

# Recovery Plan for *Phyllostegia hispida*

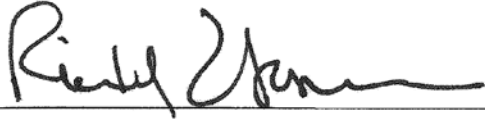
## *Addendum to the Molokai Plant Cluster Recovery Plan*



*Phyllostegia hispida*. ©Hank Oppenheimer, used with permission.

**Recovery Plan for  
*Phyllostegia hispida*:  
Addendum to the  
Moloka'i Plant Cluster  
Recovery Plan**

Region 1  
U.S. Fish and Wildlife Service  
Portland, Oregon

Approved: **Acting**   
Regional Director, U.S. Fish and Wildlife Service

Date: 7/30/13

## DISCLAIMER

Recovery plans delineate reasonable actions that are believed to be required to recover and/or protect listed species. We, the U.S. Fish and Wildlife Service (Service), publish recovery plans, sometimes preparing them with the assistance of recovery teams, contractors, State agencies, Tribal agencies, and other affected and interested parties. Plan objectives and funds are subject to budgetary and other constraints affecting the parties involved, as well as the need to address other priorities. Costs indicated for action implementation and time for achievement of recovery are only estimates and are subject to change. Recovery plans do not obligate other parties to undertake specific actions. Nor do they necessarily represent the views, official positions, or approval of any individuals or agencies involved in recovery plan formulation, other than the Service. Recovery plans represent the official position of the Service only after they have been signed by the Director or Regional Director as approved. Approved recovery plans are subject to modification as dictated by new findings, changes in species status, and the completion of recovery actions.

By approving this recovery plan, the Regional Director certifies that the data used in its development represent the best scientific and commercial information available at the time it was written. Copies of all documents reviewed in the development of the plan are available in the administrative record, located at the Service's Pacific Islands Fish and Wildlife Office in Honolulu, Hawai'i.

### **LITERATURE CITATION:**

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### **Recovery plans can be downloaded from the Service website at:**

<<http://pacific.fws.gov/ecoservices/endangered/recovery/default.htm>> and also at <<http://endangered.fws.gov/recovery/index.html>>

## **ACKNOWLEDGMENTS**

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## EXECUTIVE SUMMARY

**Current Species Status:** *Phyllostegia hispida* (no common name) is a plant species endemic to the island of Moloka'i, Hawai'i. It was federally listed as endangered in 2009 (U.S. Fish and Wildlife Service [USFWS] 2009). Currently there are fewer than 10 wild mature individuals, 3 wild seedlings, and approximately 7 to 10 reintroduced individuals on the island of Moloka'i.

**Habitat Requirements and Limiting Factors:** *Phyllostegia hispida* is typically found in wet *Metrosideros polymorpha* ('ōhi'a)–dominated forest, occurring between 1,112 and 1,280 meters (3,650 and 4,200 feet) elevation.

The major threats to all known populations are: habitat degradation by feral pigs (*Sus scrofa*); habitat degradation by and competition with invasive introduced plants; predation or herbivory by rats (*Rattus* spp.) and nonnative slugs; climate change; habitat degradation by landslides and flooding; and the negative demographic and genetic consequences of extremely small population size, as well as the consequent vulnerability to extinction through deterministic or stochastic (chance) events. Native caterpillar species may also pose an herbivory threat to this species.

**Recovery Priority Number:** The recovery priority number for *Phyllostegia hispida* is a 5, on a scale from 1 (highest) to 18 (lowest), reflecting its taxonomic position as a full species, a high degree of threat, and a moderate potential for recovery, with some threats that are well understood and easily alleviated and others that are currently difficult to alleviate.

**Recovery Strategy:** The first step toward recovery of *Phyllostegia hispida* is to protect all of the known wild populations. Continuing survey efforts will focus on identifying additional populations that may exist but are currently unknown. In order to reduce the potential for extinction due to the catastrophic loss of the small population on a single island, recovery actions will require increasing the area occupied by the existing populations where space and habitat allow, as well as establishing new populations within the estimated historical range of the species. Threats such as habitat degradation by feral pigs and habitat degradation by and competition with invasive introduced plants must be sufficiently controlled to allow for this population expansion. The effective management and

reintroduction of *P. hispida* will require gaining further knowledge about the life history of the species and the functioning of the ecosystem on which it depends. Therefore, research and monitoring are key components of the recovery strategy.

The recovery strategy is oriented to dynamic adaptive management of *Phyllostegia hispida* and its habitat in wet *Metrosideros polymorpha* ('ōhi'a)-dominated forest on Moloka'i. This strategy is consistent with the Service's Strategic Habitat Conservation process, which calls for an iterative process of biological planning, conservation design, conservation delivery, and monitoring and research. The biological planning and conservation design set forth in this recovery plan lay out the criteria for recovery and identify localities for implementing actions. The recovery actions describe a process for implementing conservation on the ground, outcome-based monitoring to assess success, and ongoing assumption-driven research to test biological hypotheses important to management.

**Recovery Goal:** The ultimate goal of recovery planning is to recover species to the point where they no longer require the protections of the Endangered Species Act. Given the current shortage of information about the biology and habitat requirements and the magnitude of current threats where *Phyllostegia hispida* occurs, only tentative criteria for stabilizing, downlisting, and delisting are established here. These criteria were formulated based on recommendations from individuals on the Hawai'i and Pacific Plants Recovery Coordinating Committee, as well as the International Union for Conservation of Nature and Natural Resources' draft red list categories (Version 2.2) and the advice and recommendations of knowledgeable biologists and individuals.

**Recovery Objectives:** In the short term, the interim recovery objective is to stabilize all existing populations of *Phyllostegia hispida*. To be considered stable, the species must be managed to control threats (*e.g.*, feral ungulates and invasive plants) and be represented in an *ex situ* population (such as a nursery or arboretum). Longer-term objectives will lead toward downlisting and delisting. These include an increase in populations and their numbers (which may involve outplanting, development of appropriate management and monitoring plans at each site) and conservation agreements with landowners to ensure threats are controlled in perpetuity.



**Recovery Criteria:** Recovery criteria are measurable, achievable goals that we believe will result from implementation of the recovery actions in this plan. Achievement of these criteria will take time and is intended to be measured over the life of the plan, not on a short-term basis, and they should not be considered near-term recommendations. This plan is designed to meet these criteria, at which time we will make a decision about whether to proceed with a downlisting or delisting proposal. Downlisting or delisting requires publication of a proposed and final rule in the Federal Register, including an analysis of the five listing factors to determine whether the species meets the definition of threatened or endangered. These recovery criteria represent our current best assessment of the conditions that should be met for such an analysis to determine the species is no longer threatened or endangered. However, we may still consider proceeding with a downlisting or delisting proposal without all recovery criteria having been exactly met, if we believe the five-factor analysis will support such a proposal.

*Phyllostegia hispida* may be considered for downlisting to threatened status when all of the following conditions have been met:

*Downlisting Criterion 1:* Population size. A total of at least five viable populations of *Phyllostegia hispida* are documented in suitable habitat on Moloka'i. Each of these populations must be naturally reproducing, stable or increasing in number, and threats must be managed so that a minimum of 300 mature individuals are maintained per population.

*Downlisting Criterion 2:* Management and monitoring plans. Habitat around each population must be managed to ensure that it will support the long-term persistence of *Phyllostegia hispida*. To achieve this, each of the five populations identified in Downlisting Criterion 1 must have implemented management and monitoring plans that will identify actions and procedures necessary to ensure that all threats are controlled and populations are stable or increasing.

*Downlisting Criterion 3:* Habitat quality. All of the populations that meet Downlisting Criterion 1 above must be fenced and protected from ungulates, with agreements from conservation partners to maintain those protections in perpetuity. The agreements will also include provisions for removal of invasive introduced plants, as appropriate, and adaptive management plans to address habitat degradation by feral pigs and herbivory by caterpillars and other unforeseeable

threats. In addition, the agreements will include provisions for maximizing native plant biodiversity in these areas that is appropriate for that particular habitat and location.

*Phyllostegia hispida* may be considered for delisting when all of the following conditions have been met:

*Delisting Criterion 1: Population size.* A total of at least eight viable populations are documented in suitable habitat on Moloka'i. Each of these populations must be naturally reproducing, stable or increasing in number, and threats must be managed so that a minimum of 300 mature individuals are maintained per population.

*Delisting Criterion 2: Management and monitoring plans.* Habitat around each population must be managed to ensure that it will support the long-term persistence of *Phyllostegia hispida*. To achieve this, each of the eight populations identified in Delisting Criterion 1 must have implemented management and monitoring plans that will identify actions and procedures necessary to ensure that all threats are controlled and populations are stable or increasing.

*Delisting Criterion 3: Habitat quality.* All of the populations that meet Delisting Criterion 1 above must be fenced and protected from ungulates, with agreements from conservation partners to maintain those protections in perpetuity. The agreements will also include provisions for invasive introduced plant removal, as appropriate, and adaptive management plans to address habitat degradation by feral pigs and herbivory by caterpillars and other unforeseeable threats. In addition, the agreements will include provisions for maximizing native plant biodiversity in these areas that is appropriate for that particular habitat and location.

**Actions Needed:**

1. Protect habitat and control threats.
2. Expand existing wild populations through natural recruitment and if needed, augmentation.
3. Conduct essential research.
4. Develop and implement detailed monitoring plans for all populations.
5. Establish new populations as needed to reach recovery objectives.
6. Validate and revise recovery criteria.

**Estimated Date and Cost of Recovery:** If all recovery criteria have been met, it is currently estimated that *Phyllostegia hispida* may be eligible for downlisting by the year 2029, and delisting by the year 2034. The estimated cost to recover *Phyllostegia hispida* to the point where it may be delisted is approximately \$6,131,000 (Table 1).

**Table 1. Total Estimated Cost of Recovery through Year 2034  
(in \$1,000).**

Year	Action 1	Action 2	Action 3	Action 4	Action 5	Action 6	Total
2014	469	20	141	20	15	18	683
2015	450	20	141	20	24	18	673
2016	437	20	141	20	19	18	655
2017	422	20	141	20	28	9	640
2018	422	20	141	20	15	9	627
2019 to 2034	2,392	51	176	118	82	34	2,853
<b>TOTALS</b>	<b>\$4,592</b>	<b>\$151</b>	<b>\$881</b>	<b>\$218</b>	<b>\$183</b>	<b>\$106</b>	<b>\$6,131</b>

## I. Background

### A. BRIEF OVERVIEW

This document is the second addendum to the Recovery Plan for the Moloka'i Plant Cluster (RPMPC) (USFWS 1996). The original RPMPC and its first addendum (USFWS 1998) jointly addressed 19 plant taxa, most of them endemic to Moloka'i. This addendum covers *Phyllostegia hispida* (no common name), which was added to the Federal List of Endangered and Threatened Wildlife and Plants on March 17, 2009 (USFWS 2009). Because *P. hispida* occurs in habitats similar to those for plants covered in the original RPMPC, and faces similar threats, many of the recommended recovery actions are similar or identical to those in the RPMPC. This Addendum will therefore refer frequently to sections of the RPMPC.

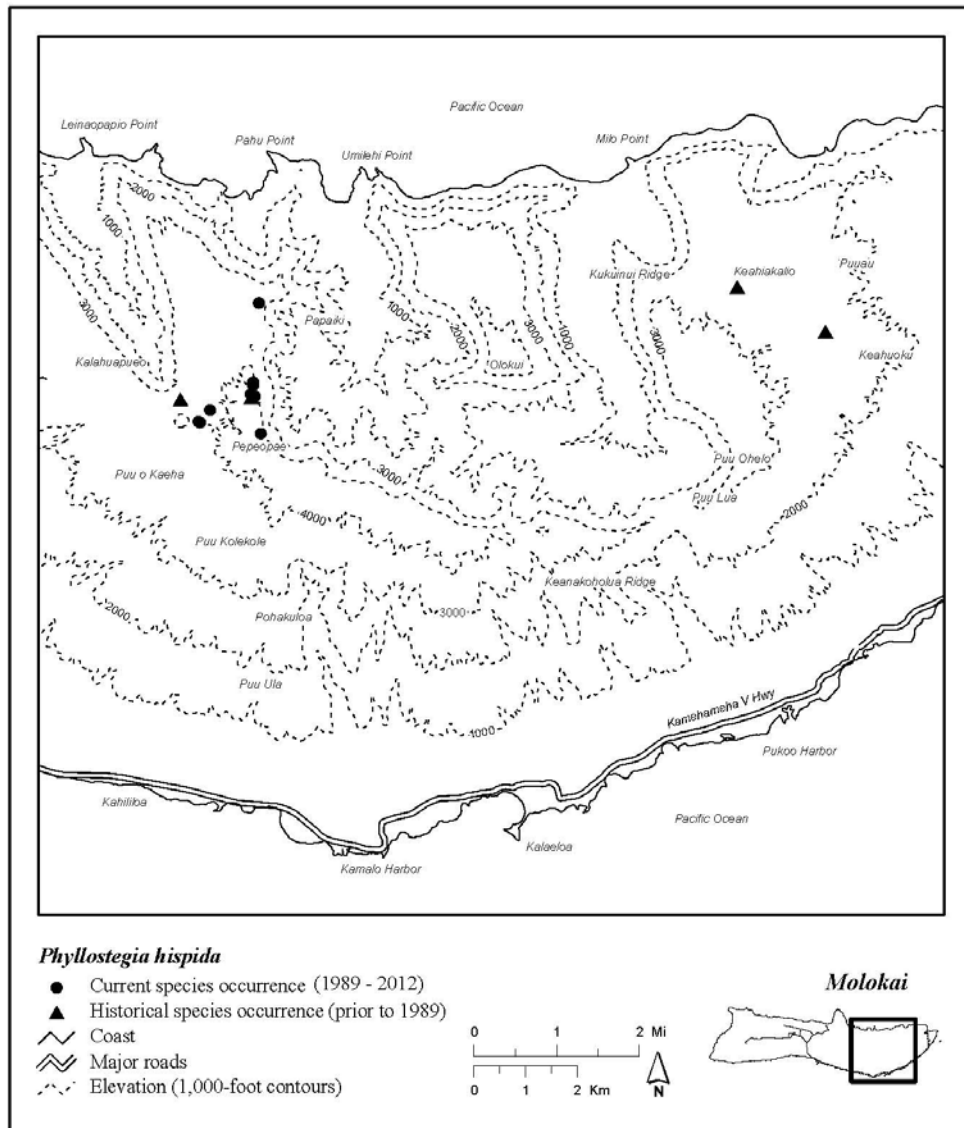
*Phyllostegia hispida* is known only from the island of Moloka'i, Hawai'i (Figure 1). *Phyllostegia hispida* and its habitat have been adversely affected and continue to be threatened by all or some of the following: habitat degradation by feral pigs (*Sus scrofa*) and invasive introduced plant species; habitat degradation by landslides and flooding; climate change; competition with invasive introduced plant species; herbivory by native caterpillars; predation or herbivory by rats (*Rattus* spp.) and nonnative slugs; and the negative demographic and genetic consequences of extremely small population size, as well as the consequent vulnerability to extinction through deterministic or stochastic (chance) events (USFWS 2009).

This Addendum outlines the strategy and actions needed to recover *Phyllostegia hispida* based on the best available information, including new information obtained since the final rule to list the species. The recovery recommendations in this plan are based on resolving the threats to the species and ensuring the persistence of self-sustaining populations in the wild.

### B. STATUS OF THE SPECIES

*Phyllostegia hispida* was first identified as a candidate for listing in the September 19, 1997, Notice of Review of Plant and Animal Taxa that are

**Figure 1. Distribution map of *Phyllostegia hispida*.**



Candidates or Proposed for Listing as Endangered or Threatened Species (USFWS 1997). On May 4, 2004, the Center for Biological Diversity petitioned us to list 225 species of plants and animals as endangered under the provisions of the Endangered Species Act (“Act”; 16 U.S.C. 1531 *et seq.*), including *P. hispida*. In the September 12, 2006, Notice of Review, *P. hispida* was included as a candidate species with a listing priority number of 2 (USFWS 2006). A proposed rule to list *P. hispida* as endangered throughout its range was published on February 19, 2008 (USFWS 2008a), and the final rule was published on March 17, 2009 (USFWS 2009). At the time of listing, critical habitat was found to be prudent but not determinable (USFWS 2009). Critical habitat was later proposed for *P. hispida* on June 11, 2012, as part of a multi-species listing and critical habitat proposed rule (USFWS 2012).

When a species is listed as endangered or threatened under the Act, it is automatically added to the list of protected species by the State of Hawai‘i (Hawai‘i Revised Statutes Chapter [HRS] 195D).

The recovery priority number for *Phyllostegia hispida* is a 5, on a scale from 1 (highest) to 18 (lowest), reflecting its taxonomic position as a full species, a high degree of threat, and a moderate potential for recovery, with some threats that are well understood and easily alleviated and others that are currently difficult to alleviate (USFWS 1983a, b).

### **C. SPECIES DESCRIPTION AND LIFE HISTORY**

*Phyllostegia* is a genus in the mint family (Lamiaceae) that is nearly endemic to Hawai‘i, consisting of approximately 27 species located in Hawai‘i and a single species in Tahiti (Wagner *et al.* 1999a). *Phyllostegia hispida* Hillebr. was first described by William Hillebrand in 1870 from a specimen collected from an area that he described as the “heights of Mopulehu” on the island of Moloka‘i (see “Type Information”, Wagner *et al.* 2005), and is recognized as a distinct taxon by Wagner *et al.* (1999a). A nonaromatic member of the mint family, *P. hispida* is a loosely spreading, many-branched vine that often forms large, tangled masses. Leaves are thin and flaccid with hispid hairs (rough with firm, stiff hairs) and rarely glandular on the lower surface of the leaves. The leaf margins are irregularly and shallowly lobed. Six to eight white flowers make up each verticillaster (a false whorl, composed of a pair of nearly sessile cymes [a

flat-topped or round-topped flower cluster] in the axils of opposite leaves or bracts), and nutlets are approximately 2.5 millimeters (0.1 inch) long (Wagner *et al.* 1999a).

The fragrant flowers of *Phyllostegia* species, which have larger lower lips and mostly white- to pink-colored corollas, are generally associated with insect pollination. By comparison, species in the related Hawaiian genus *Stenogyne* have odorless flowers and smaller lower lips, and are generally bird pollinated (Lindqvist and Albert 2002). *Phyllostegia* species have fleshy fruits (Lindqvist and Albert 2002). *Phyllostegia hispida* has been observed in fruit during April to June (H. Oppenheimer, Plant Extinction Prevention Program, pers. comm. 2008a).

#### **D. HISTORICAL AND CURRENT POPULATION STATUS**

From 1910 through 1979, a total of eight populations of *Phyllostegia hispida* were recorded from the wet forests of eastern Moloka'i (Hawai'i Biodiversity and Mapping Program 2007). Attempts to find the historical locations were made, but none of these historical populations were relocated during surveys conducted in the wet forests of east Moloka'i over the past several years (The Nature Conservancy of Hawai'i 1997; S. Perlman, National Tropical Botanical Garden, pers. comm. 2006a). In 1996, two adult plants were found in eastern Moloka'i within The Nature Conservancy of Hawai'i's Kamakou Preserve. One was found next to the Pēpē'ōpae Boardwalk, and the other east of Hanalilolilo growing along the fence within the State of Hawai'i's Pu'u Ali'i Natural Area Reserve. In 1997, a single *Phyllostegia* individual was discovered on the rim of Pelekunu Valley in the Pu'u Ali'i Natural Area Reserve (Hawai'i Biodiversity and Mapping Program 2005; The Nature Conservancy of Hawai'i 1997). There is some uncertainty, however, as to whether this individual was *P. hispida*, as it was identified as *P. manni* by Hawai'i Division of Forestry and Wildlife staff, based upon the size and lobing of its leaves (R. Hobdy, Robert Hobdy Environmental Consulting, pers. comm. 2006; J. Lau, Hawai'i Biodiversity and Mapping Program, pers. comm. 2006; T. Nohara, Division of Forestry and Wildlife, pers. comm. 2006). This individual plant was protected from feral ungulates inside a fenced enclosure. Seeds were collected, and seedlings were produced by Hawai'i Division of Forestry and Wildlife and outplanted into the enclosure with the wild plant (T. Nohara, pers. comm. 2006).

The Pēpē'ōpae Boardwalk individual died in 1998 or 1999 (Hawai'i Biodiversity and Mapping Program 2005). The fenceline individual near Hanalilolilo was reported dead in 2003 (S. Perlman, pers. comm. 2005, 2006a). The wild plant and reintroductions at Pelekunu Valley in Pu'u Ali'i Natural Area Reserve, which may not have been *Phyllostegia hispida* (the question of taxonomic identity was never resolved), died several years ago (S. Perlman, pers. comm. 2005; K. Wood, National Tropical Botanical Garden, pers. comm. 2005; G. Hughes, Kalaupapa National Historical Park, pers. comm. 2006a).

Surveys were conducted in the wet forests of east Moloka'i, but no additional *Phyllostegia hispida* plants were found. The species was thought to have been extirpated from the wild until 2005, when two seedlings were found in the headwaters of Waikolu Stream in Kamakou Preserve. The presence of these seedlings indicate the possible presence of a mature plant, or plants, somewhere in the vicinity (The Nature Conservancy of Hawai'i 1997; S. Perlman, pers. comm. 2005; S. Perlman, pers. comm. 2006a; K. Wood, pers. comm. 2006; H. Oppenheimer, pers. comm. 2009). One of the seedlings has since died (G. Hughes, pers. comm. 2006b; B. Garnett, Kalaupapa National Historical Park, pers. comm. 2006). The other seedling was collected by a botanist with the National Tropical Botanical Garden.

*Phyllostegia hispida* was again thought to be extirpated from the wild until Natural Area Reserve staff discovered a single juvenile plant in May 2006 within Pu'u Ali'i Natural Area Reserve along the Pu'u Ali'i fenceline at 1,250 meters (4,100 feet) elevation (S. Perlman pers. comm. 2006c). Although protected within a fenced enclosure (B. Stevens, Maui Division of Forestry and Wildlife, pers. comm. 2006), that individual has since died for unknown reasons (H. Oppenheimer, pers. comm. 2007). However, 10 new wild plants were discovered in April 2007: 9 within Kamakou Preserve and a single individual within Pu'u Ali'i Natural Area Reserve. The individual plant found at the Pu'u Ali'i Natural Area Reserve was in a vegetative state when it was last seen in 2009, and it is not known whether this individual produced any seed (H. Oppenheimer, pers. comm. 2009). This individual has since died after a landslide occurred in the area (A. Bakutis, Plant Extinction Prevention Program, pers. comm. 2012a).



Four of the nine wild individuals found within Kamakou Preserve in 2007 were seedlings that were closely clustered next to the Pu'u Ali'i Natural Area Reserve fenceline. These were protected with temporary emergency fencing by Natural Area Reserve Staff; however, two of these individuals are now dead. Two of the remaining seven wild individuals discovered in April 2007 are mature and have fruited and produced seeds. Seeds and cuttings have been removed from these individuals for attempted cultivation (H. Oppenheimer, pers. comm. 2009).

Since April 2007, 15 additional *Phyllostegia hispida* individuals have been found within Kamakou Preserve in the course of *Rubus argutus* (Florida prickly blackberry) control trips (H. Oppenheimer, pers. comm. 2008a, b). In 2008, there were 24 wild individuals and most of them were located on landslides or in windthrow areas (areas in which trees have been uprooted or overthrown by wind) (H. Oppenheimer, pers. comm. 2008b, c).

A single *Phyllostegia hispida* individual was found in October 2008, on the west rim of Pelekunu Valley in The Nature Conservancy's Pelekunu Preserve (H. Oppenheimer, pers. comm. 2009) in a nonreproductive state (H. Oppenheimer, pers. comm. 2011a). Although this site is located within Pelekunu Preserve, it is more easily accessible and affected by management actions occurring within Kamakou Preserve and Pu'u Ali'i Natural Area Reserve. This individual died after a large flowering and fruiting event (A. Bakutis, pers. comm. 2011).

In June 2009, a single seedling was discovered near a reintroduction site for *Schiedea laui* at Kamakou Preserve (Plant Extinction Prevention Program 2009). Another two seedlings were discovered at upper Hanalilolilo within Kamakou Preserve growing near a stream bank (Plant Extinction Prevention Program 2009); they were revisited in July 2009 but no fruits were collected (Plant Extinction Prevention Program 2010). These seedlings died after being washed out in a flood event in the spring of 2012 (A. Bakutis, pers. comm. 2012b).

In 2010, two mature individuals of *Phyllostegia hispida* were discovered in two separate locations within Kamakou Preserve (A. Bakutis, pers. comm. 2012a). Additional seedlings were found on the outskirts of a landslide within the area, but the number of seedlings was not reported (Plant Extinction Prevention

Program 2010). In May 2010, a single mature individual and a single seedling were found in Pu'u Ali'i Natural Area Reserve by staff of the Plant Extinction Prevention Program growing above known wild individuals (Plant Extinction Prevention Program 2010). In 2012, two seedlings were found within this area (A. Bakutis, pers. comm. 2012a).

As of 2012, there are less than 10 mature wild individuals and 3 seedlings known in the wild in at least 3 populations (A. Bakutis, pers. comm. 2012a, b). These populations are found in The Nature Conservancy's Kamakou Preserve (two populations) and Pu'u Ali'i Natural Area Reserve (one population). In addition, as further discussed in section I.G (Conservation Measures) below, numerous propagated individuals of *Phyllostegia hispida* have been reintroduced between 2007 and 2009 at the Kamakou Preserve and the Pu'u Ali'i Natural Area Reserve on Moloka'i (Plant Extinction Prevention Program 2009, 2010, 2011), but many individuals have died. As of 2012, only about 7 to 10 reintroduced individuals remain after growing for roughly 2 to 4 years (A. Bakutis, pers. comm. 2012c). Field botanists monitoring the plants have observed that this species survives for only 2 to 3 years, and it is considered short-lived (A. Bakutis, pers. comm. 2012a).

Natural recruitment of reintroduced individuals has been noted at a reintroduction site along Pēpē'ōpae Boardwalk in Kamakou Preserve where two seedlings were observed near a large mature individual (A. Bakutis, pers. comm. 2012a). The large mature individual died for unknown reasons and the two seedlings were not observed in July 2012 (A. Bakutis, pers. comm. 2012b).

## **E. HABITAT AND ECOSYSTEM CHARACTERISTICS**

The few documented specimens of *Phyllostegia hispida* have typically been found in wet *Metrosideros polymorpha* ('ōhi'a)-dominated forest, with most occurring at 1,112 and 1,280 meters (3,650 and 4,200 feet) elevation. Associated native species include *Cheirodendron trigynum* ('ōlapa), *Ilex anomala* (kāwa'u), *Cibotium glaucum* (hāpu'u), *Broussaisia argutus* (kanawao), *Rubus hawaiiensis* ('ākala), *Sadleria cyatheoides* ('ama'u), *Pipturus albidus* (māmaki), *Coprosma granadensis* (mākole), *Athyrium microphyllum* ('ākōlea), *Elaphoglossum fauriei* (No common name), and various species of bryophytes (Hawai'i Biodiversity and Mapping Program 2007).

It appears that *Phyllostegia hispida* is dependent on habitat that has been disturbed, such as landslides and riparian corridors. *Phyllostegia hispida* is also known to colonize windthrow areas, which are areas where trees have been uprooted or overthrown by wind (H. Oppenheimer, pers. comm. 2009). Windthrow creates openings in the canopy that provide increased sunlight for germination (USFWS 2009). In 2008, most of the remaining wild mature individuals, which numbered 20, were located on landslides or in windthrow areas (H. Oppenheimer, pers. comm. 2008a, b); it is unknown whether the currently known 10 mature individuals are located on landslides.

## **F. REASONS FOR LISTING AND CURRENT THREATS**

As identified in the final listing rule (USFWS 2009), the primary threats to *Phyllostegia hispida* and its habitat are ungulates and invasive introduced plant species. Predation or herbivory by rats and nonnative slugs has also been noted as a threat to this species. In addition, the negative demographic and genetic consequences of extremely small population size, as well as the consequent vulnerability to extinction through deterministic or stochastic (chance) events are a threat. Unidentified native caterpillar species may also be a threat to this species (H. Oppenheimer, pers. comm. 2009). A description of each of these threats is presented in the final listing rule (USFWS 2009) and in the Threats Assessment section (page 14); each is classified according to the five listing/delisting factors identified in section 4 of the Act (16 USC 1531 *et seq.*).

Additionally, *Phyllostegia hispida* is also threatened by habitat destruction and modification by climate change. Although the exact nature of the impacts of global climate change and increasing temperatures on this species are unknown, they are likely to include the loss of native species that comprise the communities in which this species occur (Benning *et al.* 2002; Pounds *et al.* 1999; Still *et al.* 1999).

## **G. CONSERVATION MEASURES**

Conservation measures implemented for *Phyllostegia hispida* have included micropropagation (*i.e.*, tissue culture); reintroduction of seedlings and cuttings cultivated from wild individuals; removal, control, and herbicide

treatment of invasive introduced plants within occupied habitat; and temporary and permanent fencing to exclude introduced feral ungulates. Staff from the Plant Extinction Prevention Program have targeted this species and have purposely conducted surveys, revisited individual plants, and followed up on observations by The Nature Conservancy and Natural Area Reserve System staff specifically for the recovery of *Phyllostegia hispida* (H. Oppenheimer, pers. comm. 2011b). To maintain the genetic variation remaining in the population, the Plant Extinction Prevention Program also attempts to collect genetic material from every wild individual known. All of the known individuals are mapped with a GPS and tagged with a unique identification number.

*Phyllostegia hispida* currently occurs entirely on public lands or lands that are managed by the State of Hawai'i's Department of Land and Natural Resources, Division of Forestry and Wildlife, Natural Area Reserve System in Pu'u Ali'i, and The Nature Conservancy's Kamakou and Pelekunu Preserves. All of these areas have some level of management for invasive introduced plants and feral ungulates.

As of 2012, The Nature Conservancy of Hawai'i continues to conduct surveys for ungulates and control pigs within the Kamakou and Pelekunu Preserves (Russell Kallstrom, Information Coordinator, The Nature Conservancy, pers. comm. 2012). In Fiscal Year 2013, The Nature Conservancy plans to begin construction on an estimated 2.4 kilometers (1.5 mile) fence extension from the existing Kamakou Preserve east boundary fence to connect to the existing Nature Conservancy- Pu'u Ali'i Natural Area Reserve fence (R. Kallstrom, pers. comm. 2012). This fence will protect approximately 327 hectares (808 acres) of wet forest in Kamakou Preserve to prevent pig ingress, and as a result is expected to protect most of the known populations of *Phyllostegia hispida* within the Preserve. In addition to ungulate control, The Natural Conservancy conducts periodic surveys and removal efforts for invasive plant species such as *Rubus argutus* (blackberry) within their Preserves (H. Oppenheimer, pers. comm. 2011b; R. Kallstrom, pers. comm. 2012).

Invasive plant species are also controlled by the Moloka'i Invasive Species Committee, which focuses on incipient ecosystem-altering invasive plant species. Aerial surveys for *Miconia calvescens* (miconia), which is not yet known from Moloka'i, are periodically conducted by the Moloka'i Invasive Species

Committee in areas where *Phyllostegia hispida* is known to occur (H. Oppenheimer, pers. comm. 2011b).

#### Pu'u Ali'i Natural Area Reserve

The University of Hawai'i's Lyon Arboretum has propagation material collected from the plant that was found in 1996 on the fenceline east of Hanalilolilo within the Pu'u Ali'i Natural Area Reserve (USFWS 2005).

Seeds and cuttings were collected from the mature individual discovered within the Reserve in April 2007 and were sent to the Lyon Arboretum and the Olinda Rare Plant Facility, jointly run by the Service and the Hawai'i Division of Forestry and Wildlife, for propagation (H. Oppenheimer, pers. comm. 2009).

Seventy-two individuals were reintroduced into Pu'u Ali'i in October 2008 (Plant Extinction Prevention Program 2009). Propagation material for these reintroductions was collected from two founder individuals located within Kamakou Preserve and was grown at Olinda Rare Plant Facility.

In January 2010, staff of the Plant Extinction Prevention Program reintroduced 17 individuals of *Phyllostegia hispida* into a large fenced area within Pu'u Ali'i Natural Area Reserve (Plant Extinction Prevention Program 2010).

#### Kamakou Preserve

In November 1996, The Nature Conservancy of Hawai'i erected an enclosure around the *Phyllostegia hispida* plant growing near the Preserve's Pēpē'ōpae Boardwalk. They also began frequent, recurrent weeding and monitoring within the fenced area (The Nature Conservancy of Hawai'i 1997). They built an enclosure approximately 200 meters (656 feet) away from this plant for future reintroductions of propagated individuals. Plants grown from leaf buds from this one known plant on the property were reintroduced into the enclosure in December 1997 (The Nature Conservancy of Hawai'i 1998a). They survived through 1998 (The Nature Conservancy of Hawai'i 1998b), but have since been confirmed dead (S. Aruch, The Nature Conservancy of Hawai'i, pers. comm. 2006; E. Misaki, The Nature Conservancy of Hawai'i, pers. comm. 2006). The

University of Hawai'i's Lyon Arboretum has propagation material from this lone individual (USFWS 2005).

Of the two seedlings that were found in 2005 in the headwaters of Waikolu Stream in the Kamakou Preserve (S. Perlman, pers. comm. 2005; H. Oppenheimer, pers. comm. 2009), one was collected and given to the Kalaupapa National Historical Park on Moloka'i for attempted propagation. That plant has since died (G. Hughes, pers. comm. 2006b; B. Garnett, pers. comm. 2006). The other seedling was collected and propagated by the National Tropical Botanical Garden. Cuttings of that seedling were given to the Kalaupapa National Historical Park for propagation (S. Perlman, pers. comm. 2006b). Thirty plants were grown from these cuttings by the National Tropical Botanical Garden and have since been reintroduced into the Preserve (H. Oppenheimer, pers. comm. 2009).

Twelve cuttings of *Phyllostegia hispida* that were grown at the National Tropical Botanical Garden were reintroduced into an enclosure in the Preserve in April 2007 (H. Oppenheimer, pers. comm. 2008a). Eleven of the cuttings that were reintroduced were doing well as of April 2008. In April 2007, seeds were collected from mature *Phyllostegia hispida* plants found within the Preserve and sent to the Lyon Arboretum and the Olinda Rare Plant Facility for propagation (H. Oppenheimer, pers. comm. 2009). In June 2007, another 12 individuals were reintroduced into a second enclosure in the Preserve, all of which remained as of April 2008 (H. Oppenheimer, pers. comm. 2008b).

In April 2008, Steve Perlman and Hank Oppenheimer collected cuttings from four wild individuals discovered by The Nature Conservancy's Moloka'i field staff in Kamakou Preserve (H. Oppenheimer, pers. comm. 2008a). These cuttings were given to Bill Garnett to propagate at his nursery on Moloka'i. Seeds were also collected from two wild individuals in the Preserve and given to the Olinda Rare Plant Facility and the National Tropical Botanical Garden for propagation (H. Oppenheimer, pers. comm. 2008a). In June 2008, cuttings were collected from four wild individuals found at three different sites in the Kamakou Preserve. These cuttings were given to Bill Garnett to propagate. Seeds from the same four wild individuals were given to the Olinda Rare Plant Facility and the National Tropical Botanical Garden for propagation (H. Oppenheimer, pers. comm. 2008a).

In August 2008, 124 individuals of *Phyllostegia hispida* were reintroduced into the Preserve within 13 sites (H. Oppenheimer, pers. comm. 2008b; Plant Extinction Prevention Program 2009). The propagation material was collected from two founder individuals located in the Kamakou Preserve (Plant Extinction Prevention Program 2009). In addition, another 46 individuals collected from 2 founder individuals in the Kamakou Preserve were reintroduced back into the Preserve on September 2008 (Plant Extinction Prevention Program 2009). During the same month, 15 individuals grown from seeds collected from a founder individual at the Kamakou Preserve were reintroduced into the Preserve (Plant Extinction Prevention Program 2009). These seedlings were grown at Olinda Rare Plant Facility.

In January 2009, four individuals were reintroduced into the Kamakou Preserve (Plant Extinction Prevention Program 2009). These individuals were propagated from cuttings grown by Bill Garnett that were collected from four new founders located at Kamakou Preserve. A few months later in June 2009, more than 50 fruits were collected from an individual growing at Hanalilolilo pipeline trail within the Kamakou Preserve and sent to the Lyon Arboretum for storage and/or propagation (Plant Extinction Prevention Program 2009).

Sixteen individuals were reintroduced at Pēpē'ōpae Boardwalk within the Kamakou Preserve in May 2010 (Plant Extinction Prevention Program 2010). By January 2011, all 16 reintroduced individuals were revisited (Plant Extinction Prevention Program 2011).

In July 2010, 55 individuals of *Phyllostegia hispida* were reintroduced at Pipeline trail within the Kamakou Preserve (Plant Extinction Prevention Program 2011). An additional 23 individuals were reintroduced into the same area in August 2010 (Plant Extinction Prevention Program 2011).

#### Summary of Reintroduction Efforts

Between 2007 and 2009, over 150 individuals were reintroduced within at least 30 discrete sites located within the Kamakou Preserve and the Pu'u Ali'i Natural Area Reserve (Plant Extinction Prevention Program 2009, 2010, 2011). In 2011, about 80 percent of the reintroduced individuals died from unknown

causes. However, these mortalities appear to be related to life history characteristics, since plants have died after major flowering events (Plant Extinction Prevention Program 2011). As of 2012, only about 7 to 10 reintroduced individuals remain after growing for roughly 2 to 4 years (A. Bakutis, pers. comm. 2012c). Monitoring by field botanists observed that this species survives for only 2 to 3 years and is considered short-lived (A. Bakutis, pers. comm. 2012a).

#### *Ex situ* and Captive Propagation Efforts

In 2009, the Olinda Rare Plant Facility had 126 individuals of *Phyllostegia hispida* representing 6 wild founders (Olinda Rare Plant Facility 2009). Propagation of this species at the Olinda Rare Plant Facility has been highly successful, with an estimated 100 percent germination of seeds (H. Oppenheimer, pers. comm. 2011b). The Lyon Arboretum Micropropagation Laboratory contained numerous propagules of *P. hispida* in storage as of 2011 (Lyon Arboretum Micropropagation Laboratory 2011). As of 2012, the Moloka'i Plant Extinction Prevention Program had collected genetic material from 62 percent of the 8 *ex situ* populations and sampled 48 percent of the 29 *ex situ* individuals (includes mature, juvenile, and seedlings) (Plant Extinction Prevention Program 2012).



## II. Threats Assessment

The major factors in the decline of *Phyllostegia hispida* are: (1) habitat degradation by feral pigs and (2) habitat degradation by and competition from invasive, introduced plant species (USFWS 2008). In addition to the primary threat factors, species like *P. hispida* that are endemic to small portions of a single island are inherently more vulnerable to extinction than widespread species. This vulnerability is due to the higher risks posed to a few populations and individuals by random demographic fluctuations and localized catastrophes such as hurricanes, landslides, flooding, and disease outbreaks. For example, a few individuals of *P. hispida* have died for unknown reasons that appear related to herbivory by a native caterpillar species.

An analysis of threats is an essential component of our listing, delisting, and reclassification decisions. The status of *Phyllostegia hispida* was determined by analyzing the following five factors, as required by section 4(a)(1) of the Act:

- A. The present or threatened destruction, modification, or curtailment of habitat or range;
  - B. Overutilization for commercial, recreational, scientific, or educational purposes;
  - C. Disease or predation;
  - D. Inadequacy of existing regulatory mechanisms; and
  - E. Other natural or man-made factors affecting the continued existence of a species.
- **Invasive plant species (Factors A and E).** Introduced plant species compete with native plants for water, light, and nutrients. They may modify habitats occupied by native plant species by changing the availability of light, altering soil-water regimes, modifying nutrient cycling, and changing the fire characteristics of the native plant community. The most common introduced plant species impacting *Phyllostegia hispida* are *Axonopus fissifolius* (narrow-leaved carpetgrass), *Clidemia hirta* (Koster's curse), *Erechtites valerianifolia* (fireweed), *Juncus effusus* (Japanese mat rush), *Rubus rosifolius*

(thimbleberry), *Sacciolepis indica* (Glenwood grass) (USFWS 2008), *Phytolacca octandra* (Southern pokeberry), *Rubus argutus* (blackberry), and *Tibouchina herbacea* (cane tibouchina) (H. Oppenheimer, pers. comm. 2011a, Plant Extinction Prevention Program 2009).

- **Climate change (Factor A).** Since climate change was not addressed as a threat in the Recovery Plan for the Moloka'i Plant Cluster (USFWS 1996) and the first addendum (USFWS 1998), a more detailed description of this threat is provided here. The exact nature of the impacts of global climate change and increasing temperatures on ecosystems of Hawai'i, including *P. hispida*, are unknown. However, these impacts are likely to include the loss of native species that comprise the communities in which this species occur (Benning *et al.* 2002; Pounds *et al.* 1999; Still *et al.* 1999).

Historically in Hawai'i, temperature has been rising over the last 100 years with the greatest increase after 1975 (Giambelluca *et al.* 2008). At lower elevation (below 800 meters [2,625 feet]), the rate of increase is 0.09 degrees Celsius (0.16 degrees Fahrenheit) per decade, which is below the observed global temperature rise of 0.18 Celsius (0.32 degrees Fahrenheit) per decade (Intergovernmental Panel on Climate Change 2007). However, at higher elevations (above 800 meters [2,625 feet]), the rate of increase is 0.27 degrees Celsius (0.48 degrees Fahrenheit) per decade, which greatly exceeds the global rate. These data show that since 1919, and especially since 1975, Hawai'i has experienced significantly warmer summer and winter temperatures. This change is mainly due to increased temperatures at night and at higher elevations (above 800 meters [2,625 feet]). These statistically significant increases are summarized as follows for non-urban areas:

- warmer summer (May through October) days (maximum daily temperature) since 1975;
- warmer summer nights (minimum daily temperature) since 1919 and since 1975, mainly due to an increase in temperature at lower (below 800 meters [2,625 feet]) elevations;
- warmer winter (November through April) days since 1919 and since 1975, mainly due to an increase in temperature at higher (above 800 meters [2,625 feet]) elevations;

- warmer winter nights due to increased temperatures at high and low elevation sites but especially at high elevation sites.

Overall, the daily temperature range in Hawai'i is decreasing, resulting in a warmer environment, especially at higher elevations and at night.

For future climate conditions, the average ambient air temperature (at sea level) is projected to increase by about 2.3 degrees Celsius (4.1 degrees Fahrenheit) with a range of 1.5 to 3.7 degrees Celsius (2.7 to 6.7 degrees Fahrenheit) by 2100 (Intergovernmental Panel on Climate Change 2007). These changes would increase the monthly average temperature from the current value of 23.3 degrees Celsius (74 degrees Fahrenheit) to between 25.0 and 30.0 degrees Celsius (77 and 86 degrees Fahrenheit). How these changes will be distributed across the topographic features of the Hawaiian Islands has not yet been determined.

Currently, in the oceans around Hawai'i, the average annual rainfall at sea level is about 635 millimeters (25 inches). The orographic (mountain) features of the islands increase this annual average to about 1,778 millimeters (70 inches) but can exceed 6,096 millimeters (240 inches) in the wettest mountain areas. Rainfall is distributed unevenly across each high island, and rainfall gradients are extreme (approximately 635 millimeters [25 inches] per mile), creating very dry and wet areas. Data on precipitation in Hawai'i, which includes sea level precipitation and the added orographic effects, shows a steady and significant decline of about 15 percent over the last 15 to 20 years (Diaz *et al.* 2005; Chu and Chen 2005). These data are also supported by a gradual but steady decline in stream flow beginning in the early 1940s (Oki 2004).

In the future, global climate modeling predicts that net precipitation at sea level near the Hawaiian Islands will decrease in winter by about 4 to 6 percent, with no significant change during summer (Intergovernmental Panel on Climate Change 2007). Downscaling of global climate models indicate that wet-season (winter) precipitation will decrease by 5 to 10 percent, while dry-season (summer) precipitation will increase by about 5 percent (Timm and Diaz 2009).

Future changes in precipitation are uncertain because they depend in part on how El Niño (a disruption of the ocean atmospheric system in the Tropical Pacific having important global consequences for weather and climate) might change. Reliable projections of changes in El Niño have yet to be made (Benning *et al.* 2002).

*Phyllostegia hispida* may be among the species most vulnerable to extinction due to anticipated global climate change, although the specific impacts of such climate change on this species cannot currently be known. Available projections of climate change in Hawai'i do not currently have the spatial landscape resolution that is needed to help identify the specific impacts of climate change on terrestrial species of Hawai'i in the mid- to late 21st Century. Impacts of climate change to *P. hispida* would be expected to include habitat loss and alteration or changes in disturbance regimes, in addition to direct physiological stress. The probability of species going extinct as a result of these factors increases when ranges are restricted, habitat decreases, and population numbers decline (Intergovernmental Panel on Climate Change 2007). Such is the case for *P. hispida*, which is characterized by limited climatic ranges and restricted habitat requirements, small population size, and low number of individuals.

- **Feral pigs (Factor A).** Feral pigs contribute to the modification and degradation of habitat. They do so by disturbing and destroying vegetative cover, trampling plants and seedlings, reducing or eliminating plant regeneration by damaging seeds and seedlings, and increasing erosion by creating large areas of bare soil. Feral pigs are also a major vector for the dispersal of invasive, nonnative plant species (USFWS 2008a).
- **Landslides and flooding (Factor A).** Landslides and flooding adversely impact the habitats of *Phyllostegia hispida* by destabilizing substrates, damaging and destroying individual plants, and altering hydrological patterns. Landslides and flooding result in habitat destruction or modification, and changes to native plant communities. During storms, rain may fall at 76 millimeters (3 inches) per hour or more, and sometimes may reach nearly 1,000 millimeters (40 inches) in 24 hours, causing destructive flash-flooding in streams and narrow gulches (Wagner *et al.* 1999b; adapted from Price (1983) and Carlquist (1980)). Like *P. hispida*, species which occur in small

- numbers in highly restricted geographic areas, such events have the potential to eradicate all individuals of a population, or even all populations of a species, resulting in extinction. Landslides and floods, although possibly necessary to create habitat for this species, may also adversely impact this species, which occurs in such low numbers.
- **Herbivory by unknown caterpillars (Factor C).** Reintroduced individuals were dying from unknown causes possibly related to herbivory by unknown species of native caterpillars (H. Oppenheimer, pers. comm. 2009). Native Lepidoptera species often use plants in the genus *Phyllostegia* as host plants (Zimmerman 1958).
  - **Rat predation or herbivory (Factor C).** Rats (*Rattus* sp.) have been noted as a threat to *Phyllostegia hispida* at the Kamakou Preserve (Plant Extinction Prevention Program 2009, 2010, 2011). There are three species of introduced rats in the Hawaiian Islands, the Polynesian rat (*Rattus exulans*), the black rat (*R. rattus*), and the Norway rat (*R. norvegicus*). Rats impact native plants by eating fleshy fruits, seeds, flowers, stems, leaves, roots, and other plant parts (Atkinson and Atkinson 2000), and can seriously affect regeneration. Rats have caused declines or even the total elimination of island plant species (Campbell and Atkinson 1999, cited in Atkinson and Atkinson 2000). In the Hawaiian Islands, rats may consume as much as 90 percent of the seeds produced by some trees, or in some cases prevent the regeneration of forest species completely (Cuddihy and Stone 1990). All three species of rat (black, Norway, and Polynesian) have been reported to seriously threaten many endangered and threatened Hawaiian plants (Stone 1985; Cuddihy and Stone 1990).
  - **Nonnative slug predation or herbivory (Factor C).** Slugs have been noted as a threat to *Phyllostegia hispida* at the Kamakou Preserve (Plant Extinction Prevention Program 2009, 2010, 2011). There are no native slugs in the Hawaiian Islands, but over a dozen introduced slug species are now established (Joe and Daehler 2008). The direct effect of nonnative slugs on the decline of this species has not been reported. However, slugs pose a threat by feeding primarily on plant seedlings and low-statured herbs (Hanley *et al.* 1995), by mechanical damage, destruction of plant parts (photosynthetic tissue and reproductive organs), and mortality (Joe 2006, Joe and Daehler 2008).

- **Small population size and restricted distribution (Factor E).**

Approximately 20 to 23 individuals of *Phyllostegia hispida* are currently known to exist in the wild: there are approximately 10 mature individuals in the wild, 3 seedlings in the wild, and 7 to 10 reintroduced individuals. Although most of the mature individuals of *P. hispida* in the wild have fruited and produced seeds, many of them have died after a large flowering or fruiting event (A. Bakutis, pers. comm. 2011). Reintroductions have been attempted (USFWS 2009), however, in 2011, about 80 percent of the reintroduced individuals died from unknown causes that appear related to life history characteristics (Plant Extinction Prevention Program 2011).

In 2012, the first documented natural recruitment of reintroduced individuals was observed at a reintroduction site located along the Pēpē'ōpae Boardwalk in the Kamakou Preserve. Two seedlings were observed near a large reproductive individual (A. Bakutis, pers. comm. 2012a). However, this large mature individual has since died for unknown reasons and the two seedlings were not observed in July 2012 (A. Bakutis, pers. comm. 2012b). Although propagules of *P. hispida* have been collected on a regular basis and some controlled propagation of the species has taken place, there is no dedicated funding for the Lyon Arboretum, Olinda Rare Plant Facility, or Plant Extinction Protection Program for continued propagation, management, and reintroduction efforts for this species (USFWS 2009).

Deterministic factors, such as habitat alteration or loss of a key pollinator, may have reduced this population to such a small size that it is now susceptible to a stochastic extinction event (Gilpin and Soule 1986). Species that are known from few wild individuals and are endemic to a single, small island are inherently more vulnerable to extinction than widespread species. This vulnerability is due to the higher risks posed to few populations and individuals by genetic bottlenecks, random demographic fluctuations, and localized catastrophes, such as hurricanes and disease outbreaks (Mangel and Tier 1994; Pimm *et al.* 1988). In the case of *Phyllostegia hispida*, the entire population of the species is small and restricted to a highly localized geographic area. This renders it highly vulnerable to the risk of extinction in the wild due to the lack of redundancy in populations. These consequences of small population size (*e.g.*, insufficient natural reproduction, loss of genetic

diversity), in conjunction with the risk of losing the entire population in the wild due to factors such as localized events (*e.g.*, hurricanes), render the species highly vulnerable to extinction at any time. Although some species are naturally rare, the poor survivorship of *P. hispida* suggests that the requisite biological or ecological needs of the species are not being met under current conditions. However, the reasons for the poor survivorship and low reproduction rates observed in the species are not currently known.

- **Lack of mature reproductive individuals (Factor E).** Approximately 20 to 23 individuals of *Phyllostegia hispida* are currently known to exist: there are roughly less than 10 mature individuals in the wild, 3 wild seedlings, and around 7 to 10 reintroduced individuals. The shortage of reproductive individuals and age-structure of the population toward young plants pose a significant threat to the species. Recruitment and the consequences of small population size may not be sufficient to offset mortality in the population (USFWS 2009). The decline of successful reproduction in *P. hispida* could lead to the extirpation of this species.

### III. Recovery

#### A. RECOVERY STRATEGY

The highest priority for the recovery of *Phyllostegia hispida* is the implementation of immediate recovery actions needed to protect and stabilize the known wild populations. These management actions include: controlling introduced plant species and feral ungulates, seed collection and long-term seed banking to protect the genetic resources of the species, the development and implementation of management plans, and reestablishment of populations within historical suitable habitat. Many of these actions are currently occurring.

Because a major threat to the species is its small population size and restricted distribution, an important component of recovery is increasing the size of the known populations, and either finding additional populations by conducting thorough surveys or establishing additional populations within the estimated historical range of the species on Moloka'i. To ultimately recover *Phyllostegia hispida*, habitat must be protected and managed for natural expansion of the current population, and reintroductions must occur into portions of its former range that are unlikely to be naturally recolonized in the near future. Research into the specific habitat needs of *P. hispida*, identification of reintroduction sites, and development of propagation and reintroduction protocols must all take place before new populations are likely to be successful. Research on *P. hispida* is complicated by the small size and vulnerability of the population, and the scarcity of mature reproductive individuals.

Habitat degradation by feral pigs is another serious threat to *Phyllostegia hispida*. While rooting the soil in search of invertebrates and plant material, feral pigs directly affect this species by disturbing and destroying vegetative cover, trampling plants and seedlings, and possibly reducing or eliminating plant regeneration by damaging or eating seeds and seedlings (USFWS 2009). Feral pigs are also major disseminators of introduced plant seeds by carrying them internally or on their bodies, and they often carry the seeds into more pristine forests, further degrading the native ecosystem. The threat of habitat degradation by feral pigs can be addressed through fencing and/or hunting to control pigs.



A research program is also recommended for *Phyllostegia hispida* to study its growth and reproductive viability, determine the parameters of viable populations, study the causes of poor survivorship for both wild and reintroduced individuals, and identify the species' pollinators and dispersal agents. A study should also be conducted on the possible pests and diseases affecting *P. hispida*, including herbivory by native caterpillars. This research should be designed to guide management practices.

This recovery strategy is congruent with our Strategic Habitat Conservation process (USFWS 2008b). The biological planning and conservation design set forth in this recovery plan lay out the criteria for recovery and identify localities for implementing actions. The recovery actions describe a process for implementing conservation on the ground, outcome-based monitoring to assess success, and ongoing assumption-driven research to test biological hypotheses important to management.

## **B. RECOVERY GOALS AND OBJECTIVES**

The goal of the recovery program is to establish a framework within which recovery actions are undertaken to ensure the long-term survival of *Phyllostegia hispida*. This includes controlling or reducing the threats to the species to the extent that it no longer requires the protections afforded by the Act and therefore warrants delisting. In order to downlist, the recovery plan identifies ways to protect *P. hispida* and enhance its habitat so that there will be an increased likelihood of the species persisting in the foreseeable future.

Given the current shortage of information about the biology and habitat requirements and the magnitude of current threats where *Phyllostegia hispida* occurs, only tentative criteria for stabilizing, downlisting, and delisting are established here. These criteria were formulated based on recommendations from individuals on the Hawai'i and Pacific Plants Recovery Coordinating Committee, as well as the International Union for Conservation of Nature and Natural Resources' draft red list categories (Version 2.2) and the advice and recommendations of knowledgeable biologists and individuals.

The interim recovery objective is to stabilize all existing populations of this species. To be considered stable, the species must be managed to control

threats (*e.g.*, feral ungulates and invasive plants) and be represented in an *ex situ* population (such as a nursery or arboretum). In addition, a minimum of three populations should be documented on Moloka'i. Each of these populations must be naturally reproducing and increasing in number, with a minimum of 50 mature individuals per population. The long-term objectives leading to downlisting and delisting are an increase in populations and their numbers. This may involve outplanting, development of appropriate management and monitoring plans at each site, and conservation agreements with landowners to ensure threats are controlled in perpetuity.

### **C. RECOVERY CRITERIA**

An endangered species is defined in the Act as a species that is in danger of extinction throughout all or a significant portion of its range. A threatened species is one that is likely to become endangered within the foreseeable future throughout all or a significant portion of its range. Downlisting or delisting is warranted when a listed species no longer meets the definition of threatened or endangered under the Act. Recovery criteria are set to serve as objective, measurable guidelines to assist in determining when an endangered species has recovered to the point that it may be downlisted to threatened, or that the protections afforded by the Act are no longer necessary and the species may be delisted. However, meeting all criteria would not automatically result in delisting, nor would not meeting all criteria necessarily preclude delisting. Determining whether a species should be downlisted or delisted requires a separate rule-making process based on an analysis of the same five categories of threats (*i.e.*, the five threat factors or the listing factors) considered in the listing of a species, as described in section 4(a)(1) of the Act (see Section I-F, Reasons for Listing and Current Threats).

We may consider downlisting or delisting *Phyllostegia hispida* when the recovery criteria outlined below are met. Recovery criteria are conditions that, when met, are likely to indicate that a species may warrant downlisting or delisting. Thus, recovery criteria are mileposts that measure progress toward recovery. Establishing these criteria articulates our conservation objectives for the species under the biological planning element of our Strategic Habitat Conservation framework. These recovery criteria are our best assessment at this time of the conditions that may result in a determination that downlisting or

delisting of the *P. hispida* is warranted based on the results of a formal five-factor analysis in a subsequent formal regulatory rule-making process. These criteria define the demographic characteristics of a recovered population and ensure that the threats to the species have been alleviated, both of which are necessary to ensure that this species is no longer threatened with extinction. Criteria for downlisting and delisting may be revised, as necessary, if additional information provided by the recommended research projects and monitoring programs indicates that a change is appropriate.

## 1. Downlisting Criteria

*Phyllostegia hispida* may be considered for downlisting to threatened status when the criteria outlined below are met:

*Downlisting Criterion 1: Population size.* A total of at least five viable populations of *Phyllostegia hispida* are documented in suitable habitat on Moloka'i. Each of these populations must be naturally reproducing, stable or increasing in number, and threats must be managed so that a minimum of 300 mature individuals are maintained per population. (Factor E, small population size and limited distribution).

*Downlisting Criterion 2: Management and monitoring plans.* Habitat around each population must be managed to ensure that it will support the long-term persistence of *Phyllostegia hispida*. To achieve this, each of the five populations identified in Downlisting Criterion 1 must have implemented management and monitoring plans that will identify actions and procedures necessary to ensure that all threats are controlled and populations are stable or increasing. (Factor A, habitat degradation by invasive introduced plants and feral pigs; Factor A, climate change; Factor A, landslides and flooding; Factor C, herbivory by unknown native caterpillar species; Factor C, predation or herbivory by rats and nonnative slugs; Factor E, small population size and limited distribution; Factor E, lack of mature reproductive individuals; and Factor E, competition with invasive introduced plants).

*Downlisting Criterion 3: Habitat quality.* All of the populations that meet Downlisting Criterion 1 above must be fenced and protected from ungulates, with agreements from conservation partners to maintain those protections in perpetuity.

The agreements will also include provisions for removal of invasive introduced plants, as appropriate, and adaptive management plans to address habitat degradation by feral pigs and herbivory by caterpillars and other unforeseeable threats. In addition, the agreements will include provisions for maximizing native plant biodiversity in these areas that is appropriate for that particular habitat and location. (Factor A, habitat degradation by invasive introduced plants and feral pigs; Factor A, climate change; Factor A, landslides and flooding; Factor C, herbivory by unknown native caterpillar species; Factor C, predation or herbivory by rats and nonnative slugs; Factor E, small population size and limited distribution; and Factor E, competition with invasive introduced plants).

## 2. Delisting Criteria

*Phyllostegia hispida* may be considered for delisting when the criteria outlined below are met:

*Delisting Criterion 1: Population size.* A total of at least eight viable populations are documented in suitable habitat on Moloka'i. Each of these populations must be naturally reproducing, stable or increasing in number, and threats must be managed so that a minimum of 300 mature individuals are maintained per population. (Factor E, small population size and limited distribution).

*Delisting Criterion 2: Management and monitoring plans.* Habitat around each population must be managed to ensure that it will support the long-term persistence of *Phyllostegia hispida*. To achieve this, each of the eight populations identified in Delisting Criterion 1 must have implemented management and monitoring plans that will identify actions and procedures necessary to ensure that all threats are controlled and populations are stable or increasing. (Factor A, habitat degradation by invasive introduced plants and feral pigs; Factor A, climate change; Factor A, landslides and flooding; Factor C, herbivory by unknown native caterpillar species; Factor C, predation or herbivory by rats and nonnative slugs; Factor E, small population size and limited distribution; Factor E, lack of mature reproductive individuals; and Factor E, competition with invasive introduced plants).

*Delisting Criterion 3: Habitat quality.* All of the populations that meet Delisting Criterion 1 above must be fenced and protected from ungulates, with agreements

from conservation partners to maintain those protections in perpetuity. The agreements will also include provisions for invasive introduced plant removal, as appropriate, and adaptive management plans to address habitat degradation by feral pigs and herbivory by caterpillars and other unforeseeable threats. In addition, the agreements will include provisions for maximizing native plant biodiversity in these areas that is appropriate for that particular habitat and location. (Factor A, habitat degradation by invasive introduced plants and feral pigs; Factor A, climate change; Factor A, landslides and flooding; Factor C, herbivory by unknown native caterpillar species; Factor C, predation or herbivory by rats and nonnative slugs; Factor E, small population size and limited distribution; and Factor E, competition with invasive introduced plants).

#### **D. RECOVERY ACTIONS**

Recovery actions are taken from the Moloka'i Plant Cluster Recovery Plan (USFWS 1996) and are summarized in Appendix A of this Addendum.

See the Moloka'i Plant Cluster Recovery Plan (USFWS 1996), beginning on page 65, for the outline of recovery actions for *Phyllostegia hispida*.

See the Moloka'i Plant Cluster Recovery Plan (USFWS 1996), beginning on page 67, for the narrative outline of recovery actions for *Phyllostegia hispida*.

These recovery actions articulate several elements of our Strategic Habitat Conservation framework. These elements include program delivery of conservation actions, outcome-based monitoring to evaluate success, and targeted assumption-driven research to correct uncertainties in the biological foundation for management (USFWS 2008b). Because the ongoing management actions for *Phyllostegia hispida* are critically important to its survival and are inherently based on limited information, it is crucial to effectively use adaptive management to iteratively assess successes and failures and modify management in response.

## IV. Implementation Schedule

The Implementation Schedule outlines the recovery actions and estimated costs for the recovery program for *Phyllostegia hispida*, as set forth in this recovery plan. It is a guide for meeting the objectives and actions suggested in this plan. The Implementation Schedule includes the following elements:

### A. DEFINITION OF RECOVERY ACTION PRIORITIES

Priorities in the Implementation Schedule are assigned according to the following definition for recovery actions:

- Priority 1** An action that must be taken to prevent extinction or to prevent a species from declining irreversibly in the foreseeable future.
- Priority 2** An action that must be taken to prevent a significant decline in species population or habitat quality or some other significant negative impact short of extinction.
- Priority 3** All other actions necessary to meet the recovery objectives.

### B. RECOVERY ACTION NUMBER AND DESCRIPTION

The recovery action number and description are extracted from the recovery action narrative found in the original Moloka'i Plant Cluster Recovery Plan (USFWS 1996).

### C. RECOVERY ACTION DURATION

The action duration column indicates the number of years estimated to complete the action if it is a discrete action, or if it is a continuous or ongoing action. Actions are defined as follows:

- C** Continuous; action will be implemented on an annual basis once it has begun.

- O** Ongoing; action is currently being implemented and will continue until no longer necessary for recovery.

#### **D. RESPONSIBLE PARTIES**

Section 7(a)(1) of the Act directs all Federal agencies to utilize their authorities in furtherance of the purposes of the Act by carrying out programs for the conservation of threatened and endangered species. Recovery actions identified in this plan imply no legal obligations of State and local government agencies or private landowners. However, the recovery of *Phyllostegia hispida* may require the involvement and cooperation of Federal, State, local, and private interests. For each recovery action described, the column titled “Responsible Parties” lists the primary Federal and State agencies we have identified as having the authority and responsibility for implementing recovery actions and other groups, partners, and partnerships, who are actively involved in recovery implementation. However, the list of possible stakeholders is not limited to those below; other stakeholders are invited to participate. When more than one party has been identified, the proposed lead party is indicated by an asterisk (\*). The listing of a party in the Implementation Schedule does not require, nor imply a requirement, that the identified party has agreed to implement the action(s) or to secure funding for implementing the action(s). However, parties willing to participate may benefit by being able to show in their own budgets that their funding request is for a recovery action identified in an approved recovery plan and is therefore considered a necessary action for the overall coordinated effort to recover *P. hispida*.

#### **E. COST ESTIMATES**

The Implementation Schedule provides total estimated costs of implementing recovery actions for the fiscal years 2014 through 2018. Cost estimates for recovery actions are based on estimated time to delisting. The inclusion of estimated costs in this recovery plan does not commit any agency or party to an expenditure of funds. Therefore, initiation and completion of these actions is subject to the availability of funds, as well as other constraints affecting the stakeholders involved.

## F. ACRONYMS AND RESPONSIBLE PARTIES

BOT	Various Botanical Gardens ( <i>e.g.</i> , National Tropical Botanical Garden, Lyon Arboretum, Waimea Botanical Garden)
BRD	U.S. Geological Survey, Biological Resources Division
DOFAW	Division of Forestry and Wildlife, Hawai'i Department of Land and Natural Resources
HDOA	Hawai'i Department of Agriculture
NPS	National Park Service
PEP	Plant Extinction Prevention Program
TNCH	The Nature Conservancy of Hawai'i
USFWS	U.S. Fish and Wildlife Service, Pacific Islands Fish and Wildlife Office, Honolulu, Hawai'i



Implementation Schedule for <i>Phyllostegia hispida</i>										
Priority Number	Recovery Action Number	Recovery Action Description	Action Duration (Years)	Responsible Parties (* = lead)	Total Costs through 2034	Cost Estimate by FY (by \$1,000s)				
						FY 2014	FY 2015	FY 2016	FY 2017	FY 2018
1	111	Collect, propagate, and maintain <i>ex situ</i> genetic stock of taxa facing imminent extinction	O	PEP	86.0	9	9	9	9	9
				DOFAW	66.0	5	5	5	5	5
				USFWS	50.0	5	5	5	5	5
				BOT*	86.0	9	9	9	9	9
				NPS	54.0	5	5	5	5	5
1	112	Protect remaining wild individuals facing imminent extinction from immediate threats	O	DOFAW*	74.0	7	7	7	7	7
				USFWS	74.0	7	7	7	7	7
				TNCH	74.0	7	7	7	7	7
1	151	Construct and maintain fencing	C	DOFAW*	445.0	35	35	35	35	35
				NPS	290.0	35	35	35	35	35
				TNCH	290.0	35	35	35	35	35
				USFWS	290.0	35	35	35	35	35
1	155	Propagate and maintain genetic stock of <i>P. hispida ex situ</i>	O	DOFAW	280.0	29	29	29	29	29
				USFWS	82.0	5	5	5	5	5
				NPS	125.0	7	7	7	7	7
				BOT*	125.0	7	7	7	7	7
1	157	Protect areas from human disturbance	O	DOFAW*	94.0	9	9	9	9	9
				TNCH	68.0	5	5	5	5	5
				NPS	58.0	5	5	5	5	5
				USFWS	48.0	5	5	5	5	5

Implementation Schedule for <i>Phyllostegia hispida</i>										
Priority Number	Recovery Action Number	Recovery Action Description	Action Duration (Years)	Responsible Parties (* = lead)	Total Costs through 2034	Cost Estimate by FY (by \$1,000s)				
						FY 2014	FY 2015	FY 2016	FY 2017	FY 2018
2	12	Identify and map all extant wild populations	0	DOFAW	34.0	5	5	5	2	2
				USFWS*	27.0	5	5	5	2	2
				TNCH	27.0	5	5	5	2	2
				NPS	27.0	5	5	5	2	2
				PEP	49.0	15	10	5	2	2
2	13	Delineate management units	5	USFWS*	25.0	5	5	5	5	5
				DOFAW	10.0	2	2	2	2	2
				TNCH	10.0	2	2	2	2	2
				NPS	10.0	2	2	2	2	2
2	14	Ensure long-term protection of habitat	0	DOFAW*	31.0	3	3	3	3	3
				NPS	26.0	2	2	2	2	2
				TNCH	26.0	2	2	2	2	2
				USFWS	31.0	3	3	3	3	3

Implementation Schedule for <i>Phyllostegia hispida</i>										
Priority Number	Recovery Action Number	Recovery Action Description	Action Duration (Years)	Responsible Parties (* = lead)	Total Costs through 2034	Cost Estimate by FY (by \$1,000s)				
						FY 2014	FY 2015	FY 2016	FY 2017	FY 2018
2	1512	Evaluate the potential for controlling ungulates through eradication programs or establishment of game preserves	10	DOFAW*	25.0	3	3	3	3	3
				USFWS	24.0	3	3	3	3	3
				NPS	25.0	3	3	3	3	3
				TNCH	26.0	3	3	3	3	3
2	152	Conduct introduced plant control	O	DOFAW*	385.0	35	35	35	35	35
				NPS	110.0	9	9	9	9	9
				TNCH	174.0	15	15	15	15	15
				USFWS	104.0	9	9	9	9	9
2	153	Provide appropriate fire protection, if necessary	C	DOFAW*	49.0	5	5	5	5	5
				NPS	35.0	3	3	3	3	3
				TNCH	35.0	3	3	3	3	3
				USFWS	35.0	3	3	3	3	3
2	154	Control rodents, if necessary	O	USFWS*	55.0	7	7	7	7	7
				DOFAW	40.0	4	4	4	4	4
				NPS	40.0	4	4	4	4	4
				TNCH	40.0	4	4	4	4	4
2	156	Ensure availability of pollination vectors	O	DOFAW*	28.0	4	4			
				USFWS	28.0	4	4			

Implementation Schedule for <i>Phyllostegia hispida</i>										
Priority Number	Recovery Action Number	Recovery Action Description	Action Duration (Years)	Responsible Parties (* = lead)	Total Costs through 2034	Cost Estimate by FY (by \$1,000s)				
						FY 2014	FY 2015	FY 2016	FY 2017	FY 2018
2	158	Control insects and/or disease, if necessary	O	DOFAW*	55.0	6	6	6	6	6
				TNCH	45.0	4	4	4	4	4
				HDOA	45.0	4	4	4	4	4
				NPS	31.0	4	4	4	4	4
				USFWS	31.0	4	4	4	4	4
2	21	Select populations for expansion	O	PEP*	15.0	1	1	1	1	1
				DOFAW	5.0	1	1	1	1	1
				USFWS	5.0	1	1	1	1	1
				NPS	5.0	1	1	1	1	1
				TNCH	5.0	1	1	1	1	1
2	22	Prepare sites and plant	O	PEP*	56.0	3	3	3	3	3
				DOFAW	15.0	3	3	3	3	3
				USFWS	15.0	3	3	3	3	3
				NPS	15.0	3	3	3	3	3
				TNCH	15.0	3	3	3	3	3
2	31	Collect diagnostic data on crucial associated ecosystem components	15	BRD*	77.0	13	13	13	13	13
				DOFAW	37.0	5	5	5	5	5
2	32	Map introduced vegetation	O	BRD*	59.0	9	9	9	9	9
				DOFAW	30.0	5	5	5	5	5
				TNCH	32.0	5	5	5	5	5
				USFWS	30.0	5	5	5	5	5

Implementation Schedule for <i>Phyllostegia hispida</i>										
Priority Number	Recovery Action Number	Recovery Action Description	Action Duration (Years)	Responsible Parties (* = lead)	Total Costs through 2034	Cost Estimate by FY (by \$1,000s)				
						FY 2014	FY 2015	FY 2016	FY 2017	FY 2018
2	33	Study various aspects of growth	O	BRD*	59.0	9	9	9	9	9
				DOFAW	25.0	5	5	5	5	5
				USFWS	25.0	5	5	5	5	5
				PEP	25.0	5	5	5	5	5
				BOT	25.0	5	5	5	5	5
2	34	Study reproductive viability	O	BRD*	59.0	9	9	9	9	9
				DOFAW	25.0	5	5	5	5	5
				USFWS	39.0	5	5	5	5	5
				TNCH	25.0	5	5	5	5	5
2	35	Determine parameters of viable populations	O	USFWS*	58.0	9	9	9	9	9
				DOFAW	45.0	9	9	9	9	9
				BRD	49.0	9	9	9	9	9
2	36	Determine effective control methods for insects and/or diseases, as needed	O	DOFAW*	39.0	5	5	5	5	5
				USFWS	24.0	4	4	4	4	4
				BRD	24.0	4	4	4	4	4
				TNCH	26.0	4	4	4	4	4
2	37	Evaluate results of actions 31 through 36 and use in future management	O	DOFAW	22.0	1	1	1	1	1
				USFWS*	22.0	1	1	1	1	1

Implementation Schedule for <i>Phyllostegia hispida</i>										
Priority Number	Recovery Action Number	Recovery Action Description	Action Duration (Years)	Responsible Parties (* = lead)	Total Costs through 2034	Cost Estimate by FY (by \$1,000s)				
						FY 2014	FY 2015	FY 2016	FY 2017	FY 2018
3	4	Develop and maintain long-term monitoring program	C	USFWS*	39.0	5	5	5	5	5
				NPS	24.0	3	3	3	3	3
				TNCH	44.0	3	3	3	3	3
				PEP	44.0	3	3	3	3	3
				BOT	43.0	3	3	3	3	3
				DOFAW	24.0	3	3	3	3	3
3	51	Investigate feasibility and desirability of reintroduction, as needed	10	USFWS*	12.0		3		3	
				DOFAW	12.0		3		3	
				BRD	12.0		3		3	
3	52	Develop and implement a plan for reestablishment of <i>P. hispida</i>	O	DOFAW	48.0	6	6	7	7	6
				USFWS*	33.0	3	3	4	4	3
				PEP	33.0	3	3	4	4	3
				BRD	33.0	3	3	4	4	3
3	61	Determine number of populations and individuals needed for long-term survival	10	USFWS*	25	3	3	3	3	3
				DOFAW	25	3	3	3	3	3
				BRD	25	3	3	3	3	3
3	62	Refine downlisting and delisting criteria	10	BRD	11	3	3	3		
				DOFAW	9	3	3	3		
				USFWS*	11	3	3	3		
<b>TOTAL COST</b>					<b>6131</b>	<b>683</b>	<b>673</b>	<b>655</b>	<b>640</b>	<b>621</b>

## V. References

### A. LITERATURE CITED

- Atkinson, I. A. E., and T. J. Atkinson. 2000. Land vertebrates as invasive species on islands served by the South Pacific Regional Environment Programme. Pages 19–84 in G. Sherley (technical editor), *Invasive species in the Pacific: a technical review and draft regional strategy*. South Pacific Regional Environment Programme, Apia, Samoa.
- Benning, T. L., D. LaPointe, C. T. Atkinson, and P. M. Vitousek. 2002. Interactions of climate change with biological invasions and land use in the Hawaiian islands: modeling the fate of endemic birds using a geographic information system. *Proceedings of the National Academy of Sciences* 99:14246-14249.
- Chu, P. S., and H. Chen. 2005. Interannual and interdecadal rainfall variations in the Hawaiian Islands. *Journal of Climate* 18:4797-4813.
- Cuddihy, L. W., and C. P. Stone. 1990. *Alteration of native Hawaiian vegetation: effects of humans, their activities and introductions*. University of Hawai'i, Honolulu. 138 pp.
- Diaz, H. F., P.-S. Chu, and J. K. Eischeid. 2005. Rainfall changes in Hawai'i during the last century. 16th conference on climate variability and change, American Meteorological Society, Boston, Massachusetts.
- Giambelluca, T. W., J. F. Diaz, and M. S. A. Luke. 2008. Secular temperature changes in Hawai'i. *Geophysical Research Letters* 35(L12702):1-5.
- Gilpin, M. E., and M. E. Soule. 1986. Minimum viable populations: processes of species extinction. Pages 19-34 in M. Soule (editor), *Conservation biology: the science of scarcity and diversity*. Sinauer Associates, Inc., Sunderland, Massachusetts.

- Hanley, M. E., M. Fenner, and P. J. Edwards. 1995. The effect of seedling age on the likelihood of herbivory by the slug *Deroceras reticulatum*. *Functional Ecology* 9:754–759.
- Hawai'i Biodiversity and Mapping Program. 2005. Program database. Unpublished.
- Hawai'i Biodiversity and Mapping Program. 2007. Program database. Unpublished.
- Intergovernmental Panel on Climate Change. 2007. Fourth assessment report. Climate change 2007: Synthesis report. Summary for policymakers. Available online at <[http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4\\_syr\\_spm.pdf](http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr_spm.pdf)>. Accessed 31 January 2008.
- Joe, S. M. 2006. Impact of alien slugs on native plant seedlings in a diverse mesic forest, O'ahu, Hawai'i, and a study of slug food plant preferences. Master's thesis for Department of Botany-Ecology, Evolution, and Conservation Biology, University of Hawai'i at Manoa, May 2006. 95 pp.
- Joe, S. M., and C. Daehler. 2008. Invasive slugs as under-appreciated obstacles to rare plant restoration: evidence from the Hawaiian Islands. *Biological Invasions* 10: 245–255.
- Lindqvist, C., and V. A. Albert. 2002. Origin of the Hawaiian endemic mints within North American *Stachys* (Lamiaceae). *American Journal of Botany* 89:1709-1724.
- Lyon Arboretum Micropropagation Laboratory. 2011. Controlled propagation report to U.S. Fish and Wildlife Service. Unpublished.
- Mangel, M., and C. Tier. 1994. Four facts every conservation biologist should know about persistence. *Ecology* 75:607-614.
- Oki, D. S. 2004. Trends in streamflow characteristics in Hawai'i, 1913-2002. U.S. Geological Survey Fact Sheet 2004-3104. 4 pp.



- Olinda Rare Plant Facility. 2009. Report on controlled propagation of listed and candidate species, as designated under the U.S. Endangered Species Act. Unpublished.
- Pimm, S., H. L. Jones, and J. Diamond. 1988. On the risk of extinction. *American Naturalist* 132:757-785.
- Plant Extinction Prevention Program. 2009. Annual report for Plant Extinction Prevention Program, fiscal year 2009 (July 1, 2008-June 30, 2009). 115 pages. Unpublished.
- Plant Extinction Prevention Program. 2010. Annual report for Plant Extinction Prevention Program, fiscal year 2010 (July 1, 2009 – June 30, 2010). 122 pages. Unpublished.
- Plant Extinction Prevention Program. 2011. Annual report for Plant Extinction Prevention Program, fiscal year 2011 (July 1, 2010 – June 30, 2011). 200 pages. Unpublished.
- Plant Extinction Prevention Program. 2012. Annual report for Plant Extinction Prevention Program, fiscal year 2012 (July 1, 2011 – June 30, 2012). 169 pages. Unpublished.
- Pounds, J. A., M. P. Fogden, and J. H. Campbell. 1999. Biological response to climate change on a tropical mountain. *Nature* 398:611-615.
- Still, C. J., P. N. Foster, and S. H. Schneider. 1999. Simulating the effects of climate change on tropical montane cloud forests. *Nature* 398:608-610.
- Stone, C. P. 1985. Alien animals in Hawai'i's native ecosystems: toward controlling the adverse effects of introduced vertebrates. Pages 254-255, 261-264 in C.P. Stone and J.M. Scott (editors), *Hawai'i's terrestrial ecosystems: preservation and management*. Cooperative National Park Resources Studies Unit, University of Hawai'i, Honolulu.
- The Nature Conservancy of Hawai'i. 1997. Emergency management of at-risk plants. Final report for Kamakou Preserve, Moloka'i. Submitted to the

U.S. Fish and Wildlife Service, Cooperative Agreement 14-48-0001-95701. 10 pp. + Appendix.

The Nature Conservancy of Hawai'i. 1998a. Kamakou Preserve Moloka'i, Hawai'i FY 1998 semi-annual progress report. Submitted to Department of Land and Natural Resources, Natural Area Partnership Program, and Moloka'i Ranch, Ltd. 11 pp.

The Nature Conservancy of Hawai'i. 1998b. Progress report on the protection of 10 rare plant species on Moloka'i. Unpublished report submitted to the U.S. Fish and Wildlife Service, Region 1, Honolulu, Hawai'i, under FWS Agreement #1448-12200-97-J136. 12 pp. + Appendix.

Timm, O. and H. F. Diaz. 2009. Synoptic-statistical approach to regional downscaling of IPCC twenty-first-century climate projections: seasonal rainfall over the Hawaiian Islands. *American Meteorological Society* 22:4261-4280.

[USFWS] U.S. Fish and Wildlife Service. 1983a. Endangered and threatened species listing and recovery priority guidance. *Federal Register* 48:43098-43105. September 21, 1983.

[USFWS] U.S. Fish and Wildlife Service. 1983b. Endangered and threatened species listing and recovery priority guidelines correction. *Federal Register* 48:51985. November 15, 1983.

[USFWS] U.S. Fish and Wildlife Service. 1996. Recovery plan for the Moloka'i plant cluster. U.S. Fish and Wildlife Service, Portland, Oregon. 143 pp. Available online at [http://ecos.fws.gov/docs/recovery\\_plan/960926b.pdf](http://ecos.fws.gov/docs/recovery_plan/960926b.pdf).

[USFWS] U.S. Fish and Wildlife Service. 1997. Endangered and threatened wildlife and plants; review of plant and animal taxa that are candidates or proposed for listing as endangered or threatened, annual notice of findings on recycled petitions, and annual description of progress on listing actions; notice of review. *Federal Register* 62:49398-49411. September 19, 1997.

- [USFWS] U.S. Fish and Wildlife Service. 1998. Moloka'i II: Addendum to the recovery plan for the Moloka'i plant cluster. U.S. Fish and Wildlife Service, Portland, Oregon. 52 pp. Available online at <[http://ecos.fws.gov/docs/recovery\\_plan/980520.pdf](http://ecos.fws.gov/docs/recovery_plan/980520.pdf)>.
- [USFWS] U.S. Fish and Wildlife Service. 2005. Captive propagation database. Unpublished.
- [USFWS] U.S. Fish and Wildlife Service. 2006. Endangered and threatened wildlife and plants; review of native species that are candidates or proposed for listing as endangered or threatened; annual notice of findings on resubmitted petitions; annual description of progress on listing actions; notice of review. Federal Register 71:53755-53835. September 12, 2006.
- [USFWS] U.S. Fish and Wildlife Service. 2008a. Endangered and threatened wildlife and plants; listing *Phyllostegia hispida* (no common name) as endangered throughout its range; proposed rule. Federal Register 73:9078-9085. February 19, 2008.
- [USFWS] U.S. Fish and Wildlife Service. 2008b. Strategic Habitat Conservation handbook: A guide to implementing the technical elements of Strategic Habitat Conservation (Version 1.0). Report from the National Technical Assistance Team, February 11, 2008. 22 pages.
- [USFWS] U.S. Fish and Wildlife Service. 2009. Endangered and threatened wildlife and plants; listing *Phyllostegia hispida* (no common name) as endangered throughout its range; final rule. Federal Register 74:11319-11327. March 17, 2009.
- [USFWS] U.S. Fish and Wildlife Service. 2011a. Draft recovery plan for *Phyllostegia hispida*: addendum to the Moloka'i plant cluster recovery plan. U.S. Fish and Wildlife Service, Portland, Oregon. 38 pp.
- [USFWS] U.S. Fish and Wildlife Service. 2011b. Endangered and threatened wildlife and plants; notice of availability of draft recovery plan for *Phyllostegia hispida*; addendum to the Moloka'i plant cluster recovery plan. Federal Register 76:31973-31975. June 2, 2011.

- Wagner, W. L., D. R. Herbst, and S. H. Sohmer. 1999a. Manual of flowering plants of Hawai'i, revised edition. University of Hawai'i Press, Bishop Museum Press, Honolulu, Hawai'i. 1,853 pp.
- Wagner, W. L., D. R. Herbst, and S. H. Sohmer. 1999b. Climate [adapted from Price (1983) and Carlquist (1980)]. Pages 36–44 in W. L. Wagner, D. R. Herbst, and S. H. Sohmer (editors), Manual of flowering plants of Hawai'i. University of Hawai'i Press, Bishop Museum Press, Honolulu, Hawai'i.
- Wagner, W. L., D. R. Herbst, and D. H. Lorence. 2005. Flora of the Hawaiian Islands website. Available online at <http://botany.si.edu/pacificislandbiodiversity/hawaiianflora/index.htm>. Accessed September 2012.
- Zimmerman, E. C. 1958. Insects of Hawai'i. Vol. 8. University of Hawai'i Press, Honolulu, Hawai'i. ix + 456 pp.

## **B. PERSONAL COMMUNICATIONS**

- Aruch, Sam. 2006. Assistant Natural Resources Manager, The Nature Conservancy of Hawai'i, Moloka'i, Hawai'i. E-mail to Karen Rosa, U.S. Fish and Wildlife Service, Pacific Islands Fish and Wildlife Office, dated May 1, 2006. Subject: *Phyllostegia hispida*.
- Bakutis, Ane. 2011. Moloka'i Coordinator, Plant Extinction Prevention Program, Moloka'i, Hawai'i. E-mail to Chelsie Javar, U.S. Fish and Wildlife Service, Pacific Islands Fish and Wildlife Office, dated February 3, 2011. Subject: *Phyllostegia hispida* – Pelekunu Preserve.
- Bakutis, Ane. 2012a. Moloka'i Coordinator, Plant Extinction Prevention Program, Moloka'i, Hawai'i. E-mail to Marie Bruegmann, U.S. Fish and Wildlife Service, Pacific Islands Fish and Wildlife Office, dated February 15, 2012. Subject: *Phyllostegia hispida* final recovery plan.

- Bakutis, Ane. 2012b. Moloka'i Coordinator, Plant Extinction Prevention Program, Moloka'i, Hawai'i. E-mail to Chelsie Javar, U.S. Fish and Wildlife Service, Pacific Islands Fish and Wildlife Office, dated September 11, 2012. Subject: *Phyllostegia hispida* final recovery plan.
- Bakutis, Ane. 2012c. Moloka'i Coordinator, Plant Extinction Prevention Program, Moloka'i, Hawai'i. E-mail to Chelsie Javar, U.S. Fish and Wildlife Service, Pacific Islands Fish and Wildlife Office, dated September 12, 2012. Subject: *Phyllostegia hispida* final recovery plan.
- Garnett, Bill. 2006. Horticulturist, Kalaupapa National Historical Park, National Park Service, Moloka'i, Hawai'i. Telephone interview by Karen Rosa, U.S. Fish and Wildlife Service, Pacific Islands Fish and Wildlife Office, dated February 1, 2006.
- Hobdy, Robert. 2006. Director, Robert Hobdy Environmental Consultant, Maui, Hawai'i. Telephone interview by Karen Rosa, U.S. Fish and Wildlife Service, Pacific Islands Fish and Wildlife Office, dated May 1, 2006.
- Hughes, Guy. 2006a. Natural Resources Chief, Kalaupapa National Historical Park, National Park Service, Moloka'i, Hawai'i. Telephone interview by Karen Rosa, U.S. Fish and Wildlife Service, Pacific Islands Fish and Wildlife Office, dated January 27, 2006.
- Hughes, Guy. 2006b. Natural Resources Chief, Kalaupapa National Historical Park, National Park Service, Moloka'i, Hawai'i. Telephone interview by Karen Rosa, U.S. Fish and Wildlife Service, Pacific Islands Fish and Wildlife Office, dated April 28, 2006.
- Kallstrom, Russell. 2012. Information Coordinator, The Nature Conservancy, Kualapu'u, Hawai'i. E-mail to Marie Bruegmann, U.S. Fish and Wildlife Service, Pacific Islands Fish and Wildlife Office, dated February 15, 2012. Subject: *Phyllostegia hispida* final recovery plan.
- Lau, Joel. 2006. Botanist, Hawai'i Biodiversity and Mapping Program, Honolulu, Hawai'i. Telephone interview by Karen Rosa, U.S. Fish and

Wildlife Service, Pacific Islands Fish and Wildlife Office, dated May 1, 2006.

Misaki, Ed. 2006. Moloka'i Program Director, The Nature Conservancy of Hawai'i, Moloka'i, Hawai'i. E-mail to Karen Rosa, U.S. Fish and Wildlife Service, Pacific Islands Fish and Wildlife Office, dated April 14, 2006. Subject: *Phyllostegia hispida* outplantings.

Nohara, Torrie. 2006. Na Ala Hele biologist, Division of Forestry and Wildlife, Maui, Hawai'i. Telephone interview by Karen Rosa, U.S. Fish and Wildlife Service, Pacific Islands Fish and Wildlife Office, dated April 27, 2006.

Oppenheimer, Hank. 2007. Maui Nui Coordinator, Plant Extinction Prevention Program, Maui, Hawai'i. Telephone interview by Karen Rosa, U.S. Fish and Wildlife Service, Pacific Islands Fish and Wildlife Office, dated June 11, 2007.

Oppenheimer, Hank. 2008a. Maui Nui Coordinator, Plant Extinction Prevention Program, Maui, Hawai'i. E-mail to Karen Marlowe, U.S. Fish and Wildlife Service, Pacific Islands Fish and Wildlife Office, dated June 9, 2008. Subject: Current status of wild *P. hispida*.

Oppenheimer, Hank. 2008b. Maui Nui Coordinator, Plant Extinction Prevention Program, Maui, Hawai'i. E-mail to Karen Marlowe, U.S. Fish and Wildlife Service, Pacific Islands Fish and Wildlife Office, dated September 29, 2008. Subject: Update on *P. hispida*.

Oppenheimer, Hank. 2008c. Maui Nui Coordinator, Plant Extinction Prevention Program, Maui, Hawai'i. Telephone interview by Karen Rosa, U.S. Fish and Wildlife Service, Pacific Islands Fish and Wildlife Office, dated May 27 and 28, 2008.

Oppenheimer, Hank. 2009. Maui Nui Coordinator, Plant Extinction Prevention Program, Maui, Hawai'i. E-mail to Marie Bruegmann, U.S. Fish and Wildlife Service, Pacific Islands Fish and Wildlife Office, dated November 18, 2009. Subject: *Phyllostegia hispida* current status.

- Oppenheimer, Hank. 2011a. Maui Nui Coordinator, Plant Extinction Prevention Program, Maui, Hawai'i. E-mail to Chelsie Javar, U.S. Fish and Wildlife Service, Pacific Islands Fish and Wildlife Office, dated January 28, 2011. Subject: *Phyllostegia hispida* – Pelekunu Preserve.
- Oppenheimer, Hank. 2011b. Maui Nui Coordinator, Plant Extinction Prevention Program, Maui, Hawai'i. Memo to Loyal Merhoff, U.S. Fish and Wildlife Service, Pacific Islands Fish and Wildlife Office, dated July 8, 2011. Subject: Peer review comments for the draft recovery plan for *Phyllostegia hispida*: addendum to the Moloka'i plant cluster recovery plan.
- Perlman, Steve. 2005. Research Biologist, National Tropical Botanical Garden, Kaua'i, Hawai'i. E-mail to Christa Russell, U.S. Fish and Wildlife Service, Pacific Islands Fish and Wildlife Office, dated December 5, 2005. Subject: *Phyllostegia hispida*.
- Perlman, Steve. 2006a. Research Biologist, National Tropical Botanical Garden, Kaua'i, Hawai'i. E-mail to Karen Rosa, U.S. Fish and Wildlife Service, Pacific Islands Fish and Wildlife Office, dated March 27, 2006. Subject: *Phyllostegia hispida* info.
- Perlman, Steve. 2006b. Research Biologist, National Tropical Botanical Garden, Kaua'i, Hawai'i. Telephone interview by Karen Rosa, U.S. Fish and Wildlife Service, Pacific Islands Fish and Wildlife Office, dated April 13, 2006.
- Perlman, Steve. 2006c. Research Biologist, National Tropical Botanical Garden, Kaua'i, Hawai'i. Telephone interview by Karen Rosa, U.S. Fish and Wildlife Service, Pacific Islands Fish and Wildlife Office, dated May 24, 2006.
- Stevens, Bryon. 2006. Natural Area Reserve Specialist, Maui Department of Forestry and Wildlife, Maui, Hawai'i. Telephone interview by Karen Rosa, U.S. Fish and Wildlife Service, Pacific Islands Fish and Wildlife Office, dated June 9, 2006.

Wood, Ken. 2005. Research biologist, National Tropical Botanical Garden, Kaua'i, Hawai'i. E-mail to Marie Bruegmann, U.S. Fish and Wildlife Service, Pacific Islands Fish and Wildlife Office, dated June 22, 2005. Subject: Potential candidates.

Wood, Ken. 2006. Research biologist, National Tropical Botanical Garden, Kaua'i, Hawai'i. E-mail to Karen Rosa, U.S. Fish and Wildlife Service, Pacific Islands Fish and Wildlife Office, dated February 28, 2006. Subject: *Phyllostegia hispida* info.



**APPENDIX A. Summary of Threats for *Phyllostegia hispida* and Recommended Recovery Actions**  
**(Action numbers are taken from the Moloka'i Plant Cluster Recovery Plan).**

<b>LISTING FACTOR</b>	<b>THREAT</b>	<b>RECOVERY CRITERIA</b>	<b>RECOVERY ACTIONS</b>
A	Degradation of habitat by invasive introduced plant species	2, 3	Protect remaining wild individuals facing imminent extinction from immediate threats, identify and map all extant wild populations, delineate management units, ensure long-term protection of habitat, construct and maintain fencing, map introduced vegetation, conduct introduced plant control (see Actions 112, 12, 13, 14, 1511, 32, 152)
A	Destruction and degradation of habitat by feral pigs	2, 3	Protect remaining wild individuals facing imminent extinction from immediate threats, identify and map all extant wild populations, delineate management units, ensure long-term protection of habitat, construct and maintain fencing, evaluate the potential for controlling ungulates through eradication programs or establishment of game preserves (see Actions 112, 12, 13, 14, 1511, 1512)
A	Habitat degradation by landslides and flooding	2, 3	Propagate and maintain genetic stock of <i>P. hispida ex situ</i> , construct and maintain fencing, evaluate the potential for controlling ungulates through eradication programs or establishment of game preserves (see Actions 155, 151, 1512)

**APPENDIX A. Summary of Threats for *Phyllostegia hispida* and Recommended Recovery Actions**  
**(Action numbers are taken from the Moloka'i Plant Cluster Recovery Plan).**

LISTING FACTOR	THREAT	RECOVERY CRITERIA	RECOVERY ACTIONS
A	Degradation of habitat from climate change	2, 3	Collect, propagate, and maintain <i>ex situ</i> genetic stock of taxa facing imminent extinction, protect remaining wild individuals facing imminent extinction from immediate threats, identify and map all extant wild populations, delineate management units, ensure long-term protection of habitat, collect diagnostic data on crucial associated ecosystem components, propagate and maintain genetic stock of <i>P. hispida ex situ</i> , select populations for expansion, study various aspects of growth, determine parameters of viable populations, develop and maintain long-term monitoring program, develop and implement a plan for reestablishment of <i>P. hispida</i> , determine number of populations and individuals needed for long-term survival (see Actions 111, 112, 12, 13, 14, 31, 155, 21, 33, 35, 37, 4, 52, 61)
C	Herbivory by unknown native caterpillars	2, 3	Identify and map all extant wild populations, delineate management units, ensure long-term protection of habitat, control insects and/or disease, if necessary, determine effect of and control methods for insects and/or diseases, as needed, develop and maintain long-term monitoring program (see Actions 12, 13, 14, 158, 36, 4)
C	Predation or herbivory by nonnative slugs	2, 3	Identify and map all extant wild populations, delineate management units, ensure long-term protection of habitat, control all other threats, develop and maintain long-term monitoring program (see Actions 12, 13, 14, 159, 4)

**APPENDIX A. Summary of Threats for *Phyllostegia hispida* and Recommended Recovery Actions**  
**(Action numbers are taken from the Moloka'i Plant Cluster Recovery Plan).**

<b>LISTING FACTOR</b>	<b>THREAT</b>	<b>RECOVERY CRITERIA</b>	<b>RECOVERY ACTIONS</b>
<b>C</b>	Predation or herbivory by rats	2, 3	Identify and map all extant wild populations, delineate management units, ensure long-term protection of habitat, control rodents if necessary, develop and maintain long-term monitoring program (see Actions 12, 13, 14, 154, 4)
<b>E</b>	Competition with invasive introduced plant species	2, 3	Protect remaining wild individuals facing imminent extinction from immediate threats, identify and map all extant wild populations, delineate management units, ensure long-term protection of habitat, construct and maintain fencing, conduct introduced plant control, map introduced vegetation (see Actions 112, 12, 13, 14, 1511, 152, 32)
<b>E</b>	Small population size and restricted distribution	1, 2, 3	Collect, propagate and maintain <i>ex situ</i> genetic stock of taxon facing imminent extinction, protect remaining wild individuals facing imminent extinction from immediate threats, identify and map all extant wild populations, delineate management units, ensure long-term protection of habitat, construct and maintain fencing, conduct introduced plant control, propagate and maintain genetic stock of <i>P. hispida ex situ</i> , control other threats, select populations for expansion, prepare sites and plant, ensure availability of pollination vectors, develop and maintain long-term monitoring programs, develop and implement specific plans for reestablishment, determine number of populations and individuals needed for long-term survival, refine downlisting and delisting criteria (see Actions 111, 112, 12, 13, 14, 151, 152, 155, 159, 21, 22, 156, 4, 52, 61, 62)

**APPENDIX A. Summary of Threats for *Phyllostegia hispida* and Recommended Recovery Actions**  
**(Action numbers are taken from the Moloka'i Plant Cluster Recovery Plan).**

LISTING FACTOR	THREAT	RECOVERY CRITERIA	RECOVERY ACTIONS
E	Lack of mature reproductive individuals	1, 2, 3	Protect remaining wild individuals facing imminent extinction from immediate threats, identify and map all extant wild populations, delineate management units, ensure long-term protection of habitat, construct and maintain fencing, conduct introduced plant control, control other threats, collect, propagate, and maintain <i>ex situ</i> genetic stock of taxa facing imminent extinction, propagate and maintain genetic stock of <i>P. hispida ex situ</i> , select populations for expansion, prepare sites and plant, ensure availability of pollination vectors, study reproductive viability, determine parameters of viable populations, develop and maintain long-term monitoring programs, develop and implement specific plans for reestablishment, refine downlisting and delisting criteria (see Actions 112, 12, 13, 14, 151, 152, 159, 111, 155, 21, 22, 156, 34, 35, 4, 52, 62)

**Listing Factors:**

- A. Present or threatened destruction, modification, or curtailment of its habitat or range
- B. Overutilization for commercial, recreational, scientific, or educational purposes (not a threat factor for *Phyllostegia hispida*)
- C. Disease or predation
- D. Inadequacy of existing regulatory mechanisms (not a threat factor for *Phyllostegia hispida*)
- E. Other natural or manmade factors affecting its continued existence

**APPENDIX B. Summary of the comments on the Draft Recovery Plan for *Phyllostegia hispida*: Addendum to the Moloka'i Plant Cluster Recovery Plan**

In June 2011, the Draft Recovery Plan for *Phyllostegia hispida*: Addendum to the Moloka'i Plant Cluster Recovery Plan was released for review and comment by Federal agencies, the State of Hawai'i, and the members of the public (USFWS 2011a). The public comment period was announced in the Federal Register (76 FR 31973) on June 2, 2011, and closed on August 2, 2011 (USFWS 2011b). More than 100 copies of the draft plan were sent out for review during the comment period, including distribution to scientific peer reviewers.

Four letters/comments were received during the comment period. Comments were received from three peer reviewers and one State agency. All comments received have been considered and incorporated into the approved recovery plan, as appropriate. A summary of the substantive comments received and the Service's responses follows below.

**Issue 1: Recovery goals and criteria**

**Comment:** Revise description of threats in the recovery objectives to include more specific examples of threats to control such as feral ungulates and invasive plants.

**Response:** We have added the suggested examples to the recovery objectives.

**Comment:** Recovery criteria should focus on establishing viable populations of *Phyllostegia hispida* in appropriate habitat on Moloka'i.

**Response:** We agree that viable populations should be established in appropriate habitat to ensure the recovery of this species. We revised downlisting criterion 1 and delisting criterion 1 to emphasize "viable populations".

**Comment:** Pollinator studies may help in recovery efforts. If a pollinator is identified, its distribution and abundance may be determined.

**Response:** Research to identify pollinators and dispersal agents has been added to the recovery strategy.

**Issue 2: Management and threats**

**Comment:** *Tibouchina herbacea* is also well established on Moloka'i and should be added to the list of invasive plants.

**Response:** We agree and have added it to the list of invasive plants in this plan.

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