

sphingid populations, *i.e.*, connectivity between habitat areas is necessary to support wide-ranging sphingid species.

Ehrlich and Murphy (1987) noted that populations of herbivorous insects such as lepidopterans are often regulated by environmental factors, such as weather conditions, and thus small populations can be particularly at risk of extinction. Ehrlich and Murphy (1987) identified a number of principles important for the conservation of herbivorous insects. First, in most cases, a series of diverse demographic units will typically be needed to conserve a species. Second, where possible, corridors among the sites should be established to promote re-colonizations in areas where the species once occurred. Lastly, they noted that when populations are very sensitive to environmental changes and limited information is available on the species' population biology, it is easy to underestimate the conservation needs of such insects.

Murphy *et al.* (1990) also noted that reviews of butterfly population ecology demonstrate that environmental factors play important roles in determining butterfly population dynamics. They stated that most documented population extinctions have resulted from habitat deterioration combined with extreme weather events. Decreases in the quality or abundance of larval host plants and adult nectar sources are caused by changes in plant community composition, particularly changes associated with succession, disturbance, and grazing regimes. But, because many butterfly species are especially sensitive to thermal conditions, habitat changes that disrupt micro-climatic regimes can cause habitat deterioration without elimination of plant resources. Ehrlich and Murphy (1987) noted several patterns within typical butterfly populations: A number of subpopulations within a given specie's metapopulation (a set of local populations or breeding sites within an area, where typically migration from one local population or breeding site to other areas containing suitable habitat is possible, but not routine) are often extirpated and later re-colonized; and a given species may not be present in many of its habitat remnants, including within those containing the highest host plant diversity.

Section 3(5)(A)(i) of the Act provides that areas outside the geographical area currently occupied by the species may meet the definition of critical habitat upon determination that they are essential for the conservation of the species. Although our knowledge of the Blackburn's sphinx moth's historical range is incomplete, we believe the

existing natural habitats needed to support viable populations of the moth are too small, isolated, and seriously threatened to ensure its long-term conservation, particularly in light of the foraging needs of adult sphingid moths (Janzen 1984) and the apparent wide-ranging Blackburn's sphinx moth foraging habits (Fern Duvall, DOFAW, pers. comm. 2001; B. Gagne, pers. comm. 2001; D. Hopper, *in litt.* 2000, 2002; HHP 2000).

Long-term conservation of the species will require the protection and subsequent restoration of additional and larger areas of dry and mesic habitat that include the larval and adult primary constituent elements at different elevational and rainfall gradients, in order to improve the likelihood of successful larval development and adult moth foraging (A. Medeiros, pers. comm. 1998; Roderick and Gillespie 1997; Van Gelder and Conant 1998). The long-term persistence of the existing populations will likely improve if they could be increased in size, and if the connectivity among the populations was enhanced, thus promoting dispersal of individuals across intervening lands. Restoring moth populations in multiple locations would decrease the likelihood that the effect of any single alien parasite, predator, or combined pressure of such species could result in the diminished vigor or extinction of the moth.

Small habitats tend to support small populations, which frequently are extirpated by events that are part of normal environmental variation. The continued existence of such satellite populations requires the presence of one or more large reservoir populations, which may provide colonists to smaller, outlying habitat patches (Ehrlich and Murphy 1987). Based on recent field observations of the Blackburn's sphinx moth, we believe the species likely occurs within two regional populations on separate islands, one centered in the area of leeward East Maui (Units 1–4 (*see* Unit Descriptions below)), and one centered near Puuwaawaa (Unit 8) on Hawaii Island, north of Kailua-Kona (A. Medeiros, pers. comm. 1998; F. Howarth, pers. comm. 2001). Both of these two areas contain populations of the moth regarded as probable source areas or "reservoirs" (Murphy *et al.* 1990) for dispersing or colonizing moth adults.

Habitat areas close to the two large reservoir areas are also designated in order to promote genetic variability in the Blackburn's sphinx moth population, contributing to the long-term persistence and conservation of the species. These areas will serve as

corridors for dispersing adult moths or as overflow habitat during particularly fecund years, which could be very important to the integrity of moth populations. For example, adult moths observed at Cape Kinau (Unit 2) on Maui may have originated from larval host plants located in the Kanaio NAR (Unit 3). The moth populations inhabiting these habitat areas appear to be taking advantage of lower elevation adult native host plants and nonnative host plants such as tree tobacco upon which the larval stage is completed successfully. In addition, these habitat areas may be able to support persistent moth populations independent of the reservoir areas, significantly contributing to conservation of the species.

Molokai is an example of essential habitat because it provides for the expansion of the species' range and for improved connectivity of the different populations. While the designated unit on this island is not known to currently harbor a Blackburn's sphinx moth population, preserving this habitat is important because some threats to the species may be absent there (Table 1 shows several of the potential moth predators and parasites are not reported on Molokai). Likewise, because of Molokai's distance from islands currently inhabited by the moth, we believe the designated critical habitat on this island will be extremely important for the species' conservation as it will help protect the species from extinction by catastrophic events, which could impact other more closely grouped populations (*e.g.*, those on Maui or the island of Hawaii). For these reasons, we find that inclusion of an area such as on Molokai, identified as containing the primary constituent elements, is essential to the conservation of the species even though it does not currently contain known Blackburn's sphinx moth populations.

Due to the species' presently reduced range, the Blackburn's sphinx moth is now more susceptible to the variations and weather fluctuations affecting quality and quantity of available habitat and food. Furthermore, the moth is now more susceptible to direct pressure from numerous nonnative insect predators and parasites. For these reasons, and the reasons discussed above, those areas currently occupied would be inadequate to ensure the conservation of the species, and we have designated 9 units on four islands.

We are developing a draft recovery plan for this species. The overall objective of this recovery plan will be to ensure the species' long-term conservation and identify research