

species is longevity (*i.e.*, long-lived perennial, short-lived perennial, and annual). In general, long-lived woody perennial species would be expected to be viable at population levels of 50 to 250 individuals per population, while short-lived perennial species would be viable at population levels of 1,500 to 2,500 individuals or more per population. The HPPRCC revised these population numbers for Hawaiian plant species due to the restricted distribution of suitable habitat and the likelihood of smaller genetic diversity of several species that evolved from a single introduction. For recovery of Hawaiian plants, the HPPRCC recommended a general recovery guideline of 100 mature, reproducing individuals per population for long-lived perennial species, 300 mature, reproducing individuals per population for short-lived perennial species, and 500 mature, reproducing individuals per population for annual species (HPPRCC 1994).

The HPPRCC recommended the conservation and establishment of 8 to 10 populations of multi-island plant species and establishment of additional colonies on other islands for Nihoa plant species in order to address the numerous risks to the long-term survival and conservation of these species. Although absent the detailed information inherent to population viability analysis models (Burgman *et al.* 2001), this approach employs two widely recognized and scientifically accepted goals for promoting viable populations of listed species: (1) The creation or maintenance of multiple populations so that a single or series of catastrophic events cannot destroy the entire listed species (Luijten *et al.* 2000; Menges 1990; Quintana-Ascencio and Menges 1996); and (2) increasing the size of each population in the respective critical habitat units to a level where the threats of genetic, demographic, and normal environmental uncertainties are diminished (Hendrix and Kyhl 2000; Luijten *et al.* 2000; Meffe and Carroll 1996; Podolsky 2001; Service 1997; Tear *et al.* 1995; Wolf and Harrison 2001). In general, the larger the number of populations (or colonies) and the larger the size of each population (or colony), the lower the probability of extinction (Meffe and Carroll 1996; Raup 1991). This basic conservation principle of redundancy when applied to Hawaiian plant species reduces the threats represented by a fluctuating environment and offers the species a greater likelihood of achieving long-term survival and recovery. Conversely, loss of one or more of the plant populations (colonies) within any

critical habitat unit could result in an increase in the risk that the entire listed species may not survive and recover. Similarly, actions that eliminate, or reduce the function of, a primary constituent element could result in an increase in the risk of adverse modification of critical habitat.

Due to the reduced size of suitable habitat areas for these Hawaiian plant species, they are more susceptible to the variations and weather fluctuations affecting quality and quantity of available habitat, as well as direct pressure from hundreds of species of nonnative plants and animals. Establishing and conserving the specific target number of populations or colonies on one or more islands within the historic range of the species will provide each species with a reasonable expectation of persistence and eventual recovery, even with the high potential that one or more of these populations will be eliminated by normal or random adverse events, such as the hurricanes which occurred in 1982 and 1992 on the island of Kauai, fires, and nonnative plant invasions (HPPRCC 1994; Luijten *et al.* 2000; Mangel and Tier 1994; Pimm *et al.* 1998; Stacey and Taper 1992). Based upon this information, we conclude that designation of adequate suitable habitat to meet recovery goals for these five plant species is essential to give each of the species a reasonable likelihood of long-term survival and recovery.

All currently or historically occupied sites or sites identified as conservation areas within the recovery plans for these species, containing one or more of the primary constituent elements considered essential to the conservation of the five plant species were examined to determine if special management considerations or protection are required. We reviewed all available management information on these plants at these sites including published and unpublished reports, surveys, and plans; internal letters, memos, trip reports; and, section 7 consultations. Additionally, we contacted staff of the HINWR to discuss their current management for these plants on national wildlife refuge lands.

Pursuant to the definition of critical habitat in section 3 of the Act, the primary constituent elements as found in any area so designated must require "special management considerations or protections." In determining and weighing the relative significance of the threats that would need to be addressed in management plans or agreements, we considered the following:

- The factors that led to the listing of the species, as described in the final rules for listing each of the species. For all or nearly all endangered plants in the NWHI, the major threats include adverse impacts due to nonnative plants and invertebrates, seed or fruit predation by rats and mice, and fire (USFWS 1998d, 1999; 59 FR 56333; 61 FR 43178).
- The recommendations from the HPPRCC in their 1998 report to the Service ("Habitat Essential to the Recovery of Hawaiian Plants").
- The management actions needed for assurance of survival and ultimate recovery of Hawaii's endangered plants. These actions are described in the Service's recovery plans for these five species (USFWS 1998d, 1999) and in the 1998 HPPRCC report to the Service (HPPRCC 1998). These actions include, but are not limited to, the following: (1) Nonnative plant control; (2) rodent control; (3) invertebrate pest control; (4) fire control; (5) maintenance of genetic material of the endangered plants species; (6) propagation, reintroduction, and/or augmentation of existing populations into areas deemed essential for the recovery of these species; (7) ongoing management of the wild, outplanted (the planting of propagated plants (material) into the wild), and augmented populations; (8) habitat management and restoration in areas deemed essential for the recovery of these species; and (9) monitoring of the wild, outplanted, and augmented populations.

In general, taking all of the above recommended management actions into account, the following management actions are ranked in order of importance. It should be noted, however, that, on a case-by-case basis, some of these actions may rise to a higher level of importance for a particular species or area, depending on the biological and physical requirements of the species and the location(s) of the individual plants: (1) Nonnative plant control; (2) Rodent control; (3) Invertebrate pest control; (4) Fire control; (5) Maintenance of genetic material of the endangered plant species; (6) Propagation, reintroduction, and/or augmentation of existing populations into areas deemed essential for the recovery of the species; (7) Ongoing management of the wild, outplanted, and augmented populations; (8) Maintenance of natural pollinators and pollinating systems, when known; (9) Habitat management and restoration in areas deemed essential for the