogales in 1982, Patagonia in 2016, San Rafael Ranch in 1967, and Sierra Vista in 2008). The high was 32.2 cm (12.68 in) at Canelo 1 NW and the low was 4.67 cm (1.84 in) at Sierra Vista. To determine the Moderate winter precipitation ranking, we took the average winter precipitation across the periods of record for the 6 weather stations mentioned previously (14.22 cm [5.6 inches]). Therefore, using this information, we rated populations with up to 12.7 cm (5 in) of precipitation during the winter months as Low, populations with 12.95 to 30.5 cm (5.1 to 12 in) of precipitation as Moderate, and over 30.48 cm (12 in) as High.

6.2.2 Water Reduction Assumptions

For water reducing activities, we make the assumption that the wine growing region around Elgin, Arizona has the potential to impact the Babocomari, Canelo Hills, and Turkey Creek Populations, though research is lacking as to the interconnectedness of the groundwater and aquifer. However, due to the closeness of the Elgin agricultural area and the Babocomari geographically, as well as the lower elevation of the Babocomari (4,585 ft) vs. Elgin (4,728 ft), and given that groundwater moves down gradient, we believe the Babocomari is most likely to experience water withdrawal at the ciénega from agricultural groundwater removal activities near Elgin.

6.2.3 Increased Competition Assumptions

To assess impacts from native and nonnative plant competition, we assessed the reporting of competition at all four populations. We determined that each population has an equal probability of increased competition in the ciénega from both native (e.g., spikerush, horsetail [*Equisetum* sp.]) and nonnative plants (e.g., *S. halepense* and *H. jubatum*), and from outside the ciénega on nearby uplands where fire frequency and intensity may be altered (e.g., *Eragrostis lehmanniana* [Lehman's lovegrass; Harlow 2015, p. 10]; Gori 1993, p. 1; Lamma 1982, p. 1; Rutman 1991, p. 1). We make the assumption that due to the invasion of dogbane currently at Canelo Hills, this plant is unlikely to be reduced in density without a great management effort. In situations where light to moderate non-flowering season disturbance removes competing vegetation on a regular basis, competition can be reduced. Fire, grazing, mowing, and other disturbances conducted during May through August could severely impact the species (Gori 1994, p. 1).

6.2.4 Altered Wildfire Regime Assumptions

For altered wildfire regime, we assessed the probability of ignition sources (lighting, cross border violator warming and cooking fires, and recreationist activities such as shooting ranges, cigarettes, and camping) and fuel load conditions (nonnative vegetation or unnaturally dense native vegetation), for each population. Based on the level of activity, we determined the level of impacts to a population. As cross border violators, recreation, and nonnative plants have been reported in proximity to all four populations, we assume these have an equal probability of occurring in any of the populations (Sivinski 2018, p. 8; Harlow 2015, pp. 16, 22, 36; Duncan *et al*. 2010, p. 125; Gori 1993, p. 1; Lamma 1982, p. 1).

6.2.5 Small Population Size and Lack of Connectivity Assumptions/ Individual Effects

Populations with fewer than 50 individuals are assumed to be less resilient to effects to individuals because most, if not all, individuals could be impacted to the point of population extirpation. Herbivory has been reported in this species (Gori and Backer 1999, p. 1; Gori 1994, pp. 1 and 6) and seed predation likely occurs. Illegal collection has not been documented; however, collection pressure from rare plant or orchid enthusiasts has been reported as a threat (Harlow 2015, p. 18; Gori 1994, p. 6). We determined that all four populations have an equal likelihood of experiencing individual effects into the future.

6.3 Future Conditions

Based on the assumptions made in sections 6.2.1 – 6.2.5, deductions and additions to current condition scores were determined for the Continuation, Conservation, Moderate Increase in Threats, and Major Increase in Threats scenarios (Tables 6.2 – 6.4). As a general rule, when a population condition reaches the Low category, the population is at greater threat of being lost to a single event such as herbivory or illegal collection and when a population reaches a level below 0.5, it is considered functionally extirpated, that is, at a level too low to contribute to the benefit of the species (little to no cross pollination, flowering, seed production, or genetic exchange).

Continuation Scenario
At both the 25 and 50-year time steps, for the Continuation Scenario, we deducted 0.1 for each of the four populations due to an equal likelihood of water reduction from historical or modern water diversions (-0.1) and an equal likelihood of increased upland vegetation invasion, and increased evapotranspiration, which can reduce available water (-0.1). At the 25-year time step, we deducted an additional 0.05 from the Babocomari Population due to increased threats of water withdrawal due to agricultural increases in the Elgin area. At the 50-year time step, we deducted an additional 0.05 from all four populations due to increased probability of water withdrawal due to agricultural or residential use. At both the 25-year time step, we deducted 0.1 for each of the four populations due to an equal likelihood of reduced summer rainfall for plant growth (-0.1) and increased probability of high intensity flood events (-0.1). At the 50-year time step, an additional 0.05 was deducted for increased likelihood of drought and flooding at all four populations. Each population was given equal reductions for altered fire regime, climate, and individual effects at the 25-year time step and this was continued at the 50-year time step. Canelo Hills had an additional deduction (-0.1) for high level of vegetation competition and no management to reduce this competition.

Conservation Scenario
For Conservation scenario, 0.25 was added to the overall score of each population, due to the removal of dams, diversions, competing woody vegetation, increase in native diversity, promotion of water savings activities, increase in conservation easements, reduction of fuels in the uplands, seed storage, etc. An additional 0.05 was added at the 50-year time step for the Babocomari Population due to additional water savings impacts in the Elgin area. In addition, climate remains similar to current levels due to reduction of carbon emissions globally.

Moderate Increase in Threats Scenario
At the 25 and 50-year time steps, for Moderate Increase in Threats Scenario, an additional 0.05 was removed from each population in the water reduction, altered fire regime, and climate categories, as these threats will continue to increase from the 50-year time frame of the Continuation Scenario levels. We do not foresee increased competition or individual effects becoming worse than their current levels.

Major Increase in Threats Scenario
At the 25-year time step, for the Major Increase in Threats scenario, an additional 0.05 was removed from each population in the water reduction, altered fire regime, and climate categories, as these threats will continue to increase from the 50-year Moderate Increase in Threats Scenario levels. Moving from 25 to 50-year time steps, in the Major Increase in Threats scenario, we deducted 0.05 for all but the Babocomari Population for further increases in water withdrawal. We anticipate a maximum effect from agricultural water withdrawal at the 25-year mark in the Babocomari Population.

6.3.1 Future Scenario 1 – Continuation

Under the Continuation scenario, those factors that are having an influence on populations of CHLT continue on the same trajectory as they are currently on. Under the Continuation scenario, water flow reduction due to groundwater withdrawal, woody plant invasion, and drought continues to reduce ciénega habitat for this species. Little to no conservation actions are being implemented. In this scenario, the following threats remain probable: water withdrawal, drought, nonnative plant invasion, wildfire, and flooding. Illegal collection, trampling, herbivory, predation, and other impacts also continue at current levels. Because three of the four ciénegas currently have grazing and/or prescription fire in use that reduce competition, and these land management methods are expected to continue, only the Canelo Hills Population has points removed for increased competition under the continuation condition scenario.

Table 6.2. Canelo Hills ladies' tresses (*Spiranthes delitescens*) population conditions under Future Scenario 1 (Continuation).

Population	**Water Reduction**	**Increased Competition**	**Altered Fire Regime**	**Climate**	**Individual Effects**	**Future Condition (Continuation - 25 years)**
Babocomari	-0.25	0	-0.1	-0.2	-0.1	**Low (0.85)**
Canelo Hills	-0.2	-0.1	-0.1	-0.2	-0.1	**Low (0.6)**
San Rafael Valley	-0.2	0	-0.1	-0.2	-0.1	**Low (0.8)**
Turkey Creek	-0.2	0	-0.1	-0.2	-0.1	**Low (1.4)**
						Future Condition (Continuation - 50 years)
Babocomari	-0.3	0	-0.1	-0.25	-0.1	**Low (0.75)**
Canelo Hills	-0.25	-0.1	-0.1	-0.25	-0.1	**Low (0.5)**
San Rafael Valley	-0.25	0	-0.1	-0.25	-0.1	**Low (0.7)**
Turkey Creek	-0.25	0	-0.1	-0.25	-0.1	**Low (1.3)**

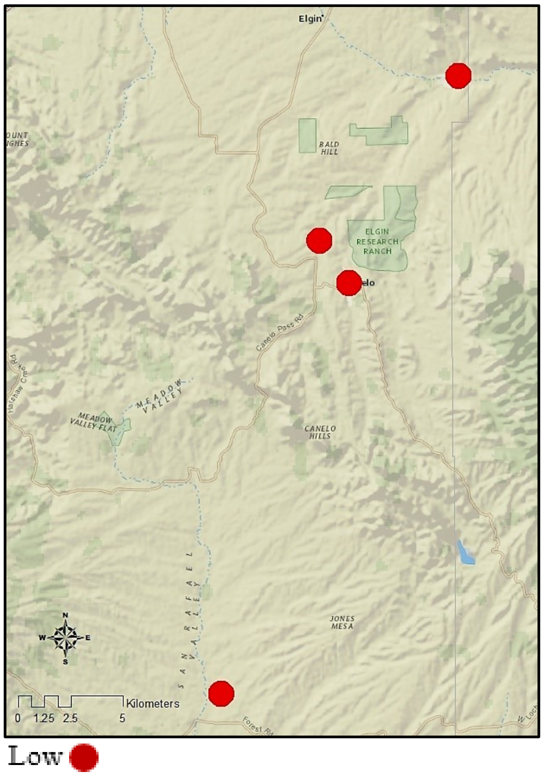


Figure 6.2. Condition of Canelo Hills ladies' tresses (*Spiranthes delitescens*) populations under the Continuation scenario (next 25 and 50 years).

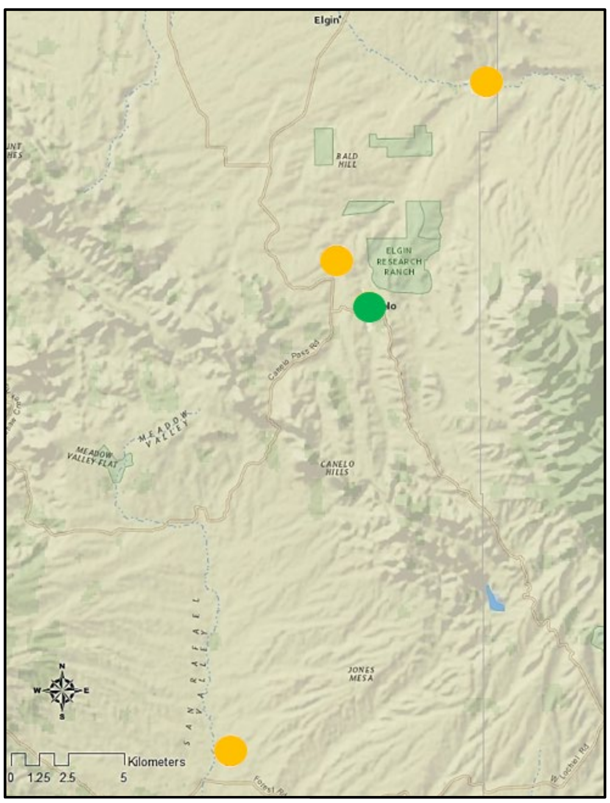
Under Future Scenario 1 (Continuation), at both the 25 and 50-year time steps, all four populations of CHLT are in Low condition, with the Canelo Hills and San Rafael Valley Populations retaining the same resiliency level as in the current condition and the Babocomari and Turkey Creek Populations experiencing a reduction in resiliency relative to current conditions. There are no CHLT populations in High or Moderate condition. Under this scenario, redundancy and representation would not be altered from the current condition, as there are no extirpated populations.

6.3.2 Future Scenario 2 – Conservation

The Conservation scenario provides an idea of the best possible condition over the next 50 years. Under the Conservation scenario, those factors that are having a negative influence on populations of CHLT are improved greatly. In this scenario, drought and climate change remain probable, though at current, not increased levels due to carbon emissions reduction worldwide. Conservation measures are also completed to reduce some threats, including: sites are monitored with additional plants located, sites are augmented, or new sites are established; seeds and mycorrhizae are preserved; upland forests are thinned; conservation easements are attained, water conservation is employed, land recontouring and restoration is undergone, native understory diversity is enhanced, nonnative and woody invaders are removed, and other conservation actions are undertaken to improve or remove diversions and headcuts. In addition, at Canelo Hills Population, regular light to moderate disturbance is reintroduced.

Table 6.3. Canelo Hills ladies' tresses (*Spiranthes delitescens*) population conditions under Future Scenario 2 (Conservation).

Population	Water Reduction	Increased Competition	Altered Fire Regime	Climate	Individual Effects	Future Condition (Conservation – 25 years)
Babocomari	+0.25	+0.2	+0.2	-0.2	+0.1	**Moderate (2.05)**
Canelo Hills	+0.25	+0.2	+0.2	-0.2	+0.1	**Moderate (1.85)**
San Rafael Valley	+0.25	+0.2	+0.2	-0.2	+0.1	**Moderate (1.95)**
Turkey Creek	+0.25	+0.2	+0.2	-0.2	+0.1	**High (2.55)**
						Future Condition (Conservation - 50 years)
Babocomari	+0.3	+0.2	+0.2	-0.2	+0.1	**Moderate (2.1)**
Canelo Hills	+0.25	+0.2	+0.2	-0.2	+0.1	**Moderate (1.85)**
San Rafael Valley	+0.25	+0.2	+0.2	-0.2	+0.1	**Moderate (1.95)**
Turkey Creek	+0.25	+0.2	+0.2	-0.2	+0.1	**High (2.55)**



Moderate ; High

Figure 6.3. Condition of Canelo Hills ladies' tresses (*Spiranthes delitescens*) populations under the Conservation scenario (next 25 and 50 years).

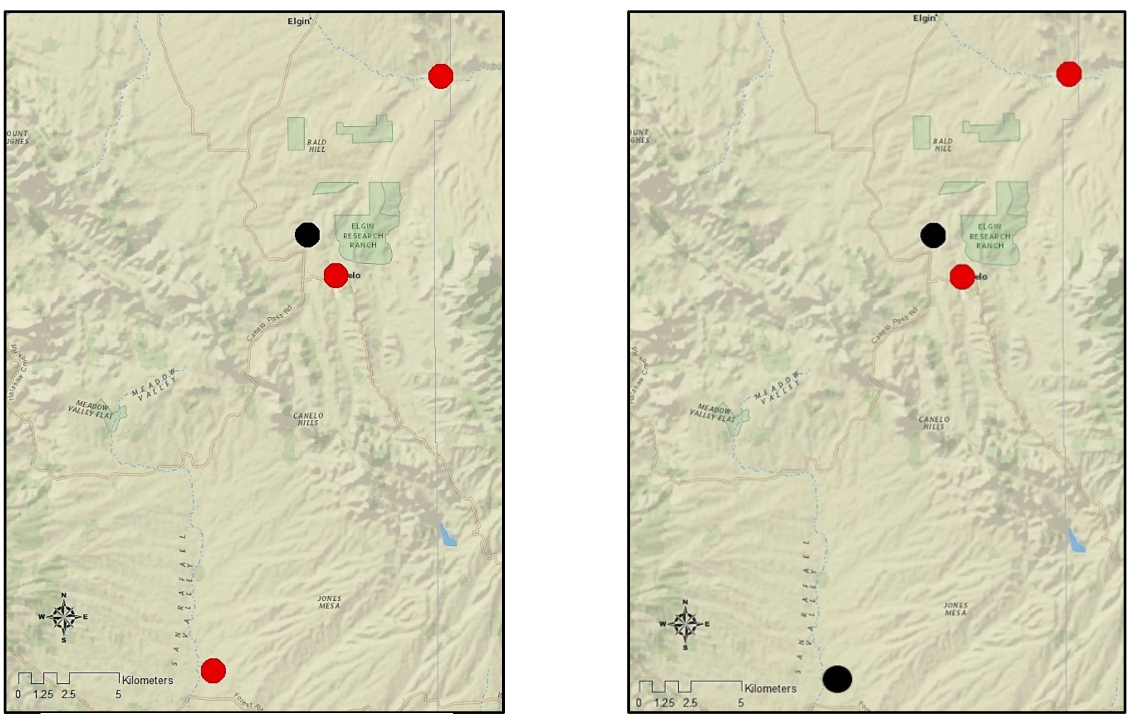
Under Future Scenario 2 (Conservation), at the 25 and 50-year time steps, three populations of CHLT are in Moderate condition and one population (Turkey Creek) is in High condition. This represents a significant improvement in resiliency levels over current condition in all four populations.

6.3.3 Future Scenario 3 –Moderate Increase in Effects

Under the Moderate increase in effects scenario, water flow reduction due to groundwater withdrawal, woody plant invasion, evapotranspiration, and drought continues to reduce ciénega habitat for this species. Threat of catastrophic wildfire is high due to dry conditions, invasion of nonnatives in the uplands, and increased threat of fire starts from illegal activity, recreation, and natural causes. Illegal collection, trampling, herbivory, predation, and human impacts also continue at current or increased levels. Light to moderate disturbance is not returned to the Canelo Hills Population.

Table 6.4. Canelo Hills ladies' tresses (*Spiranthes delitescens*) population conditions under Future Scenario 3 (Moderate Increase in Effects).

Population	**Water Reduction**	**Increased Competition**	**Altered Fire Regime**	**Climate**	**Individual Effects**	**Future Condition (Moderate Increase in Effects – 25 years)**
Babocomari	-0.35	0	-0.15	-0.3	-0.1	**Low (0.6)**
Canelo Hills	-0.3	-0.1	-0.15	-0.3	-0.1	**Functionally Extirpated (0.35)**
San Rafael Valley	-0.3	0	-0.15	-0.3	-0.1	**Low (0.55)**
Turkey Creek	-0.3	0	-0.15	-0.3	-0.1	**Low (1.15)**
						Future Condition (Moderate Increase in Effects - 50 years)
Babocomari	-0.4	0	-0.15	-0.35	-0.1	**Low (0.5)**
Canelo Hills	-0.35	-0.1	-0.15	-0.35	-0.1	**Functionally Extirpated (0.25)**
San Rafael Valley	-0.35	0	-0.15	-0.35	-0.1	**Functionally Extirpated (0.45)**
Turkey Creek	-0.35	0	-0.15	-0.35	-0.1	**Low (1.05)**



a. Functionally Extirpated ● ; Low ●

b.

Figure 6.4. Condition of Canelo Hills ladies' tresses (Spiranthes delitescens) populations under the Moderate increase in effects scenario over the next 25 years (a) and 50 years (b).

Under Future Scenario 3 (Moderate Increase in Threats), at the 25-year time step, three populations of CHLT are in Low condition and one population of CHLT (Canelo Hills) is functionally extirpated. At the 50-year time step, an additional population (San Rafael Valley), becomes functionally extirpated. There is a reduction in resiliency, redundancy, and representation from the current level at both the 25 and 50-year time steps. There are no CHLT populations in High or Moderate condition.

6.3.4 Future Scenario 4 – Major Increase in Effects

Under the Major increase in effects scenario, water flow reduction due to groundwater withdrawal, woody plant invasion, evapotranspiration, and drought increases further, continuing to reduce ciénega habitat for this species. Threat of catastrophic wildfire is high due to dry conditions, invasion of nonnatives in the uplands, and increased threat of fire starts from illegal activity, recreation, and natural causes. Illegal collection, trampling, herbivory, predation, and other impacts also continue at current or increased levels. Light to moderate disturbance is not returned to the Canelo Hills Population.

Table 6.5. Canelo Hills ladies' tresses (*Spiranthes delitescens*) population conditions under Future Scenario 4 (Major Increase in Effects).

Population	**Water Reduction**	**Increased Competition**	**Altered Fire Regime**	**Climate**	**Individual Effects**	**Future Condition (Major Increase in Effects – 25 years)**
Babocomari	-0.4	0	-0.2	-0.4	-0.1	**Functionally Extirpated (0.4)**
Canelo Hills	-0.35	-0.1	-0.2	-0.4	-0.1	**Functionally Extirpated (0.15)**
San Rafael Valley	-0.35	0	-0.2	-0.4	-0.1	**Functionally Extirpated (0.35)**
Turkey Creek	-0.35	0	-0.2	-0.4	-0.1	**Low (0.95)**
						Future Condition (Moderate Increase in Effects - 50 years)
Babocomari	-0.4	0	-0.2	-0.45	-0.1	**Functionally Extirpated (0.35)**
Canelo Hills	-0.4	-0.1	-0.2	-0.45	-0.1	**Functionally Extirpated (0.05)**
San Rafael Valley	-0.4	0	-0.2	-0.45	-0.1	**Functionally Extirpated (0.25)**
Turkey Creek	-0.4	0	-0.2	-0.45	-0.1	**Low (0.85)**

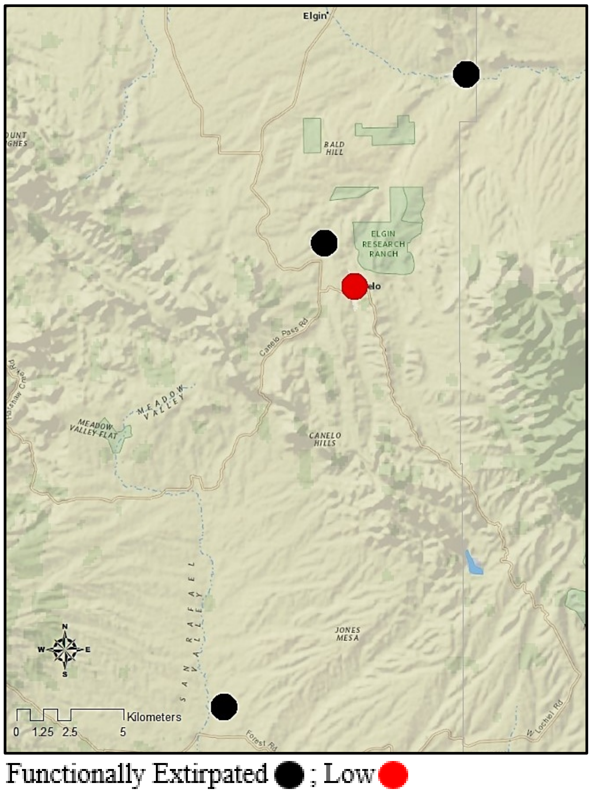


Figure 6.5. Condition of Canelo Hills ladies' tresses (*Spiranthes delitescens*) populations under the Major increase in effects scenario (next 25 and 50 years).

Under Future Scenario 4 (Major Increase in Threats), at both the 25 and 50-year time steps, three populations are functionally extirpated and a single population remains (Turkey Creek), in Low condition. This represents a loss in resiliency, redundancy, and representation relative to current conditions in three of four populations. There are no CHLT populations in High or Moderate condition.

6.8. Status Assessment Summary

We used the best available information to forecast the likely future condition of CHLT. Our goal was to describe the viability of the species in a manner that will address the needs of the species in terms of resiliency, representation, and redundancy. We considered the possible future condition of the species, considering a range of potential scenarios that include important influences on the status of the species. Our results describe a range of possible conditions in terms of how many and where CHLT populations are likely to persist into the future (Table 6.6).

Table 6.6. Canelo Hills ladies' tresses (*Spiranthes delitescens*) current and future population conditions under each scenario over 25 years.

Population	Current Condition	Scenario 1 – Continuation (25 years)	Scenario 2 – Conservation (50 years)	Scenario 3 – Moderate Increase in Effects (50 years)	Scenario 4 – Major Increase in Effects (50 years)
Babocomari	Moderate (1.5)	Low (0.85)	Moderate (2.05)	Low (0.6)	Functionally Extirpated (0.4)
Canelo Hills	Low (1.3)	Low (0.6)	Moderate (1.85)	Functionally Extirpated (0.4)	Functionally Extirpated (0.15)
San Rafael Valley	Low (1.4)	Low (0.8)	Moderate (1.95)	Low (0.55)	Functionally Extirpated (0.35)
Turkey Creek	Moderate (2.0)	Low (1.4)	High (2.55)	Low (1.15)	Low (0.95)

Table 6.7. Canelo Hills ladies' tresses (*Spiranthes delitescens*) current and future population conditions under each scenario over 50 years.

Population	Current Condition	Scenario 1 – Continuation (25 years)	Scenario 2 – Conservation (50 years)	Scenario 3 – Moderate Increase in Effects (50 years)	Scenario 4 – Major Increase in Effects (50 years)
Babocomari	Moderate (1.5)	Low (0.75)	Moderate (2.1)	Low (0.5)	Functionally Extirpated (0.35)
Canelo Hills	Low (1.3)	Low (0.8)	Moderate (1.85)	Functionally Extirpated (0.25)	Functionally Extirpated (0.05)
San Rafael Valley	Low (1.4)	Low (0.7)	Moderate (1.95)	Functionally Extirpated (0.45)	Functionally Extirpated (0.25)
Turkey Creek	Moderate (2.0)	Low (0.7)	High (2.55)	Low (1.05)	Low (0.85)

We selected the time steps for each scenario based on the likelihood of its occurrence (Table 6.9). Based on IPCC projected climate change impacts and recent known impacts from groundwater withdrawal, drought, wildfire, and other threats, near term impacts (i.e., at the 25-year time step) are highly likely. Within Scenario 3, we assume increased confidence in climate change impacts over time based on IPCC projections, in which they state high confidence in emissions scenario RCP4.5 being exceeded. Conversely, we have higher confidence in the Continuation near term, and less confidence that Continuation conditions would remain in effect over 50 years. For Scenario 4 we have less confidence that emissions scenario RCP8.5 will occur based on IPCC (2014, entire). However, the IPCC is confident that the emissions will fall within the RCP4.5 to RCP8.5 range. The Conservation scenario is only somewhat to moderately likely over time, because climate change impacts are projected to increase, and no conservation measures that may be implemented could address drying of habitat.

We examined the resiliency, representation, and redundancy of CHLT under each of the four plausible scenarios (Table 6.8). Resiliency of CHLT populations depends on future availability of mycorrhizal symbionts (though this factor was not analyzed), saturated organic soils in ciénegas, groundwater and winter precipitation, light to moderate disturbance, and presence of pollinators (though this factor was not analyzed). We expect the four CHLT populations to experience changes to these aspects of their habitat in different ways under the different scenarios. We projected the likelihood of each scenario based on the events that would occur under each scenario.

Table 6.8. Highly likely = we are greater than 90 percent sure that this scenario will occur; Moderately likely = we are 70–90 percent sure that this scenario will occur; Somewhat likely = we are 50–70 percent sure that this scenario will occur; Unlikely= we are less than 50 percent sure that this scenario will occur.

Likelihood of Scenario Occurring at:	Current Condition	Scenario 1 – Continuation	Scenario 2 – Conservation	Scenario 3 – Moderate Increase in Effects	Scenario 4 – Major Increase in Effects
25 years	n/a	Highly likely	Unlikely	Somewhat likely	Somewhat likely
50 years	n/a	Somewhat likely	Somewhat likely	Moderately likely	Moderately likely

Under scenario 1 – Continuation – We would expect the viability of CHLT to be characterized by a loss of resiliency, representation, and redundancy at the level that is currently occurring. At the 25-year time step, no populations would be in High or Moderate condition and 4 populations (100 percent) would be in Low condition and more susceptible to loss. Within Scenario 1 we assume impacts from drought, climate change, and other threats continue as in the near past. Seed is collected for conservation purposes. We think this is highly likely to occur within the 25-year time step with decreasing likelihood at future time steps. This expectation is based on climate change projections portraying emissions increases, resulting in increased impacts to the species. At the 50-year time step, all four populations remain in Low condition, but all threats increase slightly, thus reducing total scores within the Low category. We feel the continuation of this scenario in the near term is highly likely, but is reduced to somewhat likely in the longer term, as threats increase.

Under scenario 2 – Conservation – We would expect the viability of CHLT to be characterized by higher levels of resiliency, representation, and redundancy than it exhibits under the current condition. With the great increase in conservation measures aimed at restoring CHLT and its wetland habitat, at the 25 and 50-year time steps, three populations increase in condition to Moderate condition and one population increases to High condition. Within Scenario 2, the following threats are reduced greatly: water withdrawal, wildfire, flooding, illegal collection, trampling, herbivory, and predation. Climate change and drought continue at current levels and do not get worse due to carbon emissions reductions globally. Conservation measures are also completed to reduce threats, including: sites are monitored with additional plants located, sites are augmented, or new sites are established; seeds and mycorrhizae are preserved; upland forests are thinned; and land restoration occurs to improve or remove diversions and headcuts; nonnative competitors are controlled and native communities enhanced, invading upland woody plants are removed, and water conservation actions and conservation easements are put into place, etc. In addition, at the Canelo Hills Population, regular light to moderate disturbance is reintroduced. Because climate change impacts are projected to increase and it will take a concerted effort to realize these conservation measures, we think this Scenario is unlikely in the near term, but somewhat likely in the long term.

Under scenario 3 – Moderate Increase in Effects – We would expect the viability of CHLT to be characterized by lower levels of resiliency, representation, and redundancy than it has in the Continuation scenario. At both the 25 and 50-year time steps, no populations would be in High or Moderate condition. At the 25-year time step, three populations remain in Low condition and one becomes functionally extirpated. At the 50-year time step, two populations (50 percent) would be in Low condition, and two populations (50 percent) would be functionally extirpated. Within Scenario 3 we assume increased confidence in climate change impacts based on IPCC projections, in which they state high confidence in emissions scenario RCP4.5 being exceeded. Under this scenario, water flow reduction due to groundwater withdrawal, woody plant invasion, evapotranspiration, and drought continues to reduce ciénega habitat for this species. Threat of catastrophic wildfire is high due to dry conditions, invasion of nonnatives in the uplands, and increased threat of fire starts from illegal activity, recreation, and natural causes. Illegal collection, trampling, herbivory, predation, and other impacts continue at current or increased levels. Light to moderate disturbance is not returned to the Canelo Hills Population. Based on IPCC's and viticulture increase projections, we think that in the short term this scenario is somewhat likely and in the long term, this is moderately likely.

Under scenario 4 – Major Increase in Effects – We would expect the viability of CHLT to be characterized by lower levels of resiliency, representation, and redundancy than under the Moderate effects scenario. At both the 25 and 50-year time steps, no populations would be in High or Moderate condition, one population (25 percent) would be in Low condition, and three (75 percent) would be functionally extirpated. Water flow reduction due to groundwater withdrawal, woody plant invasion, and drought increases further, continuing to reduce ciénega habitat for this species. Threat of catastrophic wildfire is high due to dry conditions, invasion of nonnatives in the uplands, and increased threat of fire starts from illegal activity, recreation, and natural causes. Illegal collection, trampling, herbivory, predation, and other impacts also continue at current or increased levels. Light to moderate disturbance is not returned to the Canelo Hills Population. For Scenario 4 the IPCC confidence is low that emissions scenario RCP8.5 will occur, therefore the likelihood of Scenario 4 occurring is somewhat likely in the short term and moderately likely in the long term. However, the IPCC is confident that the emissions will fall within the RCP4.5 and RCP8.5 range.

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