Clay Phacelia

(*Phacelia argillacea*)

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

August 19, 2013

5-YEAR REVIEW
Clay Phacelia (*Phacelia argillacea*)

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 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
Seth Willey, Regional Recovery Coordinator, 303-236-4257

Lead Field Office: Utah Ecological Services Field Office
Larry Crist, Field Supervisor, 801-975-3330
Laura Romin, Deputy Field Supervisor, 801-975-3330
Bekee Hotze, Terrestrial Branch Chief, 801-975-3330 ext 146
Tova Spector, Botanist, 801-975-3330 ext 137
Dr. Suzanne Nelson, Volunteer Staff Biologist

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 clay phacelia (*Phacelia argillacea*) that may have a bearing on its classification as endangered or threatened. We received one comment from the Bureau of Land Management Utah State Office, regarding the presence and abundance of this plant on BLM lands. This 5-year review was primarily written by the Utah Ecological Services Field Office and the Mountain-Prairie Regional Office. It summarizes and evaluates information provided in the recovery plan, current scientific research, and surveys related to the species. All pertinent literature and documents that were used for this review are on file at the Utah Ecological Services Field Office (see References section below for a list of cited documents). We interviewed individuals familiar with clay phacelia 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

<u>Original Listing</u>

Federal Register notice:	43 FR 44810, September 28, 1978
Entity listed:	Species
Classification:	Endangered range-wide

1.4.3. Review History

On December 8, 1983 (48 FR 55100), and on November 6, 1991 (56 FR 56882), we initiated 5-year reviews of all species listed in 1978 and all species listed before 1991, respectively (56 FR 56882). In these cursory reviews, the statuses of many species were evaluated concurrently with no in-depth assessment of the five listing factors or threats to the species, as they pertained to recovery goals and objectives. The notices listed the species reviewed, including clay phacelia, and stated that no changes in the designation of these species were warranted at that time.

On April 12, 1982, we signed the Clay Phacelia (*Phacelia argillacea* Atwood) Recovery Plan (USFWS 1982) (see section 1.4.5, Recovery Plan). Although not technically a 5-year review per our regulatory requirements, this document summarized the status and biological requirements of the species as known at that time.

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

At the start of this 5-year review, the Recovery Priority Number for clay phacelia was 2. This number indicated that: (1) the plant was listed as a full species; (2) populations face a high degree of threat; and (3) recovery potential is high (see Table 1).

Table 1. The above 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: Clay phacelia (*Phacelia argillacea* Atwood) Recovery Plan (hereafter referred to as the "Recovery Plan")
Date approved: April 12, 1982

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 are no longer reflective of the best scientific information available. The Recovery Plan is over 30 years old, and much of the information is now dated and inaccurate. Furthermore, the criteria do not consider or address all of the known threats to the plant. In addition, we need to evaluate the recovery criteria target for achieving populations of 2,000 plants as we do not know if that constitutes a minimum viable population size.

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 1982 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

Recovery Criterion: To establish a self-sustaining population of 2,000 to 3,000 individuals on 120 acres of protected habitat, and possibly establish at least one new population.

Status: This demographic-based recovery criterion of a self-sustaining population of 2,000 to 3,000 plants is not met. The number of individuals is currently

[1] Recovery plans provide guidance to the Service, 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.

unknown and there is no current monitoring for the species. There are only three known populations of the plant that are occupied—Tucker-Clear Creek, Water Hollow-Garner Canyon, and Tie Fork (introduced population) (see section 2.3.1.2, Distribution, Abundance, and Trends)—and these populations are relatively small. The Tucker population had 200–300 plants from 1981–1987 and then dropped to 22 plants in 1989 due to sheep activity on the site (Callister 1990); the population rebounded to 230 plants in 1990 (Armstrong 1992), but remains relatively small. There were an estimated 95 plants at the Water Hollow-Garner Canyon population in 1989 (Franklin 1989), and 106 plants (seedlings plus flowering adults) at this population in 2000 (West and Walker 2000). In 2004 Red Butte Garden collected seed from 44 adults at the Tucker-TNC site and in 2006 estimated that there were 100 flowering adults at the Water Hollow-Garner Canyon population (Red Butte 2006). Mill Fork, an introduction site in the Water Hollow-Garner Canyon population, had 90 seedlings in 2011 (Meyer 2011b). The Tie Fork population had 54 seedlings in 2011 from an introduction (Meyer 2011b). We do not have a current population estimate for the species.

Seventy-four acres of clay phacelia occupied habitat is protected by The Nature Conservancy (TNC) (70 acres (28 hectares)) and the US Forest Service (USFS) (4 ac (1.4 ha)). This is below the target recovery criterion of 120 ac (49 ha).

Significant efforts have been enacted to establish a new clay phacelia population on Uinta USFS land at Tie Fork (Aanderud and Harper 1997; Meyer 2011a). In 1997, BYU conducted seeding experiments to help identify appropriate sites for establishing a population. Of their three study sites, they perceived Tie Fork site to be the most likely to support a new population of clay phacelia (Aanderud and Harper 1997). In 2007, a field introduction study began at Mill Fork and Tie Fork (Figure 1). These study sites were selected for introduction in 2007 because the physical and biological features matched those found at existing populations on the Green River Formation (Meyer 2011a; Armstrong 1992). Seeds were planted at three new sites in the Water Hollow-Garner Canyon and Tie Fork populations in 2007 and 2010. As of 2011, plants were present at all three introduction sites in the two populations (Meyer 2011a). Therefore, we consider this introduction effort to be successful.

Figure 1. Volunteers working on field introduction and seedling study projects at Tie Fork. Photo from Susan Meyer, used with permission.

2.3. Updated Information and Current Species Status

2.3.1. Background on the Species

2.3.1.1. Biology and life history

Clay phacelia has blue to violet flowers and stands 4–14 inches (10–35.6 centimeters) tall (Figure 2).

Figure 2. Clay phacelia in flower. Photo by Jana Leinbach, used with permission.

Clay phacelia was formerly considered a winter annual but new data supports the idea that it is instead a true biennial (Meyer 2011b). Biennials emerge as a seedling in the spring, grow into a rosette during the summer, become chilled over the winter and prepare for flowering and reproduce the following summer (Meyer 2011a).

Seeds (Figure 3) break dormancy under varying conditions, which is a common life-history strategy for short-lived forbs to ensure all the available seeds do not germinate at the same time (Meyer 2005). Germination seems to be triggered by late summer or early autumn storms and two rain events per summer seem to be critical for survival (Meyer 2011a). The species harbors an extended seed bank, and one successful recruitment event every 10-15 years, coupled with high seed output, may be enough for the species survival through time (Meyer 2011a, 2011b). Seeds produced in one year germinate over the course of several years thus ensuring a robust seedbank that can withstand stochastic events.


Figure 3. Clay phacelia seeds. Photo by Jana Leinbach, used with permission.

Following germination, the cotyledons enlarge and become photosynthetic. Initial foliage leaves are small, but by early to mid-October, they have formed into basal rosettes 0.4 to 2.8 inches (1 to 7 centimeters) in width. Rosettes grow slowly under the snow, and bolt only after the snow melts and the soil and air temperatures increase significantly in May (USFWS 1982). The first of the season's flowers begin opening by late May, and full blooming is reached in late June or early July. Spring and summer precipitation is necessary to allow plants to continue flowering through the summer and into autumn, with the last of the season's flowers observed in mid-October (USFWS 1982). Clay phacelia can be a very prolific seeder (Bellagamba 2000; Meyer 2011b).

Clay phacelia are likely obligate outcrossers (Smith *et al.* 1989) that require insect pollinators. The flower is large and showy and is visited by a variety of pollinators, including native sweat and carpenter bee species *Osmia bruneri*, *Dialictus spp.*, *Ceratina neomexicana, Anthophora linsleyi*, *Panurginus spp.* and a rare colletid bee species, *Hylaeus granulatus*, (Tepedino 1989; Tepedino 2013). These species are small to medium-sized, mostly solitary bees (Bartlett *et al.* 2008; DiTerlizzi *et al.* 2008; Meyer 2011b).

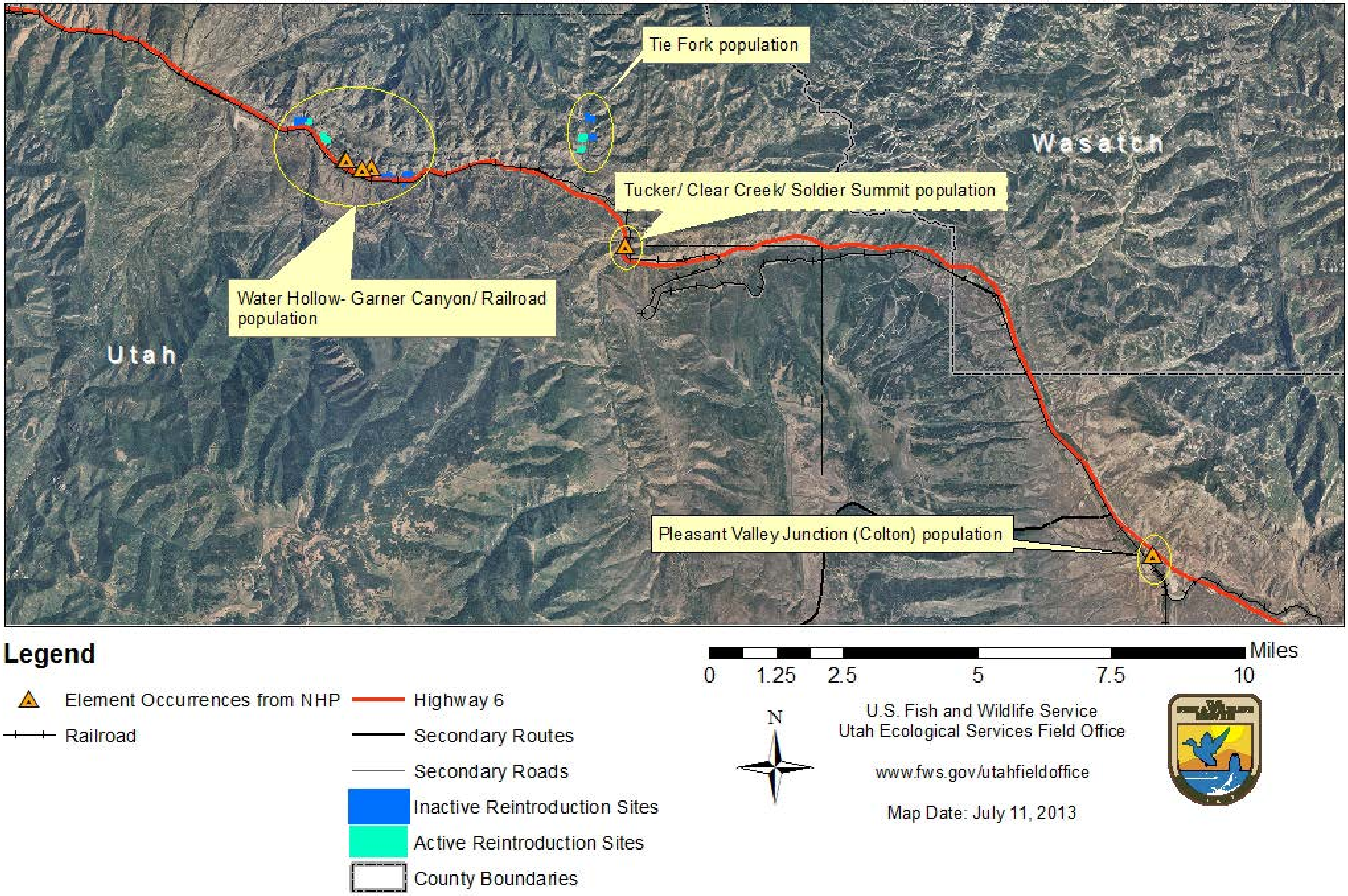
Clay phacelia is found on steep hillsides of shale clay colluvium on an extremely limited band of soil derived from an upper member of the Green River geologic formation called Green River Shale in Utah County, Utah (Armstrong 1992) at elevations ranging from 6,000–6,400 feet (1,829–1,951 meters). This formation was deposited by Lake Uinta, an Eocene epoch lake. Where clay phacelia occurs the soil is composed of an equal mix of clay, silt and sand overlain by pebble and shale (Figure 4; Armstrong 1992). Occupied soils exhibit a narrow range of pH from 7.7 to 7.9 (Armstrong 1992). Concentrations of boron, zinc, manganese, and magnesium are higher at sites occupied by clay phacelia than at unoccupied sites. Concentrations of sodium are higher at unoccupied sites than at occupied sites, suggesting an aversion to high salt soils by the plant (Armstrong 1992). Occupied sites are xeric with steep slopes and southeast- to west-facing aspects. The area occupied by clay phacelia receives an average of 16.8 inches (42.7 centimeters) precipitation annually (Brough *et al.* 1987) most of it coming from winter snow and spring precipitation (Armstrong 1992).

Figure 4. Clay phacelia growing in characteristic soils. Photo by Jana Leinbach, used with permission.

Vegetation that grows with clay phacelia includes the yellow-flowered buckwheat (*Eriogonum brevicaule*), serviceberry (*Amelanchier alnifolia* Nutt.), Gambel oak (*Quercus gambelii* Nutt.), Indian ricegrass (*Stipa hymenoides*), and houndstongue (*Cynoglossum officinale*). Additional associated species include sparse stands of pinyon-juniper (*Pinus edulis-Juniperus osteosperma*) or mountain brush (*Amelanchier alnifolia-Cercocarpus montanus-Rhus aromatica*) (Armstrong 1992). Clay phacelia does not do well competing with other vegetation, and the actively eroding shale slopes where this species occurs likely discourages competitors (Aanderud and Harper 1997).

2.3.1.2. Distribution, Abundance, and Trends

The range of clay phacelia extends along a 7.5 mile (12 kilometer) stretch of Highway 6 in Spanish Fork Canyon in Utah County, Utah (Figure 5). Based on available information, clay phacelia occurs in three populations (Table 2): Water Hollow-Garner Canyon (includes several element occurrences and three introduced sites), Tie Fork (an introduced population), and Tucker-Clear Creek (the type locality). A fourth population, the Pleasant Valley Junction (Colton) population, has not been relocated since its initial discovery in 1883. Either the location of this population was written down incorrectly or the population was extirpated over the past century. In either case, we do not believe this population exists today.



[2]

Figure 5. Locations of clay phacelia populations.

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[2] The Pleasant Valley Junction population is considered extirpated, or may have been recorded incorrectly initially.

Table 2: Populations and sites of clay phacelia

Population	Number of sites	Site manager	Site names	Site Alias	Site origin
Tucker/ Clear Creek	2	TNC	Tucker-TNC	Soldier Summit	Natural
				Clay phacelia Preserve	
				Starvation Creek	
		BLM	Tucker-BLM	Clear Creek	Natural
Water Hollow-Garner Canyon/ Railroad	7	Private	Water Hollow-Garner Canyon 1	Upper Water Hollow- Garner Canyon	Natural
		Private	Water Hollow-Garner Canyon 2	Upper Water Hollow- Garner Canyon	Natural
		Private	Water Hollow-Garner Canyon 3	Lower Water Hollow- Garner Canyon	Natural
		Private	Water Hollow-Garner Canyon 4	Lower Water Hollow-Garner Canyon	Natural
		USFS	Mill Fork	Cemetery/ Mill Site	Introduced
		USFS	Mile Marker 197 A		Introduced
		USFS	Mile Marker 197 B		Introduced
Tie Fork	2	USFS	Tie Fork		Introduced
		USFS	Upper Tie Fork		Introduced
Pleasant Valley Junction	1	Private	Pleasant Valley Junction	Colton	Natural but extirpated (if location accurate)

Sites are locations where clay phacelia is present and individual plants are clustered together. Populations are defined as a site or groupings of sites where clay phacelia occurs or previously occurred and is separated by 1.2 mi (2.0 km) distance or any occupied suitable habitat that is separated by unsuitable habitat greater than 0.25 mi (0.4 km).

Suitable habitat for clay phacelia is steep slopes with sloughing soils making surveys and accurate population estimates difficult to determine (Meyer 2011a). As previously discussed, we do not have accurate population estimates or trends (see section 2.2.3, Progress toward recovery). The next several sections the available data for each of the populations starting from the easternmost population towards the westernmost population.

Pleasant Valley Junction (Colton) population

The Pleasant Valley population comprises one site, and it is considered a historical location. No plants have been located at this site in recent surveys (Leinbach 2012). Marcus E. Jones recorded Pleasant Valley Junction as the species location on his 1883 collection of a clay phacelia specimen from the area. We do not know if this site has been extirpated or if the location information on the voucher specimen was erroneously recorded. In either case, we do not believe this population exists today and we will not discuss this population any further.

The Tucker population

The Tucker population comprises two sites that are approximately 7.5 mi (12 km) up Spanish Fork Canyon from the Water Hollow-Garner Canyon/ Railroad population, and located next to the old Tucker Rest Stop. The Tucker population, the type locality for the species, consistently has more plants than the other populations and at least some clay phacelia plants can be found at the Tucker-TNC site, even in the worst years (Meyer 2011a).

US Highway 6 bisects the Tucker population. Although some literature favors referring to the plants on different sides of the road by the names Tucker and Railroad, other researchers referred to both sides together as the Tucker site because of their close proximity to one another. We believe it may have been one contiguous site historically but we consider this population to be composed of two sites (Tucker-TNC and Tucker-BLM) since it is bisected by US Highway 6 and is managed by two different entities.

The Tucker-TNC site, located on the west side of US Highway 6, was bought by TNC and includes 70 ac (28 ha) of habitat. It is also called the Clay Phacelia Preserve (Table 2). Of the 70 ac (28 ha), approximately 8 ac (3 ha) were fenced and gated with a seven-foot game fence after the purchase, specifically to protect the clay phacelia population from herbivory by wild and domesticated ungulates. The Tucker-BLM site, located on the east side of US Highway 6 has a few plants, reported to be about 15 plants in 2011, and is unfenced (Hardy 2011).

The Tie Fork population

The Tie Fork population originated from one of two introduction efforts. There are two sites within this population that are called Tie Fork and Upper Tie Fork, which are both on the west side of the drainage. This population had 90 seedlings in 2011. South Watson Canyon A and B and North Watson Canyon, which are on the east side of the drainage are potential sites for future introduction. (Leinbach 2012).

Water Hollow-Garner Canyon/ Railroad population

The Water Hollow-Garner Canyon/Railroad population consists of seven occupied sites: Water Hollow-Garner Canyon sites 1, 2, 3, and 4; Mill Fork site; Mile Marker 197 A site; and Mile Marker 197 B site. Clay phacelia was introduced to the Mill Fork, Mile Marker 197A, and Mile Marker 197B sites 2007. Additional sites within this area that are not occupied but may have the potential to be introduction sites include Hillside sites 1, 2 and 3 (Leinbach 2012).

In summary, clay phacelia demonstrates high genetic diversity despite its small population size. The results also show that there is still gene flow between the spatially separate Tucker and Water Hollow-Gardner Canyon / Railroad populations of clay phacelia (Harrison *et al.* 2009). The high level of genetic variation seen between years and within the seed bank suggests that the seed bank serves as a repository for genetic diversity. Seed banks of long-lived seeds serve to store the genetic diversity of the species (Cabin 1998). Therefore it is critical that future sampling should include tissue derived from several years to properly reflect the genetic diversity of clay phacelia. Sampling and collection of seeds for reintroductions from only one year would seriously underestimate the genetic diversity of this species (Harrison *et al.* 2009), and reduce the genetic diversity of plants introduced into new areas.

2.3.1.3. Taxonomic classification or changes in nomenclature

Phacelia argillacea was initially collected by Marcus E. Jones in Wasatch County, Utah in 1883, but the location within this county is unclear. The species was collected by Jones a second time at Clear Creek near Soldier Summit, Utah County, Utah, in 1894. Jones did not recognize it as a new species (USFWS 1982). Rediscovered by N.D. Atwood in 1971 near Clear Creek in Utah County, the plants were initially identified with the closely related *P. glandulosa* Nutt. After further investigation, clay phacelia was found to differ substantially from populations of *P. glandulosa* and was described as a new species in 1973 called clay phacelia N.D. Atwood (Atwood 1973, USFWS 1982). Plant nomenclature follows Welsh *et al.* (1987). The current taxonomic status for *Phacelia argillacea* N.D. Atwood is not currently in dispute (ITIS 2013).

Genetic work for this species was conducted in 2009 for four specific reasons. First, the species had never been studied at the molecular level. This information was needed to understand the current level of inbreeding, molecular diversity, and viability of the species. Second, genetic analysis would determine if this species was truly a distinct species from the related *Phacelia glandulosa*. Third, this work was needed to create a better understanding of the molecular diversity within and among the two known populations of clay phacelia as part of ongoing efforts to establish a new population of clay phacelia on public lands (Harrison *et al.* 2009; USFWS 1982). Fourth, the small population size of clay phacelia is of concern genetically, as smaller populations tend to have more limited genetic diversity. In populations with less than 1,000 individuals, demographic uncertainties can play a significant role in extinction probability (Hoonay and Jacquemyn 2007; Aguilar *et al.* 2008).

DNA was extracted from clay phacelia basal leaf tissue samples from the Tucker-Clear Creek population in 2006 and 2008, and from the Water Hollow-Gardner Canyon / Railroad population in 2006, 2007, and 2008. In addition, clay phacelia tissue samples were collected from plants that were half-sibling progeny propagated from seed collected from the Tucker population in 2004. Clay phacelia was compared with 3 other phacelia species: *Phacelia crenulata* samples were collected from wild seeds propagated in greenhouses, *P. argylensis* seeds were collected from the Brigham Young University Herbarium; and *P. glandulosa* seeds came from both the Brigham Young University Herbarium and from those collected in 2007 by Frank Smith (Harrison *et al.* 2009).

The results found that the Water-Hollow-Gardner Canyon / Railroad and Tucker populations of clay phacelia are genetically similar and have not differentiated into distinct genetic populations. In addition, there was close genetic similarity of seeds from each year. For example, all the seeds from 2008 were more closely related than seeds between the years 2006 and 2007 at the Water Hollow-Gardner Canyon / Railroad population. This suggests that future genetic analysis should include samples from multiple years to adequately reflect the genetic diversity of the available seed bank (Harrison *et al.* 2009). The results of genetic analysis show that clay phacelia is genetically diverse for a species with a limited geographic distribution and small population size (Harrison *et al.* 2009). This diversity may be due to continued gene flow between populations.

Although clay phacelia grows geographically close to *Phacelia glandulosa*, there is no genetic evidence that these two species mix genetically or have so in the recent past (Meyer 2011a). Genetic analysis of the related species *P. cernulata* demonstrated that it was genetically very different from the other three *Phacelia* species studied. In contrast, *P. argylensis* and *P. glandulosa* were grouped very closely, bringing into question if they were truly distinct species (Harrison *et al.* 2009).

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

Section 4(a) of the Act lists five factors that we must analyze thoroughly before a species is listed as threatened or endangered. While clay phacelia was originally listed as endangered in 1978, initial evaluations and studies began in 1975 in order to adequately address the factors listed in Section 4 of the Act.

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

Habitat loss and modification by the D&RGW railroad and the associated service road (Tucker population) was cited as the main threat to clay phacelia when we listed the species. The Recovery Plan also cites threats from sheep trampling (USFWS 1982). Other stressors include highway improvements and invasive species. Each of these stressors is discussed below.

<u>Railway Development</u>

At the time of listing, construction of the D & RGW railroad had bisected the only known population of clay phacelia, now known as the Tucker population. Impacts from railway maintenance and access road expansion threatened to extirpate the Tucker population. Construction activities by the railroad company included stabilization of cuts and fills, control of runoff, and storage of material (USFWS 1982). When the Recovery Plan was signed in 1982, the company was "aware of the plant" and had "a positive attitude toward its protection" (USFWS 1982). Since the 1982 Recovery Plan, the D&RGW railroad has become defunct, and was absorbed by Union Pacific Railroad in 1988. Current users of this line include Union Pacific Railroad, Burlington Northern Railroad, and Amtrak.

Because three separate and large companies are now using the railroad through the area, compared with one small company in the past, the frequency of use for the railroad and the maintenance road is significantly higher. In addition, as more truckload volume is converted to rail as a means for achieving fuel efficiency and environmental benefits, there will likely be more trains in the future (Beazer 2012). Although the original data on frequency of use is not available, the assumption is that the use has increased significantly since the drafting of our 1982 Recovery Plan (USFWS 1982). The increased use, and subsequent impacts including dust creation, pollution, and increased activity, has the potential to further threaten the already bisected Tucker population of clay phacelia. Overall this increase in use of the railway represents an increase in threat since the writing of the original Recovery plan (USFWS 1982).

Grazing and Trampling

Grazing and trampling were not recognized as threats to clay phacelia at the time of listing, but were identified as threats to the species in the Recovery Plan (USFWS 1982). As a showy plant in an area lacking in flora, grazing stress can be moderate to high (Meyer 2011a).

The Utah Native Plant Society deemed livestock grazing and sheep trails as the most serious threat to the population and they placed cages over each individual plant at the Tucker-TNC site in an effort to reduce damage (Utah Native Plant Society 1980). The grazing and subsequent erosion from trampling and rainstorms was suspected of severely depleting the soil seed bank in 1987 (Callister 1990). The threat of grazing and trampling has been largely mitigated due to the installation of the fence but only at the Tucker-TNC site. In addition, cattle and sheep are not currently in the Tucker-TNC site and this area is not being used as a grazing allotment. A relatively new domestic threat is the presence of llamas, which inhabit the private lands where plants are found in the Water Hollow-Garner Canyon population. The threat of grazing has significantly decreased on the Tucker-TNC site since the installation of the fence, but may not have changed on the two privately owned sites in the Water Hollow-Garner Canyon population.

Highway Improvements

At the time of listing, highway improvements were not considered a threat to clay phacelia. Expansion of US Highway 6 was proposed in 2000, and had the potential to effect the population located near Water Hollow-Garner Canyon / Railroad (USFWS 2000). However, construction crews and the Utah Department of Transportation (UDOT) were aware of clay phacelia populations and worked to not disturb the plant, seed bank, or create soil sloughing near the plant populations as recommended in our biological opinion (USFWS 2000). UDOT oversaw protection of the plant during road building and protections were considered adequate by consulting biologists (Meyer 2011a). Crews utilized techniques designed to eliminate impacts from construction of the retaining wall, and environmental fencing was also used to provide extra protection. There were no documented direct impacts on clay phacelia plant populations from the retaining wall.

A second road improvement project, expanding US Highway 6 from a 2-lane to a 4-lane road through Spanish Fork Canyon, was completed in early summer 2011. The road expansion included a large bridge over a newly constructed culvert to replace an older outdated culvert. The new bridge and culvert system were designed specifically as a wildlife crossing, and two miles of fencing were installed along the road and adjacent to the bridge (see Figures 7 and 8). During construction activities and highway improvements, UDOT checked clay phacelia populations every two weeks for damage. Conservation measures, such as watering the roads for dust abatement during construction, were incorporated and direct impacts to clay phacelia were not observed (West 2012).

There are future construction projects projected for the area, including highway widening slated for the time period 2016-2025. This will include widening 10.7 mi (17.2 km) along US-6 between Spanish Fork Canyon and Diamond Fork Canyon (UDOT 2007). The Utah Govenor's Office of Management and Budget projects that the population of Utah county will more than double from 2010 to 2050 (Utah Govenor's Office of Management and Budget 2012) thus possibly increasing the demand for widening US Highway 6 into occupied habitat of clay phacelia. Future highway maintenance and expansion is a high threat to the species as suitable and/or occupied habitat will be impacted if the footprint of the road or maintenance activities expands.

Figure 6. The newly constructed Tucker wildlife bridge and culvert. Photo courtesy of P. West, UDOT, used with permission.

Figure 7. A second view of the Tucker wildlife bridge and culvert, completed early summer 2011 by Utah Department of Transportation. Photo courtesy of P. West, UDOT, used with permission.

Transmission lines

Energy transmission lines are proposed to transverse the narrow range of clay phacelia. Currently, we have 3 proposals for transmission lines that are proposed to be 250 feet (76 m) in width and need to be spaced at least 500 feet (152 m) apart from each other running along the east-west length of clay phacelia habitat. The disturbance from construction and maintenance of these lines and service roads may degrade suitable clay phacelia habitat, introduce invasive, exotic species, interrupt pollinators and significantly reduce available suitable habitat for establishing new populations. We consider development of multiple transmission lines through limited clay phacelia habitat a high potential threat to the species if recommended conservation measures are not followed.

Invasive species

Two invasive, exotic species occur in clay phacelia habitat at the Tucker site, houndstongue (*Cynoglossum officinale*) and horehound (*Marrubium vulgare*). Dr. Kimball Harper recommended periodic control of invasive species on clay phacelia sites to prevent competition (York 2013). TNC has hand pulled invasive, exotic plants on its property (Whitham 2003). Thistle (*Caardus spp*.) and hare's ear mustard (*Conringia spp.*) occur in clay phacelia habitat in the Water Hollow-Garner Canyon population (Aanderud and Harper 1997). More work is needed to better understand how these invasive, exotic plants affect clay phacelia populations and how they are distributed within suitable habitat. A group of scientists working on clay phacelia recommended development and implementation of a weed management plan (Whitham 2003). Because we do not know the extent of invasive, exotics or the response of clay phacelia, the threat of invasive, exotic species to clay phacelia is considered moderate.

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

There is no known commercial use or market for clay phacelia.

USFS and Red Butte Garden collect seeds for preservation, germination trials, and population augmentation and introduction efforts. USFS and BYU have collected plant tissue for genetic studies (Harrison *et al.* 2012). Genetic research on the species is described above in section 2.3.1.3 of this document. Collection for scientific use is controlled through our 10(A)(1)(a) permitting process. Scientific use has aided in species recovery and is considered a low threat to the species.

Recreational use of the area is very limited. Due to its isolated nature, steep, erodible slopes and lack of surrounding infrastructure, the area is not a destination for recreational use. The overall threat from recreational use of the area is considered low.

2.3.2.3. Disease or predation

The only known disease to effect this population was a singular occurrence of vascular wilt disease during germination trials in a laboratory. This may be an artifact of germination, where the high humidity, high plant density, and crowded conditions may have contributed to its presence among the plants (Meyer 2011a). Vascular wilt disease has never been observed on this species in the wild, and the density numbers seen in the laboratory would never exist in the wild because of the nature of the marginal habitat where clay phacelia occurs (Meyer 2011a). Therefore we don't view this as a threat to the species, nor do we know of any other diseases for this species.

Herbivory on clay phacelia occurs heavily in the winter and spring preventing wintering rosettes from becoming flowering adults in summer. Rosettes that were present in the fall 1988 were absent by January 1989 most likely due to deer grazing as there was an abundance of deer tracks (Franklin and Tuhy 1989). Mortality of seedlings that were caged from herbivores (20%) was far less than those that were uncaged (49%) with most mortality occurring in the spring from deer and elk at the Tucker population (prior to fencing)(Armstrong 1992). Herbivory was a significant component negatively affecting transplant experiments with no survival of plants between fall to spring, probably due to rabbits and deer (Meyer 2011b).

Fencing was constructed at the Tucker-TNC site in the early 1990s to protect clay phacelia from deer and other large ungulates. However, evidence of deer and rabbits was found inside the fenced enclosure in 2012 and 2013 (England 2013; Spector 2013). There were ungulate prints and scat found in the area with very few to no adults present (England 2013; Spector 2013).

The overall threat level for this species is considered high. The small population size and degree of herbivory is affecting the survival and recovery of the species.

2.3.2.4. The inadequacy of existing regulatory mechanisms

There were no Federal, State, or local laws or regulations that protected clay phacelia at the time of listing. The only law or regulation currently protecting this species is the Act. Clay phacelia did not originally occur on Federal lands and was introduced onto Federal lands at the sites in the Tie Fork population and the Mile Marker 197A, Mile Marker 197B and Mill Fork sites within the Water Hollow-Gardner Canyon / Railroad population. A recent report of clay phacelia on a small parcel owned by BLM at the Tucker population broadens the presence of the species on Federal lands and increases the number of partners involved in management and recovery of the species. On non-Federal lands in Utah, the Act provides protection only against the transport of the species across state or federal boundaries. However, collection is not considered a threat to this species (see section 2.3.2.2) and it is unlikely to become a threat in the absence of the Act's protection.

The Act is the primary Federal law—and only law at any level—that has protected clay phacelia since its listing in 1978. Section 7(a)(1) states that Federal agencies, in consultation with us, shall carry out programs for the conservation of endangered species. Section 7(a)(2) requires Federal agencies to consult with us to ensure any project they fund, authorize, or carry out is not likely to jeopardize the continued existence of listed species or modify their critical habitat. Section 9(a)(2) of the Act prohibits the following activities: 1) the removal and reduction to possession (i.e. collection) of endangered plants from lands under Federal jurisdiction, and 2) the malicious damage or destruction of lands under Federal jurisdiction, and 3) the removal, cutting, digging damaging, or destruction or endangered plants on any other area in knowing violation of a state law or regulation, or in the course of any violation of a state criminal trespass law. Section 9 also makes illegal the international and interstate transport, import, export, and sale or offer for sale of endangered plants and animals. The Act would provide some level of coordination and conservation of the species on federal lands (i.e., BLM, USFS) or on road construction projects that have a federal nexus (i.e., U.S. Highway 6).

Utah has no state laws or regulations that protect clay phacelia. In the absence of the Act's protections, there would be no regulations or laws at any level of jurisdiction to protect clay phacelia. Section 7(a)(1) of Act has been an important tool that has prevented the extinction of this plant through the consultation process during US Highway 6 enhancements and railroad maintenance. Without the Act, the species would be at risk of extinction from transportation related development.

2.3.2.5. Other natural or manmade factors affecting its continued existence

At the time of listing, climate change was not considered a threat to clay phacelia (USFWS 1982). Our analysis under the Act includes 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 (e.g., 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 2011 for a summary of observations and projections of extreme climate events.)

Various changes in climate may have direct or indirect effects on species. These effects may be positive, neutral, or negative, and they may change over time, depending on the species and other relevant considerations, such as interactions of climate with other variables (e.g., habitat fragmentation) (IPCC 2007a). Identifying likely effects often involves aspects of climate change vulnerability analysis. Vulnerability refers to the degree to which a species (or system) is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the type, magnitude, and rate of climate change and variation to which a species is exposed, its sensitivity, and its adaptive capacity (IPCC 2007a; Glick *et al.* 2011). There is no single method for conducting such analyses that applies to all situations (Glick *et al.* 2011). We use our expert judgment and appropriate analytical approaches to weigh relevant information, including uncertainty, in our consideration of various aspects of climate change.

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.

The impacts of global climate change at this time are uncertain, and could either be positive or negative for this species. Overall temperatures may not be a problem, but changes in precipitation and precipitation patterns may alter survivability and retention of a viable seed bank (Meyer 2011a).

Because this species is particularly dependent on multiple rains in the summer and fall to produce successful progeny for the year, changes in rainfall patterns have the potential to affect the seed bank and therefore long-term viability of the species. Clay phacelia shows a close correlation between rainfall patterns and germination rates, so changes to precipitation patterns that result in fewer or less substantial spring rains have the potential to decrease germination rates for this species. If projections for more spring rain and less winter precipitation hold true, this could help the species if they are chilled adequately to germinate. If less snow is present each winter, clay phacelia seedlings are less likely to emerge. However, if there is more rain in summer, they are more likely to survive. If the intensity of rain events or downpours increases, then the clay soils, which are naturally prone to sloughing, coupled with the steep slopes that the plants inhabit, may be more vulnerable to erosion by intense rains (Meyer 2011a). Overall, more data is needed to see how this species will react to changing climactic conditions; however, based on available information, climate change could have significant impacts on this species coupled with small population size and other threats.

2.4. Synthesis

The Recovery Plan for clay phacelia (USFWS 1982) stated that "only if the population can be protected in its limited habitat, propagation measures determined, and the species successfully reestablished at its known population area, can the survival of this aesthetically pleasing plant be assured." Clay phacelia is an example of a plant species that has been positively affected by the Act. Since its last review, this species has benefited from successful collaborations and partnerships with Federal, State, and private conservation groups, and the USFWS Preventing Extinction grant, which provided funding to study previously unknown life history factors for clay phacelia, and establish a seed library for the species and support seed propagation efforts.

The recovery criteria of 2,000–3,000 individuals has not been met at this time. However, the understanding of this species has increased considerably since the previous review, and several of the threats identified in the Recovery Plan (USFWS 1982) have been reduced or lessened in intensity on the Tucker-TNC site. The Tucker-TNC site is in conservation ownership and threats from sheep no longer occur on this property. The study of the seed bank, seedling success and recruitment, and attempts to understand what factors promote seedling establishment from the seed bank have been crucial to better understanding this species. The production of seeds to serve as a seed library for this species is also critical in promoting genetic diversity for future attempts to create new populations of this species.

The second criteria for recovery, the establishment of additional populations, are ongoing. Surveys are currently underway to determine the long-term success of the reintroduction sites at Tie Fork and Mill Fork. So far, seedling success has had a strong correlation to annual weather conditions, particularly to precipitation patterns (Meyer

2011b).

The greatest current threats to this species are transportation and transmission line development and herbivory. US Highway 6 is a major transportation route that bisects the largest population and has affected the westernmost population. Herbivory has affected the species survival and abundance at many sites over a period of many years. Threats may also come from transmission line development, increased railway traffic and associated dust and disturbance and transmission line development. All of these factors warrant continued monitoring. Invasive, exotic species are a moderate threat and may become a larger threat in the future. Although the population size for this species is small, the genetic diversity remains high, suggesting a possible history of small populations. These threats, coupled with shifting precipitation patterns as a result of global climate change, still act upon the species to the point where its future is precarious. Because this species is so dependent on a few rain events to release seedlings from the dormant seed bank, alterations to the timing and frequency of rainfall and snow may greatly affect species recruitment. For a complete summary of the current threats to the population and their current threat status, please see Appendix A.

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

4. RECOMMENDATIONS FOR FUTURE ACTIONS

Administrative Actions:

- Continue present efforts to establish new populations on USFS lands.
- Provide funding for ongoing and future research.
- Maintain partnerships with TNC, the USFS, and Red Butte Gardens to continue current research and monitoring projects
- Protect species from further population and habitat fragmentation from development and maintenance of developed areas.
- Continue to protect species from trampling and habitat degradation from livestock activities.
- Develop and implement an invasive, exotic plant management control plan with appropriate stakeholders.
- Secure remaining occupied habitat under conservation management.
- In conjunction with the Utah Division of Wildlife Resources, develop and implement a wildlife management plan to protect the species from ungulate and lagomorph herbivory.

Surveys and Monitoring:

- Continue to monitor population size of this species through time
- Monitor seed bank viability, seedling recruitment, and seedling survivorship
- Document and quantify herbivory pressure from free-ranging herbivores.
- Revisit the sites, creating GPS coordinates for each plant location, and identify areas to survey where the plant may occur.
- Monitor invasive, exotic species distribution and abundance in suitable habitat.

Research:

- Complete a population viability analysis (PVA) for this species and reevaluate the number of individuals needed for a healthy population
- Continue collecting and maintaining a genetically representative ex-situ seed collection for the species.
- Augment introduced sites to ensure genetic representation of the species on Federal lands.
- Study the effects of climate change on this species including how altered precipitation, water volume, availability, and timing of rain events may affect the species.
- Determine the environmental conditions and tolerances necessary for each life stage of the species.
- Determine if and how road and railway traffic volume influences this species, and its community associates such as pollinators.
- Determine the extent to which the plants and their pollinators are being affected by road and railroad maintenance activities.
- Re-examine the genetic diversity of this species in the future to determine if genetic diversity has been maintained or been reduced through time, using samples from multiple years.
- Study the plants' pollinators and the pollinators' habitats.
- Determine the effects of erosion on the species and identify actions that may restore soil conditions.
- Examine conditions surrounding seedling emergence, the dynamics and characteristics of the seed bank including seed dormancy and germination.

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U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW OF CLAY PHACELIA

Current Classification: Endangered rangewide

Recommendation resulting from the 5-Year Review:

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

Appropriate Listing/Reclassification Priority Number, if applicable:________

Review Conducted By:

FIELD OFFICE APPROVAL:

Lead Field Supervisor, Fish and Wildlife Service

Approve ________________________________ Date 8/19/2013
Field Supervisor, Utah Ecological Services Field Office

Appendix A. Clay phacelia Threats, Stressors, and Their Associated Scope, Immediacy, Intensity, Exposure[3], and Overall Threat Level Ratings

Threat	Associated Stressor	Factor	Scope	Immediacy	Intensity	Exposure	Overall Threat Level
Grazing	Predation	A	Rangewide	Historic	High	Significant	Low
Herbivory	Predation	C	Rangewide	Historic/on-going	High	High	High
Recreational use	Burial	B	Rangewide	Historic	Low	Low	Low
Erosion	Burial	E	Rangewide	Historic	High	Significant	Low
Highway Construction/Maintenance	Habitat loss	A	Rangewide	Historic/Future/ on-going	High	Significant	High
Railroad Use	Dust/ pollinator impacts	A	Rangewide	Imminent	Low	Moderate	Low
Transmission line development and maintenance	Burial, uprooting, trampling, habitat loss, pollinator impacts, dust	A	Rangewide	Future	High	High[4]	High[4]
Loss of Genetic diversity	Inbreeding depression	E	Rangewide	Future	Low	Low	Low
Disease	Mortality or Susceptibility	C	Greenhouse	Historic	Low	Significant	Low
Climate Change	Change in water availability and temperature	E	Rangewide	Imminent/Future	Unknown	Significant	Moderate
Invasive, exotic species	Competition	A	Rangewide	Imminent	Unknown	Unknown	Moderate

[3] Immediate = Timeframe of stressor; Intensity = Strength of stressor; Exposure = Level of total known population exposed to threat
[4] Assessed threat level if conservation measures are not adhered to and/or development occurs in occupied or suitable habitat