Lange's Metalmark, *Apodemia mormo langei* Comstock

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Country: U.S.A.

Status and Conservation Interest: Status – possibly out of danger; endangered listing (USFWS).

This local subspecies was one of the first eight insects to be listed as an endangered species in 1976 under the Federal Endangered Species Act. Its remnant habitat was purchased by the U.S. Fish and Wildlife Service (USFWS) in 1980 and designated as the Antioch Dunes National Wildlife Refuge, the first such refuge in the country established to protect insects and plants. Population numbers of *Apodemia mormo langei* declined over a period of 50 years to a few hundred individuals in the early 1980s. During the past decade they have increased tenfold or more in response to recovery actions, which include exclusion of vehicular and most foot traffic, removal of exotic vegetation, and extensive outplanting of the larval host plant.

General accounts of the unique insect and plant communities and destruction of the Antioch dunes by sand mining and industrial development have been recorded (Howard 1983; Howard and Arnold 1980; Farb 1964; Powell 1981, 1983).

Female Lange's Metalmark on flowers of *Senecio douglasii.*

Taxonomy and Description: Considerable polytypy is expressed, often discordantly, in hostplant species, seasonal phenology and voltinism, and in size and colour pattern of the adults (Opler and Powell 1962; Powell 1975).

Distribution: *Apodemia mormo* (Felder & Felder) (Riodininae) is widely distributed in the western Nearctic and occurs in scattered, often isolated colonies. Some forms of the butterfly are quite limited in geographic distribution and may be separated by distances of only 15–20km from other populations that are easily distinguished phenotypically. *Apodemia mormo langei* was discovered in 1933, on the riverine sand dune system just east of Antioch, Contra Costa Co., California (Comstock 1938). This subspecies is represented by just one population (Opler and Powell 1962). The nearest known colonies of *Apodemia mormo* are located on the northwest slope of Mt. Diablo and on the hills northwest of Vallejo, Solano Co., which are respectively **about** 15km SW and 39km WNW of the *langei* site. These populations have appreciable differences in colour pattern from *langei.*

Population Size: U.S. Geological Survey topographical maps and aerial photographs that span 1905 to 1969, document the destruction of the Antioch sand dunes. At the turn of the century, after agricultural development of the region, they extended for 3–4km in a narrow band along the San Joaquin **River and** reached heights of 20–35m. Sand mining operations began prior to and during the 1920s (Howard and Arnold 1980). Although the installation of two powerline towers, in 1909 and 1927, resulted in habitat disturbance including building construction and introduction of exotic plants, today these Pacific Gas and Electric (P.G. & E.) towers stand on the two remaining remnants of sand hills.

By 1931, five huge sand pits, each with a railroad spur, were in operation, for the developing San Francisco Bay area. During post World War II years, massive industrial developments replaced the eastern half of the dunes, and in the 1950s sand mining moved to the western sector. A Kaiser Gypsum plant

was completed in 1956, and this isolated the two remaining remnants of the habitat, the Stamm Property (SP) to the west and the 'Little Corral' (LC) flanked by the P.G. & E. properties to the east (Figure 1).

Although its habitat was gradually restricted during the 40 years following discovery, the local abundance of *Apodemia mormo langei* remained high. Lepidopterists observed the butterflies by the hundreds and collected specimens at rates of 25–30 per hour in various seasons during 1947–1972. Even as late as 1972, three observers took 70 specimens one day and 50 more seven days later and estimated sighting 150–200 on each date.

Soon thereafter, however, the colonies were severely affected by increased sand-mining at the western parcel (SP), by rototilling on the P.G. & E. properties in compliance with a county ordinance for fire prevention, and by overgrazing by horses. Thus by 1976, when Powell began population census by transect counts, numbers of *langei* had dropped alarmingly. During mark-recapture monitoring by Arnold and Powell from 1977–1982, the maximum number of *langei* two persons could observe in 3.5–4.5 hour periods at the two sites was 45–55 (Arnold and Powell 1983; Powell unpubl. data). Total population numbers, calculated from daily Jolly-Seber and Manly-Parr estimates and the survival rates of individual butterflies, declined from more than 2000 in 1977 to fewer than 600in 1982 (Arnold 1985 and unpubl. reports to USFWS).

The butterfly numbers stabilised and increased slightly in 1983–84 and then rose significantly as *langei* began to occupy *Eriogonum* in peripheral areas that had been both planted and colonised naturally. The estimated total population exceeded 1200 in 1985, the final year of Arnold's mark-recapture studies (Arnold, unpublished report to USFWS). Subsequently, single day sighting counts, made weekly by USFWS personnel, indicate that the numbers of *langei* have continued to climb dramatically. Seasonal peak numbers have risen from 168 in 1986 to more than 1900 in 1991. It is likely that the population has 10 to 20 times the number of butterflies that it was estimated to have contained 10 years ago (e.g. 6000 to 12,000).

Habitat and Ecology: Populations occur in close association with the larval foodplants, species of *Eriogonum* (Polygonaceae), typically in well drained semiarid sites, such as rocky desert slopes, sand dunes, or chaparral-covered hills, ranging from sea coast to timberline at 2750m. Colonies of *A. m. langei* are limited to dense or moderately dense patches of the larval foodplant, *Eriogonum nudum auriculatum* (Arnold and Powell 1983). Arnold and Powell believed that isolated or spindly, scattered plants fail to support colonies of the butterfly because early instar larvae derive insufficient protection for overwintering.

A. m. langei is univoltine, with adults flying for about 30 days beginning in early August. Males precede females by a few days, and peak numbers occur about two weeks after emergence begins. The eggs are deposited in clusters of 2–4 on withering foliage on the lower half of the plant. Eclosion of larvae takes place during winter, after rainfall and foliation begin. Feeding occurs by skeletonizing the leaf surfaces and the inflorescence stalks by later instars in June and July. Larvae feed in early morning and presumably evening and retreat to the base of the plants during the day. Pupation occurs in the litter

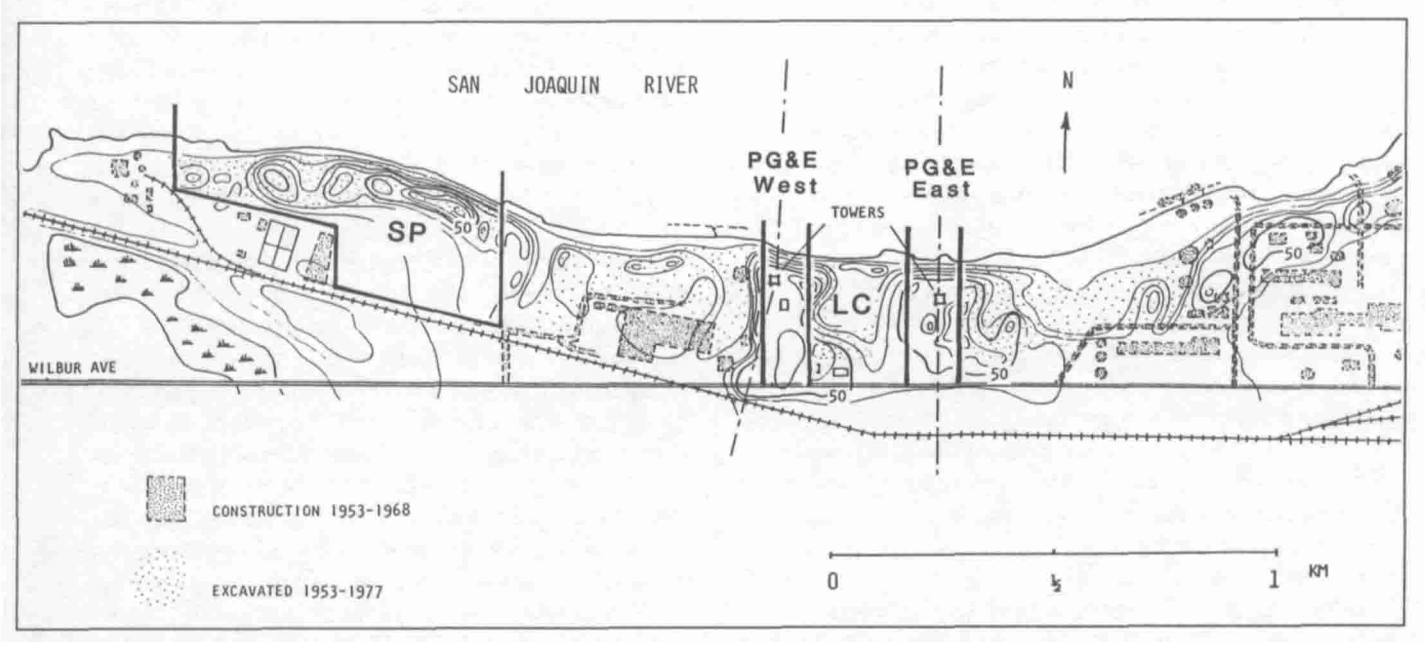

Figure 1. Map of the Antioch Dunes National Wildlife Refuge, just east of Antioch, Contra Costa Co., California.
Redrawn from Antioch North Quadrangle, U.S. Geological Survey topographic map, 1953. Shaded areas delineated by dotted lines indicate construction sites, 1953–1968, compiled from aerial photographs. Sparsely doited areas depict sand-mining excavations during 1953–1967. The two corridors traversed by P.G. & E. powerlines are the only unexcavated hills that remain. Bold lines define the two parcels of the Refuge, "Stamm Property" (SP) and "Little Corral" (LC), the latter flanked by P.G. & E. properties.

at the base of the plant, in late July and early August (Arnold and Powell 1983).

Males tend to occupy restricted areas day after day, while females move greater distances. Mark-recapture data suggested that males live an average of about 12 days. Adults of both sexes forage for nectar; *Eriogonum* serves as the primary nectar source, at least in recent years, while occasional visits are made to *Gutierrezia* and *Senecio* (Asteracecae), both of which were formerly more abundant, and other plants (Arnold and Powell 1983).

Under natural circumstances, this variety of *Eriogonum nudum* probably lived as an edge species, occupying slip slopes of active sand in the hills that were stabilised by scattered oaks and a rich flora of desert affinities (Howard 1983). There is no doubt that the active sand habitat greatly increased during the 1920–1940 era of sand-mining. Thus, it is likely that, along with its larval host, *A. m. langei* had increased in population numbers by the time of its discovery in the early 1930s.

Conservation: Rehabilitation of habitat suitable for colonisation by *A. m. langei* begore before acquisition of the Refuge lands by USFWS. Propagation and outplanting on the P.G. & E. properties began in 1979, following inadvertent rototilling of one of the primary stands of *Eriogonum,* despite efforts by the company to prevent such an accident. P.G. & E. contracted with Biosystems Analysis Inc. to develop a restoration plan, and about 450 seedlings were planted in March 1980 (Howard and Arnold 1980). Collective efforts during 1980–1984, which were orchestrated by Howard and Arnold, were financed by P.G. & E., grants from the California Native Plant Society, a USFWS contract, and assistance by the University of California, Berkeley undergraduate botany association and other volunteers (Arnold 1985). During the same years, the USFWS began planting *Eriogonum* at the western parcel (SP) by scarifying and seeding the excavated surface left bare by a final surge of sand-mining in 1978–79. In 1985 the USFWS entered a Cooperative Agreement with P.G. & E. that allows the Service to manage the additional 5ha owned by P.G. & E., which are contiguous with LC (Figure 1). In 1987, fencing of the lands was completed, and this virtually eliminated further human degradation of the habitat. Also in 1987 a vineyard to the south of the *Apodemia* colony at SP was removed and subsequently planted with 7000 *Eriogonum* seedlings. Small numbers of *langei* have begun to occupy that area (58 were observed in one day in 1991).

In 1991 a more ambitious cooperative restoration project was initiated to create new sand dunes in previously mined areas occupied by weedy vegetation. Low hills, consisting of sand mined from another P.G. & E. property up river, have been deposited and contoured on the LC and P.G. & E. western parcels. These were subsequently seeded and planted and now bear mantles of *Eriogonum* and *Senecio douglasii* seedlings, the latter a major nectar source for the butterflies, as well as two endangered plants, *Oenothera deltoides* var. *howelli* (Onagraceae) and *Erysimum capitatum* var. *angustatum* (Brassicaceae).

Altogether, we estimate that outplanted *Eriogonum* colonies that have reached densities believed to be sufficient to support *Apodemia* occupy areas of 9600m^2 at SP and 3200m^2 on the P.G. & E. properties, a total of nearly 1.3ha.

In 1979 the maximum distribution of the foodplant range (range width x range length, right angle) was estimated to be 2.3ha at LC and 1.5ha at SP, not more than one-third of which was suitable for *Apodemia* as judged by occurrence of adults (Arnold and Powell 1983). Hence, there was only about 1.3ha of viable *Eriogonum* habitat at its lowest ebb, and subsequent efforts have at least doubled that area. Several additional patches of the host plant, planted in recent years, are expected to develop into viable habitat within a few seasons.

Threats: Effects of weediness and possibility of fire are the principal threats to continued existence of *A. m. langei.* A standing crop of annual weeds poses a fire danger each year during the long dry season (May-October). The refuge is bordered inland by industrial development, and there are several small beaches that are accessible to recreational boat visits, so possible sources of human-initiated fires cannot be controlled.

Conservation and recovery efforts have been a dramatic success, increasing the population numbers from a perilously low level a decade ago. However, after 10–15 years *Eriogonum* host plants senesce, and they fail to reproduce in the absence of open, active sand. We have witnessed the growth and decline of *Eriogonum* and associated *langei* colonies in several areas during the past 15 years. For example, a robust colony developed in association with the foundations of a building that was removed after 1972 on P.G. & E. west; it was the home of a strong colony of *langei* during 1978–1982, but these plants were senescent by 1988 and have died out by 1992. The foundations protected the plants from rototilling during the 1970s, but competition with weeds prevented seedling growth. A similar fate can be predicted for most of the existing and recently planted patches of *Eriogonum.* Once a colony of the food plant is established, it is impractical to prevent a ground cover of weeds, especially annual exotic grasses, yellow star thistle, Russian thistle, and vetch, which does not kill mature *Eriogonum* but prevents development of its seedlings. Thus, it is easier to clear a site and plant new patches of the host plant than to maintain existing ones.

To be successful on a long term basis, the management plan needs to prescribe replacing senescent patches of *Eriogonum* on a continuing basis.

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