

**Recovery
Outline for the
Islands of
Maui, Moloka`i,
Kaho`olawe,
and Lāna`i
(Maui Nui)**



Scientific Name/ Hawaiian Name/ and/or Common Name

PLANTS

Bidens campylotheca ssp. *pentamera* / ko`oko`olau
Bidens campylotheca ssp. *waihoiensis*/ ko`oko`olau
Bidens conjuncta/ ko`oko`olau
Calamagrostis hillebrandii/ no common name
Canavalia pubescens/ `āwikiwiki
Cyanea asplenifolia/ hāhā
Cyanea duvalliorum/ hāhā
Cyanea horrida/ hāhā nui
Cyanea kauaulaensis/ no common name
Cyanea kunthiana/ hāhā
Cyanea magnicalyx/ hāhā
Cyanea maritae/ hāhā
Cyanea mauiensis/ hāhā
Cyanea munroi/ hāhā
Cyanea obtusa/ hāhā
Cyanea profuga/ hāhā
Cyanea solanacea/ popolo, hāhā nui
Cyperus neokunthianus/ no common name
Cyrtandra ferripilosa/ hai`wale
Cyrtandra filipes/ ha`iwale
Cyrtandra hematos/ ha`iwale
Cyrtandra oxybapha/ ha`iwale
Festuca molokaiensis/ no common name
Geranium hanaense/ nohoanu

Geranium hillebrandii/ nohoanu
Hypolepis hawaiiensis var. *mauiensis*/ olua
Mucuna sloanei var. *persericea*/ sea bean
Myrsine vaccinioides/ kōlea
Peperomia subpetiolata/ `ala`ala wai nui
Phyllostegia bracteata/ no common name
Phyllostegia haliakalae/ no common name
Phyllostegia pilosa/ no common name
Pittosporum halophilum/ hō`awa
Pleomele fernaldii/ hala pepe
Schiedea diffusa ssp. *diffusa*/ no common name
Schiedea jacobii/ no common name
Schiedea laui/ no common name
Schiedea pubescens/ mā`oli`oli
Schiedea salicaria/ no common name
Stenogyne kauaulaensis/ no common name
Wikstroemia villosa/ `ākia

ANIMALS

Hylaeus hilaris/ yellow-faced bee
Newcombia cumingi/ Newcomb`s tree snail
Partulina semicarinata/ pūpū kani oe/ Lāna`i tree snail
Partulina variabilis/ pūpū kani oe/ Lāna`i tree snail

Listing Status and Date Endangered; May 28, 2013 (78 Federal Register (FR) 32013), and September 30, 2016 (81 FR 67786)

Lead Agency/Region U.S. Fish and Wildlife Service, Interior Region 12

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Purpose of the Recovery Outline: This document lays out a preliminary course of action for the survival and recovery of 41 endangered plant and 4 endangered animal species (hereafter 45 recently listed species) listed in 2013 and 2016 (USFWS 2013, USFWS 2016a) under the Endangered Species Act (ESA) of 1973, as amended (16 USC 1531 *et seq.*). Recovery outlines include background information about the species, previous conservation efforts, and a list of recovery actions needed to meet recovery criteria. This recovery outline will address the recovery needs of the 45 recently listed species. To achieve recovery of these species, the recovery plan will designate management units encompassing all or portions of the ecosystems on which the species depend. Recovery actions within these management units will be prioritized based on criteria developed within the Pacific Islands Fish and Wildlife Office as available funding to manage all units or threats simultaneously is limited.

This outline serves as interim guidance directing recovery efforts and informing consultation and permitting activities until a comprehensive recovery plan has been completed. Recovery outlines are intended primarily for internal use by the U.S. Fish and Wildlife Service (Service); formal public participation will be invited with the release of the draft recovery plan and the Service will consider any new information or comments from the public in response to this outline during the drafting of the recovery plan. For more information on Federal recovery efforts for the 45 recently listed species, or to provide comments, interested parties may contact the lead field office for these species at the above address and telephone number.

Scope of Recovery and Available Information: The scope of this effort is at the island level. This recovery outline is based on the best scientific data contained in the proposed and final listing and critical habitat rules for the 45 recently listed species endemic to Maui Nui, the previously listed species that currently occur on, or are historically known from, Maui Nui, and the species for which critical habitat was recently designated or revised. Many of the threats to these species are well understood and include introduced species such as feral ungulates and invasive plants. These threats, along with urban development, directly affect the native habitats of these listed species. Little information beyond current status and existing threats is available for most of the

45 recently listed species. Additional research is needed to fully understand what is required for the recovery of these species, especially with regard to the effects of climate change on their distribution and habitats. Uncertainties associated with specific habitat needs and biology of these species will be resolved, to the extent possible, through the recovery implementation process, and the recovery plan may need to be periodically updated. The recovery strategy will include recommendations to address these uncertainties with specific habitat needs and the biology of the species, and will contribute to adaptive management.

I. Overview

A. BIOLOGICAL ASSESSMENT

1. Species Description and Life History

Species descriptions and life history information are contained in the final listing decision ([USFWS 2013](#), [USFWS 2016a](#)) and the proposed listing rule ([USFWS 2012](#), [USFWS 2015](#)) for the 45 recently listed species.

2. Historical and Current Population Status

Historical and current population status of these species also are contained in the final listing decision (USFWS 2013, USFWS 2016a) and the proposed listing rule (USFWS 2012, USFWS 2015) for the 45 recently listed species (Table 1) as are the species' current distribution (Appendix 2).

3. Habitat Description and Landownership

The 45 recently listed species are known from 10 terrestrial ecosystems found on Maui Nui: coastal, lowland dry, lowland mesic, lowland wet, montane dry, montane mesic, montane wet, subalpine, dry cliff, and wet cliff (Table 1; Appendix 1 – Maui Nui Species Ecosystems). These species and their habitats occur on Federal, State, County, and private lands (USFWS 2013, USFWS 2016a). Appendix 2 illustrates the occurrence of the 45 species and their designated critical habitat. In 2016, the Service designated and revised critical habitat for 135 listed species on Maui Nui including species listed in 2013 and 2016 (USFWS 2013, USFWS 2016a, USFWS 2016b). The critical habitat designation totaled 157,002 acres (ac) (63,537 hectares (ha): 31,513 ac (12,753 ha) on Moloka'i; 119,349 ac (48,299 ha) on Maui; and 6,142 ac (2,486 ha) on Kaho'olawe, and includes both occupied and unoccupied habitat (USFWS 2016b). Critical habitat includes specific areas occupied by the species that provide physical or biological features essential to their conservation. Unoccupied critical habitat was included if that

area was considered essential to the recovery of the species. While critical habitat is designated on a species-by-species basis, individual critical habitat units often support the conservation and recovery of multiple species. Therefore, each designated critical habitat unit is classified according to ecosystem type and often provides for the conservation and recovery of multiple species. The Maui Nui recovery plan will develop recovery management units based, in part, on the ecosystem-based critical habitat units.

4. Summary Biological Assessment

The species addressed in this recovery outline face threats throughout their entire range. With effective management, these species have a high to moderate recovery potential. Ecosystem-level management in Hawai'i including fencing and weed control has shown that the potential for recovery is high if major threats are controlled. The threats with the largest impacts to listed plants are habitat destruction and degradation by introduced ungulates and nonnative invertebrates, competition with invasive introduced species, natural catastrophes, and the effects of small population size on demography and genetics (Cabin *et al.*, 2000; Plant Extinction Prevention Program 2017; Hawai'i Division of Forestry and Wildlife 2011). These threats also affect listed animal species. Additional threats to listed tree snails include disease, predation by nonnative vertebrates and invertebrates, and past over-collection (USFWS 2013, USFWS 2016a). Additional threats to listed yellow-faced bees include predation by nonnative ants and wasps and competition with nonnative bees for food and nesting sites (USFWS 2016a).

In Hawai'i, management of ecosystem-level threats such as ungulates and invasive plants has been successful across many habitats. For example, an ungulate exclosure on the island of Hawai'i demonstrated that eliminating goat browsing resulted in a rapid recovery in height, growth, and numbers of vegetative re-sprouts of *Acacia koa* (koa) (Spatz and Mueller-Dombois 1973). After the removal of grazing animals at Pu'u Wa'awa'a in 1985, *Acacia koa* and *Metrosideros polymorpha* ('ōhi'a) seedlings germinated by the thousands (Hawai'i Department of Land and Natural Resources 2003). Loope *et al.* (1991) found that native plant cover increased from 6 to 95 percent after excluding pigs from a montane bog on Maui. In Hawai'i Volcanoes National Park, herbicide control of the invasive grass *Cenchrus clandestinus* (kikuyu grass) decreased cover from nearly 100 percent to less than 10 percent; most native species survived the treatment and often proliferated (Gardner and Kageler 1983). Cabin *et al.* (2000) documented an increase in native seedlings and ground cover in a dry forest after removal of *Cenchrus setaceus* (fountain grass). Removal of *Morella faya* (faya tree) by girdling resulted in better recovery of native plant species, as measured by a more diverse suite of species and a smaller increase in introduced plant species when compared to clear-cut areas (Loh and Daehler 2007, 2008).

The management of additional threats, such as rodents and slugs, is possible but requires additional research to determine the most efficient and effective control methods

and may require the registration of new pesticides for use in conservation areas. Rodent control occurs at different scales and with different tools across the Hawaiian Islands and information sharing is key for refining methods to enhance conservation (Sprague *et al.* 2018). Pesticides to control slugs are available and have been shown to decrease slugs in mesic forests (OANRP 2017); however, there has been little documentation on the response of rare plants to reductions in slugs. Propagation and reintroduction will also be needed for many species to increase the number of individuals and/or populations.

While the best available scientific information indicates the current and known historical distribution of many of these species is relatively small, it is very likely that many were much wider ranging prior to human colonization of the Hawaiian Islands (Burney *et al.* 2001, USFWS 2006a, Hadfield 1986). Further, systematic surveys are needed to assess the current distribution of these species and their habitat requirements, so recovery areas can be expanded beyond their current distributions into additional habitats. Habitat modeling will assist in selecting additional areas needed for recovery. Models incorporating climate change projections are being developed to map potential future distributions (see Fortini *et al.* 2013).

The Pacific Islands Fish and Wildlife Office's Strategic Plan (USFWS 2011a) identifies priority ecosystem conservation areas (or priority landscapes) on Maui Nui. Priority landscapes encompass key native ecosystems that, when appropriately managed, may provide for the long-term viability of entire native biotic communities, and thus, multiple native species. These areas were delineated based, in part, on designated critical habitat, forest bird recovery areas, essential plant habitats, information in the Recovery Plan for Hawaiian Waterbirds (USFWS 2011b), and other surveys and conservation planning documents (Appendix 3). The priority landscape map for the island group will be used to help develop the Maui Nui recovery plan and its conservation strategy.

Table 1. Current status and distribution of 41 plants and 4 animals, including number of populations (# pops), number of individuals (# inds), and habitat types used or occupied.

Species	# pops	# inds	Habitat Types								
			CO	LD	LM	LW	MM	MW	S	DC	WC
PLANTS											
<i>Bidens campylotheca</i> ssp. <i>pentamera</i>	6	200		X	X		X	X		X	X
<i>Bidens campylotheca</i> ssp. <i>waihoiensis</i>	1 - 2	200				X		X			X
<i>Bidens conjuncta</i>	9	7,000				X		X			X
<i>Calamagrostis hillebrandii</i>	3	< 500						X			
<i>Canavalia pubescens</i>	1	< 200	X	X							
<i>Cyanea asplenifolia</i>	8	200			X	X					
<i>Cyanea duvalliorum</i>	2	71				X		X			
<i>Cyanea horrida</i>	12	44					X	X			X
<i>Cyanea kauaulaensis</i>	1	100				X					
<i>Cyanea kunthiana</i>	15	165				X	X	X			
<i>Cyanea magnicalyx</i>	3	7				X	X				X
<i>Cyanea maritae</i>	4	23 - 50				X		X			
<i>Cyanea mauiensis</i>	Unknown	Unknown			X*					X*	
<i>Cyanea munroi</i>	1	2									X
<i>Cyanea obtusa</i>	1	< 10		X				X			
<i>Cyanea profuga</i>	4	34			X			X			
<i>Cyanea solanacea</i>	4	26			X	X	X	X			
<i>Cyperus neokunthianus</i>	Unknown	Unknown				X					
<i>Cyrtandra ferripilosa</i>	2	< 10						X	X		
<i>Cyrtandra filipes</i>	5	141 – 162			X	X					X
<i>Cyrtandra hematos</i>	2	< 100							X		
<i>Cyrtandra oxybapha</i>	2	137 - 250						X	X		
<i>Festuca molokaiensis</i>	1	Unknown			X						
<i>Geranium hanaense</i>	2	500 - 700							X		
<i>Geranium hillebrandii</i>	4	> 10,000						X	X		
<i>Hypolepis hawaiiensis</i> var. <i>mauiensis</i>	1	5 - 10							X		
<i>Mucuna sloanei</i> var. <i>persericea</i>	5	< 500				X					

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Species	# pops	# inds	Habitat Types								
			CO	LD	LM	LW	MM	MW	S	DC	WC
<i>Peperomia subpetiolata</i>	Unknown	Unknown						X			
<i>Phyllostegia bracteata</i>	Unknown	Unknown				X	X	X	X	X	
<i>Phyllostegia haliakalae</i>	0	0			X		X			X	
<i>Phyllostegia pilosa</i>	2	7			X			X			
<i>Pittosporum halophilum</i>	3	5	X								
<i>Pleomele fernaldii</i>	1	< 1,000		X	X	X				X	
<i>Schiedea diffusa</i> spp. <i>diffusa</i>						X		X			
<i>Schiedea jacobii</i>	1	0?						X			
<i>Schiedea laui</i>	1	24 - 34						X			
<i>Schiedea pubescens</i>	8	Unknown			X		X	X		X	
<i>Schiedea salicaria</i>	3	500-1,055		X							
<i>Stenogyne kauaulaensis</i>	1	3					X				
<i>Wikstroemia villosa</i>	1	1				X	X	X			
ANIMALS											
<i>Hylaemus hiliaris</i>	1	Unknown	X	X							
<i>Newcombia cumingi</i>	1	1				X					
<i>Partulina semicarinata</i>	Unknown	29				X		X		X	
<i>Partulina variabilis</i>	Unknown	90				X		X		X	

CO = Coastal; LD = Lowland Dry; LM = Lowland Mesic; LW = Lowland Wet; MM = Montane Mesic; MW = Montane Wet; S = Subalpine; DC = Dry Cliff; WC = Wet Cliff;

* = not seen since the 1800s

B. THREATS ASSESSMENT

1. Listing Factors/Primary Threats to the Species

As identified in the final listing rules (USFWS 2013, USFWS 2016a), the primary threats to the 45 recently listed species and their habitats are: habitat loss and degradation, invasive plant species, nonnative invertebrates, stochastic events (Cuddihy and Stone 1990, Smith 1985, Vitousek *et al.* 1987 in Cuddihy and Stone 1990), demographic and genetic consequences of small populations, and the effects of climate change. With the exception of stochastic events and climate change, these threats can mostly be addressed by ecosystem-level management. Herbivory and diseases resulting from nonnative invertebrates such as slugs, leaf hoppers, and twig borers are species-specific, however, and additional research is needed to develop tools to address these threats. A description of each threat is presented in the final listing rules (USFWS 2013, USFWS 2016a) and each is classified according to the five listing/delisting factors identified in section 4 of the ESA. Table 2 summarizes the known threats to each of the 45 species.

2. Summary Threats Assessment

No new threats to the 45 recently listed species have been identified since the listing rules were published (Table 2) and all threats will be addressed in the recovery plan.

Our analyses includes consideration of ongoing and projected changes in climate. The terms “climate” and “climate change” are defined by the Intergovernmental Panel on Climate Change (IPCC). “Climate” refers to the mean and variability of meteorological conditions (*e.g.*, temperature, precipitation) in a particular region over time, with 30 years being a typical period, although shorter or longer periods also may be used (IPCC 2007, p. 78). The term “climate change” refers to a change in the mean or variability of one or more measures of climate that persists for an extended period, typically decades or longer, whether the change is due to natural variability, human activity, or both (IPCC 2007, p. 78). Changes in climate can have direct or indirect effects on species and the effects can be positive, neutral, or negative and may change over time, depending on the species and other factors, such as potential interaction of climate and other variables (*e.g.*, habitat fragmentation) (IPCC 2007, pp. 8–14 and 18–19). In our analyses, we used expert judgment to weigh relevant information, including uncertainty, in considering how various aspects of climate change threaten the recovery of the species herein.

Most of the species have specialized microhabitat requirements or a limited opportunity or ability to disperse, making them vulnerable to climate change and several species are currently undergoing range contractions consistent with warming temperatures. Effects of climate warming include conditions that support invasive

species range expansion and area reduction of climate zones suitable for some Hawaiian plants (Fortini *et al.* 2013). Applying climate envelope modeling, those that predict the distribution of a species using environmental data such as precipitation and temperature, and recovery planning tools will help prioritize habitat protection actions, and highlight links between current and future habitat. This information will facilitate setting management priorities for necessary recovery areas in a warming climate.

Table 2. Summary of the ecosystems used by and the threats affecting the 45 recently listed species endemic to Maui Nui as well as their Recovery Priority Numbers. Factor A = The present or threatened destruction, modification, or curtailment of the species habitat or range. Factor B = Over-utilization for commercial, recreational, scientific, or educational purposes. Factor C = Disease or predation. Factor D = Inadequacy of existing regulatory mechanisms. Factor E = Other natural or manmade factors affecting the species continued existence.

Species	Ecosystems	Recovery Priority Number	Factor A					Factor B	Factor C				Factor D	Factor E		
			Agriculture and urban development	Ungulates	Nonnative plants	Fire	Stochastic events	Over-utilization	Disease	Predation / Herbivory by ungulates	Predation / Herbivory by other NN vertebrates	Predation / Herbivory by NN invertebrates	Inadequate existing regulatory mechanisms	Other species-specific threats	Climate Change	
PLANTS																
<i>Bidens campylotheca</i> ssp. <i>pentamera</i>	LD, LM, MM, MW, DC, WC	6		P, G, D	X	X	H			X	R		X	HY	X	
<i>Bidens campylotheca</i> ssp. <i>waihoiensis</i>	LW, MW, WC	3		P, G, D	X		F, H			X	R	S	X	HY	X	
<i>Bidens conjuncta</i>	LW, MW, WC	2		P, G	X		H			X	R	S	X		X	
<i>Calamagrostis hillebrandii</i>	MW	2		P	X		H			X			X		X	
<i>Canavalia pubescens</i>	CO, LD	2	X	P, G, D, C	X	X	H, DR			X			X		X	
<i>Cyanea asplenifolia</i>	LM, LW	2		P, G, D, C	X		L, H			X	R	S	X		X	
<i>Cyanea duvalliorum</i>	LW, MW	5		P	X		F, H			X	R	S	X		X	

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Species	Ecosystem	Recovery Priority Number	Factor A					Factor B	Factor C				Factor D	Factor E	
			Agriculture and urban development	Ungulates	Nonnative plants	Fire	Stochastic events	Over-utilization	Disease	Predation / Herbivory by ungulates	Predation / Herbivory by other NN vertebrates	Predation / Herbivory by NN invertebrates	Inadequate existing regulatory mechanisms	Other species-specific threats	Climate Change
<i>Cyanea horrida</i>	LW, WC	5		P, G, D	X		L, H			X	R	S	X	LN	X
<i>Cyanea kauaulaensis</i>	LW	5			X		E, F, L				R	S	X	LN, NR	X
<i>Cyanea kunthiana</i>	MM, MW, WC	2		P	X		DR, F, L, TF, H			X	R	S	X	LN	X
<i>Cyanea magnicalyx</i>	LW, MM, MW	5		P	X		H			X	R	S	X		X
<i>Cyanea maritae</i>	LW, MW	5		P	X		L, TF, H			X	R	S	X	LN, T	X
<i>Cyanea mauiensis</i>	LM, DC	2		P	X	X	L, TF, H			X	R	S	X	LN	X
<i>Cyanea munroi</i>	WC	5		G, D	X		TF, H			X	R	S	X	LN	X
<i>Cyanea obtusa</i>	LD, MM	5		P, G, D, C	X	X	H			X	R	S	X	HY, LN	X
<i>Cyanea profuga</i>	LM, MW	5		P, G	X		F, L, RF, TF, H			X	R	S	X	LN	X
<i>Cyanea solanacea</i>	LM, LW, MM, MW	5		P, G	X		L, H			X	R	S	X	LN	X
<i>Cyperus neokunthianus</i>	LW	2		P	X					X			X	LN	X
<i>Cyrtandra ferripilosa</i>	MM, MW	5		P, G			H			X			X	LN	X

Species	Ecosystem	Recovery Priority Number	Factor A					Factor B	Factor C			Factor D	Factor E		
			Agriculture and urban development	Ungulates	Nonnative plants	Fire	Stochastic events	Over-utilization	Disease	Predation / Herbivory by ungulates	Predation / Herbivory by other NN	Predation / Herbivory by NN invertebrates	Inadequate existing regulatory mechanisms	Other species-specific threats	Climate Change
<i>Cyrtandra filipes</i>	LM, LW, WC	5		P, G, D	X		L, RF, TF			X		S	X		X
<i>Cyrtandra hematos</i>	MW	5		P, G	X					X			X	HY, LN, NR	X, Ft.
<i>Cyrtandra oxybapha</i>	MM, MW	2		P, G, C	X					X			X		X
<i>Festuca molokaiensis</i>	LM	2		G	X	X	DR, H			X			X	LN	X
<i>Geranium hanaense</i>	MW	2		P	X		H			X			X		X
<i>Geranium hillebrandii</i>	MM, MW	2		P	X		H			X		S	X		X
<i>Hypolepis hawaiiensis</i> var. <i>mauiensis</i>	MW	3			X							S	X	LN	X, Ft.
<i>Mucuna sloanei</i> var. <i>persericea</i>	LW	3		P, C	X		H			X	R		X		X
<i>Myrsine vaccinioides</i>	MW	2		P	X		H			X	R	S	X		X
<i>Peperomia subpetiolata</i>	MW	5		P	X		H			X	R	S	X	HY, LN	X

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			Agriculture and urban development	Ungulates	Nonnative plants	Fire	Stochastic events	Over-utilization	Disease	Predation / Herbivory by ungulates	Predation / Herbivory by other NN vertebrates	Predation / Herbivory by NN invertebrates	Inadequate existing regulatory mechanisms	Other species-specific threats	Climate Change
<i>Phyllostegia bracteata</i>	LW, MM, MW, S, WC	5		P, C	X	X	H			X		S	X	LN	X
<i>Phyllostegia haliakalae</i>	LM, MM, DC, WC	5		C	X	X	H			X		S	X	LN	X
<i>Phyllostegia pilosa</i>	LM, MW	5		P, G	X		H			X		S	X	LN	X
<i>Pittosporum halophilum</i>	CO	5		P	X	X	H			X	R		X	LN	X
<i>Pleomele fernaldii</i>	LD, LM, LW, DC, WC	2		D, M	X	X	H			X	R		X	NR	X
<i>Schiedea diffusa</i> spp. <i>diffusa</i>	LW, MW	6		P	X						R	S	X	LN	X
<i>Schiedea jacobii</i>	MW	5		G, D, C			DR, L, TF, H			X		S	X	LN	X
<i>Schiedea laui</i>	MW	5			X		F, L, H				R	S	X	LN	X
<i>Schiedea pubescens</i>	LW, MW, MM, WC	5		P, G, D, C	X	X	DR, E, F			X	R	S	X	LN	X, Ft.
<i>Schiedea salicaria</i>	LD	2		G, D, C	X	X	DR, H			X			X		X
<i>Stenogyne kauaulaensis</i>	MM	5			X	X	DR, L, RF, H					S	X	LN	X

Species	Ecosystem	Recovery Priority Number	Factor A					Factor B	Factor C				Factor D	Factor E	
			Agriculture and urban development	Ungulates	Nonnative plants	Fire	Stochastic events	Over-utilization	Disease	Predation / Herbivory by ungulates	Predation / Herbivory by other NN	Predation / Herbivory by NN invertebrates	Inadequate existing regulatory mechanisms	Other species-specific threats	Climate Change
<i>Wikstroemia villosa</i>	LW, MM, MW	5		P	X		L, H			X	R	S	X	LN, T	X
ANIMALS															
<i>Hylaes hiliaris</i>	CO, LD	5	X	P, G, D, C	X	X	DR, HUR, TS					A, W	X	LN, W, B, LHP	X
<i>Newcombia cumingi</i>	LW	5			X		DR, H	Pt	Pt		R, JC	Flatworm Snails	X	LN	X
<i>Partulina semicarinata</i>	LW, MW, WC	5		D, M			DR, H	Pt	Pt		R, JC	Flatworm Snails	X	LN	X
<i>Partulina variabilis</i>	LW, MW, WC	5		D, M			DR, H	Pt	Pt		R, JC	Flatworm Snails	X	LN	X

CO = Coastal; LD = Lowland Dry; LM = Lowland Mesic; LW = Lowland Wet; MM = Montane Mesic; MW = Montane Wet; S = Subalpine; DC = Dry Cliff; WC = Wet Cliff; P = Pigs; G = Goats; D = Axis Deer; M = Mouflon; C = Cattle; R = Rats; S = Slugs; JC = Jackson's chameleon; F = Flooding; DR = Drought; H = Hurricane; L = Landslide; T = Trampling; RF = Rockfalls; TF = Treefalls; LN = Limited Numbers; HY = Hybridization; NN = Nonnative; NR = No Regeneration; Pt = Potential

C. CONSERVATION ASSESSMENT

1. Conservation Efforts

Numerous conservation efforts are occurring on Maui Nui that may benefit the 45 listed species addressed herein. Large-scale efforts by watershed partnerships (see below) mainly focused on mitigating invasive plants or nonnative ungulates are critical, but may not address all the conservation needs of individual species. The efforts of the watershed partnerships as well as other voluntary conservation efforts certainly reduce the threats to the 45 recently listed species; however, the overwhelming number of threats as well as inadequate funding (see Leonard 2008) has made these efforts insufficient to date.

The four watershed partnerships in Maui Nui (West Maui Mountains, East Maui, Leeward Haleakalā, and East Moloka`i) are voluntary coalitions of public and private landowners “committed to the common value of protecting forested watersheds for water recharge, conservation, and other ecosystem services through collaborative management” (Hawai`i Association of Watershed Partnerships 2018). Most of the ongoing conservation management actions carried out by the partnerships address threats to upland habitat from nonnative species (*e.g.*, feral ungulates, nonnative plants) and may include fencing, ungulate removal, nonnative plant control, and outplanting of native species on partnership lands. These actions help protect rare species to preserve ecosystem function. Funding for the partnerships is provided through State and Federal sources, public and private grants, and in-kind services provided by the partnerships and/or volunteers.

The Plant Extinction Prevention Program (PEPP) focuses on plant species with fewer than 50 individuals remaining in the wild. The goal of the program is to prevent extinction via guidelines set by the Hawai`i and Pacific Plants Recovery Coordinating Committee. These include having or establishing 3 to 6 populations of 25 to 75 (long-lived species), 50 to 150 (short-lived species), or 100 to 300 (annual species) mature, reproducing individuals (exact number dependent on biology of species); ensuring that all threats are managed; and having representatives of all individuals in genetic storage (HPPRCC 2011). The PEPP collects, propagates, or outplants 24 of the 41 recently listed plant species: *Canavalia pubescens*, *Cyanea duvalliorum*, *Cyanea horrida*, *Cyanea kauaulaensis*, *Cyanea magnicalyx*, *Cyanea maritae*, *Cyanea munroi*, *Cyanea obtusa*, *Cyanea profuga*, *Cyanea solanacea*, *Cyrtandra ferripilosa*, *Cyrtandra filipes*, *Cyrtandra hematos*, *Peperomia subpetiolata*, *Phyllostegia bracteata*, *Phyllostegia haliakalae*, *Phyllostegia pilosa*, *Pittosporum halophilum*, *Schiedea diffusa* ssp. *diffusa*, *Schiedea jacobii*, *Schiedea laui*, *Schiedea pubescens*, *Stenogyne kauaulaensis*, and *Wikstroemia villosa* (Plant Extinction Prevention Program 2017, pp. 6, 38-39, 43-46, 48, 50, 54-55, 58-60, 78-80, 87-88, 92-97, 100-101, 105, 111-112, 119, 166-170, 174-175, 178-179,

207, 209-211, 217-218, 223-228). However, neither this program, nor any other, has been able to directly address landscape-scale habitat threats to plants from invasive species.

Numerous landowners on Maui Nui are engaged in or are initiating voluntary conservation actions on their lands including: fencing to exclude ungulates, removing ungulates, controlling nonnative plants, and out-planting native and rare plants. These actions provide a conservation benefit, and reduce threats, to the 45 recently listed species. Many of these landowners are partners in one of the Maui Nui watershed partnerships, or work collaboratively with them.

The private landowners of Lāna`i (Lāna`i Resorts and Pūlama Lāna`i) began developing an island-wide conservation plan under a Memorandum of Understanding with the Service in 2015. The plan will provide landscape-scale management on Lāna`i that will benefit four plants (*Canavalia pubescens*, *Cyanea munroi*, *Phyllostegia haliakalae*, and *Pleomele fernaldii*) and two tree snails (*Partulina semicarinata* and *Partulina variabilis*). To date the plan outlines plans to control nonnative species, in-situ protection of snail species, and habitat restoration.

The following plant species are currently in micropropagation, living material collections, or seed collections for genetic storage or reintroduction efforts: *Bidens campylotheca* ssp. *pentamera*, *B. campylotheca* ssp. *waihoiensis*, *B. conjuncta*, *Calamagrostis hillebrandii*, *Canavalia pubescens*, *Cyanea asplenifolia*, *Cyanea duvalliorum*, *Cyanea horrida*, *Cyanea kauaulaensis*, *Cyanea kunthiana*, *Cyanea magnicalyx*, *Cyanea maritae*, *Cyanea munroi*, *Cyanea obtusa*, *Cyanea profuga*, *Cyanea solanacea*, *Cyrtandra ferripilosa*, *Cyrtandra filipes*, *Cyrtandra hematos*, *Cyrtandra oxybapha*, *Geranium hillebrandii*, *Mucuna sloanei* var. *persericea*, *Myrsine vaccinioides*, *Peperomia subpetiolata*, *Phyllostegia bracteata*, *Phyllostegia haliakalae*, *Phyllostegia pilosa*, *Pittosporum halophilum*, *Schiedea diffusa* ssp. *diffusa*, *Schiedea jacobii*, *Schiedea laui*, *Schiedea pubescens*, *Schiedea salicaria*, *Stenogyne kauaulaensis*, and *Wikstroemia villosa* (Harold L. Lyon Arboretum Micropropagation Laboratory 2016; Harold L. Lyon Arboretum Seed Conservation Laboratory 2016, 2017; National Tropical Botanical Garden 2016, 2017; Olinda Rare Plant Facility 2016; Maui Nui Botanical Garden 2015; Haleakalā National Park 2016).

The Snail Extinction Prevention Program (SEPP) receives funding from the Service, the State of Hawai`i, and other sources to propagate and maintain listed tree snails in captivity. Currently, *Partulina variabilis* is in captivity and their numbers are increasing. *Partulina semicarinata* and *Newcombia cumingi* (Newcomb's tree snail) do not exist in captivity (Sischo 2018, *pers. comm.*). In August 2012, the Service and Maui Land and Pineapple Co., Inc. entered into a cooperative agreement to provide funding for the construction of a fenced snail enclosure to protect the only known wild population of *Newcombia cumingi* (USFWS 2012, *in litt.*). The purpose of the enclosure is to protect

individuals in-situ from predation by rodents and predatory nonnative snails. In addition, habitat restoration of snail habitat will be conducted as funding is available.

The Maui Invasive Species Committee (MISC) works to prevent the establishment of invasive species on Maui Nui. Current priority species include ecosystem altering weeds such as *Coccinia grandis* (ivy gourd), *Miconia calvescens* (miconia), *Cenchrus setaceus* (previously known as *Pennisetum setaceum*, fountain grass), which produces fine fuels and creates a major fire threat to many natural areas in Hawai'i, *Eleutherodactylus coqui* (coqui frog), and *Cortaderia jubata* and *Cortaderia selloana* (pampas grass) (Maui Invasive Species Committee 2018).

2. Summary Conservation Assessment

Overall, populations of the 45 recently listed species are declining and their ranges are restricted. However, the recovery prognosis for the plant species is positive because the populations are either of sufficient size to allow for successful management and populations can be augmented or created via outplanting. Many of the threats to the species can be addressed by proven management actions such as fencing and controlling ungulates, invasive plants, and predators. The recovery prognosis for the three tree snail species is less optimistic because these species face significant threats and have small populations. However, by mitigating threats and initiating research to provide much needed life history information, it may be possible to reverse population trends to achieve recovery. Refining management protocols to minimize disturbance to sensitive areas, developing cost-effective conservation strategies, coordinating efforts among partners, and obtaining sufficient funding are critical to the recovery of all the 45 recently listed species.

II. Preliminary Recovery Strategy

A. RECOVERY PRIORITY NUMBERS

Recovery priority numbers (RPNs) are assigned to species or subspecies based on the degree of threat, the potential for recovery, and their taxonomic status (USFWS 1983a,b) and range from 1C (highest, "C" indicating the potential for conflict with human economic activities) to 18 (lowest). All of the species addressed herein have a high degree of threat to their habitat and continued existence but none has conflict with human economic activities.

Bidens conjuncta, *Calamagrostis hillebrandii*, *Canavalia pubescens*, *Cyanea asplenifolia*, *Cyanea kunthiana*, *Cyanea mauiensis*, *Cyperus neokunthianus*, *Cyrtandra oxybapha*, *Festuca molokaiensis*, *Geranium hanaense*, *Geranium hillebrandii*, *Myrsine vaccinioides*, *Pleomele fernaldii*, and *Schiedea salicaria* are assigned a RPN of 2 based on a high degree of threat, a high potential for recovery because threats are well

understood and can be managed, and their because of their status as full species. *Bidens campylothea* ssp. *waihoensis*, *Hypolepis hawaiiensis* var. *mauiensis*, and *Mucuna sloanei* var. *persericea* are assigned a RPN of 3 based on a high degree of threat, a high potential for recovery because their threats are understood and can be mitigated, and because of their status as subspecies or varieties. *Cyanea duvalliorum*, *Cyanea horrida*, *Cyanea kauaulaensis*, *Cyanea magnicalyx*, *Cyanea maritae*, *Cyanea munroi*, *Cyanea obtuse*, *Cyanea profuga*, *Cyanea solanacea*, *Cyrtandra ferripilosa*, *Cyrtandra filipes*, *Cyrtandra hematos*, *Peperomia subpetiolata*, *Phyllostegia bracteata*, *Phyllostegia haliakalae*, *Phyllostegia pilosa*, *Pittosporum halophilum*, *Schiedea jacobii*, *Schiedea laui*, *Schiedea pubescens*, *Stenogyne kauaulaensis*, *Wikstroemia villosa*, *Hylaeus hilaris*, *Newcombia cumingi*, *Partulina semicarinata*, and *Partulina variabilis* are assigned a RPN of 5 based on a high degree of threat, a low potential for recovery due to a small number of individuals and some threats being difficult to mitigate, and because of their status as full species. *Bidens campylothea* ssp. *pentamera* and *Schiedea diffusa* spp. *diffusa* are assigned a RPN of 6 based on a high degree of threat, a low potential for recovery due to a small number of individuals and some threats being difficult to mitigate, and because of their status as subspecies.

B. RECOVERY GOAL AND OBJECTIVES

The goal of the recovery plan is to establish a framework within which recovery actions are undertaken to ensure the long-term survival and recovery of the 45 recently listed species by controlling or reducing threats to the extent that these species no longer require ESA protection. These are all conservation-reliant species and some form of management will be required unless ungulates, rodents, and non-native plants are extirpated. Although subject to change, full recovery of these species is currently envisioned as follows: viable populations will persist on management units throughout the species' historical ranges (and beyond if warranted by climate models) on Maui Nui. Habitat loss and degradation and predation by introduced species will be sufficiently controlled and effects of climate change mitigated to ensure a high probability of survival for at least 100 years. Fitting with the island-wide approach to recovery for these 45 endangered species, the Service also will develop recovery objectives for individual management units.

C. INITIAL RECOVERY ACTION PLAN

The goal of the Maui Nui recovery plan will be to reverse population declines and increase the range of these 41 endangered plants and 4 endangered animals. The objectives of the recovery plan will be to:

1. Protect ecosystems and control threats
 - 1.1. Identify and survey extant populations for all species and the habitats in which they occur
 - 1.2. Develop fine-scale microclimate models to identify suitable habitat based on existing and historical ranges and determine potential future climate conditions
 - 1.3. Identify areas within each habitat necessary for recovery and develop management units
 - 1.4. Ensure long-term protection of management units
 - 1.4.1. Identify threats specific to management units
 - 1.4.2. Within management units, construct and maintain fencing, remove ungulates, and identify a funding stream to maintain fences and maintain their ungulate free status in perpetuity
 - 1.4.3. Eradicate habitat-modifying invasive plants from management units and maintain weed-free status
 - 1.4.4. Develop and implement a rodent control program within management units; for habitats where this is feasible (*e.g.*, offshore islets) or where rodent exclusion fencing can be installed, eradicate rodents
 - 1.4.5. Provide wildfire protection as necessary
 - 1.4.5.1. Develop management unit-specific fire management plans and infrastructure, and initiate management actions to reduce the likelihood of fire, especially in dry and mesic habitats
 - 1.4.5.2. Assess the need for fire management plans in wet habitats affected by climate change

- 1.4.6. Protect management units from human disturbance as necessary
- 1.4.7. Control other threats as appropriate
2. Control species-specific threats
 - 2.1. Implement current control for slugs and update as new technology becomes available
 - 2.2. Implement current control for rats and update as new technology becomes available
 - 2.3. Develop and implement control for Jackson's chameleon (*Trioceros jacksonii xantholophus*)
 - 2.4. Develop and implement control for rosy wolf snail (*Euglandina rosea*)
 - 2.5. Develop and implement control for nonnative ants (*Anoplopepis longipes*, *Pheidole megacephala*, *Solenopsis papuana*, and *S. geminate*).
 - 2.6. Develop and implement control for nonnative western yellow jacket wasps (*Vespula pensylvanica*)
 - 2.7. Control other threats as appropriate
3. Expand the range of existing wild populations, and establish new populations, to increase resilience
 - 3.1. Select populations for augmentation or sites for reintroduction
 - 3.2. Develop habitat and microclimate models to identify unoccupied areas within management units appropriate for additional populations
 - 3.3. Prepare reintroduction sites
 - 3.4. Propagate genetically appropriate individuals for genetic storage (for plants) and augmentation or reintroduction
 - 3.5. Release or translocate snails and yellow-faced bees and outplant plants that are genetically appropriate

4. Control new threats before they become widespread
 - 4.1. Facilitate surveys, focused on likely source areas (*e.g.*, airport), and control newly discovered pest or invasive species prior to their dispersal to management units
 - 4.2. Facilitate improved border security to prevent the influx of new pests and invasive species into the State and the islands of Maui Nui
5. Facilitate and conduct research essential to recovering species and restoring their habitats
 - 5.1. Conduct studies on the range, demography, and dispersal of each species
 - 5.2. Conduct Population Viability Analyses (PVA) for each species as appropriate
6. Develop and implement a detailed monitoring plan for each species and ecosystem
7. Develop objective and measurable downlisting and delisting criteria at the species and ecosystem levels as necessary to validate recovery objectives
8. Partner with key stakeholders to further develop and accomplish above objectives
9. For all recovery actions, evaluate management and research results and adapt management as necessary

D. RECOVERY ACTIONS

The recovery effort for the 45 recently listed species should build on the conservation and monitoring efforts described above. Specific actions that should be undertaken or at least initiated early in the recovery planning process include the following:

- Continue to assess the distribution, current status, and potential future distribution of existing habitats and determine the most intact sites for management. Make use of landscape modeling, spatial analysis, remote sensing technology, and existing survey data to better understand species distributions and priority areas for targeting future surveys.
- Prioritize sites for recovery actions for each species.
- Initiate control of habitat-modifying threats, such as ungulates and invasive nonnative plants, within the highest-priority management units.

- Protect all remaining extant populations by controlling species-specific threats (as indicated in section C, Initial Recovery Action Plan, #2).
- Conduct systematic, island-wide surveys for additional populations.
- Prevent the influx of new invasive species into recovery areas. Increase the efforts of the Maui Invasive Species Committee and improve border security.
- Prioritize and implement research that provides information and tools to mitigate threats to habitats and species, as well as techniques for captive propagation.
- Secure propagules and other biological materials for captive propagation for genetic storage and reintroduction.
- Increase outreach efforts and coordination with State agencies, and private landowners regarding ecosystem conservation. Promote opportunities to assist in the recovery of these species through habitat conservation plans, safe harbor agreements, Federal action agency ESA section 7(a)(1) and 7(a)(2) consultation obligations and through various conservation partnerships funded by State and Federal agencies and private organizations.

III. Preplanning Decisions

A. PLANNING APPROACH

A recovery plan for the 41 plants and 4 endangered animal species listed in May 2013 and September 2016 will be prepared pursuant to section 4(f) of the ESA. The Pacific Islands Fish and Wildlife Office will prepare the recovery plan.

B. INFORMATION MANAGEMENT

All information relevant to the recovery of the 41 plants and 4 endangered animals listed in May 2013 and September 2016 will be housed in the Pacific Islands Fish and Wildlife Office's administrative files. The Recovery Program will be responsible for maintaining a complete administrative record for the recovery planning and implementation process for these species. This recovery outline will be available on-line [here](#).

C. ANTICIPATED RECOVERY PLAN SCHEDULE

Public Review-Draft Recovery Plan	2021
Public Comment Period	60 days
Final Recovery Plan	2022

D. STAKEHOLDER INVOLVEMENT

Key stakeholders:

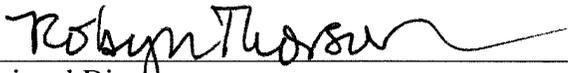
- Conservation organizations
- Local entities and County, State, and Federal agencies that own or manage lands currently or historically occupied by any of the 45 recently listed species or with habitat types suitable for establishing new populations
- Organizations representing native Hawaiians
- Outdoor sports and recreation organizations
- Private landowners who own property currently or historically occupied by any of the 45 recently listed species or with habitat types suitable for establishing new populations
- State of Hawai`i Department of Lands and Natural Resources, Division of Forestry and Wildlife
- U.S. Geological Survey, Biological Resources Discipline, Pacific Island Ecosystems Research Center
- University of Hawai`i

E. STAKEHOLDER INVOLVEMENT STRATEGY

Landowners and land managers that may be affected by the listing and recovery of the 45 recently listed species will be invited to participate in the recovery planning process. A mailing list will be maintained and the Pacific Islands Fish and Wildlife Office will foster open and ongoing communications with all interested parties. Service biologists working on these species as well as other Maui Nui resource management issues will continue to develop strong working relationships with stakeholders. Early in the recovery planning process, a meeting with interested parties will be held to exchange status information, identify recovery issues, and identify additional cooperators. Information from this meeting will assist with recovery planning and help identify private landowners who could participate in recovery efforts. Interested stakeholders will be asked to participate, on an ongoing basis, in the recovery planning and implementation

effort. As needed, additional meetings will be scheduled to discuss particular issues, and stakeholders will be invited to participate, as appropriate. Stakeholders may also be asked to contribute directly in developing recovery implementation strategies for planned actions. Stakeholders will be afforded an opportunity to review and comment on a draft of the recovery plan as per the ESA.

Approved:



Regional Director
U.S. Fish and Wildlife Service

Oct. 31, 2019
Date

Citation

U.S. Fish and Wildlife Service. 2019. Recovery Outline for the Islands of Maui, Moloka'i, Kaho'olawe, and Lāna'i (Maui Nui). Portland, Oregon. 32 pp.

References

- Burney, D.A., H.F. James, L.P. Burney, S.L. Olson, W. Kikuchi, W.L. Wagner, M. Burney, D. McCloskey, D. Kikuchi, F.V. Grady, R. Gage, and R. Nishek. 2001. Fossil evidence for a diverse biota from Kauaʻi and its transformation since human arrival. *Ecological Monographs* 71:615-641.
- Cabin, R.J., S.G. Weller, D.H. Lorence, T.W. Flynn, A.K. Sakai, D. Sandquist, and L. Hadway. 2000. Effects of long-term ungulate exclusion and recent non-native species control on the preservation and restoration of a Hawaiian tropical dry forest. *Conservation Biology* 14:439-453.
- Cuddihy, L.W. and C.P. Stone. 1990. Alteration of the native Hawaiian vegetation; effects of humans, their activities, and introductions. Cooperative National Park Resource Study Unit, University of Hawaiʻi, Honolulu, Hawaiʻi. 138 pp.
- Fortini, L, J. Price, J. Jacobi, A. Vorsino, J. Burgett, K. Brinck, F. Amidon, S. Miller, S.O. Gon, G. Koob, and E. Paxton. 2013. A landscape-based assessment of climate change vulnerability for all native Hawaiian plants. USGS Technical Report HCSU-044. Hawaii Cooperative Studies Unit, University of Hawaiʻi. 134 pp.
- Hadfield, M.G. 1986. Extinction in Hawaiian Achatinellinae snails. *Malacologia* 27:67-81.
- Haleakalā National Park. 2016. Report on controlled propagation of listed and candidate species, as designated under the U.S. Endangered Species Act. Unpublished data. 2 pp.
- Harold L. Lyon Arboretum Micropropagation Laboratory. 2016. Report on controlled propagation of listed and candidate species, as designated under the U.S. Endangered Species Act. University of Hawaiʻi at Mānoa, Honolulu, Hawaiʻi. Unpublished Microsoft Access Database.
- Harold L. Lyon Arboretum Seed Conservation Laboratory. 2017. Report on controlled propagation of listed and candidate species, as designated under the U.S. Endangered Species Act. University of Hawaiʻi at Mānoa, Honolulu, Hawaiʻi. Unpublished Microsoft Access Database.
- [HPPRCC] Hawaiʻi and Pacific Plants Recovery Coordinating Committee. 2011. Revised recovery objective guidelines. Unpublished. 8 pp.
- Hawaiʻi Association of Watershed Partnerships. 2018. Hawaiʻi Association of Watershed Partnerships (HAWP) [web application]. Hawaiʻi Association of Watershed Partnerships, Honolulu, Hawaiʻi. Available online at <http://hawp.org/partnerships/>. Accessed 28 June 2018.

- Hawai'i Department of Land and Natural Resources. 2003. Draft management plan for the ahupua'a of Pu'u Wa'awa'a and the makai lands of Pu'u Anahulu. Hawai'i Division of Forestry and Wildlife, Hilo, Hawai'i. Unpublished. 34 pp. iv + 82 pp.
- Hawai'i Division of Forestry and Wildlife. 2011. Report on controlled propagation of listed and candidate species, as designated under the U.S. Endangered Species Act. Hawai'i Division of Forestry and Wildlife, Honolulu, Hawai'i. Unpublished. 1 p.
- Gardener, D.E. and V.A.D. Kageler. 1983. Glyphosate in the control of kikuyu grass and its effects on associated native and nonnative plants in Hawaiian national parks. Cooperative National Park Resources Studies Unit, University of Hawai'i at Mānoa, Department of Botany. Technical Report 49. 20 pp.
- [IPCC] Intergovernmental Panel on Climate Change. 2007. Climate Change 2007: Synthesis report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and A. Reisinger (eds.)]. IPCC, Geneva, Switzerland. 104 pp.
- Leonard, D. L., Jr. 2008. Recovery expenditures for birds listed under the US Endangered Species Act: the disparity between mainland and Hawaiian taxa. *Biological Conservation* 141:2054-2061.
- Loh, R.K. and C.C. Daehler. 2007. Influence of invasive tree kill rates on native and invasive plant establishment in a Hawaiian forest. *Restoration Ecology* 15:199-211.
- Loh, R.K. and C.C. Daehler. 2008. Influence of woody invader control methods and seed availability on native and invasive species establishment in a Hawaiian forest. *Biological Invasions* 10:805-819.
- Loope, L.L., A.C. Medeiros, and B.H. Gagne. 1991. Recovery of vegetation of a montane bog following protection from feral pig rooting. Cooperative National Park Resources Studies Unit, University of Hawai'i at Mānoa, Department of Botany. Technical Report 77. 23 pp.
- Maui Invasive Species Committee. 2018. Maui Invasive Species Committee (MISC) target pests. Available online at < <http://mauiinvasive.org/misc-target-pests/>>. Accessed 28 June 2018.
- Maui Nui Botanical Garden. 2015. Report on controlled propagation of listed and candidate species, as designated under the U.S. Endangered Species Act. Unpublished. 13 pp.

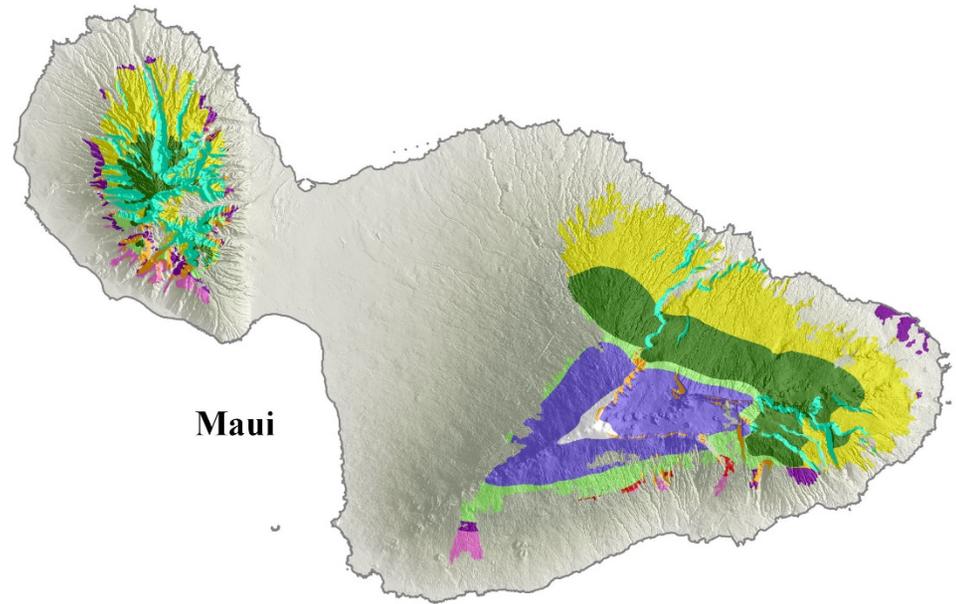
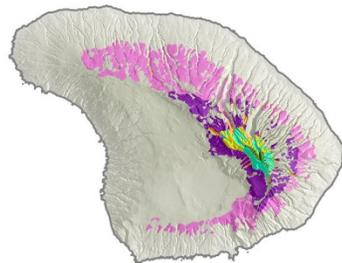
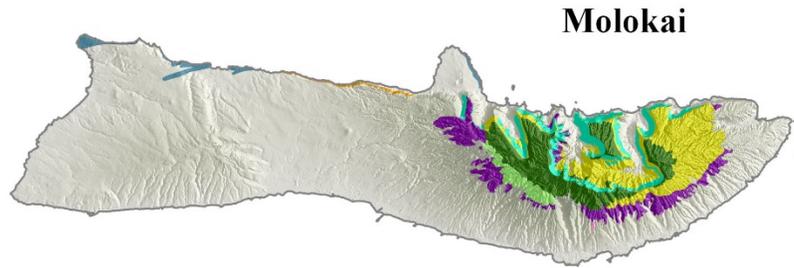
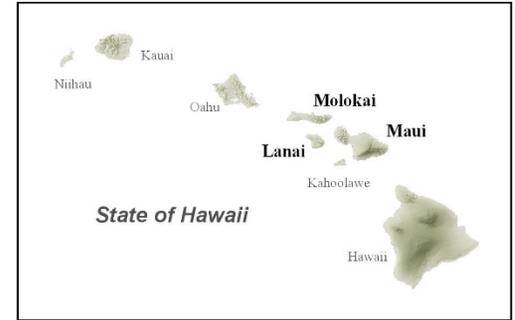
- National Tropical Botanical Garden. 2016. Report on controlled propagation of listed and candidate species, as designated under the U.S. Endangered Species Act. Kalaheo, Hawai'i. Unpublished. 3 pp.
- National Tropical Botanical Garden. 2017. Report on controlled propagation of listed and candidate species, as designated under the U.S. Endangered Species Act. Kalaheo, Hawai'i. Unpublished. 34 pp.
- [OANRP] O'ahu Army Natural Resources Program. 2017. Chapter 9.2 Improved efficacy of FerroxxAQ compared to Sluggo in a field setting. 2017 Mākuā and O'ahu Implementation Plan Status Report. Pp 217-224.
- Olinda Rare Plant Facility. 2016. Report on controlled propagation of listed and candidate species, as designated under the U.S. Endangered Species Act. Unpublished. 13 pp.
- Plant Extinction Prevention Program. 2017. Plant Extinction Prevention Program FY 2017 Annual Report (October 1, 2016 - September 30, 2017. Prepared for U.S. Fish and Wildlife Service and Hawai'i Division of Forestry and Wildlife. Unpublished. 235 pp.
- Smith, C.W. 1985. Impact of alien plants on Hawai'i's native biota. Pages 180-250 *In* Hawai'i's terrestrial ecosystems: preservation and management (C.P. Stone and J.M. Scott, eds.). Cooperative National Park Resources Studies Unit, University of Hawai'i, Honolulu.
- Spatz, G. and D. Mueller-Dombois. 1973. The influence of feral goats on koa tree reproduction in Hawai'i Volcanoes National Park. *Ecology* 54(4):870-876.
- Sprague, J., M. Bogardus, L. Crampton, T. Bogardus, R. Sprague, and K. Pias. 2018. Predator control forum. 25th Annual Hawai'i Conservation Conference, July 24 - July 26, 2018. Honolulu, HI. Poster 155. http://www.hawaiiconservation.org/wp-content/uploads/Full-Abstract-Book_FINAL_7.6.2018.pdf. Abstract last accessed August 15, 2018.
- [USFWS] U.S. Fish and Wildlife Service. 1983a. Endangered and threatened species listing and recovery priority guidance. *Federal Register* 48:43098-43105.
- [USFWS] U.S. Fish and Wildlife Service. 1983b. Endangered and threatened species listing and recovery priority guidelines correction. *Federal Register* 48:51985.
- [USFWS] U.S. Fish and Wildlife Service. 2006a. Endangered and threatened wildlife and plants; determination of status for 12 species of picture-wing flies from the Hawaiian Islands. *Federal Register* 71:26835-26852.

- [USFWS] U.S. Fish and Wildlife Service. 2011a. Conserving pacific island ecosystems and species; protecting species and their habitats for future generations; 2011-2016 Pacific Islands Fish and Wildlife Office Strategic Plan (July 13, 2011); Maps updated September 29, 2011. U.S. Fish and Wildlife Service, Honolulu, Hawai'i. 41 pp.
- [USFWS] U.S. Fish and Wildlife Service. 2011b. Recovery plan for Hawaiian waterbirds, second revision. U.S. Fish and Wildlife Service, Portland, Oregon. 233 pp.
- [USFWS] U.S. Fish and Wildlife Service. 2012. Endangered and threatened wildlife and plants; listing 38 species on Molokai, Lanai, and Maui as endangered and designating critical habitat on Molokai, Lanai, Maui, and Kahoolawe for 135 species; proposed rule. Federal Register 77:34464-34775.
- [USFWS] U.S. Fish and Wildlife Service. 2012. *in litt.* Cooperative agreement between the U.S. Fish and Wildlife Service and Maui Land and Pineapple Company, Inc. Unpublished. 12 pp.
- [USFWS] U.S. Fish and Wildlife Service. 2013. Endangered and threatened wildlife and plants; determination of endangered status for 38 species on Molokai, Lanai, and Maui; final rule. Federal Register 78:32013-32065.
- [USFWS] U.S. Fish and Wildlife Service. 2015. Endangered status for 49 species from the Hawaiian Islands; proposed rule. Federal Register 80:58819-58909.
- [USFWS] U.S. Fish and Wildlife Service. 2016a. Endangered and threatened wildlife and plants; endangered status for 49 species from the Hawaiian Islands; final rule. Federal Register 81:67786-67860.
- [USFWS] U.S. Fish and Wildlife Service. 2016b. Designation and nondesignation of critical habitat on Molokai, Lanai, Maui, and Kahoolawe for 135 species; final rule. Federal Register 81:17789-18110.
- Vitousek, P.M., L.R. Walker, L.D. Whiteaker, D. Mueller-Dombois, and P.A. Matson. 1987. Biological invasions by *Myrica faya* alter ecosystem development in Hawaii. Science 238: 802-804.

Personal communications:

Sischo, D.R. 2018. Lāna`i tree snails. Personal communication received by John Vetter, U. S. Fish and Wildlife Service, Pacific Islands Fish and Wildlife Office, Honolulu, Hawai`i. Dated September 13, 2018.

Appendix 1 – Maui Nui Species Ecosystems

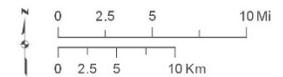


Recovery Outline Maui, Molokai and Lanai

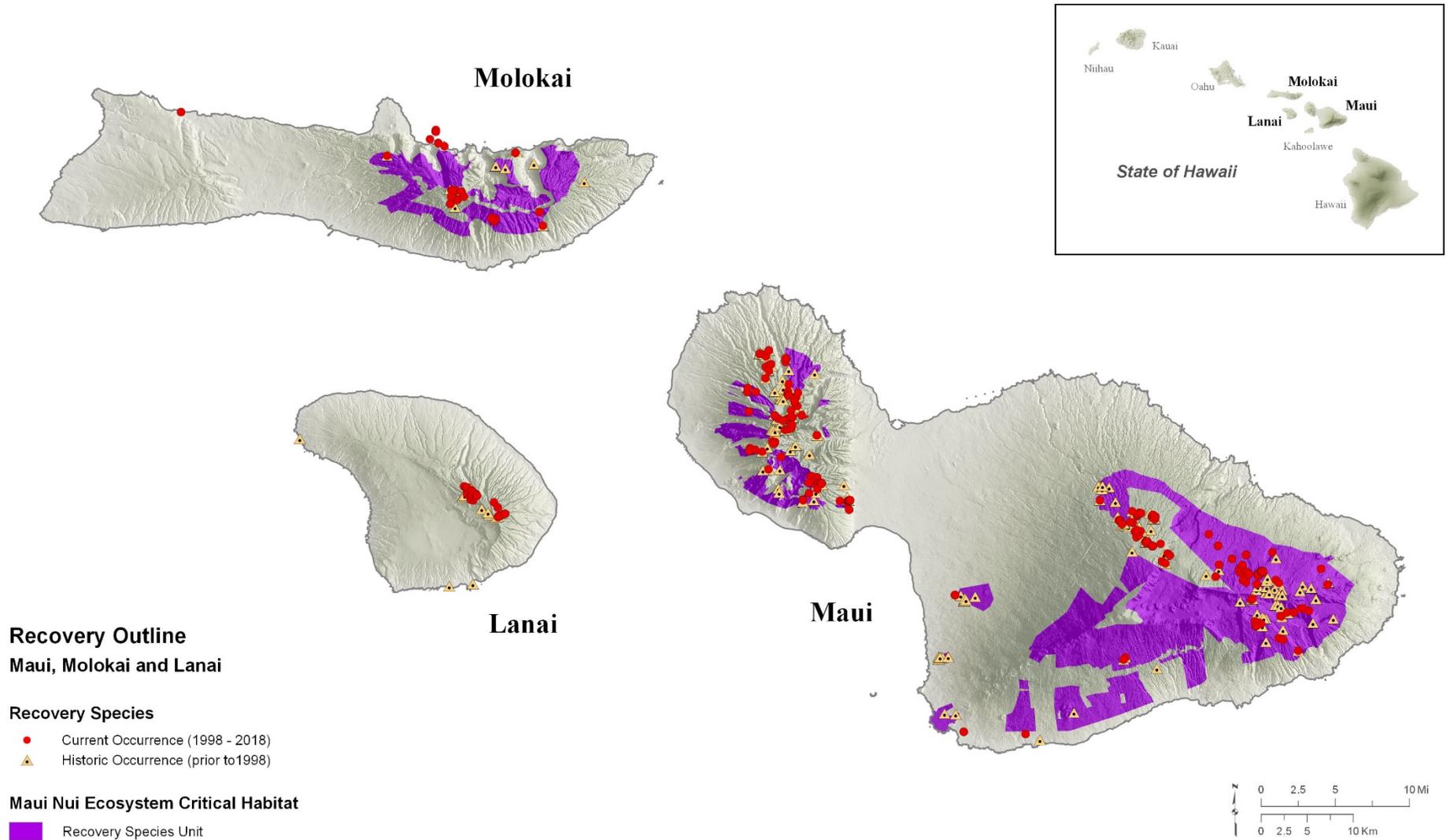
Native Ecosystems

The Nature Conservancy of Hawaii

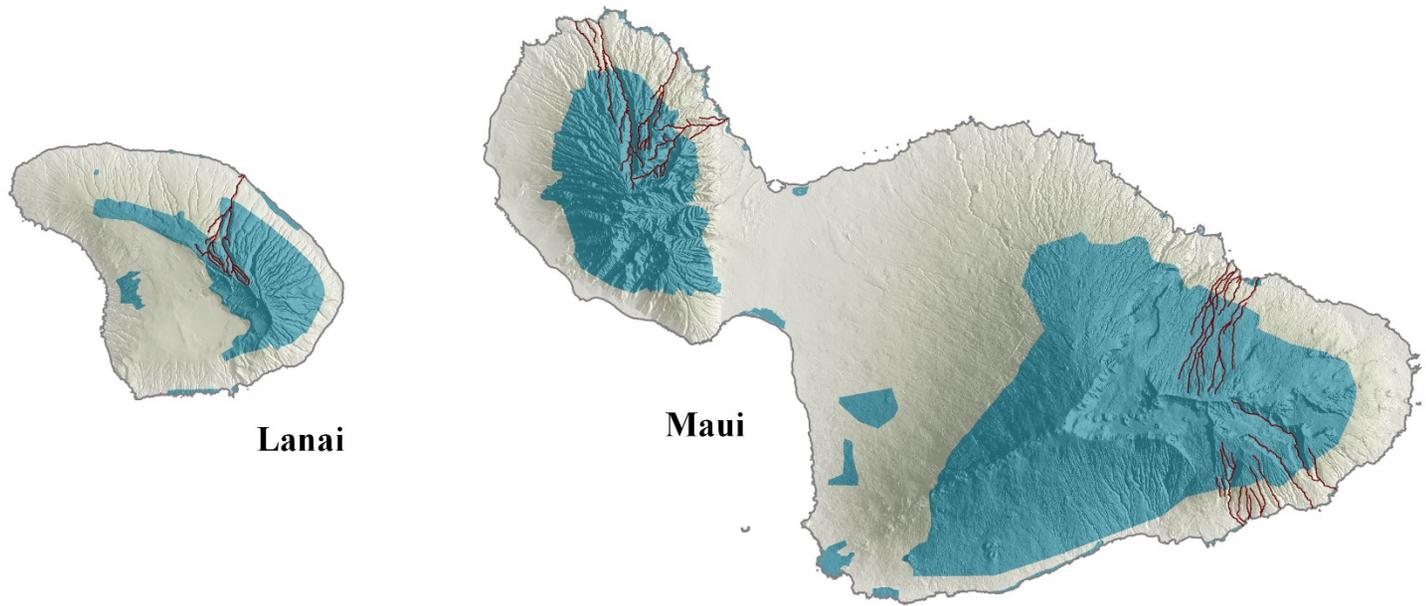
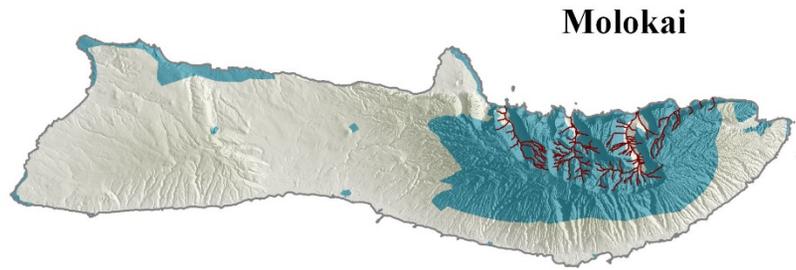
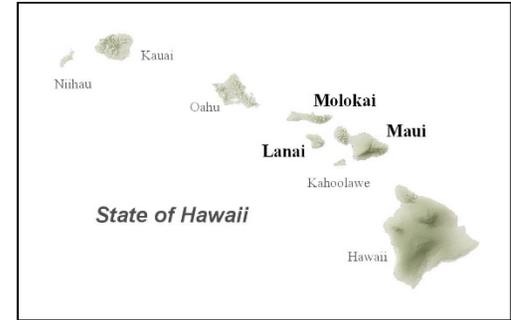
- Alpine Communities
- Coastal Dry Shrubland & Grassland
- Dry Cliff
- Lowland Dry Ecosystems
- Lowland Mesic Forest & Shrubland
- Lowland Wet Forest & Shrubland
- Montane Dry Forest & Shrubland
- Montane Mesic Forest & Shrubland
- Montane Wet Forest & Shrubland
- Subalpine Dry Shrubland & Grassland
- Wet Cliff



Appendix 2 – Distribution of the 45 Recently Listed Species and Designated Critical Habitat



Appendix 3 – Pacific Islands Fish and Wildlife Office Priority Conservation Areas



Recovery Outline
Maui, Molokai and Lanai

Priority Ecosystem Conservation Areas

-  Priority Areas
-  Priority Streams

