# Arizona Cliffrose

*(Purshia subintegra)*

# Recovery Plan


**U.S. Fish and Wildlife Service**
**Phoenix, Arizona**

**1995**

# ARIZONA CLIFFROSE (*Purshia subintegra*)

# RECOVERY PLAN


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## ACKNOWLEDGEMENTS

Thanks to Dr. James Henrickson, who provided his expertise on the genus and species, and to Robert A. Johnson for his expertise on insect ecology.

## EXECUTIVE SUMMARY

Current Status: Four distinct populations of Arizona cliffrose, listed as endangered in 1984, exist along a 322 kilometer (km) (200 mile) wide area of central Arizona. The number of plants in each population is unquantified.

Habitat Requirements and Limiting Factors: Arizona cliffrose occurs in the Sonoran desertscrub where the winters are mild, summers are hot, and the 22.9-86 centimeters (cm) (9-34 inches) of rainfall is evenly distributed between summer and winter rainfall periods. The species occurs only on limestone formed from Tertiary lakebed deposits. Threats include livestock and burro grating, poor reproduction, mineral exploration and development, construction and maintenance of roads and utility corridors, recreation, off-road vehicle (ORV) use, urbanization, pesticides, and inundation.

Recovery Objective: Reclassification to threatened.

Recovery Criteria: Maintenance of four viable populations, protection of sufficient quantity and quality of habitat needed to support viable populations, regulatory mechanisms or written land management commitments that provide for long-term protection, and determination that the species no longer is endangered.

Actions Needed:
1. Produce management plans for four recovery units.
2. Conduct research needed to guide recovery efforts.
3. Eliminate or minimize threats.
4. Enforce and apply existing laws and regulations.
5. Inform and educate.

Costs (Thousands of dollars):

| Year | Need 1 | Need 2 | Need 3 | Need 4 | Need 5 | Row Total |
|---|---|---|---|---|---|---|
| 1994 | 35.0 | 179.0 179.0 | 74.0 | 23.0 | 1.0 | 307.0 |
| 1995 | 33.5 | 139.0 | 29.5 | 53:o | 1.0 | 256.0 |
| 1996 | 0 | 106.0 | 25.5 | 3.0 | 1.0 | 135.5 |
| 1997 | 0 | 74.0 | 17.0 | 3.0 | 1.0 | 95.0 |
| 1998 | 0 | 74.0 | 17.0 | 3.0 | 1.0 | 95.0 |
| 1999 | 0 | 74.0 | 17.0 | 3.0 | 1.0 | 95.0 |
| 2000 | 0 | 74.0 | 17.0 | 3.0 | 1.0 | 95.0 |
| 2001 | 0 | 74.0 | 17.0 | 3.0 | 1.0 | 95.0 |
| 2002 | 0 | 74.0 | 17.0 | 3.0 | 1.0 | 95.0 |
| 2003-2008 | 0 | 449.0 | 102.0 | 18.0 | 6.0 | 570.0 |
| Recovery Cost | 68.5 | 1312.0 | 333.0 | 115.0 | 15.0 | 1843.5 |

Date of Recovery: If continuous progress is made, downlisting may be possible by 2008.

# TABLE OF CONTENTS

Page

DISCLAIMER . . . . . i
ACKNOWLEDGEMENTS . . . . . i
EXECUTIVE SUMMARY . . . . . ii
TABLE OF CONTENTS . . . . . iii
PART I - INTRODUCTION . . . . . 1
Brief Overview . . . . . 1
Description . . . . . 3
Taxonomy and Evolutionary History . . . . . 8
Evolutionary History . . . . . 11
Range and Distribution . . . . . 13
Ecology . . . . . 20
Associated Species . . . . . 20
Soils . . . . . 21
Climate . . . . . 24
Pollination Biology . . . . . 24
Phenology . . . . . 25
Life History and Population Dynamics . . . . . 26
Miscellaneous General Biology . . . . . 28
Land Management/Ownership . . . . . 29
Management Issues and Concerns . . . . . 30
Urbanization . . . . . 30
Mineral Exploration and Development . . . . . 31
Cattle and Feral Burro Browsing Effects . . . . . 32
Grazing Management Systems . . . . . 33
Cottonwood Population . . . . . 33
Burro Creek Population . . . . . 34
Horseshoe Dam Population . . . . . 35

Bylas Population . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 36
Roads and Utilities . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 36
Recreation . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 38
Limitation of Pollinators . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 40
Control of Insect Pests . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 40
Herbicides . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 42
Inundation . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 42
Federal Land Management Plans . . . . . . . . . . . . . . . . . . . . . . . . . . 43
Kingman Resource Area Management Plan . . . . . . . . . . . . . . . . . 43
Tonto National Forest Plan . . . . . . . . . . . . . . . . . . . . . . . . . . 45
Coconino National Forest Plan . . . . . . . . . . . . . . . . . . . . . . . . . . 46
Legal Protections . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 46
Research and Conservation Efforts . . . . . . . . . . . . . . . . . . . . . . . . 48
PART II - RECOVERY . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 50
Recovery Objective . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 50
Recovery Units . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 50
Recovery Criteria . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 52
Outline of Recovery Actions . . . . . . . . . . . . . . . . . . . . . . . . . . 54
Literature Cited . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 74
PART III - IMPLEMENTATION SCHEDULE. . . . . . . . . . . . . . . . . . . . . . . . 85
Task Priorities . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 85
Responsible Party Abbreviations . . . . . . . . . . . . . . . . . . . . . . . . 86
Tables . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 87
APPENDIX - Comments and Responses

# PART I - INTRODUCTION

## Brief Overview

The U.S. Fish and Wildlife Service (Service) added *Purshia subintegra* (Kearney) Henrickson (Arizona cliffrose) to the endangered species list on May 29, 1984 (U.S. Fish and Wildlife Service 1984). The scientific name of the species was then *Cowania subintegra.* Arizona cliffrose is known from four disjunct populations on the northern edge of the Sonoran Desert (Figure 1). These populations occur along the sub-Mogollon region of central Arizona over a distance of 200 miles. For thirty years the species was only known from the type locality near Burro Creek, Mohave County. In September 1968, a second population was discovered near Bylas, Graham County (Pinkava et *al.* 1970). In 1984 and 1985 two additional population areas were discovered near Cottonwood, Yavapai County, and near Horseshoe Lake, Maricopa and Yavapai Counties.

Arizona cliffrose is a rare Arizona edaphic endemic, restricted to nutrient deficient calcareous soils (Anderson 1986, Anderson 1993). The disjunct distribution of this species is unique. No other plant species occurs only in the same four sites as Arizona cliffrose.

Each population of Arizona cliffrose has unique biological/ecological characteristics and threats. Threats to the species include livestock, and burro grazing, mineral exploration and development, construction and maintenance of roads and utility rights-of-way, recreation, poor reproduction, off-road vehicle (ORV) use, urbanization, pesticides, and inundation. The relative importance of each of these threats varies from population to population. This recovery plan will treat each population as an individual recovery unit necessary for the survival and recovery of the species and address threats specific to those populations.

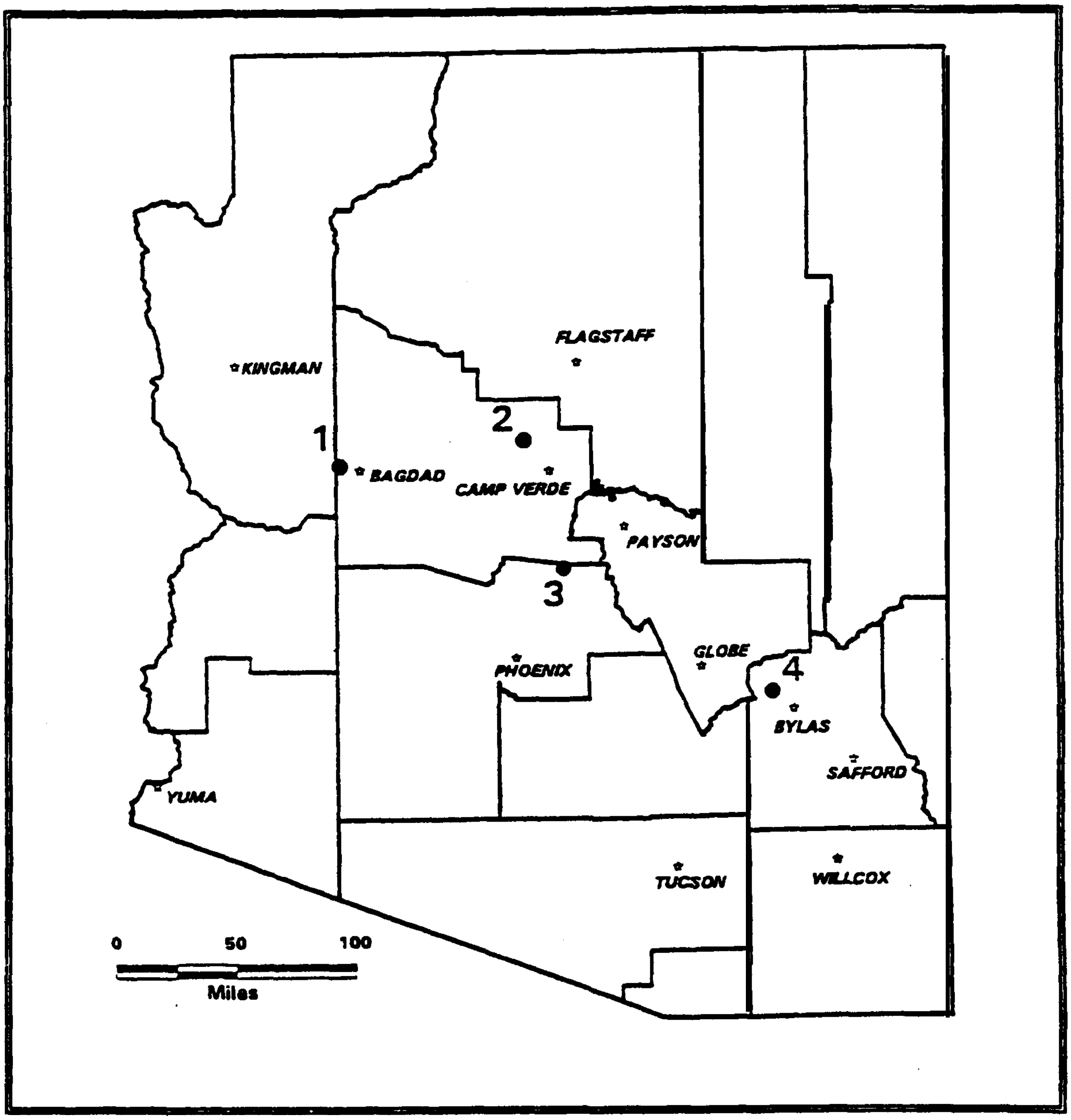


Figure 1. Map of Arizona showing location of Arizona cliffrose populations. 1 = Burro Creek; 2 = Cottonwood; 3 = Horseshoe Lake; and 4 = Bylas.

## Description

The following description of *P. subintegra* represents a composite of the original description (Kearney 1943), recent field and taxonomic work, combined with an understanding of its ecology and hypothesized evolutionary history. *P. subintegra* has certain definitive characteristics that separate it from other *Purshia* species. However, individual variation in leaf size and shape, glandularity, and other characters may occur. In this way, *P. subintegra* is no different from many other plant species that display some amount of genotypic and phenotypic variability.

Arizona cliffrose is a member of the Rose Family (Rosaceae). It is a low, straggling woody perennial usually 1 - 2 meters (m) (3 - 6 feet) high and generally wider than tall. In the Cottonwood population, plants can reach a maximum of 2.4 m (8 feet) tall and 3.7 m (12 feet) in diameter. The horizontal lower branches are spreading, and the central branches are irregularly ascending (Denham and Fobes 1992b). New shoots tend to be red-brown and pubescent with a red dot below the fascicle. The older branches have light gray bark that becomes shreddy. The herbage is not viscid (sticky), although some resin glands may be present, causing slight stickiness.

The shape of *Purshia subintegra* leaves is variable. The leaves are very narrow and short: averaging about 8 millimeters (mm) (0.3 inch) long (Denham and Fobes 1992b) and 3 mm (0.1 inch) wide. Leaves usually have no lobes, but occasionally have 1 or 2 rounded, shallow lobes or teeth just below the leaf tip (Figure 2 and 3A). The margins (edges) of the leaves are curled towards the underside (revolute). The upper leaf surface is bright or dark green and usually has no punctate glands. The upper leaf surface is usually loosely arachnoid-pubescent (having a few long hairs) on the upper surface (Figure 3A), but

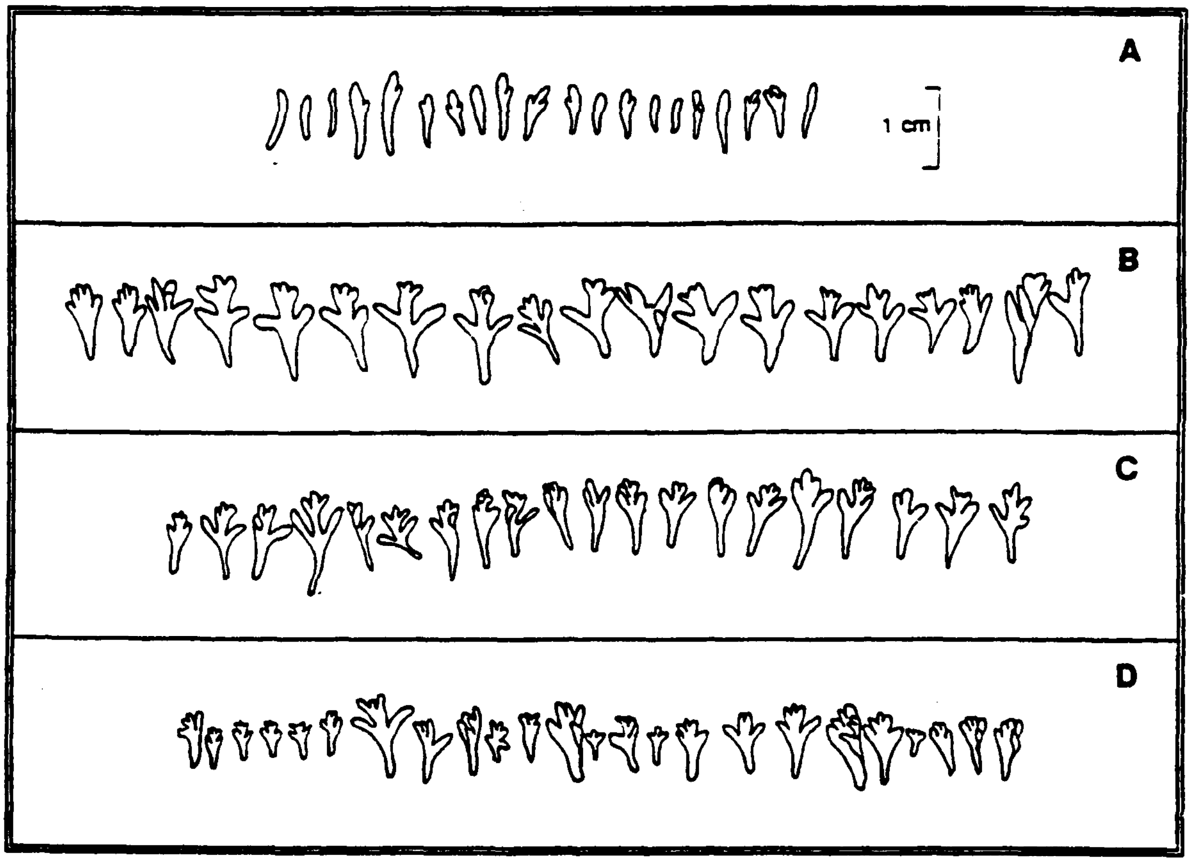


Figure *2.* Leaf shapes of a typical ***Purshia subintegm*** (A), a representative Tonto Basin form of ***P. stansburiana*** (B), a representative Verde Valley form of ***P. stansburiana*** (C), and a standard form ***P. stansburiana*** **(D)** (Reichenbacher 1993).

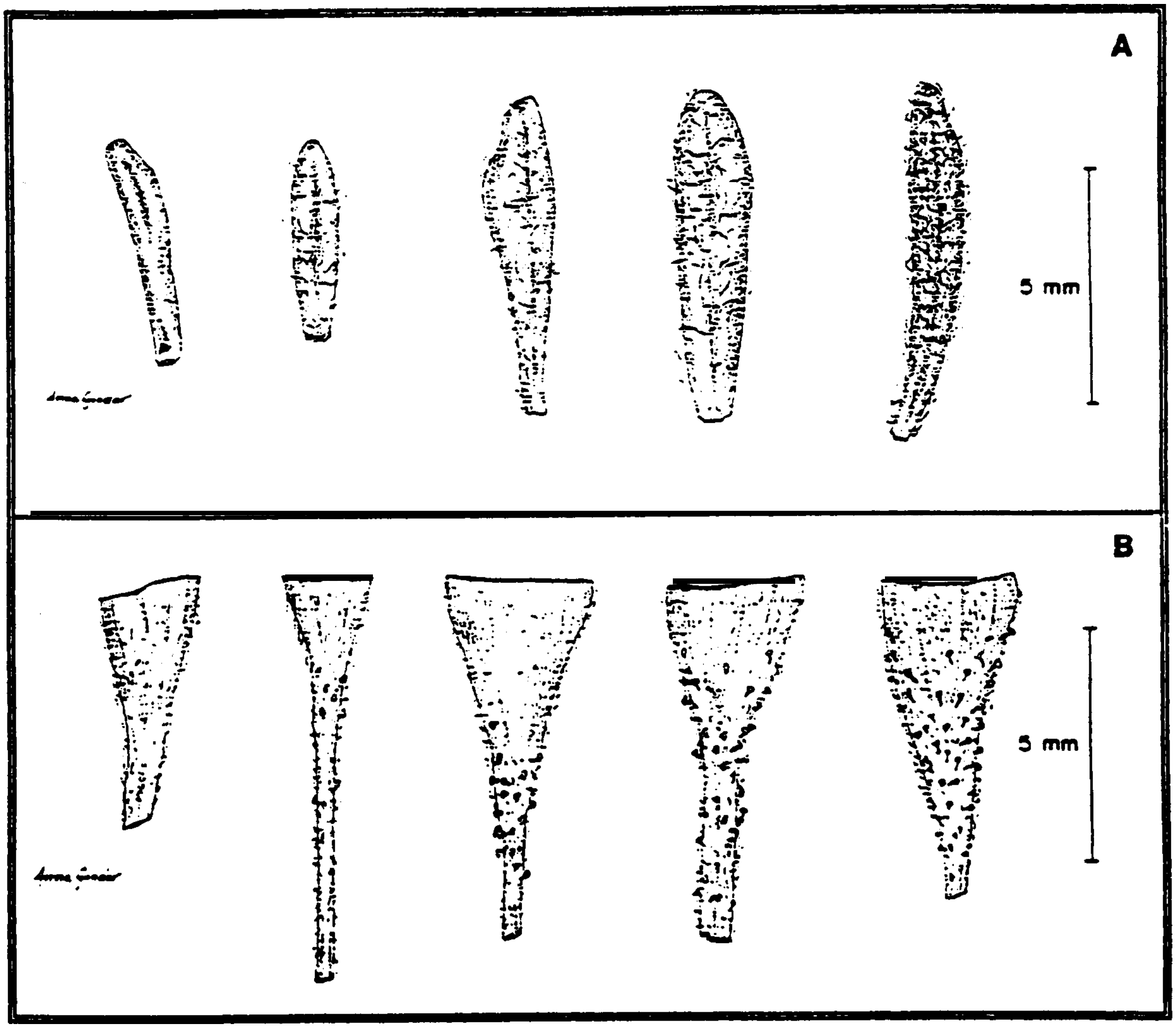


Figure *3.* (A) ***Purshia subintegra*** leaves showing variability in pubescence of upper leaf *surface.* **(B)** Representative ***Purshia subintegra*** hypanthia, including peduncles (flower stalks) (Reichenbacher 1993).

sometimes it is hairless. The lower surface is densely white-lanate (wooly) and usually has no punctate glands.

Each flower is born on a single stalk (peduncle). The end of the peduncle gradually merges with the beginning of the narrowly funnelform hypanthium, the flower part bearing the sepals, petals, and stamens. The average length of the hypanthium plus peduncle is 5.1 mm (< 0.3 inch) (Reichenbacher 1993). The hypanthium has no stipitate (stalked) glands or has few glands. The typical flower has 3 - 7 pistils and 5 white or pale yellow petals that are about 10 mm (0.4 inch) long, slightly smaller than *P. stansburiana* flowers. Occasionally, flowers have 8 - 12 petals per flower (Denham and Fobes 1992a). As the achenes (fruits) develop, the style remains attached and forms a short, white, feathery plume.

It is usually easy to distinguish *Purshia subinfegra* from *P. stansburiana.* In contrast to *P. subintegra, P. stansburiana* is a tall, erect shrub up to 7.6 m (25 feet), with numerous punctate glands on all leaves and numerous stipitate glands on new growth and hypanthia (Figure 3B) (Denham and Fobes 1992e). These glands secrete copious amounts of sticky, strong-smelling fluid, imparting a distinctive odor and touch to the plants. Some forms of *P. stansburiana* have no glands on the leaves. The hairless leaves have 3 - 5 deep lobes and tend to be folded along the midvein (conduplicate). New growth of branches tends to be bright red. For a comparison of some of the morphological characters of *P. subintegra* and *P. stansburiana,* see Table 1.

The genus *Purshia* contains seven extant species, including five recently transferred from *Cowania* by Henrickson (1986). These species range from central Mexico to western Colorado, northern Utah, and eastern California

| Group | Punctate, Resinous Leaf Glands | Number of Leaf Lobes | Hypanthium Length (average) | Geographic Locality |
|---|---|---|---|---|
| Purshia subintegra | Absent or few | Usually no lobes, sometimes 1-2 | 5.1 mm | Burro Creek, Verde Valley, Horseshoe Lake, Bylas |
| Purshia stansburiana (Verde Valley form) | Usually present | 3-5 lobes | 9.2 mm | Verde Valley |
| Purshia stansburiana (Tonto Basin form) | Usually absent | 3-5 lobes | 10.1 mm | Tonto Basin & various |
| Purshia stansburiana (common form) | Present | 3-5 lobes | 6.6 mm | Southwestern U.S. |

Table 1. Comparison of distinguishing characters of *Purshia subintegra, P. stansburiana,* and *P. stansburiana* in the Verde Valley and Tonto Basin. Hypanthium length was measured as the length of the peduncle plus the length of the hypanthium (Reichenbacher 1993).

(Anderson 1986). The chromosome counts of all *Purshia* species are $n = 9$, one of the base numbers of the Rosaceae (McArthur et *al.* 1983, Baker et *al.* 1984, McArthur and Sanderson 1985).

Plants of the genus *Purshia* tend to be phenotypically plastic and can respond to long-term and seasonal changes in climate by producing leaves and shoots that have adapted to local or seasonal climatic conditions. This plasticity can explain some puzzling differences in leaf or shoot forms found on the same plant or on different plants within the same population. In particular, seedlings and plant growth that occurs during or after above-average rainfall may exhibit variable growth forms.

## Taxonomy and Evolutionary History

From the time of its original description, the variability of *Purshia subintegra* and its similarities with *P. stansburiana* has been acknowledged. The specific epithet *subintegra* translates loosely as “leaf margins not quite entire.” In the type description of *P. subintegra,* Kearney (1943) noted that Arizona cliffrose flowers and fruit “apparently present no characters that are not within the range of variation” of *P. stansburiana.* However, he distinguished the two species by noting that *P. stansburiana* is larger and more erect, with branchlets more stiffly ascending, bark reddish brown or dark grey, the herbage usually very viscid (sticky), and pedicels (flower stalk) and hypanthium usually with stipitate (stalked) glands. He also noted that *P. stansburiana* has much larger leaves that are lobed and nearly always conspicuously punctate (dotted with pitted glands). *P. stansburiana* is a common plant occurring in the mid- to upper-elevation habitats throughout much of Arizona and usually can be clearly differentiated from *P. subintegra.*

The variability of *Purshia subintegra* and *P. stansburiana* sometimes makes it difficult to classify individual plants. This difficulty has interfered with accurately estimating the number of populations and number of plants. Differing interpretations of *P. subintegra* have tended to focus on a few morphological traits: leaf lobing, leaf glandularity, and hypanthium glandularity. *Purshia* populations on white Tertiary-age limestone deposits located at Burro Creek and Bylas have been included by most experts within the definition of *P. subintegra.* However, some people have found some plants in the Verde Valley, Tonto Basin, and a few other areas difficult to classify. Several authors have noted that variability in *P. subintegra* may be the result of hybridization with *P. stansburiana* (Reichenbacher 1986, Phillips *et al.* 1988, Schaak and Morefield 1985, Schaak 1987a, Warrick 1986, Phillips *et al.* 1987, Boucher and Goodwin 1984).

Questions about the hybrid status of *Purshia subintegra* were formalized in two publications (Schaak 1987a, Schaak 1987b). After an examination of *P. subintegra* specimens, Schaak (1987b) determined that ". . . if the variability displayed on the type preparations and observed in central Arizona populations of *P. subintegra* can be attributed to gene exchange between . . . *P. stansburiana* and an unnamed central Arizona *Purshia, P. subintegra* will be given hybrid status and the other putative parent, presently included within *P. subintegra,* will be given specific recognition." In a later publication, Schaak (1987a) decided that the type specimens of *P. subintegra* did represent material of hybrid origin. They contained glandular leaves, glandular hypanthia, and lobed leaves, which he believed were characteristics outside the original description of *P. subintegra.* Based on this definition of the species and his belief that the type specimen was a hybrid, he rejected Kearney's concept of the species, and applied the new name *P. pinkawae* to the *Purshia* plants northwest of Bylas, Graham County. Schaak believed the *Purshia* plants at Burro Creek, Horseshoe Lake, and

Cottonwood were formed via past hybridization between *P. stansburiana* and *P. pinkavae.*

Schaak's interpretation of *P. pinkawae* (Schaak 1987a) was narrowly defined and not widely accepted by the botanical community. His description was more narrowly defined than the type description of *P. subintegra,* which allowed for variability in leaf lobing, More recently, botanists familiar with the species generally agree that *P. subintegra* and *P. stansburiana* are distinct, but a more refined definition of *P. subintegra* would be helpful.

Recent studies have applied objective scientific techniques to resolve these taxonomic questions. Using horizontal starch gel electrophoretic techniques, Phillips *et al.* (1988) examined genetic variation of *P. subintegra* and *P. stansburiana* at 14 loci coding for soluble enzymes. These analyses were inconclusive because although no differences were found for the loci they tested, not all loci were tested.

Reichenbacher (1988) conducted a morphometric analysis of plants from the four known populations of *P. subintegra* and plants that were difficult to assign to either taxa ("unknowns"). This study was later expanded to include more plants of *P. subintegra* and "unknowns" and also included plants representing *P. stansburiana* from several areas around the state (Reichenbacher 1993). His discriminant function and principal component analyses concluded that the Bylas, Burro Creek, Horseshoe Lake, and Cottonwood populations of *Purshia* were *P. subintegra,* containing variability normal for a species with widely disjunct populations. He also found that certain populations, notably in the Verde Valley and Tonto Basin, contained some characters typical of *P. subintegra* and some typical of *P. stansburiana.*

Mount and Logan (1993) analyzed DNA from the same pressed Plant specimens that Reichenbacher measured for the morphometric analysis. He used the random-amplified-polymorphic-DNA (RAPD) marker technique to study genetic variability in these *Purshia* plants. He combined his DNA analysis with Reichenbacher's morphometric data (Reichenbacher 1993) and produced results that support the hypothesis that *P. subintegra* and *P. stansburiana* may have had an evolutionary history that could explain the morphologic variability. Mount and Logan's (1993) findings supported Reichenbacher's (1993) hypothesis that the Burro Creek, Bylas, Horseshoe Lake, and Cottonwood populations are *P. subintegra,* but that *in* the past *gene* exchange may have occurred between P. *subintegra* and *P. stansburiana* in the Verde Valley and Tonto Basin, resulting in plants that are difficult to classify.

## Evolutionary History

Several botanists have hypothesized that *Purshia subintegra* is a Pleistocene relict (McCarten *in litt.* 1979, Van Devender 1980, Phillips *et al.* 1980, J. Henrickson, California State University, pers. comm., 1992). Anderson (1986, 1993) concluded that the ecological and biogeographic characteristics of *P. subintegra* are typical of a Pleistocene relict. *P. subintegra* occurs within a narrow geographic area in Arizona, where seasonal temperature variation and biseasonal rainfall are similar to the Pleistocene climate (Anderson 1993).

Gaining general acceptance among the botanical community is a hypothesis that explains the distribution of *Purshia subintegra* and morphologic variability of some *Purshia* populations (Henrickson *in litt.* 1993, Anderson 1993, Reichenbacher 1993, Mount and Logan 1993). Hypothetically, *P. subintegra* was endemic to small areas of uncommon limestone soils in central Arizona thousands of years ago following the last glacial period. The wetter glacial periods of the Pleistocene favored the range expansion of *P. stansburiana* southward from northern Arizona into the present day desert areas of southern Arizona. During this period, these two *Purshia* species came in contact in some areas in central Arizona. During their contact, the two species hybridized or introgressed in certain areas. With the retreat of Stansbury cliffrose northward during the present interglacial, introgressed populations, such as Tonto Basin, may exist where the parents no longer do. The first-generation hybrids interbred for many generations to form hybrid swarms in the Verde Valley or Tonto Basin that may now be introgressing (exchanging genes), mostly with *P. subintegra.*

The Service considers the plants in these introgressing hybrid swarms to be outside the definition of *Purshia subintegra.* These plants will tentatively be referred to as forms of *P. stansburiana,* recognizing that they differ somewhat from 'classical' *P. stansburiana*. Plants in these populations may contain genes from both *P. subintegra* and *P. stansburiana.* Each hybrid swarm has a unique amount of variability related to the expression of mixed genes from past hybridization events and current introgression, and/or the degree of introgression being expressed by surviving plants after selection allows survival of certain phenotypes (Henrickson *in litt.* 1993).

Even though each hybrid swarm may be unique, Reichenbacher's (1993) morphometric analysis was able to distinguish two separate, general forms: one group of small populations in the Verde Valley and another group of small populations in the Tonto Basin and elsewhere in central Arizona, including the Verde Valley. The distinguishing features of *P. subintegra, P. stansburiana,* and the two general types of hybrid swarms are presented in Table 1.

If the Tonto Basin and Verde Valley populations of *Purshia* (excluding the Cottonwood *P. subintegra* population) are hybrid swarms, they illustrate the migratory and dynamic nature of evolving plant populations. Plants in the hybrid swarms are genetically and phenotypically variable, represent a piece of the evolutionary history of *Purshia*, and may provide the key to the future of the genus and species. For these reasons, conservation of these hybrid swarms is important. If the Tonto Basin and Verde Valley forms are described as distinct taxa in the future, the Service may consider providing protection under the Endangered Species Act. For those plants not within *Purshia subintegra*, other conservation strategies should be pursued.

## Ranae and Distribution

The four known populations of *Purshia subintegra* are spread across a 200-mile zone of central Arizona. The disjunct distribution pattern is likely the result of the infrequent overlap of infertile limestone soils in areas with current climatic conditions similar to the Pleistocene (Anderson 1993). Arizona cliffrose grows on gentle to steep slopes, open basins, and limestone ledges and outcrops. The landscape is dissected by ephemeral drainages and is sparsely vegetated.

Maps (figures 4-7) illustrating the locations of known populations follow the text of the Range and Distribution section of the text.

The longest-known population of Arizona cliffrose is the Burro Creek population in Mohave and Yavapai Counties. R. A. Darrow and Crooks first collected the species on April 20, 1938, in the foothills of the Aquarius Mountains two miles west of Burro Creek Crossing on the road from Wikieup to Hillside, southeastern Mohave County near the Yavapai County line. Three years later, the type specimen was collected by Darrow and L. Benson on April 18, 1941 (Kearney 1943). The largest subpopulation of Arizona cliffrose in the Burro Creek vicinity is located in Township 14 North, Range 11 West, sections 1, 2, 11, and 12, Mohave County (Figure 4). A small, outlier subpopulation in Township 14 North, Range 11 West, sections 20, 21, 28, and 29, Mohave County, was found by J.L. Anderson in 1991. In 1993, M. Baker found another subpopulation in Township 14 North, Range 11 West, sections 31 and 32, Yavapai County (R. Peck and R. Hall, BLM- Kingman Resource Area, pers. comm., 1993). The elevation of the three subpopulations ranges from 762 - 884 m (2,500 - 2,900 feet).

Nearly 30 years after the type specimen was collected, Pinkava, Lehto and Keil (1970) discovered a second population of the species twelve miles northwest of Bylas in Graham County, Township 2 South, Range 20 East, sections 23, 24, 25, and 26 (Figure 5). The full extent of this population is unknown, due to limited surveys. The elevation range of this population is 823 - 884 m (2,700 - 2,900 feet).

On March 16, 1984, J.L. Anderson found a third locality (Anderson 1986) at the north end of the Verde Valley in the vicinity of Dead Horse Ranch State Park near Cottonwood, Yavapai County (Figure 6). On May 10, 1984, N.B. Herkenham independently found this third population of the species during a botanical inventory of Dead Horse Ranch State Park. This population is located about halfway between the Bylas and Burro Creek populations at Township 16 North, Range 3 East, sections 22-27, 35, 36, and Township 15 North, Range 3 East, section 1. At 1,000 -1,103 m (3,280 - 3,620 feet), this population has the highest altitude of all Arizona cliffrose populations.

In August 1985, B.G. Phillips discovered a fourth population near Horseshoe Lake, Maricopa County (Figure 7), during a search for *Eriogonum ripleyi* J.T. Howell, another rare species of calcareous soils. The subpopulation she discovered is located west-southwest of Horseshoe Dam (Township 7 North, Range 6 East, sections 3 and 4). Additional subpopulations have been located on and near Chalk Mountain (Township 8 North, Range 6 East, sections 15, 16, 21, and 22), Yavapai County. These subpopulations are found between *640 - 823* m (2,100 - *2,700* feet) elevation.

Other areas in the state have been searched for *P. subintegra,* but no other populations have been located (Albee 1986, Anderson 1986, Butterwick 1979, Warrick 1986, Boucher and Goodwin 1984). Most of these surveys have focused on areas in the Verde Valley and Tonto Basin. Additional surveys in potential habitat should occur to determine if undiscovered populations exist.

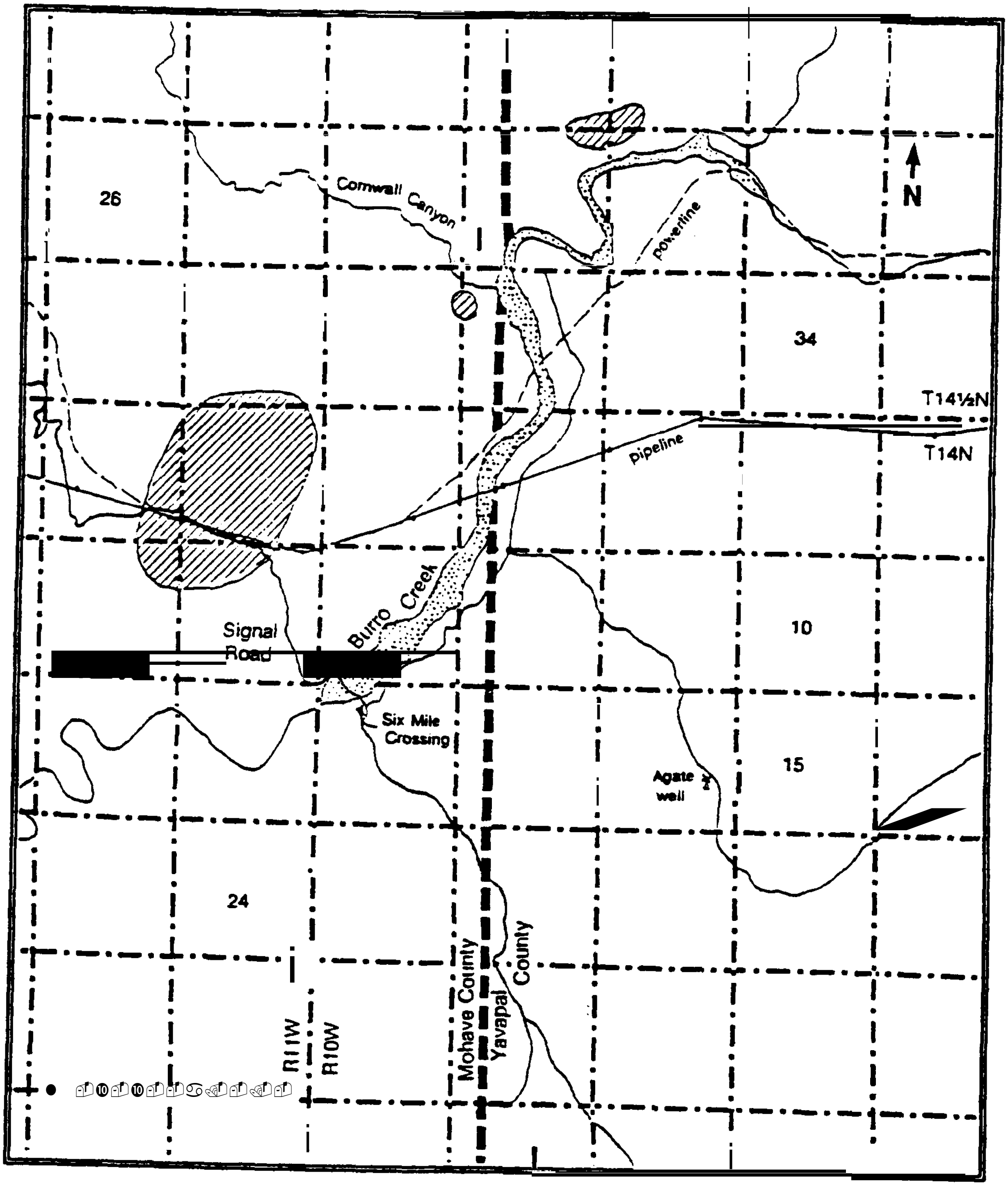


Figure 4. Diagonal lines indicate the areas occupied by ***Purshia subintegra* at Burro** Creek, Mohave and Yavapai Counties, Arizona.

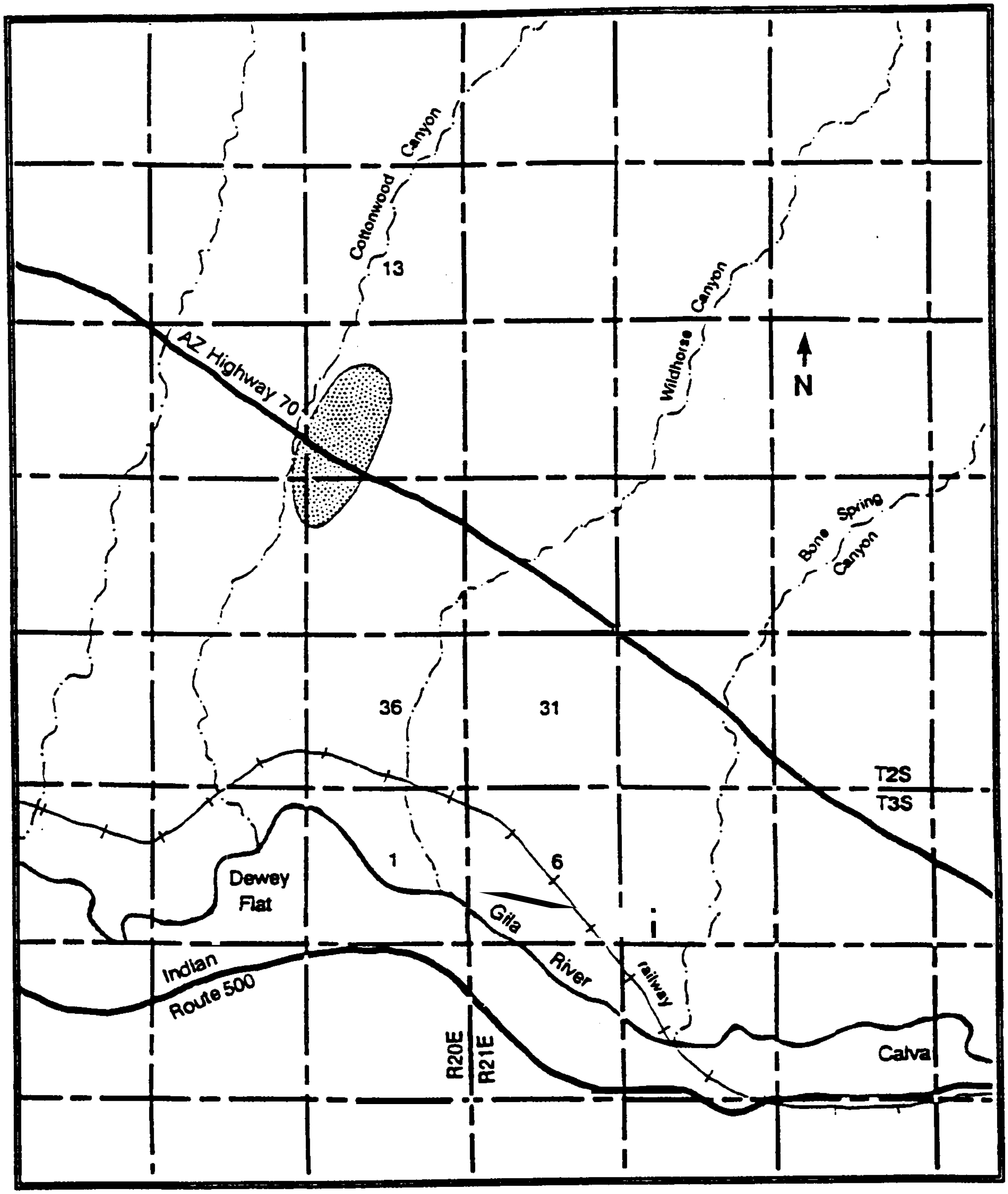


Figure 5. Shaded areas indicate the approximate boundaries of the ***Purshia subintegra*** population located near **Bylas,** Graham County, Arizona.

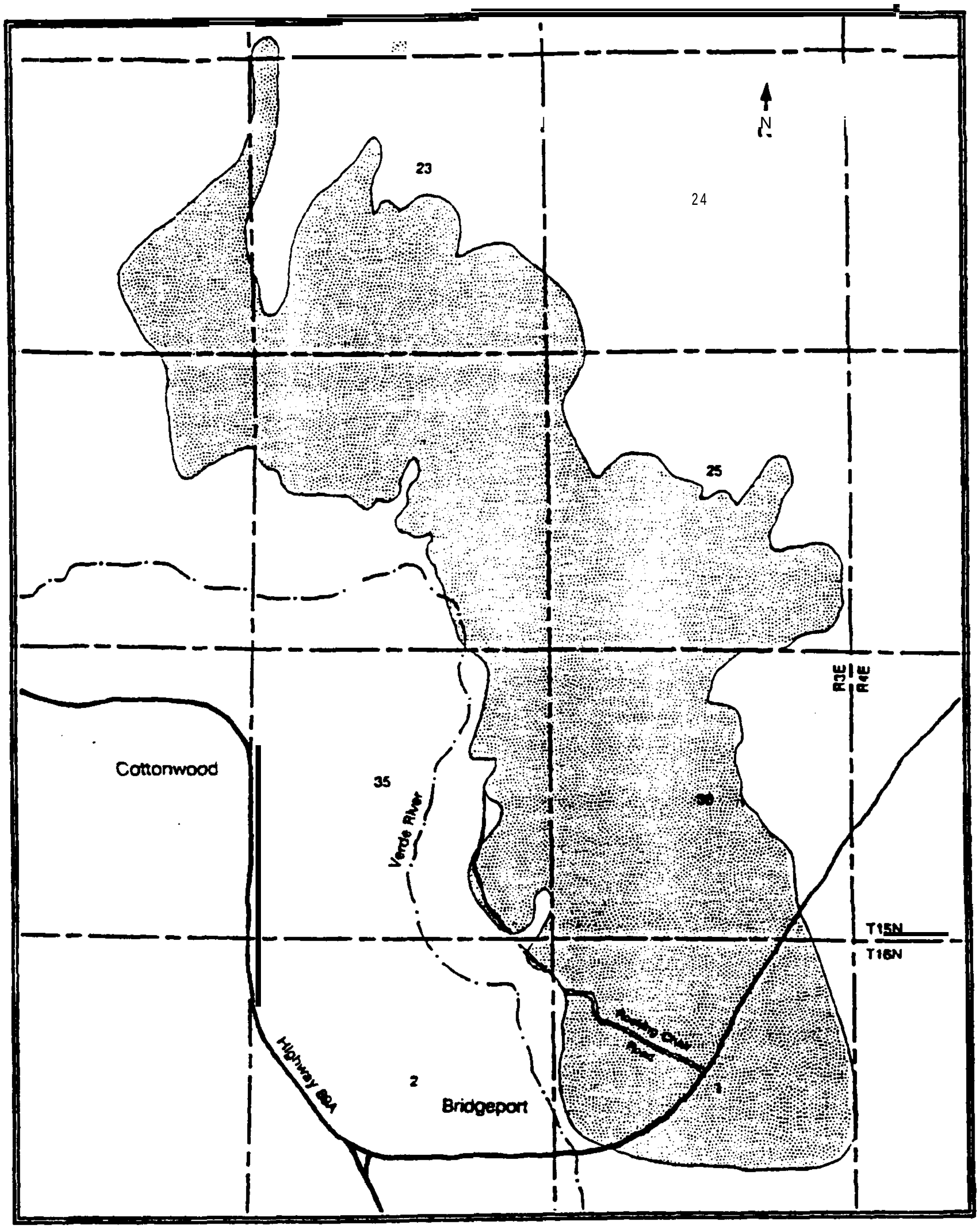


Figure 6. Shading indicates location ***of Purshia subintegra*** population in the Cottonwood area. Some ***Purshia stansburiana*** (typical and Verde Valley forms) may also occur in this area.

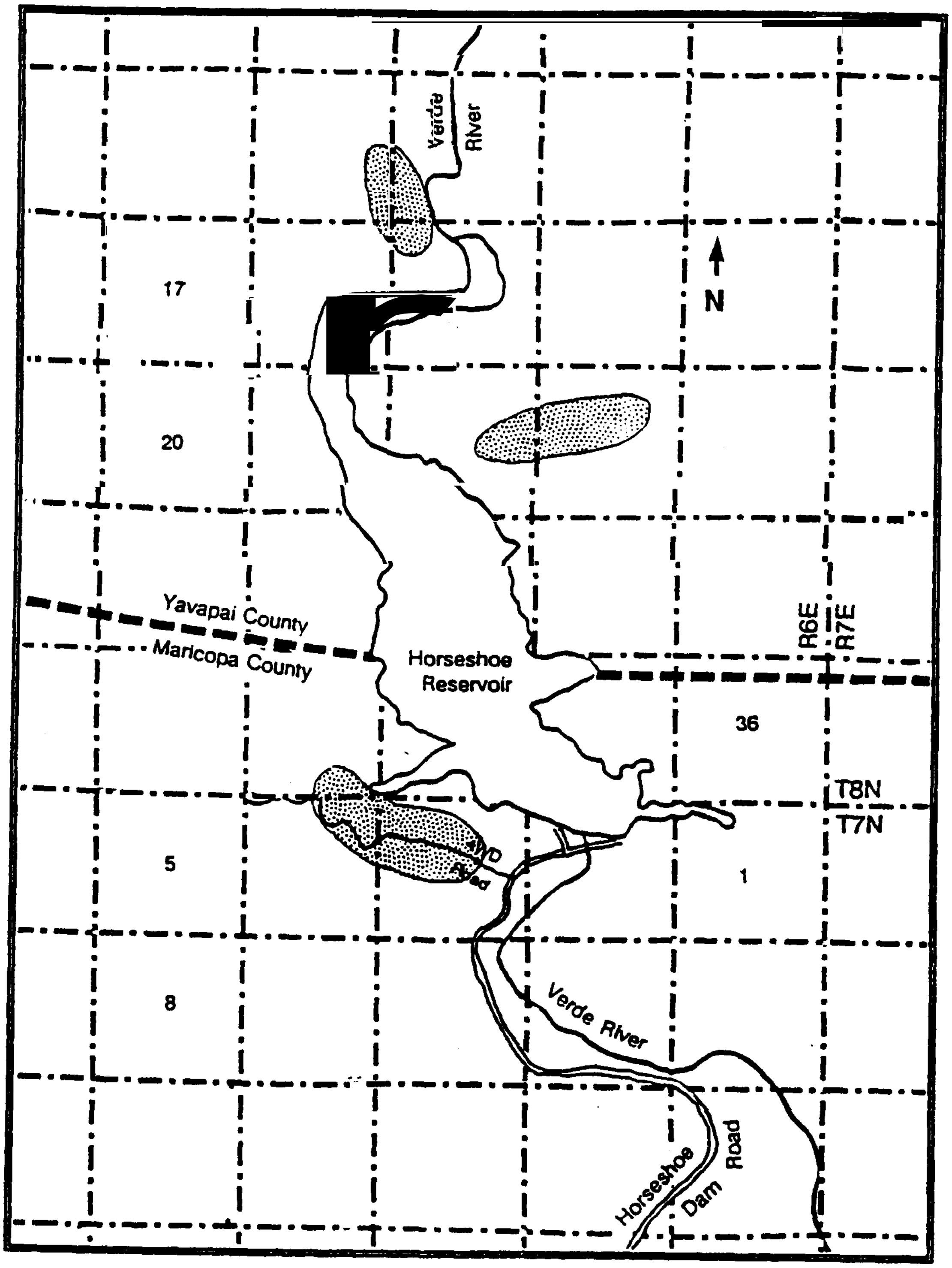


Figure 7. Shading indicates location of ***Purshia subintegra*** subpopulations near Horseshoe Lake, Maricopa and Yavapai Counties, Arizona.

## Ecology

### Associated Species

All four sites can be considered part of the *Larrea tridentata* - *Canotia holacantha* (Creosotebush - Crucifixion thorn) Association of the Arizona Upland Subdivision of the Sonoran Desertscrub (Brown 1982), because *Canotia holacantha* is a dominant at each site. The Burro Creek site contains some elements of the Mohave Desertscrub. Although *C. holacantha* is the most constant associate of *Purshia subintegra,* creosotebush is found only rarely. *Larrea* is a dominant on sites adjacent to the substrates supporting *P. subintegra,* but the density of *Larrea* drops abruptly and the species is nearly absent where the *P. subintegra* occurs. *Larrea* is apparently intolerant of the soils or is a poorer competitor than *Purshia subintegra* on those sites. The Arizona cliff rose population at Burro Creek occurs in an area that contains elements of Sonoran Desertscrub and Mohave Desertscrub.

Other dominant woody species at more than one site are: *Aloysia wrightii* (Wright lippia), *Baileya multiradiata* (desert marigold), *Berberis haematocarpa* (red barberry), *Caenothus greggii, Dalea formosa* (feather plume), *Dyssodia acerosa* (dogweed), *Eriogonum infiatum* (desert trumpet), *Glossopetalon spinescens, Fouquieria splendens* (ocotillo), *Gutierrezia sarothrae* (snakeweed), *Krameria parvifolia* (little-leaved rattany), *Oryzopsis hymenoides* (Indian ricegrass), *Parthenium incanum, Tiquilia canescens* (shrubby coldenia), *Melampodium leucanthum* (Plains blackfoot daisy), *Eriogonum fasciculatum* (flat-topped wild buckwheat), *Simmondsia chinensis* (jojoba), and *Ziziphus obtusifolia* (gray-thorn). Several authors have compiled more complete lists of *P. subintegra* associates in the Cottonwood area (Denham and Fobes 1992b, Jenkins 1991, Schaak and Morefield 1985, Boucher and Goodwin 1984, Butterwick 1979, Schaak and Morefield 1985, Anderson 1986, Reichenbacher 1986).

The disjunct ranges of several species parallel the disjunct pattern of Arizona cliffrose. Three Chihuahuan Desert species, *Poiygaia macradenia* (milkwort) and *Thamnosma texana*, and *Poiygaia scoparioides* reach the northwestern edge of their ranges with disjunctions *on* these deposits. Ten species of northern origins are disjunct into the Sonoran Desert from the Colorado Plateau: *Astragaius caiycosus* var. *scaposus, A. newberryi* var. *aquarii, Eriogonum apachense, E. ericifoiium* var. *ericifoiium, E. ripleyi, Afenafia eastwoodiae, Poiygaia rusbyi, and Penstemon thompsoniae* (Thompson penstemon), *Physaria newberryi* (Newberry twinpod), and *Streptanthus cordatus* (Anderson 1986).

Four rare, Arizona endemic plants occur in the same habitat as Arizona cliff rose. The category 2 candidate Verde Valley sage (*Salvia dorrii* var. *mearnsii*) appears to be limited to the Verde Formation in the Verde Valley area. The category 2 candidate Ripley wild buckwheat (*Eriogonum ripleyi*) occurs in Arizona cliffrose habitat in the Verde Valley and near Horseshoe Lake. The Arizona cliffrose habitat near Bylas has not been surveyed for Ripley wild buckwheat; however, the category 2 candidate Apache wild buckwheat *(Eriogonum apachense)* is known to occur there. The Aquarius Plateau milk-vetch (*Astragalus newbefryi* var. *Aquarii*) is endemic to the lacustrine deposits near Burro Creek.

Soils

All the sites consist of limy-tuff soils derived from Tertiary lacustrine (freshwater) lakebed deposits (Anderson 1986), on low, arid hillsides between 625 - 1,036 m (2,050 - 3,400 feet) elevation.

All soils are classified as sandy loams. Gravel content is significantly lower in soils occupied by Arizona cliffrose than in adjacent soils, reflecting their depositional environment in basins (Anderson 1986). Clay and silt content are not significantly higher in the basins than in the adjacent soils, however. The mean value for pH is 8.3, with no significant difference between on-site and off-site soils (Anderson 1986, Anderson 1993). On-site soil Samples are lower in phosphorus and organic matter and higher in magnesium than off-site samples (Anderson 1986, Anderson 1993). Soils supporting Arizona cliffrose populations at Burro Creek have high concentrations of magnesium and lithium (Bureau of Land Management 1993). These soils do not have the extremely low calcium-magnesium ratio of serpentine soils but fall within the normal range of 2:1 to 20:1 (Anderson 1986). The lower levels of phosphorus, nitrate, and organic matter are an indication of the infertility of these soils. On-site and off-site samples at a site in Dead Horse Ranch State Park were not significantly different in phosphorus and organic matter, suggesting that Arizona cliffrose is not necessarily limited to infertile soils (Anderson 1986, Anderson 1993). Anderson (1993) concludes Arizona cliffrose occurs,on these infertile soils at Burro Creek and Bylas because there it can escape competition from creosote bush (*Larrea tridentata*) and other common Upper Sonoran Desertscrub plants, which are excluded from the sites by low soil fertility.

Each of the three lacustrine soils tested (Burro Creek, Dead Horse Ranch State Park, Bylas) by Anderson were deposited within basins quite removed from each other and consequently had different sources of eroded parent material and ash flows. Burro Creek soils had over twice the concentration of magnesium as the other sites, and Dead Horse Ranch State Park soils were higher in phosphorus and organic matter than the other two sites (Anderson 1986).

The Burro Creek area east of Highway 93 is extremely complex geologically, with various parent materials such as basalt, granite gneiss, granite, limestone, and tuff being exposed (Wilson and Moore 1959). Parent materials on *Purshia subintegra* Burro Creek sites consist of slightly metamorphosed volcanic ash deposits and dolomitic limestone. Gypsum was not detected at this locality (Butterwick 1983). Arizona cliffrose is found on all aspects of the hills and terraces, and is found on slopes varying from 0 - 40 degrees.

At the upper end of the Verde Basin, the Verde Formation is a Pliocene limestone with interbedded clastic and tuffaceous sediments (Nations et *al.* 1981). Greatest densities of *Purshia subintegra* were found on open flat ridge-tops or other level areas near Cottonwood. Dense stands were also noted along shallow, first order drainages. It occurred on all but the steepest slopes. *P. subintegra was* found rooted in either white calcareous soils derived from a limestone member of the Verde Formation, red soils formed from a calcareous red sandy member of the Verde Formation, or a mixture of both (Schaak and Morefield 1985, Denham and Fobes 1992b). *P. subintegra* was not found on the Verde Formation at the southern end of the basin (Anderson 1986), which is stratigraphically lower and contains Miocene evaporite deposits (Nations et *a/.* 1981).

At the Horseshoe Lake locality, an unnamed lacustrine deposit outcrops along the Verde River in a small unnamed basin between the Matzatzal Mountains on the east and the New River Mountains to the west. The calcareous substrates are a mixture of materials, principally volcanic ashes with some limestone that had been weathered and transported from original sites and redeposited in river and lake bottoms. The calcium carbonate content of these materials is high and results in an alkaline soil. The poorly consolidated tuffs and sediments which characterize much of the Formation are highly unstable and erode rapidly, especially on the more steeply dipping outcrops (Reichenbacher 1986). Pollock (*in litt.* 1986) noted that the soils supporting Arizona cliffrose reacted with hydrochloric acid (indicating a high concentration of calcium carbonate), but adjacent soils did not.

At Bylas, ***Purshia subintegra*** grows on gypsum ridges on residual soil, not on decomposed substrate (Bingham 1977). Bureau of Land Management (BLM) soil scientists at Phoenix and Safford District offices believe that the soils developed on the Arizona cliffrose outcrops are most closely related to the Retriever Series. Retriever soils are shallow gravelly loams that develop over limestone bedrock.

## Climate

Rainfall in the Sonoran desert occurs in the winter and summer. These rainfall periods are normally separated by spring and fall droughts. Annual precipitation at the four Arizona cliffrose sites and the Tonto Basin is nearly equitably distributed between winter and spring rainfall periods (Anderson 1993). Summers are hot and winters are mild. Average annual precipitation and average number of frost-free days for the four Arizona cliffrose populations are provided below (Sellers and Hill 1974).

| Arizona cliffrose population | Inches of rainfall | Average number of frost-free days | Nearest weather station |
|---|---|---|---|
| Burro Creek | 13.6<br>9.4 | 126 | Bagdad<br>Wickiup |
| Horseshoe Lake | 14.5 | no data | Horseshoe Dam |
| Bylas | 8.8<br>11.7 | 249 | Fort Thomas<br>San Carlos Reservoir |
| Cottonwood | 12.2 | 282 | Cottonwood |

## Pollination Biology

The pollination biology of Arizona cliffrose was investigated by Fitts et *al.* (1993) at the Cottonwood population in 1991. They found that flowers may be pollinated on any of the first three days following anthesis (flower opening).

Arizona cliffrose flowers are pollinated primarily by bees in the superfamily Apoidea, including several native species. The introduced honeybee (*Apis mellifera*) was a common visitor to Arizona cliffrose flowers. By early May, honeybees were the most abundant pollinator, perhaps to the exclusion of native species. The second most abundant group of insects visiting Arizona cliffrose flowers were small, nondescript native bees in the genus *Dialictus.* Other pollinating insects included native bees in the families Anthophoridae, Colletidae, and Halictidae and one species of syrphid fly (family Syrphidae) (Fitts et *al.* 19931.

Arizona cliff rose is primarily cross-pollinated but is partially self-compatible (Fitts et *al.* 1993). Fitts et *al.* (1993) found that self-pollinated flowers produce significantly fewer seeds than flowers that are cross-pollinated. They also found that flowers blooming late in 1991 produced more fruits than flowers that bloomed early, but noted that this finding may be inconsistent between years.

Phenology

Arizona cliffrose begins blooming in late March and continues through early May. The flowering period of *Purshia subintegra* partially overlaps with the flowering period of *P. stansburiana,* which blooms adventitiously throughout the year. Phenology of life history events such as flowering and fruit dispersal may vary from year to year, depending on temperature, rainfall, and wind. Most Arizona cliffrose fruit develops during April in the Cottonwood area. Fruit dispersal occurs during the summer, when the summer rains dislodge seeds from plants. Timing of seed germination and seedling establishment is unknown.

According to Denham and Fobes (Denham *in litt.* 1993), most seedlings in the Cottonwood population emerge during early February to early spring. They have also seen newly emerged seedlings in the fall. However, they note that their observations occurred during years of above-average precipitation and may not be typical.

Life History and Population Dynamics

Little is known about the life history traits of Arizona cliffrose. Age at first reproduction is unknown, as are the gross and net reproductive rates and the average or maximum longetivity of plants. No demographic studies have been conducted in any of the populations to determine if recruitment is sufficient to maintain or increase the size of populations.

Mature Arizona cliffrose plants are capable of producing many seeds per year. Normally, hundreds of flowers are produced on each mature plant, which can reproduce for many years. Fitts et *al.* (1993) found that flowers in the Cottonwood area produced an average of 3 - 3.5 seeds per flower in 1991. The number of flowers and seed produced per plant may vary from year to year, depending on rainfall, temperature, plant vigor, amount of browsing, and other factors affecting reproductive output.

Two attempts to study germination requirements and rates have been made. Twenty seeds were collected on September 15, 1985, from the Cottonwood population, stratified (cooled) until December 30, 1985, and then germinated (Anonymous 1985). Final results were not recorded. For the second experiment, 14 seeds were planted on February 1, 1989, and placed in cold stratification at 12" Centigrade until April 24, 1989. One of those 14 seeds germinated (Maschinski *in litt.* 1993).

The influence of weather on seed production may explain why Butterwick (1979) observed no seeds in August and September 1976 and October 1978 at the Burro Creek population (Butterwick 1979). Frost or *snow* in the Burro Creek area is possible during late February and March when flower buds are developing on Arizona cliffrose. Peck (BLM- Kingman Resource Area, pers. comm., 1993) noted that whole Arizona cliffrose branches were frozen and killed after spring temperatures dropped in 1991. Another explanation for the lack of observed seeds in 1976 and 1978 (Butterwick 1979) may be that the seeds had already dispersed.

Arizona cliffrose plants appear to be long-lived and capable of a large reproductive output. Plant species with this life history strategy tend to have high seed and seedling mortality and low recruitment rates. If Arizona cliffrose has this life history strategy, we would not expect to find large numbers of seedlings and juveniles in each population. However, we would expect a viable population to contain plants of differing ages or sizes. We do not yet know what recruitment rates are necessary to maintain population viability.

Recruitment rates appear to vary among populations. Denham and Fobes (pers. comm., 1992) have discovered areas within the Cottonwood population supporting a relatively large number of established seedlings. About 1980 there was a consolidation of grazing permits, which changed the pattern from continuous grazing to seasonal grazing. This resulted in reduced impacts to these areas, because the forage base increased and the grazing period was shortened.

In contrast to the Cottonwood population, the other three Arizona cliffrose populations do not appear to have sufficient recruitment. Although Peck and Cordery (BLM, pers. comm., 1993) have seen seedlings with cotyledons in the Burro Creek population, age/size class distribution appears heavily weighted towards older, large plants. As discussed below, livestock utilization of plants in this population has historically been high, perhaps explaining the lack of or low recruitment. More than ten years ago, several authors (Bingham 1977, Butterwick 1979, Phillips et *al.* 1980) noted that reproduction at Burro Creek appeared to be insufficient to maintain the population.

Bingham (1977), Butterwick (1979), and Phillips et *al.* (1980) noted that reproduction at Bylas appeared to be insufficient to maintain the population. However, their observations conflict with those of Bureau of Indian Affairs (BIA), which found all age classes represented, including seedlings to senescent shrubs (F. Montague, BIA San Carlos Agency, *in litt.* 1986).

General Biology

The ability of Arizona cliffrose to recover after surface disturbance may depend on the severity of that disturbance. Where the soil profile is disturbed through digging, trenching, or other means, Arizona cliffrose may never recover or may take many decades to recover. As many as 25 years after disturbance, no colonization of severely disturbed areas along pipelines has occurred. However, in areas that received less disturbance, colonization appears possible. Reproducing plants and juveniles were noted by the authors along a seldom-used jeep trail leading to a water tank in the Cottonwood population. M. Baker (pers. comm., 1993) noted two young plants in a less disturbed area 30 - 40 feet away from a pipeline through the Burro Creek population and 3 or 4 seedlings nearby.

Propagation of Arizona cliffrose by stem cuttings has been tried but methods are not well developed. The Transition Zone Horticultural Institute (Milne 1986) took cuttings of Arizona cliffrose taken from Dead Horse Ranch State Park during the spring, summer, and fall of 1986 to determine rooting success. Cuttings taken in March had a 31% chance of rooting, while cuttings in July had a 56% chance of rooting. At the time the report was written, no results for cuttings taken in October were available. An earlier experiment was less successful at rooting cuttings of Arizona cliffrose (Anonymous 1985). The experiment involved 16 cuttings taken in late June 1985. These cuttings produced roots but died three weeks after they were transplanted into pots.

The Transition Zone Horticultural Institute tried rooting Arizona cliffrose cuttings again in 1990 (Maschinski 1990). They collected 200 cuttings from 60 plants in the Burro Creek population, treated them with rooting hormone and placed them on mist benches on October 3, 1990. Within three months, 45 of these cuttings had rooted and were potted in standard potting mix. They re-treated 151 of the unrooted cuttings with rooting hormone. Fifty-seven of these rooted and were potted, but all had died by the end of April 1991 (Maschinski *in litt.* 1993).

The Transition Zone Horticultural Institute collected 144 cuttings from Dead Horse Ranch State Park in December 1991. Only four of these cuttings successfully rooted. Three of these plants are still living, have flowered and set seed, and are three feet tall (Maschinski *in litt.* 1993).

## Land Management/Ownership

The Burro Creek Arizona cliffrose population occurs on Federal land managed by the BLM, Phoenix District, Kingman Resource Area. The Bylas population occurs on the San Carlos Apache Indian Reservation and Arizona Department of Transportation highway right-of-way. The U.S. Department of the Interior, including the BIA and Service, has Tribal Trust responsibilities, which include trust responsibilities for natural resources occurring on Indian Reservations. The Horseshoe Lake population occurs on Federal lands managed by the Tonto National Forest and Bureau of Reclamation (Reclamation). The Cottonwood population is on private lands, State Trust land managed' by the Arizona State Land Department, Dead Horse Ranch State Park, and Federal land managed by the Coconino National Forest. Denham and Fobes (1992c) provide estimates of the number of habitat acres managed by each State or Federal agency or private landowner in the Verde Valley. They estimated that 442 hectares (ha) (1,067 acres) of *P. subintegra* habitat exist in the Cottonwood area.

## Management Issues and Concerns

### Urbanization

Habitat loss due to urbanization is a serious threat for the Cottonwood Arizona cliffrose population. Urbanization does not appear to be a threat to the other three populations, which are either on Federal land, which precludes urbanization, or they occur where development is unlikely.

A significant amount of Arizona cliffrose habitat has already been lost due to development in the Cottonwood area, but the amount of habitat loss has not been estimated. The threat of urbanization continues, because some occupied habitat remains on private lands that could be developed and a substantial amount of habitat is on State Trust land.

The transfers of land from Federal ownership into private or State ownership is an indirect threat to Arizona cliffrose. These land exchanges significantly reduce the protections offered by the Endangered Species Act and may contribute to urbanization or other actions causing habitat loss or degradation. These types of transfers would be subject to section 7 consultation procedures.

If State land in the Cottonwood area is offered for sale and purchased by a private developer, the Arizona cliffrose population would be reduced and fragmented, significantly reducing the likelihood of survival and recovery of the recovery unit. In the past, the Coconino National Forest has proposed to exchange from Federal ownership into private ownership land parcels containing Arizona cliffrose habitat. In 1984, the Regional Forester instructed the Coconino National Forest Supervisor to withdraw sections of land containing Arizona cliffrose from a proposed land exchange (Southwest Regional Forester, U.S. Forest Service, *in litt.* 1984). A similar land exchange was proposed in 1991, when the Coconino National Forest proposed the Bar-T-Bar land exchange. However, the Coconino National Forest has indicated that no lands containing endangered species will be exchanged out of Federal ownership (G. Goodwin, Coconino National Forest, pers. comm. 1993).

<u>Mineral Exploration and Development</u>

Mining and mining-related activities are a serious threat to the long-term survival of this species, particularly in the Burro Creek area. The soils supporting Arizona cliffrose populations are known to contain high quality bentonite (BLM 1993), a type of clay used for cosmetics and pharmaceuticals. Drilling and bulk sample procurement have reduced the number of plants and amount of available or undisturbed habitat in the Burro Creek area. In 1990, the BLM estimated that 30 (± 10) acres (12.4 ± 4.1 ha) of the total 140 acres (58 ha) of the core Burro Creek population has been disturbed and perhaps permanently lost due to mining activities (U.S. Fish and Wildlife Service 1990). In January 1991, assessment work occurred within the Burro Creek population that caused additional habitat loss, the loss of at least 13 Arizona cliffrose plants, and damage to several others (U.S. Fish and Wildlife Service 1990 and 1991, BLM 1990 and 1991).

To date, no mineral exploration or development has occurred within the Bylas (BIA *in lift.* 1986) or Cottonwood populations of Arizona cliffrose. The Coconino Forest Plan (U.S. Forest Service 1987) states that the Forest will withdraw the Verde Valley Botanical Area from locatable mineral entry within 10 years of the implementation of the Forest Plan. To date, no mineral withdrawal has occurred in the botanical area. However, the BLM has closed mining claims in Arizona cliffrose habitat near Cottonwood in the following sections: Township 16 North, Range 3 East, the SE1 /4 of section 22, NW1 /4 of section 23, northwest corner of section 25, and the northwest corner of section 26.

Mining activities have occurred near Chalk Mountain and Lime Creek in the vicinity of or within the Horseshoe Lake population (Southwestern Regional Forester, U.S. Forest Service, *in litt.,* 1994). Mineral exploration for copper, turquoise, uranium, zeolite, and sand and gravel occurred in these areas. In some cases claims were filed. The exploration was accompanied by varying levels of surface disturbance, mostly in the 1960s and 1970s.

Cattle and Feral Burro Browsino Effects

In 1987, the BLM- Kingman Resource Area began monitoring the effects of livestock browsing on Arizona cliffrose near Burro Creek with the objective of determining the amount of utilization. Internode distances on five branches were measured on each of 50 Arizona cliffrose plants. Cages were constructed around 25 Arizona cliffrose plants to prevent browsing by livestock, wild burros, and mule deer. Twenty-five plants were left uncaged to serve as a control. Their results showed that browsing activity resulted in 65% utilization of Arizona cliffrose (BLM 1993). This high level of utilization can reduce plant vigor and fecundity, cause lack of seedling establishment, and change the form class of Arizona cliffrose plants, causing them to look hedged. Under this level of utilization, more palatable, associated plant species may be overutilized, resulting in disturbed ecosystem functions and degraded ecological values.

The BLM continued monitoring Arizona cliffrose utilization after a fence was constructed in 1989 to exclude cattle and burros from an approximately one square mile area. This large exclosure included the Caged and uncaged plants that had been monitored since 1987. After the fence was built, utilization of the Arizona cliffrose plants dropped to 16% in 1989 and 18% in 1990 (BLM 1993). Utilization of caged plants was similar to uncaged plants. These results indicate that livestock and burros were responsible for most of the browsing activity on Arizona cliffrose. Some browsing continues within the exclosure, probably from mule deer and other wildlife. Livestock and burros may occasionally enter the exclosure if the fence is not maintained. Most plants appear to be responding favorably to the lower levels of browsing. However, it appears that some plants that were very heavily browsed over a long period of time may never recover.

Only observational data are available regarding the effects of livestock grazing on the Bylas Arizona cliffrose population. At the Graham County population, Bingham (1977) noted that no young plants were observed during a one hour search in the grazed open area, whereas juvenile plants were present along an adjacent fenced ungrazed highway right-of-way. In 1986, the BIA *(in litt.* 1986) noted that the absence of quantities of dried manure and lack of hoofprints to the north of Highway 70 indicated low grazing pressure. They also noted that Arizona cliffrose plants south of Highway 70 were browsed, probably because nearby Poison Spring offers a source of water for livestock and wildlife.

Grazing Manaoement Systems

Cottonwood Population. Cattle grazing has occurred in the Cottonwood population of Arizona cliffrose for many decades. Until 1980 (D. Ward, Coconino National Forest, pers. comm., 1993), cattle had access to Arizona cliffrose habitat year-long. In 1989 the Coconino National Forest approved an interim Windmill Allotment Management Plan (AMP), which prescribed a deferred rest rotation system (Ward 1989). The Coconino National Forest (Coconino National Forest 1992, Ward 1992) revised the Windmill AMP in 1992 to better accommodate Arizona cliffrose management needs. The AMP addresses lands managed by the Arizona State Land Department and the Coconino National Forest, including the Verde Valley Botanical Area. Formal section 7 consultation on the revised Windmill AMP was completed on December 30, 1992, the date the Service issued a non-jeopardy Biological Opinion.

The Cottonwood population of Arizona cliffrose occurs in the Gyberg, Rocking Chair, and Cornville pastures covered by the Windmill AMP. Since 1992 when exclosure fences were built, no livestock grazing has occurred within the Rocking Chair and Cornville pastures. The AMP permits up to 750 head of cattle in the Gyberg unit for 20-30 days every other year during fall-winter spring periods under a deferred rest rotation system. After March 15 during these use periods, another 80 bulls may be added to the 750 head. A maximum of 20% utilization of key forage grasses is permitted in the Gyberg Unit inside the Verde Valley Botanical Area. A maximum of 50% is allowed in the Gyberg Unit outside the Verde Valley Botanical Area. Because plant cover is low and topography is rough within Arizona cliffrose habitat in the Gyberg Unit, livestock use is expected to be low. To verify this assumption, the Forest has committed to monitoring use of Arizona cliffrose while livestock are within the pasture (Ward 1992). In 1993, 500 head of cattle used the Gyberg pasture for 18 days (May 1 through May 18).

Burro Creek Pooulation. The Burro Creek Arizona cliffrose population is within the Bagdad grazing allotment administered by the BLM- Kingman Resource Area. From at least 1938 to 1989, cattle used this allotment yearlong. There were no interior pasture fences. This type of grazing management can result in some areas receiving extremely heavy use, such as riparian zones or areas with particularly palatable plants, and light use in other areas, such as rocky uplands. A range inventory completed in 1978 determined the Bagdad Allotment to be in fair range condition with a static trend rating (Butterwick 1979, BLM 1992), an indication of overgrazing. The Arizona cliffrose site was given a condition class between fair and good and a trend rating of static (BLM *in litt*. 1987). Until 1989, livestock had uncontrolled access to Arizona cliffrose plants, resulting in the hedged growth form expressed by many of the plants.

Although the largest subpopulation of Arizona cliffrose at Burro Creek is now protected from livestock and burro grazing by an exclosure fence (see "Conservation Efforts"), livestock and burros are not excluded from the two smaller outlying subpopulations. BLM issued a term grazing permit in 1992 (BLM 1992), but no formal section 7 consultation occurred when it was issued. The grazing management system that will be implemented in the area of these two subpopulations will be prescribed by the Bagdad Showcase AMP (BLM 1992). BLM has completed formal section 7 consultation with the Service on the proposed grazing system. The AMP will allow 280 yearlings to graze from October 1 through March 31 in the pasture containing Arizona cliffrose. The allotment contains two pastures. If BLM finds that utilization exceeds 20%, they will determine if reinitiation of formal consultation is necessary (Hall 1993). The BLM is predicting livestock grazing in the two subpopulations will be light because cattle will be less likely to travel in the area because of the rugged terrain and distance from water.

Horseshoe Lake Pooulation. Cattle and sheep grazing began in the Horseshoe Lake area during the late 1870's. The two Arizona cliffrose subpopulations west of the Verde River were historically located within the Tangle Creek (sheep) Driveway (Tonto National Forest 1981). At one time, the sheep used the driveway only during drives that occurred at most once per year (D. Pollock *in litt.* 1986). No sheep drives have occurred for many years (Tonto National Forest 1981, Tonto National Forest Supervisor *in litt.* 1987 and 1992). The Tonto National Forest (1981) classified 50% of the sheep driveway as unsuitable for grazing, and the remaining area of suitable range was judged to be in poor range condition. Five years later, Pollock (*in litt.* 1986) visited the Arizona cliffrose subpopulation near Horseshoe Dam and noted that the range condition was poor to very poor. Arizona cliffrose plants appeared to have low vigor and were heavily browsed by wildlife (Pollock *in litt.* 1986).

The Arizona cliffrose population near Horseshoe Lake, with the exception of a part of the subpopulation near the dam, is contained within the Sears Club-Chalk Mountain grazing allotment, which encompasses 72,591 acres (30,053 ha). In 1984, the Tonto National Forest issued a term grazing permit that allows 746 adult cattle year-long and 398 winter yearlings in the allotment. Livestock grazing is guided by the Sears Club-Chalk Mountain AMP (Fenner 1985, Tonto National Forest 1985). At the time the AMP was completed, Arizona cliffrose was not yet known in the allotment.

The Sears Club-Chalk Mountain AMP (Fenner 1985) prescribed a 5-pasture rest-rotation system. The Arizona cliffrose subpopulation to the west of the Verde River and north of the dam is in the Lower Chalk Pasture, which is grazed every other year from December 15 to April 30. Allowed percent utilization in this pasture is 40%, which equates to 55% use on key species such as side-oats grama (*Bouteloua curtipendula*).

The Arizona cliffrose subpopulation near Horseshoe Dam is divided by a livestock fence that divides two allotments. Arizona cliffrose plants to the south of that fence are within the St. Clair Allotment. No livestock grazing has occurred on this allotment since 1992, when grazing permits were cancelled (Tonto National Forest Supervisor *in litt*. 1992).

Bvlas Pooulation. Nothing is known about livestock grazing management within Arizona cliffrose habitat on the San Carlos Indian Reservation.

Roads and Utilities

All of the Arizona cliffrose populations have roads and/or utility right-of-ways within or near them. The Burro Creek population is divided by a graded dirt road paralleled by the Southern Union Gas Company pipeline and Arizona Electric Power Cooperative Incorporated high voltage power line. The gas pipeline has been in existence since at least 1969 (Butterwick 1979). No estimate of the amount of habitat lost to these developments in the Burro Creek area has been made. The Kingman Resource Management Plan (Kingman RMP) (BLM 1993) proposed a one-mile wide utilities corridor that overlies Arizona cliffrose habitat. The BLM may grant right-of-ways through this utility corridor (BLM 1993).

A graded dirt road (Forest Road 205) and a Qated road (Forest Road 530) passes near one of the three Horseshoe Lake subpopulations. Forest Road 479 passes near a second subpopulation. U.S. Highway 70, a two-lane paved road, bisects the population near Bylas.

Numerous paved and dirt roads pass through the Cottonwood population. Highway 89A nearly forms the eastern border and Rocking Chair Road passes through the Arizona cliffrose habitat. Its expansion is being planned. Other roads to access housing or for recreational purposes create a network through the habitat.

Roads and trails have direct and indirect effects. Road surfaces constitute lost habitat. The amount of habitat and number of plants lost to roads have not been estimated. Roads can change the local hydrology, affecting the amount of precipitation received and absorbed in a local area, changing the direction and speed of runoff, and perhaps changing erosion rates and patterns. These changes can adversely or beneficially affect survivorship and fecundity of individuals. Soil compaction occurs in areas of moderate to heavy vehicle use.

Roads can provide access to ORV and other users that may adversely affect Arizona cliffrose and its habitat. ORVs can destroy young plants, harm mature plants, prevent seedling establishment or seed germination, cause soil compaction, and otherwise disrupt the soil surface.

Arizona cliffrose plants have colonized a lightly used vehicle trail on the Coconino National Forest. These plants indicate that Arizona cliffrose in the actively reproducing Verde Valley population can recover after light soil surface disturbance.

Unknowingly, local residents of the Verde Valley have been using Arizona cliffrose habitat as a parking lot. The parking area is located at the intersection of Rocking Chair Road and U.S. Highway 89A. The area of impact has been expanding during recent years, increasing the number of plants and amount of habitat already lost.

The Coconino Forest Plan (U.S. Forest Service 1987) states that the Forest will manage roads adjacent to the Verde Valley Botanical Area to prevent "vehicular intrusion." In the same document, the Forest committed to blocking and obliterating existing roads entering the area within the first ten years of plan implementation. To date, road blocking and obliteration has not yet occurred.

Recreation

The Cottonwood population is adversely affected by recreation of several types. An unofficial shooting range near the eastern portion of this population on the Coconino National Forest has caused the loss of an unknown number of plants and acres of habitat. Shooters park within an Arizona cliffrose population at the base of a small hill and shoot into the population on the hill. The soil at the well-used parking area and roads leading to the shooting range is compacted and eroding, devoid of vegetation, and probably incapable of supporting cliffrose plants unless restored. The area is used not only by shooters, but also by night-time recreationists.

In addition to the shooting range, other spots in the Arizona cliffrose Cottonwood population are frequented by night-time recreationists. These "party spots" are generally severely impacted by vehicles, devoid of vegetation, and littered with trash.

ORV recreationists drive through the Cottonwood population, in some cases ignoring signs or cutting fences to gain access to prohibited areas. A fence completely surrounds a section of Arizona State Trust land, which was used by ORV users despite trespass notices.

The primary damage to Arizona cliffrose habitat in the Cottonwood area has occurred in Township 16 North, Range 3 East, section 36 by vehicles entering the section from the west. The State Land Department has been successful at notifying the offenders and eliminating this use (Denham *in litt.* 1994). Denham and Fobes (19924) also noted ORV damage in the southeast corner of Township 16 North, Range 3 East, section 22 and the northeast corner of section 27. The ORV users entered a parcel of private land via the Coconino National Forest and rode across the property.

ORVs are not currently a problem at Horseshoe Lake. The Tonto National Forest Plan (U.S. Forest Service 1985) closed the area to ORV use except where posted as open but has minimally enforced the closure. Despite the presence of a nearby lake and campground, ORV use has not yet been reported within the subpopulations.

The amount of recreational activity occurring within the core Burro Creek subpopulation is poorly known. Increased recreational activity may occur within the Clay Hills Area of Critical Environmental Concern (ACEC) when the Burro Creek campground is developed (BLM 1993). The Burro Creek site is a well-known destination for rock collecting enthusiasts. These visitors may affect Arizona cliffrose by turning over rocks and disturbing Seedling establishment microsites. They also may occasionally drive short distances across country to reach collecting sites and crush plants. Whether or not these visitors adversely affect Arizona cliffrose is unknown.

## Limitation of Pollinators

Based on the results from their pollination biology studies in the Verde Valley, Fitts et *al.* (1993) suggest but do not conclusively demonstrate that a limitation in pollinators may be limiting reproduction. They base their hypothesis on the following results: 1) open-pollinated control flowers produced fewer fruits and seeds than flowers from the xenogamy treatment (pollen from one flower transferred to a flower on a different plant); and 2) flowers produce fewer fruits during the early part of the blooming season, when competition for pollinators is greatest, than they do during the latter part of the season.

## Control of Insect Pests

General pesticides are often used to control cropland insect pests and sometimes used to control rangeland insect pests. Two Arizona cliffrose populations (Horseshoe Lake and Cottonwood) occur very close to lands under cultivation. A private parcel of land near Horseshoe Dam is being cultivated to provide food for livestock. We do not know if pesticides are currently being applied on the cultivated lands near Arizona cliffrose populations.

Four Arizona cliffrose populations occur in areas that are grazed. High densities of rangeland pests have never been reported within Arizona cliffrose populations. If problem densities develop, however, they may be accompanied by proposals from Federal and State agencies to apply chemical controls, including general pesticides.

General pesticides such as malathion, a commonly used rangeland and cropland pesticide, can drastically decrease target and non-target insect populations. Insect population sizes are regulated by a number of variables, including weather, inter- and intra-specific competition, vertebrate predators, and insect predators and parasitoids (Belovsky 1989, Wang and Walgenbach 1989, Hostetter et *al*. 1989, Dysart and Onsager 1989, Lockwood 1993). General