

Nothocestrum latifolium
(‘aiea)

**5-Year Review
Summary and Evaluation**

**U.S. Fish and Wildlife Service
Pacific Islands Fish and Wildlife Office
Honolulu, Hawai‘i**

5-YEAR REVIEW
Species reviewed: *Nothocestrum latifolium* ('aiea)

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5-YEAR REVIEW
***Nothocestrum latifolium* ('aiea)**

1.0 GENERAL INFORMATION

1.1 Reviewers:

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Lauren Weisenberger, Plant Recovery Coordinator, PIFWO
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Lead Regional Office:

Interior Region 12, Portland Regional Office

Lead Field Office:

Pacific Islands Fish and Wildlife Office

Cooperating Field Office(s):

N/A

Cooperating Regional Office(s):

N/A

1.2 Methodology used to complete the review:

This review was conducted by staff of the Pacific Islands Fish and Wildlife Office of the U.S. Fish and Wildlife Service (Service), beginning in October 2020. The review was based on the final rule listing this species; peer reviewed scientific publications; unpublished field observations and species status report by the Service, State of Hawai‘i, and other experienced biologists; unpublished survey reports; notes and communications from other qualified biologists; as well as a review of current, available information. The evaluation by Chelsie Javar-Salas, Biologist, was reviewed by Lauren Weisenberger, Plant Recovery Coordinator, and Megan Laut, Conservation and Restoration Team Manager.

1.3 Background:

1.3.1 FR Notice citation announcing initiation of this review:

[USFWS] U.S. Fish and Wildlife Service. 2019. Endangered and threatened wildlife and plants; initiation of 5-year status reviews for 91 species in Oregon, Washington, Hawai‘i, and American Samoa. Federal Register 84 (112): 27152–27154, June 11, 2019.

1.3.2 Listing history:

Original Listing

FR notice: [USFWS] U.S. Fish and Wildlife Service. 2016. Endangered and threatened wildlife and plants; endangered status for 49 species from the

Hawaiian Islands; final rule. Department of Interior, Federal Register 81 (190): 67786–67860, September 30, 2016.

Date listed: September 30, 2016
Entity listed: *Nothocestrum latifolium*
Classification: Endangered

Revised Listing, if applicable

FR notice: N/A
Date listed: N/A
Entity listed: N/A
Classification: N/A

1.3.3 Associated rulemakings:
N/A

1.3.4 Review History:
This is the first 5-year review for *Nothocestrum latifolium*.

1.3.5 Species' Recovery Priority Number at start of this 5-year review:
5

1.3.6 Current Recovery Plan or Outline:
Name of plan or outline: Recovery Outline for Hawaiian Multi-Island Species.
Date issued: July 2020.
Dates of previous revisions, if applicable: N/A

2.0 REVIEW ANALYSIS

2.1 Application of the 1996 Distinct Population Segment (DPS) policy

2.1.1 Is the species under review a vertebrate?
 Yes
 No

2.1.2 Is the species under review listed as a DPS?
 Yes
 No

2.1.3 Was the DPS listed prior to 1996?
 Yes
 No

2.1.3.1 Prior to this 5-year review, was the DPS classification reviewed to ensure it meets the 1996 policy standards?

Yes
 No

2.1.3.2 Does the DPS listing meet the discreteness and significance elements of the 1996 DPS policy?

Yes
 No

2.1.4 Is there relevant new information for this species regarding the application of the DPS policy?

Yes
 No

2.2 Recovery Criteria

2.2.1 Does the species have a final, approved recovery plan containing objective, measurable criteria?

Yes
 No

2.2.2 Adequacy of recovery criteria.

2.2.2.1 Do the recovery criteria reflect the best available and most up-to date information on the biology of the species and its habitat?

Yes
 No

2.2.2.2 Are all of the 5 listing factors that are relevant to the species addressed in the recovery?

Yes
 No

2.2.3 List the recovery criteria as they appear in the recovery plan, and discuss how each criterion has or has not been met, citing information:

A synthesis of the threats (Listing Factors A, B, C, D, and E) affecting this species is presented in section 2.3.2 and Table 2.

The recovery plan is currently being drafted. However, the Hawai'i and Pacific Plants Recovery Coordinating Committee (HPPRCC) has outlined the actions and goals for stages leading towards recovery (2011). These stages are described below.

Current information is lacking for many Hawaiian plant species on the status of the species and their habitats, breeding systems, genetics, and propagule storage options. The following downlisting and delisting criteria for plants have therefore been adopted from the revised recovery objective guidelines developed by the HPPRCC (2011). Many of the Hawaiian plant species are at very low numbers, so the Service also developed criteria for 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.

In general, 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 one year but less than 10 years; and annuals are those known or believed to have life spans less than or equal to one year. When it is unknown whether a species is long- or short-lived, the Service has 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. Narrow extant range and broad contiguous range are recognized as not needing different numbers of individuals or populations, but that the populations will be distributed more narrowly or more broadly, respectively, across the landscape. Obligate outcrossers are those 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 individuals contributing to reproduction as males and females, doubling the number of mature individuals. Species that reproduce vegetatively may reproduce sexually only on occasion, resulting in the majority of the genetic variation being between populations, therefore requiring additional populations. Species that have a tendency to fluctuate in number from year to year require a larger number of mature individuals on average to allow for decline in years of extreme habitat conditions and recuperation in numbers in years of more normal conditions.

Preventing Extinction

Stabilizing (interim), downlisting, and delisting objectives have been updated according to the draft revised recovery objective guidelines developed by the HPPRCC (2011). The HPPRCC identifies an additional initial objective, the Preventing Extinction Stage, in addition to the Interim Stabilization, Delisting, and Downlisting objectives. Furthermore, life history traits such as breeding system, population size fluctuation or decline, and reproduction type (sexual or vegetative), have been included in the calculation of goals for the number of populations and reproducing individuals for each stage. The goals for each stage remain grouped by life span defined as annual, short-lived perennial (fewer than 10 years), or long-lived perennial.

Nothocestrum latifolium is a long-lived perennial tree. To prevent extinction, which is the first milestone in recovering the species, the taxon must be managed

to control threats (e.g., fenced) and have 50 individuals (or the total number of individuals if fewer than 50 exist) from each of three populations represented in *ex situ* (secured off-site, such as a nursery or seed bank) collections that are well managed. In addition, a minimum of three populations total should be documented on the islands of Kaua‘i, O‘ahu, Moloka‘i, Maui, and/or Lāna‘i where they now occur or occurred historically. Each of these populations must be naturally reproducing (i.e., viable seeds, seedlings, saplings) with a minimum of 25 mature individuals per population.

This recovery objective has not been met (see Table 1).

Interim Stage

To meet the interim stage of recovery of *Nothocestrum latifolium*, 100 mature individuals are needed in each of three populations and all major threats must be controlled around the populations designated for recovery at this stage. Multi-island species should be represented by at least one population on each of the islands from which they were known historically as long as suitable habitat exists. There should also be demonstrated regeneration of seedlings and growth to at least sapling stage for woody species and documented replacement regeneration within each of the target populations. The populations must be adequately represented in an *ex situ* collection as defined in the Center for Plant Conservation’s guidelines (Guerrant et al. 2004, entire) that is secure and well managed. Adequate monitoring must be in place and conducted to assess individual plant survival, population trends, trends of major limiting factors, and response of major limiting factors to management.

This recovery objective has not been met (see Table 1).

Downlisting Criteria

In addition to achieving 5 to 10 populations with 200 mature individuals per population and all of the goals of the interim stage, all target populations must be stable, secure, and naturally reproducing for a minimum of 10 years. Multi-island species should be represented by at least three populations on each of the islands from which they were known historically as long as suitable habitat exists. Species-specific management actions are not ruled out. Downlisting should not be considered until an adequate population viability analysis (PVA) has been conducted to assess needed numbers more accurately based on current management and monitoring data collected at regular intervals determined by demographic parameters of the species, although they should only be one of the factors used in making a decision to downlist. Information necessary for the PVA that should be available through monitoring (ideally annually) includes major limiting factors, breeding system, population structure and density, and proven management methods for major threats.

This recovery objective has not been met (see Table 1).

Delisting Criteria

In addition to achieving 5 to 10 populations with 200 mature individuals per population and all of the goals of the interim and downlisting stages, all target populations must be stable, secure, naturally reproducing, and within secure and viable habitats for a minimum of 20 years. Multi-island species should be represented by at least three populations on each of the islands from which they were known historically as long as suitable habitat exists. Species-specific management actions must no longer be necessary, but ecosystem-wide management actions are not ruled out if there are long-term agreements in place to continue management. These numbers are initial targets, but may be revised upward as additional information is available, including adequate PVAs for individual species based on current management and monitoring data collected at regular intervals determined by demographic parameters of the species, although they should only be one of the factors used in making a decision to delist. Genetic analyses should be conducted to ensure that adequate genetic representation is present within and among populations compared to the initial variation assessed in the interim stage. Numbers need to be considered on a species-by-species basis.

This recovery objective has not been met (see Table 1).

2.3 Updated Information and Current Species Status

2.3.1 Biology and Habitat

2.3.1.1 New information on the species' biology and life history:

Nothocestrum latifolium, a member of the nightshade family (Solanaceae), is a small tree that can grow up to 10 meter (m) (33 feet [ft]) tall. Trees may have a gnarled trunk, rigid ascending branches, and young parts with yellowish-brown pubescence (short hairs). The thick, pubescent leaves, usually cluster toward the ends of the branches, and are seasonally deciduous (shed leaves annually). Flowers occur in clusters on short spurs and have a greenish-yellow corolla with the corolla tube about twice as long as the calyx. The calyx is 6 to 8 millimeters (mm) (0.2 to 0.3 inches [in]) long. Berries are yellowish-orange, succulent, depressed-globose (round), and 4 to 6 mm (0.1 to 0.3 in) in diameter (Symon 1999, p. 1263).

Little is known about the life history of *Nothocestrum latifolium*. Based on several herbarium reports, *N. latifolium* was observed in flower in November and July, and during the months of February to April (Smithsonian National Museum of National History 1978, 1988; National Tropical Botanical Garden [NTBG] 1999, 2013; HBMP 2010). This species was observed fruiting in the months of December and July, and from February through April (Smithsonian National Museum of National History 1978, 1988; NTBG 1999, 2009; HMBP 2010).

Nothocestrum latifolium has perfect flowers, which mean plants contain bisexual flowers that produce both male and female reproductive organs

(Symon 1999, p. 1262). The breeding system of *N. latifolium* is hermaphroditic (Sakai et al. 1995, p. 2528).

The presumed mode of long-distance seed dispersal of the genera *Nothocestrum* to the Hawaiian islands was likely through bird ingestion. Fruits of *N. latifolium* are fleshy, yellow-orange berries that are attractive to birds (Sakai et al. 1995, p. 2528). In 2012, possible seed dispersal via birds was documented in the Auwahi Forest Restoration Project site (part of the Kanaio-Luala'ilua population unit), where two seedlings of *N. latifolium* were found under perch trees located away from mature *N. latifolium* trees. The seeds were probably dispersed by the nonnative bird *Zosterops japonicus* (Japanese White-eye) (Medeiros et al. 2014, p. 41).

The flowers of *Nothocestrum latifolium* are believed to be insect pollinated (Sakai et al. 1995, p. 2528). Knapp (2010) studied flower morphology and pollinator types for the family Solanaceae and noted *Nothocestrum* had bilateral flower symmetry, many-flowered inflorescences, and determined moths and birds as potential pollinators based on pollination syndrome (Knapp 2010, p. 452). The pollination syndrome for moths are characterized as having white flowers with a long tube filled with nectar. Flowers that are red or orange, tubular, and filled with nectar are indicators of bird pollination syndrome (Knapp 2010, p. 453). Based on the pollination information identified by Knapp, it is not known if the native and endangered Blackburn's sphinx moth (*Manduca blackburni*) serves a pollinator for *N. latifolium*. However, *N. latifolium* and other species of *Nothocestrum* are host plants for Blackburn's sphinx moth (USFWS 2003, p. 14).

2.3.1.2 Abundance, population trends (e.g. increasing, decreasing, stable), demographic features (e.g., age structure, sex ratio, family size, birth rate, age at mortality, mortality rate, etc.), or demographic trends:

Historically, *Nothocestrum latifolium* was found on the islands of Kaua'i, O'ahu, Moloka'i, Lāna'i, and Maui (Symon 1999, p. 1263). Historic populations are known from northern Kaua'i, western, central, and eastern Lāna'i, and the southern Ko'olau and Wai'anae Mountains on O'ahu (HBMP 2010).

Nothocestrum latifolium was collected once at Kalalau on Kaua'i in 1986, but has not been observed there before or after that time (Symon 1999, p. 1263; Bernice Pauahi Bishop Museum 1986; Wood 2001, p. 1). The observation of *N. latifolium* on Kaua'i is questioned by a few botanists, who believe the specimen might actually represent *N. longifolium* instead; however, no further analysis has been conducted to confirm the misidentification (Wood 2001, p. 1).

On O‘ahu, the last wild individual in the Makaleha population unit on the Wai‘anae Mountains died in 2012 (PEPP 2019; Ching 2020, in litt.).

On Moloka‘i, five population units are known from Mākolelau, Kawela Gulch, ‘Ōnini Gulch, Kaunakakai Gulch, and Kala‘e. The ‘Ōnini Gulch population unit contained two *Nothoestrum latifolium* trees in 1986, but are now considered dead (Bakutis 2020, in litt.).

In 2011, the Maui Nui Plant Extinction Prevention Program (PEPP) conducted a survey on Lāna‘i to relocate the species, but no individuals were found (PEPP 2012, p. 129). *Nothoestrum latifolium* is now considered extirpated from Lāna‘i (Bogner and Oppenheimer 2019, in litt.).

On Maui, there are eight population units at Kanaio-Luala‘ilua, Kaupō, Pu‘u o Kali, Waiohuli, Pōhākea, Makawao-Olinda, Paunau, and Honokōwai. The Waiohuli, Pōhākea, and Makawao-Olinda population units are now extirpated (PEPP 2019).

At the time of listing in 2016, there were 19 occurrences ranging from east and west Maui and one individual on O‘ahu, totaling 1,600 individuals (USFWS 2016a, p. 67801). Currently, there are between 137 to 138 wild individuals on Maui and Moloka‘i in seven populations. There are five population units on Maui located at Kanaio-Luala‘ilua (105 mature wild individuals), Kaupō (7 mature translocated individuals), Pu‘u o Kali (5 mature wild individuals), Paunau (1 to 2 mature wild individuals), and Honokōwai (20 mature wild individuals) (PEPP 2019; Oppenheimer 2020a, b, c, in litt.; Welton 2020, in litt.). Note the seven mature translocated individuals from Kaupō is not included in total number of wild individuals on Maui. On Moloka‘i, there are six wild individuals total in two extant population units located in Mākolelau and Kawela Gulch containing three wild mature individuals each. The populations located at Kala‘e and Kaunakakai Gulch on Moloka‘i may be extirpated; however, suitable habitat still occurs in the area and plans are in place to continue surveying for *N. latifolium* (PEPP 2019; Bakutis 2020, in litt.).

2.3.1.3 Genetics, genetic variation, or trends in genetic variation (e.g., loss of genetic variation, genetic drift, inbreeding, etc.):

N/A

2.3.1.4 Taxonomic classification or changes in nomenclature:

Nothoestrum latifolium was first described by Asa Gray based on a type specimen he collected from the ridge of Ka‘ala mountain on O‘ahu (Gray 1862, p. 48). *Nothoestrum subcordatum* is a synonym for this species that was described by Horace Mann in 1866 based on a type specimen also collected from Ka‘ala mountain on O‘ahu (Symon 1999, p. 1263; Mann

1866, p. 191). This species is recognized as a distinct taxon by Symon (1999, p. 1263) in the Manual of the Flowering Plants of Hawai‘i, the most recent accepted taxonomy.

2.3.1.5 Spatial distribution, trends in spatial distribution (e.g. increasingly fragmented, increased numbers of corridors, etc.), or historic range (e.g. corrections to the historical range, change in distribution of the species’ within its historic range, etc.):

See section 2.3.1.2 and 2.3.1.4 above for spatial distribution of the species.

2.3.1.6 Habitat or ecosystem conditions (e.g., amount, distribution, and suitability of the habitat or ecosystem):

Nothocestrum latifolium occurs in mesic and dry forests, and mesic and dry shrublands and grasslands, and in developed areas where habitat conversion has occurred. Historically, its habitat range also included wet forest and wet shrublands and grasslands (USFWS 2020b, unpubl. data).

On Kaua‘i, *Nothocestrum latifolium* was last observed on a steep ridge in *Metrosideros–Nestegis* (‘ōhi‘a–olopua) forest at 1,140 m (3,740 ft) (Bernice Pauahi Bishop Museum 1986). On Lāna‘i, *N. latifolium* occurred in dry to mesic forest at 500 to 518 m (1,640 to 1,700 ft), with the associated native species *Nestegis sandwicensis* (olopua) and *Diospyros sandwicensis* (lama). On O‘ahu, *N. latifolium* was observed at 442 to 744 m (1,450 to 2,440 ft) growing in a degraded lowland mesic *Diospyros* forest with the associated native species *Antidesma platyphyllum* (hame), *Claoxylon sandwicense* (po‘olā), *Diospyros hillebrandii* (lama), *Geniostoma kaalae* (kāmakahala), *Planchonella sandwicensis* (‘āla‘a), *Psydrax odorata* (alahe‘e), *Nestegis sandwicensis*, *Nothocestrum longiflorum* (‘aiea), and *Sapindus oahuensis* (lonomea), and invaded by nonnative *Clidemia hirta* (Koster’s curse), *Leucaena leucocephala* (koa haole), *Toona ciliata* (Australian red cedar), *Schinus terebinthifolius* (Christmas berry), and *Syzygium cumini* (Java plum) (HBMP 2010).

Currently, the dry forest and mesic shrubland and grassland on Moloka‘i where *Nothocestrum latifolium* occurs with the associated native species including *Myrsine lanaiensis* (kolea), *Antidesma platyphyllum*, *Diospyros sandwicensis*, *Chrysodracon auwahiensis* (hala pepe), *Coprosma foliosa* (pilo), *Dodonaea viscosa* (‘a‘ali‘i), and *Dryopteris* sp., invaded by nonnative *Melinis minutiflora* (molasses grass) (HBMP 2010).

On the southern slope of Haleakalā, east Maui, *Nothocestrum latifolium* occurs in dry forest at the Kanaio-Luala‘ilua population unit with the associated native species including *Erythrina sandwicensis* (wiliwili), *Myoporum sandwicense* (naio), *Planchonella sandwicensis*, and *Polyscias* sp. The area is invaded by the nonnative plants *Ageratina riparia* (spreading mist flower) and *Lantana camara* (lantana) (Bernice Pauahi

Bishop Museum 1971). At Pu‘u o Kali, the associated native plant species includes *Argemone glauca* (pua kala), *Capparis sandwichiana* (maiapilo), *Chenopodium oahuense* (‘āweoweo), *Cocculus orbiculatus* (huehue), *Diospyros sandwicensis*, *Dodonaea viscosa*, *Doryopteris* sp., *Erythrina sandwicensis*, *Euphorbia* sp., *Ipomoea* sp., *Myoporum sandwicense*, *Nototrichium humile* (kulu‘i), *Planchonella sandwicensis*, *Polyscias* sp., *Sida fallax* (‘ilima), *Sophora chrysophylla* (māmane), *Sicyos* sp., *Pellaea ternifolia* (kalamoho), and *Waltheria indica* (‘uhaloa) (NTBG 2013).

On west Maui, *Nothoestrum latifolium* occurs in *Metrosideros–Diospyros* (‘ōhi‘a–lama) mesic forest at Honokōwai (HBMP 2010).

2.3.2 Five-Factor Analysis (threats, conservation measures, and regulatory mechanisms)

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

Ungulate destruction and degradation of habitat—Feral ungulates modify and degrade habitat by disturbing and destroying vegetative cover, trampling plants and seedlings, reducing or eliminating plant regeneration by damaging seeds and seedlings, and increasing erosion by creating large areas of bare soil (Loope 1998; van Riper and van Riper 1982). Feral pigs (*Sus scrofa*), goats (*Capra hircus*), cattle (*Bos taurus*), axis deer (*Axis axis*), mouflon (*Ovis gmelina musimon*), and black-tailed deer (*Odocoileus hemionus columbianus*) and evidence of their activities are observed at all populations of *Nothoestrum latifolium* (USFWS 2016a, pp. 67801, 67827–67830). Most of the extant populations and individuals are located in fenced areas, but some of the fences are not ungulate-free; therefore, ungulates continue to impact the species. Individuals of *N. latifolium* not fenced are located in the Kanaio-Luala‘ilua and Pu‘u o Kali population units (Oppenheimer 2020a, in litt.; USFWS 2020b, unpubl. data).

Established ecosystem-altering invasive plant modification and degradation of habitat—Invasive introduced plant species modify habitats occupied by native plant species by changing the availability of light, altering soil-water regimes, modifying nutrient cycling, and changing the fire characteristics of the native plant community (Cuddihy and Stone 1990). Habitat modification and destruction by invasive nonnative plants negatively affects all occurrences of *Nothoestrum latifolium* (Javar-Salas et al. 2020; Pe‘a et al. 2020; Ball et al. 2020; Lowe et al. 2020; Phillipson et al. 2020). Nonnative plants with the greatest impacts on *Nothoestrum latifolium* include *Bocconia frutescens* (plume poppy), *Cenchrus clandestinus* (kikuyu grass), *Clidemia hirta*, *Fraxinus uhdei* (tropical ash), *Grevillea robusta* (silk oak), *Lantana camara*, *Leucaena leucocephala*, *Melinis minutiflora*, *Neonotonia wightii* (glycine), *Passiflora suberosa* (huehue haole), *Prosopis pallida* (kiawe), *Psidium cattleianum*

(strawberry guava), *Schinus terebinthifolius*, and *Toona ciliata* (USFWS 2016a, p. 67801; PEPP 2019; Oppenheimer 2020a, in litt.; NTBG 2013, entire).

Landslides and erosion destruction or degradation of habitat—Landslides are a threat to *Nothocestrum latifolium* as this species occurs in gullies and along steep cliffs (PEPP 2019). Landslides, including tree falls and erosion associated with them, can have a significant effect on small populations by destabilizing substrate, altering hydrological patterns, and by damaging and destroying individual plants (Stearns 1985). Landslides and erosion are a serious threat to the populations at Honokōwai and Paunau (Oppenheimer 2020a, b, in litt.).

Fire destruction and degradation of habitat—*Nothocestrum latifolium* is at risk of negative impacts by fire because individuals of this species or their known habitat is located in or near areas that were burned in previous fires or in areas at risk for fire due to the presence of highly flammable nonnative grasses (USFWS 2016a, p. 67831). The habitats occupied by *N. latifolium* are heavily invaded by invasive grasses such as molasses grass, which are fire-adapted and yield a higher fuel load to allow fires to burn faster and hotter (Pe‘a et al. 2020, p. 10; Javar-Salas et al. 2020, p. 13; Lowe et al. 2020, p. 17; Ball et al. 2020, p. 14). Fire damages and destroys native vegetation, including dormant seeds, seedlings, 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). Successive fires burn farther and farther in native habitat and alter microclimatic conditions creating conditions favorable to nonnative plants. The threat from fire is unpredictable but is increasing in frequency in ecosystems that have been invaded by nonnative plants and fire-tolerant nonnative grasses.

Climate change loss or degradation of habitat—Fortini et al. (2013) conducted a landscape-based assessment of climate change vulnerability for native plants of Hawai‘i using high resolution climate change projections. Climate change vulnerability is defined as the relative inability of a species to display the possible responses necessary for persistence under climate change. The assessment concluded that *Nothocestrum latifolium* is vulnerable to the impacts of climate change with a vulnerability score of 0.354 (on a scale of 0 being not vulnerable to 1 being extremely vulnerable to climate change). Therefore, additional management actions may be needed, such as locating key microsites that overlap with current and future climate envelopes for translocation efforts.

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

Not a threat.

2.3.2.3 Disease or predation (Factor C):

Herbivory and predation by feral cattle, axis deer, goats, and pigs—Field observations indicate that herbivory by cattle, axis deer, goats, and pigs is a threat to *Nothoestrum latifolium* on Maui and Lāna‘i (Oppenheimer 2020a, in litt.; Welton 2020, in litt.; Bakutis 2020, in litt.).

Herbivory and predation by black twig borer—Predation and herbivory by the black twig borer (*Xylosandrus compactus*) have been observed on *Nothoestrum latifolium*. The black twig borer is known to infest a wide variety of common plant taxa, including rare native plant species (Davis 1970, p. 39; Extension Entomology and US-CTAHR Integrated Pest Management Program 2006, in litt.). This insect pest burrows into branches, introduces a pathogenic fungus as food for its larvae, and lays its eggs (Davis 1970, p. 39). Twigs, branches, and entire plants can be damaged or killed from an infestation (Extension Entomology and UH-CTAHR Integrated Pest Management Program 2006, in litt.). Predation by the black twig borer was reported as a threat to *N. latifolium* on O‘ahu (Ching-Harbin 2015, in litt.). Black twig borer predation is suspected as a threat at the Kanaio-Luala‘ilua and Honokōwai population units, but the impact is unknown (Oppenheimer 2020a, in litt.).

2.3.2.4 Inadequacy of existing regulatory mechanisms (Factor D):

Lack of adequate biosecurity regulations—Currently, four agencies are responsible for inspection of goods arriving in Hawai‘i (CGAPS 2009). The Hawai‘i Department of Agriculture (HDOA) inspects domestic cargo and vessels and focuses on pests of concern to Hawai‘i, 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 (U.S. CBP 2020, cbp.gov/about). The 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 Hawai‘i allows the importation of most plant taxa, with limited exceptions (Hawaii Legislative Reference Bureau [HLRB] 2002; U.S. Department of Agriculture-Animal and Plant Health Inspection Service-Plant Protection and Quarantine (USDA-APHIS-PPQ) 2010; CGAPS 2009). 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 Hawai‘i 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 (CGAPS 2009). Adequate staffing, facilities, and equipment for Federal and State pest inspectors and identifiers in Hawai‘i devoted to invasive species interdiction are critical biosecurity gaps (HLRB 2002; USDA-APHIS-PPQ 2010; CGAPS 2009). The introduction of new invasive plant and invertebrate species to the State of Hawai‘i is a significant risk to federally listed species including any remaining wild or translocated individuals of *Nothoestrum latifolium*.

Lack of adequate hunting regulations—Nonnative feral ungulates are an ongoing threat to this species through destruction and modification of habitat and direct predation. Management of game animals by the State ranges from providing maximal sustained public hunting opportunities and benefits (i.e., sustained yield) in some areas, with one animal allowed per day; to other areas with as few as one animal allowed per year (DLNR 2010). Most extant populations are fenced and feral ungulates have been noted as a threat to this species (Oppenheimer 2020a, in litt.; USFWS 2020b, unpubl. data). Public hunting areas are not fenced, and game mammals have unrestricted access for most areas across the landscape, regardless of underlying land use designation; therefore, any unfenced populations of *Nothoestrum latifolium* are at risk (DLNR 2010).

2.3.2.5 Other natural or manmade factors affecting its continued existence (Factor E):

Not a threat.

Current Management Actions:

- Surveys and monitoring—PEPP occasionally monitors occurrences of *Nothoestrum latifolium* on Maui and Moloka‘i, and previously monitored now considered extirpated occurrences on O‘ahu and Lāna‘i (Bakutis 2020, in litt.; Oppenheimer 2020a, b, c, in litt.; PEPP 2011, p. 140; PEPP 2012, p. 130; PEPP 2016, p. 171).
- Ungulate control—Fenced populations units that are protected from the impacts of introduced ungulates include Kanaio-Luala‘ilua, Honokōwai, and Mākolelau. However, not all individuals located in Kanaio-Luala‘ilua are fenced and are still affected by the detrimental impacts of ungulates (Oppenheimer 2020a, in litt.; USFWS 2020b, unpubl. data). The Pu‘u o Kali population is not fenced (USFWS 2020b, unpubl. data). The translocated population at Kaupō is fenced, but introduced pigs are still located within the fence and therefore, not

protected from their impacts (USFWS 2020b, unpubl. data; Welton 2020, in litt.).

- Ecosystem-altering invasive nonnative plant control—The Hawai‘i Department of Land and Natural Resources, Auwahi Forest Restoration Project, Haleakalā National Park, The Nature Conservancy, Department of Hawaiian Home Lands, and East Moloka‘i Watershed Partnership Program regularly controls nonnative plants at Kanaio-Luala‘ilua, Kaupō, Pu‘u o Kali, Honokōwai, Mākolelau, and Kawela Gulch where *Nothocestrum latifolium* occurrences are known (HDLNR 2020, p. 7; Auwahi Forest Restoration Project 2020, entire; Auwahi Forest Restoration Project 2018, pp. 14–15; National Park Service 2015, pp. 12, 58; USFWS 2016b, p. 17939; TNCH 2015, pp. 19–22).
- Captive propagation for genetic storage and reintroduction—
 - The Pahole Nursery reports two individuals propagated from plants at Makaleha from O‘ahu (Pahole Nursery 2018, 2019).
 - The Koko Crater Botanical Garden has one individual representing the Makaleha population (Ching 2020, in litt.).
- Reintroduction and translocation—
 - The Auwahi Forest Restoration Project reports reintroducing more than 1,500 individuals of *Nothocestrum latifolium* in all restoration areas at Kanaio-Luala‘ilua since 2006 (Auwahi Forest Restoration Project 2019, entire). Survival has been noted as 65 to 75 percent (Allmen 2020, in litt.).
 - Haleakalā National Park reports translocating 20 individuals of *Nothocestrum latifolium* to Kaupō in 2010 from source material collected at Kanaio Natural Area Reserve. Most of the plants were healthy and growing after planting. Seven out of the 20 individuals were relocated during a monitoring trip in January 2018, though more plants could be alive as an exhaustive survey was not conducted (Welton 2020, in litt.).

Table 1. Status and trends of *Nothocestrum latifolium* from listing through 5-year review.

Date	No. wild individuals	No. outplanted	Preventing Extinction Criteria identified by HPPRCC	Preventing Extinction Criteria Completed?
2013 (listing)	~1,600 (Maui, O'ahu, and Moloka'i)	~920	All threats managed in all 3 populations	Partially, exclosures on Maui and Moloka'i; but some exclosures are not ungulate-free
			Complete genetic storage	Partially, one extirpated founder from Makaleha represented
			3 populations with 25 mature individuals each	Partially, only at Kanaio-Luala'ilua
2021 (5-year review)	132–133 (Maui); 6 (Moloka'i)	~1,500 planted; ~1,050 survive	All threats managed in all 3 populations	Partially, exclosures on Maui and Moloka'i; but some exclosures are not ungulate-free
			Complete genetic storage	Partially, one extirpated founder from Makaleha represented
			3 populations with 25 mature individuals each	Partially, only at Kanaio-Luala'ilua
			Each population naturally reproducing	Partially, only at Kanaio-Luala'ilua and Honokōwai on Maui

Table 2. Threats to *Nothocestrum latifolium* and ongoing conservation efforts.

Threat	Listing Factor	Current Status	Conservation/Management Efforts
Destruction and degradation of habitat by ungulates	A	Ongoing	Partial, exclosures on Maui and Moloka‘i; but some exclosures are not ungulate-free
Destruction and degradation of habitat by established ecosystem-altering invasive plants	A	Ongoing	Partial, some nonnative plant control within exclosures
Fire	A	Ongoing	None
Climate change loss or degradation of habitat	A	Ongoing	None
Predation and herbivory by ungulates	C	Ongoing	Partial, exclosures on Maui and on Moloka‘i; but some exclosures are not ungulate-free
Predation and herbivory by black twig borer	C	Ongoing	None
Inadequacy of regulatory mechanisms—hunting and biosecurity	D	Ongoing	None

2.4 Synthesis

There are approximately 138 to 129 wild individuals of *Nothocestrum latifolium* on the islands of Maui and Moloka‘i. A landscape-based assessment of climate change vulnerability for native plants of Hawai‘i using high resolution climate change projections was made by Fortini et al. (2013) and their analysis showed that *N. latifolium* is vulnerable to the effects of climate change. There are fenced exclosures on Maui and Moloka‘i, but the exclosures at Kanaio-Luala‘ilua and Kaupō are not free of ungulates. There is some nonnative plant management within the exclosures. Propagation and translocation efforts are ongoing.

Preventing extinction, interim stabilization, downlisting, and delisting objectives are provided in HPPRCC’s Revised Recovery Objective Guidelines (2011). To prevent extinction, which is the first step in recovering the species, the taxon must be managed to control threats (e.g., fenced) and have 50 individuals (or the total number of individuals if fewer than 50 exist) from each of three populations represented in an *ex situ* (at other than the plant’s natural location, such as a nursery or arboretum) collection. In addition, a minimum of three populations total should be documented on the islands of Kaua‘i, O‘ahu, Moloka‘i, Maui, and/or Lāna‘i where they now occur or occurred historically and each of these populations must be naturally reproducing (i.e., viable seeds, seedlings, or saplings) with a minimum of 25 mature, reproducing individuals per population.

The preventing extinction goals for this species have not been met as, although one population may total at least 25 mature individuals, feral ungulates remain within the fenced enclosure and natural recruitment has only been reported within a fenced and ungulate-free enclosure. Genetic storage goals have partially been met with representation of the O‘ahu population. Propagation and translocations are ongoing (Table 1); however, not all threats are being sufficiently managed throughout the range of the species (Table 2). Therefore, *Nothocestrum latifolium* meets the definition of endangered as it remains in danger of extinction throughout its range.

3.0 RESULTS

3.1 Recommended Classification:

Downlist to Threatened

Uplist to Endangered

Delist

Extinction

Recovery

Original data for classification in error

No change is needed

3.2 New Recovery Priority Number:

Brief Rationale:

3.3 Listing and Reclassification Priority Number:

Reclassification (from Threatened to Endangered) Priority Number: _____

Reclassification (from Endangered to Threatened) Priority Number: _____

Delisting (regardless of current classification) Priority Number: _____

Brief Rationale:

4.0 RECOMMENDATIONS FOR FUTURE ACTIONS

- Surveys and inventories—Continue to conduct surveys for *Nothocestrum latifolium* in historical locations and potentially suitable habitat.
- Ungulate monitoring and control—Continue to construct and maintain fenced enclosures to protect individuals from the negative impacts of feral ungulates.
- Invasive plant monitoring and control—Continue to control established ecosystem-altering nonnative invasive plant species and those that compete with *N. latifolium*.
- Fire management—Develop and implement a fire management plan for all populations.

- Predation and herbivory control—Develop and implement black twig borer control methods.
- Captive propagation for genetic storage and reintroduction—Collect seeds for storage and continue propagation efforts for maintenance of genetic stock.
- Reintroduction and translocation—Translocate individuals to managed suitable habitat to increase numbers of populations and individuals to build resiliency and redundancy and reduce the impacts of habitat destruction, nonnative plant competition, predation, and climate change.
- Climate change adaptation strategy—Research suitability of habitat in the future due to the impacts of climate change.
- Alliance and partnership development—Continue to contribute to planning and implementation of ecosystem-level restoration and management to benefit this taxon.

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U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of *Nothocestrum latifolium*
(‘aiea)

Current Classification: Endangered

Recommendation resulting from the 5-Year Review:

- Downlist to Threatened
- Uplist to Endangered
- Delist
- No change needed

Appropriate Listing/Reclassification Priority Number, if applicable: _____

Review Conducted By:

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FIELD OFFICE APPROVAL:

for

Field Supervisor, Pacific Islands Fish and Wildlife Office