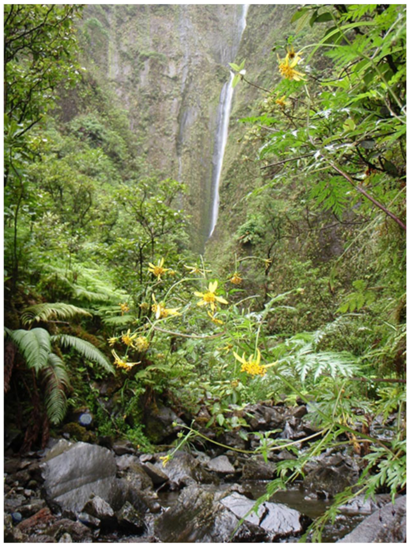
U.S. Fish & Wildlife Service

Recovery Plan for 44 Species from Maui Nui (Islands of Maui, Moloka‘i, and Lāna‘i)

Cyanea duvalliorum (hāhā)



Bidens campylotheca ssp. *waihoiensis* (ko‘oko‘olau)
Photos by Hank Oppenheimer, PEPP

Recovery Plan
for
44 Species from Maui Nui
(Islands of Maui, Molokaʻi, and Lānaʻi)

U.S. Fish and Wildlife Service
Portland, Oregon

Approved: HUGH MORRISON Digitally signed by HUGH MORRISON
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Regional Director, Pacific Region 1

DISCLAIMER

Recovery plans delineate reasonable actions needed 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, and others. Objectives of the recovery plan are accomplished, and funds made available, subject to budgetary and other constraints affecting the parties involved, as well as the need to address other priorities with the same funds.

Recovery plans do not necessarily represent the views or the official positions or approval of any individuals or agencies involved in the plan formulation, other than our own. They represent our official position only after the final recovery plan is signed by the Director or Regional Director. Draft recovery plans are reviewed by the public and may be subject to additional peer review before the Service adopts them as final. Recovery objectives may be attained and funds expended contingent upon appropriations, priorities, and other budgetary constraints. Recovery plans are guidance and planning documents only; identification of an action to be implemented by any public or private party does not create a legal obligation beyond existing legal requirements. Nothing in this plan should be construed as a commitment or requirement that any Federal agency obligate or pay funds in any one fiscal year in excess of appropriations made by Congress for that fiscal year in contravention of the Anti-Deficiency Act, 31 U.S.C. 1341, or any other law or regulation. Approved recovery plans are subject to modification as dictated by new findings, changes in species status, and completion of recovery actions.

Literature citation of this document should read as follows:
U.S. Fish and Wildlife Service. 2023. Recovery plan for 44 species from Maui Nui (islands of Maui, Molokaʻi, and Lānaʻi). Portland, Oregon. xv + 90 pages + Appendices.

An electronic copy of this recovery plan is available at:

https://www.fws.gov/program/recovery/recovery-plans

ACKNOWLEDGMENTS

We, the U.S. Fish and Wildlife Service (Service), gratefully acknowledge the contributions of the following individuals and organizations in developing the Recovery Plan for 44 Species from Maui Nui (Islands of Maui, Molokaʻi, and Lānaʻi). The primary authors of this recovery plan are Chelsie Javar-Salas, Diane Sether, and Jay Nelson (of the Service's Pacific Islands Fish and Wildlife Office [PIFWO], Honolulu, Hawaiʻi). Reviewers were Lauren Weisenberger, John Vetter, Megan Laut, Gregory Koob, and Katherine Mullett (PIFWO); and Grant Canterbury, David Leonard, Sarah Hall, and Marilet Zablan (of the Service's Pacific Regional Office, Portland, Oregon).

We particularly thank the species experts and their staff who provided information used in the development and improvement of this recovery plan: Matthew Keir, Cynthia King, and Troy Sakihara, State of Hawaiʻi, Department of Land and Natural Resources (DLNR), Division of Forestry and Wildlife (DOFAW); David Sischo and Keahi Bustamente, Snail Extinction Prevention Program, DOFAW; Hank Oppenheimer, Ane Bakutis, and Steve Perlman, Plant Extinction Prevention Program; Rachel Sprague and Jonathan Sprague, Pūlama Lānaʻi; Karl Magnacca, Oʻahu Army Natural Resources Program; Patti Welton, National Park Service; the Hawaiʻi and Pacific Plants Recovery Coordinating Committee (HPPRCC); and Susan Machida and Fred Amidon (PIFWO) who provided mapping assistance. We also acknowledge and appreciate the individuals, organizations, and agencies that provided a wide range of constructive and helpful comments during the public comment period on the draft recovery plan. Your suggestions helped to improve this final document.

RECOVERY PLANNING PROCESS

The Service is now using a three-part framework for recovery planning (see fws.gov/media/recovery-planning-and-implementation-under-endangered-species-act). This approach is intended to reduce the time needed for recovery planning, increase the flexibility of recovery planning documents by making them easier to modify as new information or circumstances arise, and thus maintain the relevancy of recovery plans over a longer time frame. Under this process, a recovery plan includes the statutorily required elements under section 4(f) of the Endangered Species Act (Act) (objective and measurable recovery criteria, site-specific management actions, and estimates of time and costs), along with a concise introduction and our strategy for how we plan to achieve species recovery. The recovery plan is supported by two supplementary documents: a Species Status Assessment for each species addressed in the recovery plan (or, as in this case, a Species Report with slightly different format and structure), which describes the best available scientific information related to the biological needs of the species and assessment of threats; and the Recovery Implementation Strategy, which details the particular near-term activities needed to implement the recovery actions identified in the recovery plan. Under this approach, new information on species biology or details of recovery implementation may be incorporated by updating these supplementary documents without concurrent revision of the entire recovery plan, unless changes to statutorily required elements are necessary.

Thus, this recovery plan document is one piece of a three-part framework:

1. **Species Status Assessments (SSAs)** or **Species Reports** inform the recovery plan. Each report describes the biology and life history needs of a listed species, analyzes its historical and current condition, and discusses its threats and conservation needs. These documents may be updated as needed based on new information. The format of the SSAs or Species Reports is structured around the conservation biology principles of resiliency, redundancy, and representation (Shaffer and Stein 2000, pp. 307–310; Wolf et al. 2015, entire; Smith et al. 2018, entire).

   There are 44 Species Reports associated with this recovery plan (USFWS 2023a through USFWS 2023rr, entire), summarizing the biology and threat status of each species addressed in the plan and including the geography and environmental context of their range within Maui Nui. Species Reports include information from Habitat Status Assessments completed by the Service (Ball et al. 2020; Browning et al. 2020; Clark et al. 2020; Javar-Salas et al. 2020; Kim et al. 2020; Lowe et al. 2020; Nelson et al. 2020; Pe‘a et al. 2020; Phillipson et al. 2020). Habitat Status Assessments are used to evaluate the current status, stressors, and future viability of the terrestrial habitats found in the Hawaiian Islands.

2. The **Recovery Plan** contains a concise overview of the recovery strategy for each species (indicating how its recovered state will achieve redundancy, resiliency, and representation), as well as the statutorily required elements of recovery criteria, recovery actions, and estimates of the time and costs to achieve the plan’s goals.

3. **The Recovery Implementation Strategy** (RIS) outlines how the recovery plan will be implemented. The RIS is a short-term, flexible operational document focused on how, when, and by whom the recovery actions from the recovery plan will be implemented. This document may be updated as needed based on new information, allowing it to be adapted to changing circumstances with greater flexibility and efficiency. The RIS will be developed and maintained in cooperation with our conservation partners and will focus on the period of time and activities that work best for our partners to achieve recovery goals.

   To identify the highest priority actions for recovery of these species to develop a RIS, we are coordinating with conservation partners at the State of Hawaiʻi, Department of Land and Natural Resources (DLNR), Division of Forestry and Wildlife (DOFAW); Plant Extinction Prevention Program (PEPP); Snail Extinction Prevention Program (SEPP); Counties of Maui and Hawaiʻi; Pūlama Lānaʻi, research institutions; watershed partnerships; native Hawaiian and local communities; public and private stakeholders; and National Park Service.

The current versions of the RIS and Species Reports, as well as other Service documents on these species, will be made available through our Environmental Conservation Online System (ECOS) at the species profile webpages, accessible by searching for the appropriate species name at ecos.fws.gov.

EXECUTIVE SUMMARY

Species Status

This recovery plan addresses 44 species (40 plants, 3 tree snails, and 1 yellow-faced bee) endemic to the Hawaiian Islands of Maui, Molokaʻi, and Lānaʻi. (These three islands, together with the smaller island of Kahoʻolawe, are collectively referred to as Maui Nui). These 44 species were listed as endangered on May 28, 2013, and September 30, 2016 (USFWS 2013, USFWS 2016a). Critical habitat was designated for 33 of the 44 species in 2016 (USFWS 2016b). Critical habitat for seven species (six plants and the hilaris yellow-faced bee) is planned but the specific timing has not been determined. Critical habitat for *Dracaena fernaldii* and the two Lānaʻi tree snails was not designated based on landowner cooperation to conserve the species. Beyond those addressed herein, there are also many other federally listed threatened and endangered species with current and/or historical range in all or a portion of Maui Nui.

Taxon	Common Name	Plant Life History and Growth Form	Distribution
Plants			
Bidens campylotheca ssp. *pentamera*	koʻokoʻolau	Perennial herb	Maui
Bidens campylotheca ssp. *waihoiensis*	koʻokoʻolau	Perennial herb	Maui
Bidens conjuncta	koʻokoʻolau	Perennial herb	Maui
Calamagrostis hillebrandii	Hillebrand's reedgrass	Perennial grass	Maui
Cyanea asplenifolia	Hāhā	Short-lived perennial shrub	Maui
Cyanea duvalliorum	Hāhā	Short-lived perennial tree	Maui
Cyanea horrida	holokea or hāhā nui	Short-lived perennial shrub	Maui
Cyanea kauaulaensis	Hāhā	Short-lived perennial shrub	Maui
Cyanea kunthiana	Hāhā	Short-lived perennial shrub	Maui
Cyanea magnicalyx	Hāhā	Short-lived perennial shrub	Maui
Cyanea maritae	Hāhā	Short-lived perennial shrub	Maui
Cyanea mauiensis	Hāhā	Short-lived perennial shrub	Maui (possibly extirpated)
Cyanea munroi	Hāhā	Short-lived perennial shrub	Maui, Molokaʻi (possibly extirpated)
Cyanea obtusa	Hāhā	Short-lived perennial shrub	Maui

Taxon	**Common Name**	**Plant Life History and Growth Form**	**Distribution**
Cyanea profuga	Hāhā	Short-lived perennial shrub	Molokaʻi
Cyanea solanacea	Popolo	Short-lived perennial shrub	Molokaʻi
Cyperus neokunthianus	no common name	Perennial sedge	Maui (possibly extirpated)
Cyrtandra ferripilosa	haʻiwale	Short-lived perennial shrub	Maui
Cyrtandra filipes	haʻiwale	Short-lived perennial shrub	Maui, Molokaʻi
Cyrtandra hematos	haʻiwale	Short-lived perennial shrub	Molokaʻi
Cyrtandra oxybapha	haʻiwale	Short-lived perennial shrub	Maui
Dracaena fernaldii (formerly *Pleomele fernaldii*)	hala pepe	Long-lived perennial tree	Lānaʻi
Festuca molokaiensis	no common name	Perennial grass	Molokaʻi (possibly extirpated)
Geranium hanaense	nohoanu	Short-lived perennial shrub	Maui
Geranium hillebrandii	nohoanu	Short-lived perennial subshrub	Maui
Hypolepis hawaiiensis var. *mauiensis*	Olua	Fern	Maui
Mucuna persericea	sea bean	Short-lived perennial vine	Maui
Myrsine vaccinioides	Kōlea	Short-lived perennial shrub	Maui
Peperomia subpetiolata	ʻalaʻala wai nui	Short-lived perennial herb	Maui
Phyllostegia bracteata	no common name	Short-lived perennial herb	Maui
Phyllostegia haliakalae	no common name	Short-lived perennial vine	Maui (extant), Lānaʻi Molokaʻi (possibly extirpated)
Phyllostegia pilosa	no common name	Short-lived perennial vine	Maui, Molokaʻi (possibly extirpated)
Pittosporum halophilum	hōʻawa	Short-lived perennial shrub/small tree	Molokaʻi
Schiedea diffusa ssp. *diffusa*	no common name	Short-lived perennial vine	Maui, Molokaʻi

Taxon	Common Name	Plant Life History and Growth Form	Distribution
Schiedea jacobii	no common name	Short-lived perennial herb/subshrub	Maui
Schiedea laui	no common name	Short-lived perennial herb/subshrub	Molokaʻi
Schiedea pubescens	maʻoliʻoli	Short-lived perennial vine	Maui, Molokaʻi, Lānaʻi (possibly extirpated)
Schiedea salicaria	no common name	Short-lived perennial shrub	Maui
Stenogyne kauaulaensis	no common name	Short-lived perennial vine	Maui
Wikstroemia villosa	ʻākia	Long-lived perennial shrub/tree	Maui
Invertebrates			
Hylaeus hilaris	hilaris yellow-faced bee	N/A	Molokaʻi (extant), Maui, Lānaʻi (possibly extirpated)
Newcombia cumingi	Newcomb's tree snail	N/A	Maui
Partulina semicarinata	pūpū kani oe or Lānaʻi tree snail	N/A	Lānaʻi
Partulina variabilis	pūpū kani oe or Lānaʻi tree snail	N/A	Lānaʻi

Recovery Vision

A recovery vision builds on the description of viability for the species and defines what recovery looks like for the species. The recovery vision of the 40 plant species addressed in this recovery plan is to have redundant, self-sustaining populations representing the genetic and ecological diversity of the species distributed across their ranges in habitats where threats are managed. A recovery vision for each species group or species is presented in the main body of the recovery plan.

Recovery Strategy

Achieving recovery for the 44 species will require a combination of population and habitat assessments, selection of sites for long-term conservation, threat management, development of regulatory protections, species-specific research, and conservation translocation (hereafter, translocation [i.e., deliberate movement of organisms for conservation]) to maximize resiliency, redundancy, and representation. The recovery strategy for each species group or species is presented in the main body of the recovery plan.

Many of the plant species covered by this recovery plan persist at very low numbers or are in rapid decline. To target and track recovery efforts for critically rare plants, the Hawaiʻi and Pacific Plants Recovery Coordinating Committee (HPPRCC) developed two interim recovery stages with the goal of minimizing the likelihood of extinction and to stabilize populations (HPPRCC 2011, entire). While defining these two interim recovery stages is not required under the Act, they are vital for the recovery of these species. In addition to these interim stages, we have identified the required recovery criteria that, when met, indicate downlisting or delisting a species may be warranted. Recovery will be achieved through a series of conservation stages: (1) preventing extinction, (2) interim stabilization, (3) downlisting, and (4) delisting.

The conservation measures recommended by these stages include genetic storage, managing threats in the immediate vicinity of individual plants, and conservation translocation with the goal of protecting and/or creating multiple resilient populations of each species across their known range. The recovery of each plant species will follow from these initial efforts and include continued assessments of the distribution and condition of the 40 plant species and their habitat, selection of sites for their long-term conservation, management of threats, and development of regulatory protections to assure their long-term protection. Species will also need protection from species-specific threats including ungulates, military activities, invasive plants, predation by nonnative invertebrates and vertebrates, introduction of disease, stochastic events (fire, drought, flood, landslide, erosion, hurricanes, etc.), limited numbers of individuals, lack of regeneration, pollinator or disperser deficiency, and human disturbances. Recovery strategies for the individual plant species are presented in the body of the recovery plan.

The three tree snail species and the hilaris yellow-faced bee presumably persist in low numbers. Preventing extinction and stabilizing populations are immediate needs. The recovery strategy for these four invertebrate species includes identification of all extant populations throughout historical and existing suitable range of each species to assess their distribution.

Extant populations of all these species will require stabilization and protection from threats to habitat, yellow-faced bee hosts, predation, and competition. Establishing captive rearing programs to prevent extinction and provide future sources for conservation translocation is an immediate need for these species. Research will inform adaptive management. Each species will need long-term protection of habitat and populations from species-specific threats including habitat degradation from a variety of sources, predation, loss of yellow-faced bee hosts, competition, disease, lack of sufficient breeding opportunities, and human-associated threats such as collection and loss of habitat.

Recovery and long-term protection of all 44 species includes collaboration with Federal, State, County, native Hawaiian and local communities, nonprofit, and private stakeholders to develop adaptive management and monitoring plans for each species' habitat, threats, and biosecurity. Some species may require conservations translocation to historical, restored, or created habitats suitable to achieve the resiliency necessary for each species to thrive. Recovery strategies for the individual species and species groups are presented in the body of the recovery plan.

Interim Recovery Stages

Plant Species:

Preventing Extinction

To meet the preventing extinction goals, a thorough and accurate population survey and population size estimate of the 40 listed plant species must be completed throughout each species' historical range. Reproductive studies must be completed as needed to inform management. Each plant species will need a minimum of 3 to 6 populations comprised of 25 to 150 mature individuals per population with evidence of natural reproduction (i.e., viable seeds, seedlings, saplings). Threats are assessed and managed in the immediate vicinity of the populations. Genetic storage of at least 50 individuals per population, or the total number of individuals if fewer than 50 remain, are secured in a well-managed *ex situ* collection (off-site, such as a nursery or seed bank) (Guerrant et al. 2004, entire).

Interim Stabilization

To meet the interim stabilization goals, all preventing extinction goals must be achieved as well as having 3 to 6 self-sustaining populations comprised of 100 to 900 mature individuals per population and threat management continues around each population. Monitoring is in place to assess plant survival, population trends, trends of major limiting factors, and the response of populations to threat management. In addition, all populations must be adequately represented in a well-managed *ex situ* collection (Guerrant et al. 2004, entire). Multi-island species should be represented by at least one population in each of the geographic units from which the species was known historically where suitable habitat exists.

The following tables summarize the downlisting and delisting criteria for the 44 species covered in this recovery plan. See the body of the recovery plan for a detailed explanation of each of the criteria.

Recovery Criteria

Plant Species

Downlisting and Delisting Criteria—40 Plant Species

	Criterion 1	Criterion 2
Downlisting Criteria	Minimum of either 5 or 10 resilient populations, each with minimum of 200 to 1,500 individuals. (Specific numbers vary with species life history characteristics – see discussion in text.)	Habitat and threats are managed; monitoring and management plans are completed and implemented for each species.
Delisting Criteria	Minimum of either 10 or 20 resilient populations, each with minimum of 200 to 1,500 individuals. (Specific numbers vary with species life history characteristics – see discussion in text.)	Habitat and threats are managed; monitoring of population status and threats is ongoing.

***Invertebrate Species*:**

Downlisting and Delisting Criteria—3 Tree Snail Species

	Criterion 1	**Criterion 2**	**Criterion 3**
Downlisting Criteria	At least 6 populations with at least 300 individuals each, distributed across all size classes, and with stable population indices are established. If management units identified, each must have one or more of these stable populations.	Suitable habitats supporting each population in *Downlisting Criterion 1* are managed, provide needed resources, and provide for natural dispersal and range expansion.	All threats are managed or absent at and around each population in *Downlisting Criterion 1*; monitoring and management plans are completed and implemented for each species; measures are in place to prevent introduction of new nonnative predators and/or disease.
Delisting Criteria	At least 12 populations with at least 300 individuals each, distributed across all size classes, and with stable population indices. If management units identified, each must have two or more of these stable populations.	Suitable habitats supporting *Delisting Criterion 1* are managed, provide needed resources, and allow for natural dispersal and range expansion; habitats are afforded land protection to ensure long-term persistence of each species.	All threats are managed, absent, or can be tolerated at and around each population in *Delisting Criterion 1*; monitoring of population status and threats is ongoing; measures are in place to prevent introduction of new nonnative predators, competitors, disease, and/or threats.

Downlisting and Delisting Criteria—Hilaris Yellow-faced Bee

	Criterion 1	Criterion 2	Criterion 3	Criterion 4
Downlisting Criteria	The species is represented by at least 5 populations with stable to increasing population indices for at least 5 years prior to downlisting consideration; each island management unit is occupied by one or more stable populations; populations are sufficiently distributed across the species range and in each island unit to reduce vulnerability to extirpation by a catastrophic event.	Populations of yellow-faced bee nest hosts supporting hilaris yellow-faced bee populations in *Downlisting Criterion 1* on each island management unit are stable and viable to ensure long-term persistence for at least 10 years immediately before downlisting consideration.	Habitats at each population in *Downlisting Criterion* 1 are managed and protected from threats, provide sufficient nesting and food resources, support breeding opportunities, natural dispersal, and expansion of occupied range, and are afforded land protection to provide for long-term persistence of the species.	All major threats to individuals and populations of the species in *Downlisting Criterion 1* are managed; monitoring and management plans are completed and implemented for the species; measures are in place to prevent introduction of new nonnative predators, competitors, and/or disease to the populations in *Downlisting Criterion 1* and/or their hosts.
Delisting Criteria	The species is represented by 10 populations that are redundant in each of the three island management units, with stable or increasing population indices for at least 10 years prior to delisting consideration.	Populations of yellow-faced bee nest hosts supporting hilaris yellow-faced bee populations in *Delisting Criterion 1* in each island management unit are stable and viable to ensure long-term persistence for at least 10 years immediately before delisting consideration.	Habitats at each population in *Delisting Criterion 1* are managed and protected from threats, provide sufficient nesting and food resources, support breeding opportunities, natural dispersal, and expansion of occupied range, and are afforded land protection for long-term persistence	All major threats to individuals and populations of the species in *Delisting Criterion 1* are managed; monitoring of threats and population status is ongoing for the species and its hosts; measures are in place to prevent introduction of new nonnative predators, competitors, and/or disease to the populations in *Delisting Criterion 1*.

Recovery Actions and Their Costs

Recovery actions and preliminary cost estimates for all 44 species are shown in the table below. Project-level details of recovery action implementation will be developed with partners in a separate recovery implementation strategy (RIS) document that will supplement this recovery plan. Implementation is subject to availability of funds and is at the discretion of partners.

Recovery Actions and Estimated Cost Over 20-Year Time Horizon

Recovery Action	**Recovery Action #**	**Estimated Cost**
Protect habitats and control threats in management units.	1.0	**$529,629,431**
Control species-specific threats.	2.0	**$297,462,523**
Expand the distribution of existing wild populations and establish new populations.	3.0	**$1,137,878,199**
Conduct additional research essential to recovering the 44 species and restoring their habitats.	4.0	**$131,018,647**
Implement regulations and policy to support species recovery.	5.0	**$9,475,686**
Total Estimated Cost for First 20 Years of Recovery[a]		**$2,105,527,486**

Date of Recovery

If all actions are fully funded and implemented as outlined, including cooperative efforts by all partners needed to achieve recovery, we estimate that the earliest the delisting criteria could be met is in 55 to 95 years for the 40 plant species, 25 to 40 years for the 3 tree snail species, and 60 years for the hilaris yellow-faced bee.

ACRONYMS AND ABBREVIATIONS

Act	Endangered Species Act
DLNR	State of Hawaiʻi Department of Land and Natural Resources
DOFAW	Division of Forestry and Wildlife
ESU	Evolutionarily significant unit
GU	geographic unit
HPPRCC	Hawaiʻi and Pacific Plants Recovery Coordinating Committee
IPCC	Intergovernmental Panel on Climate Change
PEPP	Plant Extinction Prevention Program
PIFWO	Pacific Islands Fish and Wildlife Office
RIS	Recovery Implementation Strategy
ROD	rapid ʻōhiʻa death
RPI	Recovery Planning and Implementation
SEPP	Snail Extinction Prevention Program
USFWS or Service	U.S. Fish and Wildlife Service

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[a] Over the 25- to 95-year projected time to recovery, cost estimation is highly uncertain. We focus here on estimated costs for the initial 20 years of recovery implementation.

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I. INTRODUCTION

The Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et seq.*) (Act) protects species of wildlife and plants that are listed as endangered or threatened. Recovery is defined as "the process by which listed species and their ecosystems are restored and their future is safeguarded to the point that protections under the [Act] are no longer needed," according to the 2018 updated National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (Service) Interim Recovery Planning Guidelines, Version 1.4 (NMFS and USFWS 2018).

Recovery plans are guidance documents developed to provide recommendations to reduce or alleviate threats to the species (includes distinct population segments, subspecies, species groups) and ensure self-sustaining populations in the wild. Section 4(f)(1) of the Act requires that recovery plans include: (1) a description of site-specific management actions necessary to conserve the species; (2) objective, measurable criteria that, when met, will allow the species or populations to be removed from the Federal Lists of Endangered and Threatened Wildlife and Plants; and (3) estimates of the time and cost required to achieve the plan's goals and intermediate steps.

This recovery plan addresses 44 species (40 plants, 3 snails, and 1 yellow-faced bee) that occur or occurred on the Hawaiian islands of Molokaʻi, Maui, and Lānaʻi. These islands, together with the smaller island of Kahoʻolawe (where these 44 species are not known to occur), are collectively known as Maui Nui (Figure 1). Six plant species (*Cyanea kauaulaensis*, *Cyperus neokunthianus*, *Cyrtandra hematos*, *Hypolepis hawaiiensis* var. *mauiensis*, *Schiedea diffusa* ssp. *diffusa*, *Schiedea pubescens*) and 1 yellow-faced bee species (*Hylaeus hilaris*, or hilaris yellow-faced bee) were listed as endangered on September 30, 2016, and the remaining 34 plant species and 3 tree snail species were listed as endangered on May 28, 2013 (Table 1; USFWS 2013; USFWS 2016a). The Maui Nui Recovery Outline was approved on October 31, 2019 and covers all 44 species addressed in this recovery plan (USFWS 2019a), in addition to *Canavalia pubescens* (which has also been recorded from Kauaʻi and is addressed in the Recovery Plan for 50 Hawaiian Archipelago Species [USFWS 2022, entire]). There are many federally listed threatened and endangered species with current and/or historical range in all or a portion of Maui Nui; this recovery plan addresses only 44 of those species. The remainder of the federally listed species in Maui Nui have been addressed in the following Recovery Plans:

- Recovery Plan for the Hawaiian Hoary Bat (1998)
- Revised Hawaiian Forest Birds Recovery Plan (2006)
- Recovery Plan for Hawaiian Waterbirds, Second Revision (2012)
- Draft Revised Recovery Plan for the Nēnē or Hawaiian Goose (2004)
- Hawaiian Dark-rumped Petrel and Newell's Manx Shearwater Recovery Plan (1983)
- Recovery Plan for the Multi-Island Plants (1999) and Addendum (2002)
- Recovery Plan for the Molokaʻi Plant Cluster (1996) and Addendum (1998)
- Lānaʻi Plant Cluster Recovery Plan (1995)
- Recovery Plan for the Maui Plant Cluster (1997)
- Recovery Plan for 50 Hawaiian Archipelago Species (2022)

- Recovery Plan for Four Species of Hawaiian Ferns (1998)
- Recovery Plan for *Marsilea villosa* (1998)

Ecosystem-based critical habitat was designated on March 30, 2016 (USFWS 2016b), for 32 plant species and 1 tree snail species, *Newcombia cumingi* (Table 1). Critical habitat for *Dracaena fernaldii*, *Partulina variabilis* and *Partulina semicarinata* was considered on Lānaʻi but was not designated in favor of exclusions under section 4(b)(2) of the Act (USFWS 2016a). The decision to exclude Lānaʻi from critical habitat designation was based on landowner cooperation to conserve the species. Critical habitat for hilaris yellow-faced bee and six plant species is planned, but the specific timing has not been determined.

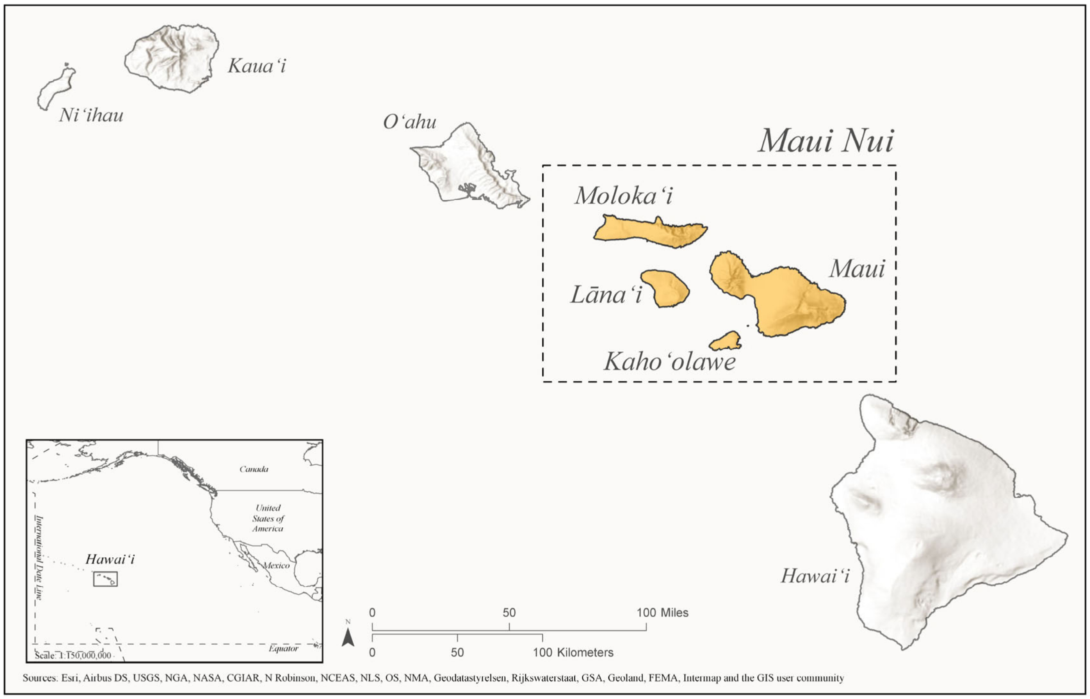
A. BACKGROUND

1. Basic Species Information

The species addressed by this recovery plan occur within Maui Nui (Table 1; Figure 1). Detailed species descriptions, life history, status, and historical and current range and distribution are contained in the proposed listing rules (USFWS 2012, USFWS 2015), listing determinations (USFWS 2013, USFWS 2016a), and 44 Species Reports (USFWS 2023a through USFWS 2023rr). The 44 listed species are known from 9 terrestrial habitats (8 natural terrestrial and 1 human developed) in Hawaiʻi: coastal, dry shrublands and grasslands, dry forest, mesic forest, mesic shrublands and grasslands, wet forest, wet shrublands and grasslands, wetlands, and developed (Tables 2 and 3; Ball et al. 2020; Browning et al. 2020; Clark et al. 2020; Javar-Salas et al. 2020; Kim et al. 2020; Lowe et al. 2020; Nelson et al. 2020; Peʻa et al. 2020; Phillipson et al. 2020). These species and their habitats occur on public and private lands (USFWS 2013, USFWS 2016a; USFWS 2023a–rr). Species with their associated Species Report and Habitat Status Assessment(s) are provided in Appendix A.

The 40 plant species consist of perennial trees, shrubs, subshrubs, vines, herbs, grasses, a sedge, and a fern. Many of these plant species are maintained in *ex situ* conservation (off-site controlled propagation, germplasm or micropropagation storage such as seedbanks, or both) (Table 1). Thirty-eight of the plant species have short life spans (greater than 1 year but less than 10 years), and the remaining 2 species (*Dracaena fernaldii* and *Wikstroemia villosa*) have life spans greater than 10 years (Table 1). Collectively the 40 plant species occupy 8 natural terrestrial habitats within Maui Nui: coastal habitat, dry shrublands and grasslands, dry forest, mesic forest, mesic shrublands and grasslands, wet forest, wet shrublands and grasslands, and wetlands.

Figure 1. The Hawaiian islands of Molokaʻi, Lānaʻi, Kahoʻolawe, and Maui, collectively known as Maui Nui. Map compiled from Esri (2020) and Hawaiʻi Statewide GIS Program (2020) datasets.



Sources: Esri, Airbus DS, USGS, NGA, NASA, CGIAR, N Robinson, NCEAS, NLS, OS, NMA, Geodatastyrelsen, Rijkswaterstaat, GSA, Geoland, FEMA, Intermap and the GIS user community

The three tree snail species addressed in this recovery plan are members of the Hawaiian endemic subfamily Achatinellinae, in the family Achatinellidae. The tree snail species are each known, historically and currently, from one island, either Maui or Lānaʻi (Newcomb 1853, p. 25; Pilsbry and Cooke 1912–1914a, pp. 10, 86, and plate 3; Pilsbry and Cooke 1912–1914b, pp. 83–86); they are also maintained via captive rearing, tree snail enclosures, or both (USFWS 2023cc, USFWS 2023jj, USFWS 2023kk). The species are endemic to lowland mesic to wet forest and wet montane forests and cliffs where the habitat provides the needed humidity for each species. Doing no known harm to their plant host, the tree snails feed on microbes living on the leaf, branch, and trunk surfaces of their plant host, called the phyllosphere (the total above-ground surface of a plant considered habitat for microorganisms).

Hilaris yellow-faced bee is known from the dry coastal strand habitat on Maui, Lānaʻi, and Molokaʻi (Perkins 1913, entire; Fullaway 1918, entire; Daly and Magnacca 2003, pp. 11 and 103–106). Currently, the species is believed to be extirpated from Maui and Lānaʻi, with only a remnant population located on Molokaʻi, at the Moʻomomi Preserve (Daly and Magnacca 2003, pp. 103–106; USFWS 2023y). The overall health and size of the population on Molokaʻi is unknown. No individuals are maintained in captivity. Hilaris yellow-faced bee is a cleptoparasitic (appropriating resources acquired by another species) bee that uses the nests of other coastal-nesting *Hylaeus* bee species for reproduction. The female enters the nests of other *Hylaeus* species and lays her own eggs. This cleptoparasite is completely dependent (obligate) on ground- or crevice-nesting *Hylaeus* species for reproduction. Its likely hosts anthracinan yellow-faced bee (*Hylaeus anthracinus*), assimulans yellow-faced bee, (*Hylaeus assimulans*), yellow-foot yellow-faced bee (*Hylaeus flavipes*), and longhead yellow-faced bee (*Hylaeus longiceps*), are themselves rare; all but *H. flavipes* are listed as endangered (USFWS 2016a). The range of these four host species includes the islands of Oʻahu, Molokaʻi, Lānaʻi, Maui, Kahoʻolawe, and Hawaiʻi (Daly and Magnacca 2003, entire; Magnacca 2007, entire; USFWS 2023y, p. 10).

Taxonomic Classification or Changes in Nomenclature

The plant *Mucuna sloanei* var. *persericea* was described by C.M. Wilmot-Dear in 1990 (Wilmot-Dear 1990, pp. 27–29). Moura et al. (2012, p. 837) identified additional differences between the two varieties of *Mucuna sloanei* (var. *persericea* and var. *sloanei*). These differences led to the separation of these varieties into separate species called *Mucuna persericea* and *M. sloanei*. *Mucuna persericea* is the most recent taxonomic treatment in the checklist of Hawaiian flora (Smithsonian Institution 2020, entire). This taxonomic change does not affect the range or endangered status of this species. This species is referred as *Mucuna persericea* throughout the plan.

The plant *Pleomele fernaldii* was described by Harold St. John in 1947 (St. John 1947, pp. 39–42 and listed as endangered under this taxonomic name (USFWS 2013, entire). The isotype was collected from the south ridge of [sic Holopoe] Hulopoʻe Gulch on Lānaʻi (University of Michigan Library Digital Collections 2019, entire). Otto Degener mistakenly named the species *Pleomele lanaiensis* but did not officially publish the name (Degener and Degener 1971, p. 9). Wagner et al. (1999, p. 1352) considered *P. lanaiensis* a synonym of *P. fernaldii*. Phylogenetic analysis of chloroplast DNA, as well as differences in floral morphology and flowering pattern, indicate that Hawaiian *Pleomele* species are a distinct group. This group has been alternatively treated as the genus *Chrysodracon* (Lu and Morden 2014, pp. 92–98), but based on new genetic analyses, *Chrysodracon* is now considered a subgenus within *Dracaena* (Jankalski 2008, pp. 17–21; Takawira-Nyenya 2018, p. 265). Thus, this species is *Dracaena fernaldii* in the most recent taxonomic treatment in the checklist of Hawaiian flora (Smithsonian Institution 2023, entire). This taxonomic change does not affect the range or endangered status of this species. We refer to this species as *Dracaena fernaldii* throughout the plan.

Table 1. Species name, current status including number of wild populations, number of individuals, *ex situ* conservation status, recovery priority number, location, and Federal Register rules for listing and critical habitat designation.

Species	Number of Populations	Number of Individuals	*Ex situ* Conservation	Recovery Priority Number	Current and Historical Distribution	Listing	Critical Habitat
PLANTS							
Bidens campylotheca ssp. *pentamera*	7	134–184	Seed storage	3[1]	Maui (extant)	USFWS 2013	USFWS 2016b
Bidens campylotheca ssp. *waihoiensis*	3	102	Seed storage, propagation	3	Maui (extant)	USFWS 2013	USFWS 2016b
Bidens conjuncta	5	2,000	Seed storage, propagation	2	Maui (extant)	USFWS 2013	USFWS 2016b
Calamagrostis hillebrandii	3	<300	Seed storage	2	Maui (extant)	USFWS 2013	USFWS 2016b
Cyanea asplenifolia	7	46	Seed storage, propagation	5[1]	Maui (extant)	USFWS 2013	USFWS 2016b
Cyanea duvalliorum	1	62	Seed storage, propagation	5	Maui (extant)	USFWS 2013	USFWS 2016b
Cyanea horrida	5	63	Propagation	5	Maui (extant)	USFWS 2013	USFWS 2016b
Cyanea kauaulaensis	1	120	Seed storage, propagation	5	Maui (extant)	USFWS 2016a	p
Cyanea kunthiana	10	516	Seed storage	2	Maui (extant)	USFWS 2013	USFWS 2016b
Cyanea magnicalyx	2	2	Seed storage, propagation	5	Maui (extant)	USFWS 2013	USFWS 2016b
Cyanea maritae	6	46	Seed storage, propagation	5	Maui (extant)	USFWS 2013	USFWS 2016b
Cyanea mauiensis	Unknown	Unknown	None	5[1]	Maui (possibly extirpated)	USFWS 2013	None

Species	**Number of Populations**	**Number of Individuals**	***Ex situ* Conservation**	**Recovery Priority Number**	**Current and Historical Distribution**	**Listing**	**Critical Habitat**
Cyanea munroi	1	2	Seed storage, propagation	5	Maui (extant), Moloka‘i (possibly extirpated)	USFWS 2013	USFWS 2016b
Cyanea obtusa	1	1	Propagation	5	Maui (extant)	USFWS 2013	USFWS 2016b
Cyanea profuga	4	34	Seed storage, propagation	5	Moloka‘i (extant)	USFWS 2013	USFWS 2016b
Cyanea solanacea	4	26	Seed storage, propagation	5	Moloka‘i (extant)	USFWS 2013	USFWS 2016b
Cyperus neokunthianus	Unknown	Unknown	None	5[1]	Maui (possibly extirpated)	USFWS 2016a	p
Cyrtandra ferripilosa	2	<10	Propagation	5	Maui (extant)	USFWS 2013	USFWS 2016b
Cyrtandra filipes	5	141–162	Seed storage, propagation	5	Maui, Moloka‘i (extant)	USFWS 2013	USFWS 2016b
Cyrtandra hematos	2	< 20	Seed storage	5	Moloka‘i (extant)	USFWS 2016a	p
Cyrtandra oxybapha	1	–>150	Seed storage, propagation	5[1]	Maui (extant)	USFWS 2013	USFWS 2016b
Dracaena fernaldii (listed as *Pleomele fernaldii*)	2	<1,000	Propagation	5[1]	Lāna‘i (extant)	USFWS 2013	e
Festuca molokaiensis	1	Unknown	None	5[1]	Moloka‘i (possibly extirpated)	USFWS 2013	USFWS 2016b
Geranium hanaense	2	500– 700	None	2	Maui (extant)	USFWS 2013	USFWS 2016b
Geranium hillebrandii	4	2000–10,000	None	2	Maui (extant)	USFWS 2013	USFWS 2016b

Species	**Number of Populations**	**Number of Individuals**	***Ex situ* Conservation**	**Recovery Priority Number**	**Current and Historical Distribution**	**Listing**	**Critical Habitat**
Hypolepis hawaiiensis var. *mauiensis*	5	<20	Propagation	6[1]	Maui (extant)	USFWS 2016a	p
Mucuna persericea (listed as *Mucuna sloanei* var. *persericea*)	5	<500	Seed storage, propagation	5[1]	Maui (extant)	USFWS 2013	USFWS 2016b
Myrsine vaccinioides	5	<1,000	Seed storage, propagation	2	Maui (extant)	USFWS 2013	USFWS 2016b
Peperomia subpetiolata	Unknown	Unknown	Seed storage, propagation [hybrids]	5	Maui (possibly extirpated)	USFWS 2013	USFWS 2016b
Phyllostegia bracteata	3	3	Seed storage, propagation	5	Maui (extant)	USFWS 2013	USFWS 2016b
Phyllostegia haliakalae	1	66–110	Seed storage, propagation	5	Maui (extant), Lānaʻi Molakaʻi (possibly extirpated)	USFWS 2013	USFWS 2016b
Phyllostegia pilosa	Unknown	Unknown	Seed storage, propagation	5	Maui, Molokaʻi (possibly extirpated)	USFWS 2013	USFWS 2016b
Pittosporum halophilum	3	7	Seed storage, propagation	5	Molokaʻi (extant)	USFWS 2013	USFWS 2016b
Schiedea diffusa ssp. *diffusa*	7–10	<30	Seed storage, propagation	6	Maui, Molokaʻi (extant)	USFWS 2016a	p
Schiedea jacobii	0	0	Seed storage, propagation	5	Maui (extant)	USFWS 2013	USFWS 2016b
Schiedea laui	1	24–36	Seed storage, propagation	5	Molokaʻi (extant)	USFWS 2013	USFWS 2016b

Species	**Number of Populations**	**Number of Individuals**	***Ex situ* Conservation**	**Recovery Priority Number**	**Current and Historical Distribution**	**Listing**	**Critical Habitat**
Schiedea pubescens	7	55	Seed storage, propagation	5	Maui, Moloka‘i (extant), Lāna‘i (possibly extirpated)	USFWS 2016a	p
Schiedea salicaria	3	853–1,405	Seed storage, propagation	2	Maui (extant)	USFWS 2013	USFWS 2016b
Stenogyne kauaulaensis	1	3	Seed storage, propagation	5	Maui (extant)	USFWS 2013	USFWS 2016b
Wikstroemia villosa	3	103	Seed storage, propagation	5	Maui (extant)	USFWS 2013	USFWS 2016b
INVERTEBRATES							
Hylaeus hilaris	1	Unknown	None	5	Moloka‘i (extant), Lāna‘i , Maui (possibly extirpated)	USFWS 2016a	e, p
Newcombia cumingi	3	<100	Captive rearing, enclosure	5	Maui (extant)	USFWS 2013	USFWS 2016b
Partulina semicarinata	2	<50	enclosure	5	Lāna‘i (extant)	USFWS 2013	e
Partulina variabilis	10	>100	Captive rearing, enclosure	5	Lāna‘i (extant)	USFWS 2013	e

[1] Recovery Priority Numbers are revised since publication of the Maui Nui Recovery Outline.
e = critical habitat for *Hylaeus hilaris* (on Lāna‘i only), *Partulina variabilis*, *Partulina semicarinata*, and *Dracaena fernaldii* was considered on Lāna‘i but were not designated for these species as a consequence of exclusions under section 4(b)(2) of the Endangered Species Act (USFWS 2016a). The decision to exclude Lāna‘i from critical habitat designation was based on landowner cooperation to conserve the associated species.
p = critical habitat is planned; specific schedule to be determined

2. Threats

A description of the threats to the 44 species addressed in this recovery plan is provided below and summarized in Tables 2 (plants) and 3 (invertebrates). Threats are organized by species groups (plants, tree snails, and yellow-faced bee) and by the five threat factors (A through E). Though some threats are shared among species groups, impacts to individual species and needed actions to eliminate or manage the threats may differ.

Plants

Factor A (Present or threatened destruction, modification or curtailment of its habitat or range)

The 40 plant species addressed in this recovery plan face varying degrees of habitat loss and degradation (Table 2). Depending on plant species, island, and habitat, at least 39 plant species are threatened by introduced axis deer (*Axis axis*), mouflon (*Ovis gmelini*), pigs (*Sus scrofa*), feral cattle (*Bos taurus*), goats (*Capra hircus*), horses (*Equus ferus caballus*), or a combination of invasive ungulates. In general, ungulates are highly destructive to the native vegetation in all occupied or suitable habitats of the plant species, including developed habitats. Ungulates as a group degrade the habitat through the following means: (a) creating trails that damage native vegetative cover; (b) destabilizing substrate causing erosion, landslides, rockfalls, and vegetation loss; (c) injuring roots, seedlings, or plants through trampling, trails, or rooting actions; (d) creating gullies that convey water and contribute to flooding or destabilization of the substrate; and (e) promoting invasion of nonnative species through transport of seeds, vegetative plant parts, or creation of openings (Cuddihy and Stone 1990, pp. 63–64; Duenus et al. 2018, entire; Wehr et al. 2018, entire).

Invasive, nonnative plant species are a threat to 39 of the plant species and their occupied or suitable habitats (Table 2). Invasive plant species can compete for water, space, nutrients, and light against listed plants. Such nonnative plant species are responsible for modifying the availability of light; altering soil-water regimes; modifying nutrient cycling; altering the fire regime affecting native plant communities; and ultimately, converting native-dominated plant communities to nonnative plant communities (Smith 1985, pp. 180–181; Cuddihy and Stone 1990, p. 74; D'Antonio and Vitousek 1992, p. 73; Vitousek et al. 1997, p. 6). The major invasive plant species affecting the listed species addressed in this recovery plan vary by habitat, island, and specific location of each population (USFWS 2013, entire; USFWS 2016a, entire).

Disturbance by humans is a major threat to *Mucuna persericea* (Oppenheimer pers. comm. 2019a, b; Oppenheimer pers. comm. 2020a). Human actions directly affect the growth, regeneration, and potentially reproduction of individuals of *M. persericea* through trimming vines with weed whackers or machetes, for landscape maintenance or agricultural activities. Some landowners conduct or oversee these activities not knowing that *M. persericea* is listed as endangered and is a very rare plant species. Additionally, *M. persericea* is very cryptic and can be easily misidentified as a weed species. Landowners often lack the botanical skills needed to identify *M. persericea* against 10 or more similar-looking vine species known from the area where the species occurs (Oppenheimer pers. comm. 2020b). Disturbance of habitat and impacts to individuals by human visitation has also been observed to be a threat to *Bidens conjuncta* at Pōhākea (HRPRG 2018–2021) and to other species within their habitats including *Cyanea* *kunthiana*, *Cyanea maritae*, *Cyanea mauiensis*, and *Phyllostegia pilosa* (USFWS 2023i, p. 12; USFWS 2023k, p. 17; USFWS 2023l, p. 18; USFWS 2023gg, p. 16).

The threat from fire to at least 15 of the plant species (Table 2) is serious and ongoing. Fire damages and destroys native plant species, including dormant seeds, seedlings, and juvenile and adult plants. Many nonnative invasive plants, particularly fire-tolerant grasses, outcompete native plants and inhibit their regeneration (D'Antonio and Vitousek 1992, pp. 70, 73–74; Tunison et al. 2002, p. 122). Wildfires are also a serious threat to dry habitats as well as lowland and montane mesic forests (Javar-Salas et al. 2020, p. 13; Lowe et al. 2020, pp. 8–9; Pe‘a et al. 2020, p. 10). Successive fires burn farther and farther into native habitat, further reducing available habitat. Microclimatic conditions are altered, creating conditions favorable to nonnative plants. The threat from fire is unpredictable but is increasing in frequency in habitats that have been invaded by nonnative, fire-prone grasses.

Drought may directly affect at least five of the plant species and their habitats (Table 2). Drought results in the direct loss (death) of individuals. In addition, it causes the loss or degradation of habitat due to death of individual native plants, increase in forest and brush fires, and modified water availability and vegetation composition (Javar-Salas et al. 2020, entire; Lowe et al. 2020, entire; Pe‘a et al. 2020, entire). These threats have the potential to occur at any time, although their occurrence is not predictable.

The habitats of all 40 plant species are vulnerable to the effects of stochastic events that can directly kill the species or destroy and alter the habitat, and thus modify the amount of light and create disturbed areas conducive to invasion by nonnative pest species (Table 2; USFWS 2013, USFWS 2016a). Gaps in the canopy also allow for the establishment of nonnative plants. Some species are also vulnerable to landslides, treefalls, and flooding that cause either direct loss of the species or alter the habitat. For the plant species that persist in low numbers, natural disasters such as hurricanes are particularly devastating.

Factor B (Overutilization)

Overutilization for commercial, recreational, scientific, or educational purposes is not known to be a significant threat to any of the 40 plant species addressed in this recovery plan.

Factor C (Disease and Predation)

The plant disease rapid ‘ōhi‘a death (ROD) is an ongoing threat to *Metrosideros polymorpha* (‘ōhi‘a), an important canopy tree in Hawaiian forest habitats. ROD, associated with two fungal pathogens, *Ceratocystis lukuohia* and *Ceratocystis huliohia*, kills individual trees as well as groups of trees (Barnes et al. 2018, entire). The disease is widespread on the island of Hawai'i where hundreds of thousands of ‘ōhi‘a have died from this fungus infection (Friday and Mokiao-Lee 2022, entire). The disease was detected on Maui in one tree, which was destroyed in July 2019 (Maui Invasive Species Committee 2020; Friday and Mokiao-Lee 2022, entire). There have been no positive ROD detections on Maui since 2019 (Friday and Mokiao-Lee 2022, entire). ROD poses a significant threat to *M. polymorpha* on Lāna‘i and Moloka‘i if it was to become established on those islands. While *M. polymorpha* is not itself a listed species, it is a major structural element of native forests; thus, ROD has potential to create canopy gaps, modify light and microclimate conditions in the understory, and promote establishment of nonnative plants. Another disease threat includes myrtle rust (*Austropuccinia psidii*), which affects *M. polymorpha* and other plants in the family Myrtaceae (Anderson 2012, entire).

The fungal plant disease powdery mildew (*Neoerysiphe galeopsidis*) affects plant species in the genus *Phyllostegia* and can impede growth or destroy populations of *Phyllostegia bracteata*, *Phyllostegia haliakalae*, and *Phyllostegia pilosa* (Table 2; Zahn and Amend 2017, pp. 1–2; Egan et al. 2021, p. 5; USFWS 2023ee, p. 19; USFWS 2023ff, 20–21; USFWS 2023gg, pp. 18–19). Powdery mildew grows as thin layers of mycelium (fungal tissue) on the surface of the affected plant parts, appearing as white, powdery spots. This fungus causes leaves to turn chlorotic and necrotic, and fall off (Davis et al. 2008, p. 2). Spores, which are the primary means of dispersal for the fungus, make up the bulk of the visible white powdery growth (Davis et al. 2008, p. 2).

Mice (*Mus domesticus*) and three species of nonnative rats (Polynesian rat [*Rattus exulans]*, black rat [*Rattus rattus*], and Norway rat [*Rattus norvegicus*]) are present throughout the Hawaiian Islands and cause considerable damage to native habitats (Atkinson and Atkinson 2000, p. 23; Daehler et al. 2005, p. 205). Rodents in general, and particularly rats, can damage or kill at least 30 plant species addressed in this plan by eating seeds, flowers, stems, leaves, roots, and other plant parts (Atkinson and Atkinson 2000, p. 23; Daehler et al. 2005, p. 205), and can significantly affect regeneration. Rats have caused declines or even the total elimination of island plant species (Cuddihy and Stone 1990, pp. 68–70) and indirect impacts from rodent degradation of the habitats likely affect all species.

Nonnative slug species in Hawaiʻi are generalist herbivores found in mesic shrublands, mesic forests and wet forest ecosystems that threaten populations of at least 36 of the plant species by feeding on seedlings and low-statured herbaceous plants, destroying plant-parts, and killing plants (Table 2; Joe 2006, p. 10; USFWS 2016a, entire; Clark et al. 2020 p. 9; Lowe et al. 2020, p. 14). Slugs directly endanger plants through mechanical damage, destruction of plant parts, mortality, and reduced recruitment by consuming seedlings. They also facilitate the success of some invasive plant species (Joe and Daehler 2008, pp. 252–253). Herbivorous insects (species not specified) also pose a threat to *Cyanea obtusa* and its habitat (USFWS 2023n, p. 17).

Predation or herbivory by seed borers or seed weevils damage and destroy the seeds of *Mucuna persericea* (Oppenheimer pers. comm. 2019a, b). Seed borers or seed weevils damage the seeds of *M. persericea* by drilling holes into them, thereby eliminating the reproductive process for this species. Therefore, reproduction and regeneration of *M. persericea* is limited by these invertebrates. Introduced ant species can interfere with pollination of some plant species. Ants, particularly yellow crazy ants (*Anoplolepis gracilipes*), deprive pollinators such as yellow-faced bees (*Hylaeus* spp.) of food by consuming large quantities of nectar without pollinating the plant (Lach 2008, entire). In addition, native bees are less likely to land on flowers occupied by ants (Krushelnycky et al. 2005, p. 9; Magnacca 2015 in litt., entire).

Factor D (Inadequacy of existing regulatory mechanisms)

Despite broad agency efforts, implementation of existing State and Federal regulatory mechanisms is not preventing the introduction of nonnative species into Hawaiʻi or effectively controlling the spread of nonnative species between islands and watersheds or establishing or maintaining instream flow standards (Howarth and Medeiros 1989, entire; Staples and Cowie 2001, entire). Currently, four agencies are responsible for inspection of goods arriving in Hawaiʻi (USFWS 2016a, entire). The Hawaiʻi Department of Agriculture (HDOA) inspects domestic cargo and vessels and focuses on pests of concern to Hawaiʻi, especially insects or plant diseases. The U.S. Department of Homeland Security-Customs and Border Protection (CBP) is responsible for inspecting commercial, private, and military vessels and aircraft and related cargo and passengers arriving from foreign locations (USFWS 2016a, entire). U.S. Department of Agriculture-Animal and Plant Health Inspection Service-Plant Protection and Quarantine (USDA-APHIS-PPQ) inspects propagative plant material, provides identification services for arriving plants and pests, and conducts pest risk assessments among other activities. (HDOA 2009, p. 1). The Service inspects arriving wildlife products, enforces the injurious wildlife provisions of the Lacey Act (18 U.S.C. 42; 16 U.S.C. 3371 *et seq*.), and prosecutes CITES (Convention on International Trade in Wild Fauna and Flora) violations. The State of Hawaiʻi allows the importation of most plant taxa, with limited exceptions (USFWS 2016a, entire). It is likely that the introduction of most nonnative invertebrate pests to the State has been and continues to be accidental and incidental to other intentional and permitted activities. Many invasive weeds established on Hawaiʻi have currently limited but expanding ranges. Resources available to reduce the spread of these species and counter their negative ecological effects are limited. Control of established pests is largely focused on a few invasive species that cause significant economic or environmental damage to public and private lands, and comprehensive control of an array of invasive pests remains limited in scope (USFWS 2013, pp. 32056–32058; USFWS 2016a, entire).

Nonnative feral ungulates pose a threat to all existing wild plant species through destruction and degradation of the species' habitat and herbivory and regulatory mechanisms are inadequate to address this threat (USFWS 2013, pp. 32051–32053). The State of Hawaiʻi provides game mammal (feral pigs and goats, axis deer, and mouflon) hunting opportunities on State-designated public hunting areas throughout the Hawaiian Islands (DLNR 2015, pp. 18–19 and 55–61). However, the State's management objectives for game animals range from maximizing public hunting opportunities (e.g., "sustained yield") in some areas to removal by State staff, or their designees, in other areas (DLNR 2015, entire).

Factor E (Other natural or manmade factors affecting the species continued existence)

Alteration in genetic composition due to hybridization is considered a threat to eight of the plant species (Table 2). Hybridization can lead to the loss of genotypically distinct species and varieties and could ultimately result in the formation of new species or, alternatively, lead to a loss of a species' unique genetic characteristics through introgression (flow of genes into a population from another species) (USFWS 2013, p. 64684; USFWS 2016a, pp. 67800–67801, 67850). Hybridization is a potential concern for any rare species coming into contact with a closely related species that is more abundant.

The relative dearth of genetic diversity in the lobeliads such as *Cyanea* spp. may reflect pre-existing conditions in this group or adoption of a"selfing" mating system (pollination of ovules by the plant's own pollen) in response to a decline in native avian pollinators, raising concerns that inbreeding and loss of genetic variation may be occurring in rare species of *Cyanea*, including the 12 endangered *Cyanea* in this recovery plan (Table 2; Jennings et al. 2016, p. 501; USFWS 2023e, p. 10; USFWS 2023f, p. 10; USFWS 2023g, p. 10; USFWS 2023h, p. 10; USFWS 2023i, p. 10; USFWS 2023j, p. 10; USFWS 2023k, p. 9; USFWS 2023l, p. 9; USFWS 2023m, pp. 10–11; USFWS 2023n, pp. 11, 13–15; USFWS 2023o, pp. 10–11; USFWS 2023p, pp. 10–11, 13).

At least six of the plant species are threatened by lack of regeneration (Table 2); we recognize that this threat may also apply to other plants, and we may revise this assessment as new information is received. Causes for this lack of reproduction and recruitment are not well understood, although inbreeding depression, fruit abortion, and/or seed predation may play roles. Lack of regeneration as a direct result of herbivory by rodents and slugs has also been noted for other plant species and is discussed in Factor C.

Over half of the plant species are threatened by limited numbers (Table 2). As a result, these species may experience the following: (a) reduced reproductive vigor due to ineffective pollination or inbreeding depression; (b) reduced levels of genetic variability, leading to diminished capacity to adapt and respond to environmental changes, thereby lessening the probability of long-term persistence; and/or (c) increased likelihood that a single catastrophic event may result in extirpation of remaining populations and extinction of the species (Barrett and Kohn 1991, pp. 3, 7; Newman and Pilson 1997, pp. 354–355). Species that are endemic to single islands are inherently more vulnerable to extinction than are widespread species, because of the increased risk of genetic bottlenecks, random demographic fluctuations, climate change effects, and localized catastrophes such as hurricanes, landslides, rockfalls, drought, and disease outbreaks (Pimm et al. 1988, p. 757; Mangel and Tier 1994, p. 607). These problems are further magnified when populations are few and restricted to a very small geographic area, and when the number of individuals in each population is very small.

All 40 plant species are susceptible in varying degrees to changes in environmental conditions as a result of global climate change (Table 2; Fortini et al. 2013, entire). Changes include increasing storm intensities, increasing temperatures, and decreasing precipitation, which can result in changes to the microclimate of a species (IPCC 2023, pp. 4–11). Such changes may lead to the loss of the listed species or loss of native species associated with a listed species' habitats.

Table 2. Summary of threats affecting the 40 plant species and their habitats. Factor A = Present or threatened destruction, modification, or curtailment of the species habitat or range; Factor C = Disease or predation; Factor D = Inadequacy of existing regulatory mechanisms; and Factor E = Other natural or manmade factors affecting the species continued existence.

Species	**Habitat**	**Factor A**					**Factor C**					**Factor D**	**Factor E**	
		Agriculture and urban development	**Ungulates**	**Nonnative plants**	**Fire**	**Stochastic events**	**Disease**	**Predation / Herbivory by ungulates**	**Predation / Herbivory by other nonnatives vertebrates**	**Predation / Herbivory by nonnative invertebrates**	**Inadequate existing regulatory mechanisms**	**Other species-specific threats**	**Climate Change**
Bidens campylotheca ssp. *pentamera*	DF, DGS, MF, WF, WSG		D, G, P	✓	✓	Hu	Pt	✓	R	S	✓	Hy	✓
Bidens campylotheca ssp. *waihoiensis*	WF, WSG		D, G, P	✓		F, Hu, L	Pt	✓	R	S	✓	Hy	✓
Bidens conjuncta	WF, WC		G, P	✓		Hu, Tf		✓	R	S	✓	HD,Hy	✓
Calamagrostis hillebrandii	WT		P	✓		Hu	Pt	✓	R	S	✓		✓
Cyanea asplenifolia	MF, WF, WSG		C, D, G, P	✓	✓	F, Hu, Tf	Pt	✓	R	S	✓	HD, LN, LP, LR	✓
Cyanea duvalliorum	WF		P	✓		F, Hu	Pt	✓	R	S	✓	LN, LP	✓
Cyanea horrida	MF, WF, WSG		D, G, P	✓		Hu, L, Tf	Pt	✓	R	S	✓	LN, LP	✓
Cyanea kauaulaensis	MF, WF			✓	✓	F, Hu, L	Pt		R	S	✓	LN, LP, LR	✓
Cyanea kunthiana	MF, WF		P	✓		Dr, F, Hu, L, Tf	Pt	✓	R	S	✓	HD, LN, LP	✓

Species	Habitat	Factor A					Factor C				Factor D	Factor E	
		Agriculture and urban development	Ungulates	Nonnative plants	Fire	Stochastic events	Disease	Predation / Herbivory by ungulates	Predation / Herbivory by other nonnatives vertebrates	Predation / Herbivory by nonnative invertebrates	Inadequate existing regulatory mechanisms	Other species-specific threats	Climate Change
Cyanea magnicalyx	MF, WF		C, D, G, P	✓		F, Hu	Pt	✓	R	S	✓	LN, LP, LR	✓
Cyanea maritae	MF, WF		P	✓	✓	F, Hu, L, Rf, Tf	Pt	✓	R	S, Se	✓	HD, LN, LP, LR, Tr	✓
Cyanea mauiensis	MF		P	✓	✓	Hu, L, Tf	Pt	✓	R	S	✓	HD, LN, LP	✓
Cyanea munroi	WF		D, G	✓		Hu, Tf	Pt	✓	R	S	✓	LN, LP	✓
Cyanea obtusa	MF		C, D, G, P	✓	✓	F, Hu, L	Pt	✓	R	S	✓	Hy, LN, LP	✓
Cyanea profuga	WF, WSG		G, P	✓		F, Hu, L, Tf,	Pt	✓	R	S, Se	✓	LN, LP	✓
Cyanea solanacea	WF		G, P	✓		Er, H, L, Tf	Pt	✓	R	S, Se	✓	LN, LP	✓
Cyperus neokunthianus	WF		P	✓		F, L	Pt	✓	R		✓	LN	✓
Cyrtandra ferripilosa	MF, WF		G, P	✓		Hu	Pt	✓	R	S	✓	LN	✓
Cyrtandra filipes	MF, WF, WSG		D, G, P	✓		F, L, Tf	Pt	✓	R	S	✓	Hy	✓
Cyrtandra hematos	WF		G, P	✓			Pt	✓		S	✓	Hy, LN, LR	✓

Species	**Habitat**	**Factor A**					**Factor C**				**Factor D**	**Factor E**	
		Agriculture and urban development	**Ungulates**	**Nonnative plants**	**Fire**	**Stochastic events**	**Disease**	**Predation / Herbivory by ungulates**	**Predation / Herbivory by other nonnatives vertebrates**	**Predation / Herbivory by nonnative invertebrates**	**Inadequate existing regulatory mechanisms**	**Other species-specific threats**	**Climate Change**
Cyrtandra oxybapha	WF		D (Pt), P	✓				✓	R	S	✓	Hy	✓
Dracaena fernaldii	MF, MSG, WF		D, M	✓	✓	Hu, Tf	Pt	✓	R		✓	LR	✓
Festuca molokaiensis	MF		G	✓	✓	Dr, Hu	Pt	✓	R	S	✓	LN	✓
Geranium hanaense	WT		P	✓		Hu	Pt	✓		S	✓		✓
Geranium hillebrandii	WSG, WC, WT		D (Pt), P	✓		Hu		✓	R	S	✓		✓
Hypolepis hawaiiensis var. *mauiensis*	WF, WSG, WT		P	✓						S	✓	LN	✓
Mucuna persericea	MSG, WF, D	✓	C, P	✓	✓	Hu, L, Tf	Pt	✓	R	S, Se	✓	HD	✓
Myrsine vaccinioides	WT		P	✓		Hu		✓	R	S	✓		✓
Peperomia subpetiolata	MF		P	✓		Hu	Pt	✓	R	S	✓	Hy, LN	✓
Phyllostegia bracteata	MF, MSG, WF, WSG		C, P	✓	✓	F, Hu, L	✓	✓	R	S	✓	LN	✓
Phyllostegia haliakalae	DSG, MF, WF, WSG		C	✓	✓	F, Hu, L, Tf	✓	✓	R	S	✓	LN	✓
Phyllostegia pilosa	MF, WF		P, G	✓		Hu	✓	✓	R	S	✓	HD, LN	✓

Species	**Habitat**	**Factor A**					**Factor C**				**Factor D**	**Factor E**	
		Agriculture and urban development	**Ungulates**	**Nonnative plants**	**Fire**	**Stochastic events**	**Disease**	**Predation / Herbivory by ungulates**	**Predation / Herbivory by other nonnatives vertebrates**	**Predation / Herbivory by nonnative invertebrates**	**Inadequate existing regulatory mechanisms**	**Other species-specific threats**	**Climate Change**
Pittosporum halophilum	CO, MSG		P	✓	✓	Hu, L			R		✓	LN	✓
Schiedea diffusa ssp. *diffusa*	WF		P	✓			Pt		R	S	✓	LN	✓
Schiedea jacobii	WF		C, D, G			Dr, Hu, L	Pt			S	✓	LN, Tf	X
Schiedea laui	WF		P	✓		F, Hu, L	Pt		R	S	✓	LN	✓
Schiedea pubescens	MF, MSG, WF, WSG		C, D, G, P	✓	✓	F, L	Pt	✓	R	S	✓	LN	✓
Schiedea salicaria	DSG, DF		C, D, G P	✓	✓	Dr, Hu	Pt	✓			✓		✓
Stenogyne kauaulaensis	MF		D, G, P	✓	✓	Dr, Hu, L	Pt			S	✓	LN	✓
Wikstroemia villosa	MF, WF		P	✓		L, H	Pt	✓	R	S	✓	Tr	✓

Habitats: CO = Coastal; DSG = Dry Shrubland and Grassland; DF = Dry Forest; MF = Mesic Forest; MSG = Mesic Shrubland and Grassland; WC = Wet cliff; WF = Wet Forest; WSG = Wet Shrubland and Grassland; WT = Wetland; D = Developed
Threats: C = Cattle; D = Axis Deer; Dr = Drought; Er = Erosion; F = Flooding; G = Goats; Hu = Hurricane; HD = Human disturbance; Hy = Hybridization; I = Insects (nonspecified); L = Landslide; LN = Limited Numbers; LP = Lack of pollinators and dispersers; LR = Lack of Regeneration; M = Mouflon; P = Pigs; Pt = Potential threat to species; R = Rats; Rf = Rockfall; S = Slugs; Se = Seed borers or weevils; Tf = Treefalls; Tr = Trampling; ✓ = Known threat to species, not itemized

Tree Snails

Factor A (Present or threatened destruction, modification or curtailment of its habitat or range)

Habitat loss and degradation have contributed significantly to population declines of the three tree snail species (Table 3). Land use conversion to nonnative lowland wet forest, invasive species, fire, and climate change all contribute to habitat loss and degradation. Habitat loss likely began when humans first settled Maui and Lāna‘i. Wet lowland forests that likely began just above the coastal habitat were cleared during the period of first human occupation to make way for agriculture and urban development (Clark et al. 2020, pp. 329–342; Lowe et al. 2020, pp. 347–356).

Ungulates were introduced for hunting and consumption. Forests not cleared for agriculture were invaded by feral cattle, horses, mouflon, goats, axis deer, and pigs (Cuddihy and Stone 1990, pp. 63–67). In general, ungulates are highly destructive to the host plants and montane habitat of the three species of tree snails (Table 3). As described in the *Plants* section *Factor A*, ungulates degrade the habitat in a variety of ways. In addition, ungulates such as mouflon and axis deer, which can jump over a 6-foot (2-meter) wall, pose a threat to tree snail enclosures, both to the fence itself and the habitat inside the enclosures.

Nonnative plants represent an ongoing threat to the tree snail species because they adversely affect microhabitat of the snail by modifying the availability of light and humidity regimes and alter fire characteristics of native plant habitat, leading to incursions of fire-tolerant nonnative plant species into native habitat (Table 3). As described in the *Plants* section *Factor A*, invasive plant species can alter fire regime and convert native-dominated plant communities to nonnative plant communities (Smith 1985, pp. 180–181; Cuddihy and Stone 1990, p. 74; D’Antonio and Vitousek 1992, p. 73; Vitousek et al. 1997, p. 6). Invasive plants may also outcompete, and possibly directly inhibit the growth of, native plant communities on which the tree snails live. This conversion has negative effects on the tree snails’ host plants. Changes of the plant community can destroy continuity of the phyllosphere created by overlapping canopies. Invasive plant species such as *Rubus* spp. (blackberry) and invasive grasses continue to degrade the tree snails’ native habitat (Thacker and Hadfield 1998, entire). Invasive plants such as *Psidium* spp. (guava) change the hydrology, canopy structure, and microclimate needed for the habitat of the tree snails.

Drought is a significant direct threat to juvenile tree snails (Table 3) (Kobayashi and Hadfield 1996, entire; Sischo 2019 in litt., entire; SEPP 2019, entire). Adults can create a seal between the opening of their shell and the plant surface to minimize moisture loss during times of drought or high temperatures. However, juveniles have a large surface area to body mass ratio that makes them far less tolerant to drought. In addition, drought can cause habitat degradation and loss of host trees, as well as an increase in forest and brush fires. Because the limited dispersal capability of the tree snails makes access to moist microclimates difficult, drought conditions are lethal to juveniles and can be lethal to adults in wild populations if the drought is prolonged.

As described in the *Plants* section *Factor A*, wildfires are also a serious threat to lowland and montane mesic forests (Lowe et al. 2020, pp. 8–9; Pe‘a et al. 2020, p.10). Successive fires burn farther and farther into native habitat, further reducing available habitat. Microclimatic conditions are altered, creating conditions favorable to nonnative plants. The threat from fire is unpredictable but is increasing in frequency in habitats that have been invaded by nonnative, fire-prone grasses. Neither juvenile nor adult tree snails can survive a fire. Fire at the rearing facility would pose a direct and lethal threat.

High winds and intense rains from hurricanes can dislodge snails from host plants and deposit them on the forest floor where they may be crushed by falling vegetation or exposed to predation by rats and predatory snails (Table 3) (Hadfield et al. 1993, p. 620). Tree snails require a shaded, high-humidity habitat. Hurricanes adversely impact the tree snail species' habitats by destroying native vegetation, opening the canopy and thus modifying the availability of light, and creating disturbed areas conducive to invasion by nonnative pest species (Asner and Goldstein 1997, p. 148; Harrington et al. 1997, pp. 539–540). Windstorms can disperse tree snails but can also result in isolation of individuals. Predator-proof enclosures are particularly vulnerable to high winds and tree falls.

Factor B (Overutilization for commercial, recreational, scientific, or educational purposes)

Achatinellid tree snails were extensively collected for scientific as well as recreational purposes in the 18th to early 20th centuries, resulting in decreases in population sizes and reproductive potential (Table 3) (Hadfield 1986, pp. 67–68). Despite listed tree snail species being protected by State and Federal laws, the deployment of tree snail enclosures has resulted in a new risk to the tree snails that ranges from illegal harassment to potential collection by trespassers that enter the enclosures illegally.

Factor C (Disease and Predation)

Disease is a potential threat to the tree snails (Hadfield 1994, pp. 328–329); however, wild and captive tree snails have not been subjected to testing for disease pathogens. Protocols are in place to avoid or minimize introduction of disease organisms to the captive populations. Captive populations that grow larger than 100 individuals are divided and maintained to minimize the risk of a contagion being introduced into the subpopulations.

As described in the *<u>Plants</u>* section *Factor C*, the plant disease, rapid ʻōhiʻa death (ROD) is an ongoing threat to ʻōhiʻa, an important host and canopy tree for the tree snails. The impacts of ROD on the tree snails and their habitat will depend on the ability of the snails living on a dying tree to find a new food source.

Predation by nonnative species is a well-documented threat to the tree snail fauna of Hawaiʻi and other Pacific islands (Table 3) (Hadfield and Mountain 1980, p. 355; Hadfield 1994, p. 327). *Euglandina* spp., a complex of predatory wolf snails, actively hunt by following the slime trails of their prey (Clifford et al. 2003, entire; Holland et al. 2018, entire). These predators will climb the host tree to find its tree snail prey and can decimate a tree's snail population (Hadfield 1994, p. 327). The introduced predatory wolf snails are a mixture of two or more *Euglandina* species that are a major cause of the decline and extinction of native tree and terrestrial snails throughout Hawaiʻi (Hadfield 1994, p. 327; Hadfield et al. 1993, entire; Meyer III et al. 2017, pp. 1402–1404). The nonnative terrestrial garlic snail, *Oxychilus alliarius*, also poses a predatory threat to smaller-sized tree snails (Hadfield 2007, p. 8). Strict sanitation protocols are used on all plant material entering the captive-rearing facility to eliminate the risk of garlic snail introduction to the facility and into tree snail populations. *Euglandina* spp. and *Oxychilus* spp. are not known to not pose a threat to captive-reared tree snail populations.

Rat predation poses a serious threat to tree snail populations not protected by predator-proof enclosures or in captive rearing (Table 3) (Hobdy 1993, p. 208; Hadfield and Saufler 2009, p. 1; Shiels et al. 2017, entire; Thacker and Hadfield 1998, entire). Rats appear to selectively prey on large snails rather than juveniles. Three rat species (black rat [*Rattus rattus*]; Norway rat [Ratus *norvegicus*]; and Polynesian rat [*Ratus exulans*]) are present on Lānaʻi and Maui, although of the three, the black rat appears to pose the most serious threat to the tree snails (Hobdy 1993, entire; Hadfield 1994, entire; Thacker and Hadfield 1998, entire; Hadfield 2007, entire).

Jackson's chameleon (*Chamaeleo jacksonii*) is known to prey on native insects and tree snails (Table 3) (Holland et al. 2010, entire). Currently, there are established populations on all the main Hawaiian Islands, with the greatest number of individuals on the islands of Hawaiʻi, Maui, and Oʻahu (Holland et al. 2010, entire). Inter-island transport of Jackson's chameleons for the pet trade was unrestricted until 1997, when they were classified as "injurious wildlife," and both export and inter-island transport were prohibited (State of Hawaiʻi 1996, Hawaiʻi Administrative Rule 13–124–3; Holland et al. 2010, p. 1439). Snail enclosures are expected to prevent the ingress of Jackson's chameleon into the enclosure. However, this requires maintenance of the vegetation borders surrounding the predator-proof enclosure to avoid or minimize entry of Jackson's chameleon into the snail enclosure (Rohrer et al. 2016, entire). Jackson's chameleon does not pose a threat to captive-reared tree snail populations because they are excluded from the rearing facility.

Terrestrial flatworms (*Geoplana septemlineata* and *Platydemus manokwari*) have been reported to feed on terrestrial and tree snails (Table 3) (Barker 1989, 76–77; Sugiura and Yamaura 2009, entire). Flatworms can climb wet trees and locate arboreal snails via scent (Sugiura and Yamaura 2009, p. 740–741). *Platydemus manokwari* decimated populations of native tree snails in Guam (Hopper and Smith 1992, entire). Although *P. manokwari* has been found on the islands of Oʻahu or Hawaiʻi and is likely to occur on all of the main Hawaiian Islands, the flatworm is not yet known from the mesic to wet forests of Maui or wet forest on Lānaʻi where the wild populations of tree snails are found (Sischo 2019 in litt., entire). Flatworms are not a threat to snails in captive-rearing facilities.

Factor D (Inadequacy of existing regulatory mechanisms)

As previously described in the *Plants* section *Factor D*, the introduction of harmful nonnative species and nonnative feral unglates into their habitat is a threat to tree snails.

Factor E (Other natural or manmade factors affecting the species continued existence)

As a result of having low numbers, the three tree snail species may experience: (a) reduced reproductive vigor due to inbreeding depression; (b) reduced levels of genetic variability leading to diminished capacity to adapt and respond to environmental changes; and (c) increased vulnerability to a catastrophic event (e.g., hurricane, drought). Together these may result in population extirpation and potentially the extinction of these species (Hadfield 1986, entire; Hadfield and Miller 1989, pp. 7–15; Hadfield et al. 1993, entire; Kobayashi and Hadfield 1996, entire).

The persistence of the tree snails is hampered by having limited populations and shrinking geographic range (Table 3). These circumstances make these species extremely vulnerable to extinction due to a variety of natural and anthropogenic caused factors. Although the tree snails are hermaphroditic (possessing both male and female reproductive organs, structures, or tissue) and can store sperm for a limited time, small populations are particularly vulnerable to reduced mating encounters and loss of reproductive vigor caused by inbreeding depression. They may suffer a loss of genetic variability over time due to random genetic drift, resulting in decreased evolutionary potential and ability to cope with environmental change (Lande 1988, entire). Stochastic physical events such as hurricanes and droughts could eliminate the known populations of the tree snail species. This vulnerability is compounded due to several life-history characteristics that include: (a) adults requiring several years to reach sexual maturity; (b) low reproductive rates; (c) offspring emerging fully developed (live); and (d) limited dispersal, with most individuals remaining in the bush, tree, or tree complex on which they were born (Hadfield 1986, entire; Hadfield and Miller 1989, entire; Hadfield et al. 1993, entire; Hadfield 1994, entire; Kobayashi and Hadfield 1996, entire; Hadfield 2005, entire). These traits make these tree snails very sensitive to any event that could lead to a reduction or loss of reproductive individuals and an imbalance in demographic distribution (Lande 1988, entire).

Climate change has the potential to adversely affect the tree snail species, particularly those species that occupy the habitats in the highest elevation of an island (Table 3). The remaining lowland and montane mesic and/or wet forests on which the three snail species depend may be affected by changes in temperature, humidity, precipitation and the frequency and severity of storms. These stressors may change the forest habitat rendering it unsuitable for the tree snails (Miller 2018, entire; Clark et al. 2020, entire). Lānaʻi tree snails occupy the highest elevation on the island and may require translocation if the island's remaining habitat becomes unsuitable.

Table 3. Summary of threats affecting the four invertebrate species and their habitat. Factor A = Present or threatened destruction, modification, or curtailment of the species habitat or range; Factor B = Overutilization 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	**Habitat**	**Factor A**					**Factor B**	**Factor C**			**Factor D**	**Factor E**	
		Agriculture and urban development	**Ungulates**	**Nonnative plants**	**Fire**	**Stochastic events**	**Collection**	**Disease**	**Predation by nonnative vertebrates**	**Predation by nonnative invertebrates**	**Inadequate existing regulatory mechanisms**	**Other species-specific threats**	**Climate Change**
Hylaeus hilaris	CO, DSG	✓	D, G, H, P	✓	✓	Dr, Hu, Ts		Pt		A, W	✓	Cp, LF, LHN, LN, NC	✓
Newcombia cumingi	MF, WF	✓	C, D, G, H, P	✓	✓	Dr, Hu	Pt	Pt	R, JC	F (pt), PS	✓	LH, LN, Tf, Tr	✓
Partulina semicarinata	WF	✓	C, D, G, M, P	Pt	✓	Dr, Hu	Pt	Pt	R, JC (pt)	F (pt), PS	✓	LN, NC, Tf, Tr,	✓
Partulina variabilis	WF	✓	C, D, G, M, P	Pt	✓	Dr, Hu	Pt	Pt	R, JC (pt)	F (pt), PS	✓	LN, Tf, Tr	✓

Habitats: CO = Coastal; DSG = Dry shrubland and grassland; MF= Mesic forests; WF = Wet forests.
Threats: A = Ants; C = Cattle; Cp = Competion (nonnative bees and ants);D = Axis Deer; Dr = Drought; F = Flatworms; G = Goats; H = horses; Hu = Hurricane/high winds; JC = Jackson's chameleon; LF = Lack of sufficient food resources; LH = Loss of plant hosts; LHN = Lack of host nests; LN = Limited numbers of individuals; M = Mouflon; NC = Not in captive rearing program; P = Pigs; PS
PS = Predatory snails; Pt = Potential threat; R = Rats; Tf = Treefalls; Tr = Trampling; Ts = Tsunami; W = Western yellowjacket (wasp); ✓ = Known threat to species, not itemized.

Hilaris Yellow-faced Bee

Factor A (Present or threatened destruction, modification or curtailment of its habitat or range)

Habitat loss and degradation have contributed significantly to population declines of yellow-faced bee species (Table 3). Native coastal habitat is one of the rarest habitats on each island (Cuddihy and Stone 1990, pp. 94–95; Wagner et al. 1999, pp. 45, 54; Magnacca 2007, p. 180). The yellow-faced bee species that are cleptoparasitized by hilaris yellow-faced bee nest and forage in coastal strand habitats. These nest-host species nest opportunistically within existing ground crevices, coral or rock walls, beach coral, under bark, or in dried stems, depending on yellow-faced bee species (Daly and Magnacca 2003, p. 106; Magnacca 2007, p. 187–188; Magnacca 2011 in litt., entire; Magnacca and King 2013, pp. 13–14; Graham et al. 2021, entire). Much of the coastal strand has undergone urban or agricultural development and no longer provides adequate nesting resources for the hilaris yellow-faced bee complex. Nesting and foraging resources for the yellow-faced bee hosts and subsequently the cleptoparasitic hilaris yellow-faced bees, are becoming increasingly rare and fragmented (Cuddihy and Stone 1990, entire; Wagner et al. 1999, entire; Magnacca 2005, entire). As a result, hilaris yellow-faced bees and their host species have disappeared from much of their historical range throughout Hawai‘i.

The hilaris yellow-faced bee and its nest hosts are reliant on the coastal strand, and likely on adjacent shrubland habitats, to provide their food resources (Table 3). The yellow-faced bees mostly rely on native plants for nectar and pollen; consequently, the bees are almost completely absent from habitats dominated by nonnative plant species (Table 3). The majority of lowland habitats once occupied by *Hylaeus hilaris* are now dominated by invasive plant species that are replacing native flora (Table 3) (Cuddihy and Stone 1990, pp. 73–74; Kim et al. 2020, entire; Mascaro et al. 2008, entire; Wagner et al. 1999, p. 52). Most of the coastal habitats of the Hawaiian Islands lack significant amounts of native foraging plants other than *Scaevola taccada* (naupaka), which cannot support *Hylaeus* populations on its own (Magnacca 2007, p. 187). Nonnative *Heliotropium foertherianum* (tree heliotrope) and a few other nonnative plant species are a few forage-resource exceptions (Daly and Magnacca 2003, p. 11; Magnacca 2007, p.185; Krushelnycky 2021, entire). Several of the coastal nesting yellow-faced bee species, including the anthracinan yellow-faced bee, have adapted to use, and even favor, the nonnative tree heliotrope and several other nonnatives, especially when availability of native pollen sources is low (Krushelnycky 2021, entire). This has allowed yellow-faced bees to occupy some places where the native coastal vegetation has been largely lost (Magnacca and King 2013, entire; Magnacca 2020, p. 3). In addition to the presence of suitable forage plants, the yellow-faced bee hosts appear to use a diversity of suitable forage plants that flower throughout the year so that multiple plant types and consistent food sources (pollen and nectar) need to be available for nest provisioning (Magnacca 2007, entire).

Nonnative animals such as feral pigs, goats, horses, axis deer, mouflon, and cattle, are considered one of the primary factors underlying degradation of native vegetation in the coastal and shrubland habitats used by hilaris yellow-faced bee and its hosts (Table 3). Resulting habitat changes remove food sources and nesting sites for hilaris yellow-faced bee and its nest-host species (Stone 1985, pp. 262–263; Cuddihy and Stone 1990, pp. 60–66, 73). Specific threats to the *Hylaeus* bee habitat posed by introduced ungulates were described previously in the *Plants* section *Factor A*. Because the yellow-faced bees nest in dead or dying stems or crevices in the ground, ungulate activity from feral or domestic ungulates in the coastal strand or other nesting areas may result in damage of plants and trampling or crushing of nests while crossing or occupying areas with yellow-faced bee nests. Habitat degradation by these species also removes food sources and nesting sites for yellow-faced bees (Stone 1985, pp. 262–263; Cuddihy and Stone 1990, pp. 60–66, 73).

Fire, as previously described in the *Plants* section *Factor A*, is a threat to hilaris yellow-faced bee and its hosts because it destroys native coastal and lowland plant communities on which these *Hylaeus* species forage and opens habitat for increased invasion by nonnative plants (Table 3). The dry and mesic habitats used by the species and its hosts are highly vulnerable to fire. Fire poses a risk to yellow-faced bees because their habitats are in or near areas that are at risk of fire due to cumulative and compounding effects of drought and the presence of highly flammable nonnative grasses (USFWS 2016a, p. 67814).

Drought can modify and destroy the habitats of the hilaris yellow-faced bees and its hosts (Table 3; Magnacca 2007, pp. 181, 183). The dry coastal habitat already incurs cyclical droughts, which in turn affect vegetation flushes and food availability. Although rare, the nest-host species of hilaris yellow-faced bee may survive in small numbers during adverse periods and increase once conditions improve. However, the inherently smaller population of a cleptoparasite makes it more likely to become extirpated during a time of poor weather and lack of resources for reproduction and survival (Magnacca 2007, p. 181). Drought also creates disturbed areas conducive to invasion by nonnative plants and eliminates food and nesting resources (Kitayama and Mueller-Dombois 1995, p. 671; Businger 1998, pp. 1–2; Magnacca 2015 in litt., entire). Annual variation in abundance of floral species used by anthracinan yellow-faced bees, and possibly others, is strongly correlated with spring to summer rainfall patterns (Krushelnycky et al. 2022, p. 13). As a result, periods of extended drought can result in lack of food resources for native yellow-faced bees. Drought leads to an increase in the number of forest and brush fires (Giambelluca et al. 1991, p. v), causing a reduction of native plant cover and habitat (D'Antonio and Vitousek 1992, pp. 77–79). Such environmental events can be particularly devastating to the hilaris yellow-faced bee and its nest-host species because they persist in low numbers and have restricted geographic ranges.

Because hilaris yellow-faced bees are known from only one coastal site on Molokaʻi, the species is extremely vulnerable to extirpation by a catastrophic event such as a tsunami or coastal flooding. Two known populations of anthracinan yellow-faced bees, a host of hilaris yellow faced bee, were decimated by a high-tide event in early 2016 (Plentovich et al. 2021, pp. 143, 146). The dry coastal habitat inhabited by yellow-faced bees is extremely vulnerable to storm surge and flooding associated with severe storms. As previously described in the *Plants* section *Factor A*, stochastic events may also alter microclimatic conditions (e.g., soil erosion and decreasing soil moisture) so that the habitat no longer supports the native host plants necessary for nectar and pollen, nor provides nesting substrates or existing burrows. Small populations are demographically vulnerable to extinction caused by random fluctuations in population size and sex ratio. Thus, random and stochastic events may extirpate a species from an island with a single population (Lande 1988, p. 1455). Climate change may also affect the frequency or severity of storms affecting coastal and nearby habitats. Thus, both acute and chronic flooding impacts are likely to increase over time.

Factor B (Overutilization for commercial, recreational, scientific, or educational purposes)

Overutilization is not known to be a threat.

Factor C (Disease and Predation)

Disease caused by pathogens carried by nonnative bees, wasps, and ants could be transmitted to yellow-faced bees through shared food sources (Table 3; Graham 2015 in litt., entire; Reed 2022 in litt., entire). American foulbrood is a bacterial disease caused by a spore-forming bacteria (*Paenibacillus larvae*) that causes a disease of honeybees. Molecular analyses detected *Paenibacillus larvae* in pollen from failed *Hylaeus anthracinus* nests (Reed 2022 in litt., entire). Two fungus-caused diseases, chalkbrood (*Ascosphaera* sp.) and stonebrood (*Aspergillus fumigatus*), affect broods from several species of bees and pose potential threats to yellow-faced bees (Reed 2022 in litt., entire). It has been suggested that introduced *Ceratina* spp. and *Hylaeus strenuus* may have behavioral adaptations, resistance, or both, to pathogens that native yellow-faced bees lack (Graham et al. 2021, p. 368). The impact of disease on hilaris yellow-faced bees is not yet known. Disease may directly affect the cleptoparasite by causing death, or indirectly by affecting the species' *Hylaeus* hosts, and therefore reducing the number of nests available to parasitize.

Several nonnative ant species have a deleterious effect on the native invertebrate fauna including yellow-faced bee species, leading to bee populations being drastically reduced in ant-infested areas (Table 3) (Perkins 1913 pp. xxxviii to xlii; Gagne 1979, entire; Cole et al. 1992, entire; Reimer 1993, entire; Daly and Magnacca 2003, p. 10; Krushelnycky et al. 2005, entire; Krushelnycky et al. 2017, entire). Big-headed ants (*Pheidole megacephala*), yellow crazy ants, Papuan thief ants (*Solenopsis papuana*), black household ants (*Ochetellus glaber*), and tropical fire ants (*Solenopsis geminata*) are aggressive, generalist predators (preying on a variety of species) that occur in coastal and shrubland habitats (Reimer 1993, 17; Daly and Magnacca 2003, p. 10; Krushelnycky et al. 2005, entire; Krushelnycky et al. 2017, entire; Plentovich et al. 2021, entire). Ground-nesting *Hylaeus* species such as hilaris yellow-faced bee are particularly vulnerable to predation by nonnative ants. Because the brood (i.e., egg, larvae, and pupal stages) of hilaris yellow-faced bee and its nest-host species are immobile, nests are easily accessible in or near the ground, and are undefended (Cole et al. 1992, entire). From their frequent co-occurrence, yellow-faced bees can evidently tolerate big-headed ants in at least moderate abundance; however, black household ants and yellow crazy ants appear to severely reduce or entirely exclude yellow-faced bees where they occur in high numbers (Magnacca and King 2013, entire; Plentovich et al. 2021, p. 150).

In addition to predation, nonnative ants also compete with yellow-faced bees for nectar resources (Table 3; Howarth 1985, p. 155; Hopper et al. 1996, p. 9; Holway et al. 2002, pp. 188, 209; Daly and Magnacca 2003, p. 9; Lach 2008, p. 155; Magnacca 2015 in litt., entire; Plentovich et al. 2021, entire; Krushelnycky et al. 2022, pp. 48–58). Ants, particularly yellow crazy ants, deprive *Hylaeus* spp. of food by consuming large quantities of nectar without pollinating the plant (Lach 2005, entire). Native *Hylaeus* bees are less likely to land on flowers occupied by big-headed ants (Krushelnycky et al. 2005, p. 9; Magnacca 2015 in litt., entire).

Predation by nonnative western yellow jacket wasps (*Vespula pensylvanica*) is a threat to the hilaris yellow-faced bee and its nest-host species (Table 3). This wasp species is an aggressive generalist predator that will opportunistically prey upon yellow-faced bees, although they are not its primary prey source (Gambino et al. 1987, entire). In temperate climates, western yellow jacket wasps have an annual life cycle, but in Hawaiʻi, colonies often persist through a second year. This allows them to have larger numbers of individuals per colony (Gambino et al. 1987, entire) and thus, a greater impact on prey populations. Most colonies are found between elevations of 1,969 to 3,445 feet (600 to 1,050 meters), but they can be found down to sea level where yellow-faced bees and their hosts occur (Gambino et al. 1987, p. 169; Graham 2015 in litt., entire). Although hilaris yellow-faced bee is a very rare solitary bee, the presence of western yellow jacket wasp colonies near a hilaris yellow-faced bee nest or its hosts may extirpate a local population.

Factor D (Inadequacy of existing regulatory mechanisms)

As previously described in the *Plants* section, the loss of habitat and introduction of harmful nonnative species because of inadequate regulation and biosecurity is a threat to yellow-faced bees (Table 3). Recovery of the hilaris yellow-faced bee and its hosts will require active management of protected areas, which will include exclusion and removal of feral ungulates, control and removal of invasive plant and insect species, and the restoration of native vegetation. Existing regulatory mechanisms are inadequate to provide the necessary effective management to protect the hilaris yellow-faced bee.

Factor E (Other natural or manmade factors affecting the species continued existence)

Hilaris yellow-faced bees also face competition from parasitization of active nests in which to breed (Table 3). Parasitization of the nests of anthracinan yellow-faced bee in artificial twig and tube nest blocks has been observed by several parasitoid wasp species including a wasp (family Eupelmidae, *Eupelmus* sp.) of unknown origin and a nonnative ectoparasitoid wasp, (family Eulophidae, *Melittobia hawaiiensis*) (Krushelnycky et al. 2022, p. 32, 39–40). Two endemic wasps in the family Encyrtidae, *Coelopencyrtus kaalae* and *Coelopencyrtus odyneri*, have been observed parasitizing anthracinan yellow-faced bee brood in artificial tube nest blocks on Oʻahu (Krushelnycky et al. 2022 p. 41). The *Coelopencyrtus* species are known endoparasitoids (a parasite that lives inside another animal and ultimately kills it) of native yellow-faced bees, although only *C. kaalae* and *C. sexramosus* had previously been recorded from yellow-faced bee nests (Daly and Magnacca 2003, pp. 12–13, 53). The threat of competition for provisioned nests on hilaris yellow face bees is not known at this time but is considered a potential threat.

Competition for nest resources is a significant threat to anthracinan yellow-faced bees (Graham and King 2016, entire; Graham et al. 2021, entire; Krushelnycky et al. 2022, pp. 38–39) and subsequently, to hilaris yellow-faced bees. There is substantive overlap in nest parameters among native yellow-faced bees and introduced solitary bees such as *Hylaeus strenuus*, *Ceratina smaragdula*, and *Ceratina dentipes* (Graham et al. 2021, entire). These three introduced bee species have been observed in many coastal habitats on Oʻahu, including the only remaining sites where anthracinan yellow-faced bee populations persist (Graham et al. 2021, p. 368; Krushelnycky et al. 2022, p. 36). In addition to *H. strenuus*, keyhole wasps (*Pachodynerus nasidens*) and a leafcutter bees (*Megachile* sp.) have been observed nesting in artificial nest boxes established for anthracinan yellow-faced bees (Plentovich et al. 2021, pp. 146, 151). Termites and sphecid wasps (*Trypoxylon* sp.) were observed in artifical twig nests and may also compete for nests in stems (Krushelnycky et al. 2022, p. 32).

Competition from nonnative bees for food resources is a potential threat to the anthracinan yellow-faced bee and subsequently for hilaris yellow-faced bee (Table 3; Magnacca 2007, p. 188; Graham 2015 in litt., entire; Magnacca 2015 in litt., entire). Most nonnative bees inhabit lowland areas including the native coastal strands where yellow-faced bees may occur (Daly and Magnacca 2003, entire; Krushelnycky et al. 2022, pp. 12–13, 38). European honeybee (*Apis mellifera*) is a social species often very abundant in areas with native vegetation and aggressively competes with *Hylaeus* spp. for nectar and pollen (Magnacca 2007, p. 188; Snelling 2003, p. 345; Ing and Mogren 2020, entire). Other nonnative bee species also use the same native vegetation as the anthracinan yellow-faced bee. These include sweat bees, *Lasioglossum* spp.; carpenter bees, *Ceratina smaragdula*, and *Ceratina dentipes*; and the nonnative *Hylaeus albonitens* and *Hylaeus strenuus* (Snelling 2003, entire; Magnacca 2007, entire; Magnacca et al. 2013, p. 61; Graham et al. 2021, pp. 367–368; Krushelnycky et al. 2022, p. 58). *Hylaeus strenuus, C. smaragdula*, and *C. dentipes* have been found on Oʻahu and pose a threat to all populations on the North Shore area of Oʻahu. The species are potentially serious competitors for floral resources, and regularly visit both naupaka kahakai and tree heliotrope, the two main food plants of the anthracinan yellow-faced bee (Magnacca and King 2013, entire). On Oʻahu, *H. strenuus, C. smaragdula* and *C. dentipes* have been observed foraging on the same flowers as anthracinan yellow-faced bee, often in densities that appeared to exclude native yellow-faced bees (Magnacca and King 2013, entire; Graham et al. 2021, pp. 367–368). Bees of similar size often overlap with the flower species used for nectar and pollen. Such food resource competition from nonnative species can have significant negative biological effects on all stages of anthracinan yellow-faced bees (Magnacca 2007, p. 189; Magnacca et al. 2011, entire).

The persistence of the hilaris yellow-faced bee is significantly hampered by having only one small wild population on Molokaʻi, the rarity of host nests throughout its range, and the shrinking geographic range of the species (Daly and Magnacca 2003, pp. 103, 106; Magnacca 2005, p. 2; Magnacca 2007, p. 181). The dependence of the hilaris yellow-faced bee on the nests of its host species leaves it highly vulnerable to mortality, reproductive failure, and cyclical population variation related to fluctuations in host abundance. These circumstances make this species extremely vulnerable to extinction due to a variety of natural and anthropogenic factors.

Dispersal and gene flow is now likely impaired or nonexistent despite the mobility of the *Hylaeus* bees. The population dynamics that likely functioned historically to allow dispersal and gene flow between populations along the coastal habitats of each island and among islands now appear to be severely impaired or nonexistent due to the limited population of the hilaris yellow-faced bee and the relative rarity of its nest hosts. Although yellow-faced bee females can store sperm for life, a small, isolated population may be vulnerable to reduced mating encounters and decreased reproductive vigor caused by inbreeding depression. As a result of having extremely low numbers, yellow-faced bee species may experience reduced reproductive vigor due to inbreeding depression and/or a loss of genetic variability over time due to random genetic drift. Reduced levels of genetic variability may lead to diminished capacity to respond and adapt to environmental changes and increased vulnerability to localized catastrophes such as hurricanes, tsunami, and drought (Lande 1988, p. 1455; Daly and Magnacca 2003, p. 3; Magnacca 2007, p. 173; Magnacca 2015 in litt., entire). These may result in population extirpation and extinction of yellow-faced bee species.

Climate change has the potential to adversely affect hilaris yellow-faced bees (Table 3). The yellow-faced bees reproduce in the dry coastal and dry and mesic forest habitat. Sea level rise will further reduce the already limited remaining coastal habitat. This will force the species to nest at higher densities in the remaining suitable habitat, which may lead to further isolation from other populations. As described in the ***Plants*** section *Factor E*, changes in temperature, humidity, precipitation, and the frequency and severity of storms may change the habitats on the islands occupied by the species and exacerbate the threats rendering the habitats unsuitable for yellow-faced bees. Floral abundance and the associated pollen and nectar resources used by the yellow-faced bees and its hosts are correlated with annual rainfall, and would be altered or eliminated (Krushelnycky et al. 2022, p. 13).

II. RECOVERY

A. RECOVERY VISION AND STRATEGY

A recovery vision is an explicit expression of recovery in terms of resiliency (the ability of a species to recover from periodic disturbance), redundancy (the number of populations of a species distributed across the landscape), and representation (the range of variation found within a species). It builds upon the description of viability for the species and defines what recovery looks like for the species. The recovery strategy provides a recommended approach for achieving the recovery vision, and ultimately, the down- and delisting criteria.

1. Recovery Vision

Recovery of the 40 plant species entails each species having redundant populations distributed throughout their respective habitat on each island within their respective historical ranges. These populations should be self-sustaining, resilient, and represent the full genetic diversity existing in the species. Habitats should be protected from ungulates, fire, agriculture and urban development, and other forms of degradation. Habitats of each species should support connectivity among populations for genetic exchange, when possible. Nonnative plants, pests, and disease should be sufficiently managed so that each plant species maintains stable, secure, and naturally reproducing populations.

Recovery of the three tree snail species entails each species having redundant populations distributed throughout their forest habitat. These populations should be resilient and self-sustaining, with stable to increasing trends in population indices, and represent full existing genetic diversity. Habitats should support connectivity among populations for genetic exchange, where appropriate. Their habitats should be protected from ungulates, fire, and other forms of degradation. Nonnative predators and other threats should be managed such that each tree snail species maintains stable, secure, and naturally reproducing populations.

Recovery of the hilaris yellow-faced bee entails the species having redundant populations distributed throughout the dry coastal habitat of each island (Maui, Lānaʻi, and Molokaʻi). These populations should be resilient and self-sustaining, with stable to positive trends in population indices, and represent full existing genetic diversity. The coastal strand habitat should be protected from ungulates, fire, development, and other forms of degradation. Yellow-faced bee habitat should provide sufficient native plant food and nesting resources to support the species and its nest-host species. Yellow-faced bee habitat should support connectivity among populations for genetic exchange, when possible. All threats should be managed such that trends in population indices of the hilaris yellow-faced bee and its nest-host species remain stable, secure, and naturally supporting.

2. Recovery Strategy

Management Units

For purposes of management, we identify management units based on islands where a species is endemic within Maui Nui (Table 1). Management units include various small islets in the vicinity of the major islands of Maui Nui (e.g., Huelo, Mōkapu, and ʻŌkala islets located near Kalaupapa on Molokaʻi).

Evolutionarily significant units (ESUs) based on genetics, or if ESUs are not identified, geographic units (GUs) that are based on geographic distance between populations, will be identified and used to delineate populations of both Lānaʻi tree snails (*Partulina variabilis* and *Partulina semicarinata*) and Newcomb's tree snail (*Newcombia cumingi*) whenever possible and appropriate based on genetic analyses. These units are used in the planning of management and translocation activities.

For the purposes of this recovery plan, conservation translocation (hereafter, translocation) is the human-mediated deliberate movement of organisms from one site for release to another for conservation benefit and includes population restoration (reinforcement and reintroduction) and conservation introduction (assisted colonization and ecological replacement) as defined by the International Union for Conservation of Nature (IUCN). Translocations will follow the guidelines of the IUCN's Species Survival Commission (IUCN 2013, entire).

General Cross-Species Recovery Strategy

The 44 plant, tree snail, and yellow-faced bee species addressed in this recovery plan use 8 natural habitat types on Maui Nui that range from coastal zones, across shrublands and grasslands, to montane forests. Large portions of these habitats have either been destroyed, reduced in size, degraded such that the habitat no longer supports stable or growing populations, are in need of management and protection, or a combination of these conditions (Ball et al. 2020; Browning et al. 2020; Clark et al. 2020; Javar-Salas et al. 2020; Kim et al. 2020; Lowe et al. 2020; Nelson et al. 2020; Peʻa et al. 2020). Collectively, restoration and protection of the 8 natural habitats is beneficial to all 44 species and provides for species-specific habitat needs necessary for the recovery of each species. Restoration, management, and protection of coastal, grassland, shrubland, and forest habitats can be enhanced through management plans and conservation agreements with landowners in these habitats.

Nonnative species, particularly invasive plants, herbivores, competitorss, diseases and disease vectors, and predators, affect all 44 species either by altering their habitats or directly impacting the species. Recovery of the species will require monitoring and management of nonnative invasive plant species, ungulates, other vertebrates, and invertebrates; fencing and lethal or nonlethal control of herbivores or predators; and minimizing expansion of development into habitats. Specific microclimate needs of each species should be documented and modeled to determine how suitable microclimates will shift due to climate change. Events such as hurricanes, tsunamis, and floods will intermittently affect habitats to varying degrees. Mitigating the effects of these events requires conserving sufficient habitats to support redundant viable populations of the listed species throughout their respective ranges and management units.

Having species representation in genetic storage will provide a source for propagation of some species. *Ex situ* collections and captive propagation may be necessary as sources for translocation and to ensure preservation of genetic representation if a species becomes extirpated from the wild.

Recovery will require partnerships with State, Federal, County, native Hawaiian and local communities, non-profit, and private stakeholders (collectively, conservation partners) to reestablish the viability of each species across its range. Recovery will require collaboration and partnerships with conservation partners to prevent the introduction and establishment of new pests and invasive species that could impede recovery of any or all of the 44 species or their habitats. These partnerships should work to expand and improve border inspections and implement the Hawaiʻi Interagency Biosecurity Plan (State of Hawaiʻi 2017, entire). Biosecurity measures are critical to avoid introducing new pests and invasive species to each species habitat, prevent reintroduction of invasive species if eradication programs are successful, and intercept or control invasive species brought in from outside the State. New invasive species may include invasive plants; invasive vertebrates and invertebrates; and diseases of plants, tree snails, and yellow-faced bees. Implementation of the biosecurity plan requires continued outreach to travelers into Hawaiʻi and between islands, enforcement, and adaptive management to address new introductions.

Monitoring and evaluation of the effects of actions implemented to achieve recovery are critical to inform and adapt future management. In addition, all populations will require monitoring to identify new threats, track demographic variables, and resiliency, where feasible. Post-delisting monitoring will be needed to confirm delisted species continue to meet recovery criteria.

General Recovery Strategy

The recovery strategy for the 40 plant species, 3 tree snail species, and 1 yellow-faced bee species addressed in this recovery plan entails 5 principal steps to recovery. For some species, the first three steps may be accomplished sequentially. Monitoring and evaluation throughout the five steps are important components associated with each action and its consequences within each of the five steps. The results of monitoring and evaluation form a continuous feedback loop for adaptively adjusting management strategies for each species in each step.

The first step to achieving recovery for each of the 44 species is identifying and prioritizing all populations, curtailing their decline, and stabilizing each species. Prioritization and population management should conserve the existing representation and diversity of each species. To stabilize the existing populations of the 44 species, threats identified in recent Species Reports (USFWS 2023a through USFWS 2023rr) need to be managed. Management may be species-specific or habitat-based, depending on the threat and landscape-wide strategic plans for species recovery. Regulation development, codification, and enforcement will be required to manage resource- and species-based threats and provide long-term protection of habitats and resources for terrestrial and aquatic ecosystems. Continuous monitoring and feedback will be necessary to identify any new or previously unrecognized threats. These threats must then be managed. This will require working with conservation partners to protect and manage populations of the species throughout their range.

After halting declines in populations, the second step is to determine the status of each species' population(s) and their respective habitats, then prioritize, protect, and manage the habitats supporting these populations such that threats are managed and the populations are stabilized or increasing.

Once populations are protected and managed with a stable or increasing trend, the third step is to increase redundancy and resiliency throughout each species' range and in each management unit. For many species, this will require establishing new populations, using genetically appropriate individuals in occupied or unoccupied habitat to increase redundancy within each species' historical and/or current range, and/or reinforcing small populations to increase their resiliency. Populations of some species may be established outside their historical range via conservation introductions in response to changing environmental conditions.

The fourth and fifth steps entail downlisting and delisting. An assessment of a species' status in relation to the five listing factors found in section 4(a)(1) and the definitions of "endangered" and "threatened" in section 3 of the Act, respectively, will be used to determine whether downlisting or delisting is appropriate. This subsequent review may be initiated without all the recovery criteria in this plan having been fully met. A decision to downlist or delist a species is informed by the recovery criteria but is ultimately based on an analysis of threats using the best scientific and commercial data available. However, recovery criteria are mileposts that measure progress toward recovery. Because we cannot envision the exact course that recovery may take, and our understanding of the vulnerability of a species to threats is likely to change as more is learned, it is possible that a status review may indicate that delisting is warranted although not all recovery criteria are met. Conversely, it is possible that recovery criteria could be met, but a status review indicates that delisting is not warranted. For example, a new threat not addressed by the current recovery criteria could result in the species continuing to be threatened or endangered.

Many aspects of the 44 species' life history, genetics, demographics and ecology, propagation and captive rearing, population viability, priority threats, and management are poorly understood. In addition, the effects of climate change on each species will need to be evaluated to plan for possible conservation translocations to new suitable habitats outside their historical range. Research will occur concurrently with each of the five steps, and the results will inform future management and recovery actions.

The general recovery actions and overarching strategy for each of the identified threats of the three species groups (plants, tree snails, and yellow-faced bee) are described below.

Recovery Strategy for Plants

For most of the plant species, recovery will require some degree of protection from introduced ungulates throughout the range of their habitat within island-based management units (Table 2). Construction and maintenance of ungulate-proof fencing around each plant species population or multi-species habitat sites should be considered in conjunction with removal of ungulates. Ungulates must be removed from all fenced areas needed for recovery of the plant species.

For most of the plant species, recovery will require some degree of protection and management from invasive plants throughout their existing range and in any new areas needed for the recovery of each species (Table 2). Management or eradication of habitat-modifying invasive plants is necessary to improve survival of at least 39 of these plant species and to enhance their habitat. Research and development of new control tools for invasive plants should be considered. As discussed above, coordinated biosecurity measures are needed to prevent spread and establishment of invasive species in new locations within Maui Nui.

For at least 15 of the plant species, recovery will require fire prevention strategies (Table 2). Specific fire management plans and infrastructure (e.g., firefighting equipment, water sources, firebreaks) should be developed for each management unit needed for recovery, including suitable but unoccupied sites. Plans should consider the likely increased risk of wildfire due to climate change. Management actions that reduce the likelihood of fire should be implemented to protect the occupied and suitable habitats of these plant species.

Recovery of plant species susceptible to drought and stochastic events (such as hurricanes, flood, and landslides) will require resilient populations that are redundant and well-represented throughout their range, and possibly outside of their historical range (Table 2). Redundant populations should incorporate each species' existing genetic representation where possible within each population, as appropriate. Translocation supported by genetic information, captive rearing, and *ex situ* propagation should be considered and implemented when needed. Distribution of multiple resilient populations within the range of their habitat will decrease the probability of all populations being affected by a single event. The feasibility and conservation benefit of translocating species outside of their known historical range to mitigate the threat of stochastic events should be considered.

Long-term protection of the habitats of all the plant species will be necessary to support long-term persistence of the species. Such long-term protection will require working with conservation partners to protect, restore, and manage the 8 natural habitats and 1 developed habitat that support the 40 plant species. Habitat sites necessary for the survival of these plant species will need to be identified and protected throughout the management units of the species. For at least one plant species, *Mucuna persericea*, recovery will require habitat protection from agricultural and urban development (Table 2). Outreach to prevent human disturbance of the species through mechanical weed-whacking and herbicide treatment will be needed.

Research should be conducted as needed to better understand plant diseases that may affect species' viability or their habitat and to develop tools to detect, manage, and eradicate diseases. At least three of the listed plant species are threatened by powdery mildew disease (Table 2). Plant diseases such as ROD are also an ongoing threat to ʻōhiʻa, which is an important canopy tree in mesic and wet forest habitats that support most of the listed plant species. Preventing the establishment of ROD-causing fungal organisms at sites within Maui Nui will be necessary to protect mesic and wet forest habitats. Research into replacement of overstory canopy and planning of interim measures will be necessary to create and maintain the microclimate required by the species in mesic and wet forests, should ROD become established. The habitats of 34 of the plant species will need to be monitored to detect diseases, assess their impacts, and control outbreaks as soon as possible.

Recovery of most of the plant species will require long-term management to control rodents, slugs, and seed herbivores (Table 2). A rodent eradication program to protect the management units for at least 34 of the plant species should be developed and implemented to support reproduction, natural recruitment, and survival of each plant species. In addition to rodent control, protection of at least 36 of the plant species will require a slug and invasive snail control program to be developed and implemented. Recovery of at least four of the plant species will require long-term management and protection against nonnative seed borers or seed weevils (Table 2). Management or eradication will require that new tools be developed and implemented to effectively control these nonnative insects. In cases where native pollinators avoid plants occupied by ants or other nonnative invertebrates, development and implementation of a long-term control program for the ants or other invertebrates will be necessary to support seed production and natural recruitment.

Recovery of 13 of the plant species that experience hybridization (8), lack of regeneration (6), or both (1) will require research to inform management (Table 2). Propagation of genetically appropriate individuals for genetic storage and translocation efforts to augment existing populations or increase the number of populations should be considered. Methods to monitor population growth and status, including the genetic composition of progeny for species threatened by hybridization, will need to be developed. Research on population genetics to identify hybrid individuals and adapt management actions to vulnerable plant populations will likely be needed. Removal of hybrid plants will need to be considered. Research on demographics, pollination, and propagule dispersal as well as evaluation of genetic threats may be required to inform management. Tools to control and manage the limiting factors and enhance survival and reproduction will need to be developed and implemented.

Threats to over half of the plant species are exacerbated by their having a very limited number of individuals (Table 2). Translocation to increase population distribution will be crucial to achieving recovery and will require species-specific plans. Plans will need to consider the genetic composition, number of founders, and suitable source population(s), as well as the species' reproductive capacity and the suitability and availability of habitat. Plants propagated for translocation should be genetically representative of the source populations, and translocated individuals should represent the appropriate genetic composition for the habitat to which they are translocated. The selection of translocation sites should be prioritized based on a suite of factors including their conservation value to multiple species and the likelihood of successful threat management. If necessary, sites will be prepared to support translocation. The feasibility and conservation benefit of translocating species outside of their known historical range (i.e., conservation introduction) should also be considered where necessary to provide sufficient redundancy and representation.

Recovery of plant species endemic to a single island will require resilient populations that are redundant and represented throughout their range and possibly outside of their historical range. Because of the vulnerability of single-island species, *ex situ* storage and propagation of individuals that are representative of the full genetic scope should be considered.

Recovery of plant species susceptible to environmental changes from global climate change (Table 2) will require microclimate modelling and identification of suitable habitat based on historical and existing species' distributions and potential future climate conditions. This information will be central when considering expansion of species' ranges so that translocation sites will have suitable habitat and continue to do so in the future. Prior to establishing any populations outside of a species' known range, habitat suitability and existing and new threats need to be assessed and managed. Translocations should be informed by each species' life history, demographic viability, pollinators, natural recruitment, and other factors that could influence the likelihood of successful population establishment.

Recovery Strategy for Tree Snails

Recovery of tree snails will require active management of tree snail enclosures and tree snail habitat not protected by enclosures to keep them free of predators such as predatory snails, rats, and Jackson's chameleon. Systematic surveys to assess the distribution and abundance of the listed snails as well as the status of predators will inform recovery. Snail enclosures should be constructed so as to prevent the ingress of rats, predatory snails, and Jackson's chameleons into the enclosure. Maintenance of the vegetation borders surrounding the predator-proof enclosure will be required to avoid or minimize entry of predators into snail enclosures. Multiple enclosures will be needed throughout the habitat ranges of the tree snails to provide redundancy and appropriate representation. Separate enclosures for different ESU or GUs should be considered. Genetic analyses will be necessary to determine which GUs within a species may share the same enclosure or other predator-exclusion technology. Research will be needed on the genetic composition, viability, and population trends of snails within predator-proof fences, populations remaining in the wild, and those in captivity. Predator-proof enclosures will require sufficient monitoring and maintenance to maintain the integrity of the structure and the habitat within.

Predator control methods will need to be developed and implemented to protect the remaining tree snail populations in the wild. Research to better define management strategies and identify control or eradication technologies for existing or new predators of the tree snail species should be considered. To date, there are no efficient methods available for controlling or eradicating *Euglandina* spp., Jackson's chameleon, or other predators, other than constructing tree snail predator-proof fences or enclosures and manually removing the predatory snails and other threats from inside. Recovery will require control of new or emerging threats. Surveys for flatworms or other new or potential threats should be considered, especially for tree snail populations in the wild. Inspections and biosecurity measures should be implemented to prevent introduction or spread of flatworms or other identified predators of tree snails to or within Maui Nui. Control and eradication methods should be developed and implemented if flatworm or other new or emerging threats are identified.

Recovery of the tree snail species will require some degree of protection from introduced ungulates. Ungulate control and eradication in tree snail habitats on each island will be needed. Construction and maintenance of ungulate-proof fencing around the habitats of the tree snails should be considered in conjunction with removal of ungulates. Ungulate control will be needed around predator-proof snail enclosures to prevent ungulates from entering or damaging the enclosures. Ungulates must be removed from all fenced areas that are needed for recovery of the tree snail species.

Recovery of the tree snail species will require some degree of management and protection from invasive plants throughout their habitat range. Control or eradication of habitat-modifying invasive plants in each of the tree snail habitats will be needed. Research and development of new control tools should be considered. As discussed above, coordinated biosecurity measures are needed to prevent spread and establishment of invasive species in new locations within Maui Nui.

Recovery of the tree snail species will require long-term fire protection and management. This will require management-unit specific fire management plans, development of firefighting infrastructure, and initiating management actions to reduce the likelihood of fire in the tree snail habitats. Plans should consider the likely increased risk of wildfire due to climate change.

Limited populations and shrinking geographic range of tree snail species exacerbates threats and makes them extremely vulnerable to extinction. Having resilient populations of each tree snail species that represent all ESUs or GUs within their natural habitats and in captive rearing would provide a level of redundancy and improve the likelihood of the species surviving localized drought or catastrophic events. Existing genetic representation of each species should be incorporated within redundant populations, where possible and appropriate. Critical biological needs for breeding and population growth should be identified through research. Translocation supported by genetic information and captive rearing will be considered and implemented when needed. The demographic structure needed to support the three tree snail species should be defined through research and monitoring. Translocation supported by genetic information and captive rearing will be considered and implemented when needed, We will consider the feasibility and conservation benefit of translocating species outside of their known historical range to improve redundancy by increasing population distribution.

Recovery will require close coordination with conservation partners. New risks to the tree snails posed by illegal harassment to potential collection by trespassers that illegally enter the manmade tree snail enclosures will need to be managed. Enforcement of Federal and State laws that protect listed species from illegal harassment and collection will be needed. Public outreach, signage and education, and enforcement of penalties should be implemented to prevent harassment or illegal collection of tree snails without a permit.

Evaluation of recovery actions should take into consideration the potential threat of disease to the tree snails in the wild or in captivity. Recovery efforts will consider redundancy, representation, and resiliency in captive-rearing programs and in wild populations. Research and development of tools to avoid, detect, or cure diseases that could affect the tree snails should be considered.

If plant diseases, such as ROD on ʻōhiʻa, affect plants inside a tree snail enclosure(s), alternative plant hosts may be necessary. Tree snail enclosures should be managed for host plant diversity and sustainability. Research to identify food resources and host plants should be considered.

Climate change has the potential to adversely affect the tree snail species, particularly those species that occupy the habitats in the highest elevation of an island. Recovery of the tree snail species will require microclimate modelling and identification of suitable habitat based on historical and existing species' distributions and potential future climate conditions. Use of appropriate scale in the analysis will be necessary to identify microclimates or niches that will be appropriate for sustaining tree snail populations long-term. Expanding the range of tree snail species through translocation to include new suitable habitat should be considered. Such consideration should be informed by research and analyses to assess habitat suitability, threats, protection of habitat, demographic and species viability, and other individual and population concerns and consequences.

Recovery Strategy for Hilaris Yellow-faced Bee

Recovery of hilaris yellow faced bees requires immediate identification of remaining populations and protection of the species and their nest hosts from threats. Recovery will require surveys throughout the habitat ranges of the hilaris yellow-faced bee and its nest-host species to identify host bee populations and subsequently those parasitized by hilaris yellow-faced bees. All populations that are identified should then be actively managed to protect them from threats. Recovery will also require protecting nest-host populations even in the absence of hilaris yellow-faced bees, to provide the potential for restoration of additional populations of hilaris yellow-faced bees. Research on population needs of both the cleptoparasites and their nest hosts is necessary to implement appropriate restoration actions and allow population growth.

Recovery of hilaris yellow-faced bees, along with their nest hosts, will require restoration and protection of the coastal strand and shrubland and grassland habitats of the species and its nest hosts. Interactions among multiple threats including habitat degradation and reduction, loss of nesting and foraging resources, and habitat fragmentation are likely responsible for the extirpation of the species from many of their historical sites. Recovery of the hilaris yellow-faced bee will require working with conservation partners to protect, restore and manage the coastal strand and other suitable habitats. Within each island-based management unit, coastal areas that provide the resources necessary for nesting and foraging or that can be restored to provide these basic needs should be identified and prioritized for management and protection. Restoration and management plans for the coastal areas identified should focus on actions that will support stable to growing populations of the hilaris yellow-faced bee and its nest-host species. Conservation agreements and other modes of habitat conservation and protections will be necessary to provide for protection of the coastal stand habitat and adjacent shrublands for the long-term persistence of the species and its nest hosts.

Measures to enhance population growth need to be developed and implemented. Little is known about the biology or demographics of the cleptoparasite or how to benefit the nest-host species other than providing nesting resources for its nest hosts and foraging resources for the hilaris yellow-faced bee species complex. Research to identify species of plants used for pollen and nectar, basic breeding needs, and population dynamics will be needed to inform management actions for each population of the species and its nest hosts.

Once the pollen and nectar sources are identified for each yellow-faced bee species, recovery will require protecting, restoring, and creating the diversity of appropriate and sustainable pollen and nectar sources the species require. Management and restoration should consider the quality, quantity, and diversity of pollen and nectar host plants that the hilaris yellow-faced bee and its hosts need throughout their life cycle, so that pollen and nectar resources are continuously available. Because invasive plants can compete with important native plant resources that yellow-faced bees use, recovery will require management or eradication of habitat-modifying invasive plants at each hilaris yellow-faced bee population throughout the management units.

Ungulate control, eradication, and management in hilaris yellow-faced bee habitats throughout the management units will be needed. Where appropriate, ungulate-proof fencing around hilaris yellow-faced bee habitat should be constructed and maintained, accompanied by removal of ungulates from within each fenced area.

Recovery of the hilaris yellow-faced bee and its respective dry coastal and dry shrubland and grassland will require long-term, population specific, fire management plans, development of firefighting infrastructure, and initiating actions to reduce the likelihood of fire. Fire management plans will need to be adaptive to accommodate increased fire risk and fuel load resulting from climate change or stochastic variability.

Once habitats are secured, establishing resilient populations of hilaris yellow-faced bees throughout each management unit will require redundancy and representation to buffer the species against stochastic events such as drought, or catastrophic events such as hurricanes, flooding, and tsunamis. Populations created to increase redundancy should incorporate the species' remaining genetic diversity where possible, to minimize the loss of diversity. Research to identify dispersal distance and current and future range of the species will be needed. Populations of the species in each management unit needed for recovery should be distributed such that a repeated catastrophic event, such as flooding or tsunami that damages or destroys a population, would not eliminate the entire population of a species on a particular island. This may entail a large contiguous population of the species occurring throughout the coastal habitat facing different shores of each island. Alternatively, noncontiguous populations of the species that face different shores could also meet this need, but multiple redundant populations with full genetic representation must be present for each yellow-faced bee species in its respective management unit.

Should disease (e.g. American foulbrood, chalkbrood, stonebrood) emerge as a threat to hilaris yellow-faced bee viability, research and development of tools to prevent or minimize spread and manage or eradicate the disease(s) should be considered.

Management of all hilaris yellow-faced bee populations will require ant monitoring and careful consideration of ant control methodologies. Recovery of the hilaris yellow-faced bee and its nest hosts will require identifying appropriate ant control or eradication methods, applying these methods, and monitoring the results. Management and control of ant predation at the sites occupied by or near the hilaris yellow-faced bee and its nest-host species should consider: (a) the species of ant present; (b) the methods available and the need to develop additional new control technology; and (c) the risks of controlling one ant species and replacement by another ant species. Research to identify technologies that can be used for sustainable ant control or eradication will be necessary. Similarly, programs to control western yellowjackets should be developed and implemented where research indicates predatory wasps are adversely affecting the hilaris yellow-faced bee recovery.

Research to quantify competition for food, nests, or other resources by nonnative invertebrates will be needed. Techniques to control such competition should be developed and implemented if research shows that hilaris yellow-faced bee population growth is being adversely affected by the competition.

The hilaris yellow-faced bee is likely extirpated from all islands other than Molokaʻi. Natural recolonization of the hilaris yellow-faced bee from the last known population on Molokaʻi is likely to be slow or nonexistent given dispersal distance and current conditions. Thus, conservation translocation will likely be necessary in order to increase the redundancy of the hilaris yellow-faced bee and its nest-host populations. Stable to increasing populations of the nest-host species that occur in the historical range of the hilaris yellow-faced bee may eventually serve as sites for reintroduction of hilaris yellow-faced bees, if research indicates the host population would be able to thrive in the presence of the cleptoparasite. To design a successful translocation program, it will be necessary to document the hilaris yellow-faced bees' current distribution and genetic structure as well as their breeding (e.g., mate selection) and dispersal behavior. A captive-rearing program will be needed to provide the individuals necessary for reintroduction, reinforcement, and conservation introductions. Because the hilaris yellow-faced bee is dependent on its nest-host species, research to define important biological needs for breeding and necessary demographic structure of the species and its hosts is important to inform captive-rearing programs and future translocations.

Because the hilaris yellow-faced bee is known only from one coastal site on Molokaʻi, it is extremely vulnerable to extirpation by progressive sea level and tidal rise caused by climate change. Expanding the number and distribution of hilaris yellow-faced bee populations throughout each management unit (islands of Maui, Lānaʻi, and Molokaʻi) is necessary to increase the overall redundancy of the species and to limit its vulnerability to extirpation and extinction. In addition, the development of microclimate models and identification of suitable habitat based on historical and existing species' distributions and potential future climate conditions will be necessary. Coastal habitat and adjacent shrubland and grassland habitat are extremely vulnerable to climate change and will require extensive research, mitigation, and habitat reclamation or creation approaches in order to support the species in the future.

All management plans should be adaptive and include monitoring to provide feedback to the plan and its accompanying actions. Tools to effectively monitor and measure population growth and status should be developed and used to inform management plans for hilaris yellow-faced bee and its host species, their respective food and nesting resources, and their habitat. Research to identify control strategies and management tactics for the vertebrate and invertebrate threats to the yellow-faced bees and their pollen and nectar hosts will be required. Newly identified threats (existing or introduced) to each population will need to be identified and managed. As discussed above, coordinated biosecurity measures are needed to prevent spread and establishment of invasive species in new locations within Maui Nui.

B. RECOVERY CRITERIA

Section 4(f)(1)(B)(ii) of the Act states that each recovery plan shall incorporate, to the maximum extent practicable, “objective, measurable criteria which, when met, would result in a determination... that the species be removed from the List.” Legal challenges to recovery plans (see Fund for Animals v. Babbitt, 903 F. Supp. 996 (D.D.C. 1995)) and a Government Accountability Office Audit (GAO 2006, entire) also have affirmed the need to frame recovery criteria in terms of threats assessed under the five listing factors.

Recovery criteria 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. Delisting is the removal of a species from the Federal Lists of Endangered and Threatened Wildlife and Plants (Lists). Downlisting is the reclassification of a species from endangered to threatened. The term “endangered species” means any species (species, subspecies, or distinct population segment) that is in danger of extinction throughout all or a significant portion of its range. The term “threatened species” means any species that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.

Recovery criteria represent our best assessment, at the time the recovery plan is completed, of the conditions that would likely result in a determination that listing under the Act as threatened or endangered is no longer required. However, revisions to the Lists, including delisting or downlisting a species, must reflect determinations made in accordance with sections 4(a)(1) and 4(b) of the Act. Section 4(a)(1) requires that the Secretary determine whether a species is an endangered species or threatened species because of threats to the species, based on an analysis of the five listing factors in section 4(a)(1). Section 4(b) require that the determination be made “solely on the basis of the best scientific and commercial data available.” Thus, while recovery plans provide important guidance to the Service, States, and other partners on methods of minimizing threats to listed species and measurable criteria against which to measure progress towards recovery, they are guidance and not regulatory documents.

Thus, a decision to delist or downlist a species is informed by the recovery criteria but is ultimately based on an analysis of threats using the best scientific and commercial data then available. All classification decisions consider an analysis of the following five factors: (1) is there present or threatened destruction, modification, or curtailment of the species’ habitat or range; (2) is the species subject to overutilization for commercial, recreational scientific or educational purposes; (3) is disease or predation a limiting factor; (4) are there inadequate existing regulatory mechanisms in place outside the Act (taking into account the efforts by States and other organizations to protect the species or habitat); and (5) are other natural or manmade factors affecting its continued existence. When delisting or downlisting a species, we first propose the action in the *Federal Register* and seek public comment and peer review of our analysis. Our final decision is announced in the *Federal Register*.

The species addressed in this recovery plan should be considered for downlisting and delisting when the following objective[s] and criteria have been met. Downlisting and delisting criteria are subject to change as additional information becomes available about species biology and threats.

Monitoring and evaluation of each management unit, which is required for downlisting and delisting of a species, is an essential part of assessing the viability needed to meet the recovery criteria of the 44 species addressed by this recovery plan. It will be necessary to: (a) monitor the number of individuals and population distribution to determine population growth status and redundancy, (b) identify and evaluate new or existing threats and their management in each unit's habitat, (c) evaluate habitat management actions, and (d) use the evaluations to adapt the management actions. Evaluations will require the establishment of baselines against which each recovery criterion can be compared. As such, monitoring and evaluation is expected to be continuous and long-term, continuing throughout the listing status of the species and past the time of delisting.

1. Recovery Criteria – Plants

Objective – Manage threats and habitats to establish self-sustaining, resilient, naturally reproducing viable populations of each listed plant species within Maui Nui.

The Hawaiʻi and Pacific Plants Recovery Coordinating Committee (HPPRCC), comprised of biologists from Federal and State agencies, private conservation organizations, botanical gardens, and universities, was established to advise the Service on the biology and management needs for recovery of listed plants. The HPPRCC has outlined general actions and goals for stages leading towards recovery of listed Hawaiian plants (HPPRCC 2011, entire). Current information is lacking for many Hawaiian plant species with respect to the status of the species and their habitats, breeding systems, genetics, and propagule storage options. We have, therefore, adopted downlisting and delisting criteria for Hawaiian plants based on the revised general recovery objective guidelines developed by the HPPRCC (2011, entire). Many of the Hawaiian plant species are at very low numbers, so we also developed criteria for two additional stages (avoiding imminent extinction and an interim stage before downlisting), based on the recommendations of the HPPRCC, to assist in tracking progress toward the ultimate goal of recovery. These criteria are assessed on a species-by-species basis, especially as additional information becomes available, before considering downlisting and delisting.

For the purposes of recovery criteria in this recovery plan, a plant population is considered a group of conspecific individuals that are in close spatial proximity to each other (i.e., less than 3,280 feet [1,000 meters] apart) and are presumed to be genetically similar and capable of sexual reproduction. The numbers of reproducing individuals per population are used as a surrogate for effective population size (i.e., the number of individuals contributing to the next generation), since we do not have adequate data on most species to determine their effective population size. The numbers of mature individuals per population identified for the interim stage address concerns that numbers above 100 to 500 individuals have been recently shown as needed to avoid inbreeding, while those numbers in the downlisting and delisting criteria address concerns that around 5,000 mature individuals are needed to maintain evolutionary potential and resiliency, so that a species can adapt to changing environments (Reed et al. 2002, pp. 12–13; Traill et al. 2010, pp. 30, 32).

General distinctions made by the HPPRCC that are relevant to the 40 plants in this recovery plan include the following:

- *Life span*: Long-lived perennials are those taxa either known or believed to have life spans greater than 10 years; short-lived perennials are those known or believed to have life spans greater than 1 year but less than 10 years; and annuals are those known or believed to have life spans less than or equal to 1 year. When it is unknown whether a species is long- or short-lived, we have erred on the side of caution and considered the species short-lived. This will be revised as more is learned about the life histories of these species. We recognize that anecdotal observations of some translocated plants and long-term monitoring of other wild remnant individuals indicate that some species can live longer than 10 years. However, we do not know the natural life spans of many of these plants.

- *Range size*: Species with a narrow range are those currently known from one or two adjacent gulches or ridges within the same mountain range and may even include species that have been known only from a single population. For these species, given the limited information known of their habitat requirements, the number of mature individuals needed to prevent extinction was doubled within the known population rather than expanding the known range of the species for preventing extinction and the interim stage.

- *Reproduction strategies*: Obligate outcrossers are species that either have male and female flowers on separate plants or otherwise require cross-pollination to fertilize seeds, and, therefore, require equal numbers of male and female individuals contributing to reproduction, doubling the number of mature individuals needed for recovery. Species that reproduce vegetatively (i.e., without the use of seeds) may reproduce sexually only on occasion, resulting in the majority of the genetic variation being between populations; therefore, species that are dependent on vegetative reproduction require additional populations.

- *Population size trends*: Species that fluctuate in number of individuals from year to year require a larger number of mature individuals on average to allow for a decline in years of extreme habitat conditions and recuperation in numbers during years of more normal conditions.

- *Immediate vicinity*: Immediate vicinity of a population is defined as a 164-foot (50-meter) buffer around the existing population, but also depends on the threats specific to the population and on the response of the population to control of those threats, so will require adaptive management to ensure improving populations (HPPRCC 2011, p. 4).

The following downlisting and delisting criteria were determined based on known biology of the 40 plants in this recovery plan with consideration given to the above general guidelines.

Preventing Extinction Stage

In addition to achieving the number of reproducing individuals identified in Table 4, to meet the Preventing Extinction Stage target, a thorough and accurate population survey should be conducted and the population size estimated, all major threats must be controlled in the immediate vicinity of the populations, each population must show evidence of natural reproduction (i.e., viable seeds, seedlings, saplings), and 50 mature individuals from each population, or the total number of individuals if fewer than 50 remain, must be represented in an *ex situ* collection that is secure and well maintained as defined in the Center for Plant Conservation guidelines (Guerrant et al. 2004, entire).

Table 4. Number of populations and individuals needed for each plant species to meet Preventing Extinction Stage target based on population and life history characteristics.

Life Span	Population and Life History Characteristics	Number of Populations	Mature Individuals Per Population	Species
Long	No specific characteristics known	3	25	*Dracaena fernaldii*
Long	Obligate outcrosser	3	50	*Wikstroemia villosa*
Short	No specific characteristics known	3	50	*Bidens campylotheca* ssp. *pentamera*
		3	50	*Bidens campylotheca* ssp. *waihoiensis*
		3	50	*Bidens conjuncta*
		3	50	*Calamagrostis hillebrandii*
		3	50	*Cyanea duvalliorum*
		3	50	*Cyanea horrida*
		3	50	*Cyanea kauaulaensis*
		3	50	*Cyanea kunthiana*
		3	50	*Cyanea magnicalyx*
		3	50	*Cyanea maritae*
		3	50	*Cyanea obtusa*
		3	50	*Cyanea profuga*
		3	50	*Cyanea solanacea*
		3	50	*Cyrtandra filipes*
		3	50	*Cyrtandra hematos*
		3	50	*Geranium hillebrandii*
		3	50	*Hypolepis hawaiiensis* var. *mauiensis*
		3	50	*Mucuna persericea*
		3	50	*Myrsine vaccinioides*
		3	50	*Phyllostegia bracteata*
		3	50	*Phyllostegia haliakalae*
		3	50	*Phyllostegia pilosa*
		3	50	*Schiedea diffusa* ssp. *diffusa*
		3	50	*Schiedea pubescens*

Life Span	Population and Life History Characteristics	Number of Populations	Mature Individuals Per Population	Species
Short	Narrow range	Known populations	100	*Cyanea mauiensis*
		Known populations	100	*Cyanea munroi*
		Known populations	100	*Cyperus neokunthianus*
		Known populations	100	*Cyrtandra ferripilosa*
		Known populations	100	*Cyrtandra oxybapha*
		Known populations	100	*Festuca molokaiensis*
		Known populations	100	*Geranium hanaense*
		Known populations	100	*Peperomia subpetiolata*
		Known populations	100	*Schiedea jacobii*
		Known populations	100	*Schiedea laui*
Short	Obligate outcrosser	3	100	*Pittosporum halophilum*
		3	100	*Schiedea salicaria*
Short	Tendency for decline or fluctuation in numbers	3	150	*Cyanea asplenifolia*
Short	Vegetatively reproducing	6	50	*Stenogyne kauaulaensis*

Interim Stage

In addition to achieving the minimum number of populations and reproducing individuals per population identified in Table 5, to meet the Interim Stage targets, populations should be successfully reproducing, including evidence of seedlings transitioning to mature individuals and/or age-class distribution indicative of a stable population. The populations must be adequately represented in an *ex situ* collection that is secure and well maintained as defined in the Center for Plant Conservation's guidelines (Guerrant et al. 2004, entire). Reintroduced populations can be counted toward the minimum number of populations when it is demonstrated that they are producing viable seed or vegetatively regenerating. Species known from multiple islands will be represented by at least one population on each of the islands from which they were known historically, so long as suitable habitat exists. Genetic analysis must be conducted for all wild and any reintroduced populations to determine the genetic variation within and among populations, incorporating any stock in controlled propagation that has been lost in the wild. The results of the genetic analysis will be used to develop translocation strategies to correct any genetic deficiencies and determine if translocation efforts should be single-sourced or from multiple wild populations. Adequate monitoring should be in place to assess individual plant survival, population trends, trends of major limiting factors, and the response of populations to threat management.

Table 5. Number of populations and individuals needed for each plant species to meet the Interim Stage target based on population and life history characteristics.

Life Span	Population and Life History Characteristics	Number of Populations	Mature Individuals Per Population	Species
Long	No specific characteristics known	3	100	*Dracaena fernaldii*
Long	Obligate outcrosser	3	200	*Wikstroemia villosa*
Short	No specific characteristics known	3	300	*Bidens campylotheca* ssp. *pentamera*
		3	300	*Bidens campylotheca* ssp. *waihoiensis*
		3	300	*Bidens conjuncta*
		3	300	*Calamagrostis hillebrandii*
		3	300	*Cyanea duvalliorum*
		3	300	*Cyanea horrida*
		3	300	*Cyanea kauaulaensis*
		3	300	*Cyanea kunthiana*
		3	300	*Cyanea magnicalyx*
		3	300	*Cyanea maritae*
		3	300	*Cyanea obtusa*
		3	300	*Cyanea profuga*
		3	300	*Cyanea solanacea*
		3	300	*Cyrtandra filipes*
		3	300	*Cyrtandra hematos*
		3	300	*Geranium hillebrandii*
		3	300	*Hypolepis hawaiiensis* var. *mauiensis*
		3	300	*Mucuna persericea*
		3	300	*Myrsine vaccinioides*
		3	300	*Phyllostegia bracteata*
		3	300	*Phyllostegia haliakalae*
		3	300	*Phyllostegia pilosa*
		3	300	*Schiedea diffusa* ssp. *diffusa*
		3	300	*Schiedea pubescens*

Life Span	Population and Life History Characteristics	Number of Populations	Mature Individuals Per Population	Species
Short	Narrow range	Known populations	600	*Cyanea mauiensis*
		Known populations	600	*Cyanea munroi*
		Known populations	600	*Cyperus neokunthianus*
		Known populations	600	*Cyrtandra ferripilosa*
		Known populations	600	*Cyrtandra oxybapha*
		Known populations	600	*Festuca molokaiensis*
		Known populations	600	*Geranium hanaense*
		Known populations	600	*Peperomia subpetiolata*
		Known populations	600	*Schiedea jacobii*
		Known populations	600	*Schiedea laui*
Short	Obligate outcrosser	3	600	*Pittosporum halophilum*
		3	600	*Schiedea salicaria*
Short	Tendency for decline or fluctuation in numbers	3	900	*Cyanea asplenifolia*
Short	Vegetatively reproducing	6	300	*Stenogyne kauaulaensis*

Downlisting Stage

To consider downlisting the 40 plant species from endangered to threatened, the following criteria must be met:

Downlisting Criteria

Criterion 1: In addition to achieving the numbers of mature individuals per population identified in Table 6 and meeting all of the goals in the Interim Stage, at least 5 or at least 10 populations (depending on the species' life history characteristics) designated for downlisting must be stable, secure, and naturally reproducing for a minimum of 10 years to be considered for downlisting. Species known from multiple islands should be represented by at least three populations on each of the islands from which they were known historically, so long as suitable habitat exists. Downlisting should not be considered until an adequate viability analysis has been conducted to confirm the number of individuals needed to achieve a viable population. This analysis should be based on current management and monitoring data collected at regular intervals determined by the life history, threats, and management parameters of the species (i.e., major limiting factors, breeding system, population structure and density, and proven management methods for major threats). However, a viability analysis should be only one of the factors used in making a recommendation to downlist a species.

Criterion 2: Habitat around each population that contributes to meeting Downlisting Criterion 1 must be managed to ensure that it will support the long-term persistence of the species. To achieve this, each of the populations identified for downlisting will have a management and monitoring plan that will identify actions and procedures necessary to ensure that all habitat-level threats (i.e., ungulates, invasive plants) are controlled. Species-specific management actions may continue to be necessary to ensure that populations of each species are increasing.

Table 6. Number of population and individuals of each plant species needed for downlisting based on population and life history characteristics.

Life Span	Population and Life History Characteristics	Number of Populations	Mature Individuals Per Population	Species
Long	No specific characteristics known	5	200	*Dracaena fernaldii*
Long	Obligate outcrosser	5	400	*Wikstroemia villosa*
Short	No specific characteristics known	5	500	*Bidens campylotheca* ssp. *pentamera*
		5	500	*Bidens campylotheca* ssp. *waihoiensis*
		5	500	*Bidens conjuncta*
		5	500	*Calamagrostis hillebrandii*
		5	500	*Cyanea duvalliorum*
		5	500	*Cyanea horrida*
		5	500	*Cyanea kauaulaensis*
		5	500	*Cyanea kunthiana*
		5	500	*Cyanea magnicalyx*
		5	500	*Cyanea maritae*
		5	500	*Cyanea obtusa*
		5	500	*Cyanea profuga*
		5	500	*Cyanea solanacea*
		5	500	*Cyrtandra filipes*
		5	500	*Cyrtandra hematos*
		5	500	*Geranium hillebrandii*
		5	500	*Hypolepis hawaiiensis* var. *mauiensis*
		5	500	*Mucuna persericea*
		5	500	*Myrsine vaccinioides*
		5	500	*Phyllostegia bracteata*
		5	500	*Phyllostegia haliakalae*
		5	500	*Phyllostegia pilosa*
		5	500	*Schiedea diffusa* ssp. *diffusa*
		5	500	*Schiedea pubescens*

Life Span	Population and Life History Characteristics	Number of Populations	Mature Individuals Per Population	Species
Short	Narrow range	5	500	*Cyanea mauiensis*
		5	500	*Cyanea munroi*
		5	500	*Cyperus neokunthianus*
		5	500	*Cyrtandra ferripilosa*
		5	500	*Cyrtandra oxybapha*
		5	500	*Festuca molokaiensis*
		5	500	*Geranium hanaense*
		5	500	*Peperomia subpetiolata*
		5	500	*Schiedea jacobii*
		5	500	*Schiedea laui*
Short	Obligate outcrosser	5	1,000	*Pittosporum halophilum*
		5	1,000	*Schiedea salicaria*
Short	Tendency for decline or fluctuation in numbers	5	1,500	*Cyanea asplenifolia*
Short	Vegetatively reproducing	10	500	*Stenogyne kauaulaensis*

Delisting Stage

To consider delisting the 40 listed plant species, the downlisting criteria above should be met for a 10-year period, as well as the following criteria:

Delisting Criteria

Criterion 1: In addition to meeting the downlisting targets and achieving the number of mature individuals identified in Table 7, a taxon must be represented by at least 10 or at least 20 populations (depending on life history characteristics) that are stable, secure, and naturally reproducing for a minimum of 20 years within secure and viable habitats to be considered for delisting.

Criterion 2: Species-specific management actions (e.g., hand-pollination, propagation, and translocation) should no longer be necessary, but an ongoing need for habitat-wide management actions may remain if long-term agreements are in place to continue management. Management and monitoring plans shall be fully implemented for each management unit so that habitat level threats are controlled. All populations that contribute to meeting Delisting Criterion 1 shall be within areas fenced and protected from ungulates, and with agreements from conservation partners to maintain those protections long-term.

Table 7. Number of populations and individuals of each plant species recommended for delisting based on population and life history characteristics.

Life Span	Population and Life History Characteristics	Number of Populations	Mature Individuals Per Population	Species
Long	No specific characteristics known	10	200	*Dracaena fernaldii*
Long	Obligate outcrosser	10	400	*Wikstroemia villosa*
Short	No specific characteristics known	10	500	*Bidens campylotheca* ssp. *pentamera*
		10	500	*Bidens campylotheca* ssp. *waihoiensis*
		10	500	*Bidens conjuncta*
		10	500	*Calamagrostis hillebrandii*
		10	500	*Cyanea duvalliorum*
		10	500	*Cyanea horrida*
		10	500	*Cyanea kauaulaensis*
		10	500	*Cyanea kunthiana*
		10	500	*Cyanea magnicalyx*
		10	500	*Cyanea maritae*
		10	500	*Cyanea obtusa*
		10	500	*Cyanea profuga*
		10	500	*Cyanea solanacea*
		10	500	*Cyrtandra filipes*
		10	500	*Cyrtandra hematos*
		10	500	*Geranium hillebrandii*
		10	500	*Hypolepis hawaiiensis* var. *mauiensis*
		10	500	*Mucuna persericea*
		10	500	*Myrsine vaccinioides*
		10	500	*Phyllostegia bracteata*
		10	500	*Phyllostegia haliakalae*
		10	500	*Phyllostegia pilosa*
		10	500	*Schiedea diffusa* ssp. *diffusa*
		10	500	*Schiedea pubescens*

Life Span	Population and Life History Characteristics	Number of Populations	Mature Individuals Per Population	Species
Short	Narrow range	10	500	*Cyanea mauiensis*
		10	500	*Cyanea munroi*
		10	500	*Cyperus neokunthianus*
		10	500	*Cyrtandra ferripilosa*
		10	500	*Cyrtandra oxybapha*
		10	500	*Festuca molokaiensis*
		10	500	*Geranium hanaense*
		10	500	*Peperomia subpetiolata*
		10	500	*Schiedea jacobii*
		10	500	*Schiedea laui*
Short	Obligate outcrosser	10	1,000	*Pittosporum halophilum*
		10	1,000	*Schiedea salicaria*
Short	Tendency for decline or fluctuation in numbers	10	1,500	*Cyanea asplenifolia*
Short	Vegetatively reproducing	20	500	*Stenogyne kauaulaensis*

Rationale for Plant Recovery Criteria

The recovery criteria for the 40 plants are based on the current known biology of the species from the latest Species Report, the Hawai‘i and Pacific Plants Recovery Coordinating Committee’s Revised Recovery Objective Guidelines, and expert opinion (HPPRCC 2011, entire; Table 2).

Several life history traits explained above were identified as important to maintaining stable effective population size and were therefore incorporated into the numbers of populations or mature individuals needed for downlisting or delisting, depending on the impact of each life history trait (Pavlik 1996, entire). Translocations will be a crucial action to achieving recovery for many of these Hawaiian plants, especially to increase resiliency and redundancy in the face of increasing catastrophic events. Each translocation effort should consider the genetic composition of the founders, number of founders used, number of individuals from each founder, and the species’ reproductive capacity and habitat availability. For all species, some level of habitat management will be required to maintain viable populations, and in some cases habitat restoration will be necessary.

The minimum number of populations and the number of reproducing individuals in each population necessary to prevent extinction (and meet those preventing extinction goals) are based on models that demonstrate loss of genetic variation in populations of various sizes. For example, a population of 25 individuals will lose approximately 25 percent of its genetic variation over 10 generations. Vegetatively-reproducing and dioecious (i.e., obligate-outcrossing) species are believed to possess less genetic variation than monoecious and hermaphroditic species; hence, to minimize the loss of genetic variation, the number of populations or individuals per population of the former species (vegetatively-reproducing and dioecious, respectively) needs to be higher than the that for the latter species (see HPPRCC 2011, entire; Hartl and Clark 1989, entire).

2. Recovery Criteria – Tree Snails

Objective – Manage threats and habitats to establish self-sustaining, resilient, naturally reproducing viable populations of each listed tree snail species within Maui Nui.

Using available data on collection localities, survey history, habitat distribution, and genetic differentiation, appropriate GUs and ESUs should be identified and delineated for both species of Lānaʻi tree snails and Newcomb's tree snail whenever possible. A GU for a morphotype (i.e., any of a group of different types of individuals from the same species in a population) of a *Partulina* or *Newcombia* tree snail species is defined as the landscape distribution of the morphotype in relation to other morphotypes of the same species. Tree snail morphotypes and GUs will be determined by expert tree snail ecologists and taxonomists working with botanists, invertebrate and wildlife biologists, and landscape ecologists and in consultation with the State of Hawaiʻi and the Service. ESUs are groups within a species that are defined by genetic characters that cluster individuals into populations that are exclusive from other such clusters (Vogler and DeSalle 1994, entire; Waples 1998, entire; Pennock and Dimmick, 1997, entire; Riddle and Hafner 1999, entire; Fraser and Bernatchez 2001, entire; Holland and Hadfield 2002, entire; Holland and Hadfield 2007, entire). Because genetic information should reflect evolutionary structure more directly, the delineation of genetically based ESUs should take precedence over the GUs of morphotypes if genetic data are available. Whenever possible, ESUs will be defined by analysis of genetic data for each extant species, following the best available scientific standards.

We provide both downlisting and delisting criteria for the Lānaʻi tree snails and Newcomb's tree snail as follows:

Downlisting Criteria

To downlist either of the Lānaʻi tree snails or Newcomb's tree snail from endangered to threatened, the following criteria must be met for each species being considered:

Criterion 1. At least six stable populations (possibly actively managed) exist on Lānaʻi (for the Lānaʻi tree snails) or Maui (for Newcomb's tree snail). To be considered stable, a population must number at least 300 individuals distributed across all size classes combined and must have a population growth curve or index trend that is stable or positive for at least 4 of the 5 years prior to consideration of downlisting. If multiple management units have been identified for the species based on genetic characters or geography, each unit must comprise one or more of these stable populations.

Criterion 2. Each population in *Downlisting Criterion 1* occurs on suitable habitat that is managed to protect native forest vegetation. Habitat must be capable of supporting natural dispersal, expansion of the occupied range, and positive population growth as determined by the best available scientific information.

Criterion 3. All predation threats are controlled or absent around each population in *Downlisting Criterion 1*. Evaluation of predation risk for each population in *Downlisting Criterion 1* indicate that nonnative predators are absent or that predation is unlikely to have significant short-term impacts on the population. Species-specific management actions may continue to be necessary. Measures are in place to prevent introduction of new predators or disease to the populations in *Downlisting Criterion 1* and captive reared populations.

Delisting Criteria

For either of the Lānaʻi tree snails or Newcomb's tree snail to be considered fully recovered, the species must maintain viable free-living populations in areas actively managed to protect native vegetation. The following criteria must be met for either of the Lānaʻi tree snail species or Newcomb's tree snail to be considered for delisting:

Criterion 1. At least 12 populations (possibly actively managed) exist on Lānaʻi (for the Lānaʻi tree snails) or Maui (for Newcomb's tree snail). All populations must number at least 300 individuals, distributed across all size classes combined. Each of these populations must have a population growth curve or index trend that is stable or positive for at least 7 of 10 years prior to consideration of delisting. If multiple management units have been identified for the species based on morphological or genetic characters, each unit must comprise two or more of these populations.

Criterion 2. Each population in *Delisting Criterion 1* occurs in suitable habitat that is managed to protect natural forest vegetation and is capable of supporting expansion of the occupied range, positive population growth, and establishment of new populations through natural dispersal.

Criterion 3. Evaluation of predation risk for each population in *Delisting Criterion 1* indicates at least one of the following: (a) all nonnative predators are absent; (b) predator control with long-term management commitment has successfully reduced predation pressure such that population viability is maintained; and/or (c) quantitative data on demography and predator/prey dynamics in the population indicate that the population will maintain long-term viability without active predator control. Species-specific management actions may continue to be necessary. Measures are in place to prevent introduction of new predators or disease to the populations in *Delisting Criterion 1*.

Rationale for Tree Snail Recovery Criteria

The downlisting and delisting criteria for both species of Lānaʻi tree snails and Newcomb's tree snail are based on information about the three species' biology and threats as described in the associated Species Reports (USFWS 2023cc; USFWS 2023jj; USFWS 2023kk), their general similarity to the Oʻahu tree snails (*Achatinella* spp.) in the same family (Achatinellidae) and Hawaiian endemic subfamily (Achatinellinae), and expert opinion.

The strategic plan and mission of the Snail Extinction Prevention Program (SEPP) in Hawaiʻi focuses on conserving and preventing extinction of tree snails throughout the islands (DLNR

2017). Alignment of the mutual strategies of SEPP and the Service are necessary to recover listed tree snails. Expanding the SEPP program's capacity for protecting and conserving tree snail species throughout Maui Nui is a critical component in the recovery of the three listed tree snail species on Maui and Lāna‘i.

The general biology of the Lāna‘i and Newcomb's tree snail species is similar to that of the O‘ahu tree snail species. Likewise, the three genera face the same threats in their respective habitats. In 2003, the Service recommended active management of 10 populations of each species of O‘ahu tree snail to stop the continuing declines in number of populations, number of individuals, geographic ranges, and species' genetic diversity (USFWS 2003). In practice, the management of six to eight populations has proven to be effective for stabilizing one species, *Achatinella mustelina* (U.S. Army Garrison 2008, pp 9–1 through 9–46). Successful protection and management of several populations of *A. mustelina* have demonstrated that each of the extant species of federally-listed O‘ahu tree snails can be stabilized by actively managing 6 to 10 populations of each species (USFWS 2019b). This estimate of 6 to 10 populations per species is based on the snails' extreme vulnerability to catastrophic decline from predation by nonnative predators (snails, rats, flatworms, and chameleons; Hadfield and Mountain 1980, p. 355; Hadfield 1986, entire; Hadfield et al. 1993, entire; Hadfield and Saufler 2009, entire; Holland et al. 2010, entire), and the need to protect the remaining genetic diversity across the historical range of each species (Erickson and Hadfield 2014, entire; Price and Hadfield 2014, entire; Price et al. 2015, entire; Sischo et al. 2016, entire), as shown for *A. mustelina* (Holland and Hadfield. 2002, entire).

The population size threshold of 300 individual snails, required for a population to contribute to meeting downlisting or delisting criteria, is based on the recorded size of a growing wild population of *Achatinella mustelina* in the Pahole Natural Area Reserve (Hadfield et al. 1993, pp. 615-618) on O‘ahu. This population consisted of a single group of tree snails in an unprotected 270-square-foot (25-square-meter) area that was relatively free of predation. However, the population was eventually decimated by nonnative predatory snails and rats prior to reaching a stable population size or carrying capacity. In a population of this size with a typical distribution of size classes, approximately 120 individuals are anticipated to be adults (Sischo pers. comm. 2019, entire). Depending on the area that is actively managed, the size of a population may increase beyond 300 snails. These numbers are initial targets, but may be revised as additional information is available, including adequate viability analyses for individual species.

Because predation risk is the primary conservation concern for these species, downlisting and delisting will require a clear understanding of nonnative predator distribution, abundance, and predator-prey dynamics within each snail population unit. In order for a snail population to contribute to meeting downlisting and delisting criteria, its sustained viability with stable to positive growth must be clearly confirmed. If a population does successfully coexist with predators, with or without special management, it could potentially meet this standard with continuing population monitoring. However, given the extensive history of Achatinellinae extirpations in the Pacific islands, it is necessary to maintain a diverse range of populations at sites where predation risk is completely absent. Thus, we expect that establishing and maintaining snail populations in predator-free sites that may include predator-proof snail enclosures or other protected sites will continue to be a necessary part of recovering the species.

The recovery criteria for both Lānaʻi tree snail species and Newcomb's tree snail support representation by ensuring the ecological, morphological, behavioral, and genetic diversity of the species is conserved across their historical range. The criteria support redundancy by recommending distribution of more than one of each population unit be distributed throughout their historical range. The criteria support resiliency through stable or increasing populations. Continuous monitoring and evaluation loops will be used to measure progress toward meeting the recovery criteria. Population viability modeling or other scientific methods approved by the Service and utilizing best available science at the time downlisting or delisting is considered, will be necessary to determine if the habitat is capable of supporting natural dispersal, expansion of the occupied range, and positive population growth.

3. Recovery Criteria – Hilaris Yellow-faced Bee

Objective – Manage threats and habitats to establish self-sustaining, resilient, naturally reproducing viable populations of hilaris yellow-faced bees throughout Maui Nui.

Downlisting Criteria

No critical habitat has been designated for the hilaris yellow-faced bee. Until more specific management units are otherwise identified, criteria for this species will refer to three management units in coastal strand habitat on the islands of Maui, Lānaʻi, and Molokaʻi.

To downlist the hilaris yellow-faced bee from endangered to threatened, the following criteria must be met:

Criterion 1. Existing population(s) of hilaris yellow-faced bees are identified and stabilized. The hilaris yellow-faced bee is established in coastal habitats within its historical range in each island management unit (Maui, Lānaʻi, and Molokaʻi). Populations within each management unit are sufficiently distributed to reduce their vulnerability to extirpation by a single tsunami, flood, or other catastrophic event. For each management unit, a population index based on repeated surveys with consistent methodology indicates stable to increasing index trends for at least 5 years immediately prior to consideration of downlisting.

Criterion 2. Systematic research, surveys, and evaluation over at least 10 years indicate the nest-host species of hilaris yellow-faced bee are maintaining viable reproducing populations, and their long-term persistence in the coastal strand of each island (Maui, Lānaʻi, and Molokaʻi) is not threatened by development, fire, invasive plants, or cleptoparasitization by other species.

Criterion 3. Coastal strand habitat occupied by the hilaris yellow-faced bee and its nest-host species at population sites in *Downlisting Criterion 1* is protected from threats (e.g., invasive plants, ungulates, and fire), provides sufficient native plant food and nesting resources to support the hilaris yellow-faced bee and its nest-host species, and is protected and managed in perpetuity.

Criterion 4. At each population site in *Downlisting Criterion 1*, monitoring indicates that all major species-specific threats (e.g., predation, competition, and disease) are absent or controlled. Nonnative predators are absent, or predation and competition are unlikely to have significant long-term impacts on population indices of the hilaris yellow-faced bee and its nest-host species. Species-specific management actions may continue to be necessary. Measures are in place to prevent introduction of new nonnative predators, competitors, or disease to the populations in *Downlisting Criterion 1*.

Delisting Recovery Criteria

For the hilaris yellow-faced bee to be considered fully recovered, the species must maintain viable populations in suitable habitats that are either naturally self-sustaining or actively managed to protect native vegetation and prevent habitat degradation. The following criteria must be met for the species to be considered for delisting:

Criterion 1. In addition to the downlisting criteria being met, an additional 10 years of systematic surveys have shown significant increases in the abundance and distribution of the hilaris yellow-faced bee and its nest-host species throughout the three management units (Maui, Lānaʻi, and Molokaʻi). For each management unit, a population index based on repeated surveys with a consistent methodology indicates stable to increasing index trends over at least 7 of 10 years prior to consideration of delisting. Populations should exist within habitat that is capable of supporting natural dispersal, breeding opportunities, and expansion of the occupied range, and should provide redundancy on each island (Maui, Lānaʻi, and Molokaʻi).

Criterion 2. Systematic research, surveys, and evaluation over at least 10 years since downlisting indicate that the nest-host species of hilaris yellow-faced bee are maintaining viable reproducing populations, and their long-term persistence in the coastal strand of each island (Maui, Lānaʻi, and Molokaʻi) is not threatened by development, fire, invasive plants, or cleptoparasitization.

Criterion 3. Coastal strand habitat occupied by the hilaris yellow-faced bee and its nest-host species at population sites in *Delisting Criterion 1* is protected from threats (e.g., invasive plants, ungulates, and fire), provides sufficient native plant food and nesting resources to support the hilaris yellow-faced bee and its nest-host species, and is protected and managed in perpetuity.

Criterion 4. At each population site in *Delisting Criterion 1*, monitoring in at least 4 of the 10 years immediately prior to delisting consideration indicates that all major species-specific threats (predation, competition, or disease) are absent or controlled. Nonnative predators are absent, or predation and competition are unlikely to have significant long-term impacts on population indices of the hilaris yellow-faced bee and its nest-host species. Species-specific habitat management actions may continue to be necessary. Measures are in place to prevent introduction of new nonnative predators, competitors, or disease to the populations in *Delisting Criterion 1*.

Rationale for Hilaris Yellow-faced Bee Recovery Criteria

The downlisting and delisting criteria for the hilaris yellow-faced bee (*Hylaeus hilaris*) are based on the information about the species' biology, ecology, distribution, and threats (USFWS 2023y). The species is a solitary cleptoparasite that is dependent on the nests of other ground-nesting *Hylaeus* species, several of which are themselves endangered (USFWS 2016a). Therefore, recovery of the hilaris yellow-faced bee also requires the recovery of one or more of its host species. The recovery criteria consider all threats to the species and its nest-host and will be informed by the best available science at the time that downlisting or delisting is considered.

Because this cleptoparasitic species is dependent upon the availability of suitable *Hylaeus* host nests for reproduction, recovery criteria also include the basic requirements of establishing those, also rare, hosts. Three of those nest-host species (*Hylaeus anthracinus*, *Hylaeus assimulans*, and *Hylaeus longiceps*) are listed and have their own recovery criteria (USFWS 2022). The criteria require each population of the cleptoparasite and its nest-host species have stable to positive trends in population indices sustained for a minimum number of sequential years. Methods to assess population indices of solitary bee aggregations will need to be developed and tested.

The criteria require establishing a diverse range of suitable food resources (nectar and pollen) available for the hilaris yellow-faced bee and its nest-host species during the entire nesting period. The food resources for pollen and nectar must be from a diverse range of suitable hosts capable of sustaining the population throughout the breeding period. The amount of acreage, species composition, and percentage of native cover will depend on which nest-host species is or are supporting the hilaris yellow-faced bee population. Research and quantification methodologies will be needed to determine the amount and composition of such food (pollen and nectar) or nesting resources necessary to support a stable to growing population of the nest-host species and the cleptoparasite. Required composition, percentage, and amount of suitable plant-host resources within the habitat of the breeding populations will be based on the best available science at the time that downlisting and delisting are considered. In addition, the food resources must be within the foraging range of individuals in order to allow successful reproduction. These factors must be adequate to sustain a stable to positive growth rate of the population, as determined by population viability analyses or other analyses that are approved by the Service and considered the best science at the time that downlisting and delisting are considered.

Predation by ants and other nonnative insects, as well as competition for pollen and nectar, are primary conservation concerns for the hilaris yellow-faced bee and its nest hosts. Downlisting and delisting will require a clear understanding of nonnative predator distribution, abundance, and predator-prey dynamics within each population within each management unit. Populations of the hilaris yellow-faced bee and its nest hosts could contribute to meeting downlisting and delisting criteria if they are successfully coexisting with predators and have been clearly confirmed to be sustaining viability and showing stable to positive growth, with or without special management. However, given the extreme rarity of the hilaris yellow-faced bee, establishing procedures to augment the population via captive rearing or other measures will continue to be a necessary part of recovering the species.

The recovery criteria for the hilaris yellow-faced bee support species redundancy by recommending multiple populations be distributed throughout the species historical range on each island (Maui, Lāna‘i, and Moloka‘i). The criteria support species representation by ensuring the ecological, behavioral, and genetic diversity of the species is conserved across its historical range. The criteria support population resiliency through stable or increasing populations. The recovery criteria will require population viability evaluations or other approved analyses to consider downlisting or delisting.

III. RECOVERY ACTIONS

This recovery plan identifies recovery actions needed to implement the recovery strategy and attain the recovery criteria. Implementation of a recovery action will depend on its priority, availability of funds and resources, coordination with partners, and complexity and logistical constraints. A broad action may have multiple components developed as needed to best accomplish recovery implementation. Specific project-level implementation of these actions will be accomplished through shorter-term activities (collectively referred to as the Recovery Implementation Strategy) in coordination with recovery partners interested and willing to work on implementing the activities. Activities are intended to be adaptable and guide recovery partners to coordinate recovery implementation and further describe those responsible for each action described in the recovery plan. Because these activities will be described in working documents, they can be modified as needed without requiring future revision of the recovery plan, so long as they are consistent with the recovery plan.

As discussed in the Introduction, this recovery plan is a guidance document rather than being regulatory in nature. As such, implementation of recovery actions is voluntary and depends on the cooperation and commitment of numerous partners in this conservation effort. Note that all Federal agencies have an obligation under section 7(a)(1) of the Act to carry out programs for conservation of federally-listed species.

The actions needed to alleviate threats to all species and achieve recovery criteria are organized below into five categories: (1) Protect habitats and control threats in management units; (2) Control species-specific threats; (3) Expand the distribution of existing wild populations and establish new populations; (4) Conduct additional research essential to recovering the 44 species and restoring their habitats; and (5) Implement regulations and policy to support species recovery. Development and implementation of a detailed monitoring plan for each management action is necessary to assess the effects of an action on each species, inform adaptive management responses, and evaluate progress towards recovery criteria. The applicability of each action to the three groups of species (plants, tree snails, and yellow-faced bee) is summarized in Tables 8, 9, and 10, respectively.

1. **Protect habitats and control threats in management units.**

   The habitats that support the species throughout their range must be identified and protected from threats. Each management unit required for the species' recovery must have sufficient protected habitat to sustain the recovered population.

   1.1. Identify habitats that may support each species and survey for extant individuals and populations.

   1.2. Develop microclimate models and identify suitable habitat based on historical and existing species' distributions and potential future climate conditions.

   1.3. Identify and prioritize management units that are necessary for species recovery.

   1.4. Ensure long-term protection of management units.

    - 1.4.1. Identify threats specific to management units.
    - 1.4.2. Construct and maintain ungulate fences around high-priority areas within management units.
    - 1.4.3. Construct and maintain predator-proof enclosures around high-priority populations or in high-priority areas within management units.
    - 1.4.4. Remove ungulates from high-priority fenced areas.
    - 1.4.5. Remove predators from predator-proof enclosures.
    - 1.4.6. Control or eradicate habitat-modifying invasive plants from management units.
    - 1.4.7. Develop and implement a rodent eradication program within management units.
    - 1.4.8. Provide wildfire protection as necessary.
        - 1.4.8.1. 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.
        - 1.4.8.2. Assess the need for fire management plans in habitats affected by climate change.
    - 1.4.9. Protect management units from human disturbance as necessary.
    - 1.4.10. Conduct surveys, focused on likely source areas (e.g., airports, docks), and control newly discovered pest or invasive species prior to their dispersal to management units.
    - 1.4.11. Control other threats to management units as appropriate.
- 1.5. Monitor management and use results to adapt management actions.

2. Control species-specific threats.

These management interventions are needed to address factors that negatively influence species viability. The threats, which may be human-caused or naturally occurring, contributed to the listing of the species or have since been negatively affecting the species and/or its habitat and impeding recovery of the species.

- 2.1. Develop and implement control programs for slugs.
- 2.2. Develop and implement control programs for rodents.
- 2.3. Develop and implement control programs for predatory snail species (*Euglandina* spp. and others).
- 2.4. Develop and implement control programs for Jackson’s chameleon.
- 2.5. Develop and implement control programs for nonnative ants (e.g., big-headed ant, yellow crazy ant, Papuan thief ant, and tropical fire ant).
- 2.6. Develop and implement control programs for western yellow jacket wasps.
- 2.7. Monitor populations to detect disease, assess impacts, and control outbreaks as soon as possible, if needed.

2.8. Control other threats to specific species as appropriate.

2.9. Monitor management and use results to adapt management actions.

3. **Expand the distribution of existing wild populations and establish new populations.**

Captive propagation of each species will be maintained to establish pools of genetic resources to safeguard against loss in wild populations. Increasing the abundance of individuals in each population and the number of populations across the range of each species is expected to improve each species' resiliency, redundancy, and representation, and therefore, improve species viability. Improved species viability is needed for recovery of each species.

3.1. Identify areas within management units appropriate for translocating individuals.

3.2. Identify species suitable for translocation and develop and implement translocation plans for each according to IUCN Reintroduction Guidelines (2013).

3.3. Select populations for translocation.

3.4. Prepare reintroduction sites.

3.5. For plants, propagate genetically appropriate individuals for genetic storage and for translocation; for invertebrates, develop or expand captive rearing systems and establish populations from appropriate genetic sources for translocation.

3.6. Translocate genetically appropriate individuals into managed sites.

3.7. Consider the feasibility and conservation benefit of translocating species outside of their known historical range as appropriate (e.g., assisted colonization or ecological replacement).

3.8. Monitor management and use results to adapt management actions.

4. **Conduct additional research and develop methods essential to recovering the 44 species and restoring their habitats.**

Research and develop tools and methods that assess species biology and ecology, manage threats, establish or improve propagation, captive rearing, or genetic storage, inform species growth rate and viability, and improve outcomes.

4.1. Develop tools to enhance habitat and species survival and reproduction.

4.2. Develop tools to inform actions that will improve species viability *in situ* and *ex situ.*

4.3. Conduct studies on the range, demography, and dispersal of each species.

4.4. Conduct research on threats to species' viability.

4.5. Develop tools for monitoring population growth and status.

4.6. Conduct Population Viability Analyses (PVA) for each species.

4.7. Conduct studies to optimize conservation translocation survival and success.

4.8. Develop spatial and operational planning tools to enhance cost effectiveness of implementation.
4.9. Identify and prioritize opportunities for multiple-species management and recovery.

5. Implement regulations and policy to support species recovery.

Recovery will require partnerships with State, Federal, and private stakeholders to prevent introduction and establishment of new invasive species or other factors that will negatively affect the species, their habitats, or both, and impede recovery of the species.

5.1. Implement the Hawaiʻi interagency biosecurity plan to prevent the influx of new pests and invasive species into Hawaiʻi and more specifically the islands of Maui Nui.

5.2. Implement public outreach and education and enforce policies that prohibit species collection and harassment.

Table 8. Crosswalk relating threats, recovery criteria, and recovery actions for plants.

Species Group: Plants			
Listing Factor	**Specific Threat Under the Listing Factor**	**Recovery Criteria Numbers**	**Recovery Action Numbers**
A Present or Threatened Destruction, Modification or Curtailment of its Habitat or Range	Agriculture and urban development	Downlisting 1 and 2; Delisting 1 and 2	1.3, 1.4, 1.5, 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7, 3.8, 4.4, 4.6, 4.7, 4.8, 4.9, 5.1, 5.2
	Ungulates	Downlisting 1 and 2; Delisting 1 and 2	1.4, 1.5, 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7, 3.8, 4.4, 4.6, 4.7, 4.8, 4.9
	Nonnative plants	Downlisting 1 and 2; Delisting 1 and 2	1.4, 1.5, 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7, 3.8, 4.1, 4.4, 4.6, 4.8, 4.9
	Fire	Downlisting 1 and 2; Delisting 1 and 2	1.4, 1.5, 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7, 3.8, 4.6, 4.8, 4.9
	Stochastic events	Downlisting 1 and 2; Delisting 1 and 2	1.4, 1.5, 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7, 3.8, 4.4, 4.6, 4.8, 4.9
B Overutilization	Not applicable		
C Disease or Predation	Disease	Downlisting 1 and 2; Delisting 1 and 2	1.4, 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7, 3.8, 4.1, 4.2, 4.4, 4.6, 4.8, 4.9
	Predation / Herbivory by nonnative ungulates	Downlisting 1 and 2; Delisting 1 and 2	1.4, 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7, 3.8, 4.4, 4.7, 4.8, 4.9
	Predation / Herbivory by other nonnative vertebrates	Downlisting 1 and 2; Delisting 1 and 2	1.4, 2.2, 2.3, 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7, 3.8, 4.4, 4.7
	Predation / Herbivory by nonnative invertebrates	Downlisting 1 and 2; Delisting 1 and 2	1.4, 2.1, 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7, 3.8, 4.4, 4.7, 4.8, 4.9

Species Group: Plants			
Listing Factor	**Specific Threat Under the Listing Factor**	**Recovery Criteria Numbers**	**Recovery Action Numbers**
D Inadequacy of Existing Regulatory Mechanisms	Inadequate existing regulatory mechanisms	Delisting 1 and 2	5.1
E Other Natural or Manmade Factors	Other species-specific threats	Downlisting 1 and 2; Delisting 1 and 2	1.1, 1.4, 2.7, 2.8, 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7, 3.8, 4.3, 4.4, 4.5, 4.6, 4.7, 4.8, 4.9, 5.1, 5.2
	Hybridization	Downlisting 1 and 2; Delisting 1 and 2	1.1, 1.3, 1.4, 1.5, 2.7, 2.8, 2.9, 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7, 3.8, 4.3, 4.4, 4.6, 4.7, 4.8, 4.9
	No regeneration	Downlisting 1 and 2; Delisting 1 and 2	1.1, 1.3, 1.4, 1.5, 2.1, 2.2, 2.7, 2.8, 3.4, 3.5, 3.8, 4.1, 4.2, 4.3, 4.4, 4.5, 4.6, 4.7, 4.8, 4.9
	Limited numbers	Downlisting 1 and 2; Delisting 1 and 2	1.1, 1.3, 1.4, 1.5, 2.2, 2.7, 2.8, 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7, 3.8, 4.1, 4.2, 4.3, 4.4, 4.6, 4.7, 4.8, 4.9
	Trampling	Downlisting 1 and 2; Delisting 1 and 2	1.1, 1.3, 1.4, 1.5, 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7, 3.8, 4.7, 4.8, 4.9
	Climate change	Downlisting 1 and 2; Delisting 1 and 2	1.1, 1.2, 1.3, 1.4, 1.5, 2.7, 2.8, 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7, 3.8, 4.1, 4.2, 4.3, 4.4, 4.6, 4.7, 4.8, 4.9, 5.1

Table 9. Crosswalk relating threats, recovery criteria, and recovery actions for tree snails.

Species Group: Tree Snails			
Listing Factor	**Specific Threat Under the Listing Factor**	**Recovery Criteria Numbers**	**Recovery Action Numbers**
A Present or Threatened Destruction, Modification or Curtailment of its Habitat or Range	Agriculture and urban development	Downlisting 1, 2, and 3; Delisting 1, 2, and 3	1.1, 1.3, 1.4, 1.5, 3.1, 3.2, 3.3, 3.4, 4.1, 4.3, 4.4, 4.5
	Ungulates	Downlisting 1, 2, and 3; Delisting 1, 2, and 3	1.1, 1.3, 1.4, 1.5, 4.1, 4.2, 4.4, 4.5, 4.8, 4.9
	Nonnative plants	Downlisting 1, 2, and 3; Delisting 1, 2, and 3	1.1, 1.3, 1.4, 1.5, 3.1, 3.4, 3.8, 4.1, 4.2, 4.3, 4.4, 4.8, 4.9
	Fire	Downlisting 1, 2, and 3; Delisting 1, 2, and 3	1.4, 1.5, 4.8, 4.9
	Stochastic events	Downlisting 1, 2, and 3; Delisting 1, 2, and 3	1.1, 1.2, 1.3, 1.4, 1.5, 3.1, 3.2, 3.3, 3.4, 3.6, 3.7, 3.8, 4.1, 4.2, 4.3, 4.4, 4.5, 4.7, 4.8, 4.9
B Overutilization	Shell collection	Downlisting 1, 2, and 3; Delisting 1, 2, and 3	5.1
C Disease or Predation	Disease	Downlisting 1, 2, and 3; Delisting 1, 2, and 3	1.1, 1.2, 1.3, 1.4, 1.5, 2.7, 2.8, 3.1, 3.3, 3.4, 3.6, 3.7, 3.8, 4.1, 4.2, 4.4, 4.6, 4.7, 4.8, 4.9, 5.1
	Predation by nonnative vertebrates	Downlisting 1, 2, and 3; Delisting 1, 2, and 3	1.1, 1.3, 1.4, 1.5, 2.2, 2.4, 2.7, 2.8, 3.3, 3.4, 3.5, 3.6, 4.1, 4.2, 4.4, 4.8, 4.9, 5.1
	Predation by nonnative invertebrates	Downlisting 1, 2, and 3; Delisting 1, 2, and 3	1.1, 1.3, 1.4, 1.5, 2.3, 2.7, 2.8, 3.1, 3.2, 3.3, 3.6, 3.7, 3.8, 4.1, 4.2, 4.4, 4.8, 4.9, 5.1
D Inadequacy of Existing Regulatory Mechanisms	Inadequate existing regulatory mechanisms	Downlisting 1, 2, and 3; Delisting 1, 2, and 3	1.4, 5.1, 5.2

Species Group: Tree Snails			
Listing Factor	**Specific Threat Under the Listing Factor**	**Recovery Criteria Numbers**	**Recovery Action Numbers**
E **Other Natural or Manmade Factors**	Other species-specific threats	Downlisting 1, 2, and 3; Delisting 1, 2, and 3	1.1, 1.2, 1.3, 1.4, 1.5, 2.2, 2.3, 2.4, 2.7, 2.8, 3.1, 3.2, 3.3, 3.4, 3.6, 3.7, 3.8, 4.1, 4.2, 4.4, 4.8, 4.9, 5.1
	Loss of plant hosts	Downlisting 1, 2, and 3; Delisting 1, 2, and 3	1.1, 1.2, 1.3, 1.4, 1.5, 2.7, 2.8, 3.1, 3.2, 3.3, 3.4, 3.5, 3.7, 3.8, 4.1, 4.2, 4.3, 4.4, 4.7, 4.8, 4.9, 5.1
	Limited numbers of individuals	Downlisting 1, 2, and 3; Delisting 1, 2, and 3	1.1, 1.3, 1.4, 1.5, 2.2, 2.3, 2.4, 2.7, 2.8, 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7, 3.8, 4.1, 4.2, 4.3, 4.4, 4.5, 4.6, 4.7, 4.8, 4.9, 5.1
	Low population numbers	Downlisting 1, 2, and 3; Delisting 1, 2, and 3	1.1, 1.3, 1.4, 1.5, 2.2, 2.3, 2.4, 2.7, 2.8, 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7, 3.8, 4.1, 4.2, 4.3, 4.4, 4.5, 4.6, 4.7, 4.8, 4.9, 5.1
	Treefall	Downlisting 1, 2, and 3; Delisting 1, 2, and 3	1.1, 1.3, 1.4, 1.5, 2.7, 2.8, 3.6, 3.8, 4.3, 4.7, 4.8, 4.9
	Trampling	Downlisting 1, 2, and 3; Delisting 1, 2, and 3	1.1, 1.3, 1.4, 1.5, 3.1, 3.5, 3.6, 3.8, 4.8, 4.9
	Climate change	Downlisting 1, 2, and 3; Delisting 1, 2, and 3	1.1, 1.2, 1.3, 1.4, 1.5, 2.7, 2.8, 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7, 3.8, 4.1, 4.2, 4.3, 4.4, 4.6, 4.7, 4.8, 4.9, 5.1

Table 10. Crosswalk relating threats, recovery criteria, and recovery actions for hilaris yellow-faced bee.

Hilaris yellow-faced bee			
Listing Factor	**Specific Threat Under the Listing Factor**	**Recovery Criteria Numbers**	**Recovery Action Numbers**
A Present or Threatened Destruction, Modification or Curtailment of its Habitat or Range	Agriculture and urban development	Downlisting 1, 2, 3, 4, and 5; Delisting 1, 2, 3, 4, and 5	1.1, 1.3, 1.4, 1.5, 3.1, 3.2, 3.3, 4.1, 4.3, 4.4, 4.5, 4.8, 4.9
	Ungulates	Downlisting 1, 2, 3, 4, and 5; Delisting 1, 2, 3, 4, and 5	1.1, 1.3, 1.4, 1.5, 3.1, 4.1, 4.2, 4.4, 4.5, 4.8, 4.9
	Nonnative plants	Downlisting 1, 2, 3, 4, and 5; Delisting 1, 2, 3, 4, and 5	1.1, 1.3, 1.4, 1.5, 3.1, 3.4, 3.8, 4.1, 4.2, 4.3, 4.4, 4.5, 4.8, 4.9
	Fire	Downlisting 1, 2, 3, 4, and 5; Delisting 1, 2, 3, 4, and 5	1.4, 1.5, 3.1, 4.8, 4.9
	Stochastic events	Downlisting 1, 2, 3, 4, and 5; Delisting 1, 2, 3, 4, and 5	1.1, 1.2, 1.3, 1.4, 1.5, 3.1, 3.2, 3.3, 3.4, 3.6, 3.8, 4.1, 4.2, 4.3, 4.4, 4.5, 4.7, 4.8, 4.9
B Overutilization	Not applicable		
C Disease or Predation	Disease	Downlisting 1, 2, 3, 4, and 5; Delisting 1, 2, 3, 4, and 5	1.1, 1.2, 1.3, 1.4, 1.5, 2.7, 2.8, 3.1, 3.3, 3.4, 3.6, 3.7, 3.8, 4.1, 4.2, 4.4, 4.6, 4.7, 4.8, 4.9, 5.1
	Predation by nonnative vertebrates	Downlisting 1, 2, 3, 4, and 5; Delisting 1, 2, 3, 4, and 5	1.1, 1.3, 1.4, 1.5, 2.7, 2.8, 3.2, 3.1, 3.4, 3.5, 3.6, 3.8, 4.1, 4.2, 4.3, 4.4, 4.5, 4.8, 4.9, 5.1
	Predation by nonnative invertebrates	Downlisting 1, 2, 3, 4, and 5; Delisting 1, 2, 3, 4, and 5	1.1, 1.2, 1.3, 1.4, 1.5, 2.5, 2.6, 2.8, 3.1, 3.2, 3.3, 3.6, 3.8, 4.1, 4.2, 4.3, 4.4, 4.8, 4.9, 5.1
D Inadequacy of Existing Regulatory Mechanisms	Inadequate existing regulatory mechanisms	Downlisting 1, 2, 3, 4, and 5; Delisting 1, 2, 3, 4, and 5	1.4, 5.1

Hilaris yellow-faced bee			
Listing Factor	**Specific Threat Under the Listing Factor**	**Recovery Criteria Numbers**	**Recovery Action Numbers**
E Other Natural or Manmade Factors	Competition	Downlisting 1, 2, 3, 4, and 5; Delisting 1, 2, 3, 4, and 5	1.1, 1.3, 1.4, 1.5, 2.7, 2.8, 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.8, 4.1, 4.2, 4.7, 4.8, 4.9, 5.1
	Lack of sufficient food resources	Downlisting 1, 2, 3, 4, and 5; Delisting 1, 2, 3, 4, and 5	1.1, 1.3, 1.4, 1.5, 2.5, 2.5, 2.7, 2.8, 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.8, 4.1, 4.2, 4.3, 4.4, 4.7, 4.8, 4.9, 5.1
	Lack of host nests	Downlisting 1, 2, 3, 4, and 5; Delisting 1, 2, 3, 4, and 5	3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.8, 4.1, 4.2, 4.3, 4.7, 4.8, 4.9
	Limited numbers of individuals	Downlisting 1, 2, 3, 4, and 5; Delisting 1, 2, 3, 4, and 5	1.1, 1.3, 1.4, 1.5, 2.5, 2.6, 2.7, 2.8, 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.8, 4.1, 4.2, 4.4, 4.6, 4.7, 4.8, 4.9
	Low population number	Downlisting 1, 2, 3, 4, and 5; Delisting 1, 2, 3, 4, and 5	1.1, 1.2, 1.3, 1.4, 1.5, 2.5, 2.6, 2.7, 2.8, 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.8, 4.1, 4.2, 4.3, 4.4, 4.5, 4.6, 4.7, 4.8, 4.9
	Not in captive rearing	Downlisting 1, 2, 3, 4, and 5; Delisting 1, 2, 3, 4, and 5	3.1, 3.5, 4.1, 4.2, 4.8, 4.9
	Climate change	Downlisting 1, 2, 3, 4, and 5; Delisting 1, 2, 3, 4, and 5	1.1, 1.2, 1.3, 1.4, 1.5, 2.7, 2.8, 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7, 3.8, 4.1, 4.2, 4.3, 4.4, 4.5, 4.6, 4.7, 4.8, 4.9, 5.1

IV. TIME AND COST ESTIMATES

Recovering species can be time-consuming and expensive, as it often entails undoing centuries of impacts that have led to their current imperiled state. When species are listed under the Act they are often restricted to a fraction of their historical range, in habitats where major ecological processes have been disrupted. Demographic characteristics and genetic structure of populations may be degraded. Stressors such as invasive species, diseases, climate change, and habitat loss and degradation can interact synergistically with severe consequences for species. While the Act mandates that recovery plans include an estimate of the cost to recover species, this does not signify that these funds will be allocated. A wide range of partners often contribute to the cost of recovery, including the Department of Defense, other Federal agencies, States, and non-governmental organizations. Funds actually dedicated to species recovery are typically a fraction of the estimated cost. Because recovery periods may cover multiple decades, annual costs are much lower than overall cost estimates. While our focus here is on recovery of the 44 listed species addressed in this recovery plan, implementation of recovery actions will also often benefit other listed and nonlisted species as well as human welfare.

Achieving the recovery criteria for these 44 species is expected to require, at minimum, approximately 25 to 95 years. The Draft Recovery Plan for 44 Species from Maui Nui included a cost estimate of $6,543,883,720 for the 25 to 95 years necessary to recover all 44 species. While we acknowledge all of the estimated costs of implementing recovery actions to recover these species, it is most relevant and accurate to focus on the costs over the first 20 years. Under the best circumstances, given the myriad of uncertainties associated with recovering listed species, estimating recovery costs over a longer period is difficult. In general, these uncertainties include: (1) emergence of new threats, (2) responses of species to management, (3) innovations in methods / technologies to address threats, and (4) potential economies of scale.

We calculated the annual implementation cost for each recovery action (total cost divided by the mean number of years needed to recover the species addressed by the action) and then multiplied these annual costs by 20 years. Presented below is a table of site-specific recovery actions and their estimated implementation costs, projected over the first 20 years of recovery (Table 11). Estimated costs include only project specific contract, staff, or operations costs that exceed base budgets. They do not include budgeted amounts that support ongoing agency staff responsibilities. This recovery plan does not commit the Service or any partners to carry out a particular recovery action or expend the estimated funds. Estimated costs include planning, design, implementation, research, monitoring, and evaluation associated with specific actions (Table 11). Adaptive management will be used to evaluate these actions to ensure that they are effectively addressing impacts to the species and meeting the objective of this recovery plan. If actions are not effective, changes in management should be made; additional planning and scientific research may be necessary.

Table 11. Priority and estimated cost of recovery actions over a 20-year time horizon.

Recovery Actions	**Priority**	**Estimated 20-Year Cost**	**Species Addressed**	**Notes**
1. Protect habitat and control threats in management units.	1	**>$529,629,431**	All	Includes identifying habitats and surveys for extant individuals (≈$11,325,777); developing microclimate models (≈$4,247,166); identifying and prioritizing management units (≈$965,265); ensure long-term protection of management units (≈$158,239,122); identify and manage threats in management units, including fencing, ungulates, invasive plants, rodents, wildfire, human disturbance, and prevention or interception of entry of new threats (>≈$347,386,033); monitoring and adaptive management (≈$7,529,068).
2. Control species-specific threats.	1	**>$297,462,523**	All	Develop and implement control programs for slugs (≈$33,221,207), rats (≈$34,025,594), predatory snail species (≈$25,740,402), Jackson’s chameleon (≈$321,755), ants (≈$96,526,508), yellow-jacket wasps (≈$19,305,302), other threats (TBD); and monitor and adapt management actions (≈$88,321,755).

Recovery Actions	**Priority**	**Estimated 20-Year Cost**	**Species Addressed**	**Notes**
3. Expand the distribution of existing wild populations and establish new populations.	1	**$1,137,878,199**	All	Select populations for translocation or identify sites for translocation (≈$450,457); identify areas within management units for population establishment (≈$900,914); prepare translocation sites (≈$962,762); captive propagation and storage (≈$1,124,574,040); release (≈$1,771,744); evaluate feasibility of translocation outside of historic habitat (≈$965,265); and monitor actions to inform adaptive management (≈$8,253,016).
4. Conduct additional research essential to recovering the 44 species and restoring their habitats.	1	**$131,018,647**	All	Develop tools to enhance habitat and species survival and reproduction (≈$14,157,221) and to inform actions to improve species viability *in situ* and *ex situ* (≈$14,157,221); conduct studies on range, demography, and dispersal of each species (≈$14,157,221); conduct research on threats to species viability (≈$77,221,207); develop tools for monitoring populations growth and status (≈$1,415,722); conduct population viability analyses (≈$2,831,444); and conduct studies on optimization of translocation survival and success (≈$7,078,611).
5. Implement regulations and policy to support species recovery.	2	**$9,475,686**	All	Implement biosecurity (all species, ≈$9,170,018) and public outreach and enforcement of prohibited actions (≈$305,667).

Estimated cost for the first 20 years of recovery implementation is estimated to be at least: $2,105,527,486. Annual costs prorated by species are estimated at $2,392,645.

Cost estimates are preliminary. Project-level details of recovery action implementation are to be developed cooperatively with partners in a Recovery Implementation Strategy for this recovery plan. Implementation is subject to availability of funds and is at the discretion of partners.

Priority 1:	An action that must be taken to prevent extinction or prevent the 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.

Date of Recovery

If all actions are fully funded and implemented as outlined, including full cooperation of all partners needed to achieve recovery, then we estimate the earliest that the delisting criterion could be met would be between 2078 and 2118 for listed plants, 2048 for *Partulina variabilis*, 2068 for *Partulina semicarinata* and *Newcombia cumingi*, and not likely before 2088 for hilaris yellow-faced bee.

For the 40 plant species, delisting is likely to require between 55 to 95 years, depending on the lifespan (short- or long-lived) and recovery potential (high or low) of the species (Table 12). Short- and long-lived plants are identified in section II.B.1 (*Recovery Criteria – Plants;* Tables 4 to 7) and a species' recovery potential is identified by its recovery priority number in Table 1. For the nine short-lived plants with a high recovery potential (recovery priority numbers 2 and 3), delisting criteria could be achieved within 55 years (*Bidens campylotheca* ssp. *pentamera*, *Bidens campylotheca* ssp. *waihoiensis*, *Bidens conjuncta*, *Calamagrostis hillebrandii*, *Cyanea kunthiana*, *Geranium hanaense*, *Geranium hillebrandii*, *Myrsine vaccinioides*, and *Schiedea salicaria*). For the 29 short-lived plants with a low recovery potential (recovery priority numbers 5 and 6), delisting criteria could be achieved within 65 years. Lastly, for the two long-lived plants with a low recovery potential (recovery priority numbers 5 and 6), delisting criteria could be achieved within 95 years (*Dracaena fernaldii* and *Wikstroemia villosa*). None of the long-lived plants addressed in this recovery plan has a high recovery potential.

For each plant species, its lifespan and biological requirements were factored into the estimated time to delisting. Long-lived perennials are those taxa either known or believed to have life spans greater than 10 years. Short-lived perennials are those known or believed to have life spans greater than 1 year but less than 10 years. Therefore, the delisting time for long-lived species is greater due to the additional time needed for plants to mature as a seedling and reproduce, longer growth time in nurseries before translocation, longer time to collect seeds from mature plants, and longer period for translocated plants to reproduce and the population to naturally regenerate. In contrast, the delisting time for short-lived species is reduced due to the relatively shorter generation time needed to reach maturity and reproduce, shorter growth time in nurseries before translocation, and shorter period for translocated plants to reproduce and the population to naturally regenerate.

Table 12. Estimated time to delisting for plant species.

Species	Lifespan	Recovery Potential	Time to Delisting
Bidens campylotheca ssp. *pentamera*, *Bidens campylotheca* ssp. *waihoiensis*, *Bidens conjuncta*, *Calamagrostis hillebrandii*, *Cyanea kunthiana*, *Geranium hanaense*, *Geranium hillebrandii*, *Myrsine vaccinioides*, and *Schiedea salicaria*	Short (<10 years)	High	55 years (2078)
Cyanea asplenifolia, *Cyanea duvalliorum*, *Cyanea horrida*, *Cyanea kauaulaensis*, *Cyanea magnicalyx*, *Cyanea maritae*, *Cyanea mauiensis*, *Cyanea munroi*, *Cyanea obtusa*, *Cyanea profuga*, *Cyanea solanacea*, *Cyperus neokunthianus*, *Cyrtandra ferripilosa*, *Cyrtandra filipes*, *Cyrtandra hematos*, *Cyrtandra oxybapha*, *Festuca molokaiensis*, *Hypolepis hawaiiensis* var. *mauiensis* , *Mucuna persericea*, *Peperomia subpetiolata*, *Phyllostegia bracteata*, *Phyllostegia haliakalae*, *Phyllostegia pilosa*, *Pittosporum halophilum*, *Schiedea diffusa* ssp. *diffusa*, *Schiedea jacobii*, *Schiedea laui*, *Schiedea pubescens*, and *Stenogyne kauaulaensis*	Short (<10 years)	Low	65 years (2088)
Dracaena fernaldii and *Wikstroemia villosa*	Long (>10 years)	Low	95 years (2118)

For all plant categories, the time to delisting includes the time needed to achieve the interim and downlisting stages and the 20-year monitoring period. The length of time needed to achieve the interim and downlisting stages is determined by each species' recovery potential. Plants with a low recovery potential will probably require additional decades of habitat restoration, threat reduction, and increasing populations to specified delisting criteria numbers. On the other hand, plants identified with a high recovery potential will probably require less time for habitat restoration, allowing earlier effort toward increasing the number of populations and controlling or researching species-specific threats. Because populations must be stable, secure, and naturally reproducing throughout the 20-year monitoring period identified in the delisting criteria, this period should not start until the interim and downlisting stages are met.

For *Partulina variabilis*, delisting might be reached in a minimum of 25 years. This is due to the presence of multiple populations, presence in captivity, relatively low reproductive rate, and the age at which the species becomes reproductively mature. For *Partulina semicarinata* and *Newcombia cumingi*, delisting is likely to require at least 40 years, largely due to their relatively slow growth rate, low reproductive capacity, and extremely low numbers with one or two known wild populations. These time frames include monitoring periods of 5 years for downlisting and 10 years for delisting, as well as time to establish and protect additional population sites and allow several generations for population increase and implementation of translocation efforts.

For the hilaris yellow-faced bee, delisting is not likely to be achieved for at least 60 years. This species is dependent upon several ground-nesting *Hylaeus* species for reproduction. The four species of nest hosts are themselves rare; three of the four are listed as endangered. For the hilaris yellow-faced bee to have full viability, it will require stable to growing populations of its nest-host species to be established throughout its full range. To achieve this will first require the recovery of more than one nest-host species to support the cleptoparasitism by hilaris yellow-faced bees and provide the necessary resiliency. These time frames include monitoring periods of 5 years for downlisting and 10 years for delisting, as well as time to establish and protect additional population sites, recover host species so that their populations are capable of sustaining cleptoparasitism of nests, allow several generations of population increase, and potential translocation.

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[USFWS] U.S. Fish and Wildlife Service. 2023gg. Species report for *Phyllostegia pilosa*. Version 1.0. Pacific Islands Fish and Wildlife Office, Honolulu, Hawai‘i. 30 pp.

[USFWS] U.S. Fish and Wildlife Service. 2023hh. Species report for *Pittosporum halophilum* (hōʻawa). Version 1.0. Pacific Islands Fish and Wildlife Office, Honolulu, Hawaiʻi. 25 pp.

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APPENDIX A

List of Species with Corresponding Species Report and Habitat Status Reports

Species	Species Report	Habitat Status Report
PLANTS		
Bidens campylotheca ssp. *pentamera*	USFWS 2023a	Clark et al. 2020; Javar-Salas et al. 2020; Lowe et al. 2020; Nelson et al. 2020; Pe‘a et al. 2020
Bidens campylotheca ssp. *waihoiensis*	USFWS 2023b	Clark et al. 2020; Nelson et al. 2020
Bidens conjuncta	USFWS 2023c	Clark et al. 2020
Calamagrostis hillebrandii	USFWS 2023d	Browning et al. 2020
Cyanea asplenifolia	USFWS 2023e	Clark et al. 2020; Lowe et al. 2020; Nelson et al. 2020
Cyanea duvalliorum	USFWS 2023f	Clark et al. 2020; Nelson et al 2020
Cyanea horrida	USFWS 2023g	Clark et al. 2020; Lowe et al. 2020; Nelson et al. 2020
Cyanea kauaulaensis	USFWS 2023h	Clark et al. 2020; Lowe et al. 2020; Nelson et al. 2020
Cyanea kunthiana	USFWS 2023i	Clark et al. 2020; Lowe et al. 2020
Cyanea magnicalyx	USFWS 2023j	Clark et al. 2020; Lowe et al. 2020; Nelson et al. 2020
Cyanea maritae	USFWS 2023k	Clark et al. 2020; Lowe et al. 2020; Nelson et al. 2020
Cyanea mauiensis	USFWS 2023l	Clark et al. 2020; Lowe et al. 2020; Nelson et al. 2020
Cyanea munroi	USFWS 2023m	Clark et al. 2020
Cyanea obtusa	USFWS 2023n	Ball et al. 2020; Lowe et al. 2020; Nelson et al. 2020; Pe‘a et al. 2020
Cyanea profuga	USFWS 2023o	Clark et al. 2020; Lowe et al. 2020; Nelson et al. 2020
Cyanea solanacea	USFWS 2023p	Clark et al. 2020; Lowe et al. 2020; Nelson et al. 2020
Cyperus neokunthianus	USFWS 2023q	Clark et al. 2020
Cyrtandra ferripilosa	USFWS 2023r	Clark et al. 2020; Lowe et al. 2020
Cyrtandra filipes	USFWS 2023s	Clark et al. 2020; Lowe et al. 2020; Nelson et al. 2020
Cyrtandra hematos	USFWS 2023t	Clark et al. 2020
Cyrtandra oxybapha	USFWS 2023u	Clark et al. 2020

Dracaena fernaldii	USFWS 2023ii	Ball et al. 2020; Clark et al. 2020; Lowe et al. 2020
Festuca molokaiensis	USFWS 2023v	Lowe et al. 2020
Geranium hanaense	USFWS 2023w	Browning et al. 2020
Geranium hillebrandii	USFWS 2023x	Browning et al 2020; Nelson et al. 2020
Hypolepis hawaiiensis var. *mauiensis*	USFWS 2023z	Browning et al 2020; Clark et al. 2020; Nelson et al. 2020
Mucuna persericea	USFWS 2023aa	Ball et al. 2020; Clark et al. 2020; Phillipson et al 2020
Myrsine vaccinioides	USFWS 2023bb	Browning et al. 2020
Peperomia subpetiolata	USFWS 2023dd	Lowe et al. 2020
Phyllostegia bracteata	USFWS 2023ee	Ball et al. 2020; Clark et al. 2020; Lowe et al. 2020; Nelson et al. 2020
Phyllostegia haliakalae	USFWS 2023ff	Clark et al. 2020; Lowe et al. 2020; Nelson et al. 2020; Peʻa et al. 2020
Phyllostegia pilosa	USFWS 2023gg	Clark et al. 2020; Lowe et al. 2020
Pittosporum halophilum	USFWS 2023hh	Ball et al. 2020; Kim et al. 2020;
Schiedea diffusa ssp. *diffusa*	USFWS 2023ll	Clark et al. 2020
Schiedea jacobii	USFWS 2023mm	Clark et al. 2020
Schiedea laui	USFWS 2023nn	Clark et al. 2020
Schiedea pubescens	USFWS 2023oo	Ball et al. 2020; Clark et al. 2020; Lowe et al. 2020; Nelson et al. 2020
Schiedea salicaria	USFWS 2023pp	Javar-Salas et al. 2020; Peʻa et al. 2020
Stenogyne kauaulaensis	USFWS 2023qq	Lowe et al. 2020
Wikstroemia villosa	USFWS 2023rr	Clark et al. 2020; Lowe et al. 2020
INVERTEBRATES		
Hylaeus hilaris	USFWS 2023y	Kim et al. 2020
Newcombia cumingi	USFWS 2023cc	Clark et al. 2020; Lowe et al. 2020
Partulina semicarinata	USFWS 2023jj	Clark et al. 2020
Partulina variabilis	USFWS 2023kk	Clark et al. 2020

APPENDIX B

Summary of Comments on the Draft Recovery Plan

On February 15, 2022, we released the Draft Recovery Plan for 44 Species from the Islands of Maui, Molokaʻi, Kahoʻolawe, and Lānaʻi (Maui Nui) for a 90-day comment period for local, territorial, and Federal agencies, nongovernmental organizations, and the public. The comment period closed May 16, 2022. We received comments from four different individuals and groups. We thank the commenters for their input and respond in detail below.

Comment: A State agency made the following suggestion: Given so many species at risk, more than 300 in Maui Nui alone, it is not practical or cost effective to implement the recovery actions for these species one plan at a time. As managers prepare to implement this plan and the many others that are available for listed species in Maui Nui, we must first identify the specific and best sites to implement the recommended actions. The plan does not do this as written because it only identifies larger-scale, general management units. However, a key consideration in determining which sites are best suited for management is the potential for recovery of multiple species at those sites. This is because many species share common threats and management needs, creating opportunities for complementary management of multiple species at each site. Cost effectiveness and success depends on managers ability to identify those sites, but with more than 300 species at risk, that task is spatially complex and logistically challenging. In other words, further planning is needed, and improved planning tools are needed for that planning to be most effective.
Response: The identification of specific sites for species recovery and the implementation of specific actions is part of the associated Recovery Implementation Strategy (RIS), rather than the recovery plan. The RIS is a short-term and flexible document focused on how, when, and by whom the recovery actions from the recovery plan will be implemented. The RIS is intended to be adaptable to changing circumstances. Because the RIS is developed and implemented in cooperation with our conservation partners, it focuses on the period of time and scope of activities that work best for our partners to achieve recovery goals. For this recovery plan, we are in the process of coordinating with conservation partners at the State of Hawaiʻi, DOFAW; Counties of Kauaʻi, Honolulu, Maui, and Hawaiʻi; PEPP; SEPP; research institutions; watershed partnerships; native Hawaiian and local communities; public and private stakeholders; and national parks to identify the highest priority action and action areas for species in need of recovery. As noted in the comment, a key consideration is identifying sites that can be effectively managed for multiple species at the same time to maximize cost-effectiveness and species benefit. Currently, DLNR-DOFAW and species experts representing a variety of state, federal, and conservation partners are in the process of developing Maui Nui Conservation Action Optimization plans for various groups of species (e.g. seabirds, invertebrates, aquatic species, etc.) that occur in Maui Nui and are in need of protection and recovery. This planning effort, originally referred to as the Maui Nui Landscape Conservation Plan, may serve as a model for how RIS development and implementation can be carried out in the future for other islands.

Comment: A State agency made the following suggestion: DOFAW and the Service, along with state and federal partners, are developing the Maui Nui Landscape Conservation Plan, an

analytical framework to provide managers with these types of spatial and operational tools. I would suggest this recovery plan presents an opportunity to recognize and support that effort.
Response: We anticipate that this interagency planning effort for Maui Nui will provide a crucial basis for the RIS of this recovery plan. As described in the previous response, PIFWO staff are actively participating with DOFAW and other partners in a Conservation Action Optimization planning process for Maui Nui that will integrate threats assessment, management strategies, and cost-effectiveness of actions to prioritize actions and inform future recovery implementation across taxonomic groups . To support and recognize this effort, under Recovery Action 4 we have added two second-tier recovery actions:

- 4.8 Develop spatial and operational planning tools to enhance cost effectiveness of implementation.
- 4.9 Identify and prioritize opportunities for multiple species management and recovery.

Comment: A private landowner is open to working with the Service on the recovery of any of the listed species as appropriate on their preserve on Molokaʻi. The protected acreage is slated for restoration back to native coastal strand and lowland dry forest habitat and is currently occupied by *Hylaeus* species.
Response: We thank you for your ongoing efforts to support protection and recovery of listed species, and will be contacting you to explore ways we can work together in the effort to recover *Hylaeus hilaris* and its hosts.

Comment: A private landowner in Kanaio, Kula, Maui, would like to work with the Service to explore possible use of a portion of the owner's land for assisting with recovery or protection of listed species.
Response: We thank you for your interest in assisting with protection and recovery of listed species, and will be contacting you to explore ways in which we can work together.