Autumn Buttercup

(Ranunculus acriformis var. *aestivalis)*

5-Year Review:
Summary and Evaluation

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U.S. Fish and Wildlife Service

Utah Field Office — Ecological Services

West Valley City, Utah 84119

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5-YEAR REVIEW
Autumn Buttercup (*Ranunculus acriformis* var. *aestivalis*)

1. GENERAL INFORMATION

1.1. Purpose of 5-Year Reviews

The U.S. Fish and Wildlife Service (USFWS) is required by section 4(c)(2) of the Endangered Species Act (Act) to conduct a status review of each listed species at least once every 5 years. The purpose of a 5-year review is to evaluate whether or not the species' status has changed since the time it was listed or since the most recent 5-year review. Based on the outcome of the 5-year review, we recommend whether the species should: 1) be removed from the list of endangered and threatened species; 2) be changed in status from endangered to threatened; 3) be changed in status from threatened to endangered; or 4) remain unchanged in its current status. Our original decision to list a species as endangered or threatened is based on the five threat factors described in section 4(a)(1) of the Act. These same five factors are considered in any subsequent reclassification or delisting decisions. In the 5-year review, we consider the five threat factors using the best available scientific and commercial data on the species, and we review new information available since the species was listed or last reviewed. If we recommend a change in listing status based on the results of the 5-year review, we must propose to do so through a separate rule-making process that includes public review and comment.

1.2. Reviewers

Lead Regional Office: Mountain-Prairie Region (Region 6)
Bridget Fahey, Chief of Endangered Species, 303-236-4258
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1.3. Methodology used to complete the review

On June 20, 2011, we published a Notice of Review in the *Federal Register* (76 FR 35906) soliciting any new information on the autumn buttercup (*Ranunculus acriformis* var. *aestivalis*) that may have a bearing on its classification as endangered or threatened. We did not receive any comments in response to the Federal Register notice.

This 5-year review was primarily written by the Utah Field Office with review by the Mountain-Prairie Regional Office. It summarizes and evaluates information provided in the recovery plan, current scientific research, and surveys related to the subspecies. All

pertinent literature and documents on file at the Utah Field Office were used for this review (See References section below for a list of cited documents). We interviewed individuals familiar with autumn buttercup as needed to clarify or obtain specific information.

1.4. Background

1.4.1. Federal Register Notice citation announcing initiation of this review

76 FR 35906; June 20, 2011

1.4.2. Listing history

Original Listing
Federal Register notice: 54 FR 30550; July 21, 1989
Entity listed: Subspecies
Classification: Endangered range-wide

1.4.3. Review History

Since the Federal listing of autumn buttercup in 1989, we have not conducted a status review or 5-year review. However, we considered the species status in the 1991 Recovery Plan (USFWS 1991).

1.4.4. Species' Recovery Priority Number at start of 5-year review

At the start of the 5-year review, the Recovery Priority Number for the autumn buttercup was 6. This number indicates that this plant is a subspecies with a high degree of threat and a low recovery potential.

Table 1. The below ranking system for determining Recovery Priority Numbers was established in 1983 (48 FR 43098, September 21, 1983 as corrected in 48 FR 51985, November 15, 1983).

Degree of Threat	Recovery Potential	Taxonomy	Priority	Conflict
High	High	Monotypic Genus	1	1C
		Species	2	2C
		Subspecies/DPS	3	3C
	Low	Monotypic Genus	4	4C
		Species	5	5C
		Subspecies/DPS	**6**	6C
Moderate	High	Monotypic Genus	7	7C
		Species	8	8C
		Subspecies/DPS	9	9C
	Low	Monotypic Genus	10	10C
		Species	11	11C
		Subspecies/DPS	12	12C
Low	High	Monotypic Genus	13	13C
		Species	14	14C
		Subspecies/DPS	15	15C
	Low	Monotypic Genus	16	16C
		Species	17	17C
		Subspecies/DPS	18	18C

1.4.5. Recovery Plan

Name of plan: Autumn Buttercup (*Ranunculus acriformis* var. *aestivalis*) Recovery Plan (hereafter referred to as the "Recovery Plan").
Date approved: September 16, 1991

2. REVIEW ANALYSIS

2.1. Application of the 1996 Distinct Population Segment (DPS) policy

This section of the 5-year review is not applicable to this species because the Act precludes listing Distinct Population Segments (DPSs) for plants. For more information, see our 1996 DPS policy (61 FR 4722, February 7, 1996).

2.2. Recovery Planning and Implementation[1]

2.2.1. Does the species have a final, approved recovery plan?

☒ Yes
☐ No

2.2.2. Adequacy of Recovery Plan?

Section 4(F)(1)(B)(ii) of the Act defines, "objective, measurable, criteria" as those that when met, would result in a determination that the species be removed from the Act. The recovery criteria in the Recovery Plan are not entirely objective and measureable, and may not be adequate in defining the scope of necessary actions required to recover this species. Criterion 1 should be re-evaluated since a target population of 1,000 plants on The Nature Conservancy's Sevier River Valley Preserve (Preserve) may not constitute a self-sustaining or equivalent minimum viable population size for that population. Criterion 2 is not measureable because neither a target population size nor genetic diversity guidelines are identified for establishing two artificial populations at botanic gardens. Since the Recovery Plan is 21 years old, most of the recommended conservation measures, population trends, and scientific findings are dated and inaccurate.

In order to determine whether a species is endangered or threatened, or has improved to the point of reclassification or delisting, the Act requires an explicit analysis of the 5 listing factors. The recovery objectives and criteria found in the 1991 Recovery Plan do not reference the five listing factors, nor does the Recovery Plan include downlisting criteria. Nevertheless, the species' status relative to these criteria are discussed below so as to show progress, or lack thereof, toward recovery.

2.2.3. Progress toward recovery

Criterion 1: Increase the current population on the Preserve to a self-sustaining population of 1,000 plants on 10 acres of land at the present known site.

[1] Recovery plans provide guidance to the USFWS, States, and other partners and interested parties on ways to minimize threats to listed species, and on criteria that may be used to determine when recovery goals are achieved. There are many paths to accomplishing the recovery of a species, and recovery may be achieved without fully meeting all recovery plan criteria. For example, one or more criteria may have been exceeded while other criteria may not have been accomplished. In that instance, we may determine that, over all, the threats have been minimized sufficiently, and the species is robust enough, to downlist or delist the species. In other cases, new recovery approaches and/or opportunities unknown at the time the recovery plan was finalized may be more appropriate ways to achieve recovery. Likewise, new information may change the extent that criteria need to be met for recognizing recovery of the species. Overall, recovery is a dynamic process requiring adaptive management, and assessing a species' degree of recovery is likewise an adaptive process that may, or may not, fully follow the guidance provided in a recovery plan. We focus our evaluation of species status in this 5-year review on progress that has been made toward recovery since the species was listed (or since the most recent 5-year review) by eliminating or reducing the threats discussed in the five-factor analysis. In that context, progress towards fulfilling recovery criteria serves to indicate the extent to which threat factors have been reduced or eliminated.

Status: The population of autumn buttercup on the Preserve is comprised of two subpopulations (a part or subdivision of a population). The original subpopulation on the Preserve was first documented in 1983 with 407 mature plants and 64 seedlings (Mutz 1984). This subpopulation has shown a variable trend since its documentation. An additional subpopulation of 200 plants was found in 1990 on the Preserve. The two subpopulations combined reached the criterion of 1,000 plants in 1992, with 1,009 plants. However, both subpopulations declined dramatically after that year, and by 2006, only 18 plants were found on the Preserve (USFWS 2007). We discuss population trends and potential reasons for population declines in more detail in section 2.3.1.2 Distribution, Abundance and Trends.

Two reintroductions were performed at the Preserve in 2007 and 2010 to avoid the possibility of extinction in the wild and to work toward meeting this recovery criterion; however, these two reintroduction efforts were not successful. There was 100% mortality of reintroduced plants as of the fall of 2010. The autumn buttercup continues to persist in dangerously low numbers on the Preserve. In two extensive surveys on the Preserve in 2010 and 2011, zero and 15 adult plants were found, respectively (TNC 2010; USFWS 2011). A cursory survey in 2012 only found 1 non-flowering autumn buttercup plant (USFWS 2012).

A minimum population viability analysis has not been performed, so we do not know what number constitutes a self-sustaining population size for this species. The criterion of 1,000 plants does not appear to be large enough to sustain the population. For example, this population size was reached in 1992, but the population subsequently declined and we do not have a self-sustaining population on the Preserve today. Even if 1,000 plants were sufficient, we are not close to meeting that goal with the 1–15 plants being detected the past three years.

This recovery criterion is **not met**.

Criterion 2: Establish at least two artificial populations of the autumn buttercup at suitable, recognized botanical gardens.

Status: The Arboretum at Flagstaff (Arboretum) and the Center for Conservation and Research of Endangered Wildlife (CREW) at the Cincinnati Zoo collectively maintain around 300 autumn buttercup plants from tissue culture propagation. However, the majority of these plants will be reintroduced to the Preserve in 2013, with 10 plants to remain at the Arboretum. The Arboretum retained 5 of the 50 propagated plants in 2010 as a back-up reserve in case the 2010 reintroduction was unsuccessful. CREW continues to maintain seven genotypes in culture (Pence 2012). Seeds are also stored at the National Center for Genetic Resources Preservation (NCGRP) in Fort Collins, Colorado for long-term preservation. No measureable criteria for population size or genetic diversity guidelines were developed to aid the establishment of two artificial populations at botanic gardens.

This recovery criterion is **partially met** and **ongoing**.

Criterion 3: Establish viable self-sustaining populations in at least 5 additional sites on land managed to protect the species.

Status: No additional sites were purchased or managed to protect the species. The population on the Preserve, which is managed to protect the species, does not appear to be self-sustaining. A second population (Dale Ranch) occurs on private property and contains several hundred plants. We have very little data to assess population stability of the Dale Ranch population. Given the close proximity of the two populations and the fact that livestock grazing was the historic land use at both locations, we assume that historic threats to the species were similar. Presently, threats to the species at the two populations only differ with respect to livestock grazing practices. No other populations of the autumn buttercup are known to exist.

This recovery criterion is **not met**.

Criterion 4: Establish an overall self-sustaining population of at least 20,000 plants.

Status: Comprehensive surveys within suitable habitat throughout the Sevier River valley are incomplete. The two known populations of the autumn buttercup on the Preserve and on the Dale Ranch combined are estimated to support considerably less than the 20,000 individuals recommended in the Recovery Plan (see Table 2 below). A population viability analysis has not been performed for this species so we do not know if this number is a reasonable target for this criterion.

This recovery criterion is **not met**. A population viability analysis to re-evaluate this criterion is warranted.

Recovery Plan Actions

In addition to the above criteria, the Recovery Plan includes recovery actions. In this section, we briefly review our progress for each action.

(1) Protect the existing population on The Nature Conservancy's Sevier River Valley Preserve: develop a habitat management plan, monitor the population and conduct minimum viable population studies, enforce existing protective regulations, and rebuild the Preserve perimeter fence.

Neither we nor The Nature Conservancy have prepared a habitat management plan for the Preserve.

Demography and monitoring studies were conducted on the population within the Preserve (Spence 1996). A habitat characterization was performed for this taxon as well as other closely associated taxa (Van Buren and Harper 1996). More recent studies have focused on the species' response to litter removal through manual vegetation clipping and spring burning (Van Buren *et al.* 2001). In addition, annual monitoring of the reintroduced plants was performed from 2007 until 2010. To date, a minimum viable population study has not been performed.

Existing regulations are enforced on the Preserve. Admittance to the Preserve is by permission only. No unlawful activity, as per section 9 of the Act, has occurred. Section 9 of the Act prohibits the removal, cutting, digging, damage, or destruction of an endangered plant species in knowing violation of any Federal or State law or regulation, or in the course of any violation of State criminal trespass law.

The Preserve's fence was inspected and refurbished in 1989, protecting the known population at the time. Completion of the perimeter fence occurred in 1994. A breach in the fence occurred in 2002, allowing cattle to access and graze on the Preserve. The fence was quickly repaired by the adjacent landowner and cattle owner. The Nature Conservancy continues to maintain and repair the fencing as necessary. This recovery action is an important component of the Recovery Plan because of the threat from livestock grazing. Although the Preserve is fenced, the Dale Ranch population is not protected from potential overgrazing.

This recovery action is **partially met**. A minimum viable population study has not been completed. A habitat management plan for the Preserve has not been completed. In addition, the impact of grazing and the need to provide additional conservation measures to minimize the potential for overgrazing should be explored.

(2) Inventory potential habitat of the autumn buttercup in south-central Utah.

Comprehensive surveys of potential habitat have not been performed. Employees from the Utah Heritage Program have made periodic visits to the area to look for plants but have not surveyed on private property (Fitts pes. comm. 2012a). One of our botanists obtained permission to confirm the existence of an autumn buttercup population on private land (Dale Ranch) in 2011 and documented several hundred plants in full flower on approximately 1 acre of land (USFWS 2011). It is likely that autumn buttercup occurs on private land at other locations, and possibly on surrounding public lands. A coordinated effort to identify potential habitat followed by surveys should be initiated.

This recovery action is **not met**. Comprehensive surveys have not been done to provide us with an accurate population estimate and species' distribution.

(3) Acquire and protect occupied and potential habitat of the autumn buttercup.

The Nature Conservancy purchased the Preserve in 1988, a 44-acre parcel of land that, at the time, contained the only known extant population of autumn buttercup. Since then, one other population on private land (Dale Ranch) has been discovered. Currently, the landowner at the Dale Ranch property has not indicated a willingness to sell or protect the property for conservation of the autumn buttercup. There are no other known occupied habitats.

This recovery action **is partially met and ongoing**. The purchase or protection of occupied and potential habitat is still warranted.

(4) Establish artificial autumn buttercup populations through seed collection, horticultural practices, and plant propagation techniques.

The Arboretum was involved in the propagation of autumn buttercup as early as 1988, when five seedlings were transplanted from the Preserve to the Arboretum's greenhouse (USFWS 1991). In 1990, 100 seeds were collected and germination trials were performed. The results of the germination trials suggest that seeds require a 2-month minimum cold stratification treatment[2] before germinating (Maschinski 1991).

In 2006, CREW propagated seeds using tissue culture methods. Tissue culture methods were successful and used to propagate individual plants for three separate reintroduction efforts. Two reintroductions occurred on the Preserve with 138 plants in 2007 and 45 plants in 2010. These two reintroductions were not successful, as all of the plants were dead by late-summer 2010. A third reintroduction effort on the Preserve is planned for 2013, with the planting of approximately 300 plants from tissue culture techniques. The Arboretum and CREW continue to maintain small, artificial populations of plants at their respective institutions outside of the reintroduction efforts.

Seeds of autumn buttercup are stored at NCGRP in Fort Collins, Colorado, for long-term preservation. A total of 445 seeds are stored there from two collection events: 54 seeds collected in 1996 from the Preserve, and 391 seeds collected in 2012 from the Dale Ranch population (Murray 2012; USFWS 2012).

This recovery action is **partially met and ongoing**. Additional seed collections and the propagation of additional artificial populations are warranted.

[2] Seeds are exposed to a cold, moist environment to simulate winter conditions and overcome seed dormancy.

(5) Research the biology and the ecology of the autumn buttercup on known and potential habitat. Determine the following requirements for the subspecies: soil, hydrology, pollination, plant community structure, animal interactions, and phylogenetic relationship with its congeners.

Soil characteristics were studied as part of a doctoral dissertation (Van Buren 1994), and were subsequently published in a peer-reviewed journal article (Van Buren and Harper 1996). See section 2.3.1.1 for further information.

Hydrologic requirements for the subspecies have not been studied.

Pollination biology and pollinators have not been studied extensively. Floral visitors were observed at the family level in 1991 (Spence 1996). See section 2.3.1.4 for further information.

A number of studies have documented the plant community structure associated with the autumn buttercup. See section 2.3.1.4 for further information.

The impact of animals and their interaction with the autumn buttercup is well-documented. The species is highly palatable to both livestock and small mammals. The Recovery Plan considered grazing by both wildlife and livestock as the most significant threat to the species (USFWS 1991). Grazing pressure by livestock was heavy with significant losses of flowers and reproductive structures before the Preserve was purchased in 1988 and the repaired fence excluded livestock in 1989 (Mutz 1984; USFWS 1985; USFWS 1987). Herbivory continued to occur to the plants on the preserve from small mammals after livestock was excluded, with a complete loss of flowers and reproductive structures from adult plants in 1993 (Schelz 1990; Spence 1996). The failure of the 2007 and 2010 plant reintroductions in the Preserve was attributed to herbivory from small mammals, likely voles, with 100% mortality occurring in a matter of weeks after the second planting (TNC 2010). Given the sustained herbivory on the autumn buttercup after livestock removal, a study is in progress to determine the impact of small rodent herbivory on the buttercup population, as well as the interaction of livestock grazing with the rodent populations (USFWS 2011).

Alternately, the autumn buttercup persists with livestock grazing on the private property in much greater numbers than on the Preserve. Therefore, the impact of animals and their interaction with the autumn buttercup may be more complex than previously thought. Potential beneficial factors associated with livestock grazing, such as reduced vegetative competition, weed suppression, and trampling, complicate our ability to recommend beneficial management actions for the autumn buttercup. Future investigations will need to consider a more detailed study of livestock grazing to see what level of intensity and

frequency will support the growth of autumn buttercup populations.

The phylogenetic relationship[3] of the autumn buttercup with closely related taxa (congeners) has been studied since the completion of the recovery plan, but its taxonomic treatment continues to be disputed by taxonomists. See section 2.3.1.4 for more information.

This recovery action is **partially met** and **ongoing**. The hydrologic requirements and pollination biology of the autumn buttercup have not been completed, and additional research on the effects of livestock grazing is warranted.

(6) Establish and maintain additional autumn buttercup populations. Reintroduce plants into potential habitat, develop a management plan for the introduced populations, monitor and protect the introduced populations.

Two reintroductions occurred on the Preserve with 138 plants in 2007 and 45 plants in 2010 (TNC 2008; TNC 2010). The plan was to monitor the survival of reintroduced plants on a frequent basis throughout the growing season. The first reintroduction was under the direction of Utah Valley University staff, and the planting occurred in mid-June at two selected locations, named the wet and dry sites. Survival was high at both sites by the end of that growing season, 97.1% and 88.4%, for the wet and dry sites, respectively. In 2008, the plants were revisited and survivorship was 5.8% and 67% on the wet and dry sites, respectively. By 2010, there was 100% mortality of reintroduced plants at both sites.

A second reintroduction of plants occurred in 2010 under the direction of the Arboretum botanist, and the planting occurred on June 5, 2010. The planting site was selected because it was nearby and similar to the dry site from the first planting. Follow up monitoring a few weeks later revealed that all of the plants had been eaten, presumably by voles.

A third reintroduction is planned for 2013, under the direction of the Arboretum botanist. The goal of this reintroduction is to evaluate plant survival under different management regimes and planting procedures using a split plot experimental design. Autumn buttercup plants will be planted in ungrazed (control) plots and plots grazed by livestock (experimental). Half of the plants in each plot will be unprotected from grazing and herbivory (control) while the other half will be protected from grazing and herbivory (experimental) by wire-mesh cages (Murray 2011).

This recovery action is **partially met** and **ongoing**. Additional reintroduction efforts are warranted.

[3] The development or evolutionary history of a particular group of organisms.

(7) Develop public awareness and appreciation for the autumn buttercup. Inform private landowners of the importance of the subspecies protection.

There were a number of media articles in 1988 during the time The Nature Conservancy purchased the Preserve, and when the autumn buttercup was proposed for listing as endangered under the Act. A primary goal of both the USFWS and The Nature Conservancy is to be a good neighbor and develop positive relations with the local community. We continue to strive to educate and inform land owners of the autumn buttercup in the Sevier River Valley. The achievements we make for this recovery action will influence our ability to successfully perform other recovery actions including conducting comprehensive surveys, seed collection, and population monitoring.

This recovery action is **ongoing**. Additional public relation efforts are warranted.

(8) Develop downlisting criteria.

No downlisting criteria were developed.

This recovery action is **not met**.

2.3. Updated Information and Current Species Status

2.3.1. Background on the Species

2.3.1.1. Biology and life history

The autumn buttercup appears to be a short-lived perennial that reproduces only by seed (Spence 1996). Plants are 1 – 2 feet (0.3 – 0.6 meters) tall, with deeply divided leaves at the base and on the stem of the plant. Flowers are yellow with five rounded petals. Plants flower from late June through September, with seed dispersal occurring in August through October. Fruits are achenes[4] and are thick and round with one seed. Each flower produces approximately 15-25 seeds. Seeds require an exposure to cold temperatures before they germinate (Maschinski 1991). For a technical description of the species, see Benson (1948) or Holmgren *et al.* (2012).

[4] A dry fruit containing one seed and the seed does not adhere to the fruit wall.

The species occurs in saline, wet meadow habitat in the upper Sevier River Valley. The elevation range for the species is 6,374 – 7,000 feet (1,943 – 2,133 meters). Plants inhabit the transition zone between wet, sedge-dominated, spring-fed meadows and dry, upland meadows. Within this transition zone, the plants occupy raised hummocks of soil which are presumed to be formed from livestock trampling (Mutz 1984; Spence 1996; USFWS 2011). Juvenile plants are strongly associated with hummocks, which are drier than the surrounding soil within the Preserve (Spence 1996). We do not know if hummocks occurred prior to livestock grazing nor do we know the habitat conditions prior to livestock grazing.

The soils of the wet meadows on both the Preserve and the second population are described as Villy family silty clay loam (Web Soil Survey 2012). These soils are characterized as slightly saline, with a high water table that fluctuates between depths of 10 and 35 inches (25.4 and 88.9 centimeters). This soil class is found on flood plains in Panguitch and Johns Valleys, and is used for both irrigated pasture and rangeland. Soil characteristics in autumn buttercup habitat were compared to soils occupied by closely related buttercup taxa using a principal components analysis and were found to be quite different (Van Buren and Harper 1996). The authors characterized the soil at the Preserve and the original type locality as "saline" and these soils were separated from the other soils studied by differences in soil electrical conductivity, depth, organic matter, and free carbonate concentration. Additional soil characteristics that were compared include soil pH, texture, available phosphorus, and soil depth.

The plant community structure on the Preserve is well documented. The most common species in the vicinity of autumn buttercup were blue-eyed grass (*Sisyrinchium demissum*), wiregrass (*Juncus arcticus*), scratchgrass (*Muhlenbergia asperifolia*), and other autumn buttercup plants. In the saline meadow, species richness, coverage of forbs and grasses, cryptogamic[5] cover, and maximum height of associated plants were measured (Van Buren and Harper 1996). An extensive species list was developed for the Preserve that includes vascular plants, microphytes (algae), and aquatic macroinvertebrates (Van Buren *et al.* 2001). Occupied autumn buttercup habitat on the Preserve is associated with greater plant diversity, lower amounts of plant litter, and shorter vegetation than unoccupied habitat (Van Buren and Harper 1996). After livestock removal, the vegetation at the Preserve appeared to smother or limit reproduction of the autumn buttercup in the absence of grazing. Please see section 2.3.2.1 for further details.

A demographic study of the autumn buttercup was performed on a single subpopulation within the Preserve over a four year period shortly after

[5] Cryptogams are non-flowering plants that reproduce by spores: bryophytes, lichens, fungi, algae, ferns, and fern allies.

livestock removal (Spence 1996). Adults were significantly larger than juveniles, indicating a threshold size was necessary before flowering occurred. Overwinter survival of adults was low, less than 30%, for two of the three winters. The number of juveniles transitioning to adults declined over the four year study. The only parameter that remained stable, albeit low, over the study period was the proportion of seedlings transitioning to juveniles. Seedling mortality was consistently high during the study period, which is similar to other *Ranunculus* species (Sarukhan and Harper 1973). A seed bank study was not performed but was presumed to be short-lived since fewer seedlings appeared the year after reduced flowering and seed production.

Even with the apparently high numbers of autumn buttercup on the Preserve during the study period (see Table 2), there were few adult plants in the population, few juveniles successfully reached adulthood, and adult plants were short-lived. This study was crucial in documenting the demographic limitations that contributed to the second decline of autumn buttercup on the Preserve. The first population decline on the Preserve after 1983 was attributed to heavy livestock grazing, but we do not have data to support this hypothesis. Even with demography data, we still do not know the factors contributing to the second decline, although we know livestock grazing was not involved. Possible causes of the decline were (1) reduced available water in 1991 due to a dry year, and (2) the absence of trampling and grazing from livestock, with the resulting increased plant competition and plant litter on the Preserve (Spence 1996). Another widely-distributed buttercup, *Ranunculus acris*, also exhibits great population fluctuations at certain locations (Spence 1996). However, at these locations, there did not appear to be a permanent population, but rather a series of overlapping, short-lived generations (Sarukhan and Harper 1973).

Table 2. Timeline of autumn buttercup plant collections, plant surveys, and population estimates.

Population	Year	Number of Plants	Citation
Orton Ranch	1894	9 type specimen collected by Marcus Jones	Benson (1948)
	1948	16 isotype specimens collected by L. Benson	Benson (1948)
	1960	Surveyed, no plants	Ripley (1975)
	1974	Surveyed, no plants	Palmieri (1976)
	1982	Surveyed, no plants	Mutz (1983)
	1983	Surveyed, no plants	Mutz (1983)
	1985	Surveyed, no plants	54 FR 30550; July 21, 1989
	1986	Surveyed, no plants	54 FR 30550; July 21, 1989
	1987	Surveyed, no plants	54 FR 30550; July 21, 1989
TNC Preserve	1982	Plants found, not surveyed	Mutz (1983)
	1983	471 (407 adults, 64 seedlings)	Mutz (1984)
	1985	8	USFWS (1985)
	1986	14 (4 adults, 10 vegetative)	USFWS (1986)
	1987	12	USFWS (1987)
	1988	22 (9 adults, 13 seedlings)	54 FR 30550; July 21, 1989
	1989	11	USFWS (1991)
	1990	Approx. 200 plants	USFWS (1991)
	1991	488 (45 adults, 443 vegetative)	Spence (1993)
	1992	1009 (13 adults, 996 vegetative)	Spence (1993)
	1993	837 (16 adults, 821 vegetative)	Spence (1993)
	1994	282 (11 adults, 271 vegetative)	Spence (1996)
	2006	18	USFWS (2007)
	2007	142 (4 wild, 138 reintroduced)	Van Buren (2007); TNC (2008)
	2008	50 (? wild, 50 reintroduced survived)	TNC (2008)
	2009	42 (2 wild, 40 reintroduced survived)	TNC (2009)
	2010	0 (0 wild, 0 reintroduced survived)	TNC (2010)
	2011	15	USFWS (2011)
	2012	1, limited survey	USFWS (2012)
Dale Ranch	1991	Plants found, pop est. 200+	Fitts (2012b)
	2007	Pop est. 1,000-2,000	Van Buren (2007)
	2011	Pop est. several hundred	USFWS (2011)
	2012	Pop est. 500	USFWS (2012)

We have limited information on the pollinators of autumn buttercup and the pollination biology has not been studied. Floral visitors were observed at the family level in 1991, and included species of Diptera, Lepidoptera, and Hymenoptera (Spence 1996). This information is not particularly detailed and the study design was not documented.

2.3.1.2. Distribution, Abundance, and trends

The autumn buttercup is narrowly distributed in the Sevier River Valley of Garfield County, Utah. It is likely not a species of recent origin, but has been postulated as a "taxonomic bridge" between *Ranunculus acriformis*

of the northern Rocky Mountains and *R. occidentalis* of the more coastal mountains in the western United States. (USFWS 1991). The historical distribution of this species is unknown, but was presumed to be more widespread throughout southern Utah in wet meadow habitat associated with perennial springs (Benson 1948). The autumn buttercup is likely a 'Pleistocene relict' based upon the geographic distribution of its suggested relatives where they occur in mesic boreal-temperature climates, and in one case, an arctic-boreal climate (Benson 1948, Spence 1991). However, the increased aridity of the region in recent geologic time during the Holocene and major changes in land use since the early settlers have likely contributed to the reduced distribution of this species.

When we published the Recovery Plan in 1991, we knew of one extant population of autumn buttercup on the Preserve with an estimated total population of 200 individuals from a 1990 survey (USFWS 1991). The type locality at Orton Ranch described by Benson in 1948 approximately 0.5 miles south of the Preserve was presumed to be extirpated.

We now know of three populations of autumn buttercup—two extant and one extirpated. The two extant populations occur on the Preserve and the Dale Ranch, with an estimated total population less than 1,000 plants (see Table 2). The Dale Ranch population was discovered in 1991, shortly after the Recovery Plan was finalized. The Orton Ranch type locality is still presumed to be extirpated; however, the site has not been visited since 1991. See Figure 1 for the three population locations.

Figure 1. Locations of three populations north of Panguitch, Garfield, County, Utah.

Plant counts and population estimates over time are summarized in Table 2. Life stage information was included when available. Numbers are distinguished between reintroduced plants and those naturally occurring (wild) on the Preserve. There were no plants on the Preserve in the fall of 2010, shortly after the second reintroduction occurred (see section 2.2.3.(6) for more details). Population trend data for the Preserve is depicted in Figure 2.

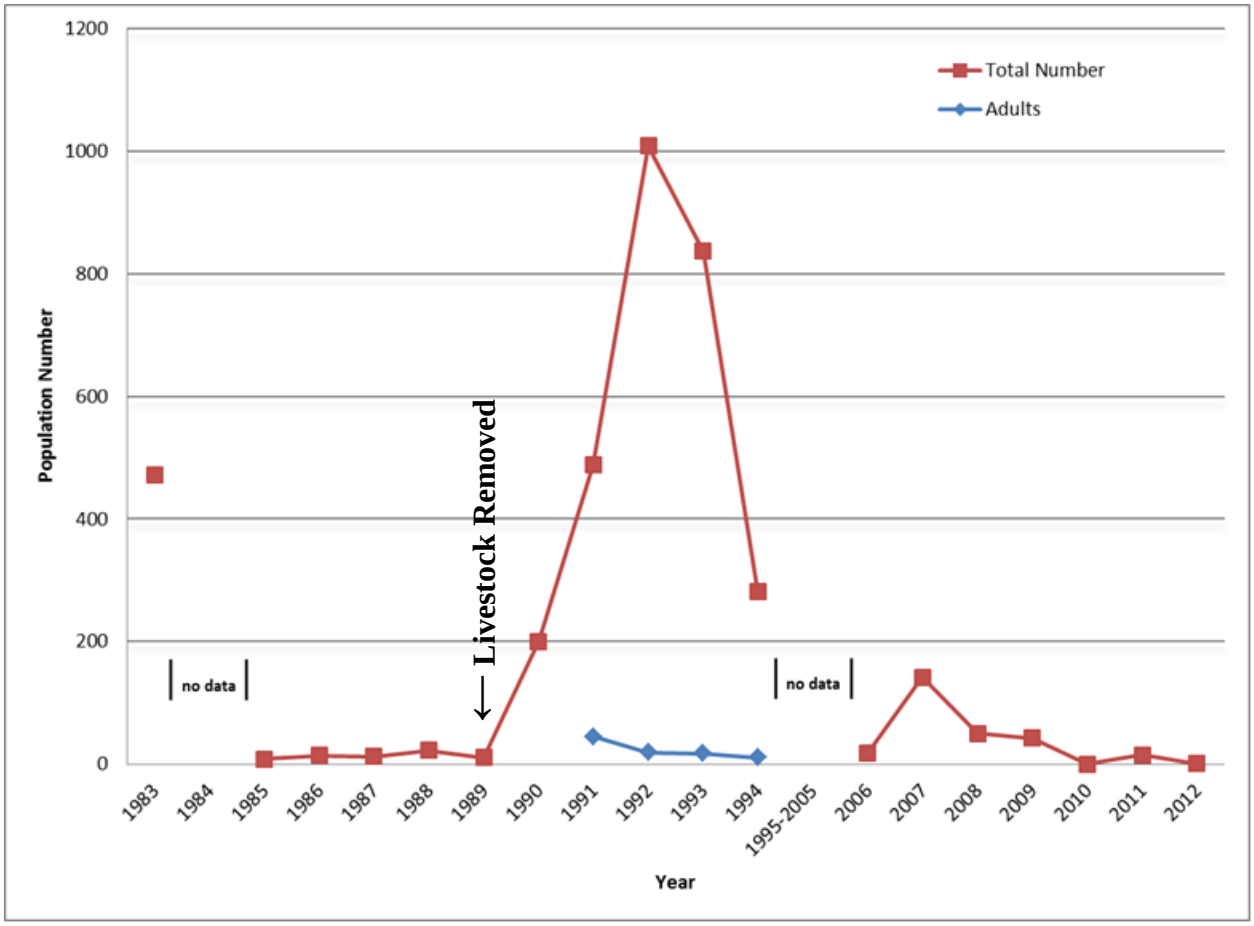

Figure 2. Autumn buttercup population trend on the Preserve. Years without data are identified. The number of adult plants in the population are shown from 1991–1994.

We do not have a clear understanding of the total distribution of autumn buttercup within the Sevier River Valley. Comprehensive surveys were not performed and are hindered by lack of access to private property. Additionally, an analysis of potential habitat using available environmental variables that include elevation, soil type, spring locations and wet meadow habitat has not been performed for this species.

2.3.1.3. Genetics, genetic variation, or trends in genetic variation (e.g., loss of genetic variation, genetic drift, inbreeding, etc.)

When we wrote the Recovery Plan, we only knew of one extant population of autumn buttercup on the Preserve. Genetic markers were characterized for this population, but were used to clarify taxonomic questions rather than questions related to small population size (Van Buren *et al.* 1994). There have been no studies to assess trends in genetic variation, inbreeding depression, or the genetic similarity of the two populations.

2.3.1.4. Taxonomic classification or changes in nomenclature

The phylogenetic relationship of the autumn buttercup with closely related taxa has been studied since the completion of the Recovery Plan, but its taxonomic treatment continues to be disputed. The autumn buttercup was recommended to be a separate species based upon a genetic analysis of molecular markers that showed a clear separation of the autumn buttercup from other varieties of *Ranunculus acriformis* (Van Buren 1994; Van Buren *et al.* 1994). Environmental characteristics of the occupied habitat also clearly separated autumn buttercup habitat from habitat occupied by closely related taxa (Van Buren and Harper 1996); however, morphological characteristics were not so clear (Van Buren 1994). Due to genetic separation, Van Buren *et al.* (1994) recommended reclassifying the variety *R. acriformis* var. *aestivalis* to a full species *R. aestivalis*.

A taxonomic review was later published in 1997 in the Flora of North America, and the author retained the varietal rank of *R. acriformis* var. *aestivalis* (Whittemore and Parfitt 1997). It must be noted that the author states it was his preference to retain the varietal rank and that the molecular results of Van Buren *et al.* "are consistent with either interpretation."

The 4th edition of A Utah Flora, published in 2008, disagrees with both treatments, and considers it a variety of *R. acris* based upon morphological characteristics (Welsh *et al.* 2008). The latest taxonomic review was published in 2012 for the Intermountain Flora, and the authors accepted the species rank, *R. aestivalis*, recommended by Van Buren *et al.* (Holmgren *et al.* 2012). Two online plant databases accept the species rank, *R. aestivalis*, the USDA PLANTS Database (USDA PLANTS Database 2012) and The Biota of North America Program (Kartesz 2011).

Given the recent taxonomic evaluation which accepts the autumn buttercup as a valid species rank, we recommend updating the synonymy (same identity) of *R. acriformis* var. *aestivalis* = *R. aestivalis* and find this taxonomic change does not affect the listing or protection of the autumn buttercup under the Act. The recovery priority number will change from 6

to 5 when the full species rank is accepted. We recommend the taxonomy be amended through a technical revision to the list at 50 CFR 17.12 (see section 4). We also will formally request the name be changed in ITIS database. Until the name can be changed in the Federal Register, we will continue to refer to this species as *R. acriformis* var. *aestivalis.*

2.3.2. Five-Factor Analysis—threats, conservation measures, and regulatory mechanisms

Autumn buttercup was listed as endangered based upon low population numbers, limited distribution, threats associated with livestock grazing and small mammal herbivory, and scientific voucher specimen collecting (54 FR 30550, July 21, 1989). In the Recovery Plan, we also considered water diversion, agricultural development, and environmental stochasticity (e.g., changes in weather, available pollinators, amount of predation) to be threats to autumn buttercup (USFWS 1991). To help identify new threats in addition to assessing the threats we identified when we listed the species, we systematically examined what we know about autumn buttercup's life history in the context of the same five factors we considered when we listed the species. In order to better understand how any given threat actually affects the species, each identified threat was partitioned into **stressors**, which are processes or events that negatively impact the species. Through this threats assessment process, we evaluated each stressor for its **scope**, **immediacy**, and **intensity**, as a way to identify the true magnitude of the potential threat to autumn buttercup. We then characterized the **exposure** of autumn buttercup to the stressors and the **response** we would expect from the species if exposed to the stressor. Using this approach, we are able to integrate the scope, immediacy, intensity, exposure, response at the species level, and our professional interpretation, into an **overall threat level** (see Table 3 and APPENDIX A). The threats presented in the table are ranked according to our "Draft Guidance for Conducting Threats Assessment under the Act" (USFWS 2006).

Table 3. Key to overall threat level ranking components.

Scope (geographic extent of the stressor)	Localized – less than 1 population
	Moderate – 1 population
	Rangewide – stressor is present throughout both extant populations
Immediacy (timeframe of the stressor)	Imminent – is the stressor present and acting on the target now
	Future – anticipated in the future
	Historic – or has the impact already occurred
Intensity (the strength of the stressor itself)	Low
	Moderate
	High
Exposure (the extent to which a target resource & stressor actually overlap in space and/or time given the scope)	Small (<10% of population is exposed)
	Moderate (11-30% of population is exposed)
	High (>31% of population is exposed)
Response (level of physiological/behavioral response due to a specific stress considering growth, fecundity, and mortality rates)	Basic need inhibited–basic plant needs for growth & development
	Basic need supported-basic plant needs for growth & development
	Injury – direct physical injury
	Mortality – identifiable reduction in growth rate or survival
Overall Threat Level (integration of the scope, immediacy, intensity, exposure, and response at the species level)	Beneficial (no action is needed)
	Potential (at this point in time, we lack scientific information regarding this factor to determine the overall threat level)
	Low (at this point in time, no action is needed)
	Moderate (action is needed)
	High (immediate action necessary)

2.3.2.1. Present or threatened destruction, modification or curtailment of its habitat or range

Appendix A lists the threats we identified in our current threats assessment that could or have resulted in the destruction, modification, or curtailment of the habitat or range of autumn buttercup.

Livestock Grazing Practices

In the Recovery Plan, we considered livestock grazing by cattle, horse, and sheep to be the most significant threat to the autumn buttercup. For this review, we consider two stressors of this threat: (1) soil and vegetation disturbance from livestock grazing and trampling, and (2) plant injury and mortality from livestock grazing and trampling. We consider the stressors separately in the threats matrix (see Appendix A), but combine them in the overall threat level for livestock grazing practices.

We recognize that the effects of livestock grazing on this species are complex and may not always be negative. For example, the autumn buttercup was presumed extirpated at the Orton Ranch type locality from intense grazing pressure by livestock in the wet meadows. However, the benefits of removing grazing on the Preserve are not as evident. Grazing pressure by livestock was heavy with significant losses of flowers and reproductive structures before the Preserve was purchased in 1988 (Mutz 1984; USFWS 1985; USFWS 1987). To protect the autumn buttercup on the Preserve, The Nature Conservancy fenced the property to exclude livestock in 1989. An increase in plant vigor and flowering were noted shortly after livestock was removed from the Preserve (USFWS 1991). The autumn buttercup population on the Preserve continued to increase for four years after livestock removal. However, the alleviation of this threat did not achieve the desired result of long-term population growth and stability because the population again plummeted to very low levels after 1993 (see Figure 2). The reasons for the population decline are unknown but are presumed to be related to the complete removal of livestock grazing.

After livestock removal, the vegetation at the Preserve appeared to smother or limit reproduction of the autumn buttercup in the absence of grazing. The invasive weed, Scotch thistle (*Onopordum acanthium*), increased more than 10-fold and completely occupied some areas where the buttercup occurred (Spence 1996). To reduce competition from neighboring plants, manual clipping, litter removal, and spring burns were performed. Autumn buttercup plants responded positively to the annual removal of plant litter on the Preserve. Clipped plots had a greater diversity of plant species and significantly more autumn buttercup plants than unclipped plots (Van Buren *et al.* 2001). A series of spring burns was initiated on the Preserve to mimic the presumed natural fire cycle of the area in 1996, 2000, 2004, 2005, and 2006 (Whitham 2012). Spring burning was discontinued when Utah Valley University researchers decided it provided little obvious benefit to the autumn buttercup (Whitham 2012).

Livestock grazing, at appropriate levels, within wet meadow habitat can improve plant biodiversity, reduce plant litter accumulation, and provide suitable microsites for seed germination (Huhta *et al.* 2001; Hellström *et al.* 2003). The potential benefit of livestock grazing is clearly shown by the habitat data associated with autumn buttercup presence on the Preserve (see section 2.3.1.1). It is important to note that the habitat data for the Preserve were collected before livestock were removed. However, the vegetation cover on the Preserve has changed considerably since then; a thick litter layer has developed and plant diversity is low on the ungrazed Preserve. The microhabitat (e.g., hummocks) that autumn buttercup prefers is absent on the ungrazed Preserve, but still occurs on the actively-grazed Dale Ranch property which supports a relatively large population of autumn buttercup (USFWS 2012). Cattle grazing and trampling on the Dale Ranch are creating and maintaining the desired hummock microhabitat for autumn buttercup, removing plant litter, and fostering plant diversity. We conclude the inherent threat posed by livestock grazing is less than previously assessed, based on the near extirpation of the autumn buttercup on the Preserve and the abundance of autumn buttercup on the Dale Ranch with cattle grazing. Autumn buttercup persists with and may benefit from a certain level of grazing (see Appendix A).

Grazing and trampling may lead to plant injury (includes reduced reproduction due to removal of flowers and seeds) and mortality; this impact would be detrimental to individual autumn buttercup plants. We do not have data to know how many autumn buttercup plants are injured or die from grazing and trampling, other than the field observations included in the final rule to list the species that document flowers and reproductive structures were repeatedly grazed (54 FR 30550; July 21, 1989). We are aware of a trampling study that was performed on two, widespread buttercup species, *Ranunculus repens* and *R. acris*, which showed that livestock trampling had no effect on their survival, growth and biomass (Deimer and Schmid 2001). See Appendix A for the stressor evaluation.

The threat of livestock grazing and trampling to autumn buttercup depends upon whether appropriate grazing practices are utilized. An appropriate grazing regime is considered beneficial and does not pose a threat if it supports the necessary habitat characteristics for the species and does not lead to significant plant injury and mortality. However, an inappropriate grazing regime poses a high threat to autumn buttercup if it includes practices such as excessive stocking rates and inappropriately timed grazing. These practices were likely in place at the time of listing at the Orton Ranch type locality which is presumed to be extirpated. We also now consider the complete elimination of grazing to be an inappropriate grazing practice and a high threat to autumn buttercup since this is a

presumed contributing factor in the population decline on the Preserve. We acknowledge that we need more information in order to develop appropriate grazing practices for the species, specifically the levels of intensity, timing, and duration of grazing and trampling that support the population growth and recovery of autumn buttercup.

We assign a **high** overall threat level for livestock grazing practices at the present time, not because grazing and trampling are inherently detrimental to autumn buttercup, but because an appropriate grazing regime is not currently implemented on the Preserve and we do not have sufficient population trend data to assess the suitability of the grazing regime at the Dale Ranch population. We will re-evaluate this threat level when we have more information regarding appropriate grazing practices.

Water Diversion for Agricultural Development

In the Recovery Plan, we identified that diverting groundwater from the perennial springs or altering the hydrology or aquifer upon which the springs depend would affect the autumn buttercup populations by reducing the total acreage of wet meadow habitat. Agricultural uses in the Sevier River Valley include irrigated pasture, irrigated crops, and rangeland. We considered the threat of both onsite and offsite agricultural water development in our threats analysis (see Appendix A). With regard to onsite water development, there is no threat of this occurring on the Preserve. The present land use of the Dale Ranch property is un-irrigated rangeland for cattle and we are unaware of any imminent plans to change this land use. For the two extant populations, we no longer consider this factor to be a threat to autumn buttercup habitat because this threat is presently not occurring, nor has it occurred in the past 29 years. However, if additional potential habitat or occupied habitat of autumn buttercup is found and if future water diversion occurs, we will re-evaluate the degree of threat this poses to the species.

To assess the threat of offsite water development on the habitat of the two extant autumn buttercup populations, we looked for new agricultural development immediately adjacent to both properties. We compared aerial photography taken between 1983 and 2012, and found no new agricultural development and no change in land use, immediately adjacent to the Preserve and the Dale Ranch property. For the two extant populations, we no longer consider this factor to be a threat to autumn buttercup habitat because this threat is presently not occurring, nor has it occurred in the past 29 years. However, if additional potential habitat or occupied habitat of autumn buttercup is found and if future water diversion occurs, we will re-evaluate the degree of threat this poses to the species.

We do not have data on the hydrology of the wet meadow on the Preserve and no documentation to suggest the spring is affected by nearby agricultural water use. If water development commences in the future that may affect the autumn buttercup populations, or we have hydrologic data which suggests agricultural water use is affecting autumn buttercup habitat, we will re-evaluate the degree of threat this poses to the species.

Development of Buildings and Structures in Habitat

In the Recovery Plan, we identified construction of corrals and outbuildings associated with agricultural land use to be a threat to the autumn buttercup. We believed that structures would lead to an increased use of the immediate area around them and would likely degrade the wet meadow habitat. However, there have been no corrals or outbuildings built within the known habitat for the two extant populations. There is no concern of these structures being built on the Preserve, and there are no new structures on the Dale Ranch property. Given the high water table and periodic flooding that occurs in the wet meadows, it is unlikely that large structures will be built on the habitat. Therefore, we no longer believe this to be a threat because this threat is presently not occurring, nor has it occurred in the past 21 years. However, if future development does occur, we will re-evaluate the degree of threat this poses to the species.

Invasive Species

Invasive species were not considered a threat to autumn buttercup in the Recovery Plan. However, in the years following livestock removal from the Preserve, a noxious weed, Scotch thistle (*Onopordum acanthium*) increased ten-fold and completely occupied some areas where autumn buttercup originally occurred (Spence 1996). The Nature Conservancy developed a weed management plan and began controlling the Scotch thistle in 1995 and the spread of Scotch thistle continues to be controlled as per their weed management plan (TNC 1995). Scotch thistle was not documented to be a threat to autumn buttercup on the Dale Ranch (USFWS 2011; USFWS 2012). We conclude that invasive species are a **low** threat since weeds are being controlled on the Preserve, and are negligible on Dale Ranch. The intensity of this threat is presently low as well and the exposure of this threat is low.

Summary

We conclude that livestock grazing practices pose a high threat to autumn buttercup at the present time because livestock removal likely contributed to the population decline at the Preserve and we now consider this to be an inappropriate grazing practice. We evaluated the threat of water diversion and associated agricultural development for onsite and offsite

development; however, neither is considered a threat. Development of structures within autumn buttercup habitat is no longer considered a threat because no development has occurred since the species was listed and future development is unlikely given the high water table.

The invasive species, Scotch thistle, spread within previously occupied subpopulations of autumn buttercup on the Preserve and was thought to contribute to the extirpation of those subpopulations. The present threat is much lower now that a weed control program was implemented on the Preserve. We conclude invasive species pose a low threat to autumn buttercup, and the existing weed management on the Preserve is adequately controlling this threat. The overall threat level for all factors considered in this section is **moderate**.

2.3.2.2. Overutilization for commercial, recreational, scientific, or educational purposes

Overutilization for scientific purposes was considered a threat at the time of listing, and was specifically mentioned by Benson (1948) to discourage other taxonomists from collecting autumn buttercup specimens for their plant collections. However, this threat has not been realized, and only limited seed collection for conservation and recovery purposes is known to occur. We conclude this is not a threat to autumn buttercup because it is not known to occur; however, if future collecting does occur, we will re-evaluate the degree of threat this poses to the species. We are not aware of any commercial, recreational, or educational threats to autumn buttercup.

2.3.2.3. Disease or predation

Disease and insect predation were not considered threats to autumn buttercup in the listing decision or in the Recovery Plan. We have no new information to suggest they are present or future threats to autumn buttercup.

In the Recovery Plan, we mentioned small mammals, in addition to livestock, were consuming autumn buttercup plants; however, we did not have data at the time to inform us as to how serious a threat this was to the population on the Preserve (Schelz 1990; USFWS 1991). Herbivory from small mammals resulted in the complete loss of flowers and reproductive structures from adult plants in 1993 (Spence 1996). The failure of the 2010 plant reintroduction in the Preserve was attributed to herbivory from small mammals, likely voles, with 100% mortality occurring in a matter of weeks after the 2010 planting (Murray 2010; TNC 2010).

The combined effect of plant herbivory and seed predation by small mammals can exert significant effects on plant species richness and diversity in wet meadows (Fraser and Madson 2008). Voles selectively

reduce herbaceous plant cover and seed banks for those plants they prefer to consume, giving a competitive advantage to less preferred species (Huntley 1991; Howe and Brown 1999; Howe *et al*. 2002; Howe and Lane 2004). Voles were documented to consume *Ranunculus* seeds in areas protected from livestock grazing, but quickly stopped after livestock grazing resumed (Sarukhan 1974). Voles prefer to occupy habitat with sufficient plant cover or plant litter found in unmowed and ungrazed areas and have shown to avoid areas of open ground or low plant cover even though seeds and seedlings are present (Howe and Brown 1999; Jacob and Brown 2000; Skopec 2012). Vole populations also exhibit population pulses with a periodicity of 3 – 6 years, and during those high abundance periods, the reduction or elimination of some plant species can occur (Howe *et al*. 2002). We are currently working with a local college to research small mammal abundance, foraging diet, and to identify which mammals are foraging on the autumn buttercup at the Preserve.

Herbivory occurs at high intensity levels at one of the two extant populations. Small rodents may have devastating consequences for individual plants and populations. Therefore, we conclude the threat posed by small mammal herbivory is **high**, and is greater than previously assessed.

2.3.2.4. Inadequacy of existing regulatory mechanisms

There were no Federal, State, or local laws or regulations that protected autumn buttercup at the time of listing. The only law or regulation currently protecting this species is the Act. Autumn buttercup does not occur on Federal lands; therefore, the Act provides protection only against the removal or transport of the species. Collection was initially considered a threat to this species but is not known to occur (see section 2.3.2.2). It is unlikely collection will become a threat in the absence of the Act's protection.

At the time of listing and in the Recovery Plan, we considered livestock grazing, small mammal herbivory, scientific collection, water diversion, agricultural development, and stochastic events threats to the species. . Water diversion and agricultural development are no longer considered threats. The threat of scientific voucher collection has not been realized. The greatest threats to autumn buttercup are inappropriate grazing practices, small mammal herbivory, small population size, and climate change and there are presently no laws or regulations designed to manage for these threats.

The Clean Air Act of 1970 does not adequately address the effects of global climate change such that the threat to autumn buttercup and the species' habitat from insufficient recharge of the groundwater aquifer would be ameliorated in the forseeable future. The Clean Air Act of 1970

(42 U.S.C. 7401 et seq.), as amended, required the Environmental Protection Agency (EPA) to develop and enforce regulations to protect the general public form exposure to airborne contaminants that are known to be hazardous to human health. In 2007, the Supreme Court ruled that gases that cause global warming are pollutants under the Clean Air Act, and the EPA has the authority to regulate carbon dioxide and other heat-trapping gases (Massachusetts *et al.* v. EPA 2007 [Case No. 05-1120]). The EPA published a regulation to require reporting of greenhouse gas emissions from fossil fuel suppliers and industrial gas suppliers, direct greenhouse gas emitters, and manufacturers of heavy-duty and off-road vehicles and engines (74 FR 56260; October 30, 2009). The rule does not require control of greenhouse gases; rather it requires only that sources above certain threshold levels monitor and report emissions. At this time, it is not known what regulatory mechanisms will be developed by the EPA.

In summary, prior to listing, autumn buttercup had no significant State or Federal protections. Under the Act's protection, a review of Federal actions potentially impacting the species can be performed. Because the species occurs on private land, two of the three high threats to the species cannot be addressed by regulatory mechanisms (small mammal herbivory and inappropriate grazing practices). As documented in section 2.3.2.5, climate change is a high threat to the species that can be addressed by regulatory mechanisms, but the Clean Air Act of 1970 presently does not regulate greenhouse gas emission levels. We assign an overall threat level to this factor as **high** because climate change is a high threat to the species and is not adequately addressed by the existing Federal regulatory mechanisms.

2.3.2.5. Other natural or manmade factors affecting its continued existence

The following are other threats to autumn buttercup which are not fully analyzed in the preceding sections.

Vulnerability due to Small Population Sizes

The listing decision stated that the small population and limited distribution of autumn buttercup contribute to the vulnerability of the species to natural and human-caused stresses. Population size is likely the best predictor of extinction rate for isolated populations (Pimm *et al.* 1988; Fischer and Stöcklin 1997). Small plant populations are at an increased risk of extinction due to the potential for inbreeding depression, loss of genetic diversity, and lower sexual reproduction rates (Ellstrand and Elam 1993; Wilcock and Neiland 2002), and are more likely to succumb to natural catastrophes (e.g., drought, fire, and flood) and environmental stochasticity. In addition, extinction is significantly more likely for

populations undergoing large fluctuations in population size (Fisher and Stöcklin 1997).

The extremely small population size and only two extant occurrences of autumn buttercup make this one of the most endangered plants in Utah. Small population size in and of itself is not considered a threat; however, it may increase the species' vulnerability if other threats discussed in this analysis are impacting the species. For the autumn buttercup, the species' small population size means that even moderate levels of small mammal herbivory or invasive weed species (see Disease or Predation, above), or short periods of drought conditions associated with climate change (see Climate Change, below), could lead to the extirpation of a population.

We conclude the threat posed by small population size and small range of autumn buttercup is **high** when evaluated cumulatively with small mammal herbivory, invasive weed species, and climate change. We have attempted to alleviate this threat through three separate reintroduction efforts (see section 2.2.3.(6) after acknowledging that the greatest impediment to recovery was small population size (USFWS 2007)). However, these reintroduction efforts have not been successful.

Lack of Scientific Knowledge/Monitoring

The lack of scientific knowledge to identify the meaningful threats contributing to the population decline of autumn buttercup has caused the species to be managed ineffectively. While not a threat in and of itself, lack of scientific knowledge and monitoring information affects our ability to manage and recover the species. We acknowledge the complexity of biotic interactions directly and indirectly affecting autumn buttercup. We could promote population growth on the Preserve if we could better quantify the threats the species faces and better understood how the threats could be alleviated. We consider this factor to have a **high** level of impact to the species because we believe that beneficial management is crucial to preventing the extinction of autumn buttercup by providing the essential ecological processes necessary to recover the species.

Climate Change

Our analyses under the Act include consideration of ongoing and projected changes in climate. The terms "climate" and "climate change" are defined by the Intergovernmental Panel on Climate Change (IPCC). The term "climate" refers to the mean and variability of different types of weather conditions over time, with 30 years being a typical period for such measurements, although shorter or longer periods also may be used (IPCC 2007a). The term "climate change" thus refers to a change in the mean or variability of one or more measures of climate (e.g., temperature or

precipitation) that persists for an extended period, typically decades or longer, whether the change is due to natural variability, human activity, or both (IPCC 2007a).

Scientific measurements spanning several decades demonstrate that changes in climate are occurring, and that the rate of change has been faster since the 1950s. Examples include warming of the global climate system, and substantial increases in precipitation in some regions of the world and decreases in other regions. (For these and other examples, see IPCC 2007a; and Solomon *et al*. 2007). Results of scientific analyses presented by the IPCC show that most of the observed increase in global average temperature since the mid-20th century cannot be explained by natural variability in climate, and is "very likely" (defined by the IPCC as 90 percent or higher probability) due to the observed increase in greenhouse gas (GHG) concentrations in the atmosphere as a result of human activities, particularly carbon dioxide emissions from use of fossil fuels (IPCC 2007a; Solomon *et al*. 2007). Further confirmation of the role of GHGs comes from analyses by Huber and Knutti (2011), who concluded it is extremely likely that approximately 75 percent of global warming since 1950 has been caused by human activities.

Scientists use a variety of climate models, which include consideration of natural processes and variability, as well as various scenarios of potential levels and timing of GHG emissions, to evaluate the causes of changes already observed and to project future changes in temperature and other climate conditions (Meehl *et al*. 2007; Ganguly *et al*. 2009; Prinn *et al*. 2011). All combinations of models and emissions scenarios yield very similar projections of increases in the most common measure of climate change, average global surface temperature (commonly known as global warming), until about 2030. Although projections of the magnitude and rate of warming differ after about 2030, the overall trajectory of all the projections is one of increased global warming through the end of this century, even for the projections based on scenarios that assume that GHG emissions will stabilize or decline. Thus, there is strong scientific support for projections that warming will continue through the 21st century, and that the magnitude and rate of change will be influenced substantially by the extent of GHG emissions (IPCC 2007a; Meehl *et al*. 2007; Ganguly *et al*. 2009; Prinn *et al*. 2011). (See IPCC 2007b, for a summary of other global projections of climate-related changes, such as frequency of heat waves and changes in precipitation. Also, see IPCC 2011for a summary of observations and projections of extreme climate events.)

Although many species already listed as endangered or threatened may be particularly vulnerable to negative effects related to changes in climate, we also recognize that, for some listed species, the likely effects may be positive or neutral. In any case, the identification of effective recovery

strategies and actions for recovery plans, as well as assessment of their results in 5-year reviews, should include consideration of climate-related changes and interactions of climate and other variables. These analyses also may contribute to evaluating whether an endangered species can be reclassified as threatened, or whether a threatened species can be delisted.

Global climate projections are informative, and, in some cases, the only or the best scientific information available for us to use. However, projected changes in climate and related impacts can vary substantially across and within different regions of the world (IPCC 2007a). Therefore, we use "downscaled" projections when they are available and have been developed through appropriate scientific procedures, because such projections provide higher resolution information that is more relevant to spatial scales used for analyses of a given species (see Glick *et al*. 2011, for a discussion of downscaling). With regard to our analysis for the autumn buttercup, downscaled projections are not available.

At the time of listing and in the Recovery Plan, climate change was not specifically mentioned as a threat to autumn buttercup. However, the present restricted range of autumn buttercup is thought to be directly affected by drier climate conditions of the Holocene, as former lakes and springs dried-up within the region. Autumn buttercup is likely a "Pleistocene relict" and was formerly widespread during the cooler and wetter conditions of the Pleistocene based upon the geographic distribution of relatives of autumn buttercup, where they occur in mesic boreal-temperature climates, and in one case, an arctic-boreal climate (Benson 1948; Spence 1991). If the narrow distribution of autumn buttercup can be explained by climatic variables, as opposed to other factors suggesting plant endemism such as soil type or pollinator specificity, then the species would be particularly vulnerable to future climatic change (Schwartz *et al.* 2006).

In the southwestern United States, including Utah, average temperatures have increased ~1.5°F (0.8°C) compared to a 1960 – 1979 baseline (Karl *et al.* 2009). By the end of this century, temperatures are expected to warm a total of 4 to 10°F (2 to 5°C) in the southwest (Karl *et al.* 2009). Much of the Southwest remains in a 10-year drought, recently assessed as the most severe western drought of the last 110 years (Karl *et al.* 2009). Water resources in the western United States are predicted to be sensitive to climate change (Karl *et al.* 2009). The levels of aridity of recent drought conditions are predicted to become the new climatology for the southwestern United States (Seager *et al.* 2007). Utah is expected to see longer periods between precipitation events, while those precipitation events become more intense (Steenburgh *et al.* 2007).

The survival of autumn buttercup directly depends upon the continued existence of the perennial springs that support their wet meadow habitat. These springs and the water table of the Sevier River Valley are associated with a groundwater aquifer that is primarily recharged from precipitation that falls on the higher elevations as snow (Thiros and Brothers 1993). Measured water levels in wells throughout the Sevier River Valley fluctuate with precipitation, and long-term water level fluctuations follow climatic trends for the area (Thiros and Brothers 1993). An increase in frequency of extreme weather, like drought and flooding and reduced snowpack under drought conditions, are likely to affect water table and aquifer levels in the Sevier River watershed. Since the aquifer is highly dependent upon recharge from winter precipitation in the local mountain ranges to maintain flows, we assume this aquifer will likely be sensitive to the anticipated effects from climate change as reported for other aquifers in Nevada where downscaled climate projections are available (NDOW 2012).

In addition to habitat impacts, severe climate conditions have the potential to profoundly impact individuals, populations, and plant communities (Levine and Paige 2004). Drought conditions can directly affect autumn buttercup through declines in survival, plant vigor, and reproductive output, which have been documented for other rare plants in the Southwest during the drought years of 2001 through 2004 (Anderton 2002; Van Buren and Harper 2003; Clark and Clark 2007). Unlike some other rare plants in the region, we cannot assume that autumn buttercup is drought tolerant. Indirect effects to autumn buttercup include biotic interactions with other plants and with herbivores, which should also be considered when assessing how a plant species will respond to climate change (Fox *et al.* 1999). Shifts in the timing and availability of water are likely to indirectly affect autumn buttercup by influencing plant dominance and floristic composition of the wet meadow thereby altering vegetation competition with neighboring plants (Bruelheide 2003). Herbivory and small mammal foraging may intensify under drought conditions (Fox *et al.* 1999; Bruelheide 2003; Levine and Paige 2004), and extreme water limitation will diminish a plant's capacity to tolerate herbivory (Levine and Paige 2004). While we are uncertain how these climate-related interactions will affect autumn buttercup, they should be mentioned here, and considered in future research of climate-related effects to the species.

Our current understanding is that the habitat of autumn buttercup was sensitive to historic climate change in the region, and the restricted range of the species can be explained by the prolonged period of aridity during the Holocene post-glacial epoch (12,000 years before present). Autumn buttercup has not been able to maintain a large range or robust population under current climate conditions, and therefore does not appear to have the adaptive capacity (Glick *et al.* 2011; Dawson *et al.* 2011) to adjust to a

future climate change scenario of prolonged arid conditions. Extinction risk from climate change is predicted to be higher for species such as autumn buttercup with small ranges, particularly for those species whose current distributions are constrained by climate variables (Schwartz *et al.* 2006). We conclude that autumn buttercup is vulnerable to climate change, and that the threat of climate change to autumn buttercup is **high**, mainly due to the range-wide scope, the imminent and future immediacy, and the high exposure of the threat. There are uncertainties in our threat evaluation since downscaled climate projections are not available for our specific location and aquifer, and a vulnerability assessment has not been performed for autumn buttercup. We will re-assess the degree of threat climate change poses on autumn buttercup when more information becomes available.

Summary of Factor E

The effects of small population size is a detriment to the survival of autumn buttercup, particularly if the species is subjected to other threats (see Factor C and Climate Change). In addition, our lack of scientific knowledge of this species is a key factor in limiting our ability to effectively manage autumn buttercup on the Preserve. However, neither of these two factors are considered threats in this analysis. Climate change is considered a high threat to autumn buttercup because the wet meadow habitat and the species are highly vulnerable to changes in the aquifer under protracted and severe arid conditions. Autumn buttercup has not been able to maintain a large range or robust population under current climate conditions, and therefore does not appear to have the adaptive capacity to adjust to anticipated effects from climate change. The overall threat level for this factor is **high**.

2.4. Synthesis

At the time of listing, we concluded that autumn buttercup was endangered (i.e., in danger of becoming extinct throughout all or a significant portion of its range) due to low population numbers, limited distribution, and threats associated with livestock grazing, small mammal herbivory, and scientific voucher specimen collecting. In the Recovery Plan, we also considered water diversion, agricultural development, and environmental stochasticity to be threats to autumn buttercup (USFWS 1991).

We examined the same five factors we considered when we listed the species and identified any potential new threats we have not previously considered. Once these potential threats were identified, we systematically analyzed the impacts using the rankings components presented in Table 3. This allowed us to assess the factors in relation to the species' exposure and evaluate the relative importance of each potential threat to the species' persistence and recovery, allowing us to rank the threats in order of importance (USFWS 2006; Appendix A).

We assessed the factors related to overutilization (for personal and commercial uses), deleterious effects of research efforts (includes scientific voucher specimen collecting), onsite agricultural development (water diversion), offsite agricultural development (water diversion), development of structures on autumn buttercup habitat, disease, and insect predation and determined these factors are not considered threats to the species.

We assessed the factor of invasive species and determined this factor pose a low threat to the species.

We assessed the factors of inappropriate livestock grazing practices, herbivory from small mammals, climate change, and inadequacy of regulatory mechanisms and determined these factors pose a high threat to the species, exacerbated by the vulnerability due to small population size and our lack of scientific understanding of the species' needs.

When analyzing the human-induced threats the species faces in conjunction with small population size and climate change, the species is inherently more vulnerable to stochastic extinction events and environmental changes. The species is vulnerable to the effects of inbreeding depression, low reproductive rates and reduced genetic diversity. In addition, prolonged or more frequent droughts and increased frequency of heavy rainfall events associated with climate change may threaten the species and its habitat in the future.

The autumn buttercup population on the Dale Ranch property is not presently threatened by agricultural development (water diversion), development of structures, invasive species, overutilization, and personal/commercial uses, because of the land use practice of un-irrigated rangeland for livestock. This population also does not appear to be threatened by inappropriate grazing practices; however, more data are needed before we can evaluate this threat. The Preserve population on The Nature Conservancy property was provided adequate protection from threats for which the species was originally listed, but the necessary habitat characteristics were not maintained to support the recovery of autumn buttercup when livestock were removed. The intent of The Nature Conservancy is to protect autumn buttercup from threats, and they plan to adaptively manage their property to alleviate known threats.

The species has not achieved recovery and remains endangered. Over the past 21 years since the Recovery Plan was finalized, even though a considerable amount of research was performed on autumn buttercup at the Preserve, none of the recovery criteria have been met. Of the eight Recovery Plan actions, two actions are not met, two actions are partially met, and four actions are partially met and ongoing:

Recovery Actions Not Initiated

- We have not inventoried potential habitat of autumn buttercup in south-central Utah.
- We have not developed downlisting criteria.

Recovery Actions Partially Completed

- The Nature Conservancy protected the Preserve population, monitored the Preserve population, installed a perimeter fence, and enforced existing regulations. This action is incomplete because we did not develop a habitat management plan, and a minimum viable population study was not performed.
- Researchers have studied the biology and ecology of autumn buttercup on the Preserve, including the plant community structure, and phylogenetic relationship with its congeners. This action is incomplete because the hydrologic requirements and pollination biology of autumn buttercup have not been studied.

Recovery Actions that are Ongoing

- The Arboretum at Flagstaff and CREW have established artificial autumn buttercup populations at their respective institutions. The plant propagation and seed collection for this species are ongoing activities.
- The Nature Conservancy acquired and protected the occupied habitat on the Preserve. We shall continue to acquire and protect occupied and potential habitat of the autumn buttercup.
- We and our partners have reintroduced plants into potential habitat on the Preserve, and have monitored and tried to protect the introduced populations. The reintroduction efforts will continue until they are successful in assisting in the recovery efforts of autumn buttercup.
- Developing public awareness and appreciation for the autumn buttercup is an ongoing activity.

3. RESULTS

3.1. Recommended Classification:

☐ Downlist to Threatened
☐ Uplist to Endangered
☐ Delist (Indicate reasons for delisting per 50 CFR 424.11):
☐ Extinction
☐ Recovery
☐ Original data for classification in error
☒ No change is needed

3.2. New Recovery Priority Number

We recommend changing the recovery priority number to 5 because we support the taxonomic acceptance of full species rank for autumn buttercup.

Brief Rationale

Using our system for determining recovery priority numbers (48 FR 43098 and 48 FR 51985), we determine that the recovery priority number for autumn buttercup should move to 5, after we update the synonomy (same identity) of autumn buttercup to a full species rank. Until the name can be changed in the Federal Register, we will continue to use the current recovery priority number.

This number indicates: 1) the plant's taxonomic standing as a species; 2) a perceived high degree of threat from activities such as small population size, small mammal herbivory, and climate change as described above in the 5-factor analysis; and 3) a low potential for full recovery.

4. RECOMMENDATIONS FOR FUTURE ACTIONS

4.1. Taxonomy

- We recommend revising the species' taxonomy in the Federal Register to reflect the best available scientific information.
- We recommend formally requesting the name be changed in the ITIS plant database.

4.2. Surveys

- We recommend the Utah Heritage Program identify potential habitat and survey for autumn buttercup.

4.3. Research & Monitoring (in order of priority)

- We recommend that qualified scientists monitor and evaluate threats to autumn buttercup in conjunction with population monitoring of both extant and reintroduced autumn buttercup plants on the Preserve.
- Since there is a complex web of processes that occur within grazed wet meadow habitat (small mammal herbivory, vegetative competition, livestock trampling, weed suppression, litter removal), we recommend qualified scientists assess the relative importance of each process with regard to autumn buttercup abundance and distribution on the Preserve.
- We recommend qualified scientists assess whether small mammal herbivory is reduced when livestock grazing is reintroduced and to monitor their population levels in tandem with the autumn buttercup on the Preserve. We recommend the scientists identify measures to reduce small mammal populations and that The Nature Conservancy implement these measures on the Preserve at least in the near-term to reduce the threat of herbivory and encourage the recovery of autumn buttercup.
- We recommend initiating discussions with landowners about land use practices (stocking rates and seasonality of grazing) the ranchers believe would benefit the autumn buttercup.
- We recommend qualified scientists reinitiate a multi-year demography study of subpopulations both on the Preserve and other available populations to study survivorship, growth, and reproduction. This study should include a seedbank component to determine seed longevity in soil, and seedling recruitment patterns at different microsites.
- We recommend qualified scientists perform a minimum viable population analysis for the species based upon data collected from the demography study.
- We recommend qualified scientists document the identity and availability of pollinators, and determine the breeding system of autumn buttercup.
- We recommend qualified scientists perform a climate change vulnerability assessment of autumn buttercup.
- We recommend qualified scientists implement long-term monitoring of the hydrology in the wet meadow habitat on the Preserve to document water table fluctuations on a regular basis.

- We recommend The Arboretum at Flagstaff, or another qualified and permitted botanic garden, assess the drought tolerance and plant response to drought by evaluating plant establishment, growth and reproduction of autumn buttercup under different water regimes in a greenhouse setting.

4.4. Ex-situ Conservation

- We recommend The Arboretum at Flagstaff, or another qualified and permitted botanic garden, collect seed annually of wild (not reintroduced) autumn buttercup plants.

4.5. Administrative Actions

- We recommend the USFWS host an annual workshop to prioritize, assess, and fulfill recovery actions.
- Once we have new survey and research data, we recommend that the USFWS revise the Recovery Plan to explicitly address the relevant listing factors. The number of plants and populations referenced in the current recovery plan that are required for long-term viability of autumn buttercup are unsupported by our current understanding of the population status. The revised Recovery Plan will include objective, measureable criteria which, when met, will result in a determination that the species be removed from the Federal List of Endangered and Threatened Plants. The Recovery Plan also will estimate the time required and cost to carry out those measures needed to achieve the goal for recovery and delisting.
- We recommend that the USFWS support autumn buttercup recovery by providing personnel and fiscal resources yearly to implement recovery actions.
- We recommend that the USFWS and The Nature Conservancy write a management plan for the Preserve.

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U.S. FISH AND WILDLIFE SERVICE

5-Year Review of Autumn Buttercup (*Ranunculus acriformis var. aestivalis*)

Current Classification: Endangered rangewide

Recommendation resulting from the 5-Year Review:

- ☐ Downlist to Threatened
- ☐ Uplist to Endangered
- ☐ Delist
- ☒ No change needed

Review Conducted By: Jennifer Lewinsohn, Botanist, Utah Ecological Services Field Office

FIELD OFFICE APPROVAL:

Lead Field Supervisor, Fish and Wildlife Service

Approve _____ Date 1/24/13

Field Supervisor, Utah Ecological Services Field Office

APPENDIX A
Autumn Buttercup (*Ranunculus acriformis* var. *aestivalis*)
Threats, Stressors, and Their Associated Scope, Immediacy, Intensity, Exposure, Response, and Overall Threat Level

	Threat[4] / Potential Threat[5]	Stressor[6]	Factor[7]	Scope[8]	Immediacy[9]	Intensity[10]	Exposure[11]	Response[12]	Overall Threat Level[13]
1	Agricultural Development	onsite loss of acreage from onsite water diversion	A	Moderate; 1 of 2 populations	Future	Moderate	Small	Basic need inhibited & Mortality	Not known to occur
2		onsite loss of acreage from offsite water diversion	A	Rangewide	Future	Moderate	Small	Basic need inhibited & Mortality	Not known to occur
3	Development of outbuildings, corrals, etc.	degradation and loss of total acreage	A	Moderate; 1 of 2 populations	Future	Moderate	Small	Basic need inhibited & Mortality	Not known to occur
4	Grazing and Trampling	direct physical injury / mortality to individuals	A	Moderate; 1 of 2 populations	Historic / Imminent / Future	Low	Small	Mortality & Injury	Low
5		soil and vegetation disturbance	A	Moderate; 1 of 2 populations	Historic / Imminent / Future	Low	Small	Basic need supported	Benefit
6	Invasive Species	vegetative competition	A	Moderate; 1 of 2 populations	Historic	Moderate	Small	Basic need inhibited & Mortality	Low
7	Overutilization	direct physical injury / mortality to individuals	B	Not known to occur	Not known to occur	Low	Small	Basic need inhibited & Mortality	Not known to occur
8	Personal, Commercial Uses	direct physical injury / mortality to individuals	B	Not known to occur	Not known to occur	Low	Small	Basic need inhibited & Mortality	Not known to occur

	Threat[4] / Potential Threat[5]	Stressor[6]	Factor[7]	Scope[8]	Immediacy[9]	Intensity[10]	Exposure[11]	Response[12]	Overall Threat Level[13]
9	Deleterious Effects of Research Efforts (includes scientific collecting)	Reduction in population numbers; Reduction in seedbank	B	Not known to occur	Not known to occur	Low	Small	Basic need inhibited & Mortality	Not known to occur
10	Disease	direct physical injury / mortality to individuals	C	Not known to occur	Not known to occur	Low	Small	Basic need inhibited & Mortality	Not known to occur
11	Insect Predation	direct physical injury / mortality to individuals	C	Not known to occur	Not known to occur	Low	Small	Basic need inhibited & Mortality	Not known to occur
12	Herbivory from small mammals	direct physical injury / mortality to individuals	C	Rangewide	Historic / Imminent / Future	High	High	Mortality & Injury	High
13	Lack of (or inefficiency of) existing regulatory mechanisms independent of the Act	Insufficient protective measures	D	Rangewide	Imminent / Future	Moderage	High	Basic need supported	High
14	Small Populations	Loss of genetic diversity, resiliency	E	Rangewide	Historic / Imminent / Future	High	High	Basic need inhibited	High[14]
15	Climate Change	Changes in hydrological conditions, habitat conditions	E	Rangewide	Imminent / Future	Moderate	High	Basic need inhibited & Mortality	High
16	Lack of Scientific Knowledge/ Monitoring	Potentially inadequate management of species	E	Moderate; 1 of 2 populations	Historic / Imminent / Future	High	High	Basic need inhibited & Mortality	High[15]

	Threat[4] / Potential Threat[5]	Stressor[6]	Factor[7]	Scope[8]	Immediacy[9]	Intensity[10]	Exposure[11]	Response[12]	Overall Threat Level[13]
17	Lack of Scientific Knowledge/ Monitoring	Potential failure to detect meaningful threats contributing to population decline	E	Rangewide	Historic / Imminent / Future	High	Moderate	Basic need inhibited & Mortality	High[15]

[4] Any circumstance or event that is causing or will cause harm to the resource.
[5]Any circumstance or event with the potential to cause harm to the resource.
[6] A process or event with negative impact on target species.
[7] Same factors used when making a listing decision: A – The present or threatened destruction, modification, or curtailment of its habitat or range; B – Overutilization for commercial, recreational, scientific, or educational purposes, C – Disease or predation; D – The inadequacy of existing regulatory mechanisms; or E – Other.
[8] Geographic extent of the stressor: Localized – less than one population; Moderate – one population; or Rangewide – stressor is acting on species rangewide.
[9] Timeframe of the stressor: Imminent – is the stressor present and acting on the target now; Future – anticipated in the future; or Historic – or has the impact already occurred.
[10] The strength of the stressor itself: Low, Moderate, or High.
[11] The extent to which a target resource and stressor actually overlap in space and/or time given the scope: Small, Moderate, or High.
[12] Level of physiological / behavioral response due to a specific stress considering growth, fecundity, and mortality rates: Basic need inhibited – basic plant needs for growth & development; or Mortality – identifiable reduction in growth rate or survival.
[13] Integration of the scope, immediacy, intensity, exposure, and response at the species level: Potential, Low, Moderate, or High.
[14] Small population size in and of itself is not considered a threat; however, it may increase the species' vulnerability if other threats are impacting the species.
[15] While not a threat in and of itself, this factor affects our ability to manage and recover the species.