STATUS OF POPULATIONS OF THE ENDEMIC PLANTS OF ASH MEADOWS, NYE COUNTY, NEVADA

a report to

U.S. Fish and Wildlife Service

Great Basin Complex, Reno Nevada

Endangered Species Act-Section 6

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Introduction

Ash Meadows National Wildlife Refuge is one of the highest regions of endemism in the continental United States. An oasis of the Mohave Desert just east of Death Valley, the refuge encompasses 23,000 acres in southern Nye County, Nevada, and is perhaps best known for its inhabitant, the Devils Hole pupfish.

Ash Meadows was apparently named by emigrants of the mid 1800's for the abundant desert ash trees which historically dominated the landscape (Palmer 1893); although there is an alternate suggestion that the name was given in reference to the ashy color of the alkaline soils of the area (Beatley 1977, Carlson 1974). This localized Leatherleaf Ash and several narrow endemic plants are dependent on the wetlands of the Meadows.

Waters in a vast aquifer to the northeast surface in Ash Meadows forming a series of almost 30 named warm springs, and numerous seeps and sloughs. Runoff is to the southwest toward the Amargosa Valley and the California state line. There is general agreement among hydrologists that the discharge along the fault lines in Ash Meadows is from a carbonate aquifer deposited during pluvial periods from 8,000 to 12,000 years ago (Soltz and Naiman 1978).

The permanent waters and native vegetation, particularly the mesquite, were important to early native Americans (Mordy and McCaughey 1968); their artifacts are abundant (Becker, pers.

comm.[1]). Emigrants in search of California goldfields used the area as a base camp as early as 1849 (the Death Valley Forty-Niners). By the turn of the century a tent camp and saloon were built to support local miners and railroad workers. Mining families and small farming operations raised the population to a level that supported a small school at School Spring. The extemely alkaline soils deterred profitable farming, and the population levels remained low as other workers moved on. Thus these early inhabitants had little discernible effects on the area and its native fauna and flora.

Botanists collected in Ash Meadows as early as 1891 and used the area as a base camp for excursions to adjacent areas of interest. A small fish that inhabited an isolated limestone pool called Devil's Hole was also noted in 1891. The Devils Hole pupfish has figured heavily in landmark conservation efforts in the American southwest. Concern for plants came much later.

Devil's Hole is an isolated limestone pool in a hillside fault fracture above Ash Meadows. The pool measures about 55 by 10 feet at the surface, but is reportedly over 300 feet deep. The Devils Hole pupfish resides only in the upper column of the pool which may be the most restricted habitat of any known vertebrate. It was recognized as a distinct species almost 40 years after its discovery and described in 1930 (Ono et al. 1983). A tract of 40 acres surrounding Devil's Hole was given

[1] Becker, A. 1987. Office of State Historic Preservation and Archeology. Carson City, NV.

Park Service status as an adjunct to Death Valley National Monument in 1952. This recognition and protection came through the diligent efforts of Drs. Carl L. Hubbs and Robert R. Miller who initiated conservation efforts for Ash Meadows decades ahead of the extensive destruction brought on by a series of developers in the 1960's and 70's.

In the early 1960's mining of peat in Carson Slough destroyed approximately 2000 acres of wetlands which served as habitat for enormous concentrations of waterfowl and several fishes. A renewed interest in agriculture on a corporate scale brought major changes to the area during the early 1970's. Dam building, irrigation canals, and rampant earth moving transformed the landscape while pumps lowered the water table to the extent that at least one spring went dry. With development came a wide array of introduced exotics, animals and plants, which began encroaching on native forms.

The extensive damages to Ash Meadows caused alarm to several concerned biologists who began planning in the late 1960's on some means of arrest and reversal of the destructive trends and promised developments (see Pister 1981, for an account of this history).

The Devils Hole pupfish was the first focus of concern. The fish was listed as endangered by the U.S. Fish and Wildlife in 1967. Pumping operations immediately adjacent to Devil's Hole dangerously lowered the water table and limited crucial habitat. After lengthy litigation, the Supreme Court in 1976 ruled in

favor of maintaining a minimum water level in Devil's Hole to protect the endemic pupfish.

Several additional fishes in Ash Meadows were later listed as either threatened or endangered. Numerous aquatic invertebrates, insects and snails, were added to listings of endemics. These remain relatively unknown; many are undescribed. Meanwhile competition and habitat modification brought about the extinction of the Ash Meadows poolfish (or killifish), Empetrichthys merriami (Williams et al. 1985).

Surveys and descriptions of Ash Meadows plants date back to those by Coville of the Death Valley Expedition in 1891. The endemics, Mentzelia leucophylla and Astragalus phoenix were described from materials collected by Purpus in 1898. Mentzelia leucophylla was described in 1899, but not seen again until 1968. At this time Reveal estimated that the entire population of this blazing-star included fewer than 100 individual plants. The plants inhabit a small area that had been barely missed by the blade of a bulldozer. Astragalus phoenix was collected again in 1966, but not described until 1970. Extensive searches and collecting by Beatley and others led to a compiled listing of 200 plants for Ash Meadows by the late 1970's (Beatley 1977 a, b, c, d) and a realization that several were strict endemics that warranted protection. (See Mentzelia 1977 (3); the entire issue is devoted to the endangered and threatened plants of Nevada; Ash Meadows is heavily featured.) Endangered and threatened status for seven of the Ash Meadows plants was officially

designated in May 1985.

Various conservation efforts during the 1970's and early 1980's were thwarted. In 1984 some 12,000 acres owned by Preferred Equities Corporation were sold to The Nature Conservancy. These lands were later conveyed to the U.S. Fish and Wildlife Service for the establishment of Ash Meadows National Wildlife Refuge for the primary function of protecting the habitat of the numerous endemics of this unique and rich oasis.

In April of 1987, Ash Meadows was designated as one of four wetlands of the United States of international importance under the Ramsar Convention, a 40 nation compact that pledges protection of significant wetlands of the world.

Field Studies

The present study was contracted by the U.S. Fish and Wildlife Service to survey and better map the distribution of the Federally listed plants of Ash Meadows. Previous to this survey most were known from roadside areas. After known populations were plotted, we examined unsurveyed regions and also spent some time in peripheral areas to determine if habitat and plants extended beyond the general confines of Ash Meadows.

We visited the Meadows in April 1986, March and April 1987, but surveyed mostly in late July and early August 1986, the peak flowering season for the majority of the plants of concern.

Acknowledgements

Don Sada, U.S. Fish and Wildlife Service (FWS), assisted with contractual arrangements, and visited Ash Meadows with us for orientation and to arrange local contacts. He spent considerable time with mappings and editing and provided literature from his library, but most importantly shared his extensive knowledge and enthusiasm for the area. Bob Love, long-time resident of the Meadows, furnished housing and full access to his garden, orchard, and vinyard during our stay. Bob drove us to the more inaccessible areas and directed us to sites where he had spotted obscure Astragalus clusters many seasons past. This report is in many ways an update of the sightings that Bob has made through the years. Curt Soper of The Nature Conservancy (TNC) and Randy McNatt (FWS) arranged the office transactions; Roy Trenowith (State Forestry) helped guide the same. State Forestry also provided us a field vehicle. State Parks provided our office facilities. Audrey Godell (TNC) cheerfully supported us with hours of data entry and computer rescue.

Purpose of Study

The purpose of this study was to produce a baseline map of the rare flora of Ash Meadows for future refuge management. Such baseline research will allow comparison between historic and current plant distribution patterns, provide a basis for long-term successional monitoring, and guide recovery to reestablish species in formerly occupied areas.

This study and the resulting maps are by no means definitive. Varying scales among maps and poor landmarks for field reference make accuracy difficult. Field reconnaissance was based largely upon the 1952 edition of the U.S.G.S 15 minute topographic sheet (Ash Meadows). Verification of roads and other landscape features was ameliorated by use of aerial photography (Becker and Lake 1982). However, errors were identified on the atlas overlays, and many dwellings have been removed since the area was flown.

The report is targeted mainly for the refuge manager(s). Each species of concern is described, has an illustration if available, includes habitat and associated species, an overall species distribution map for the refuge, and a discussion of the regional as well as local distributional pattern.

In Ash Meadows, the rare plant species grow in soils that are predominantly clay in texture and heavily encrusted with whitish evaporite minerals. A definite preference for habitats exists among these species as well (Table 1). Calochortus, Centaurium, Cordylanthus, Grindelia, Ivesia and Nitrophila grow

Table 1. Habitat preference and phenology of rare plant species in Ash Meadows.

SOIL MOISTURE PREFERENCE

Moist	**Arid**
Calochortus striatus	Arctomecon merriamii
Centaurium namophilum	Astragalus phoenix
Cordylanthus tecopensis	Enceliopsis nudicaulis var. corrugata
Grindelia fraxino-pratensis	Mentzelia leucophylla
Ivesia eremica	
Nitrophila mohavensis	

FLOWERING PERIOD

Early Spring	**Late Spring/Summer**	**Summer**
Astragalus phoenix	Arctomecon merriamii	Centaurium namophilum
Enceliopsis nudicaulis var. corrugata	Calochortus striatus	Grindelia fraxino-pratensis
	Cordylanthus tecopensis	Ivesia eremica
	Nitrophila mohavensis	Mentzelia leucophylla

in habitats where the substrate is continually saturated. The remaining four species (Arctomecon, Astragalus, Enceliopsis, and Mentzelia) occur only on arid, upland soils.

Based on field observation and herbarium collections, flowering periods of the rare species can be grouped under early spring, late spring/summer, and late summer. There appears to be a relationship between soil moisture (habitat preference) and phenology. Generally, species of arid sites bloom from early to late spring when moisture in the upland soils is at field capacity. Springs, seeps, and sloughs tend to support late-blooming, mesic species such as Calochortus, Centaurium, Grindelia, Ivesia, and Nitrophila. At these sites, water sources have been relatively stable over several thousand years, enabling these endemics the luxury of blooming during extremely high temperatures--a period when most other Mojavean plant taxa are dormant.

Two species, Arcotmecon merriamii and Mentzelia leucophylla, do not fit into this pattern of arid soils-early flowering. Arctomecon californica, a congener and rare gypsum endemic of southern Nevada, is known to have "Kranz" anatomy (Meyer, pers. comm.[2]) and follows a different photosynthetic pathway called "C4". Based on leaf morphology, it is likely that Arctomecon merriamii and Mentzelia leucophylla are also C4 species, possibly explaining their phenology.

Interesting areas of research remain for the Ash Meadow

[2] Meyer, Susan E. Provo Shrub Laboratory, Provo, Utah.

plant species. Definitive studies are needed on the soils and their relationship with the rare plants. What is so unique about the immediate soils of the refuge area that has encouraged edaphic endemism? How do similar-looking soils within 0.25 mile differ such that rare species are excluded?

The species of upland sites should be investigated to determine if "Kranz" anatomy and the C4 photosynthetic pathway is typical. Interesting physiological research could be conducted using these xeric taxa that would lead to a better understanding of rarity and edaphic endemism and assist during implementation of recovery programs.

A composite distribution of all rare plants in Ash Meadows and the vicinity is presented in Figure 1. Additionally, a map of areas of disturbance (Fig. 2) is included. Sites of historic human-mediated disturbance are now experiencing invasion by both exotic weedy trees and herbs, e.g. tamarisk, and alfalfa, as well as native seral species such as mesquite. Many herbaceous forms are invading fallow agricultural sites, including the more resilient mesic rare species such as Centaurium namophilum, Cordylanthus tecopensis, and Grindelia fraxino-pratensis.

The map showing disturbed areas (Fig. 2) is intended to help the refuge manager complete an exotic plant species eradication program, as identified in the draft recovery plan (U.S. Fish and Wildlife Service 1986). In particular, Elaeagnus angustifolia (Russian olive) has been noted in several areas of the refuge. These trees could easily be removed before they become a

Figure 1. Composite distribution (shaded area) of all rare plant species in Ash Meadows, Desert National Wildlife Refuge, Nye County, Nevada.

place fig 1 here

Figure 2. Distribution of disturbed habitats (stipled area) and areas of invasion by exotic weedy plant species in Ash Meadows, Desert National Wildlife Refuge, Nye County, Nevada.

place fig 2 here

widespread nuisance (Olson and Knopf 1986) spreading throughout Ash Meadows. Several sites that once served as residential dwellings were planted with shade and fruit trees (mostly stone fruits). These horticultural species are not becoming naturalized, thus present little problem. However, if the character of the refuge is to reflect the original, natural ash woodland scene that was enjoyed by Coville, Funston, and other 19th century explorers, removal of exotics needs to be considered.

Ten sensitive plant species are being protected by the Fish and Wildlife Service in Ash Meadows National Wildlife Refuge. Seven species are listed as either threatened or endangered and are protected by Federal law (Table 2). Additionally, three sensitive species, Arctomecon merriamii, Calochortus striatus, and Cordylanthus tecopensis, are discussed because they are regionally rare, with few sites being protected elsewhere. Because these species are rare, their conservation should be considered in overall management decisions.

The majority of the rare flora of Ash Meadows has not been studied in any fashion other than taxonomic descriptions. Compilations of data into status reports are available for only four of the ten species of concern at Ash Meadows (Table 2). Surprisingly, most of these species have been known and repeatedly collected for over 100 years.

In Ash Meadows, rare plant populations have been fragmented into numerous subpopulations due to historic disturbance by

Table 2. Vascular plant species of concern in Ash Meadows, Desert National Wildlife Refuge.

Species of Concern	Federal Status*	Status Report	Date Discovered
Astragalus phoenix	LT	YES	1898
Arctomecon merriamii	3C	NO	1892
Calochortus striatus	3C	NO	1882
Centaurium namophilum	LT	NO	1891
Cordylanthus tecopensis	C2	NO	1888
Enceliopsis nudicaulis var. *corrugata*	LT	NO	1965
Grindelia fraxino-pratensis	LT	YES	1965
Ivesia eremica	LT	NO	1892
Mentzelia leucophylla	LT	YES	1898
Nitrophila mohavensis	LE	YES	1953

* LT=listed as threatened, LE=listed as endangered by the U.S. Fish and Wildlife Service.

European man and his livestock. These artificial subpopulations may recover depending upon the resilience of the ecosystem involved. Vegetation on some moist habitats in Ash Meadows have rebounded quite well since disturbance ended. Other areas such as North Carson Slough, which was commercially mined for peat, have been heavily invaded by the African exotic Tamarix. Some areas on the refuge also show evidence of expansion of the native taxon, Prosopis. The mesic herbs Cordylanthus tecopensis, Centaurium namophilum, and Grindelia fraxino-pratensis are also expanding in range. Apparently, these fragmented mesic populations have not yet returned to equilibrium and may possibly form more or less continuous populations on moist habitats, such as Carson Slough, within the refuge.

Habitats of xeric vegetation may show similar population rebound, but on a time scale are much more difficult to discern. Disturbed sites on the arid uplands do not appear to have rebounded or been invaded. Range expansion of these xeric species is not apparent either. Even though species such as Astragalus phoenix, Mentzelia leucophylla, and Enceliopsis nudicaulis var. corrugata appear to germinate and reproduce successfully, the integrity of the soil matrix may be the limiting factor to population expansion and recovery. The soil system should be considered in management plans as well.

To help orient the refuge manager, a list of geographic places in Ash Meadows is given in Table 3 of Appendix B, and mapped in Figure 13. These locations are a compilation of

unpublished data on the hydrobiid snails of the refuge (Sada 1985b), and information gathered from private landowners (Bob Love) on the refuge .

Beatley (1976) published a checklist of the vascular plants of Ash Meadows. Field trips by the Northern Nevada Native Plant Society added to the list (Northern Nevada Native Plant Society 1979), as did the authors during recent field work. A checklist of vascular plants of Ash Meadows is given in Appendix C. More detailed information on these rare plant species is housed with the Nevada Natural Heritage Program in Carson City, Nevada.

Plant species of concern

1. Arctomecon merriamii "white bearpaw poppy"

The type specimen was collected on the Death Valley expedition on May 1, 1891 "west of Vegas Ranch, Lincoln County" (now Clark County) by Merriam and Bailey (Coville 1892), and later collected at the type locality by Coville. Arctomecon merriamii (Fig. 2a) was named to honor C. Hart Merriam's contribution to the field of geobotany.

a. Non-technical description.

Arctomecon merriamii is a low, caespitose perennial (or biennial?) herb growing from stout tap roots. Leaves are largely basal, forming a broad, gray, caespitose tuft approximately 10 cm or less in height. Basal leaves are cuneate-oblanceolate, 2 to 3 cm long, tridentate at the truncate apex, and clothed with very long, up to 1 cm, white, spreading flexuous, barbellate hairs. Upper leaves are sessile, often entire or acute at the apex. Flowering stems are several, erect, 20 to 30 cm tall and glabrous. Flowers occur singly, nodding when in bud, but erect and showy in blossom. Sepals 3, quickly falling away and hairy like the leaves. Petals 6, white, 3 to 3.5 cm long, showy and deciduous. Fruit is a linear-oblong capsule, 3.5 to 4.0 cm long, the valves splitting down from the apex for 8 mm (Coville 1892).

b. Habitat

Clokey (1951: 92) described the type locality as "...level, and the soil is a mixture of limestone gravel and sediment

Figure 3a. Illustration of Arctomecon merriamii and regional distribution (insert) within Nevada (Mozingo and Williams 1980).

place fig. 3a here

Figure 3b. Distribution of Arctomecon merriamii in Ash Meadows, (diagonal stripe), Desert National Wildlife Refuge and vicinity.

place fig. 3b here

deposited in an old lake bed." In all sites but Ash Meadows, soils are limestone, and associated species are Haplopappus brickellioides, Agave utahensis, Gilia ripleyi, Perityle intricata, and Salvia funerea. Sites in Ash Meadows are on arid, alkaline soils with Enceliopsis nudicaulis var. corrugata, Mentzelia leucophylla, and Astragalus phoenix.

c. Regional geographic distribution.

Arctomecon merriamii has been collected in south-central Nevada for nearly one hundred years, but sites are sporadic, with low abundance at any one locale. Approximately 25 collections have been made on the Nevada Test Site, Nye County, with others known from Clark County (Cochrane 1978). Arctomecon merriamii is a regional endemic found in Clark and Nye counties, Nevada and adjacent Inyo and San Bernardino counties, California (see map insert on Fig. 2a). The species is distributed widely across southern Nevada, but nowhere is it found abundant or covering large acreage (Beatley 1977a).

d. Local geographic distribution.

Arctomecon merriamii is know from three areas within Ash Meadows (Fig. 2b).

(1) Purgatory Spring: In the knolls surrounding Purgatory Spring (unmapped) T17S R50E section 14. Only two individuals were noted in 1986.

(2) Collins Ranch: Site around Collins Ranch and directly east of the dirt road in T18S R50E section 1.

(3) County Road junction: The area where Death Valley

junction and Stateline roads intersect contained ca. 20 individuals during summer 1986. The intersection is formed from three directions with approximately two acres of land forming a central triangle. Most poppies are isolated on this remnant parcel, with a few being roadside and vulnerable to road grading.

2. Astragalus phoenix "Ash Meadows milk-vetch"

Astragalus phoenix (Fig. 4a) was first collected in 1898 by Carl Anton Purpus. His original specimen was fragmentary and left unnamed until better material was collected by Art Cronquist in 1966. The species was formally described by Rupert C. Barneby in 1970 (Barneby 1970).

a. Non-technical description

Astragalus phoenix is a long-lived, low, matted perennial composed of spreading branches that eventually form large, pulvinate mounds. Mature mounds may reach 5 dm across. Each mat bears a few short, erect stems that are terminated by 1, 2 or rarely 3 flowers. The flowers are 2 to 2.5 cm long, pink-purple when fresh and fading to purple when spent. The fruit is a small legume less than 2 cm long and 1 cm wide, holding approximately 30 light brown seeds. Flowering occurs in early spring, from March to late May with fruit forming in April and lasting to June-July. Both foliage and fruit are matted with dense, grayish hairs. The plants accumulate air-borne particles, becoming partially buried by maturity. Technical descriptions of Astragalus phoenix can be found in Barneby (1970) and Reveal (1978). The specific epithet means "born of ashes".

b. Habitat

Astragalus phoenix grows on and is restricted to flats and knolls of hard, dry alkaline clays in Ash Meadows. It is associated with Distichlis spicata var. stricta, Atriplex confertifolia, Mentzelia leucophylla, Haplopappus acradenius, and

Figure 4a. Illustration of Astragalus phoenix and regional distribution (insert) within Nevada (Mozingo and Williams 1980).

place fig 4a here

Figure 4b. Distribution of Astragalus phoenix (diagonal stripe) in Ash Meadows, Desert National Wildlife Refuge and vicinity.

place fig. 4b here

Enceliopsis nudicaulis var. corrugata. Ash Meadows milk-vetch is found between 2200 and 2300 feet in elevation.

c. Regional geographic distribution.

As known, Ash Meadows milk-vetch is restricted to Ash Meadows, Nye County, (see map insert on Fig. 4a) where it has evolved as an edaphic endemic (Barneby 1970, Beatley 1976).

d. Local geographic distribution.

Astragalus phoenix is known from six sites (Fig. 4b). These sites represent subpopulations of one historically larger, biological unit growing as edaphic endemics.

(1) Rogers-Longstreet springs: A large population is located between Rogers and Longstreet springs on both sides of the county dirt road in T17S R50E sections 14 and 15. The majority of the population lies in section 14, east of the dirt road that leads to Purgatory Spring (unmapped) in the center of section 14. The remaining plant population is dissected by dirt road access to both springs and now remnant agricultural fields.

(2) Old Rooker Ranch: A small population occurs on dry portions of the bluffs along the 2240 ft contour line in the center of section 21, T17S R50E. The county dirt road forms the western boundary, with the population extending sporadically to the east-bound dirt road along the quarter section towards Cold Spring (unmapped).

(3) Five-Chalk-Shaft springs: A scattered population occurs along the dry, undisturbed alkali knolls between Five Springs and Chalk/Shaft springs in T17S R50E sections 22, 23, and

26. Habitat betweeen sections 22 and 23 is broken by the dirt road and a fairly large abandoned clay mine in the southwest 1/4 of section 23.

(4) Collins Ranch: A relatively widespread population occurs on the habitat surrounding Collins Ranch spring. The spring/seep habitat still exists, but the ranch has been destroyed. The Ash Meadows milk-vetch occurs on arid knolls of sections 1 and 12, T18S R50E. This area is dissected by county dirt roads from Pahrump, Crystal, Amaragosa, and Stateline, intersecting at the corner of sections 1, 2, 11, 12.

(5) Jack Rabbit-Big springs: A large, but fragmented population occurs from south of Point of Rocks spring to north of Big Spring, T18S R51E sections 7, 18, and 19 and T18S R50E section 13. This population is dissected by current and historic flow patterns from the three spring complexes. Abandoned dirt roads and an old pipeline disrupt the habitat of this population. Easternmost critical habitat for Astragalus phoenix generally stops in this vicinity.

(6) North-South County Road: An area of fairly dense Ash Meadows milk-vetch occurs in T18S R50E sections 14 and 24, where it is broken by the main north-south county road from Death Valley junction. Much of the eastern portion of this habitat, especially section 24, has been disturbed by agricultural practices of private land owners.

3. Calochortus striatus "alkali mariposa"

a. Non-technical description

Calochortus striatus (Fig. 5a) is a glabrous perennial herb, rising from a corm. Stems are erect, 1-4.5 dm high; basal leaves 1-2 dm long, 6-8 mm wide. Flowers are subumbellate, one to several per stem, campanulate with a narrow base; with flower color being lavender with purple veins. Sepals are lanceolate, 1.5-2 cm long; petals obovate, cuneate, 2-2.5 cm long, sparsely hairy about the gland; the gland is oblong, not depressed and covered with linear processes. Capsule is linear, angled, erect, 4.5- 5 cm long. Seeds are flat, light colored, and reticulate (Munz and Keck 1959:1350).

b. Habitat

The alkali mariposa is found in open, alkali meadows and spring locations from 2500 to 4300 feet in creosote bush scrub vegetation of the Mojave Desert. Associated plants include Distichlis spicata var. stricta, Cleomella brevipes, Iva acerosa, Anemopsis californica, and Dodecatheon pulchellum var. pulchellum. Flowering is from April to May.

c. Regional geographic distribution

The alkali mariposa is found sporadically in the Mojave Desert of California and Nevada (see map insert on Fig. 5a). In southern California, it has been found in four counties around seeps. It is known from two locations in Nevada: Calico Spring in Clark County and Ash Meadows, Nye County. Calochortus striatus has rarely been collected in Nevada and is not seen at

Figure 5a. Illustration of Calochortus striatus and regional distribution (insert) within Nevada (Mozingo and Williams 1980).

place fig. 5a. here

these locations every year (Mozingo and Williams 1980).

d. Local geographic distribution

Calochortus striatus is known from one site in Ash Meadows (Fig. 5b).

(1) Collins Ranch spring: The mariposa lily has been found at only one location on the refuge, at T18S R50E section 1. Calochortus does not appear to bloom every year, however, in April 1987 the alkali mariposa was a noticeable part of the spring flora.

Figure 5b. Distribution of Calochortus striatus (diagonal stripe) in Ash Meadows, Desert National Wildlife Refuge and vicinity.

place 5b here

4. Centaurium namophilum "spring-loving centaury"

This taxon (Fig. 6a) was first collected by Coville and Funston in 1891 while on the Death Valley expedition. The specimen collected was in poor shape, with no flowers and shattered fruit. Two varieties were described for the species, with C. n. var. nevadense (Broome 1981) being lumped under C. exaltatum in the Intermountain Flora (Cronquist et al. 1984). C. namophilum was maintained as a readily distinguishable endemic taxon.

a. Non-technical description

Centaurium namophilum is an erect, annual herb, up to 5 dm tall with flowering stems borne from the base and flowering lateral branches. Stems and herbage are glaucous. Leaves are opposite, not forming basal rosettes, entire, linear, sessile and up to 5 cm long and 5 mm wide. Stems are yellowish to tannish with internodes up to 4 cm long. Inflorescences extend more than half the length of the plant, are paniculate-cymose, and mostly trichotomously branched. Bracts subtending the flower are minute (1 mm), opposite and becoming longer at lower nodes. The calyx is tubular, 7-8 mm long, the 5 segments linear-oblanceolate, united one-quarter of the tube length, green with a thin hyaline margin. The corolla is salverform, 7-8 mm long, greenish except for a yellowish tubular portion below the petals. Flowers are deep rose-pink above and below; the throat is yellowish with five dark purplish spots below the juncture of

Figure 6a. Illustration of Centaurium namophilum and regional distribution (insert) (Mozingo and Williams 1980).

place fig. 6a here

adjacent petals. Stamens are conspicuously exserted, anthers golden yellow, linear, about 3 mm long and becoming spirally twisted following pollen release. Capsules at maturity are narrowly fusiform, 7-8 mm long. The seeds are black, rectangular, and number less than 50 per capsule. Flowering occurs from July to September, with fruiting into October.

b. Habitat

Spring-loving centaury occurs in wet meadows or along seeps and springs in highly alkaline clay soils. Where found, it occurs in abundance and is associated with Cordylanthus tecopensis, Distichlis spicata var. stricta, Baccharis emoryi, Fraxinus velutina, and Prosopis.

c. Regional geographic distribution

Historically, Centaurium namophilum existed at Furnace Creek and Tecopa Springs, Inyo County, California (see map insert on Fig. 6a). These California sites are now believed extinct, leaving Ash Meadows as the only known living populations.

f. Local geographic distribution

Six centaury populations occur in Ash Meadows (Fig. 6b). They are generally defined by drainage patterns of spring complexes in the north, central and southern portions of the refuge.

(1) Purgatory-Rogers-Longstreet-Five springs-North Carson Slough: A widespread population follow seeps and outflow from these springs on into north Carson Slough, in T17S R50E sections 14, 15, 16, 20, 21, 22, and 23. Much of this habitat has been

Figure 6b. Distribution of Centaurium namophilum (diagonal stripe) in Ash Meadows, Desert National Wildlife Refuge and vicinity.

place fig 6b here

disturbed for economic development, e.g. alfalfa fields and peat mining. Thus, present distribution patterns along the main slough drainage has been disrupted. Since the change in land use within the refuge by U.S. Fish and Wildlife Service, populations are appearing to "invade" into previously unpopulated sites and on disturbed soils.

(2) Scruggs-Mary Scott-Indian-School-Crystal-Marsh springs: This complex of springs is in T17S R50E sections 34 and 35 and T18S R50E sections 2 and 3 and drains from central Ash Meadows into the southern end of Carson Slough in T18S R50E sections 7, 8, 9, 10, 15, 16, 17, and 18. In the slough Centaurium is fairly ubiquitous. With continued spring flow, this species may eventually be distributed south to the California-Nevada border.

(3) Unmapped seep west of the County Road: A small population of Centaurium occurs along the 2200 ft contour line in T18S R50E sections 14 and 23 where a seep is exposed along the ground surface.

(4) Point of Rocks Springs: A small population occurs at Point of Rocks Springs in T18S R51E section 7 and along the drainage into section 12. This spring area has been significantly altered with numerous ponds being created to build a community park.

(5) Jack Rabbit-Big springs: A widespread population occurs from Jackrabbit Spring in T18S R51E section 18 to Big Spring in T18S R51E section 19 where the habitat is moist from

subsurface drainage. This population extends westward from the springs into sections 23 and 24, following the drainage pattern to Carson Slough.

(6) Last Chance-Bole-Brahma springs: Small, sporadic occurrences of Centaurium can be found at these isolated springs in the southeast corner of the refuge in T18S R51E sections 20, 29, and 30. All of these springs have been altered. Bole Spring, privately owned, has several structures and piled construction debris, all highlighted by bright pink blossoms of the spring-loving centaury.

5. Cordylanthus tecopensis "Tecopa birds-beak"

Originally, Cordylanthus tecopensis (Fig. 7a) was collected by William Shockley in 1888 but the specimen remained unidentified until Chuang and Heckard's (1973) monographic work on the genus Cordylanthus.

a. Non-technical description

Cordylanthus tecopensis is an hemiparasitic, halophytic annual reaching 15-30 cm tall, divaricately branching throughout. The herbage is grayish, glaucous, sometimes tinged with purple. Leaves are 5-15 mm long, 1-2 mm broad, linear-lanceolate to subulate, and entire. The inflorescence is a loose spike, 2-6 cm long, 1-1.5 cm broad. Floral bracts are 10-13 mm long, 3-5 mm broad, ovate-lanceolate with a pair of linear-lanceolate lobes near the middle. The calyx is lanceolate, 1-1.3 cm long, puberulent, especially along margins, the apex divided to 1 mm. The corolla is 10-15 mm long, exceeding the bracts and calyx, pale lavender and densely puberulent throughout. Functional stamens are 2, the style is filiform. Capsules are oblong, 7 mm long; seeds are 2-3 mm long, irregularly reniform, deeply reticulate and light brown, with 8-10 seeds per capsule (Chuang and Heckard 1971, Munz and Roos 1950). Flowering is from July to October (Chuang and Heckard 1973).

b. Habitat

Tecopa birds-beak occupies alkaline meadows and flats at 2000 to 2700 feet elevation along bottomlands of the Amaragosa River drainage in California and Nevada. It also occurs

Figure 7a. Illustration of Cordylanthus tecopensis and regional distribution (insert) within Nevada (Mozingo and Williams 1980).

place fig 7a here

approximately 150 miles to the north in Fish Lake Valley, Nevada 4700 feet (Mozingo and Williams 1980). Cordylanthus tecopensis grows with Distichlis spicata var. stricta in all cases as is typical of the subgenus Hemistegia (Chaung and Heckard 1971). Chaung and Heckard (1971) suggested that Distichlis is its principal host. Other associates are Cirsium mohavense, Juncus balticus, Haplopappus acradenius, and Centaurium namophilum.

c. Regional geography

Cordylanthus occus on alkaline meadows and bottomlands of the Amaragosa River drainage, east of Death Valley in California and Nevada and in Fish Lake Valley, Nevada (see map insert on Fig. 7a).

d. Local geography

Six populations occur in Ash Meadows, each following major drainage patterns of the springs (Fig. 7b).

(1) South Carson Slough: Two low relief populations occur along Carson Slough, in areas of historic drainage and in sites where more recent rerouting of water has occurred in T18S R50E sections 7, 8, 9, and 17.

(2) Scruggs-Marsh-Crystal Pool springs: Dense populations occur along drainages of these central Ash Meadows springs and seeps in T17S R50E sections 34 and 35 and T18S R50E sections 2, and 3.

(3) Amaragosa Reservoir: A large population occurs in the seepage below Amaragosa Reservoir in T18S R50E sections 9, 10, 15, and 16.

Figure 7b. Distribution of Cordylanthus tecopensis (diagonal stripe) in Ash Meadows, Desert National Wildlife Refuge and vicinity.

place fig 7b here

(4) Collins Ranch: Cordylanthus occurs sporadically in seeps around Collins Ranch in T18S R50E section 1.

(5) Point of Rocks-Jack Rabbit-Big springs: Tecopa birds-beak occurs in drainages from Point of Rocks south to Big Spring in T18S R51E sections 7, 18, and 19. It also follows drainages from these springs westward into T18S R50E sections 23 and 24.

(6) Bole Spring: A small population occurs around Bole Spring in T18S R51E section 30.

6. Enceliopsis nudicaulis var. corrugata "Ash Meadows sunray"

a. Non-technical description

Enceliopsis nudicaulis var. corrugata (Fig. 8a) is a clump-forming perennial growing from a woody rootstock. The leaves are relatively small, 1-2 cm long, densely tomentose and strongly ruffled along the margins. Leafless stalks rise up to 4 dm to support singular flowers with 11 to 23 ray florets. Distinctive characteristics of this variety include the leaves, which are corrugate-ruffled, and the limited and distinct habitat of hard, whitish, alkaline soils.

b. Habitat

The variety corrugata has a distinctive and limited habitat, occurring in strongly alkaline, poorly drained soils in the Larrea zone (Beatley 1971). Ash Meadows sunray is geographically peripheral to the more widespread var. nudicaulis. Variety nudicaulis has entire and longer leaves, occuring on well-drained soils in the Artemisia zone. Ash Meadows sunray grows with Astragalus phoenix, Atriplex confertifolia, Haplopappus acradenius, Arctomecon merriamii and Cryptantha confertifolia.

c. Regional geography

Enceliopsis nudicaulis var. corrugata is a strict Ash Meadows endemic (see map insert on Fig. 8a). It is found throughout the refuge and is the most widespread of the rare species.

d. Local geography

Three subpopulations of Ash Meadows sunray can be defined

Figure 8a. Illustration of Enceliopsis nudicaulis var. corrugata and regional distribution (insert) within Nevada (Mozingo and Williams 1980).

place fig 8a here

Figure 8b. Distribution of Enceliopsis nudicaulis var. corrugata (diagonal stripe) in Ash Meadows, Desert National Wildlife Refuge and vicinity.

place fig 8b here

(Fig. 8b). Habitat destruction and mineral development has broken the hard, xeric, alkali clay slopes of the upland topography into sporadic patterns. Where found, Enceliopsis is generally a common component of the perennial flora. Much of the lower elevation alkali clay soils have an underlying watertable making the habitat inappropriate for Enceliopsis distribution. This is particularly true along the western and southern borders of the refuge.

(1) Rogers-Purgatory-Longstreet springs: Habitat in this northeastern location is variably disturbed from clay mining and off road vehicle (ORV) use. The population lies in T17S R50E sections 11, 14, and 15, as well as the northern portion of sections 23 and 26.

(2) Central Ash Meadows: A very large, somewhat fragmented population occurs from the terrace overlooking Old Rooker Ranch to Collins Ranch and southwest to Amaragosa Reservoir in T17S R50E sections 21, 22, 23, 26 27, 28, 33, 34, and 35; T18S R50E sections 2 and 3; and T18S R51E sections 1 and 12. This area is riddled with roads, ORV tracks, agricultural fields, and other human-mediated disturbances.

(3) Southeast Ash Meadows: Enceliopsis populations and habitat run from west of the county dirt road, in T18S R50E sections 13 and 14, to Jack Rabbit Spring in T18S R51E sections 7 and 18 and south nearly to Big Spring. The area is disturbed by county and private roads, private ranches and natural and altered drainage patterns from the springs.

7. Grindelia fraxino-pratensis "Ash Meadows gumplant"

a. Non-technical description.

Grindelia fraxino-pratensis (Fig. 9a) is an erect biennial or short-lived perennial taprooted herb, 7 to 10 dm tall with 1 to several stems rising from a woody root stock. The plants are openly branched with conspicuously resinous punctate leaves throughout. Stems are light to red brown, glabrous, leafy and branched in the upper half. Leaves are narrow, 2-7 cm long and 5-12 mm wide, dark green, leathery and resin-coated. They are sticky to touch. Basal leaves are longer and wider than stem leaves. The leaf margin is entire to faintly toothed at the tip. The inflorescence is openly branched with several heads on terminal branchlets. Individual flowering heads are many, 8-10 mm in diameter with overlapping resin-dotted phyllaries and golden to lemon-yellow florets (Reveal and Beatley 1971, Cochrane 1981). In bud, the disk flowers are covered with a white gumlike substance, hence the common name "gumplant". Achenes are 2.5-3.5 mm long with 2 stout awns 3-4 mm long. Immature plants may be confused with Baccharis emoryi "coyote bush".

b. Habitat

Grindelia is found in moist clay soils in open meadows and borders of scrub woodland and occasionally is weedy in disturbed areas. Best population development is on moist intact soils. It is rather widely distributed over Ash Meadows, usually in small, local populations. Grindelia occurs most frequently in the southern half of the refuge where it is associated with salt-

Figure 9a. Illustration of Grindelia fraxino-pratensis and regional distribution (insert) within Nevada (Mozingo and Williams 1980).

place fig 9a here

encrusted, alkaline, heavy clay soils indicative of spring activity (Cochrane 1981). In these saturated areas, Grindelia fraxino-pratensis achieves its most robust development. The gumplant is not found on rocky, sandy, arid upland sites in Ash Meadows. Ash Meadows gumplant is locally abundant and associated with Distichlis spicata var. stricta, Atriplex confertifolia, Iva acerosa, Haplopappus acradenius, Fraxinus velutina, Baccharis emoryi, Centaurium namophilum, and Cordylanthus tecopensis.

c. Regional geography

Grindelia fraxino-pratensis is a strict Ash Meadows endemic (see map insert Fig. 9a).

d. Local geography

Ash Meadows gumplant appears to be distributed widely over Ash Meadows (Fig. 9b) with populations centered around moist areas. Population expansion is expected with the cessation of land disturbance practices.

(1) Scruggs-Indian-Crystal Pool springs: Grindelia appears with scattered coverage along seeps and spring outflow throughout the central spring complex in T17S R50E section 35; T18S R50E sections 2 and 3.

(2) Collins Ranch: A few sporadic occurrences are located around Collins Ranch seep and east of the county road in T18S R50E section 1.

(3) County Road-Tubbs Ranch: Seeps and water diversions in south Ash Meadows provide habitat for Grindelia. Here, population density varies with more robust individuals occurring

Figure 9b. Distribution of Grindelia fraxino-pratensis (diagonal stripe) in Ash Meadows, Desert National Wildlife Refuge and vicinity.

place 9b here

where water flow is more constant and pooled along the 2160 foot contour line in T18S R50E section 14 and 23, and SW 1/4 of section 24. Some of this habitat showed trampling from horses, with pronounced destruction occuring in sections 22 and 23, making much of the population in section 22 appear isolated. Altered spring flow, originating at Jack Rabbit and Big springs probably followed a course through this population in earlier times.

(4) Jack Rabbit Spring: A few, sporadic Grindelia occur along the spring outflow in T18S R51E section 18.

(5) Crystal Pool/Amaragosa Reservoir: A large robust population of Grindelia occurs in seeps along the east and "downstream" side of the reservoir in T18S R50E sections 2, 10, 11, and 15. The majority of this population lies in a woodland of Fraxinus and Prosopis.

(6) South Carson Slough: An extensive population of Grindelia occurs in Carson Slough in T18S R50E sections 4, 5, 7, 8, 9, 16, 17, 18, 19, 20, 29, and on into California in T26S R6E section 30. In the slough, Grindelia grows on Distichlis-Cordylanthus meadows that are relatively higher in topography than the adjacent, interspersed Nitrophila habitat. Soils in the Slough are moist from natural drainage contributed by almost all of the springs in Ash Meadows. In this portion of the Slough disturbance is mainly from trampling by horses and burros. In some areas the ground is completely pitted by hooves.

(7) Garner Ranch: The Garner Ranch population in T18S R50E

section 3 was not found in 1986 or 1987. Further searching should be done at this site.

(8) Chalk-Shaft springs: Both springs in T17S R50E section 26 have limited outflow with Distichlis meadows immediately adjacent to the springs. Here Grindelia grows along the spring margins.

(9) Old Rooker Ranch: A sparse population occurs at the bluff along contour line 2240 in T17S R50E section 21, where it grows with Distichlis, Cordylanthus, and Ivesia along seeps.

8. Ivesia eremica "Ash Meadows mousetails"

Ivesia eremica (Fig. 10a) was first discovered by Coville and Funston on March 2, 1891 near Watkins Ranch. The Ivesia was collected mid-winter with remains of spent flowers and was thought to be Potentilla santolinoides. Coville and Funston found the Ivesia only in one location east of Watkins/Collins Ranch in an alkaline limestone marsh with Spartina gracilis, Anemopsis californica, and Schoenus nigricans (Beatley 1977a).

a. Non-technical description

Ivesia eremica is a prostrate perennial herb, 2-4 dm tall, growing from an erect thick woody root that bears a basal tuft of grayish, pubescent leaves. The leaves are pinnately compound with 60 pairs of imbricate leaflets covered by an appressed-hirsute tomentum. The inflorescence is a cyme, the pedicels 5-15 mm long, bearing a few, small, white flowers. The hypanthium is puberulent to glabrate, saucer-shaped, 3 mm broad. Petals are white, obovate, exceeding the sepals. Taxonomy of this species and genus is controversial (Federal Register 50(97): 20780). A revision of the Horckelia-Ivesia-Potentialla complex is expected in the near future (Ertter, pers. comm.[3]).

b. Habitat

In Ash Meadows, Ivesia eremica grows on alkali clay soils heavily saturated by seeps and springs. Ivesia is associated with Distichlis spicata var. stricta, Centaurium namophilum, Haplopappus acradenius, Spartina gracilis, Juncus balticus and

[3] Ertter, Barbara. Letter dated April 1987.

Figure 10a. Illustration of Ivesia eremica and regional distribution (insert) within Nevada (Mozingo and Williams 1980).

place fig 10a here

Cordylanthus tecopensis.

c. Regional geography

Ivesia eremica is restricted to Ash Meadows (see map insert Fig. 10a).

d. Local geography

Seven populations are located in Ash Meadows (Fig. 10b).

(1) Old Rooker Ranch: In T17S R50E, Ivesia extends along the bluff at the 2240 foot contour line in the center of section 21. Here it occurs with Centaurium and Grindelia in seeps. The area is surrounded by arid soils with Astragalus phoenix and Enceliopsis nudicaulis var. corrugata.

(2) Shaft-Chalk springs: A small population of mousetails occurs in local Distichlis-Centaurium meadows around the two springs in T17S R50E sections 23 and 26.

(3) Mary Scott-Indian-School-Crystal Pool springs: Ivesia occurs along spring outflow and seeps from this complex in central Ash Meadows in T17S R50E section 35 and T18S R50E sections 2 and 3.

(4) Crystal Pool/Amaragosa Reservoir: A fairly large population occurs along northern shorelines and marshes extending south out of the Amargosa Reservoir. The Ivesia population is dense, intermingling with Centaurium, Distichlis, and Fraxinus in T17S R50E sections 2, 3, and 10. Sections 2 and 3 have been criss-crossed by people attempting to gain access to the reservoir and boat launch.

Figure 10b. Distribution of Ivesia eremica (diagonal stripe) in Ash Meadows, Desert National Wildlife Refuge and vicinity.

place fig 10b here

(5) Collins Ranch: There are sporadic occurrences of Ivesia in T18S R50E section 1 and 12 in marsh areas and seeps around Collins Ranch.

(6) Bluffs west of County Road: Ash Meadows mousetails can be located on the bluffs approximately 0.5 miles west of the County Road along the 2200 foot contour line. It is found adjacent to seeps with Fraxinus velutina, Distichlis spicata var. stricta, and Centaurium namophilum in T18S R50E sections 14, 22, and 23. Drainage from Big Spring apparently influences water levels in the southern half of sections 22 and 23.

(7) Tubbs-Love ranches: A small remnant area of Ivesia occurs in disturbed, channelized soils along the private ranch access road in T18S R50E section 24 that is drained by Big Spring.

9. Mentzelia leucophylla "Ash Meadows blazing-star"

Mentzelia leucophylla (Fig. 11a) was first collected in 1898 by Carl Purpus and not collected (recognized) again until the 1970's (Darlington 1934, Reveal 1977). Purpus' collection was "lumped" under M. oreophila by Darlington (1934) and Abrams (1951). The reverse synonomy (M. oreophila under M. leucophylla) was published by Jepson (1936) and Munz and Keck (1959). Taxonomic difficulties plagued the species and its interpretation as rare until Reveal's status report (1977, 1978).

a. Non-technical description

Mentzelia leucophylla is an erect biennial herb, ca. 5 dm tall, with several pubescent stems per rosette. Stems are covered with a white epidermis that peels in long segments. Leaves are mainly basal, linear-oblong, 6-8 cm long, 1 cm wide, rigid, densely tomentose with strongly revolute margins. Upper and lower leaf surfaces are covered with short, rigid, barbed hairs and minute glochidiate hairs along the margins. Cauline leaves are oblong, 4 cm long, 1-1.5 cm wide, rounded at the apex and cordate-clasping at the base. Flowers are few, small, bright yellow, opening only briefly, 1-8 mm long in a divaricately branching panicle. Calyx is triangular-acuminate, 6 mm long; petals broadly spathulate, 10 mm long, producing a capsule about 1.5 cm long. Seeds are flat and narrowly margined. Flowering is from June to September.

Figure 11a. Illustration of Mentzelia leucophylla and regional distribution (insert) within Nevada (Mozingo and Williams 1980).

place fig 11a here

b. Habitat

Mentzelia occurs on hard, dry, alkaline, undisturbed soils in arroyos, canyon washes and near spring areas, but is not associated with saturated soils. Associated species include Atriplex confertifolia, Cryptantha confertifolia, Haplopappus acradenius, and Enceliopsis nudicaulis var. corrugata. This plant species is probably the rarest taxon of the Ash Meadows ensemble.

c. Regional geography

Mentzelia leucophylla is considered an Ash Meadows endemic (see map insert Fig. 11a), with other questionable specimens falling under Mentzelia oreophila (Reveal 1977; 1978). Few individuals occur at any one site, with a total of 30 seedlings (rosettes) observed in 1986. Fewer than 200 individuals are estimated on the entire refuge. This estimate appears accurate, but Ash Meadows blazing-star blends well into the landscape, thus some individuals may be missed.

d. Local geography

Four populations are thought to occur in the refuge (Fig. 11b) and vicinity.

(1) Purgatory Spring: Mentzelia occurs on undisturbed hard pans to the north and east of Purgatory Spring in T17S R50E section 14. It occurs with Arctomecon merriamii, Enceliopsis nudicaulis var. corrugata, and Atriplex confertifolia.

(2) Old Rooker Ranch-Cold Spring: Mentzelia is thought to occur on arid bluffs to the north and east of Old Rooker Ranch in

Figure 11b. Distribution of Mentzelia leucophylla (diagonal stripe) in Ash Meadows, Desert National Wildlife Refuge and vicinity.

place fig. 11b here

sections 21 and 28 and east of the 2240 foot contour line in sections 16, 21, and 22, T17S R50E. Mentzelia was not found in this area in 1986 or 1987.

(3) North County Road: This population is divided between the County road about 0.25 mile southwest of Five Springs at T17S R50E sections 22 and 23. Mentzelia leucophylla was not found at this site in 1987.

(4) Marsh to Bradford springs: A large, sporadic and dissected population occurs on arid bluffs surrounding the major spring complex in central Ash Meadows from Marsh to Bradford to Collins Ranch Spring in T17S R50E sections 35, 36 and T18S R50E sections 1, 2, 11, and 12. Mentzelia was only seen in swales southwest of Collins Spring in T18S R50E section 1. It was not located around Bradford Spring, sections 11 and 12, due to past agricultural development. Mentzelia was not observed in the Marsh-Mary Scott-School springs vicinity.

10. Nitrophila mohavensis "Amaragosa niterwort"

Nitrophila mohavensis was first collected by Philip Munz and John Roos on June 13, 1954 in open flats of the Amaragosa Desert, Inyo County, California (Munz and Roos 1954). This, the only known location, consisted of an area of approximately 2 square miles along the road from Death Valley Junction to Ash Meadows. The distributional range was expanded when Nitrophila was found in the Nevada portion of Ash Meadows by Donald W. Sada on March 20, 1984 (Sada 1986, pers. comm.). No illustration is available for the Amaragosa niterwort.

a. Non-technical description

Nitrophila mohavensis is an erect, long-lived perennial herb growing to 0.5 to 1 dm tall, with extensive underground rootstocks. Leaves are opposite, thick, amplexicaul, light green, round and small, about 0.2-0.3 cm long. Flowers are solitary, hidden in leaf axils and sessile. Calyx lobes are oblong-ovate, 2 mm long, rose colored when fresh (Munz and Roos 1955), but drying brownish and papery. Fruits are small with round, shiny black seeds. Flowering occurs from late April through June, fruiting from June to September (Reveal 1978b).

b. Habitat

Nitrophila mohavensis is found locally abundant in the Carson Slough in both California and Nevada in heavily alkaline, moist clay soils. When found, it is locally dominant and edaphically restricted. It is considered to represent part of the "climax" assemblage of Ash Meadows (Beatley 1977, Reveal

1978b). Populations are surrounded by Distichlis spicata var. stricta, Cleomella brevipes, and Atriplex confertifolia. However, Nitrophila is generally the only species growing in the immediate habitat. The species is restricted to the Amaragosa River drainage, specifically Carson Slough where it depends on the discharge from various springs in Ash Meadows (Reveal 1978b). Disruption of water flow or disturbance of the mineral-encrusted clay soils may be of special concern to the survival of this species.

c. Regional geography

Ash Meadows niterwort is an endemic to the Carson Slough area of Ash Meadows (Fig. 12a) and is known from Tecopa Hot Springs in California

d. Local geography

Two populations are given for the Amaragosa niterwort (Fig. 12a). It is more likely that this is one large population, an artifact of inaccessability and management across political boundaries.

(1) Central Carson Slough: A large, healthy population of Ash Meadows niterwort occurs in T18S R50E sections 8, 9, and 17. It is surrounded by dense populations of Cordylanthus, Grindelia, and Centaurium.

(2) South Carson Slough, CA: The major population and type locality of Nitrophila mohavensis, is located in T25S R6E sections 5, 6, 7, and 8. This area is bissected by Ash Meadows-Death Valley Junction Road.

Figure 12a. Distribution of Nitrophila mohavensis in Ash Meadows (diagonal stripe), Desert National Wildlife Refuge and vicinity.

place fig 12a here

Recommendations

A. Additional lands

We recommend that the following lands be included within the refuge boundaries.

1. T17S R50E section 14. Addition of section 14 would include Purgatory Spring (unmapped) and habitat for Arctomecon merriamii, Astragalus phoenix, Centaurium namophilum, Cordylanthus tecopensis, Enceliopsis nudicaulis var. corrugata, and Ivesia eremica.

2. T18S R50E section 7, the eastern 1/2, section 8, section 9 the southwest 1/4, the remainder of section 16, all of section 17, 19, and 20 and the eastern 1/3 of section 19. In California T26N R6E sections 29, 30, 31, and 32. This land area represents an extension of south Carson Slough that has subsurface drainage supporting Centaurium, Cordylanthus, Grindelia, Ivesia, and Nitrophila. Acquisition of the Nevada property would give continuity to the niterwort population known previously only from California.

3. T17S R50E section 26. Shaft and Chalk springs (unmapped) occur in the "gap" area of Devils Hole Range and have populations of Centaurium, Cordylanthus, Enceliopsis, Grindelia, and Ivesia.

B. Nuisance Areas

Areas of mesquite cutting were noted along the Carson Slough, near dwellings and around springs. Some cut stumps appeared "fresh" in 1986. Since the removal of major disturbance

activities in the refuge, Prosopis appears to be rapidly expanding its range. Mesquite grows on the same habitat as Tamarix and is much preferable as it is a native component of the Mojave Desert flora. Cutting of mesquite is unfortunate as the remaining open space provides habitat for tamarisk invasion, thus continuing the exotic problem. The presence of an on-site ranger would help ameliorate the problem of wood harvesting on the refuge.

A large trash dump was noted in T17S R50E section 20, approximately in the center of the section and south of the dirt road from Cold Spring. Relocation of this dump outside of the refuge would be a good project for honor camp crews.

Several Russian olive tree were located in Ash Meadows. These trees have invaded moist habitats throughout the United States (Olson and Knopf 1986) and have become insidious weeds when permitted to flourish. Figure 2 shows areas within the refuge where Russian olives occur. Because of the low tree numbers, it is felt that an immediate eradication program (and close follow up) could eliminate this species before it becomes a management problem.

C. Ideas for protection on a species-by-species basis

Populations of the more widespread species are not in danger of extirpation mainly because habitat disturbance throughout the refuge has been restricted. Species of more limited distribution are still vulnerable.

1. Arctomecon merriamii. The population at Purgatory Spring needs to be added to the refuge. Driving, if done in this area, should be along one designated road, with all others being permanently closed.

The population at the county roads junction (T17S R50E section 12) should be fenced. This area has been used for vehicle parking, camping and is vulnerable to road widening. Several poppies are now adjacent to the road margins and could be destroyed by road "improvements".

2. Mentzelia leucophylla. The population at Purgatory Spring needs to be added to the refuge and road access restricted.

Fencing should be placed along the county road in T17S R50E section 2, NE 1/4 SW 1/4 so that maintenance crews cannot continue to cut away road margins and visitors cannot accidentally drive over individuals by leaving the road. Twenty-six individuals were noted at this site in 1987.

3. Nitrophila mohavensis.

Sections of south Carson Slough should be added in T17S R50E, portions of sections 5, 7, 9, 16, and 18 as well as all of sections 8, 17, 19, and 20. This area provides crucial habitat for the niterwort and should be protected by inclusion into the refuge. Access should be prohibited across the slough in locations other than the already existing dirt road to Amaragosa Junction.

4. Calochortus striatus. One population of alkali mariposa is known in Ash Meadows. The site south of Collins Ranch Spring should remain inaccessible except for pedestrian activity.

Appendix A. Distribution of each plant species in the Ash Meadows vicinity for field use (see attached map tube).

Appendix B. List (Table 3) and map (Fig. 13) of geographic place names in Ash Meadows, Desert National Wildlife Refuge and vicinity.

Table 3. List of geographic place names in Ash Meadows and vicinity.

Springs

1 Big Spring (=Deep Spring)
2 Bole Spring
3 Bradford Spring
4 Brahma Spring
5 Chalk Spring
6 Cold Spring
7 Collins Spring
8 Crystal Pool (=Big Spring)
9 Devil's Hole
10 Fairbanks Spring
11 Five Springs
12 Forest Spring
13 Frenchy Spring
14 Indian Spring
15 Indian Seed Spring
16 Jack Rabbit Spring
17 Last Chance Spring
18 Longstreet Spring
19 Marsh Spring
20 Mary Scott Spring
21 Mexican Spring
22 Point of Rocks Springs
23 Purgatory Spring
24 Rogers Spring
25 School Spring (=Lovell's Spring)
26 Scruggs Spring (=Skruggs Spring)
27 Shaft Spring
28 Soda Spring
29 Tubbs Spring (=Bradford Spring 3)

Other Aquatic Areas

30 Amaragosa(=Crystal) Reservoir
31 Carson Slough
32 Horseshoe Reservoir
33 King's Pool
34 Mud Reservoir
35 Peterson Reservoir

Place Names

A Ash Meadows Headquarters
B Ash Meadows Rancho
C Collins (=Watkins?) Ranch
D Devil's Hole
E Garner Ranch
F Harris Ranch
G Jap Ranch
H Love Ranch
I Old Peterson Ranch
J Old Rooker Ranch
K Peterson Ranch
L Rooker Ranch
M Swink Ranch
N Tubbs Ranch

Figure 13. Map of geographic places in Ash Meadows and vicinity.

place fig 13 here

Appendix C. Checklist of vascular plant species in Ash Meadows, Desert National Wildlife Refuge, and vicinity.

Checklist of vascular plants of Ash Meadows refuge

GYMNOSPERMS

EPHEDRACEAE

Ephedra funerea Cov. & Mort.
E. torreyana S. Wats.

DICOTYLEDONS

AMARANTHACEAE

Amarantha albus L.
A. blitoides S. Wats.
A. retroflexus L.
Tidestromia oblongifolia (S. Wats.) Standl. var. oblongifolia

ANACARDIACEAE

Rhus trilobata Nutt. ex Torr. & Gray var. anisophylla (Greene)Jeps.
Berula erecta (Huds.) Cov.

APIACEAE

Hydrocotyle verticellata Thunb. var. verticellata

APOCYNACEAE

Amsonia brevifolia Gray
A. tomentosa Torr. & Frem.
Apocynum cannabinum L. var glaberrimum A.DC.

ASCLEPIADACEAE

Asclepias erosa Torr.
A. fascicularis Dcne in A. DC.
A. speciosa Torr.

ASTERACEAE

Ambrosia dumosa (A. Gray) Payne
Aster exilis Ell.
A. intricatus (A. Gray) Blake
A. pauciflorus Nutt.
Baccharis emoryi A. Gray
*Brickellia desertorum Cov.
Centaurea melitensis L.
Chaetadelphia wheeleri A. Gray
Chrysothamnus albidus (M.E. Jones) Greene

C. nauseosus (Pall.) Britton ssp. mohavensis (Greene) Hall
Cirsium mohavense (Greene) Petr.
C. vulgare (Savi) Airy-Shaw
Conyza canadensis (L.) Cronq.
C. coulteri A. Gray
Crepis runcinata (James) Torr. & Gray ssp. hallii Babc. & Steb.
Encelia frutescens A. Gray
LT Enceliopsis nudicaulis (A. Gray)A. Nels. var. corrugata Cronq.
Gnaphalium luteo-album L.
LT Grindelis fraxino-pratensis Reveal & Beatley
Gutierrezia microcephala (DC.)A. Gray
Haplopappus acradenius (Greene)Blake ssp. acradenius
H. a. ssp. eremophilus (Greene)Hall
H. brickellioides Blake
H. racemosus (Nutt.)Torr. ssp. sessiliflorus (Greene)Hall
H. a. ssp. lenticularis (Dougl.) Ckll.
Helianthus annuus L. ssp. jaegeri (Heiser)Heiser
H. nuttalii Torr. & Gray
Iva acerosa (Nutt.) Jacks.
Machaeranthera ammophila Reveal
M. tortifolia (A. Gray) Cronq. & Keck var. tortifolia
Monoptilon bellioides (A. Gray)Hall
Pleurocoronis pluriseta (A. Gray)King & Robinson
Pluchea purpurascens (Sw.)DC.
P. sericea (Nutt.)Cov.
*Prenanthella exigua (A. Gray)Rydb.
Psathyrotes annua (Nutt.) A. Gray
Solidago spectabilis (D.C. Eat.) A. Gray
Sonchus asper L.
Stephanomeria pauciflora (Torr.) Nutt.
Xanthium strumarium L. var. canadense (Mill.) Torr. & Gray

BORAGINACEAE

Cryptantha angustifolia (Torr.) Greene
C. confertiflora (Greene) Pays.
C. virginensis (M.E. Jones) Pays.
Heliotropium curvassavicum L. var. oculatum (Heller) Jtn.
Plagiobothrys stipitatus (Greene)Jtn.

BRASSICACEAE

Descurainia pinnata (Walt.) Britt. ssp. glabra (Woot. & Standl.) Detl.
D. sophia (L.) Webb.
Hutchinsia procumbens (L.) Desv.
Lepidium flavum Torr. var. flavum
L. fremontii S. Wats.
L. lasiocarpum Nutt.
L. montanum Nutt. ssp. cinereum (C.L. Hitchc.) C.L. Hitchc.
Rorippa nasturtium-aquaticum (L.) Schinz. & Thell.
Sisymbrium irio L.

Stanleya pinnata (Pursh.) Britt. var. inyoensis (Munz & Roos) Reveal
S. p. var. pinnata
Streptanthella longirostris (S. Wats.) Rydb.
Thelypodium integrifolim (Nutt.) Endl. ssp. affine (Greene) Al-Sheh-baz

CACTACEAE

Echinocactus polycephalus Engelm. & Bigel.
Echinocereus engelmannii (Parry) Lem. var. engelmannii
Opuntia basilaris Engelm. & Bigel. var. basilaris
O. echinocarpa Engelm. & Bigel.
O. ramosissima Engelm.

CAPPARACEAE

Cleome sparsifolia S. Wats.
Cleomella brevipes S. Wats.
C. obtusifolia Torr. & Frem.
Oxystylis lutea Torr. & Frem.

CARYOPHYLLACEAE

Scopulophila rixfordii (Bdg.) Munz & Jtn.

CHENOPODIACEAE

Atriplex canescens (Pursh.) Nutt. var. canescens
A. confertifolia (Torr. & Frem.) S. Wats.
A. hymenelytra (Torr.) S. Wats.
A. parryi S. Wats.
A. phyllostegia (Torr.) S. Wats.
A. polycarpa (Torr.) S. Wats.
A. torreyi (S. Wats.) S. Wats.
Bassia hyssopifolia (Pall.) Kuntze
Chenopodium album L.
Monolepis nuttaliana (Schult.) Greene
LE Nitrophila mohavensis Munz & Roos
N. occidentalis (Nutt.) Moq.
Salsola paulsenii Litv.
Sarcobatus vermiculatus (Hook.) Torr.
Suaeda intermedia S. Wats.
S. occidentalis S. Wats.
S. torreyana S. Wats. var. ramosissima (Standl.) Munz
S. t. var. torreyana

CONVOLVULACEAE

Convolvulus arvensis L.
Cressa truxillensis HBK.

CUSCUTACEAE

Cuscuta nevadensis Jtn.

ELAEAGNACEAE

Elaeagnus angustifolia L.

EUPHORBIACEAE

Euphorbia micromera Boiss.
E. parishii Greene
E. serpyllifolia Pers.

FABACEAE

LT Astragalus phoenix Barneby
A. preussii A. Gray var. preussii
Glycyrrhiza lepidota Pursh. var. glutinosa (Nutt.) S. Wats.
Medicago sativa L.
Melilotus albus Desr.
M. officinalis (L.) Lam.
Prosopis glandulosa Torr. var. torreyana (L. Benson) M.C. Jtn.
P. pubescens Benth.
Psorothamnus fremontii (Torr.) Barneby var. fremontii

GENTIANACEAE

LT Centaurium namophilum Reveal, Broome & Beatley

GERANIACEAE

Erodium cicutarium (L.) L'Her.

HYDROPHYLLACEAE

Nama pusillum Lemmon ex Gray
Phacelia calthifolia Brand

KRAMERIACEAE

Krameria parvifolia Benth.

LAMIACEAE

Salazaria mexicana Torr.

LOASACEAE

LT Mentzelia leucophylla Bdg.
M. obscura Thompson & Roberts
M. oreophila Darl.
Petalonyx thurberi A. Gray var. thurberi

LYTHRACEAE

Lythrum californicum Torr. & Gray

MALVACEAE

Sida hederacea (Dougl. ex Hook.) Torr. ex Gray

OLEACEAE

Fraxinus velutina Torr. var. coriacea (S. Wats.) Rehder

ONAGRACEAE

Camissonia boothii (Dougl.) Raven ssp. condensata (Munz) Raven
C. brevipes (A. Gray) Raven ssp. pallidula (Munz) Raven
C. claviformis (Torr. & Frem.) **??** ssp. funerea (Raven) Raven
C. heterochroma (S. Wats.) Raven
Guara parviflora Dougl. ex Hook.
Oenothera hookeri Torr. & Gray

PAPAVERACEAE

Arctomecon merriamii Cov.

PLANTAGINACEAE

Plantago insularis Eastw. var. fastigiata (Morris) Jeps.
P. major L.

POLEMONIACEAE

Gilia latifolia S. Wats.
Ipomopsis polycladon (Torr.) V. Grant
Langlosia punctata (Cov.) Goodd.
Langlosia schottii (Torr.) Greene
L. setosissima (Torr. & Gray) Greene

POLYGALACEAE

Polygala acanthoclada A. Gray

POLYGONACEAE

Chorizanthe rigida (Torr.) Torr. & Gray
Eriogonum brachypodum Torr. & Gray
E. contiguum (Reveal) Reveal
E. heermannii Dur. & Hilg. var. sulcatum (S. Wats.) Munz & Reveal
E. inflatum Torr. & Frem.
E. reniforme Torr. & Frem.
E. thomasii Torr.
E. trichopes Torr.
Polygonum argyrocoleon Steud. ex Kunze

PRIMULACEAE

Dodecatheon pulchellum (Ref.) Merr. var. pulchellum
Samolus parviflorus Raf.

RESEDACEAE

Oligomeris linifolia (Vahl) Macbr.

ROSACEAE

Ivesia eremica (Cov.) Rydb.

SALICACEAE

Populus fremontii S. Wats. var. fremontii
Salix exigua Nutt. ssp. exigua var. stenophylla (Rydb.)Schneid.

SAURURACEAE

Anemopsis californica Hook.

SCROPHULARIACEAE

Castilleja linariaefolia Benth. var. linariaefolia
Cordylanthus tecopensis Munz & Roos
Mimulus guttatus Fisch. ex DC var. guttatus
Veronica americana (Raf.) Schw.
V. anagallis-aquatica L.

SOLANACEAE

Datura meteloides A. DC.
Lycium andersonii A. Gray
L. pallidum Miers. var. oligospermum C.L. Hitchc.
L. shockleyi A. Gray
Solanum elaeagnifolium Cav.

TAMARICACEAE

Tamarix aphylla (L.) Karst
T. parviflora DC.
T. ramosissima Ledeb.

VISCACEAE

Phoradendron californicum Nutt.

VITACEAE

Vitis arizonica Engelm.

ZYGOPHYLLACEAE

Larrea tridentata (Sesse & Moc. ex DC) Cov.
Tribulus terrestris L.

MONOCOTYLEDONS

CYPERACEAE

Carex praegracilis W. Boott
Cladium californicum (S. Wats.) O'Neill in Tidestr. & Kittell.
Eleocharis parishii Britt.
E. rostellata (Torr.) Torr.
Fimbristylis thermalis S. Wats.
Schoenus nigricans L.
Scirpus olneyi A. Gray
S. robustus Pursh.

IRIDACEAE

Sisyrinchium demissum Greene

JUNCACEAE

Juncus balticus Willd.
J. cooperi Engelm.
J. nodosus L.

JUNCAGINACEAE

Triclochin concinnum Davy var. debile (Jones) J.T. Howell

LILIACEAE

Asparagus officinalis L.
Calochortus striatus Parish

NAJADACEAE

Najas marina L.

ORCHIDACEAE

Spiranthes romanzoffiana Cham. & Schlect

POACEAE

Agrostis semiverticellata (Forsk.) C. Christ.
Avena sativa L.
Bromus rubens L.
Distichlis spicata (L.) Greene var. stricta (Torr.) Scribn.
Echinochloa crusgalli (L.) Beauv.
Elymus cinereus Scribn. & Merr.
Festuca arundinacea Schreb.
F. pratensis Huds.
*Hordeum glaucum Steud.
H. vulgare L.
Leptochloa univervia (Presl.) Hitchc. & Chase
* Lolium perenne L.
Muhlenbergia asperifolia (Nees & Meyen) Parodi
M. utilis (Torr.) A.S. Hitchc.
Panicum virgatum L.
Phragmites australis (Cav.) Trin. ex Steud.
Poa scabrella (Thunb.)Benth. ex Vasey
Polypogon monspeliensis (L.) Desf.
Schismus arabicus Nees
Sorghum bicolor Pers. (L.) Moench.
Spartina gracilic Trin.
Sporobolus airoides (Torr.) Torr.

POTAMOGETONACEAE

Ruppia maritima L.

TYPHACEAE

Typha domingensis Pers.

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