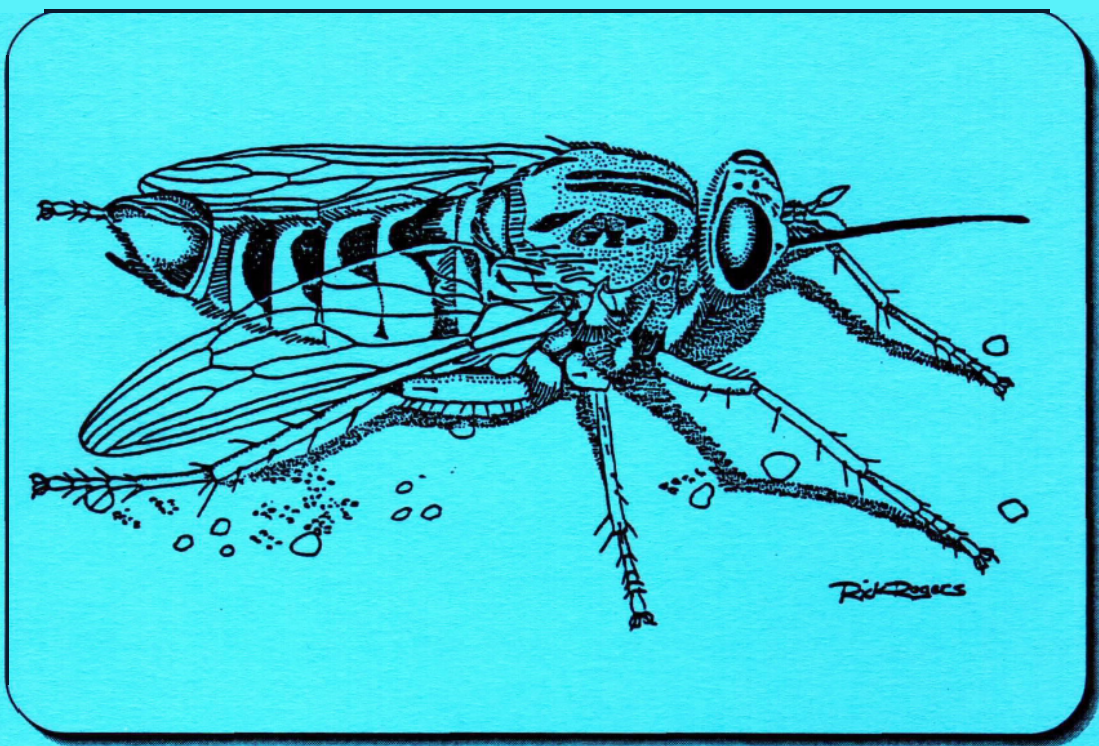




FINAL RECOVERY PLAN FOR THE DELHI SANDS FLOWER-LOVING FLY

1997

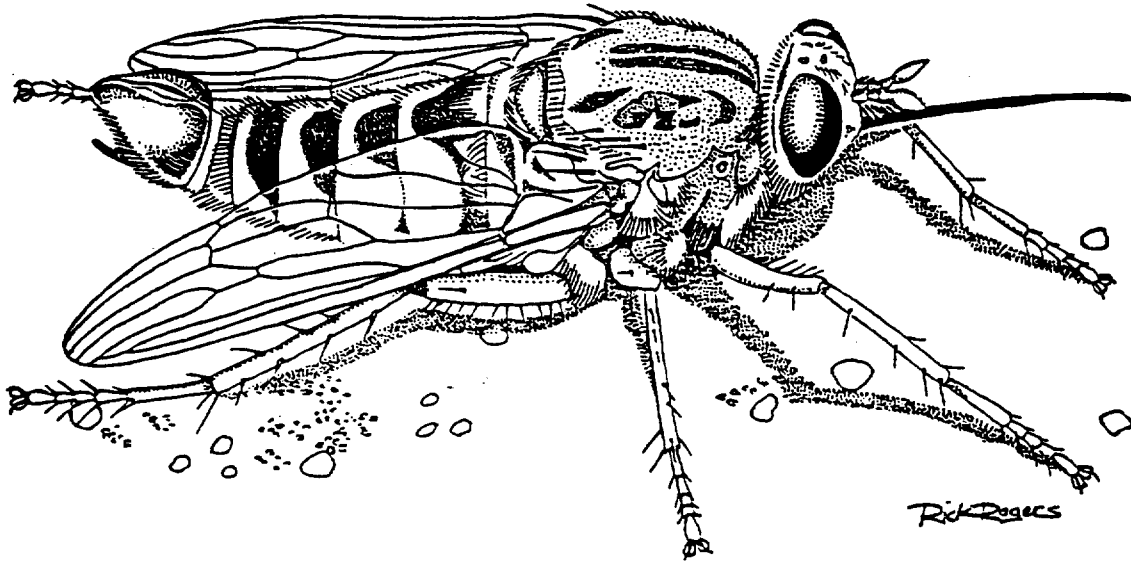
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DELHI SANDS FLOWER-LOVING FLY
(*Rhaphiomidas terminatus abdominalis*)

RECOVERY PLAN



Published by U.S. Fish and Wildlife Service

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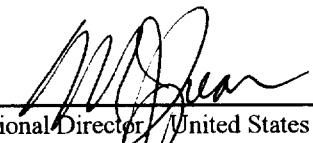
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and

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U.S. Fish and Wildlife Service

Approved: _____


Regional Director, United States Fish and Wildlife Service

Date: _____

9/14/97

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EXECUTIVE SUMMARY

Current Status: The number of individuals and the habitat of the Delhi Sands flower-loving fly has been dramatically reduced in recent years. It is listed as endangered, and occurs at twelve separate remnants of the Colton Dunes in San Bernardino County, California. Occupied habitat is secure at portions of only two of these sites. Some restorable habitat occurs in western Riverside County. An estimated 1,200 acres contain occupied or restorable habitat for this endangered species. Immediate action, as prescribed in this recovery plan, is needed to prevent the extinction of this animal.

Habitat Requirements and Limiting Factors: The Delhi Sands flower-loving fly is endemic to the Colton Dunes (Delhi series soils) in areas that contain suitable conditions for the subterranean early stages, adult nectar sources, and adult feeding, breeding, and perching areas. Soil and climatic conditions, and other ecological and physical factors contribute to the maintenance of open sand areas within the species' range. Urban development, agricultural conversion, sand mining, invasion by exotic species, dumping of cow manure and trash have caused significant loss and modification of the species' habitat. Other threats include off-road vehicles and collecting. Conservation needs include protection and management of occupied and restorable habitat, removal of exotic vegetation, captive breeding and release, and reduction of other threats to the species and/or its habitat.

Recovery Objective: Down-listing to Threatened status.

Recovery Criteria: The Delhi Sands flower-loving fly can be considered for reclassification to threatened status when:

- 1) At least eight populations in the three Recovery Units (RUs)—Colton, Jurupa, and Ontario—are permanently protected. The population that inhabits the largest remaining block of Colton Dunes (located east of Riverside Avenue, south of Interstate 10, north of the Santa Ana River, and west of the cement plant) must be protected. A total of at least four populations must be in the Colton RU; two of these located north of Interstate 10 (including the San Bernardino Hospital Reserve), and two south of Interstate 10. In the Jurupa RU, the Jurupa Hills population in the City of Fontana must be secured. The location of the remaining populations will be determined using information collected during implementation of this recovery plan. Dispersal corridors must be maintained between the populations.
- 2) The sites of all 8 populations and dispersal corridors connecting the sites are managed to maintain perpetual sand supply and sparse total native vegetative cover (no more than 20 percent) dominated by native species such as California buckwheat, California croton, and telegraph weed; and
- 3) As determined by scientifically credible monitoring, each of the eight populations must exhibit

a statistically significant upward trend for at least 15 years (approximately seven fly generations) and has an estimated adult population of at least 200 individuals.

- 4) The public is informed about the Delhi Sands flower-loving fly and its habitat and landowners are encouraged to cooperate to manage protected sites efficiently.

Actions Needed and their costs:

1. Protect existing habitat and determine species needs.	Cost:	\$215,000
2. Establish captive breeding and release program		218,000
3. Restore and manage habitat		653,000
4. Monitor populations		425,000
5. Coordinate with public		<u>92,000</u>
	total	\$1,603,000

The cost excludes land acquisition costs and operational costs for management of lands. If land acquisition is used to secure habitat for the species, costs will need to be determined.

Date of Downlisting: Downlisting may occur when management plans for each of three RUs are completed and implemented, and management has shown its effectiveness by maintaining recovery criteria for at least five consecutive years. Downlisting should occur in less than 20 years.

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PART I. INTRODUCTION

Overview

The number of individuals and the habitat of the Delhi Sands flower-loving fly (*Rhaphiomidas terminatus abdominalis*) has been dramatically reduced in recent years. Immediate management of its habitat and the initiation of a captive breeding program as prescribed in this recovery plan are needed to prevent this animal's extinction in the near future.

The Delhi Sands flower-loving fly is restricted (endemic) to the Colton Dunes (Delhi soil series) that once covered over approximately 40 square miles in northwestern Riverside and southwestern San Bernardino Counties in California. The historic range of the Delhi Sands flower-loving fly likely extended over much of this area. Recent studies show that more than 97 percent of the area containing Delhi series soil has been converted to agriculture, developed for urban or commercial uses, or otherwise adversely altered for the animal. Due to these human actions, the present distribution of the Delhi Sands flower-loving fly is less than two percent of its former range.

As of spring 1997, 12 sites are known to be inhabited by the Delhi Sands flower-loving fly, encompassing approximately 450 acres (190 hectares) of suitable habitat. Two additional sites likely are occupied but have not been recently surveyed, and two more recently occupied sites may no longer be extant (R. Mattoni, Univ. of Calif. Los Angeles, pers. obs.). Eight of the 12 presently documented populations (equivalent to the animals at an occupied site) appear to contain fewer than 20 breeding individuals (adults), 3 populations number fewer than 100 breeding individuals each, and only 1 population likely numbers more than 100 individuals. Densities of the Delhi Sands flower-loving fly are unknown, but are likely about 10 per acre (24 per hectare). By comparison, other species of *Rhaphiomidas* studied in desert scrub communities have standing densities exceeding 500 adults per acre (1,200 per hectare) (R. Mattoni, R. Rogers, and J. George, UCLA, unpublished data).

The Delhi Sands flower-loving fly was listed as an endangered species by the U. S. Fish and Wildlife Service (Service) on September 23, 1993 (58 **Federal Register** 49881). Critical habitat has not been designated for this species. The Service considers this species to have a high degree of threat and low potential for recovery, equivalent to a Recovery Priority of 6 (48 **Federal Register** 43098). This recovery plan attempts to reduce the risk of global extinction of the species by spreading protection across three separate Recovery Units (RUs) that include adequate habitat and area.

Taxonomy and Description

The Delhi Sands flower-loving fly is a large insect in the Dipteran family Mydidae. It has an elongate body, much like that of a robber fly (Asilidae), but unlike asilids, it has a long tubular proboscis (mouthparts)¹ that may be used, as in butterflies, for extracting nectar from flowers. The Delhi Sands flower-loving fly is approximately 2.5 centimeters (1 inch) long, orange-brown in color, and has dark brown oval spots on the upper surface of the abdomen. This animal is a strong fast flier, and, like a hummingbird, is capable of stationary, hovering flight.

The genus *Rhaphiomidas* formerly was considered to be a member of the fly family Apioceridae. However, recent taxonomic studies of the insect order Diptera indicate that it belongs in the family Mydidae (Sinclair, Cumming and Wood 1993; Woodley 1989; Ovchinnikova 1989; Yeates 1994). The distribution of *Rhaphiomidas* and the three related genera is unusual and indicates the group has great geological antiquity. The latter three genera are each found in South Africa, Chile, and Australia. This southern hemisphere distribution strongly indicates that the origin of these groups lies with a common ancestor that inhabited the southern landmass known as Gondwana before its breakup, caused by continental drift during the Mesozoic era more than 100 million years ago.

Rhaphiomidas is a North American genus of 19 species and 5 subspecies, which inhabit arid regions of the southwestern United States and northwestern Mexico (Cazier 1985, Peterson 1981, Rogers and Mattoni 1993). At least one species, the Acton flower-loving fly (*Rhaphiomidas acton*) is an important pollinator of the Santa Ana woolly star (*Eriastrum densifolium* ssp. *sanctorum*) (Muñoz 1991), a federally endangered plant (52 **Federal Register** 36265).

Rhaphiomidas terminatus consists of two subspecies, the El Segundo flower-loving fly (*Rhaphiomidas terminatus terminatus*) and the Delhi Sands flower-loving fly (*Rhaphiomidas terminatus abdominalis*) (figure 1). Specimens of *R. terminatus* were misidentified as *Rhaphiomidas episcopus* by D.W. Coquillett (1891) from Los Angeles, California. Townsend (1895) referred to these specimens as *Rhaphiomidas mellifex*. Cazier (1941) noted that both identifications were in error and used the specimens collected by Coquillett to describe *R. terminatus* as a new species. Later in the same publication, the Delhi Sands flower-loving fly was described as *Rhaphiomidas abdominalis*, based on an adult male collected in August 1888 in Colton, California. In 1941, when both *R. terminatus* and *R. abdominalis* were described, Cazier had only two specimens of each taxon available for examination, and these individuals appeared to represent distinct species. However, when the genus was revised (Cazier 1985), it was determined that *abdominalis* is a subspecies of *R. terminatus*, based on abdominal spot patterns and other

¹ Technical terms are explained in Appendix C at the end of this document.

morphological characters. Historically restricted to the El Segundo dunes and associated habitats, *Rhaphiomidas terminatus terminatus* is presumed extinct; thus, *Rhaphiomidas terminatus abdominalis* is the only extant representative of this species. A complete description and illustration of this subspecies can be found in Cazier (1985).

Geographic Distribution

All extant populations known of the Delhi Sands flower-loving fly occur within an 8-mile radius of each other. The distribution straddles Interstate 10 in the vicinity of Colton and Rialto, Riverside and San Bernardino Counties, California. One of the remaining population sites is on land owned by the County of San Bernardino, another is on land owned by a public utility, and portions of the largest remaining habitat are owned by a municipality. The remaining sites are on private land. Small patches of restorable habitat may exist in remnants of the Colton Dunes in the same counties.

Ecosystem Description

The most characteristic feature of all known sites of *Rhaphiomidas terminatus abdominalis* is their fine sandy soils, often wholly or partly sand dunes stabilized by the sparse native vegetation. The Colton dunes are the result of sand blown from the canyons in the San Gabriel and San Bernardino Mountains by the Santa Ana winds in the fall. Over the millenia, the dunes grew to cover some 40 square miles. Santa Ana winds continue to carry sand down from the mountains, but the dune system has largely been eliminated by urban development and agricultural conversion. The Colton dune soils are generally classified as the Delhi series (primarily Delhi fine sand). Delhi series soils cover about 40 square miles in several irregular patches extending from the city of Colton to Ontario and Chino in northwestern Riverside and southwestern San Bernardino Counties (U. S. Soil Conservation Service 1971, 1980).

The Delhi series soils are a biologically sensitive and very rare environment, and are inhabited by a number of plant and animal species of special concern. The region, also known as the Colton Dunes, is the largest inland sand dune formation in southern California, exclusive of the desert². The vegetation of these dunes has been defined as the Desert Sand-verbena series in Sawyer and Keeler-Wolf 1993. Plants on the Colton Dunes include California buckwheat (*Eriogonum fasciculatum* ssp.), California croton (*Croton californicus*), deerweed (*Lotus scoparius* var. *scoparius*), and California evening primrose (*Oenothera californica* ssp. *californica*). The habitat supports several plants and animals of limited distribution, including the legless lizard (*Anniella pulchra*), San Diego

² The flora and vegetation of “cismontane” California from the coast to the Sierra Nevada—also called the California Floristic Province—are distinct from the transmontane Desert and Great Basin floristic provinces. Hickman (1993) provides an overview.

horned lizard (*Phrynosoma coronatum blainvillii*), Delhi Sands metalmark butterfly (*Apodemia mormo* new subspecies), Delhi Sands Jerusalem cricket (*Stenopelmatus* new species), convergent apiocerid fly (*Apiocera convergens*), Delhi Sands sandroach (*Arenivaga* new species) and, potentially, Pringle's monardella (*Monardella pringlei*).

Much of the Colton Dunes area has been used for agriculture, chiefly grapes and citrus since the 1800's. More recently, nearly all the remaining area has been used for dairies, housing tracts, and commercial/industrial sites. Most of the remaining area with restoration potential is degraded to some degree. The present distribution of the Delhi Sands flower-loving fly represents less than two percent of its former range; the habitat existing today is approximately half of what existed in 1975 (Ballmer in litt. August 24, 1991). Before European settlement, the Delhi Sands flower-loving fly likely occurred throughout much or all of the Colton Dunes in San Bernardino and Riverside Counties, California, an assumption that is based on the animal's biology and records of museum specimens of the Delhi Sands flower-loving fly, which extend from the eastern margin of the Delhi sand formation in Colton to near its western limit in Mira Loma.

The other subspecies of *R. terminatus*, the El Segundo flower-loving fly, is almost certainly extinct. It was confined to the El Segundo sand dunes, the coastal prairie east of the dunes, and portions of the sandy alluvial plain of the Los Angeles River. This subspecies was recorded from Huntington Park near downtown Los Angeles in 1940, a region that had been connected to the El Segundo sand dunes via the corridor of the Los Angeles River when it discharged to the sea at Playa del Rey prior to 1830. The El Segundo subspecies was last collected in 1965 (Hogue 1967), although the animal likely continued to be present on a sand dune remnant in Hermosa Beach through the late 1960's (R. Rogers, pers. obs). The El Segundo sand dunes system has been virtually eliminated as a result of urban development (Mattoni 1992). The Airport Dunes and associated coastal dune fragment, which contained the last known viable habitat that could have supported a population of the El Segundo flower-loving fly was highly degraded by construction activities associated with the Los Angeles International Airport in the 1960's. Extensive surveys of the remaining El Segundo sand dunes have failed to produce any observations of this animal (Mattoni 1990).

Life History

The life history, ecology, and behavior of the Delhi Sands flower-loving fly and other members of the genus *Rhaphiomidas* were discussed by Rogers and Mattoni (1993). Kingsley (1996) summarized their work and several studies on members of the related fly family Apioceridae, and presented some additional observations made at the San Bernardino Hospital reserve.

The Delhi Sands flower-loving fly undergoes a complete metamorphosis (egg, larva, pupa, and adult)

(figure 2). The life span of this animal is unknown, but the larval stage may last two years or longer, depending on availability of food, temperature, rainfall, and other environmental conditions. The adults are active in the late summer and the early stages can be found throughout the year. Except for the adults, the animal spends its entire life cycle underground. The adults emerge and become active in the late summer.

Mating among the members of this genus was described by Rogers and Mattoni (1993). After mating, the females lay their eggs in suitable sandy soil. Rogers and Mattoni (1993) described their observations of two male and two female captive Delhi Sands flower-loving flies. The males lived for 3 days in captivity and would not eat. The females lived for 5 and 8 days, respectively. The females became active at 10:00 a. m. Pacific Daylight time (PDT) each day, regardless of light conditions and became inactive about 5:00 PDT, except when ovipositing.

One of the females was observed to oviposit at about 7:30 p. m. PDT. She laid a total of 40 eggs in the sand. The eggs were about 1.5 x 3 millimeters (less than 0.1 square inch), almost kidney-shaped, and pure white with a slight pink iridescence.

Female flower-loving flies possess specialized egg-laying organs on the last segment on their abdomens (acanthophorites). A single acanthophorite consists of a circle of strong spines that can be rapidly revolved to serve as a drill adapted to boring through sandy soils, enabling the abdomen to be inserted almost completely underground. The abdomen and the ovipositor are extensible and the eggs can be placed between 3 and 5 centimeters (1 to 2 inches) beneath the surface of the sand. This adaptation assures that the eggs are placed in a cooler and moisture environment than the surface of the sand. Most oviposition takes place in the shade of shrubs, such as the telegraph weed (*Heterotheca grandiflora*) (Rogers and Mattoni 1993). The larvae hatched from the eggs in 11 to 12 days.

The early stages of the Delhi Sands flower-loving fly are specialized for a fossorial (burrowing) existence in substrates with a high sand fraction. The body shape and structures enable the larva to burrow through the sand. The head of the pupa possess a large spine that may be useful in tunneling through the soil for emergence.

The larvae of the Delhi Sands flower-loving fly and two other *Rhaphiomidas* species were held in captivity by Rogers and Mattoni (1993). All items of food, including synthetic diets that were offered to the animals, were rejected. Rogers and Mattoni (1993) reported that captive larvae refused to feed on small beetle larvae collected from the sand dunes, fruit fly larvae, or sand dune cockroach nymphs. None of the fly larvae became cannibalistic, even when starving. The larvae all died within 15 days. It remains unclear as to whether the early stages of *Rhaphiomidas* are herbivores, detritivores, or carnivores.

Hogue (1967) described the emergence of an adult El Segundo flower-loving fly at a site in Hermosa Beach in 1965. Based on this and other observations, it appears that the pupae are located underground. Rogers and Mattoni (1993) found a large number of the pupal cases of three desert species of *Rhaphiomidas*. In all instances, the pupal cases were found on the surface of hardened sand in open areas at least 5 feet (1.5 m) from perennial plants. When they emerge, the pupae extend only their anterior half from the soil substrate, creating distinctive emergence holes that are clearly not the burrows of other animals.

The flight season of the Delhi Sands flower-loving fly extends from early August to early September. The adults are active during the warmest portions of the day during periods of direct sunlight, generally from 10:00 a. m to 2:00 p. m. PDT (Ballmer in litt. August 24, 1991). Adults have not been observed to fly during cloudy, overcast, or rainy conditions (Ballmer, *ibid*). The animals rarely fly during windy or breezy conditions, which typically occur in the afternoon. However, during these periods they have been located by disturbing the vegetation where they are perching (Ballmer, *ibid*). Ovipositing has only been observed from mid to late afternoon, between 2:00 and 5:00 p. m., when temperatures start to cool.

Delhi Sands flower-loving flies have rarely been observed taking nectar and have not been seen taking other fluids. The nectaring events have been brief, on the order of 2-10 seconds, and have all been restricted to flowers of the common buckwheat (*Eriogonum fasciculatum*) (R. Rogers, pers. obs.). The only other flowers available during the flight time are croton (*Croton californicus*) and telegraph weed (*Heterotheca grandiflora*), but visitations to these plants have not been noted.

The introduced Argentine ant (*Iridomyrmex humilis*) has been observed to attack and kill a recently emerged adult Delhi Sands flower-loving fly (R. Rogers, pers. obs.). Rogers and Mattoni (1993) and Cazier (1985) report that large asilid flies in the genera *Proctocanthus* and *Promachus* prey upon *Rhaphiomidas* flies. Other predators of the adult flies likely include dragonflies and insectivorous birds. The early stages may be eaten by ants, subterranean predatory insects, and reptiles.

Habitat Requirements and Population Dynamics

Areas containing sandy substrates with a sparse cover of perennial shrubs and other vegetation constitute the primary habitat requirement for *Rhaphiomidas* flies. Based on observations of several other members of this genus, optimal vegetation cover is sparse, usually less than 50 percent, and usually in the range of 10-20 percent.

Several correlations have been noted between the fly and vegetation within its habitat, as follows: 1) three indicator plant species are usually present in occupied Delhi Sands flower-loving fly habitat:

common buckwheat (*Eriogonum fasciculatum*), telegraph weed (*Heterotheca grandiflora*), and croton (*Croton californicus*). The plants may be present in low density, as exemplified by only three buckwheat plants on two occupied habitat patches. 2) Adults do not appear to use areas of dense vegetation, either of buckwheat or where annual grasses provide more than 50 percent cover. 3) Sightings of adults are more likely in relatively undisturbed habitats, as indicated by the presence of native annuals and perennials, including *Eriastrum saphirinum*, *Opuntia parryi*, two annual buckweats, and a suite of other native plants (See Appendix E).

The number of flies observed in a population fluctuates greatly from day to day and from year to year at a given locality (Ballmer *ibid*). Ballmer (*ibid*) found that no Delhi Sands flower-loving flies were observed at a site in 1989, whereas a single male was observed during a survey lasting a total of approximately five hours that was conducted over a three day period in August 1990. Moreover, Ballmer observed four males and a single female at this same location during a one hour period on a single day in August 1991. Environmental conditions, such as air temperature, wind speed, and cloud cover, may significantly affect the activities of these animals. It is also possible that the early stages of the fly can aestivate for long periods.

The past abundance of the Delhi Sands flower-loving fly may be inferred from museum specimens. The largest single day collections are 15, 13, and 13 individuals from Colton (1986), Mira Loma (1941), and Rialto (1956), respectively. However, the lack of data concerning the size of the habitat, time periods, and intensity of collecting precludes a definitive analysis based solely on these specimens. Rogers and Mattoni (1993) note that the population densities of the Delhi Sands flower-loving fly may have approached the low hundreds at some sites. However, they reported that areas containing significant habitat for this species had been eliminated by 1989. The largest 1-day number of Delhi Sands flower-loving flies in 1989 was 13 animals observed on approximately 20 acres (8 hectares) in the City of Colton. The animals were most abundant in an area that contained a high percentage of native vegetation (low levels of introduced plants) and more than 60 percent open sand substrate.

Estimates of the local population size of the Delhi Sands flower-loving fly have been reported for a few sites (Ballmer 1989, Kiyani Environmental Consultants 1994, Rogers and Mattoni 1993). The studies involved direct counts of the animals in the field. At the San Bernardino Hospital preserve, a population size of 12-20 flies was estimated during the 1994 flight season (Kiyani Environmental Consultants 1994). At another site a direct count of 13 individuals was made within a half hour over a 10 acre (4 hectare) sample of the 150 acre (60 hectare) site. This information, incorporated into a population model, provided the basis for the conclusion that the total population size was in the low hundreds. However, portions of this site have been developed, and it is unlikely the population currently contains numbers in this range.

Threats and Listing Rationale

The human population of California experienced especially rapid growth during the 1960s and 1970s, and it continues to grow beyond the 30 million mark (U.S. Dept. of Commerce 1990). A significant portion of this growth has occurred in the San Bernardino County area (California Department of Finance 1993). The western third of Riverside County currently contains approximately 800,000 people, which is predicted to increase to 1.4 million by 2010 (Monroe et al. 1992).

Historically, lands in San Bernardino and Riverside Counties containing Delhi series soil have been used for agriculture. Current land altering activities in this area that adversely affect the Delhi Sands flower-loving fly include surface mining for sand, and residential and commercial development. Unauthorized collecting of the Delhi Sands flower-loving fly by insect collectors is a threat to the species. Critical Habitat was not designated because of the danger posed by insect collectors. Since the animal was listed, construction of a hospital, commercial development, and dumping of cow manure and other trash have eliminated populations and restorable habitat.

Invasive exotic vegetation severely degrades or eliminates the habitat of the Delhi Sands flower-loving fly. Non-native plants of concern include Russian thistle (*Salsola tragus*), horehound (*Marrubium vulgare*), mustard (*Brassica tournefortii*), cheeseweed (*Malva parviflora*), and many species of introduced grasses such as ripgut (*Bromus diandrus*) and red brome (*Bromus madritensis* ssp. *rubens*). These plants likely alter the amount of soil moisture or make the substrate physically unsuitable for the survival of the Delhi Sands flower-loving fly and other native subterranean invertebrates. The diversity and abundance of arthropods have been found to be significantly reduced or absent in coastal dune areas containing exotic plants versus areas with native vegetation (Nagano et al. 1981, Nagano and Hogue 1982, Slobodchikoff and Doyen 1977).

Tons of cow manure from local dairies have been dumped on several sites containing restorable habitat for the Delhi Sands flower-loving fly, often apparently without permission of the landowners. The manure smothers the animals, plants, and habitat where it is dumped. The manure also provides high levels of nutrients for invasive exotic plants, such as cheeseweed (*Malva parviflora*). The organic matter and nutrients can only be removed at large expense over a long time period. Restoration of manured sites, although possible, is of the lowest priority, even though manured sites under powerline rights-of-way would otherwise provide ideal habitat.

Off-road vehicles (ORVs) have a negative impact on the Delhi Sands flower-loving fly and the other plants and animals found in this habitat. ORVs compact the soil, crushing and killing subterranean

species; flatten and destroy vegetation, thus removing food and cover; alter natural behavioral patterns of animals; and increase rates of erosion. The environmental damage caused by ORVs has been described by Hardy and Andrews (1976), Powell (1981), and Weaver (1978). The use of even low numbers of ORVs likely disturbs the feeding, breeding, and resting behavior of adult Delhi Sands flower-loving flies.

Trampling, or disruption of the substrate, is a concern usually overlooked for dune systems. Trampling is deleterious because it destroys the cryptoflora crust, which is important to resisting invasive microorganisms and maintaining soil ecosystem integrity (Belnap 1994).

The impact of parasites and disease on the Delhi Sands flower-loving is unknown.

In addition to directly destroying habitat, agricultural conversion, and residential and commercial development likely affect the dispersal of the Delhi Sands flower-loving fly. Roads have been found to be a barrier to the movements of butterflies, beetles, and other arthropods (Mader 1984, Thomas Reid Associates 1982). Although, adult Delhi Sands flower-loving flies have been observed to turn or reverse the direction of their flight upon encountering paved roadways (R. Rogers, pers. obs.), the animals likely disperse across these barriers.

Although flies in general are not especially popular with insect collectors, *Rhaphiomidas* flies are prized because of their unusual size and rarity. Specimens of the Delhi Sands flower-loving flies have been sold by a commercial insect dealer (Taylor 1993). The collection of the Delhi Sands flower-loving fly is a threat because the species exists in very small populations and handling and marking, and/or removal of even a few individuals would seriously damage the species through loss of individuals and genetic variability. Collection of females could also significantly reduce the probability that new colonies would be founded.

The status of the Delhi Sands flower-loving fly has dramatically declined in the last few years. One population of the animal was extirpated by urban development since 1990; another was partially destroyed by sand mining between 1991-1992; one large former population is now bisected by a county park; another large population was recently discd for fire protection, and at least four sites are for sale. Between the publication of the proposed rule to list this species in 1992 and the issuance of the final rule in 1993, about 45 acres of occupied habitat were destroyed. This represented a loss of 6-13 percent of the extant habitat that existed at the time of the proposed rule. There is presently an estimated 1,200 acres of habitat that can support the species. Although several hundred potentially restorable acres exist, restoration is expensive and not without unresolved problems. Of the remaining pristine habitat, only two acres (0.8 hectare) of a ten-acre (four hectare) site (comprising the San Bernardino County hospital preserve) is permanently protected. At this

preserve, the species is in imminent danger of extirpation, because the effective size of the breeding population is only about five (Mace and Lande 1991).

Recovery Units

Areas known to be inhabited by the Delhi Sands flower-loving fly or areas that contain restorable habitat for the animal have been grouped into three Recovery Units (RUs) based on geographic proximity, similarity of habitat, and potential genetic exchange (Figure 3). Each RU includes occupied habitat containing one or more populations of the Delhi Sands flower-loving fly and/or restorable habitat for at least one population. The occupied and restorable habitat in the RUs includes only those areas that contain Delhi Series soils. The distribution of historical records suggests that the fly occurred extensively throughout these three units. Note that the RUs do not include residential and commercial development, nor areas that have otherwise been permanently altered by human actions.

Colton Recovery Unit (figure 4) — All but two of the known populations of the animal are located in the Colton RU. This Recovery Unit is bounded to the west by Cedar Avenue, to the east by Pennsylvania Avenue in San Bernardino County, extending along a straight line to the west side of Interstate 215, to the north by Baseline Road, and to the south by the Santa Ana River. The San Bernardino County Hospital preserve, approximately 10 acres in size, is in the Colton RU. This is one of the only permanently protected locations for the Delhi Sands flower-loving fly. Restorable habitat is located along the Southern California Edison powerline right-of-way and several other locations in the Colton RU.

Activities that have eliminated Delhi Sands flower-loving flies and their habitat in the Colton RU include surface mining, commercial and residential development, dumping of cow manure, and invasive exotic plants. This recovery unit is threatened by intense development pressure within an area known as the Agua Mansa Enterprise Zone.

Jurupa Recovery Unit (figure 5) — This RU is bounded on the north by Valley Boulevard, by Cedar Avenue on the east, Hemlock Avenue in San Bernardino County and Pedley Road in Riverside County on the west, and the Santa Ana River to the south. This RU is located in the Cities of Fontana and Riverside, and unincorporated areas of Riverside County. An extant population is in an unnamed canyon in the Jurupa Hills in the City of Fontana. The site has been proposed for residential development (Thomas Olsen Associates 1996a, 1996b).

The majority of Delhi Sands flower-loving flies and their habitats in the Jurupa RU have been eliminated by commercial and residential development, dumping of cow manure, and invasive exotic

vegetation. A site in this RU was disced shortly after a biological study indicated it likely contained the fly. Restorable habitat is located along the Southern California Edison powerline right-of-way and a few other locations in the Jurupa RU.

Ontario Habitat Recovery Unit (figure 6) — This area historically contained the largest block of the Colton Dunes, however, most of the area has been converted to agriculture, or developed for commercial and residential projects.

The eastern border of the Ontario RU is bounded by Hemlock Avenue in San Bernardino County and Pedley Road in Riverside County, to the west by Central Avenue extending to Highway 71, to the north by Baseline Road, and to the south by a line extending from the intersection of Central Avenue and Highway 71, east to the south bank of the Santa Ana River. The Delhi series soils are found in the Cities of Cucamonga, Ontario, Chino and Riverside, and unincorporated areas of San Bernardino and Riverside Counties.

Based on museum specimens, one of the populations containing the highest densities of Delhi Sands flower-loving fly was located at Mira Loma in the Ontario RU.

The majority of Delhi Sands flower-loving fly habitat in the Ontario RU has been eliminated by long-standing agricultural land uses. Recent actions that have eliminated the animal and its habitat include commercial and residential development, dumping of cow manure, and invasive exotic vegetation.

There are significant blocks of Colton Dunes in the Ontario Airport area. An extant population is located south of Interstate 10 in the vicinity of the Ontario Airport.

Restorable habitat is located along the Southern California Edison powerline right-of-way and a few other locations in the Ontario RU. Other sites containing restorable habitat for the Delhi Sands flower-loving fly are located on lands in the vicinity of Ontario Airport, the Jurupa Hills, and along a shallow wash located in southwestern Ontario owned by Southern California Edison Company.

Conservation and Management

The mechanisms for conservation and management of the Delhi-sands flower-loving fly include actions by landowners that are either voluntary or mandated by law. The Service encourages voluntary actions to conserve and manage listed species through outreach efforts, technical and funding assistance, and cooperative agreements. To date, few private landowners have taken voluntary actions to conserve or manage the Delhi Sands flower-loving fly.

Most conservation and management actions have occurred due to a regulatory mechanism. The Service enforces the regulatory prohibition against take in section 9 of the Act. Section 7 of the Act requires Federal agencies to consult with the Service if their actions may affect listed species or adversely modify designated critical habitat. Federal agencies receive authorization for take through the incidental take statement of the Service's biological opinion on proposed Federal actions.

For proposed projects without a Federal nexus that may take a listed species incidental to an otherwise lawful activity, the Service issues incidental take permits after approving habitat conservation plans pursuant to section 10 of the Act. HCPs are key to the conservation of the Delhi Sands flower-loving fly because threats to the species' habitat are largely from private development on private land, and few landowners have taken steps to conserve this animal through voluntary actions. The Service has approved one HCP to date and is working with private landowners and local governments on a number of other HCPs that will address the needs of the Delhi Sands flower-loving fly. In particular, Memorandums of Understanding (MOUs) have been signed to develop two HCPs that will be essential to the fly's recovery.

On November 22, 1996, the Service signed a MOU with the members of AMIGA (Agua Mansa Industrial Growth Association): the cities of Colton, Rialto, and Riverside and the Counties of Riverside and San Bernardino. AMIGA administers the AMEZ or Agua Mansa Enterprise Zone. The purpose of the AMEZ is to encourage industrial development of the area through various tax and other economic incentives. The designation of the enterprise zone has led to considerable interest in the development of additional commercial facilities in the Colton RU. At least one population of the Delhi Sands flower-loving fly has been significantly impacted by the recent construction of commercial development and associated infrastructure in the Agua Mansa Enterprise Zone. The AMEZ's area is approximately 10,700 acres, including approximately 4,000 acres of vacant land. Of this 4,000 acres of vacant land, the Service estimates that 360 acres of contiguous habitat is key to meeting the conservation needs of the Delhi Sands flower-loving fly within the Colton RU. The largest known population of the fly occurs in this area. Due to the size of this area, land use history, and ecosystem integrity (blowing sand and shifting dunes), this site could represent the best opportunity to save the fly from extinction through creation of a core reserve.

The MOU with the members of AMIGA is a critical first step in the conservation strategy for the Delhi Sands flower-loving fly within the Colton RU. The MOU outlines steps for preparation of a regional HCP. The goal of the MOU is to assist in the survival and recovery of the Delhi Sands flower-loving fly by assuring the conservation of appropriate habitat within the AMEZ (subject to the conservation and management of all quality habitat and contiguous supporting lands that are designated by a cohesive reserve design process) in exchange for the Service granting authorization to develop the remaining vacant lands in the AMEZ. The conservation area is roughly bounded by

the AMEZ boundary to the north near Interstate 10, Riverside Avenue on the west, Agua Mansa Road on the south, and the California Portland Cement operation to the east (approximately 310 acres), plus approximately 50 acres of existing quality habitat near the intersection of the Southern California Edison easement and Riverside Avenue. Side agreements executed as part of the MOU allowed three projects to move forward with proposed mitigation. The Service also recently negotiated with the City of Colton the opportunity to secure the core of this reserve and its sand source as part of development of an HCP for a proposed paper recycling plant.

A regional HCP in San Bernardino County also will be key to the conservation strategy for the Delhi Sand flower-loving fly. Management of habitat for the fly could be consolidated through this regional effort. In 1995, San Bernardino County and approximately 15 local jurisdictions signed a MOU to develop a Multiple Species Habitat Conservation Plan/Natural Community Conservation Plan to address approximately 80 species on over 500,000 acres throughout the southwestern portion of the county. The Delhi Sands flower-loving fly is one of the focal species for this planning effort. Field surveys are underway to determine the distribution of sensitive species within the planning area. The Service has allocated \$400,000 in support of this planning effort to date.

In addition, the Service has approved one small-scale HCP for the fly. The City of Colton constructed a transmission line and electrical substation between Interstate 10 and the Santa Ana River within the Colton RU. This project resulted in the take of Delhi Sands flower-loving flies occupying 4.6 acres of habitat; 2.4 acres of habitat were permanently lost and 2.2 acres were temporarily disturbed. The City of Colton implemented several actions to minimize the adverse effects of this project, including no construction during the breeding season and conducting fly surveys to determine pole placement and access routes that minimized disturbance to the animal and its habitat. In addition, to compensate for the temporary and permanent habitat loss associated with this project, the City owns and will grant a conservation easement to the Service for 7.5 acres of occupied habitat, on which Delhi Sands flower-loving flies will be managed and monitored in perpetuity (ENSR Consulting and Engineering 1995). In view of these considerations, the Service issued an incidental take permit for this project.

The implementation of HCPs can be expedited through mitigation banking, which can help assure that parcels of Delhi Sand flower-loving fly habitat that are set aside are adequately large to support populations and be manageable. The Service supports development and use of mitigation banks within the Recovery Units for the Delhi Sands flower-loving fly. Such conservation banking agreements established on Delhi Sands flower-loving fly habitat would provide permanent management and protection of the most valuable remaining habitat while allowing other non-essential habitat to be developed and the impacts fully mitigated. This process provides for an economic return on the banked property.

The San Bernardino County Hospital established a 10-acre preserve for the Delhi Sands flower-loving fly on its property, so that hospital expansion would not risk taking this species. There was thus no need for a Habitat Conservation Plan. Thus far, management and monitoring efforts for the fly have been initiated at this site, and the program has produced some information on the biology and ecology of the animal, as summarized in the Life History section above.

California state law provides some additional regulatory benefits to the Delhi Sands flower-loving fly. The environmental review process under the California Environmental Quality Act for projects that result in loss of habitat for the Delhi Sands flower-loving fly sometimes require development and implementation of mitigation plans. However, the effectiveness of this statute in protecting Colton Dunes has not been consistent among projects. As documented above, habitat for this listed species typically has been eliminated without offsetting measures.

Finally, under section 6 of the Act, the Service may establish Cooperative Agreements with states for conservation of listed species. The California Department of Fish and Game (CDFG) has indicated it does not have the authority to protect insects (Pete Bontadelli in litt. February 20, 1990). If the CDFG could protect insects the Service could enter into a Cooperative Agreement with that agency. Such a Cooperative Agreement would fund CDFG conservation programs for the Delhi Sands flower-loving fly and qualify CDFG to apply for Federal funds through section 6 of the Act. These funds could support research projects, surveys, and recovery actions.

Recovery Strategy

Reducing the immediate risk of extinction of the Delhi Sands flower-loving fly will require: (1) working with the appropriate landowners and local governments to preserve and enhance the presently occupied habitat; (2) implementing a program to restore lands with the highest potential; and (3) initiating a captive breeding and release program.

Any proposed project that might reduce the area of habitat used by the species should be carefully evaluated, and compensation that fully protects and/or restores Colton Dune should be included in the project design. Project proponents should be encouraged to begin working with the Service in the early stages of project design to avoid and minimize project impacts and time delays.

The survival and recovery of the Delhi Sands flower-loving fly is dependent on protection of occupied and restorable habitat. Occupied habitat contains individuals of the species and associated habitat used for breeding, feeding, shelter, and/or as a dispersal corridor. Restorable habitat consists of areas that contain Delhi series soil and are not currently occupied by the animal, but could be managed for the species. Colonization of restored areas by the fly would result in increased numbers

of individuals, ultimately expanding the number and size of populations until the species reaches the point where it can be downlisted.

Approaches to habitat restoration will vary from simple, relatively inexpensive, and predictably successful (in cases of enhancing partially occupied sites that are weed overgrown) to complex, costly and unpredictable (in cases of manured or imported fill sites). Isolated sites may require re-introduction of the fly. A functional foodweb with many other invertebrate species, including the unknown food sources of the Delhi Sands flower-loving fly larvae, should be restored around the approximately 50 native plant species that define the native vegetation.

The three Recovery Units (RUs) must be conserved to maintain the species' distribution and its genetic diversity throughout its present range. At least eight populations across the three RUs are needed to reduce the risk of extinction from random events that may affect any one local area. Line transect counts should be conducted at each site to measure the relative population abundance of the flies. This method, as described by Gall (1985), Pollard (1977), and Pollard et al. (1986) will provide an estimate of the relative number of adult animals at each site.

With habitat quality varying from the location of one population and RU to another, acreage needed to sustain viable populations also varies from site to site. However, the data needed to determine specific habitat acreage objectives for each RU are not available at this time. Additional data will be needed on reproduction and mortality rates, dispersal, and habitat variables before further refinement of RU boundaries, development of alternative RU preserve designs, and analyses of population viability can be made.

Until such data are obtained, the highest priority will be to protect existing populations of the Delhi Sands flower-loving fly. Habitat may be protected through fee acquisitions, conservation easements, and voluntary management agreements. Additional habitat surveys and detailed inventories to identify sites needing protection are essential, particularly at the Jurupa and the Ontario RUs. Part of protecting existing populations is the protection of dispersal corridors between the populations. Dispersal corridors likely are critical for movement of the Delhi Sands flower-loving fly, especially given the nearly total urbanization throughout its distribution.

Along with protecting existing populations, equally high priority is assigned to the urgently-needed program to augment existing populations and to establish new populations of the Delhi Sands flower-loving fly. Recent studies indicate the number of individuals at the known sites is extremely low in comparison with population sizes of related species with similar ecological and life history strategies (R. Mattoni, R. Rogers, and J. George, UCLA unpublished data). The likelihood of extinction remains high unless the habitat protection and captive breeding and release programs are

initiated without delay. Neither reintroduction nor augmentation is an appropriate means of mitigating habitat loss because the animal's prospects for recovery are already severely limited by lack of habitat. Similarly, the maintenance of this animal in captivity does not substitute for the maintenance of wild populations.

As management plans are started, monitoring of Delhi Sands flower-loving fly populations will provide the ultimate test of management effectiveness. Census surveys should be coordinated to extend over the species range whenever possible. Monitoring methods should be applied consistently over a sufficient period, and monitoring should be coupled with a long-term program for management of the species' habitat to evaluate its status. The collection of census data over a period of several years (possibly 15) will be needed to include the variability of environmental conditions experienced by the species.

As existing populations are protected and managed, emphasis in conservation for the species will shift toward determining whether or not viable populations are being sustained. There will be a need to protect additional habitat if population data indicate that populations are not viable and at high risk for extirpation or extinction.

The Delhi Sands flower-loving fly is sought by some insect collectors. The Service enforces the Endangered Species Act's prohibition against take (including collection) and commerce in this species.

Although this plan emphasizes the biological aspects of conserving this animal and its habitat, the actual work of conserving habitat is in the hands of landowners, so it is very important that landowners cooperate to find cost-effective solutions to guarantee survival of the Delhi Sands ecosystem on protected portions of their lands. Conservation of the Delhi Sands also depends on an informed general public.

PART II. RECOVERY

Objectives and Criteria

The Delhi Sands flower-loving fly can be considered for reclassification to threatened status when:

- 1) At least eight populations in the three Recovery Units (RUs), i.e., Colton, Jurupa, and Ontario, are permanently protected. The population that inhabits the largest remaining block of Colton Dunes located east of Riverside Avenue, south of Interstate 10, north of the Santa Ana River, and west of the cement plant, must be protected. At least four populations must be in the Colton RU, two of them north of Interstate 10 (including the San Bernardino Hospital Reserve), and two south of Interstate 10. In the Jurupa RU, the Jurupa Hills population in the City of Fontana must be secured. The location of the remaining populations will be determined using information collected during implementation of this recovery plan. Dispersal corridors must be maintained between the populations.
- 2) Each of the 8 population sites and dispersal corridors are managed to maintain perpetual sand supply and sparse total vegetation cover (no more than 20 percent) dominated by native species such as California buckwheat, California croton, and telegraph weed.
- 3) As determined by scientifically credible monitoring, each of the 8 populations must exhibit a statistically significant upward trend for at least 15 years (approximately 7 fly generations) and has an estimated adult population of at least 200 individuals.
- 4) A program is initiated to inform the public about the Delhi Sands flower-loving fly and its habitat. This outreach effort should garner public support for conservation of the sand dune system upon which the Delhi Sands flower-loving fly depends.

Narrative

1. **Protect and restore existing and potentially suitable habitat in each of the three Recovery Units (Colton, Jurupa, and Ontario).**

Recovery of the Delhi Sands flower-loving fly and the associated endemic and rare species inhabiting the Colton Dunes requires a comprehensive program designed to reestablish natural community dynamics (see Part I, Ecosystem Description). The most important requirement for the survival of these species is preventing activities that reduce populations by destroying or

damaging Colton Dune habitat. Control of invasive non-native plants is also of utmost importance.

The majority of habitat in the Colton RU is in private ownership. The Colton RU contains the only two sites that have been permanently designated for protection of the animal. In 1993, the County of San Bernardino set aside, and is managing, about ten acres for the Delhi Sands flower-loving fly as part of mitigation for the San Bernardino County Hospital site in Colton. Management of the hospital site must include removal of exotic invasive plants and conservation of the sand supply. Other habitat is found on the Southern California Edison right-of-way. Additional lands critical to the Colton population must be identified based on understanding the animal's ecological and biological requirements through scientific research and observations. Additional habitat should be protected through fee acquisition, conservation easements, voluntary management agreements, and habitat conservation plans.

The majority of the Delhi Sands flower-loving fly habitat in the Jurupa and Ontario RUs is also in private ownership. Habitat suitable for flower-loving fly populations within the Jurupa and Ontario RUs should be identified. Additional habitat should be protected through fee acquisition, conservation easements, voluntary management plans, and habitat conservation plans.

The recovery actions enumerated below may be carried out jointly, or individually within each RU, depending upon funding and local participation.

1.1 Map habitat areas and dispersal corridors

Occupied and restorable habitat, and dispersal corridors in the RUs must be mapped. Mapping may be expedited by using a Geographic Information System (GIS). The data also will be provided to the Natural Diversity Data Base of the California Department of Fish and Game. Mapping of unoccupied habitat suitable for the animal is for informational, not regulatory, purposes.

1.2 Determine willingness of landowners to participate in recovery of the Delhi Sands flower-loving fly

Ownership information will be compiled for occupied and restorable habitat areas and dispersal corridors. Landowners will be contacted by the Service and queried as to their interest in participating in the recovery of the Delhi Sands flower-loving fly. Restoration of unoccupied habitat depends entirely on the voluntary participation of landowners.

1.3 Select Delhi Sands flower-loving fly habitat within the RUs for protection

To achieve downlisting, areas containing occupied and/or restorable habitat and dispersal corridors need to be evaluated relative to the extent of distribution patterns necessary to support secure populations (see task 2). Sites to be protected should be selected based on habitat needs of adults and larvae, and willingness of landowners to participate in recovery efforts. Determination of the best possible sites for restoration and reintroduction may require intensive and long-term fieldwork.

1.4 Protect habitats identified in 1.3

Much of the necessary habitat conservation in the RUs will be arranged through the Habitat Conservation Plans. In general, habitat needed for breeding, feeding, and/or the development of early stages should be acquired in fee. Dispersal corridors may be protected through easements and voluntary management agreements. Mitigation banking is likely to be effective. The means of habitat protection will be arranged individually for each tract and landowner.

1.4.1. Employ the Habitat Conservation Plan process

Support the preparation and implementation of HCPs that cover the Delhi Sands flower-loving fly, especially regional or ecosystem-based HCPs that conserve remnants of the Colton Dunes ecosystem (e.g., AMIGA HCP and San Bernardino County Multiple Species HCP). This process is the most effective way to develop a coherent system of protected habitat.

1.4.2. Seek conservation through non-HCP means

Probably, not all tracts needed or desired for conservation of this animal will be protected through HCPs. Select protection methods individually for these parcels, in cooperation with landowners and with regard to the management needs of the habitats. Apart from fee title, protection can be arranged through conservation easements and voluntary management agreements by Federal, State, or local governments or non-profit conservation organizations. Voluntary management agreements should include a description of each entity's commitment and role in the recovery of the Delhi Sands flower-loving fly.

1.4.3. Identify funding sources for land acquisition

The Fish and Wildlife Service is authorized by the Endangered Species Act to acquire land for conservation of endangered and threatened species. HCPs and mitigation banking will also provide necessary support.

1.5 Develop management plan for habitats protected in I.4

Each management unit needs a site-specific plan to address habitat management needs and threats to the habitat or population. Habitat restoration may figure prominently in management plans, particularly in areas where fly populations have been extirpated or reduced. Each management plan should set general/qualitative goals and contain site-specific, measurable objectives. Each plan should specify how and when to achieve those objectives, identifying funding sources. The management plan should be coupled with a monitoring plan (see task 3). Management plans should be reviewed periodically, or after significant changes in threats, management, research, or status of the species occur, and revised as appropriate.

1.6 Implement management plans developed in 1.5

Although implementation will vary depending on the plan, the major components to be addressed in management are as follows:

1.6.1 Enhance occupied sites

Habitat enhancement within occupied or partially occupied sites involves conservation of sand sources and removal of non-native weeds—such as tumbleweed, mustard, horehound, and grasses—that invade the dune habitat, crowding out nectar plants, native vegetation, and, especially, open areas needed by the fly. Techniques used to remove the non-native species should be selected to avoid harming the fly and associated native ecosystem components. Following weed removal, some revegetation with native species may be required (see below). Efforts should be made to minimize trampling of the substrate during habitat enhancement activities. Enhancement should be prioritized and coordinated both within and among Recovery Units.

1.6.2 Restore presently unoccupied sites

Unoccupied habitat across most of the RUs has a history of degradation from a variety of land uses. Restoration usually will take several years. For most unoccupied sites, revegetation to local native species can proceed only after removal of alien plants as a first step. Reduction of excessive nutrient levels and state-of-the-art revegetation techniques will be implemented to establish appropriate native plants representing local ecotypes. Complete restoration may require re-introducing some minimum assemblage of invertebrates that cannot be expected to migrate naturally to these areas.

1.6.3 Determine effects of selected management methods on habitat needs of non-target species

The remaining Colton Dunes inhabited by the Delhi Sands flower-loving fly harbor a unique assemblage of endemic species, including San Diego horned lizard, Delhi Sands metalmark butterfly, Delhi Sands Jerusalem cricket, convergent apiocerid fly, Delhi Sands sandroach, and, potentially, Pringle's monardella. Habitat requirements of these species, and the effects of management for the Delhi Sands flower-loving fly, will be studied so that detrimental impacts can be avoided.

2. Determine ecological requirements, population constraints, and population augmentation needs and methods for the Delhi Sands flower-loving fly

To ensure survival and recovery of the Delhi Sands flower-loving fly, the following should be undertaken:

2.1 Refine understanding of habitat requirements of the Delhi sands flower-loving fly for the purposes of conservation planning.

A better understanding of the animal's ecological requirements will facilitate development of recovery actions and site-specific plans.

2.1.1 Clarify the extent and condition of habitat areas necessary to provide for development of the early stages, breeding, nectaring, and shelter by the Delhi Sands flower-loving fly

Habitat areas that support the Delhi Sands flower-loving fly need to be identified for each life stage. The environmental correlates of fly distribution and abundance, considering soil type, vegetation composition and structure, and historical management need to be determined. The ecology, including distribution and habitat requirements of the eggs, pupae, and especially the larvae need to be determined.

2.1.2 Determine larval food sources, and their distribution and habitat requirements

The food sources utilized by the larvae need to be determined, as do the distribution and habitat requirements of prey or host plants, including all food web components.

2.1.3 Identify dispersal patterns (distances, direction) and dispersal habitat characteristics of the Delhi Sands flower-loving fly to facilitate movement between RUs and populations

Dispersal patterns of adults need to be analyzed, using direct observation to identify dispersal routes between habitat areas. Mark-recapture may be utilized if it can be done without harming the animals, and only at sites with populations greater than 200 animals. The length, width, and structural characteristics of routes likely to be used by most of the dispersing individuals should be determined.

2.2 Determine methods of introducing flies to augment extant populations or into restorable habitat

Reintroduction and population augmentation are essential to the recovery of the Delhi Sands flower-loving fly. Techniques must be developed to successfully introduce animals to augment extant populations or into sites with restorable habitat and willing landowners.

2.2.1 Determine methods for captive breeding and rearing of the Delhi Sands flower-loving fly

Techniques for successful captive breeding and rearing of the Delhi Sands flower-loving fly should be perfected immediately. Initial research would be conducted using related species of *Rhaphiomidas*. The difficulties with study of *Rhaphiomidas* reproduction to date have been low egg yields, poor hatchability, and food rejection, leading to starvation of larvae. Although *Rhaphiomidas* clearly are a challenge, it is likely that artificial rearing will be possible once the requirements of the early stages are understood. The difficulties in rearing need to be studied in the field and the laboratory. Fieldwork would involve marking many oviposition sites of related *Rhaphiomidas* species and returning frequently to follow life stages, if possible. In the laboratory, determining the feeding requirements of neonate larvae should be studied by confining larger numbers of females in controlled chambers with a wider array of host choices than has previously been attempted (Rogers and Mattoni 1993). Both natural and artificial diets should be tested. The possibility of early instar diapause also requires investigation.

2.2.2 Determine methods for the release of propagated Delhi Sands flower-loving flies into restored or unoccupied habitat

Variables to be considered include optimal season, life stage, numbers, and placement methods for release. Handling and transportation techniques should be carefully designed to minimize mortality.

2.3 Implement captive propagation and release of Delhi Sands flower-loving flies, as appropriate

To meet recovery objectives, captive bred animals should be introduced to sites with suitable habitat owned by willing parties. Augmentation of existing populations also likely may be necessary.

2.3.1 Implement captive propagation program

Methods perfected in task 2.2.1 should be used to establish an ongoing captive propagation program. Ideally, this program would be conducted at a minimum

of two facilities, to decrease the possibility of accidental loss of the entire captive population. Sizes of captive colonies and percent of various life stages to be maintained will be based on the results of task 2.2.1 and the demand for population augmentation or reintroduction.

2.3.2 Implement introduction program, if appropriate

Methods developed in task 2.2.2 will be used to reintroduce individuals to sites determined in task 1.3 and 1.6.2. Reintroductions should be conducted over at least a 3-year period at each site to increase the probability of population establishment.

3. Monitor the status of the Delhi Sands flower-loving fly and its habitat

The purpose of monitoring is to track the status (distribution and abundance) of the species and progress toward recovery objectives. Because the Delhi sands flower-loving fly inhabits sand dune habitat that can change rapidly, the results of habitat management actions should also be tracked. Parameters need to be selected, methods and techniques determined, and a plan developed and implemented.

3.1 Develop monitoring guidelines and techniques for tracking population status and habitat trends

Population monitoring should: 1) have an acceptable level of accuracy, 2) be repeatable over time and among observers, 3) have a low impact on the fly and its habitat.

Monitoring guidelines should specify the methods and equipment, the frequency and timing of the monitoring activity, and skills and experience needed by observers collecting data.

Standardized records must be maintained of all management actions, including a description of what was done, where, and when. This information will be important in helping to evaluate the effectiveness of management actions and in accurate implementation of management plans.

3.2 Develop a monitoring program for each population

Monitoring programs for each known population will conform to the guidelines

developed in task 3.1. Slight variations in techniques may be required at each site to accommodate local conditions, but above all, techniques will be consistent, so that results among sites are comparable. Monitoring protocols should be developed for each site within each of the recovery units that has a current population or any ongoing habitat restoration project. Although the development of monitoring programs is not considered a separate task for each RU, these programs may be developed individually, depending on priority and/or local interest.

The monitoring program will describe the specific methods for each site, how and when it will be implemented, where data will be stored and what personnel will be involved. The programs should be reviewed and updated every three years or as new information and/or modifications are made to the program. Efforts must be made to coordinate monitoring between sites to maximize their usefulness.

3.3 Implement monitoring program for each RU

Data gathered will be used to evaluate the effectiveness of management activities and to track recovery and population trends of the Delhi sands flower-loving fly. The reports, original field notes, photographs and all associated material should be provided to the Service. Copies of all reports must be provided to the California Department of Fish and Game Natural Diversity Data Base. Although the implementation of monitoring programs is not considered a separate task for each RU, monitoring may be implemented individually for each RU, depending on priority and/or local interest.

Data should be gathered according to the methods outlined in the monitoring program. Any deviations from the plan should be noted. Data should be reviewed annually and summarized in the report. A summary of monitoring efforts should be compiled annually and provided to the Service and any interested State agencies for further review and assessment of populations and habitat status. Any new threats to species should be identified.

4. Coordinate with the public

Coordination with the public is particularly important for recovery of the Delhi Sands flower-loving fly, in order to reduce take, dispel misconceptions, and foster partnerships with landowners.

4.1 Establish landowner committees

Within each RU, landowner committees should be established, to create a team approach to finding cost-effective solutions that guarantee survival of the unique Delhi Sand ecosystem. One major corporation has already indicated willingness to support habitat protection measures.

4.2 Conduct public outreach

Public outreach efforts should focus on the unique and vanishing ecosystem that the Delhi Sands flower-loving fly represents. A specific educational effort should be aimed at dispelling the public's automatic association with, and disdain for, house flies. *Rhaphiomidas terminatus abdominalis* is a unique animal capable of commanding great public interest, if the facts are properly presented (Booth 1997). Two programs, one targeting elementary and middle school-age children and the other targeting high school through adults, should be prepared and presented at schools and other local venues. This outreach effort also should serve as a clearinghouse for information in response to erroneous statements made about the fly in the media. Finally, public outreach needs to include effective warnings to insect collectors who might be tempted to take specimens in violation of the Endangered Species Act, which provides both criminal and civil penalties.

The volunteer program Rhapsody in Green, which has been successful in protecting two Los Angeles area insects, has a record of promoting public participation and awareness in natural area enhancement. Such volunteer involvement is not only economical, but also establishes a positive public image for the participating organizations. Rhapsody in Green, highly experienced in generating favorable public relations, is willing to establish a grassroots effort for the Delhi Sands ecosystem.

PART III. IMPLEMENTATION SCHEDULE

The Implementation Schedule that follows outlines actions and estimated costs for the Delhi Sands flower-loving fly recovery program, as set forth in this recovery plan. It is a *guide* for meeting the objectives discussed in Part II of this Plan. This schedule indicates task priority, task numbers, task descriptions, duration of tasks, the agencies responsible for committing funds, and lastly, estimated costs. The agencies responsible committing funds are not, necessarily, the entities that will carry out the tasks. When more than one agency is listed as the responsible party, an asterisk is used to identify the lead entity.

The Implementation Schedule shows the priority in scheduling tasks to meet the objectives, which agencies are responsible to perform these tasks, a time-table for accomplishing these tasks, and the estimated costs to perform them. Initiation of these actions is subject to the availability of funds.

Priorities in Column 1 of the following implementation schedule are assigned as follows:

Priority 1 - An action that must be taken to prevent extinction or to prevent the species from declining irreversibly.

Priority 2 - An action that must be taken to prevent a significant decline in species population/habitat quality or some other significant negative impact short of extinction.

Priority 3 - All other actions necessary to provide for full recovery of the species.

Key to acronyms used in the implementation schedule

DFG	California Department of Fish and Game
FWS	U. S. Fish and Wildlife Service, Carlsbad Field Office
RC	Riverside County Planning Board
RIG	Rhapsody in Green
SBC	San Bernardino County Planning Council
TBD	To be determined

RECOVERY PLAN IMPLEMENTATION SCHEDULE—DELHI SANDS FLOWER-LOVING FLY

Need 1: Protect habitat and determine species requirements

Priority #	Task #	Task Description	Duration (Years)	Responsible Parties	Total Cost	Estimated Cost, by fiscal year. All costs in \$1,000's									
						97	98	99	00	01	02	03	04	05	06
1	1.1	Map habitat areas	1	FWS	20	20									
1	1.2	Determine willing landowners	2	FWS	14		11	3							
1	1.3	Select habitat areas, including release sites	cont	FWS DFG	84			5	19	5	5	5	5	5	5
1	1.41	Protect habitats by employing the Habitat Conservation Plan (HCP) process	TBD	FWS RIG SBC RC	TBD										
1	1.42	Seek habitat conservation through non-HCP means	TBD	FWS DFG RIG SBC RC	TBD										
1	1.43	Identify funding sources for land acquisition	TBD	FWS DFG SBC RC											
1	2.1.1	Determine ecological requirements for the Delhi Sands flower-loving fly	4	FWS	40	10	10	10	10						
1	2.1.2	Determine larval food sources and their distribution	4	FWS	28	7	7	7	7						
1	2.1.3	Determine dispersal patterns and dispersal habitat characteristics of the Delhi Sands flower-loving fly	4	FWS	29	8	8	7	6						
		Need 1: Subtotal of costs			215	45	36	32	42	5	5	5	5	5	5

RECOVERY PLAN IMPLEMENTATION SCHEDULE—DELHI SANDS FLOWER-LOVING FLY

Need 2: Captive Propagation

Priority	Task #	Task Description	Duration (Years)	Responsible Parties	Total Cost	Estimated Cost, by fiscal year. All costs in \$1,000's									
						97	98	99	00	01	02	03	04	05	06
1	2.2.1	Develop captive rearing techniques	2	FWS	45	25	20								
1	2.2.2	Determine methods for the release of captive propagated animals	4	FWS	23			10	6.5	6.5					
1	2.3.1	Implement captive rearing program	cont	FWS	75			5	5	5	5	5	5	5	5
1	2.3.2	Implement release program	cont	FWS	75			5	5	5	5	5	5	5	5
		Need 2: Subtotal of costs			218	25	20	20	16.5	16.5	10	10	10	10	10

29

Need 3: Manage Habitat

Priority #	Task #	Task Description	Duration (Years)	Responsible Parties	Total Cost	Estimated Cost, by fiscal year. All costs in \$1,000's									
						97	98	99	00	01	02	03	04	05	06
1	1.5	Develop management plans for all 3 RUs	1	FWS DFG	28		28								
1	1.6.1	Enhance occupied sites (vegetation removal)	5	FWS	15	3	3	3	3	3					
1	1.6.2	Restore presently unoccupied sites	cont	TBD	450		30	30	30	30	30	30	30	30	30
1	1.6.3	Determine effects of management on non-target species	10	FWS	160	10	10	10	10	10	10	10	10	10	10
		Need 3: Subtotals of costs			653	13	71	43	43	43	40	40	40	40	40

RECOVERY PLAN IMPLEMENTATION SCHEDULE—DELHI SANDS FLOWER-LOVING FLY

Priority #	Task #	Task Description	Duration (Years)	Responsible Parties	Total Cost	Estimated Cost, by fiscal year. All costs in \$1,000's									
						97	98	99	00	01	02	03	04	05	06
2	3.1	Develop population and habitat monitoring guidelines	2	FWS DFG	10	5	5								
2	3.2	Develop individual monitoring programs	2	FWS DFG	5	2.5	2.5								
2	3.3	Implement monitoring programs for each RU	cont.	FWS DFG	410			30	30	30	30	30	30	30	30
		Need 4: Subtotal of costs			425	7.5	7.5	30	30	30	30	30	30	30	30

Need 5: Coordinate with Public

Priority #	Task #	Task Description	Duration (Years)	Responsible Parties	Total Cost	Estimated Cost, by fiscal year. All costs in \$1,000's									
						97	98	99	00	01	02	03	04	05	06
1	4.1	Establish landowner committees	1	FWS DFG RC SBC	20	20									
1	4.2	Conduct public outreach	cont.	FWS DFG RIG	72	20	10	10	5	5	2	2	2	2	2
		Need 5: Subtotal of costs			92	50	15	15	10	10	7	7	7	7	7
TOTAL COST of recovery					1,603	130.5	144.5	135	136.5	99.5	87	87	87	87	87

PART IV. APPENDICES

Appendix A - Literature Cited

Appendix B - Range Map, Life History, and Maps of Recovery Units

Appendix C - Glossary

Appendix D - Museum records of the Delhi Sands flower-loving fly

**Appendix E - Partial lists of plant species occurring in occupied and restorable Delhi sands
flower-loving fly habitat**

Appendix F - Summary of Comment letters and Responses

Appendix A: Bibliography

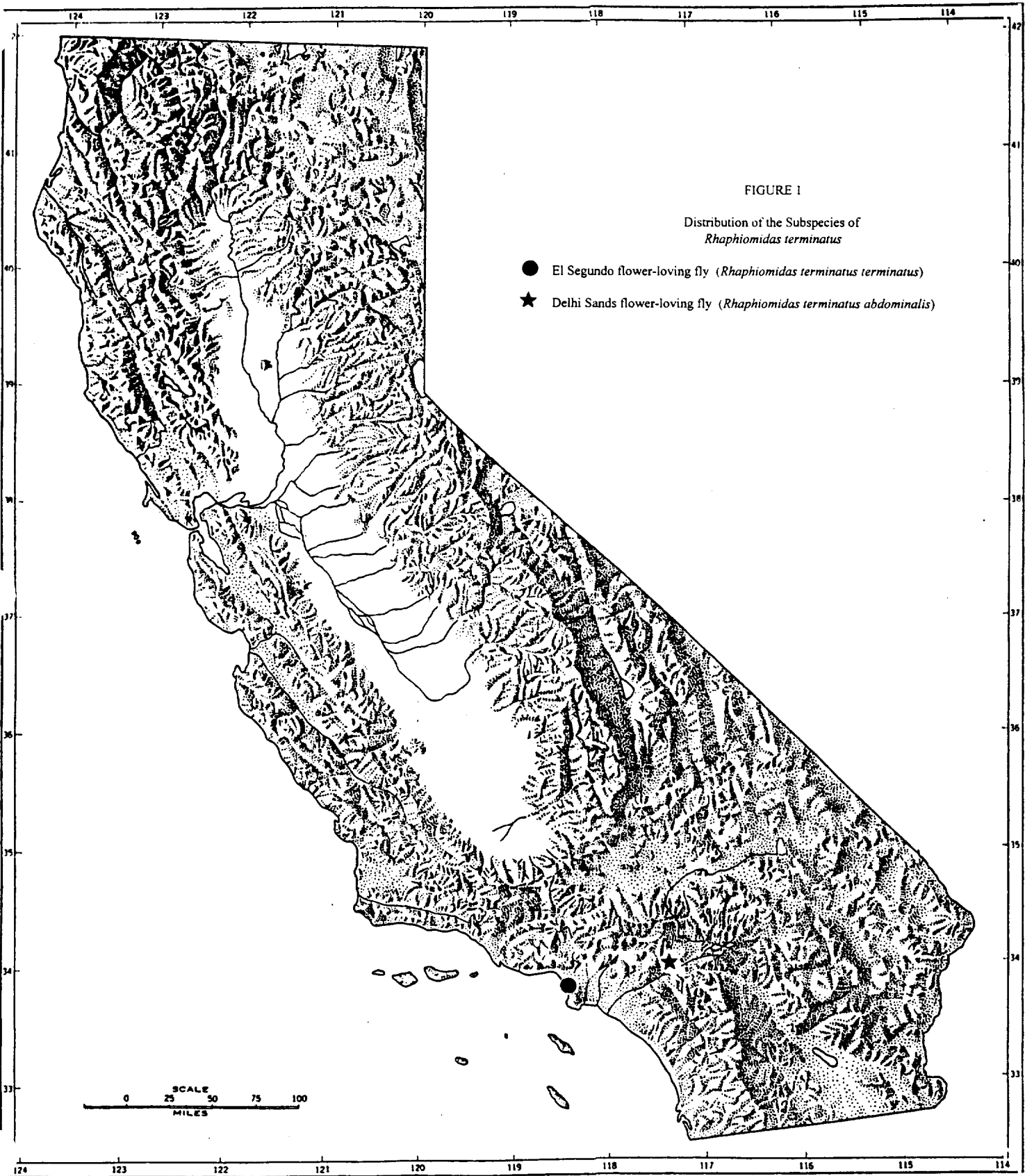
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Appendix B: Range Map, Life History and Recovery Units



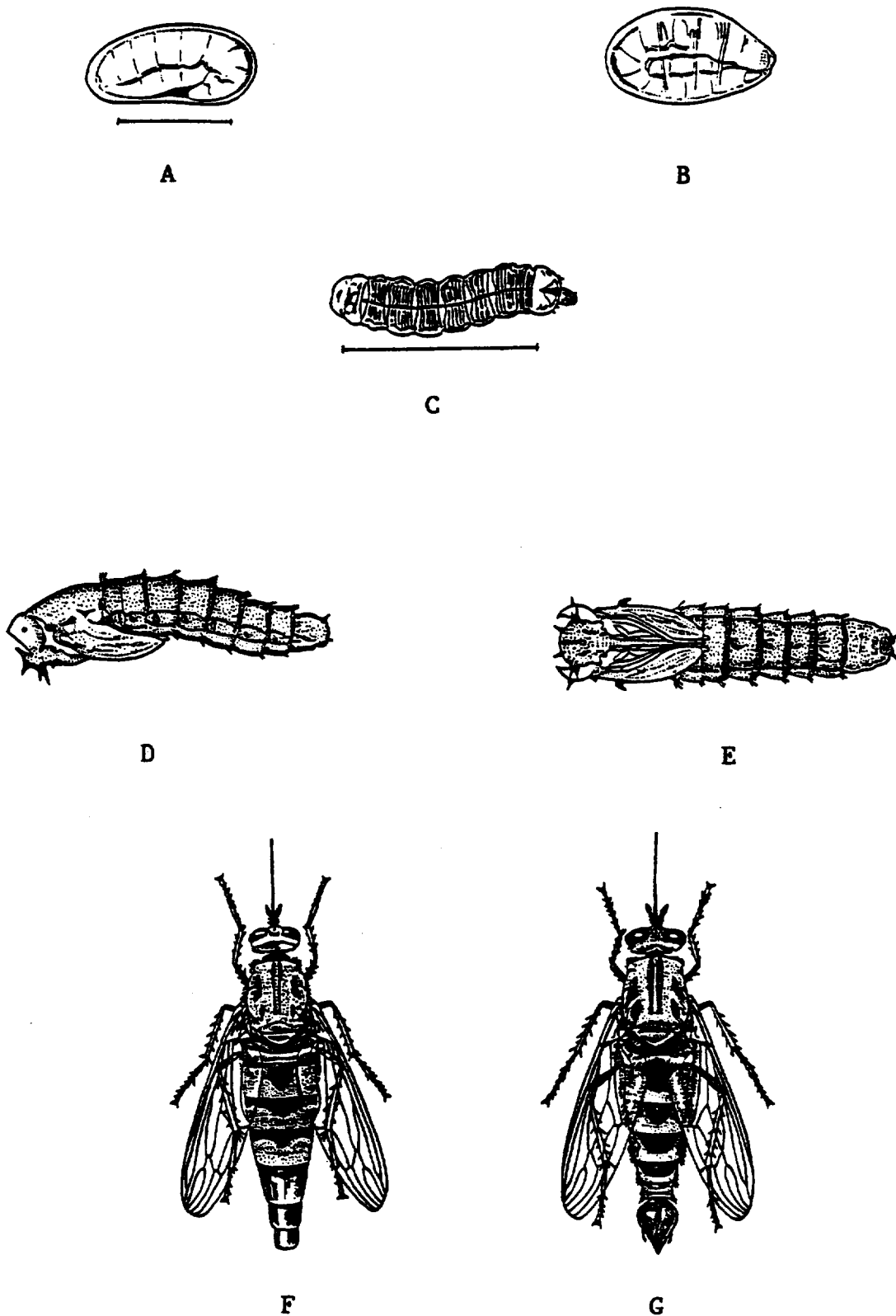


Figure 2: Line drawings of all known life history stages of the Delhi Sands flower-loving fly. A) egg at 7 days showing position of the developing larva (scale bar = 1 mm); B) egg at 11 days, a few hours before hatching; C) larva shortly after hatching (scale bar = 5 mm); D) side view of pupal case; E) top view of pupal case; F) adult female; and G) adult male.

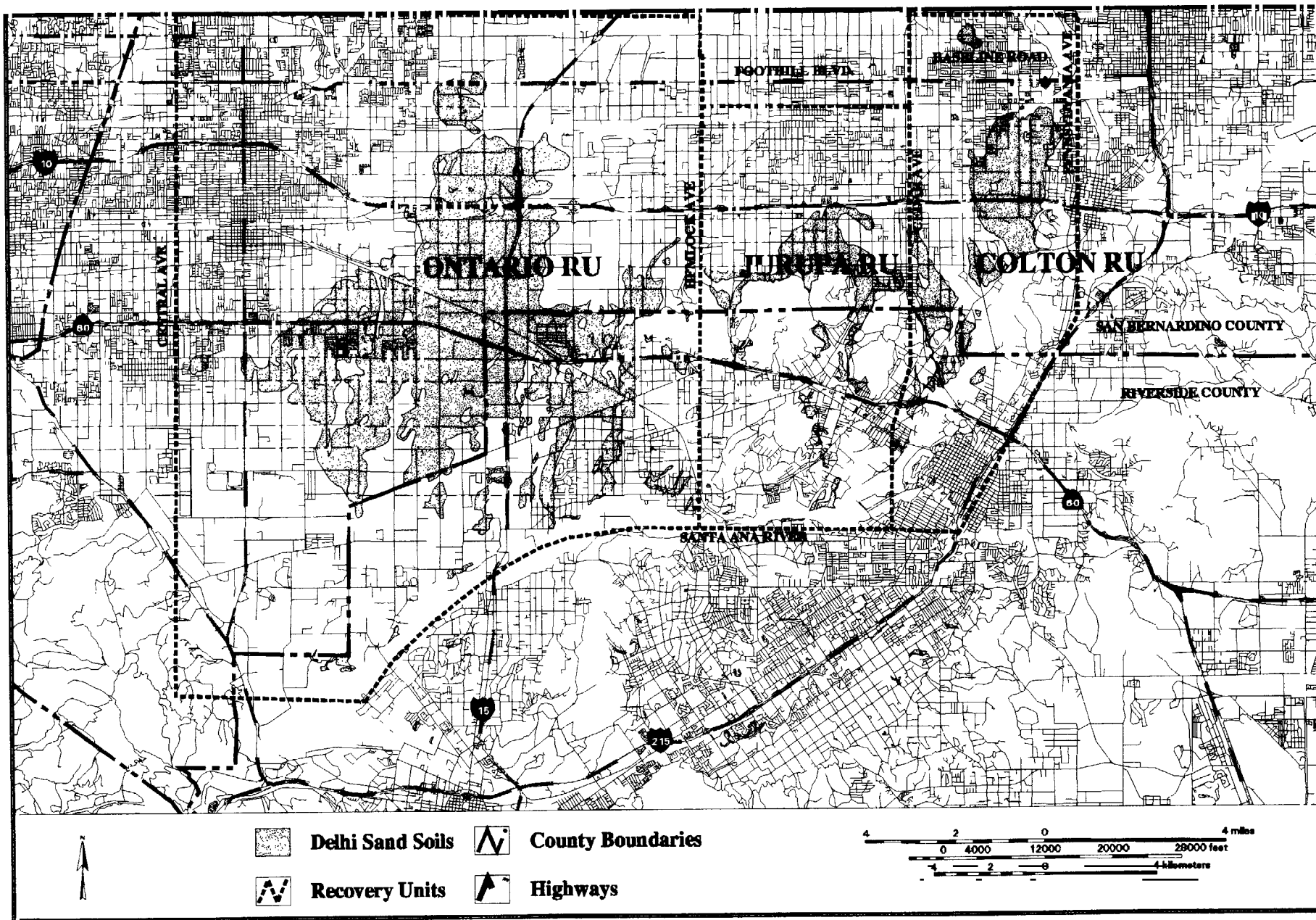


Figure 3. Distribution of the Delhi Sands flower-loving fly and Recovery Units (RU).

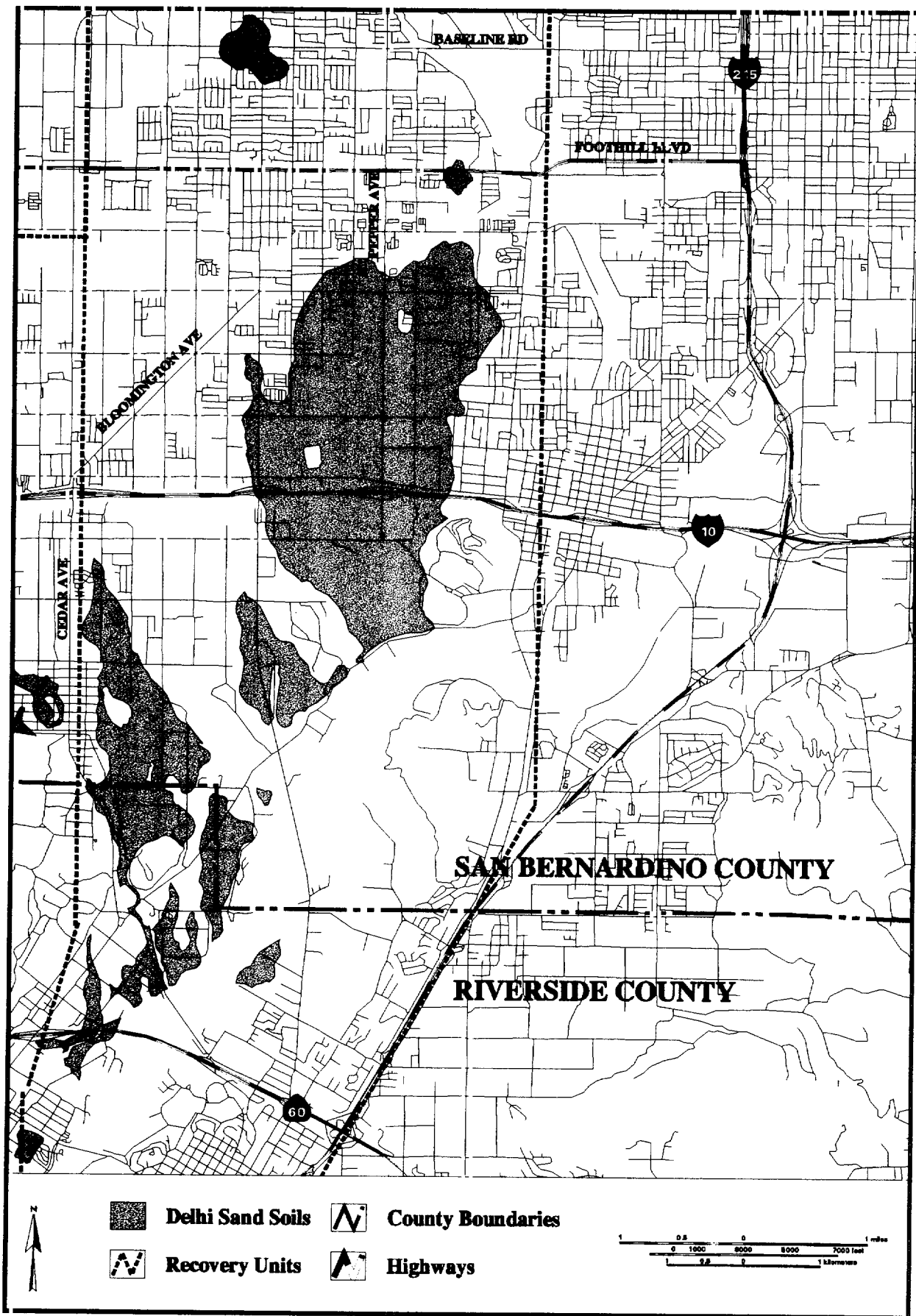


Figure 4. Colton Recovery Unit

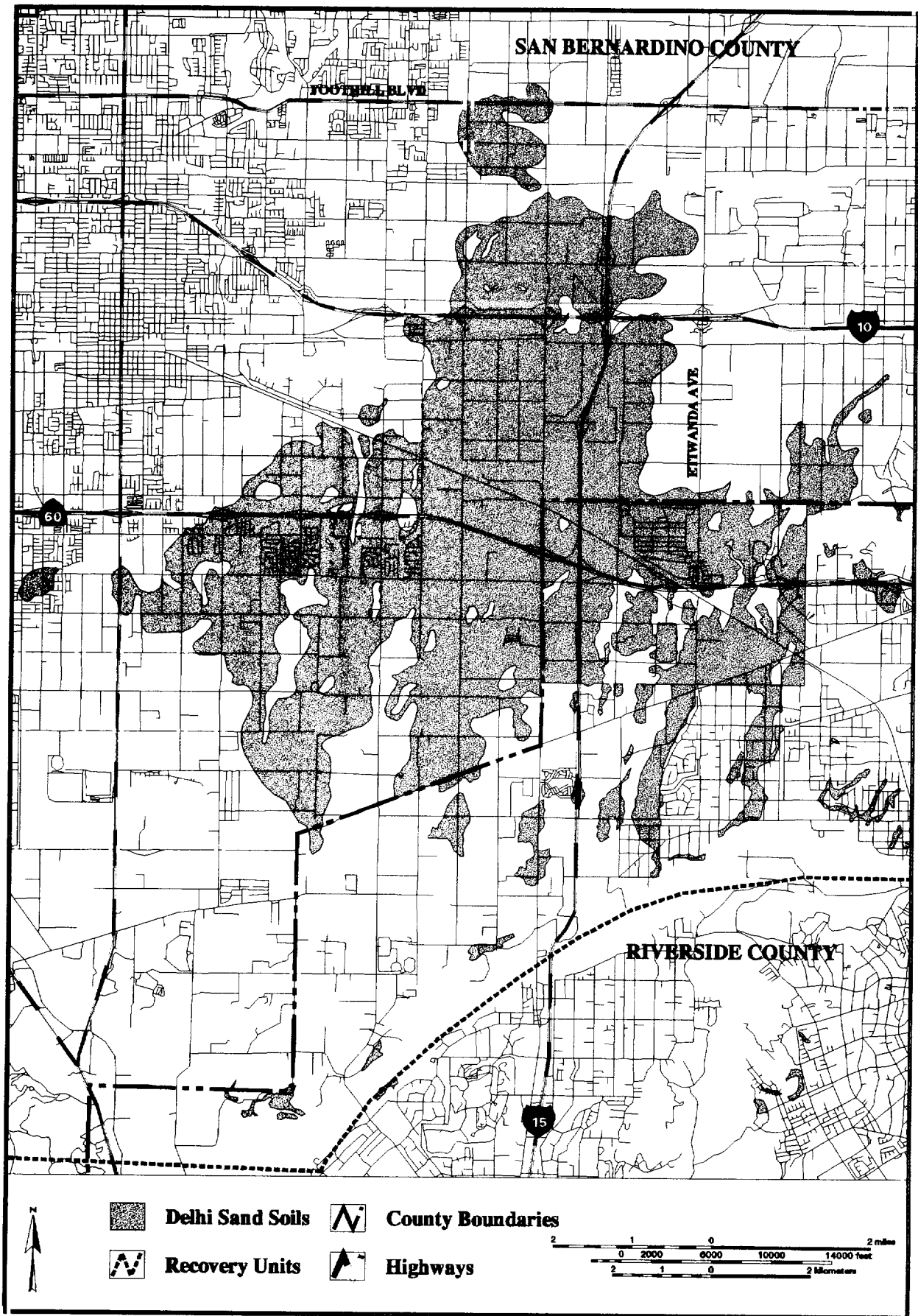


Figure 6. Ontario Recovery Unit

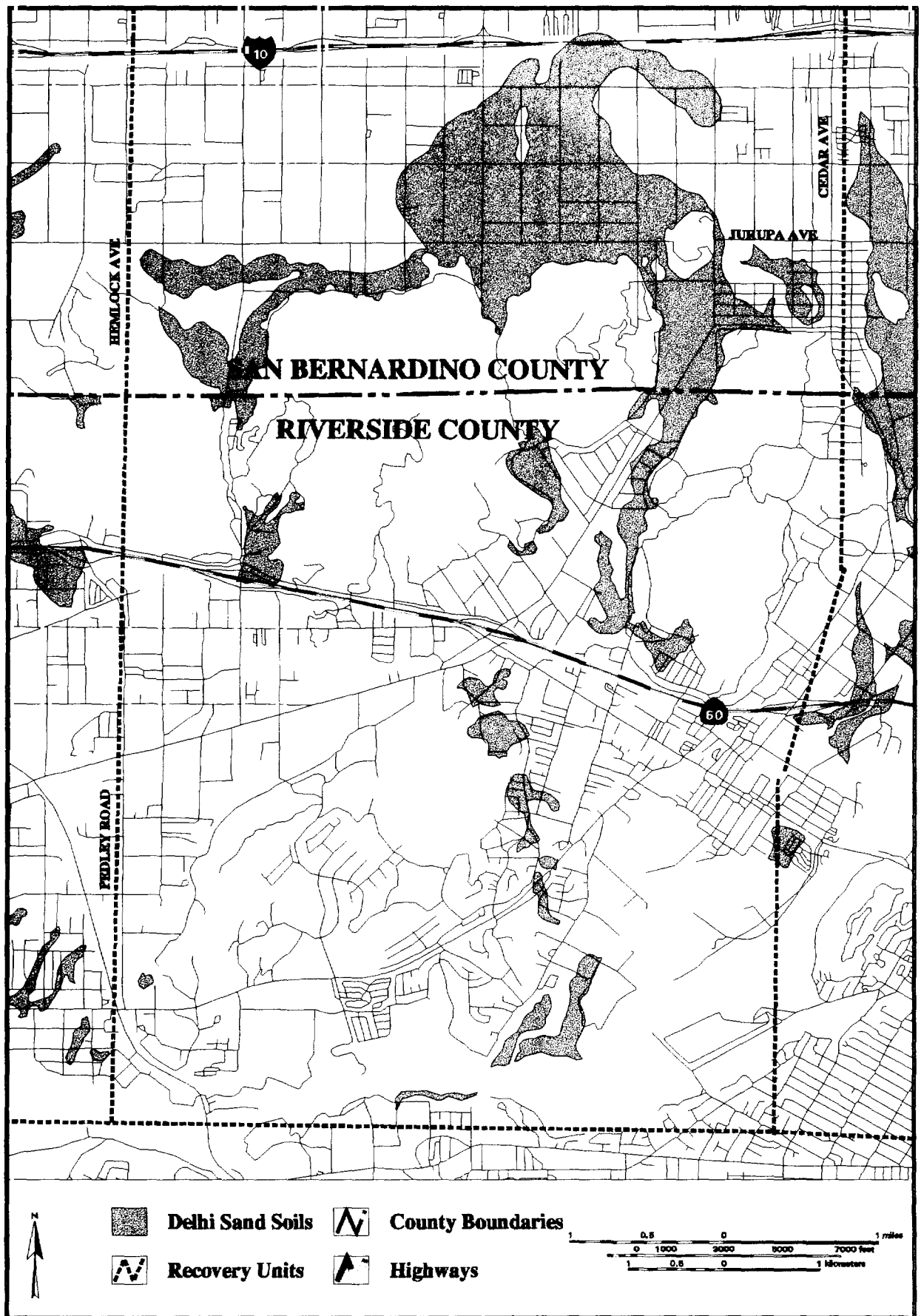


Figure 5. Jurupa Recovery Unit

Appendix C: Glossary

aestivate: A process where the dry, hot months are passed in a dormant state.

cismontane: California, like Roman Gaul, is divided into two parts. “This” side of the mountains (cismontane), has a Mediterranean climate and the distinctive California flora. The “other side” of the mountains, transmontane California, contains parts of the Sonoran and Mojave Deserts and the Great Basin.

diapause: A period of physiologically enforced dormancy, i.e. developmental arrest in an insect between periods of activity.

emergence: Exit of an adult insect from an immature stage. Compare with hatching

endemic: Confined to a specific geographic area and found nowhere else.

extinction: The complete disappearance or death of species from its total range. Compare with extirpation.

extirpation: The disappearance of a species from a particular area but not the total range. Compare with extinction.

fossorial: Adapted for burrowing beneath the surface of the ground.

Habitat Conservation Plan (HCP): A plan developed for the management of lands to conserve endangered or threatened species as a condition of obtaining an incidental take permit pursuant to section 10(a) of the Endangered Species Act of 1973, as amended. The permit holder is allowed to take specified numbers of specified species incidentally to carrying out an otherwise lawful activity, such as real estate development.

hatch: Exit of an immature insect from the egg stage. Compare with emergence.

instar: The immature insect between molts during development.

larva (plural = larvae): The immature and wingless form that hatches from the egg of a holometabolous insect and that will eventually transform into a pupa before reaching adulthood.

management plan: A plan developed for the conservation and management of a species or

ecosystem. Conservation measures specified in a management plan generally include but are not limited to habitat protection, habitat management, and land use practices, but may include additional measures or methods of conservation, such as artificial propagation.

mandibles: The first of the paired mouth appendages in insects and other arthropods; usually jaw-like (in chewing forms) or needle-like (in sucking forms).

metamorphosis: A series of marked and more or less abrupt changes in the form of a developing insect. See holometabolous.

occupied habitat: An area containing Delhi Sands soils and associated habitat used for breeding, nectaring, shelter, and/or as a dispersal corridor by the Delhi Sands flower-loving fly.

oviposition: Egg laying

ovipositor: An organ used by insects for depositing eggs in a place suitable for their development.

population: A group of individuals at a given locality which interbreed when mature.

restorable habitat: An area containing Delhi series soil with habitat components that are not currently occupied by the Delhi Sands flower-loving fly and/or an area that could be feasibly managed for the Delhi Sands flower-loving fly.

pristine habitat: An area containing Delhi series soil with habitat components for the Delhi Sands flower-loving fly that has been received few or no adverse impacts as a result of human activities.

proboscis: Elongate, often extensile, mouthparts of insects that take liquid food.

pupa (plural = pupae): An intermediate, usually quiescent, stage in the life cycle of a holometabolous insect in which the insect is usually enclosed in a hardened cuticle (chrysalid or puparium) or in a cocoon and from which the adult will eventually emerge.

Recovery Unit (RU): An area containing one or more populations or restorable habitat for management of at least two viable populations. The definition is for this recovery plan.

(minimum) viable population: A threshold level at which the population has a reasonable chance of survival or sustainability over time.

APPENDIX D: Museum records of the Delhi Sands flower-loving fly

Preserved specimens of the Delhi Sands flower-loving fly are known from the following localities:

CALIFORNIA, San Bernardino County:

Bloomington: August 22, 1948, no collector (1 male, 1 female)(MC)

Rialto: August 17, 1938, P.D. Hurd (2 females)(MC), September 24, 1938, P.D. Hurd (1 male)(MC), August 15, 1956, P.D. Hurd (1 male)(MC), August 15, 1956, E.G. Linsley, P.D. Hurd (10 males, 2 females)(MC), August 10, 1955, J.C. Hall (1 male)(MC), August 3, 1956, J.C. Hall (1 male, 1 female)(MC);

San Bernardino: August 17, 1977, Sandahl (1 male)(MC)

Colton/Rialto (south side of San Bernardino Avenue between Pepper Avenue and Riverside Avenue): August 8, 1985, G. Gorelick (2 males, 1 female, about 20 individuals observed on both sides of San Bernardino Avenue)(RM); August 21, 1985 G. Gorelick (2 males, 1 female)(RM); September 7, 1985 (1 male north side of San Bernardino Avenue)(RM); August 8, 1986 (2 males, 2 females)(RM); August 16, 1986 J. Wiseman (2 males, 2 females)(RM); August 21, 1987 (1 male, 2 females)(RM); August 12, 1988, L. Mueller (1 male, 1 female, 1 pupal case)(RM); August 15, 1988 D. Colby (5 males, 2 females, San Bernardino Avenue, Pepper Avenue and Slover Avenue)(RM); August 18, 1988 R. Mattoni (1 female, San Bernardino Avenue, Pepper Avenue and Slover Avenue)(RM); August 12, 1989, L. Mueller (1 female)(RM); August 16, 1989, R. Rogers, G. Ballmer, and R. Mattoni (5 pupal cases)(RM)

CALIFORNIA, Riverside County:

Mira Loma, August 24, 1941, Guy Toland, J. Wilcox (10 males, 3 females)(MC)

Source of data is as follows: MC=Cazier (1985), RM=R. Mattoni (unpub. notes)

APPENDIX E: Partial List of Plant Species Occurring in Occupied and Restorable Delhi Sands
Flower-loving Fly Habitat

Native Perennials

Adenostoma fasciculatum
Artemisia californica
Artemisia dracuncululus
Baccharis pilularis
Croton californica
Dichelostemma capitatum
Encelia farinosa
Ephedra sp.
Eriogonum fasciculatum
Eriogonum fasciculatum var. *polifolium*
Gutierrezia californica
Ericameria palmeri (*Haplopappus palmeri*)
Lessingia filaginifolia
Lotus scoparius
Marah macrocarpus
Mirabilis californica
Oenothera californica ssp. *californica*
Opuntia littoralis
Opuntia ×*vaseyi*
Penstemon spectabilis
Prunus ilicifolia
Rhamnus crocea
Rhus trilobata
Rumex hymenosepalum
Sambucus mexicana
Solanum douglasii
Stillingia linearifolia
Urtica sp.

Native annuals

Ambrosia acanthicarpa
Amsinckia menziesii var. *intermedia*
Camissonia bisorta
Camissonia californica
Camissonia hirta
Centaureum venustum
Chaemaesyce sp.
Crassula connata
Crypthantha intermedia
Cryptantha sp.
Eriastrum sapphirinum
Eriogonum gracile
Eriogonum thurberi
Eucrypta chrysanthemifolia
Filago californica
Gilia angelensis
Heterotheca grandiflora
Lessingia glandulifera
Lupinus bicolor
Lotus purshianus
Lotus strigosus
Oenothera californica
Pectocarya linearis
Pectocarya penicillata
Phacelia distans
Vulpia myuros var. *myuros*
Vulpia octoflora var. *octoflora*

Introduced Species

(T=tree; P=perennial; A=annual)

Agapanthus africanus (P)
Brassica geniculata (A)
Brassica tournefortii (A)
Centaurea melitensis (A)
Chenopodium murale (A)
Conyza canadensis (A)
Cotula australis (A)
Cycloloma atriplicifolia (A)
Erodium botrys (A)
Erodium cicutarium (A)
Euphorbia sp. (A)
Filago gallica (A)
Helianthus annuus (A)
Herniaria hirsuta ssp. *cinerea* (A)
Hypochaeris glabra (A)
Malva parviflora (A)
Marrubium vulgare (P)
Medicago polymorpha (A)
Medicago sativa (A)
Melilotus indica (A)
Oxalis sp. (A)
Parkinsonia aculeata (T)
Salsola tragus (A)
Schinus molle (T)
Senecio vulgaris (A)
Sisymbrium orientale (A)
Sonchus oleraceus(A)

APPENDIX F: Summary of the Agency and Public Comments on the Draft Delhi Sands Flower-loving Fly Recovery Plan

On February 9, 1996, the Service released the Draft Recovery Plan for the Delhi Sands Flower-loving Fly for a 60-day comment period that ended on April 12, 1996, for Federal agencies, State and local governments, and members of the public (61 **Federal Register** 5025).

Twelve letters were received, each containing varying numbers of comments. The local jurisdictions that responded included the County of San Bernardino, and the Cities of Ontario, Fontana, and Rancho Cucamonga. The Service sent letters to 27 experts on the Delhi Sands flower-loving fly, mydid flies, Colton Dunes, and/or invertebrate conservation requesting comments on the Draft Recovery Plan. Responses were received from four of these experts, who provided comments and recommendations on the need to protect the habitat of the Delhi Sands flower-loving fly, the value of movement corridors, the potential threat from pathogens and parasites, and the need for a public education program.

The number of letters received, by affiliation:

Federal agencies	1 letter
local governments	4 letters
Business/industry	1 letter
environmental/conservation organizations	2 letters
academia/professionals	4 letters

Summary of Significant Comments and Service Responses

The Service reviewed all of the comments received during the comment period. Many specific comments re-occurred in the letters. A number of the comments dealt with matters of opinion, or unsubstantiated natural history observations, which are not relevant to the recovery of the Delhi Sands flower-loving fly. Comments updating the information in the draft recovery plan have been incorporated into the appropriate section of the recovery plan. The substantive comments and the Service's response to each are summarized as follows:

Comment: The budget is unconvincing. Where did the numbers come from?
Response: The numbers in the Implementation Schedule are estimates of what recovery will cost. The numbers will be revised as new information becomes available. Costs for full implementation of recovery actions will be based on the management plans that will be developed for each of the eight populations

and other recommended actions.

Comment: The recovery plan should provide for specific details and criteria on the implementation on the recovery plan, how habitat will be acquired and restored, and the proposed captive breeding program.

Response: The recovery plan provides guidance and direction on the actions needed to protect and manage the Delhi Sands flower-loving fly so that it is no longer endangered. It is not intended to provide specific and rigid instructions for these activities. Differing situations will necessarily require that the appropriate activities be tailored for each situation.

Comment: The target population size for the Delhi Sands flower-loving fly is specified without reference or knowledge of predisturbance population levels.

Response: The Service agrees with this comment, however, the target densities of Delhi Sands flower-loving flies are based on related, non-listed species in the genus *Rhaphiomidas*.

Comment: The City of Rancho Cucamonga requested that they be removed from the recovery plan. They stated that the City does not contain suitable habitat for the fly and reported that several surveys have not found evidence of the animal.

Response: Recovery plans are advisory in nature and do not require any party or governmental entity to undertake specific tasks. However, the prohibitions against take of the Delhi Sands flower-loving fly apply to any person subject to the jurisdiction of the United States. Therefore, the deletion of Rancho Cucamonga from the recovery unit would not alter the review received by projects pursuant to the Endangered Species Act. The research to be conducted under recovery tasks 1.1 and 1.2 will determine if specific parcels should be included in the Ontario Recovery Unit.

Comment: Public education is not adequately addressed in the Recovery Plan.

Response: The Service agrees that public information is a vital component of Delhi Sands flower-loving fly recovery. Local involvement is critically needed for the protection and management of the species. Rhapsody in Green, an environmental education group, has been restoring Colton Dune habitat since 1996 using local volunteers. Cost estimates for development of a public information program are provided in the Implementation Schedule.

- Comment:** The potential impact of pathogens and parasites on the Delhi Sands flower-loving fly should be addressed by the Recovery Plan.
- Response:** The impact of pathogens and parasites on the animal are unknown. However, these agents will be investigated as part of the proposed ecological studies on the species.
- Comment:** The justification for the time period required for the Delhi Sands flower-loving fly to reach recovery is not clear.
- Response:** Too allow for periods of drought or other adverse natural environmental conditions, the eight populations must exhibit a statistically significant upward trend for at least fifteen years, as determined by scientifically credible monitoring .
- Comment:** The draft recovery plan recommended line-transect counts to measure the population size of the species. Line transect counts were designed for butterflies and mark-recapture of the Delhi Sands flower-loving fly should be allowed by the Service because it is a more accurate means of estimating population size.
- Response:** The use of line transect counts is an accurate technique for obtaining relative population sizes of not only butterflies, but other animal species as well (Gall 1985), including the Delhi Sands flower-loving fly. Despite its hardy appearance, the Delhi Sands flower-loving fly can easily be killed or injured when captured and handled. The recovery plan stipulates that mark-recapture techniques must first be perfected on non-listed surrogate species of *Rhaphiomidas*.
- Comment:** The Department of the Interior and the Service should acquire all of the remaining Delhi Sands habitat.
- Response:** Both the Department of the Interior and the Service will, subject to budgetary constraints, attempt to acquire sites containing the Delhi Sands flower-loving fly and associated habitat from willing landowners. The Service also will work with State and local jurisdictions, and private partners to protect the animal.
- Comment:** The Service should refrain from issuing section 7 and section 10(a)(1)(B) incidental take permits under all circumstances.
- Response:** The Service has to consult if requested (section 7) or consider permit applications (section 10). In determining whether to issue “no jeopardy”

biological opinions (section 7) or permits, the Service is bound by the Endangered Species Act's requirement to insure that any action authorized, funded, or carried out by a Federal agency is not likely to jeopardize the continued existence of this species (section 7), and by the Act's section 10 requirement that an incidental take permit be granted only if the applicant's proposed habitat conservation plan "would not appreciably reduce the likelihood of the survival and recovery of the species in the wild."

Comment: The draft recovery plan incorrectly emphasizes captive breeding as a recovery tool for the Delhi Sands flower-loving fly. All efforts to date have failed to successfully breed the fly and there is no data to support its "urgency."

Response: Augmentation of individuals to several of the extant populations likely is appropriate, given the low numbers of the Delhi Sands flower-loving fly at these sites, or to reintroduce the animal to locations containing suitable habitat. Inbreeding increases the likelihood of extinction (Frankham 1995). Reintroduction has been used as a conservation tool for other insects, such as the large blue butterfly (Barnett and Warren 1995) and the endangered northeastern beach tiger beetle (Clancy 1996). The Service is confident that on-going research on surrogate species of *Rhaphiomidas* holds promise that will allow the successful captive breeding and release of the Delhi Sands flower-loving fly.

Comment: Three commenters felt that "dispersal routes" is a hypothetical concept that should be eliminated from the recovery plan. Expressing a contrary viewpoint, a recognized entomologist stated that dispersal corridors are important for adequate gene flow between populations and should be protected.

Response: The biological importance of dispersal corridors and the need for their protection is addressed in the recovery plan. Dispersal corridors provide opportunity for the Delhi Sands flower-loving flies to move between their populations and thus maintain genetic diversity.