Phacelia scopulina (A. Nels) J.T. Howell var. *submutica* (J.T. Howell) Halse (Debeque phacelia): A Technical Conservation Assessment

Prepared for the USDA Forest Service, Rocky Mountain Region, Species Conservation Project

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Phacelia scopulina var. *submutica* (Debeque phacelia). © 1999 by B. Jennings. Used with permission.

SUMMARY OF KEY COMPONENTS FOR CONSERVATION OF *PHACELIA SCOPULINA* VAR. *SUBMUTICA*

Status

Phacelia scopulina var. *submutica* (Debeque phacelia) is designated a candidate species with a low priority (11) for listing by the U.S. Fish and Wildlife Service, which recognizes it as the full species, *P. submutica*. It is designated a sensitive species by the USDA Forest Service Region 2. The Bureau of Land Management does not list it on their sensitive species list, but it is represented on their "Threatened, Endangered and Candidate species list" that is managed on another administrative level. NatureServe recognizes Halse's treatment, which gives the species varietal status, *P. scopulina* var. *submutica* (J.T. Howell) Halse, and assigns it a Global Rank of imperiled (G4T2). It is also designated imperiled (S2) by the Colorado Natural Heritage Program.

Primary Threats

Phacelia scopulina var. *submutica* is inherently vulnerable to habitat loss by virtue of it being restricted to barren and semi-barren habitat on only specific members of the Wasatch geological formation that has a limited distribution within the Piceance Basin. This area has high amounts of gas reserves and has historically been impacted by activities associated with resource extraction. Current and future levels of resource extraction activity are likely to be substantial. Activities that lead to significant soil disturbance, or progressive soil erosion, would likely eliminate or sharply reduce the seed bank, which appears to be the mechanism by which populations survive. Therefore, all actions that cause significant disturbances, including mechanized vehicle traffic and intensive hoof action, are threats. *Phacelia scopulina* var. *submutica* has evolved in habitats where interspecies competitive pressures are very low, and evidence suggests that weed infestations are potentially a significant threat. It is likely to be palatable to non-selective herbivores, such as livestock and some species of wildlife and arthropods, but the potential magnitude of the impact is not known. Some evidence suggests that livestock grazing, which includes disturbance as well as herbivory, may be a threat to some occurrences.

Primary Conservation Elements, Management Implications and Considerations

Phacelia scopulina var. *submutica* is a regional and substrate endemic to western Colorado. Few occurrences have been visited multiple times, and because population sizes are temporally quite variable, it is difficult to evaluate the significance of the observed, general downward trend in population sizes. In addition, relatively few specific facts are known about its biology or ecological requirements. Populations exist within an Area of Critical Environmental Concern on Bureau of Land Management land and within a proposed Research Natural Area in the White River National Forest. The Area of Critical Environmental Concern is managed specifically to afford the taxon some protection. The proposed Research Natural Area is managed to preserve qualities qualifying the area for this status until formal designation. Additional areas where the variety would be assured protection from anthropogenic activities are desirable because its restricted habitat requirements make it vulnerable to habitat destruction.

TABLE OF CONTENTS

EDITOR: Beth Burkhart, USDA Forest Service, Rocky Mountain Region

LIST OF TABLES AND FIGURES

Tables:

Figures:

INTRODUCTION

This assessment is one of many being produced to support the Species Conservation Project for USDA Forest Service (USFS), Rocky Mountain Region (Region 2). *Phacelia scopulina* var. *submutica* (Debeque phacelia) is the focus of an assessment because it is a sensitive species in USFS Region 2. Within the National Forest System, a sensitive species is a plant or animal whose population viability is identified as a concern by a Regional Forester because of significant current or predicted downward trends in abundance in habitat capability that would reduce its distribution (FSM 2670.5 (19)). A sensitive species may require special management, so knowledge of its biology and ecology is critical.

This assessment addresses the biology of *Phacelia scopulina* var. *submutica* throughout its range in Region 2. The lack of information on the species and the broad nature of the assessment leads to some constraints on the specificity of information for particular locales. This introduction defines the goal of the assessment, outlines its scope, and describes the process used in its production.

Goal

Species conservation assessments produced as part of the Species Conservation project are designed to provide forest managers, research biologists, and the public a thorough discussion of the biology, ecology, conservation status, and management of certain species based on available scientific knowledge. The assessment goals limit the scope of the work to critical summaries of scientific knowledge, discussion of broad implications of that knowledge, and outlines of information needs. The assessment does not seek to develop specific management recommendations but provides the ecological background upon which management must be based. However, it does focus on the consequences of changes in the environment that result from management (i.e. management implications). Furthermore, it cites management recommendations proposed elsewhere and, when management recommendations have been implemented, the assessment examines the success of the implementation.

Scope

This *Phacelia scopulina* var. *submutica* assessment examines the biology, ecology, conservation status, and management of this species with specific reference to the geographic and ecological characteristics of the USFS Rocky Mountain Region. Although some of the literature relevant to the species may originate from field investigations outside the region, this document places that literature in the ecological and social context of the central Rockies. Similarly, this assessment is concerned with reproductive behavior, population dynamics, and other characteristics of *P. scopulina* var. *submutica* in the context of the current environment rather than under historical conditions. The evolutionary environment of the species is considered in conducting this synthesis but placed in a current context.

In producing the assessment, refereed literature, non-refereed publications, research reports, and data accumulated by resource management agencies were reviewed. The assessment emphasizes the refereed literature, because this is the accepted standard in science. In cases where information was otherwise unavailable, non-refereed publications and reports were used but regarded with greater skepticism. Many reports or non-refereed publications on rare plants are often 'works-in-progress' or isolated observations on phenology or reproductive biology. For example, demographic data may have been obtained during only one year when monitoring plots were first established. Insufficient funding or manpower may have prevented work in subsequent years. One year of data is generally considered inadequate for publication in a refereed journal but still provides a valuable contribution to the knowledge base of a rare plant species. Unpublished data (for example, Natural Heritage Program and herbarium records) were important in estimating the geographic distribution and population sizes. These data required special attention because of the diversity of persons and methods used to collect the data. Records that are associated with locations at which herbarium specimens have been collected at some point in time tend to be the most reliable.

Treatment of Uncertainty

Science represents a rigorous, systematic approach to obtaining knowledge. Competing ideas regarding how the world works are measured against observations. However, because our descriptions of the world are always incomplete and our observations are limited, science includes approaches for dealing with uncertainty. A commonly accepted approach to science is based on a progression of critical experiments to develop strong inference (Platt 1964). However, it is difficult to conduct critical experiments in the ecological sciences, and often observations, inference, good thinking, and models must be relied on to guide the understanding of ecological relations.

In this assessment, the strength of evidence for particular ideas is noted, and alternative explanations are described when appropriate. While well-executed experiments represent the strongest approach to developing knowledge, alternative approaches (modeling, critical assessment of observations, and inference) are accepted approaches to understanding features of biology.

Publication of the Assessment on the World Wide Web

To facilitate use of species assessments in the Species Conservation Project, they are being published on the Region 2 World Wide Web site. Placing the documents on the Web makes them available to agency biologists and the public more rapidly than publishing them as reports. More important, it facilitates revision of the assessments, which will be accomplished based on guidelines established by Region 2.

Peer Review

Assessments developed for the Species Conservation Project have been peer reviewed prior to release on the Web. This assessment was reviewed through a process administered by the Center for Plant Conservation, employing at least two recognized experts on this or related taxa. Peer review was designed to improve the quality of communication and increase the rigor of the assessment.

MANAGEMENT STATUS AND NATURAL HISTORY

Management Status

The U.S. Fish and Wildlife Service (USFWS) accepts that *Phacelia scopulina* var. *submutica* is the full species and tracks it as *P. submutica* (U.S. Fish and Wildlife Service 2002). Due primarily to a lack of resources, the USFWS uses a priority system for listing species under the Endangered Species Act (U.S. Fish and Wildlife Service 1996). The system considers the magnitude and immediacy of the threats, and also the species' taxonomic distinctiveness when assigning a numerical listing priority on a scale of one through twelve (U.S. Fish and Wildlife Service 1983). The USFWS has designated *P. submutica* a candidate for listing with a priority of 11 (U.S. Fish and Wildlife Service 2001).

Phacelia scopulina var. *submutica* is designated sensitive by Region 2 of the USFS (2003). The Bureau of Land Management (BLM) does not list it as a sensitive species but includes it in another administrative group, namely "Plants in Colorado Federally listed as Threatened or Endangered and Candidates for Listing" (Colorado Bureau of Land Management 2000).

NatureServe (2001) recognizes Halse's treatment, which gives the species varietal status, *Phacelia scopulina* var. *submutica* (J.T. Howell) Halse, and assigns it the Global Rank[1] of G4T2. This rank indicates that it is an imperiled variety of an apparently secure taxon. It is designated imperiled (S2) by the Colorado Natural Heritage Program.

Existing Regulatory Mechanisms, Management Plans, and Conservation Strategies

Phacelia scopulina var. *submutica* is restricted to habitat that has a limited distribution within the Piceance Basin in western Colorado. An area of approximately 223 ha (515 acres) around Pyramid Rock in Mesa County has been designated a Colorado Natural Area (Pyramid Rock Natural Area, Article of Designation June 1, 1987) and an Area of Critical Environmental Concern (ACEC) by the Colorado Natural Areas Program and the Bureau of Land Management, respectively. The area was given Natural Area and ACEC status because it contains populations of not only *P. scopulina* var. *submutica* but also of the federally threatened *Sclerocactus glaucus* (Uinta Basin hookless cactus) and another rare species, *Astragalus debequaeus* (Debeque milkvetch). An activity plan and an environmental assessment were developed to address management of all three sensitive plant species in 1992. Recreational off-road vehicles are prohibited in the area, and the area is signed to that effect. Livestock grazing continues according to the relevant BLM Allotment Management Plan. There is a No Surface Occupancy (NSO) leasing stipulation for all new oil and gas leases in the area. Existing oil and gas leases are pre-Federal Land Policy and Management Act of 1976 and therefore NSO cannot be required. However, the BLM can negotiate for a NSO stipulation on applications for any permits to drill existing leases (Bureau of Land Management/Colorado Natural Areas

[1]For definitions of G and S ranking see Rank in the Definition section at the end of this document.

Program 1992, 1996). The Colorado Natural Areas Act requires the site to be visited by a steward at least every three years. Presently there is a steward who makes, at minimum annual and sometimes more frequent, visits to monitor the condition of the site and, if the time of year is appropriate, to survey for sensitive plant species (Lindauer personal communication 2002).

In 2001, three sites were identified on the BLM Glenwood Springs Resource Area in Garfield County. These may represent new occurrences in a region previously believed to be devoid of this species. However, the plants were vegetative during the survey, and definitive identification still remains to be made (Scheck personal communication 2002). A management plan for the species will be written for this BLM district if the populations are confirmed. Protocols for managing this species are in place on other districts, but they have not been formally documented (Smith personal communication 2002). General guidelines for managing sensitive species are outlined in BLM (1983) and BLM (1985).

In Region 2 of the USFS, several occurrences have been found within 2.5 sections in the White River National Forest. Currently the area occupied by *Phacelia scopulina* var. *submutica* on the White River National Forest is within a grazing allotment that is vacant and not used for livestock grazing (Johnston personal communication 2002). Grazing in this allotment is unlikely in the future. According to the revision of the White River National Forest Management Plan (2002), this area is part of the proposed Lower Battlement Mesa RNA. The management of the area has been designated as category 2.2 (RNA) with category 5.42 (Bighorn sheep habitat) in some areas. However, the more restrictive management guidelines associated with a 2.2 management area would be enforced throughout the region when the RNA is designated. This means that activities associated with timber harvest, motorized and mechanized recreation, developed recreation, livestock grazing, and locatable minerals will not be permitted. Until the RNA is designated, the area is managed to protect those qualities that qualify it for consideration as a RNA. This is not as restrictive as management of a formally designated RNA. There are currently several established two-track roads through the proposed RNA, linking adjacent BLM land. Although the travel management status of this Forest Service land is "closed to all motor vehicles off established roads and trails," there is always the potential for trespass.

Biology and Ecology

Classification and description

Systematics and synonymy

Phacelia scopulina var. *submutica* is a member of the *Miltitzia* section in the Hydrophyllaceae, the waterleaf, family. Species in the *Miltitzia* section are distinguished from other members of the waterleaf family by their yellowish, persistent corolla (petals) and their transversely ribbed seeds (Halse 1981). Howell (1944) recognized *P. submutica* as "undoubtedly closely related" to *P. scopulina* but listed 13 characteristics that clearly distinguish the two taxa. Halse (1981) gave *P. submutica* varietal status that has been challenged as being incorrect (O'Kane 1987). Cronquist et al. (1984) reported a total of seven varieties of *P. lutea* that they described as a "geographically significant but not wholly discrete species". In their treatment, both *P. scopulina* and *P. scopulina* var. *submutica* were recognized as subspecies of *P. lutea*. According to O'Kane (1987), although these taxonomic statements concerning *P. submutica* may be correct, they are both based upon very limited material and little or no first-hand experience with the taxon. Apparently Halse's treatment was based upon only two specimens: one was from the type location collected near DeBeque, Colorado in 1911, and the other was a specimen collected approximately 100 years ago from near Winslow, Arizona. The identification of the Arizona specimen is questionable, and the label data on the Arizona specimen is too vague to permit relocation (O'Kane 1987). *Phacelia submutica* is geographically isolated from both *P. scopulina* and *P. lutea*.

Harrington (1964), Weber (1987), and Weber and Wittman (1992) recognize *Phacelia submutica* as a valid taxon. U.S. Fish and Wildlife Service tracks the species as *P. submutica*, while NatureServe follows Kartesz (1994) and tracks it as *P. scopulina* var. *submutica* (NatureServe). A synonym for *P. scopulina* is *Emmenanthe scopulina*.

History of species

Phacelia scopulina var. *submutica* was first collected from DeBeque on May 19, 1911, by George E. Osterhout who identified it as *Emmenanthe scopulina* A. Nels (Holotype and isotype specimens: No. 4458 in Rocky Mountain Herbarium, University of Wyoming; isotype specimen No. 4458 at the University of Colorado - Boulder Herbarium). Osterhout also collected a specimen (no. 4726) identified as *E. scopulina* from the type locality, again just describing it as from DeBeque in Mesa County, on June 22, 1912 (specimen at University of Colorado – Boulder Herbarium). It was thus named Debeque phacelia because it was originally found near, or perhaps within, the town of DeBeque. Howell (1944) formally described *P. submutica* as part of an extensive treatment of the genus. There are relatively few herbarium specimens, and very infrequent observations were made on the species between 1911 and 1980. Specifically there are herbarium records from 1912, 1920, 1955, and 1965 at the University of Colorado-Boulder Herbarium, the Colorado State University Herbarium, the Kathryn Kalmbach Herbarium at the Denver Botanic Garden, and the Rocky Mountain Herbarium, University of Wyoming. In the 1978 field season, one population was observed near Highway 204 just north of the city of DeBeque (O'Kane 1987). The variety was not relocated in the area in 1981 but was observed in the same vicinity in 1982, and the area was proposed a preserve, namely the DeBeque Phacelia Preserve (Baker 1981). However, in 1982, additional populations were also located in the Pyramid Rock area, and the latter area was registered a Colorado Natural Area (see Management Status section). It is not known if the population originally located in the area proposed as the "DeBeque Phacelia Preserve" is extant.

Non-technical description

Phacelia scopulina var. *submutica* is a small, summer annual plant (**Figure 1**). The stems are 2 to 8 cm long, often branched at the base and generally lay flat on the ground surface in a disc-shaped clump. The stems are often a deep red color. The reddish-colored leaves are 5 to 15 mm long, egg-shaped or tending to be almost rectangular with rounded corners, with the bases abruptly tapering to a wedge-shaped point. The leaf margins are smooth or toothed. The stems and leaves are covered by variable numbers of straight, stiff hairs. The root is a tap-root. The very small, tube-shaped flowers are crowded and light-yellow or cream colored, often with a purple tinge (Harrington 1964). Unlike many *Phacelia* species, the stamens do not protrude beyond the petals. The elongated-egg shaped seeds are 1.5 to 2 mm long with 6 to 12 fine ridges, or corrugations. They are blackish brown and tend to be iridescent (description after Howell 1944 and Halse 1981).

It is very unlikely that any other sympatric species would be mistaken for *Phacelia scopulina* var. *submutica* when it is flowering. Early in the season, when the plant is a seedling, it may be confused with many different annual species (Scheck personal communication 2002).

Figure 1. Photograph of *Phacelia scopulina* var. *submutica*. Photographer is B. Jennings, with permission.

Phacelia scopulina var. *submutica* is less leafy with more flowers than *P. scopulina* var. *scopulina*. In addition, the flowers of var. *submutica* are yellowish-colored compared to those of var. *scopulina*, which are more or less tinged with lavender or violet. The seed of the two taxa are also different. The seed of var. *submutica* tends to be larger than those of var. *scopulina* with finer, less round, and deeper corrugations on the coat. Other than these somewhat subjective characteristics, there are three main differences between *P. scopulina* var. *submutica* and *P. scopulina* var. *scopulina*: the size of the fruiting calyx, the shape of the capsules, and the hairiness of the style. The fruiting calyx of var. *scopulina* is 5 to 7 mm long, while that of var. *submutica* is 6 to 10 mm long. The capsules of *P. scopulina* var. *scopulina* end in an abrupt, slender, somewhat flexible tip, whereas those of var. *submutica* are not or only slightly tipped. The style of var. *scopulina* is 1 to 2 mm long and hairy from one-third to all of its length. The style of var. *submutica* is 1 to 1.5 mm long and essentially hairless, having hairs only at its base (Howell 1944, Halse 1981).

References to technical descriptions, photographs, line drawings

Technical descriptions are in Howell (1944), Harrington (1964), Halse (1981), Cronquist et al. (1984), and Weber and Wittman (2001). A description and photograph are published in Weber (1987) and in Colorado Native Plants Society compilation (1997). A description, photograph, and line drawing are published on the Colorado Natural Heritage Program Web site and in the Colorado Rare Plant Field Guide (Spackman et al. 1997). A photograph of the plant is also published on the Colorado Natural Areas Program Web site (Pyramid Rock Natural Area). A digital photograph of the specimen sheet of the isotype, No. 4458, is published on the New York Botanical Garden Web site (2002). Potentially confusing information is on Web sites that refer to *Phacelia scopulina* var. *scopulina* by the common name Debeque phacelia, which is generally reserved for *P. scopulina* var. *submutica* (Taxonomic Information System 2002, U.S. Department of Agriculture 2002).

Distribution and abundance

Phacelia scopulina var. *submutica* grows only in Garfield and Mesa counties within the Piceance Basin in western Colorado (**Figure 2**). Given the known occurrences, the reference to Grand (GA) County in Weber (1987) and Weber and Wittmann (2001) was likely a typing error, and the name should have been Garfield (GF) County. The species' total range is less than 300 square miles. It can be locally common within its restricted habitat although population size varies from year to year, presumably because of environmental conditions. A slight extension northwards, by approximately 10 miles, from the known range was reported to have occurred in 2001 (Tabor and Thomas 2001). These were cursory surveys made too early in the year to definitively identify the plants (Scheck personal communication 2002). No plants were found at the sites in 2003 and the habitat was unlike that typically associated with the taxon (Scheck personal communication 2003). Therefore, it is likely that the non-flowering rosettes were misidentified in 2001, rather than *P. scopulina* var. *submutica* plants being absent in 2003 (Scheck personal communication 2003). Because of geologic restrictions the geographic range of this species is unlikely to extend substantially out of the currently known region. As described in the Systematics and synonymy section, the one record that was reported from Navajo County in Arizona is likely erroneous (Burt and Spackman 1995).

An occurrence is generally ascribed to a population, and one occurrence typically consists of several sub-occurrences. Sub-occurrences interact either through pollination or seed dispersal. In some cases a reported occurrence may be more accurately described as a sub-occurrence, but there may be insufficient information associated with the report to make an accurate delineation. In **Table 1**, a letter (A, B, C or D) has been placed beside occurrences that may possibly be related sub-occurrences.

Of the 39 occurrences that have been recorded, 13 were observed more than 15 years ago and have not been relocated. At least one occurrence may be extirpated. Occurrence size varies in both number of individuals and density. *Phacelia scopulina* var. *submutica* may be densely (less than 5 cm between individuals) or sparsely distributed. The individuals appear to have a spatially aggregated, or patchy, distribution even within suitable habitat. For example, ostensibly suitable habitat was estimated to be 40,000 sq. ft., but only four plants were found in one small (25 sq. ft.) area. At another occurrence only one plant was seen in a "large area of potential habitat." Potential habitat has not been critically defined and may be loosely described as that habitat, which from casual observation, appears to be suitable for the species but is not occupied by it. Areas occupied by contiguous occurrences tend to be small, less than 5 acres, except for the Pyramid Rock population that has been delineated to occupy approximately 160 acres (Burt and Spackman 1995). However, even within this

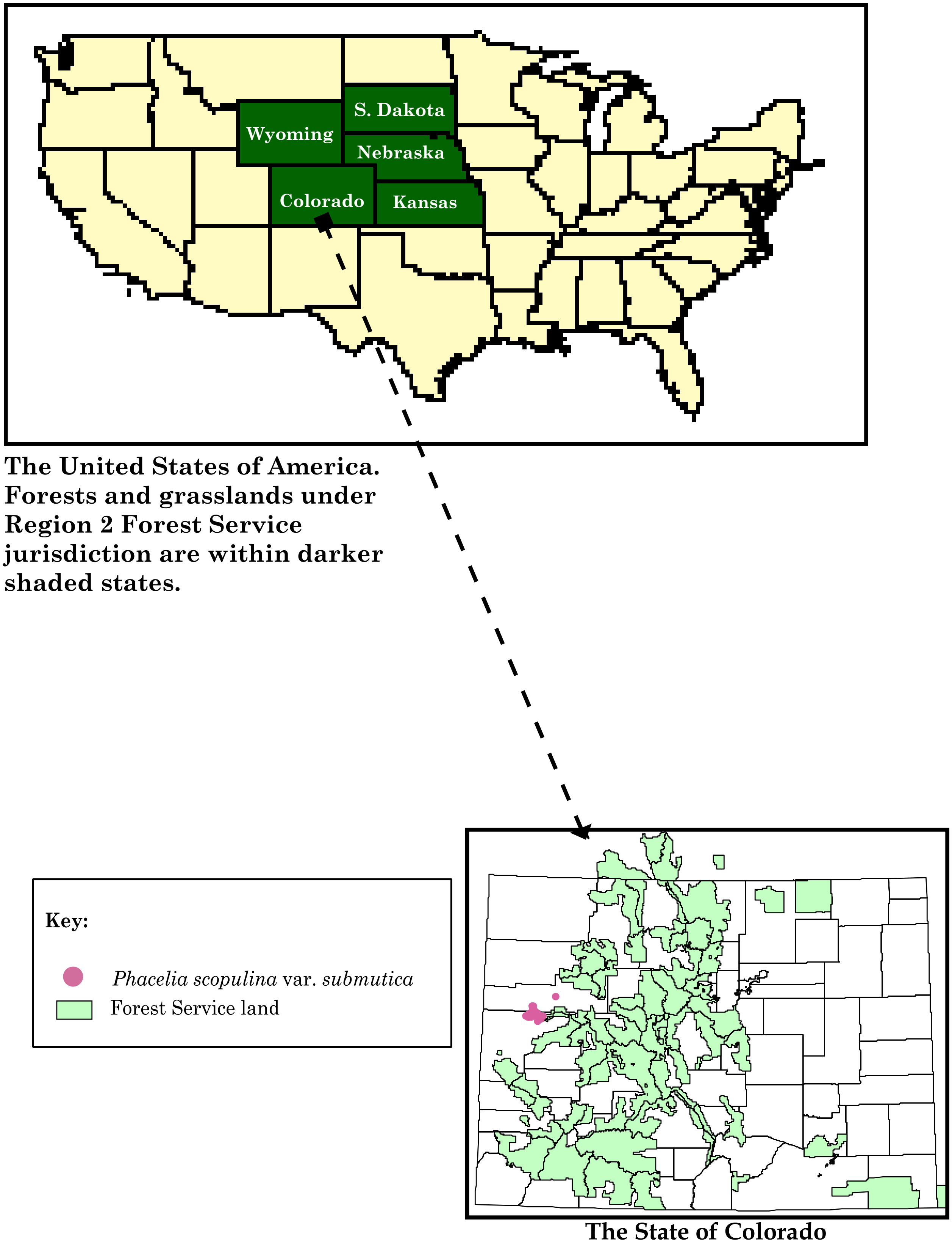

Figure 2. Distribution of *Phacelia scopulina* var. *submutica*.

Table 1. Occurrence information for *Phacelia spulina* var. *submutica*. Under Possibly Related Occurrences, a letter (A, B, C, or D) denotes possibly related suboccurrences. See **Table 2** for information on the numbers of plants found over multiple years at selected occurrences.

Arbitrary Occurrence No.	Possibly Related Suboccurrences	County	Location	Ownership	Observations	Source of Information or Specimens[1]
1		Mesa	Along Roan Creek, northwest of DeBeque.	BLM and/or private	April 27, 1982; May 7, 1982; May 21, 1982; June 21, 1994; 1995	CSU Herbarium, CNHP, COLO
2	A	Mesa	Across 2 sections between Coon Hollow and Sulphur Gulch, west of DeBeque.	BLM	May 22,1982; 1984; 1986; June 21, 1994; 1995	CSU Herbarium, CNHP, COLO
3	A	Mesa	Coon Hollow and north of Coon Hollow (north of occurrence no. 2).	BLM	May 1,1983; May 6, 1995	CNHP
4	A	Mesa	West-northwest of Pyramid Rock.	BLM	May 24, 1983; May 1, 1986	CSU Herbarium, CNHP
5	A	Mesa	South of Coon Hollow.	BLM	May 24, 1983	CNHP
6	A	Mesa	North of Coon Hollow approximately 3 miles northeast of Pyramid Rock ACEC.	BLM	May 6, 1986	CNHP
7	A	Mesa	Approximately 2 miles west of Pyramid Rock ACEC.	BLM	June 21, 1994	CNHP
8	A	Mesa	Approximately 2 miles northwest of Pyramid Rock ACEC.	BLM	May 7, 1995	CNHP
9		Garfield	Near confluence between Roan Creek and a dry fork.	BLM and/or private	May 21, 1982; May 3, 1993	CNHP, CSU Herbarium
10		Garfield	West of junction of Roan Creek Road & Dry Fork Road.	BLM and/or private	May 21, 1982; May 20, 1986; May 6, 1995	COLO, CSU Herbarium, CNHP
11		Garfield	Roan Creek, south of Logan Wash.	BLM and/or private	1982	CNHP
12		Garfield	Within and north of Pyramid Rock ACEC.	BLM	May 7, 1995	CNHP
13		Mesa	Southwest of the Pyramid Rock ACEC (may be a combination of two occurrences - descriptions were difficult to interpret).	BLM	May 22, 1982; May 7, 1995	CNHP
14		Mesa	Above Coon Hollow, west of DeBeque.	BLM	May 20, 1986; May 7, 1995	CNHP, COLO
15		Mesa	North of Little Horseshoe Creek.	BLM and/or private	May 1, 1983; May 7, 1995	CNHP
16		Mesa	East of Highway 6, due east of DeBeque.	BLM and/or private	May 17, 1989	CNHP
17		Mesa	Approximately 2 miles south of DeBeque on DeBeque Road.	BLM and/or private	May 11, 1989	CNHP
18		Mesa	Due west of DeBeque, near resevoir ditch.	BLM and/or private	May 5, 1984	CNHP
19		Mesa	West of occurrence 8.	BLM and/or private	1982; 1986; May 17, 1995	CNHP
20	C	Mesa	South of Little Horsethief Creek.	BLM	1986; 1991; 1992; May 5, 1998	CNHP

Table 1 (concluded).

Arbitrary Occurrence No.	Possibly Related Suboccurrences	County	Location	Ownership	Observations	Source of Information or Specimens[1]
21	C	Mesa	Hills south of Piute resevoir, east of Horsethief Creek Road.	White River National Forest	May 24, 1986; 1991; 1992	CSU Herbarium, CNHP
22	C	Mesa	Near junction of Horsethief Creek Road and head of Horsethief Creek.	White River National Forest	May 23, 1986; 1991; May 5, 1998	CNHP, COLO
23	C	Mesa	North of junction between Horse Creek Road and the US Forest Boundary (near Sunnyside Road).	White River National Forest, BLM, may extend into private	1986; 1989; June 6, 1995; May 21, 1996	CSU Herbarium, CNHP
24	B	Garfield	On the east slope of Roan Cliffs.	BLM	May 6, 2001	CNHP
25	B	Garfield	Near Anvil Points Oil Shale Mines.	BLM (may extend onto private)	May 6, 2001	CNHP
26	D	Garfield	Northwest of Roan Creek-Conn Creek junction and west of Roan Creek-Logan Wash confluence.	BLM and/or private	May 13, 1982	CSU Herbarium, CNHP
27		Mesa	East end of Moffat Gulch.	BLM and/or private	May 17, 1989	CNHP
28		Mesa	East edge of DeBeque.	BLM and/or private	May 17, 1965; May 15, 1965; May 5, 1982; May 6, 1995	CSU Herbarium, CNHP, COLO, Kathryn Kalmbach Herbarium (Denver Botanical Garden)
29		Mesa	Due east of DeBeque.	BLM	June 9, 1920	CNHP
30		Mesa	Due west of Pyramid Rock.	BLM	May 24, 1983; May 11, 1989	CSU Herbarium, CNHP
31		Mesa	South of Horsethief Creek.	BLM and/or private	May 17, 1989	CNHP
32		Mesa	South of Grand Mesa National Forest boundary and northeast of Jerry Gulch.	Private	June 6, 1995	CSU Herbarium, CNHP
33		Mesa	Between Ashmead Draw and Little Horsethief Creek.	BLM	May 12, 1989	CNHP
34		Mesa	Southeast of Pyramid Rock ACEC.	BLM	May 7, 1995	CNHP
35		Mesa	South end of Ashmead Draw.	BLM and/or private	May 12,1989	CNHP
36		Mesa	Approximately 1 mile north northwest of Baugh Resevoir.	BLM and/or private	May 1, 1983; May 12, 1983	CSU Herbarium, CNHP
37		Mesa	Between Coon Hollow and Sulphur Gulch.	BLM	May 28, 1986	CNHP
38		Mesa	Sulphur Gulch, northeast of north end of Horseshoe Canyon.	BLM	May 28, 1986	CNHP
39		Mesa	North of Winter Flats	BLM	May 29, 1986	CNHP
40	D	Garfield	Northwest of Roan Creek-Conn Creek junction.	BLM and/or private	May 13, 1982	CSU Herbarium, CNHP

[1]COLO - University of Colorado Herbarium, Boulder, Colorado

CNHP - Colorado Natural Heritage Program unpublished element occurrence records

CSU - Colorado State University

area *P. scopulina* var. *submutica* occurs sporadically, only occupying small patches of habitat (O'Kane 1987). In an area just outside Pyramid Rock Colorado Natural Area, ten thousand individuals were estimated within 1 acre (Neese 1984).

In Region 2, several occurrences have been found within approximately 2.5 sections in the White River National Forest (see occurrence numbers 21, 22, 23 in **Table 1**). The sizes of the individual occurrences are approximately one acre and range from an estimate of 2,000 to 2,500 individuals at one site to as few as 12 at another (Colorado Natural Heritage Program 2002).

Population trend

Phacelia scopulina var. *submutica* exhibits highly variable population sizes over time. This variability is likely due to environmental conditions that affect seed germination and seedling establishment, like precipitation. The contribution of the seed bank size and annual fecundity is unknown. In addition, the role of management practices in contributing to its variable population size has not been studied.

Based on observations made periodically at the same sites over two or more years, the population size over its range appears to be generally in decline. No population trend data are available. Colonies of *Phacelia scopulina* var. *submutica* within the Pyramid Rock ACEC have been mapped and have been visited periodically over the last six years (Colorado Natural Areas Program 1997). In 1995, over three hundred plants were observed within the ACEC (Burt and Spackman 1995). In 1998, no *P. scopulina* var. *submutica* plants were found at any of the mapped occurrence sites (Colorado Natural Areas Program 1999). In 1999, only one of the known occurrence sites had plants and then it was only six individuals (Colorado Natural Areas Program 2000). No plants were found within the ACEC in 2000 (Colorado Natural Areas Program 2000, Lindauer 2000, Lindauer personal communication 2002). The population on the White River National Forest, which includes three occurrences, has been equally variable, and observations also support a characterization of general decline. In 1986, O'Kane reported two sites, each approximately 1 acre in size. He estimated 2,000 to 2,500 individuals occupied one of the sites in 1986. In 1991, 50 individuals and in 1992, 100 individuals were observed in the same area (Wood 1992, Colorado Natural Heritage Program 2002). However, no plants were observed in 1998 (Grode and Goedert 1998, Colorado Natural Heritage Program 2002). O'Kane (1986) estimated 300 individuals at a second site. At this site approximately 50 individuals were observed in 1991 and only 12 in 1998 (Myser and Meunier 1991, Grode and Goedert 1998, Colorado Heritage Program records 2002). The numbers of individuals at two populations on the BLM Glenwood Springs resource district appeared to be lower in 2003 than in the past (Scheck personal communication 2003).

Additional occurrence data between 1978 and 1995 (Burt and Spackman 1995) is tabulated to illustrate the variation in temporal and spatial abundance (**Table 2**). As illustrated in **Table 2**, in one year no plants may be found in a given area whereas in another year hundreds or even thousands of individuals may be observed (Burt and Spackman 1995, O'Kane 1987). One occurrence with multiple visits from the Colorado Natural Heritage Program (occurrence number 1 in **Table 1**) illustrates the high degree of variation very well. Thirty individuals were observed in 1978, zero in 1980, 150 to 500 in 1982, and zero in both 1994 and 1995. The site was not visited from 1983 to 1993.

Trends in population size are very difficult to evaluate because of apparently extreme natural year-to-year variation. The absence of individuals over two, or perhaps more, consecutive years may not be significant. The pattern established over the last 15 years suggests that when individuals are not found in areas of suitable habitat during one year, they may be found in a subsequent year. In addition, it is possible that the occurrences are spatially dynamic and monitoring specific occurrences without additional inventory may not reflect the overall population. There is no evidence that *Phacelia scopulina* var. *submutica* is more limited in its range than in the past. It is likely that some populations have been reduced in size or even extirpated where substantial disturbance and subsequent habitat modification have occurred within its restricted habitat. The impact on the total population from such events is unknown, and any speculation either supporting "no impact" or "considerable impact" is subject to error because of the lack of specific information.

Habitat

Phacelia scopulina var. *submutica* occurs within Rocky Mountain Forest (Bailey 1976) and juniper-piñon woodland (Kuchler 1966) regional vegetation types. Its habitat lies at the interface of the North-Central Highlands and Rocky Mountain Section and the Intermountain Semi-desert and Desert Province (McNab and Avers 1994). However, *P. scopulina* var. *submutica* only grows at the periphery of the evergreen, needle-leaved woodlands and evergreen, broad-leaved shrub lands where herbaceous annuals are the dominant

Table 2. Individuals of *Phacelia scopulina* var. *submutica* counted or estimated at occurrences between 1978 and 1995. Surveys were not made in years where there are no values. "0" indicates that no plants were observed during a survey (after Burt and Spackman 1995). Note: occurrences as delineated by these researchers included multiple occurrences or occurrences divided into suboccurrences, relative to the organization of occurrences in **Table 1**. Numbering for a given occurrence is based on **Table 1.**

Arbitrary Occurrence No.	1978	1981	1982	1983	1984	1986	1989	1991	1992	1994	1995	Trend
1	30	0	<500							0	0	Decrease
2						830				0	1500+	Increase
2					1000	2						Decrease
9						50					0	Decrease
10						50				300		Increase
11, 12, 13, 14						0					300+	Increase
15, 16, 17				30		0	45				1	Decrease
3				5000							2000	Decrease
18, 19					10,000	400						Decrease
20						1700		100	50			Decrease
21						2500		50				Decrease
22						300		50				Decrease
23						3000	200					Decrease

life form (O'Kane 1987). *Juniperus osteosperma* (Little Utah juniper) is typically dominant in the evergreen, needle-leaved woodlands, and *Artemisia tridentata* (big sagebush) is commonly dominant in the evergreen, broad-leaved shrub lands.

Phacelia scopulina var. *submutica* is restricted to the barren, dark gray and brown, clay soils of the Atwell Gulch and Shire members of the Eocene and Paleocene Wasatch geological formation (Donnell 1969, O'Kane 1987). O'Kane (1987) and Burt and Spackman (1995) reported that *P. scopulina* var. *submutica* does not occur on the Molina member of the Wasatch formation. The Molina formation lies between the Atwell Gulch and Shire Formations and comprises primarily sandstone (Donnell 1969). Soils are most easily recognizable to the layperson by their color. The dark gray soils generally do not support any other species except *P. scopulina* var. *submutica*, while the brown soils support a community of native and introduced pioneer species (Burt and Spackman 1995). On the latter soils, *P. scopulina* var. *submutica* only grows were vegetation is sparse (Burt and Spackman 1995). *Phacelia scopulina* var. *submutica* appears to be adapted to the shrink-swell feature of the soils that tends to expel plants that grow on them. Because of the soil characteristics, susceptibility to erosion, and subsequent low vegetation cover, the sites are always in a pioneer state of development.

Precipitation occurs evenly throughout the year with a small peak in May and October (Burt and Spackman 1995). Cool season precipitation usually falls as snow, and thunderstorms likely account for most warm season precipitation. Because of the largely clay soils, sediment runoff from rainfall on slopes may be substantial. The majority of occurrences are between 1,500 m and 1,890 m in elevation. A report in 2001, which has yet to be confirmed at an appropriate time of year (flowering), extends the elevation range to at least 1,995 m and possibly 2,161 m (Scheck personal communication 2002). Plants grow on benches, ridgetops, and apparently steep slopes. However, in the latter case, individuals tend to grow on small benches within the slope and thus grow where the local grade is less (O'Kane 1987). Where aspect was reported, plants were most often observed on south, southwest, and west facing slopes, in that order. However, individuals with north, east, and northeast aspects have also been observed.

Grindelia fastigiata (pointed gumweed) and *Eriogonum gordonii* (Gordon's buckwheat) are frequently associated with *Phacelia scopulina* var. *submutica* and have been dubbed "indicator species." However, some botanists have specifically stated in occurrence records (Colorado Natural Heritage Program 2002) that *G. fastigiata* has not been observed with *P. scopulina* var. *submutica*, and so reliance on associated species to identify potential habitat could be misleading. Three other species of concern grow in *P. scopulina* var. *submutica* habitat: *Sclerocactus glaucus* (K. Schum.) Benson, listed as threatened by the U.S. Fish and Wildlife Service, *Astragalus debequaeus* Welsh, a federal candidate for listing, and *Lomatium eastwoodiae* (C. & R.) Fern. (Eastwood's desert parsley), a BLM sensitive species. Other associates that occur within *P. scopulina* var. *submutica* habitat include species of *Atriplex*, *Chenopodium*, *Helianthus*, *Lepidium*, *Mentzelia*, *Rumex*, and *Thelypodiopsis*. Specifically[2], associated plants include *Asclepias cryptoceras*, *Astragalus flavus*, *Astragalus lonchocarpus*, *Atriplex canescens*, *Atriplex confertifolia*, *Bromus tectorum*, *Ceratocephala testiculata*, *Cymopterus planosus*, *Elymus elymoides*, *Euphorbia fendleri*, *Gutierrezia sarothrae*, *Lactuca serriola*, *Monolepis nuttalliana*, *Oenothera caespitosa*, *Oryzopsis hymenoides*, *Sarcobatus vermiculatus*, *Sphaeralcea coccinea*, and *Streptanthus cordatus*.

Reproductive biology and autecology

Phacelia scopulina var. *submutica* is a summer annual species occurring in an unstable habitat and fitting the profile of a ruderal, or r-selected species (MacArthur and Wilson 1967, Grime et al. 1988). "Unstable habitat" refers to environmental conditions associated with the habitat, such as unpredictable temperature and precipitation and highly erosive, saline soils. The known characteristics of its morphology and life history fit well into the model of a ruderal species developed by Grime et al. (1988) and from such a model further characteristics may be inferred. However, it is appreciated that inference is not a substitute for facts and should not be regarded as such. Grime et al. (1988) described a persistent seed bank of numerous small, wind-dispersed seeds and seasonal regeneration in vegetation gaps as important to the regenerative strategy of ruderal species. Considering what is known, these characteristics likely apply to *P. scopulina* var. *submutica*.

Seeds are believed to germinate in early April in a typical year (Burt and Spackman 1995), and plants flower from late April through late June (O'Kane 1987). Fruit set is from mid-May through late June. Individuals finish their life cycle by late June to early July, at which time their remains soon deteriorate and are mostly blown away. Occurrence data (Colorado Natural Heritage Program 2002) suggest that there is some degree of phenological synchrony within populations, although individual size differences are reported. That is, all individuals within an occurrence are reported to be at about the same stage, such as vegetative, flowering, and/or fruiting, at the same time. The average size of individuals has been reported to differ between adjacent occurrences; for example, individuals on a particular slope were all generally bigger than those on a nearby level area. It was not clear if density could simply explain the difference (Silvertown 1987). The size of individuals within a population is likely an important aspect of population structure, as size plays an important role in reproductive output and differential survivorship (Sarukhan et al. 1984). *Phacelia scopulina* var. *submutica* has perfect (hermaphrodite) flowers and, being an annual, it is likely to be able to self-pollinate. Some species of *Phacelia* are gynodioecious, and female-flowered individuals can make up 15 percent of a population (Eckhart 1992). This is unlikely the case for *P. scopulina* var. *submutica* where the female and male parts of each flower are typically functional (Halse personal communication 2002). It is not known if the small, yellow-cream flowers of *P. scopulina* var. *submutica* are attractive or important to any arthropods. *Phacelia* species with more showy purple corollas are frequently described as important nectar plants for pollinators, especially native bees and flies (Bugg 1992, Kantor 1999). Parallels in speciation between arthropods and habitat-specialist plant species generally need much more research. No evidence of hybridization between sympatric *Phacelia* species has been reported.

Nothing is known about the seed biology of *Phacelia scopulina* var. *submutica*. The species grows in environments with wide temperature fluctuations, long drought periods, and erosive, saline soils. Upon drying, the soils form deep cracks. Seeds are believed "self-planted" by falling into the cracks that close when wetted, thus covering the seeds (O'Kane 1988). The species has a well-documented temporal variation in abundance, and it is likely that seeds have a moisture-controlled dormancy (O'Kane 1987, Burt and Spackman 1995). Spring temperatures were noted as "cold" in some years when no plants were observed, and it is quite likely that seeds also have a temperature-controlled component to dormancy (Kemp 1989). Some species of desert annuals also have some type of innate dormancy, where a fraction of the seeds remain dormant in any one season even if growing conditions are optimal. This mechanism provides protection against depletion of the seed bank in the event that successful reproduction could not be accomplished in any given year (Freas and Kemp 1983, Silvertown 1987). Seeds

[2] For synonyms of plant species see Definitions section.

within the seed bank may also have a light component to dormancy control (Baskin and Baskin 1989). One can speculate that seeds in the seed bank respond to light introduced by the shrink-swell cracking of the substrate. This localized, often subtle, disturbance regime may be important and contribute to the patch dynamics of the species. A persistent seed bank seems to be a requirement for continued survival of this species consistent with the model of a ruderal species (Grime et al. 1988). Inference of a requirement for substantial seed longevity is also supported by observations of other annuals in deserts and semi-deserts where conditions are unstable, precipitation is variable, and relatively long droughts are frequent (Moseley 1989).

Seed dispersal mechanisms have not been observed. No evidence of either arthropod or mammalian granivory has been documented, although granivores generally have a significant impact on desert seed banks (Kemp 1989). Ruderals tend to have numerous, small, wind-dispersed seeds, and wind dispersal is thus likely for this *Phacelia*. The dispersal pattern for *Phacelia scopulina* var. *submutica* seed has not been studied, but the aggregated spatial distribution of plants suggests that seeds are not widely dispersed. In general, wind-dispersed seeds move only short distances (Silvertown 1987).

Demography

There is no information on the genetic diversity within *Phacelia scopulina* var. *submutica*. Locally endemic species tend to exhibit reduced levels of polymorphism (Karron 1991) that may imply genetic vulnerability. However, while rare species can have statistically less genetic variation than their widespread congeners, there is a large range in values and some rare species exhibit levels of diversity equal to, or exceeding, that of widespread congeners (Gitzendanner and Soltis 2000). Therefore, without more information, few useful deductions can be made.

Populations are difficult to delineate because information on seed dispersal and pollination biology, including pollinators, is lacking. Because many of the reported occurrences may interact at some level, occurrences should not be strictly equated with populations (see Distribution and Abundance section and **Table 1**). Four meta-populations have been identified: Roan Creek and Dry Creek, Coon Hollow, Sulphur Gulch, and around Horsethief Mountain (O'Kane 1987). A meta-population is defined as being composed of populations that are likely to interact in some way, for example sharing pollinators. Although some populations do not fit precisely into the prescribed meta-population boundaries, it has been suggested that distances separating the satellite occurrences are sufficiently small to support this delineation (O'Kane 1987). Spatially disjunct groups can have high levels of dispersal and gene flow between them. Osborne et al. (1999) tracked individual bumblebees using harmonic radar and recorded that most bees regularly fly over 200 m (range 70 to 631 m) from the nest to forage even when apparently plentiful food was available. Honeybees apparently can regularly forage 2 km away from their hive (Ramsey et al. 1999). Even though interaction is expected between many occurrences, it is not known to what extent some patches are genetically isolated. Occurrence reports indicate that potential habitat is found within a patchwork of unsuitable habitat and individuals tend to be found in aggregated patterns within areas of potential habitat (see Distribution and Abundance section for definition of potential habitat). There may be an individual-density dependent aspect to successful cross-pollination, because some pollinators, such as bees, are density-dependent foragers (Geer and Tepedino 1993). Small populations of *Phacelia scopulina* var. *submutica* with few flowers separated by relatively large distances that also have few flowering plants may be pollinator limited.

No analyses of population viability have been documented. As well as direct and indirect threats associated with human activities, there are uncertainties that can only be addressed by increasing both the number and size of populations. These uncertainties, which are typically addressed in a population viability analysis, include elements of environmental stochasticity, demographic stochasticity, genetic stochasticity, and natural catastrophes (Shaffer 1981). The term "stochasticity" is replaced by "uncertainty" in the following discussion (Frankel et al. 1995). The influences of the different uncertainties to *Phacelia scopulina* var. *submutica* may only be commented upon with little supporting quantitative data.

Environmental uncertainty lies in random, partly unpredictable, changes in weather patterns or in biotic members of the community (Frankel et al. 1995). Demographic uncertainty relates to the random variation in the survival and fecundity of individuals within a fixed population. Genetic uncertainties are associated with random changes, such as inbreeding and founder effects, in the genetic structure of populations. Specific environmental uncertainties that affect survival and reproductive success of *Phacelia scopulina* var. *submutica* include variation in precipitation, soil erosive forces, and perhaps variable populations of arthropods (pollinators, herbivores, granivores) and rodents.

Where occurrences are small (less than 50 individuals) demographic uncertainties may be significant (Pollard 1966, Keiding 1975). That is, chance events independent of the environment may affect the reproductive success and survival of individuals that, in very small populations, have an important influence on the survival of the whole population. Many *Phacelia scopulina* var. *submutica* occurrences are very small, especially in some years, and an individual can be relatively important to those populations. It is not clear whether the aggregated pattern is solely related to limited seed dispersal. However, if seed dispersal is limited, pollen transfer between occurrences is critical to maintain gene flow. If self-pollination is the primary reproductive strategy, there may be significant inbreeding among small, dispersed groups of plants leading to vulnerability to genetic uncertainties within populations.

Because there are few details on germination, survivorship, fecundity, and dispersal of *Phacelia scopulina* var. *submutica*, only a generalized life history diagram has been developed (**Figure 3**). Superficially, the life cycle diagram of this short-lived annual is quite simple. Heavy arrows indicate the basic life cycle, and dashed arrows and bordered question marks indicate that specifics are unknown. Transition probabilities between one stage and the next cannot be speculated although, considering the year-to-year variation in population size, they may vary. The levels of recruitment and mortality at various stages of growth and development have not been identified. Specifically, values for recruitment of seeds to the seed bank, seedling pool, and mortality before seed maturation (abortion rate) are unknown. There are also no data on longevity of seed or on seed bank dynamics. There have been no documented analyses of population matrices, but an important part of the life cycle of this species would appear to be the seeds and seed bank. Contributions of recruitment and fecundity are also likely critical to overall survival. Intense disturbance that leads to soil removal, and thus seed bank removal or to seed predation can be predicted as being particularly devastating to local populations.

Community ecology

Phacelia scopulina var. *submutica* is described as a pioneer, early successional species (Burt and Spackman 1995, see Habitat section). It is found at sites characterized by sparse vegetative cover that likely represents a "climax" condition maintained by edaphic properties, harsh environmental factors, and occasional disturbance. Therefore, this taxon may not represent an early successional species in the classical sense but occupies a specialized ecological niche. This alternative view of the taxon may influence some human perception of its position within the community. "Early successional" suggests a taxon that is eventually replaced, whereas one that is "part of a climax community" suggests a permanence. *Phacelia scopulina* var. *submutica* does have many of the attributes of a ruderal species (see Reproductive Biology and Autecology section); it is a small, potentially fast growing, rapidly flowering annual (Grime et al. 1998).

Ruderal species often have very high palatability to unspecialized herbivores (Grime et al. 1988), but no herbivore activity or seed predation has been reported on *Phacelia scopulina* var. *submutica*. The barren, or nearly barren, habitat in which *P. scopulina* var. *submutica* has developed suggests that it has not evolved to be a competitor for water, light, and/or nutrients. Therefore, *P. scopulina* var. *submutica* may not be able to tolerate invasive and aggressive species that colonize areas of potential habitat. O'Kane and Anderson (1986) observed that plants were small and of low vigor in a site that was especially weedy. It is unknown how long the site had been weedy or what the condition of the population was before weeds colonized the site. Seed dispersal is an important aspect of a species' relationship to its environment, but there is no information available on this subject. Seeds are likely dispersed by wind, but interactions with arthropods such as ants cannot be excluded at the present time (see Reproductive Biology and Autecology section).

An envirogram is a graphic representation of the components that influence the condition of a species and reflects its chance of reproduction and survival. Envirograms have been used extensively to describe the conditions of animals (Andrewartha and Birch 1984) but may also be applied to describe the condition of plant species. Those components that directly impact *Phacelia scopulina* var. *submutica* make up the centrum and the indirectly acting components comprise the web (**Figure 4** and **Figure 5**). Unfortunately, much of the requisite information to make a comprehensive envirogram for *P. scopulina* var. *submutica* is unavailable. These envirograms are constructed to outline some of the major components believed to directly impact the species and also to provide some speculation that can be tested in the field by observation or management manipulation. Some evidence exists for factors in closed boxes. Factors in dashed boxes are more speculative. Dashed crossed lines indicate that the interaction is speculated. Precipitation, specifically soil moisture, has frequently been cited as the reason for variable year-to-year abundance. Soil temperatures or

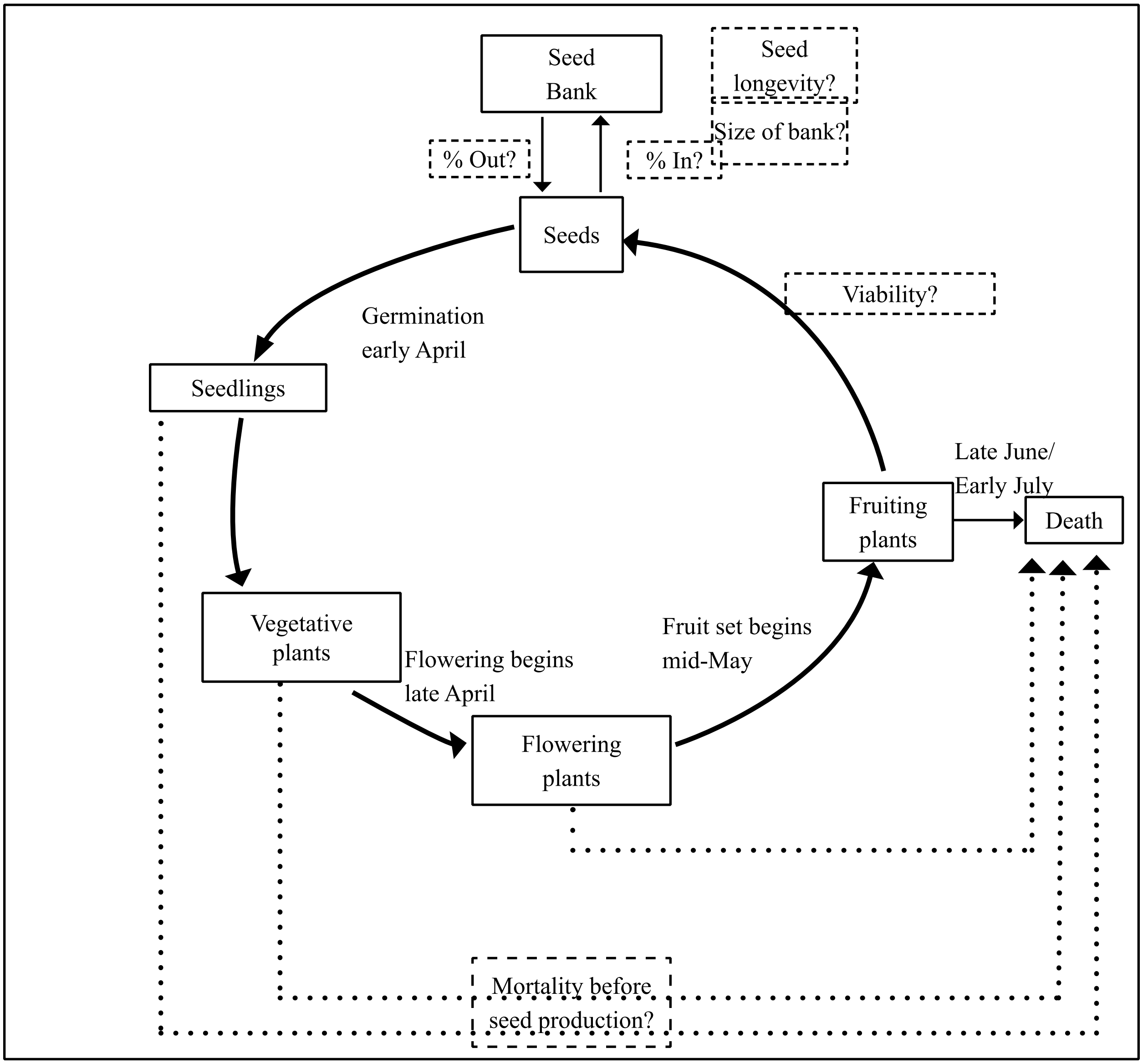

Figure 3. Simple life-cycle diagram for *Phacelia scopulina* var. *submutica*.

the interaction between soil temperature and moisture may also be a significant factor. The soil properties, both physical and chemical, to which *P. scopulina* var. *submutica* is adapted, are unique. Malentities will be discussed in the following Threats section.

CONSERVATION

Threats

Current evidence suggests that this species is particularly vulnerable to habitat destruction and loss because of its restricted habitat requirements. Any elimination of potential habitat would likely have a negative long-term impact, because this species is restricted by geology and cannot extend beyond a limited habitat type.

In general, all activities leading to substantial soil disturbance are potential threats to *Phacelia scopulina* var. *submutica*. Disturbance alters soil structure, which is likely important to a species that has evolved to colonize a substrate with specific and unique properties (see Demography section). In addition, although no information is available specifically for *P. scopulina* var. *submutica*, seeds in desert soils are generally distributed near the ground surface, and seeds below 7 cm of the surface are considered lost from the seed bank (Kemp 1989). The seed bank appears to be critical to the survival of this species. The detrimental effects of

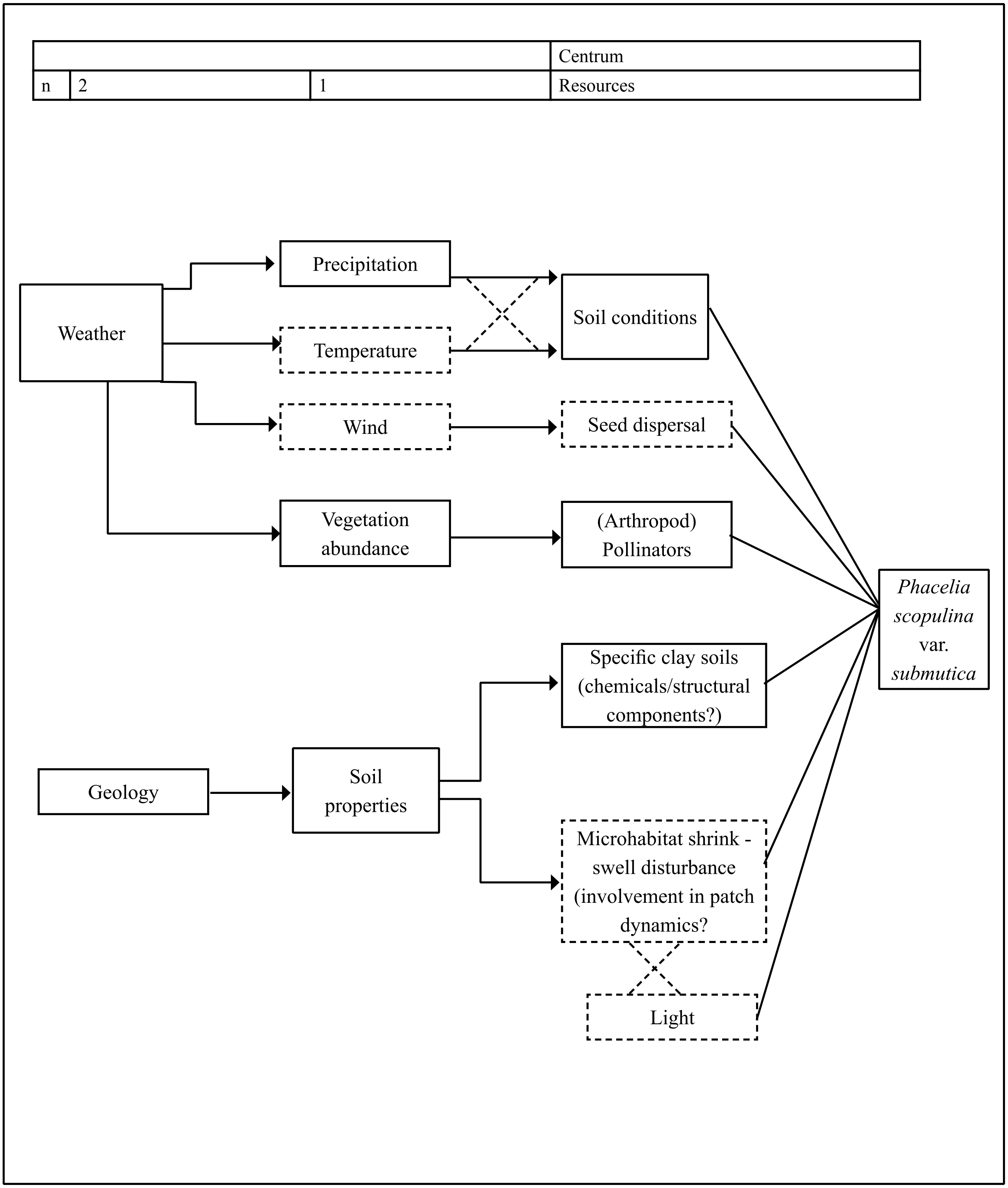

Figure 4. Envirogram illustrating some of the resources of *Phacelia scopulina* var. *submutica*.

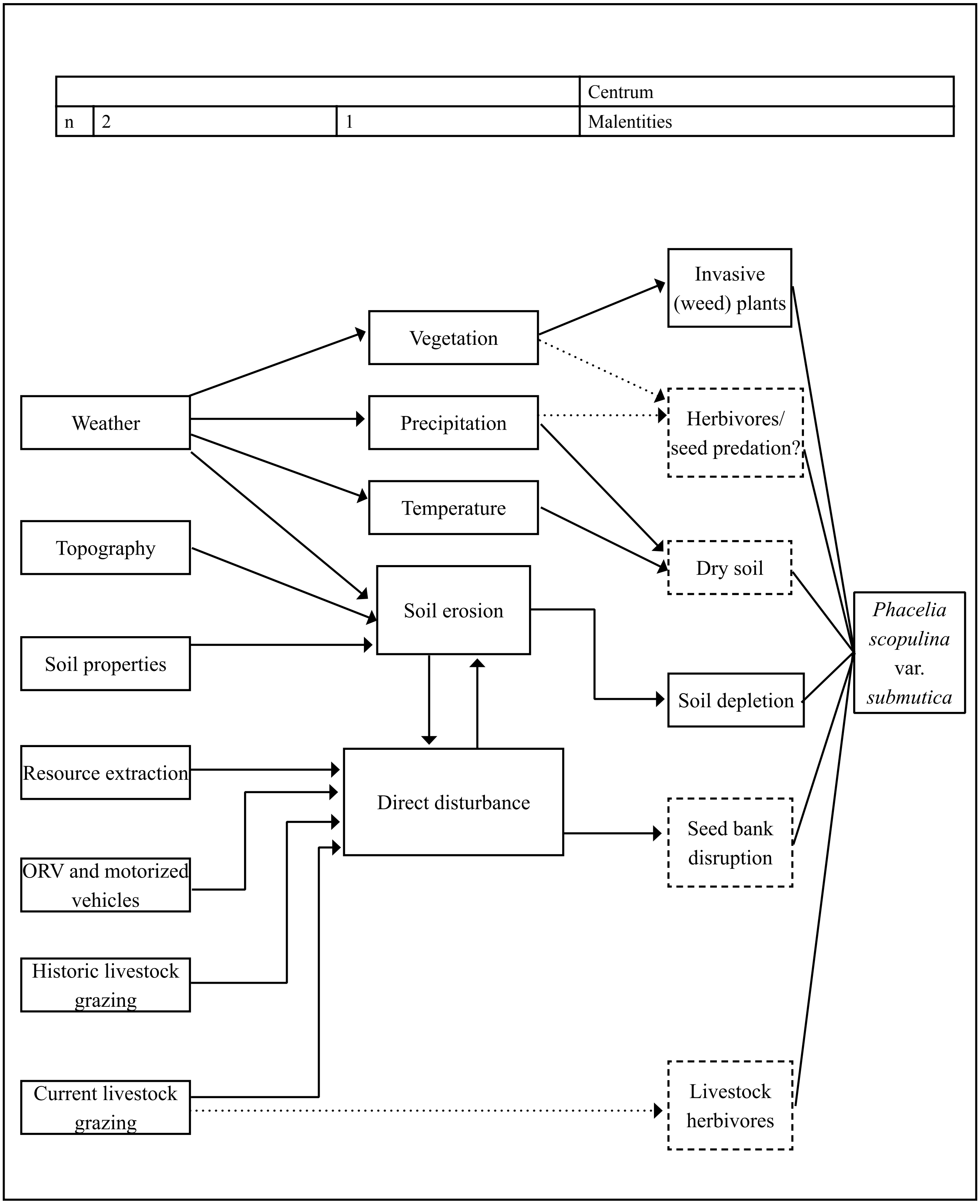

Figure 5. Envirogram illustrating some of the malentities of *Phacelia scopulina* var. *submutica*.

off-road vehicle traffic have frequently been reported (O'Kane 1987, Burt and Spackman 1995, Colorado Natural Heritage Program 2002). Road building and maintenance have also impacted populations in the past, for example on Highway 17.

The increase in resource extraction activity is probably the most imminent threat to rare plant populations in the Piceance Basin (Scheck personal communication 2002). The badland habitat of *Phacelia scopulina* var. *submutica* is on substantial oil and gas reserves (Hinaman and Hudson 1976). Although oil shale development is not yet economically feasible on lands occupied by *P. scopulina* var. *submutica*, natural gas deposits are currently being exploited (Scheck personal communication 2002). Natural gas is an important cornerstone of President Bush's National Energy Policy, and the natural gas reserves of the Rocky Mountain states can be developed more economically and more quickly than other deep reservoir onshore gas or deepwater offshore gas reserves (Watson 2002). Of the BLM land that is occupied by *P. scopulina* var. *submutica* more than 90 percent can be potentially leased for resource development although there may be some leasing stipulations within that area (Bureau of Land Management 1987, Bureau of Land Management 1999). However, some provisions of the proposed energy policy aim at reducing such stipulations. Throughout the Uinta and Piceance basins, 80 percent of federally managed land is open to resource development (Bureau of Land Management et al. 2002).

The U.S. Geological Service estimated more than 5 trillion cubic feet of gas is undiscovered in the Piceance Basin (USGS Uinta-Piceance Assessment Team 2002). The time it will take to extract this quantity depends upon several variables, including allowable well density and the degree to which companies pursue extraction. An area immediately adjacent to known *Phacelia scopulina* var. *submutica* populations is one of the largest, if not the largest, natural gas producing areas in Colorado (Scheck personal communication 2002). This region appears to have soil conditions and suitable habitat for *P. scopulina* var. *submutica*, but there is no information as to whether plants grow there. This gas field is currently being developed at 20-acre (downhole) spacing, but there is a pilot project in the area testing the use of 10-acre spacing. Early indications are that 10-acre spacing will prove more effective at extracting the maximum amount of gas reserves (Scheck personal communication 2002). A denser well spacing also leads to an increase in incidental impacts, such as more informal vehicle turn-sites. Therefore, the most significant foreseeable threats are the activities associated with oil and gas development, such as road building, pipe installation, pad construction, and the installation of associated buildings and holding tanks (Smith personal communication 2002). Historically, well sites have been placed on valley bottoms, and *P. scopulina* var. *submutica* is generally found on slopes (Burt and Spackman 1995), but new technology and more aggressive exploration could potentially change that situation. The impacts of oil and gas developments on the hydrology of *P. submutica* habitat have not been investigated.

The habitat of *Phacelia scopulina* var. *submutica* seems unlikely to appeal to livestock. Considering the low vegetation cover, livestock are more likely to pass through the areas in search of more abundant forage. However, herbivory is only one consequence of livestock grazing. Livestock trample and compact soils, and the soils of *P. scopulina* var. *submutica* are highly erodible. There is some observational evidence that suggests livestock grazing poses a threat. One population of *P. scopulina* var. *submutica* existed on a slope with a fence running down the middle. Soil, slope, exposure, and species composition were identical on either side of the fence, except for the presence of *P. scopulina* var. *submutica*. No plants were observed on the side that was used by livestock, while there were at least 2,500 individuals on the ungrazed side (O'Kane 1987). It can be speculated that direct soil disturbance, soil compaction, herbivory, or a change of soil properties such as increased nitrogen and other minerals may all have contributed to the difference. The effects of other herbivores, predators, pests, and disease have not been observed.

The observation that *Phacelia scopulina* var. *submutica* grows where other vegetation is sparse suggests that it may not be able to tolerate aggressive fast growing species. Aggressive species of *Lepidium* (species unreported), annual *Chenopodium*, and invasive non-native weeds such as *Lappula* species, *Bromus tectorum* (cheatgrass), and *Malcomia africana* (African mustard) have been observed in regions of potential habitat and may be a threat. It is likely that disturbance is necessary before such species can become established on the dark-gray soils, but they may be able to invade the more hospitable brown soils quite readily. Thistles have also been observed at some of the occurrences. The significance of the potential threat they pose is unclear because the specific species of thistle was not noted. The noxious weed, *Cirsium arvense* (Canada thistle), is common within the range of *P. scopulina* var. *submutica* (Baker 1981, Zimdahl 1998).

Habitat modification, rather than direct competition, is another concern associated with weed invasion. Weeds such as *Bromus tectorum* can alter the frequency at which a site will experience fire. Other weed species exhibit allelopathy and essentially poison the soil to reduce competitors. Herbicide use, especially to clear roadsides, has been identified as a potential problem at one occurrence (Burt and Spackman 1995).

The effects of climate change are not obvious for this particular species. In the last 100 years the average temperature in Fort Collins, Colorado has increased 4.1°F, and precipitation has decreased by approximately 5 percent in the Grand Junction area although the decrease has been up to 20 percent in other parts of the state (U.S. Environmental Protection Agency 1997). Based on projections made by the Intergovernmental Panel on Climate Change and results from the United Kingdom Hadley Centre's climate model (HadCM2), by 2100 temperatures in Colorado could increase 3 to 4°F in the spring and fall (range 1 to 8°F) and 5 to 6°F in the summer and winter (range of 2 to 12°F). HadCM2 is a model that accounts for both greenhouse gases and aerosols. As a minimum winter temperature may be required for successful seed germination (Baskin and Baskin 1989), a warming trend suggests that there exists the potential for depression of seed germination. However, because *Phacelia scopulina* var. *submutica* appears to be adapted to unstable weather patterns, it may fare relatively well in a changing climate.

Threats on land managed by the USFS appear to be low at the current time. The White River National Forest Management Plan was revised in 2002, and the area in which *Phacelia scopulina* var. *submutica* occurs on that forest is proposed as the Lower Battlement Mesa Research Natural Area (see Existing Regulatory Mechanisms, Management Plans, and Conservation Strategies section).

Conservation Status of the Species in Region 2

Phacelia scopulina var. *submutica* grows on land owned and managed by the USFS, BLM, and several private individuals and corporations. It is restricted to a particular geologic formation and fairly limited habitat conditions. Observations that have been made on several populations over the last two decades indicate a decline in abundance. However, the observed trend may be due to the sporadic nature of data collection and the very variable temporal abundance of the species that appears strongly influenced by environmental conditions. Private landowners are unlikely to be aware of *P. scopulina* var. *submutica*, because it has no legally binding status. The U.S. Fish and Wildlife Service have designated it as a candidate species for listing, and both the USFS and BLM personnel currently consider it in management plans.

A small part of *Phacelia scopulina* var. *submutica*'s range has been simultaneously designated a Colorado Natural Areas Program Natural Area and a BLM Area of Critical Environmental Concern. Another population is partially within the proposed Lower Battlement Mesa Research Natural Area on the White River National Forest. These land use designations afford some level of protection from impacts of resource extraction and other anthropogenic activities (see Management section). Additional areas where it would receive protection are desirable. Establishing formal protection for the population(s) on the White River National Forest would have particularly high conservation value in maintaining genetic diversity of the species; the site is relatively far from the currently protected area (Pyramid Rock ACEC) and is separated by substantial barriers to interaction, namely the Colorado River and Highway 6. A criticism of the White River National Forest population may be that it is a relatively small population and as such may be genetically depauperate as a result of changes in gene frequencies due to inbreeding, or founder effects (Menges1991). However, this observation is only a generalization, and the value of small populations in maintaining genetic diversity should not be belittled. For example, alleles that were absent in larger populations were only found in a small population of a rare *Astragalus* (Karron et al. 1988). Therefore, without molecular data on genetic structure, in order to conserve genetic variability it is as important to conserve as many geographically separated populations as possible and remain aware that "larger" is not necessarily "better".

U.S. Forest Service and BLM land managers work with the Colorado Natural Heritage Program to identify sites where plants occur. Both agencies currently require a biological survey for *Phacelia scopulina* var. *submutica* and an evaluation of impact on the population before any project occurs in occupied habitat. Within the last two years, development activities, such as road and pipeline construction, have been relocated several times to avoid known *P. scopulina* var. *submutica* populations on BLM land (Scheck personal communication 2002, Smith personal communication 2002). Monitoring and inventory programs have been relatively few and vary between management districts depending upon the resources available in any given year.

Management of the Species in Region 2

Implications and potential conservation elements

The populations under USFS Region 2 jurisdiction are now included within the proposed Lower Battlement Mesa Research Natural Area (see Existing Regulatory Mechanisms, Management Plans, and Conservation Strategies section). During the RNA evaluation process and when the RNA is established, livestock grazing, mechanized recreation activities, and resource extraction would be restricted. Under these conditions, long term (two decades or more), non-project related monitoring of populations would prove very valuable in determining the spatial dynamics and the natural temporal variability in population size.

The primary past and present land uses of *Phacelia scopulina* var. *submutica* habitat are livestock grazing and resource extraction activities. Recreation pressures, including off-road vehicle traffic, may become more important as human population increases in areas within easy access of *P. scopulina* var. *submutica* habitat. A frequent observation has been made that resource extraction efforts are compatible with sustainable populations of *P. scopulina* var. *submutica* because the development activity is located on the basin floor and occurrences occur on the slopes (O'Kane 1987). This fact may be critical to consider when developing management plans.

Some disturbance may be tolerated, but the impact will be critically dependent upon the condition of the seed bank, the condition of *Phacelia scopulina* var. *submutica* populations in the vicinity that may act as a seed source, and the resultant soil condition. The seed bank condition refers to the proportion of *Phacelia* seeds in relation to other invasive or weedy species, as well as seed position with respect to germination requirement and soil structure. Disturbance affects soil structure, and there is no information as to what conditions *P. scopulina* var. *submutica* needs. With this type of habitat specialist, any loss of soil structure and properties may be very detrimental to long-term sustainability.

Tools and practices

Species inventory. Inventory activity has been irregular over the last two decades. *Phacelia scopulina* var. *submutica* received considerable attention in 1986, during which time the range of the species was more clearly understood. Inventory records that include the numbers of individuals, the area they occupy, their spatial distribution within potential habitat, and the extent of potential unoccupied habitat are the most useful for future comparisons. Life stage at the date of the survey and details of the habitat also provide important information for comparative studies within and between years. Specific geographic information on where the plants occur provides the means for precisely relocating occurrences. With the advent of low cost global positioning systems such information is easier to provide. *Phacelia scopulina* var. *submutica* populations are understood to be spatially dynamic, and therefore occurrences may need to be extended beyond original boundaries in subsequent years, rather than the number of occurrences being increased (Burt and Spackman 1995). Inventories need to be conducted when the plants are flowering.

Habitat inventory. There has been little inventory, *per se*, of habitat. Generally when habitat is found but no plants are observed, the survey is not recorded. *Grindelia fastigiata* and *Eriogonum gordonii* are frequently associated with *Phacelia scopulina* var. *submutica* and have been dubbed "indicator species". However, some botanists have specifically stated in occurrence records (Colorado Natural Heritage Program 2002) that *G. fastigiata* and *E. gordonii* have not been observed with *P. scopulina* var. *submutica*, and so reliance on associated species to identify potential habitat would be misleading.

Population monitoring. Several occurrence sites have been visited more than once, and some have been visited multiple times over successive years. However, it is often unclear whether the same site was visited or whether the occurrence is approximately located within the section, except in the case of sites at Pyramid Rock ACEC, which have been mapped. Thus there is no way to judge the spatial dynamics of this species, which may be very important when considering future management alternatives. This species is temporally and, apparently, spatially dynamic, and although permanent plots are very valuable for collecting specific demographic data, there is a high probability that problems associated with autocorrelation will occur (Goldsmith 1991). A transect that encompasses both occupied and unoccupied suitable habitat in the year it is established would likely be able to detect changes that a fixed plot design would miss (Elzinga et al. 1998, Goldsmith 1991). Fixed plot designs fail to reveal boundary changes. Measurements of population size are important. Purely recording the presence or absence of individuals at an occurrence will not permit detection of changes in population size over time, and thus potential vulnerability cannot be evaluated. Current understanding suggests that populations with the highest numbers of individuals are most robust against stochasticity. When the biology and ecology of this species is further understood, there may be other parameters on which to evaluate sustainability.

When populations are monitored, habitat conditions should be carefully recorded. Monitoring populations is the only way to determine the effects of management practices, which are frequently reflected in the condition of the soils and associated species. Furthermore, the monitoring duration should be sufficient to identify underlying trends in the presence of normal year-to-year variability. Where possible, current management practices or development projects should be recorded, even if there is no evidence of the activity at the time of the survey. For example, information on livestock stocking rate or the location of an existing pipeline installation may be useful in interpreting biological observations made several years after the activity or event. Establishing photo points and taking appropriate photographs are very helpful in describing site conditions. Even though digital copies are convenient and easy to store, many museums and researchers suggest storing additional slides or even hardcopies, as in 50 years time the technology to read memory sticks and CDs may no longer be available.

Habitat monitoring. Habitat for this species is defined as barren and near barren soils of two particular geologic formations. Although precise habitat requirements may not be known, the existing general characterization permits habitat monitoring in the absence of plants. The extent of invasive, exotic species or aggressive native species is an important factor in considering the relative condition of potential habitat. However, the frequency at which colonization of isolated patches of potential habitat occurs is unknown. Occurrences appear to be spatially dynamic, but seed dispersal appears limited and plants may only slowly move into unoccupied habitat. Unfortunately, if habitat is not occupied at the start of the monitoring period, the effects of management decisions cannot be effectively evaluated. If unoccupied land that becomes weedy or disturbed by livestock does not become colonized, it may have little to do with the weeds or the livestock but may be a function of inappropriate microsite characteristics. Alternatively, if plants are observed at a site, it is clear that the site is capable of supporting the taxon and comparisons with the original population may be made. Habitat monitoring *per se* is likely to be most effective if the goal is to detect changes in vegetation cover, weed density, or physical parameters such as soil erosion.

Information Need

Much more needs to be known about the population dynamics and vulnerability to disturbance of *Phacelia scopulina* var. *submutica*. These questions should be a priority, as their answers will determine appropriate management strategies. The temporal variability in population size makes it very difficult to evaluate different management strategies within a time frame that is consistent with short-term goals. Monitoring known occurrence sites at the appropriate time over consecutive years and recording information on environmental conditions (temperature, precipitation, soil moisture) in conjunction with further inventory would substantially contribute to understanding the significance of the trends currently observed. Even though precipitation appears to be a likely cause of the temporal variation in population size, this supposition has not been rigorously tested. The correlations between population size, seed set, and local climate conditions (especially precipitation and temperature) are critical to understanding population trends. The relationship between climate and population size may be evaluated to a limited extent with the information available but was beyond the scope of this report.

It is also important to understand the associations between relatively small and isolated occurrences. Analysis of the genetic structure of the different metapopulations (see Demography section) would be very useful in determining which populations have the highest conservation value. A study of the patch dynamics of the area in which *Phacelia scopulina* var. *submutica* occurs may reveal how occurrences relate to surrounding vegetation types and how disturbances affect distribution at the local level. Disturbance may be thought of as the natural shrink-swell cracks of the soil, as well as gross disturbances of the soil surface. Determinations of seed longevity, seasonal mortality, and other components of minimum viable population size (Menges 1991), as well as its reproductive mechanism would be valuable in further evaluating the vulnerability of this species.

Information needs may be summarized thus:

❖ Conduct documented, formal monitoring studies of defined occurrence sites. These will clarify the population dynamics and the taxon’s vulnerability to disturbance.

- Conduct surveys in order to inventory populations in areas with appropriate geological formations. These will further clarify the rarity and habitat requirements of the taxon.

- Conduct studies on demography and reproductive biology. These will clarify the vulnerability of individuals and populations to environmental, demographic, and genetic uncertainties as well as to specific management practices.

DEFINITIONS

Allelopathy. The release into the environment of a chemical substance that negatively impacts the germination or growth of another organism (Allaby1992).

Calyx. The outer series of the perianth, used especially when it differs in size, shape, or color from the inner petals (Harrington and Durrell 1979).

Capsule. A dry, dehiscent fruit made up of more than one carpel (Harrington and Durrell 1979).

Rank. Global rank. NatureServe considers *Phacelia scopulina* var. *submutica* a variety of *Phacelia scopulina* and assigns it a rank of "G4T2". "G4" refers to *Phacelia scopulina* and indicates this species is "apparently secure globally though it may be quite rare in parts of its range, especially at the periphery".

"T2" refers specifically to the variety *submutica*, and indicates the species is "imperiled globally because of rarity (6-20 occurrences), or because of other factors demonstrably making it very vulnerable to extinction throughout its range (endangered throughout its range)".

State rank (Subnation). "S2" (Colorado Natural Heritage Program 2000) means that *Phacelia scopulina* var. *submutica* is imperiled within the state of Colorado because of rarity (6-20 occurrences), or because of other factors demonstrably making it very vulnerable to extirpation from the state.

Ruderal. A plant that colonizes waste ground (Allaby 1992).

Section. According to taxonomic principles, a genus can be divided into sections and sometimes further into sub-sections.

Style. Part of the female reproductive organs of the flower. The (usually) stalk-like part of a pistil connecting the ovary to the stigma (Harrington and Durrell 1979).

Succession. "The sequential change in vegetation either in response to an environmental change or induced by the intrinsic properties of the plants them selves. Classically, the term refers to the colonization of a new physical environment by a series of vegetation communities until the final equilibrium state, the climax, is achieved" (Allaby 1992).

Commonly Used Synonyms of Plant Species

Commonly used synonyms of plant species (Kartesz 1994) mentioned in this report.

Ceratocephala testiculata (Crantz) Roth	*Ranunculus testiculatus* Crantz
Elymus elymoides (Raf.) Swezey	*Sitanion hystrix* (Nutt.) J.J. Sm.
Juniperus osteosperma (Torr.) Little	*Sabina osteosperma* (Torrey) Antoine
Oryzopsis hymenoides (Roemer & J.A. Schultes) Ricker ex Piper	*Stipa hymenoides* Roemer & J.A. Schultes

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