Hedyotis megalantha
Pao dedu

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: *Hedyotis megalantha* (Pao dedu)

TABLE OF CONTENTS

5-YEAR REVIEW
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1.0 GENERAL INFORMATION

1.1 Reviewers:

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Lauren Weisenberger, Plant Recovery Coordinator, PIFWO
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Lead Regional Office
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Lead Field Office:
Pacific Islands Fish and Wildlife Office (PIFWO), Honolulu, Hawai‘i

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 (PIFWO) of the U.S. Fish and Wildlife Service (USFWS), beginning in January 2020. The review was based on the final rule listing this species; peer reviewed scientific publications; unpublished field observations by the USFWS, Territory of Guam and the Commonwealth of the Northern Mariana Islands (CNMI) and other experienced biologists; unpublished survey reports; notes and communications from other qualified biologists; as well as a review of current, available information since the listing of *Hedyotis megalantha* (Pao dedu, USFWS 2015). The evaluation by Dawn Bruns, Biologist, was reviewed by Lauren Weisenberger, Plant Recovery Coordinator, and Megan Laut, Conservation and Restoration Team Manager.

1.3 Background:

For information regarding the species' listing history and other facts, please refer to the Fish and Wildlife Service's Environmental Conservation On-line System (ECOS) database for threatened and endangered species (http://ecos.fws.gov/tess_public).

1.3.1 FR Notice citation announcing initiation of this review:

U.S. Fish and Wildlife Service. 2018. Endangered and Threatened Wildlife and Plants; Initiation of 5-Year Status Reviews for 156 Species in Oregon, Washington, Hawaii, Palau, Guam, and the Northern Mariana Islands. Federal Register 83(88): 20088–20092, May 7, 2018.

1.3.2 Listing history

Original Listing
FR notice: U.S. Fish and Wildlife Service. 2015. Endangered and Threatened Wildlife and Plants; Endangered Status for 16 Species and Threatened Status for 7 Species in Micronesia; Final Rule. Department of the Interior, Federal Register 80 (190): 59424-59497.
Date listed: October 1, 2015
Entity listed: *Hedyotis megalantha*
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 *Hedyotis megalantha*. This species was listed endangered on October 1, 2015 (80 FR 59424, USFWS 2015).

1.3.5 Species' Recovery Priority Number at start of this 5-year review: 8

1.3.6 Current Recovery Plan or Outline

Name of plan or outline: Recovery outline for 23 Mariana Island species.
Date issued: February 3, 2020.
Dates of previous revisions, if applicable: N/A
Critical habitat has not been designated for this species. The draft recovery plan for this species is in preparation.

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***
__X__ ***No***

2.1.2 Is the species under review listed as a DPS?

_____ ***Yes***
__X__ ***No***

2.1.3 Was the DPS listed prior to 1996? N/A

____ ***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? N/A

____ ***Yes***
____ ***No***

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

____ ***Yes***
____ ***No***

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

____ ***Yes***
____ ***No***

2.2 Recovery Criteria

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

____ ***Yes***
__X__ ***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? N/A

____ ***Yes***
____ ***No***

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

____ ***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.

The recovery plan for this species is currently in preparation. A synthesis of the threats (Listing Factors A, D, and E) affecting this species is presented in section 2.3.2 and Table 1. Listing Factor B (overutilization for commercial, recreational, scientific, or educational purposes) and C (predation) are not currently known to be threats to this species.

The Hawai‘i and Pacific Plants Recovery Coordinating Committee (HPPRCC) has outlined the actions and goals for stages leading towards recovery (HPPRCC 2011). These stages are described below. Current information is lacking for many Mariana Island plant species on the status of the species and their habitats, breeding systems, genetics, and propagule storage options. Many of the plant species in the Mariana Islands are at very low numbers or are declining rapidly, so the USFWS 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 USFWS 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, Downlisting, and Delisting objectives. 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.

Hedyotis megalantha is a short-lived perennial herb. To prevent extinction, which is the first step in recovering the species, the taxon must be managed to control threats (e.g., fenced and free of pests) 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 secure and well managed. In addition, a minimum of three populations should be documented where they now occur or occurred historically. Each of these populations must be naturally reproducing (i.e., viable seeds, seedlings), with a minimum of 50 mature individuals per population.

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

Interim Stabilization

In addition to meeting the Preventing Extinction goals, to meet the interim stage of recovery of *Hedyotis megalantha*, 300 mature, reproducing individuals are needed in each of three populations, and threats are controlled around each population designated for recovery at this stage. There should also be demonstrated regeneration of seedlings, growth to maturity, and documented replacement regeneration within each of the populations. The populations are adequately represented in *ex situ* collections as defined in the Center for Plant Conservation's guidelines (Guerrant et al. 2004, entire) that are secure and well maintained. Adequate monitoring is 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 preventing extinction and interim stabilization targets, a minimum of five populations with 500 mature, reproducing individuals per population are stable, secure, and naturally reproducing for a minimum of 10 years. 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 10 populations with 500 mature individuals per population and all of the goals of the preventing extinction and interim stages, all target populations must be stable, secure, naturally reproducing, and within secure and viable habitats for a minimum of 20 years. 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: *Hedyotis megalantha*, a perennial short-lived herb in coffee family (Rubiaceae), is endemic to the island of Guam in the Mariana Archipelago. This plant is endemic to the savanna habitat with highly weathered volcanic clay soil of southern Guam (Digital Atlas of Southern Guam–http://south.hydroguam.net/index.php). *Hedyotis megalantha* is often found growing in the *Dimeria* community and erosion scar community within the savanna habitat, frequently in patches with the native fern *Dicranopteris linearis* (Gawel et al. 2013, in litt.; Demeulenaere, 2020, in litt.). The plant primarily occurs in quality savanna habitat with diverse native vegetation with little human disturbance (Demeulenaere, 2020, in litt.). Native *Dimeria* vegetation is dominated by *Dimeria chloridiformis*–a low-

growing grass and erosion scar vegetation consists of low-growing shrubs such as *Melastoma marianum*, *Decaspermum fruticosum*, *M. beningseniana*, *G. micranthum*, low-growing sedges such as *Rhynchospora rubra, Fimbristylis* sp. and *Machaerina mariscoides,* and ferns such as *Lycopodium cernuum* and *Dicranopteris linearis* (Demeulenaere 2020 in litt.). *Hedyotis megalantha* grows among these low-growing grasses, sedges, and ferns (Demeulenaere 2020 in litt.). The *Dimeria* and erosion scar savanna communities are usually not shaded by tall grasses or other canopy cover. Erosion scar "badlands" and *Dimeria* habitat for this species is patchily distributed throughout the savanna landscape (Kottermair et. al. 2011, p. iii; GPEPP 2020, in litt.).

Savanna habitat occurs primarily on deeply weathered volcanic clay soil that is highly acidic due to an abundance of aluminum (Mueller-Dombois and Fosberg, 1998, p. 270). Acid soils are characterized by a deficiency in nutrients and toxicity of metal (most often aluminum as it is the most abundant metal on earth) (Bojórquez-Quintal et al. 2017, p. 1). Further contributing to low nutrient availability is the lack of organic matter in the soil. *Hedyotis megalantha* individuals may require highly acidic soils and minimal nutrients for survival or they may have an enhanced ability to uptake nutrients from the soil. The presence of aqueous (water-based) aluminum in the soil can stimulate or inhibit plant growth (Bojórquez-Quintal et al. 2017, pp. 2–8). In some plant species, aluminum stimulates growth by promoting the uptake of nutrients (Bojórquez-Quintal et al. 2017, p. 4). *Hedyotis megalantha* may be among those taxon that benefit from the presence of aqueous aluminum, and aluminum may be needed for the plant's survival in nutrient-poor soils. *H. megalantha* could also have an alternative intrinsic biological mechanism for surviving in an environment with a paucity of nutrients such as via a symbiotic relationship with the microbial community or through commensalism (when one benefits with no effect on the other organism)).

There have been little studies on the breeding system and pollination biology of *Hedyotis megalantha*, and it is suspected that the species likely requires cross-pollination for optimal breeding success. Due to the number of reports citing insects as the primary pollinator for species within the genus *Hedyotis*, it is likely that a variety of insects pollinate *H. megalantha*. It is possible that butterflies and other generalist insect pollinators are drawn to its white flowers with purple anthers (USFWS 2011, in litt.).

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: An estimated 800 *Hedyotis megalantha* individuals occur in populations that are sparsely distributed across the savanna. Where it occurs, there are often hundreds of plants (Demeulenaere 2020 in litt.). Recent sightings of *H. megalantha* include along Cross Island Road inward toward the mountains in the Talofofo Watershed, Nimitz Hill, Mount Lam Lam (Demeulenaere 2020 in litt.), and the Santa Rita area near Mount Alifan (iNaturalist.org 2020). Much of the suitable habitat for *H.*

megalantha has not been surveyed. Conservation translocations of this species have not been conducted.

2.3.1.3 Genetics, genetic variation, or trends in genetic variation (e.g., loss of genetic variation, genetic drift, inbreeding, etc.): No new information.

2.3.1.4 Taxonomic classification or changes in nomenclature: No new information.

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.): No changes in the spatial distribution of the species. Populations and individuals have been detected within the species range as described in 2.3.1.2.

2.3.1.6 Habitat or ecosystem conditions (e.g., amount, distribution, and suitability of the habitat or ecosystem): *Hedyotis megalantha* is endemic to savannas of southern Guam where it is found in *Dimeria* vegetation and edges of erosion scar and badland areas within the savanna habitat along mountain ridgetops, slopes, and forest edges and patches (Demeulenaere 2020 in litt.). *Hedyotis megalantha* appears to be absent from areas that have been converted to dense grass by wildfire.

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: Most *H. megalantha* are found in native *Dimeria* vegetation and at the edges of erosion scars and forest communities within the savanna habitat along ridgetops, slopes, and forest edges (Demeulenaere 2020 in litt.). Erosion scar "badlands", forest patches, and *Dimeria* vegetation are patchily distributed throughout the savanna landscape (Kottermair et. al. 2011, p. iii; GPEPP 2020, in litt.). *Hedyotis megalantha* individuals are not found in areas that have been converted to tall dense grass by wildfire. Because conservation of this species will require an abundance of intact undisturbed native savanna vegetation distributed across southern Guam, the species is vulnerable due to the loss of its habitat that is occurring due to non-native animals, invasive plants (particularly grass invasion following wildfire), typhoons, off-road vehicles, and effects due to climate change.

Agricultural, military training, and urban development loss of degradation of habitat— Military, urban, residential, resort, and agricultural development have resulted in the permanent loss of native savannas. Native vegetation on the Mariana Archipelago has undergone significant alteration because of past and present land use including ranching, agricultural development, military actions,

and war (Ohba 1994, pp. 17, 28, 54–69; Mueller-Dombois and Fosberg 1998, p. 242; Berger et al. 2005, pp. 45, 105, 110, 218, 347, 350). More than 20% of the island of Guam is developed (Spies et al. 2019).

Invasive animal destruction and degradation of habitat—Non-native animals including ungulates, the brown treesnake (*Boiga irregularis*), rodents, and invasive ants degrade the habitat upon which *Hedyotis megalantha* relies. Ungulates degrade the habitat through the following means: a) create trails that damage native vegetative cover; b) destabilize substrate causing erosion, landslides, rockfalls, and vegetation loss; c) injure roots, seedlings, or plants through trampling, trails, or rooting actions; d) create gullies that convey water and contribute to flooding or destabilization of the substrate; and, e) promote invasion of non-native species through transport of seeds, vegetative plant parts, or creation of openings (Cuddihy and Stone 1990, pp. 63–64).

The introduction of the brown treesnake poses a threat to the persistence of habitat needed for the recovery of *Hedyotis megalantha*. The introduction of the brown treesnake to Guam in approximately 1949, has caused the extirpation of a large percentage of bird and small animal species and appears to be responsible for elimination of all or most of the species that disperse seeds and pollinate native plants on Guam (Rodda et al. 1997 p. 565-567, Fritts and Rodda 1998 pp. 115, 131, Savidge 1987 entire, Perry and Morton 1999, p. 137; Rodda and Savidge 2007, p. 311; USFWS 2015). Almost three quarters of the native tree species on Guam were once dependent on birds to eat their fruits and disperse their seeds and germination of some tree species is reduced when the seed coat is not digested by passing through the gut of a bird (USFWS 2015). The only remaining native avian frugivore on Guam is the Micronesian starling (*Aplonis opaca*) (Pollock et al. 2019). On Saipan, the median dispersal distance modeled by Rehm et al. (2018, pp. 1, 5) for five bird species and 15 tree species was 184 feet (56 meters). In the absence of dispersal, seeds fall under the parent tree resulting in reduced connectivity between disjunct plants and reduced survival of seedlings due to conspecific competition (Nathan and Muller-Landau 2000). Loss of seed dispersers on Guam has resulted in reduced recruitment, altered spatial distribution of native tree species, reduced species richness, and reduced forest regeneration on Guam in comparison to the other islands (Rogers et al. 2017). Elimination of seed dispersers has cascading effects on other trophic levels, and can affect ecosystem stability (Perry and Morton 1999, p. 137; Fricke et al. 2017). The brown treesnake's elimination of native plant seed dispersers is an indirect threat that negatively impacts the habitat of *H. megalantha*.

Because rodents have caused declines or even the complete elimination of island plant species (Campbell and Atkinson 1999, in Atkinson and Atkinson 2000, p. 24), they pose a threat to the persistence of the native habitat needed by *Hedyotis megalantha*. Rodents can alter species composition of forested areas by reducing plant regeneration by eating fleshy fruits, seeds, flowers, stems, leaves, roots, and other plant parts (Atkinson and Atkinson 2000, p. 23; Cuddihy and Stone 1990, p.

69). Three rat species are found throughout the Mariana Islands: the Polynesian rat (*Rattus exulans*), the Norway rat (*R. norvegicus*), and a putative new southeast Asian *Rattus* line, originally thought to be *R. diardii* (synonymous with *R. tanezumi*) (Kuroda 1938 in Wiewel et al. 2009, p. 208; Wiewel et al. 2009, pp. 210, 214–216). One or more of these rat species are present on all of the Mariana Islands where *H. megalantha* is found (Wiewel et al. 2009, pp. 205– 222; Kessler 2011, p. 320). Where rodent populations are currently suppressed where the brown treesnake occurs, rodent threats are expected to increase as brown treesnake suppression is implemented. Degradation of forest habitat by rodents is a potential threat to recovery of *H. megalantha.*

Invasive invertebrates, such as ants, are a potential threat to the habitat of *Hedyotis megalantha*. Ants commonly occur in dense numbers on vegetation in the Mariana Islands (Schreiner and Nafus 1996, pp. 3-4). The habitat upon which *Hedyotis megalantha* relies may not be able to persist where invasive ants occur in high numbers. Ant species such as the dwarf pedicel ants (*Tapinoma minutum*), tropical fire ants (*Solenopsis geminata*), white-footed ants (T*echnomyrmex albipes*), bi-colored trailing ants (*Monomorium floricola*), and little fire ants (*Wasmannia auropunctata*) feed on vertebrate and invertebrate eggs, pupae, larvae, and adults (Wild 2014, p. 1). Several incipient populations of little fire ants occur on Guam and there is a potential for the little fire ant to be moved to other locations on Guam and to other islands via the movement of green waste and potted plants. Invasive ant occurrence within proximity of populations of *H. megalantha* are likely to reduce the abundance of invertebrates and vertebrates and reduce the reproduction of native habitat plants that are pollinated or dispersed by animals (Willsey et al 2019).

Established ecosystem-altering invasive plant modification and degradation of habitat—The greatest risk posed by invasive plant species in the Marianas is aggressive displacement of native species. Invasive grasses threaten the quality and availability of habitat for and can directly outcompete *Hedyotis megalantha*. The native flora of the Mariana Islands consists of approximately 500 taxa, 10 percent of which are endemic to the Mariana Islands. Over 100 plant taxa have been introduced from elsewhere, and at least one third of these plants have become invasive (Stone 1970, pp. 18–21; Mueller-Dombois and Fosberg 1998, pp. 242– 243, 249, 262–263; Costion and Lorence 2012, pp. 51–100). Invasive plant species, including native grasses, are responsible for modifying the availability of light, altering soil-water regimes, modifying nutrient cycling, increasing wildfire threat to native plant communities, and ultimately converting native-dominated plant communities to non-native plant communities (Smith 1985, pp. 180–181 and 217-218; Cuddihy and Stone 1990, p. 74; D'Antonio and Vitousek 1992, p. 73; Ohba 1994, pp. 17, 28, 54– 69; Vitousek et al*.* 1997, p. 6-9; Mueller-Dombois and Fosberg 1998, pp. 242–243, 249, 262–263; Berger et al. 2005, pp. 45, 105, 110, 218, 347, 350). Invasive vines can grow in dense patches that smother and kill native plants following typhoons by encroaching in areas where trees were defoliated or destroyed and covering areas which takes light and

water resources needed for the recovery and regeneration of the forest (Marler, 2001, p. 264; Willsey, et al. 2019, p. 17). The colonization of invasive plants within native forests has led to the establishment of secondary forest currently found on large portions of Guam, Tinian, and Saipan (Willsey, et al. 2019, p. 17).

Because of the presence of invasive grasses, wildfire is among the primary factors resulting in the conversion of diverse savanna vegetation to invasive species-dominated grassland, and is a threat to *Hedyotis megalantha*. Wildfires burn an annual average of 1.6 to 2.4 percent of the land area in the Northern Mariana Islands and 3.5 to 4.0 percent of the land area of Guam (Minton 2006 p. 23, Dendy 2019 in litt., and Trauernicht and Kunz 2019, p. 1). Wildfires in the Mariana Islands are primarily human-caused and are usually limited to previously-burned grass-dominated areas (Minton 2006, p. 3; Dendy 2019 in litt.; Demeulenaere 2020 in litt.). Wildfires are most destructive to native ecosystems during severe droughts such as the February through June wildfire seasons and during El Nino years (Aydlett 2017; Athens and Ward 2004, p. 18, Greenlee 2010 p.1, Kunz 2018 p. 1, Dendy 2019, and Trauernicht and Kunz 2019 p. 1, Trauernicht and Chimera 2020, p. 1). Fire damages and destroys native plant species, including dormant seeds, seedlings, and juvenile and adult plants and can impact microclimatic conditions creating conditions favorable to invasive plants. Where native herbs and shrubs are killed by fire, grasses can outcompete seedlings of other species for light, water, and nutrients resulting in native vegetation conversion to grassland (Fosberg 1960, p. 40; Stone 1970, p. 184; D'Antonio, and Vitousek 1992 p. 68-70, Minton 2006 p. 21, pp. 25-29, NRCS 2011 p. 1, Johnson 2012, p. 27; and Leary 2018, p. 3-4) and facilitating spread of future fires (Fujioka and Fujii 1980 in Cuddihy and Stone 1990, p. 93; D'Antonio and Vitousek 1992, pp. 70, 73–74; Tunison et al. 2002, p. 122). *Miscanthus floridulus* (swordgrass), one of the dominant species in the savanna habitat, also exacerbates the spread of fire in the savanna habitat and recovers quickly once burned (Fosberg 1960, p. 40; Stone 1970, p. 184; Minton 2006, p. 21). *Miscanthus floridulus* outcompetes other species due to its tall and dense growth habit (Demeulenaere 2020, in litt.). It allows very little space for other species to grow. The presence of nonnative invasive grasses such as *Dicanthium bladhii* and *Pennisetum polystachion* further contribute toward an increase in fire frequency and intensity (Minton 2006, p. iii). Because patches of the native fern, *Dicranopteris linearis* do not burn readily (Minton 2006, p. 30), *H. megalantha* may be protected from fires by patches of *D. linearis*.

Typhoons and climate change degradation or loss of habitat—The impacts of climate change on *Hedyotis megalantha* are not well understood but climate change has had impacts in the tropical Pacific generally. The Mariana Islands lie in the world's most prolific typhoon basin. Typhoons cause a number of impacts to native species and native ecosystems. Disturbed or destroyed vegetation due to typhoons modifies light availability and facilitates invasion by invasive plant species that compete for space, water, and nutrients, and alter basic soil hydrology and nutrient cycling processes (USFWS 2015, Wilsey et al. 2019). Climate change is expected to increase typhoon frequency and intensity, increase

temperatures, and decrease precipitation, which can result in changes to the microclimate of a species (IPCC 2014, pp. 6-11). During typhoons, intense winds can defoliate trees, break primary branches, and uproot or topple trees. Native vegetation can take several years to recover and during this time the habitat is susceptible to encroachment from invasive trees, shrubs, and vines (Marler 2001, p. 1). "Dry" typhoons have very little rainfall, causing salt water to be carried by the wind and deposited far inland. This causes the leaves on most dicot trees to wither and fall within two days of a storm and can cause mortality (Kerr 2000, p. 895). Droughts and vegetation changes following typhoons can cause an increase in wildfires (Aydlett 2017, in litt.). Such changes may lead to the direct loss of *H. megalantha* or habitat needed for its conservation. These threats can be particularly devastating to species that persist in limited numbers or distribution. Although there are currently no climate change studies that specifically address impacts to *H. megalantha*, an increase in intensity and/or frequency of rainfall would increase savanna erosion and expand areas of badlands and further reduction in the size and quality of the savanna habitat for *H. megalantha.* Additionally, because *H. megalantha* may require a distinct wet and dry seasons to complete its life history, alterations in the seasonality of precipitation could impact *H. megalantha* reproduction.

2.3.2.2 Overutilization for commercial, recreational, scientific, or educational purposes: N/A

2.3.2.3 Disease or predation: Specific disease and herbivory threats have not been identified.

2.3.2.4 Inadequacy of existing regulatory mechanisms: Guam's Endangered Species Act does not recognize *Hedyotis megalantha* as endangered. Therefore, existing regulatory mechanisms on Guam are inadequate to address threats imposed upon the species.

2.3.2.5 Other natural or manmade factors affecting its continued existence: Off-road recreational vehicles are also a direct threat to the survival of *Hedyotis megalantha* individuals. Recreational vehicles have been identified as a threat to *H. megalantha*. Off-roading is a popular pastime on Guam, particularly in the mountainous savanna lands of southern Guam. Because recreational vehicles tend to consistently follow the same paths, the soil trails deepen and erosion worsens preventing the soil and plants from recovering (Swaddell 2019, in litt.). The increasing area of badlands across the savanna contribute toward a decreasing trend in available habitat for *H. megalantha*. The phenomenon also further decreases already limited nutrient availability.

Current Management Actions:

- Surveys and inventories –
    - The University of Guam's Center for Island Sustainability & Guam Plant Extinction Prevetnion Program surveys for *Hedyotis megalantha* in savanna habitat (Demeulenaere 2020, in litt.).
- Captive propagation for genetic storage and reintroduction
    - The Guam Plant Extinction Protection Program (GPEPP) is an island-wide program to prevent the extinction of Guam's native and rarest plants, such as *Hedyotois megalantha*. With the help of conservation partners, GPEPP helps to protect extant species, propagate species to preserve seeds and genetic material, and reintroduce propagated individuals to their native habitats. This program has attempted to propagate *H. megalantha* in the nursery; however, they found *H. megalantha* difficult to grow and that the seedlings grow slowly (McConnell 2020, in litt.).
- Habitat protection –
    - A major biosecurity focus within the Mariana Islands is on controlling the brown treesnake on Guam. Federal agencies support local capacity. The U.S. Department of Agriculture, Wildlife Services, in coordination with the National Wildlife Research Center (NWRC), U.S. DoD Environmental Security Technology Certification Program, and the Department of Interior-Office of Insular Affairs (U.S. Geological Survey, USFWS), are developing methods to suppress the snake on the landscape scale (Dorr, et al. 2016, in litt.; Phillips 2014, in litt; BTSTWG 2015, entire; (Siers, et al. 2018, in litt.).
    - Researchers and students at the University of Guam's Center for Island Sustainability (CIS) conduct biological monitoring in the savanna habitat and are currently exploring optimal restoration methods to restore degraded savanna habitat. The biologists at CIS monitor the watersheds throughout the savanna focusing on sedimentation, erosion, and runoff. There are several graduate student projects focused on savanna ecology and restoration (e.g., seed balls, plant propagation and outplanting) to reduce erosion and runoff. One of these student projects includes *Hedyotis megalantha*.
    - In 2018, public outreach/awareness efforts to protect *Hedyotis megalantha* and the savanna habitat were initiated by NOAA Fisheries Pacific Island Regional Office. As part of this effort, NOAA created outreach materials to warn the public about the impacts of erosion on reef ecosystems and to prevent any damage to native savanna species. Cards with pictures and details about *H. megalantha* and other savanna species are being given to individuals before outplanting efforts in the savanna so extant individuals can be marked and buffers put in place. Although the cards are only currently provided to volunteers as part of outplanting trees, they may be made available to hikers or off-road bikers.
    - In 2002, a community effort known as the "Humåtak Project" was created to revive the watershed that is affecting Fouha Bay on southern Guam. Sediment traps to control erosion are improving habitat suitability for native plants in the savanna. Swordgrass is very opportunistic and commonly the first plant to

colonize an open area possibly limiting or prohibiting recolonization by *Hedyotis megalantha* and other native herbs.

- A fire management plan to reduce wildfire potential, protect and enhance natural and cultural resources, integrate applicable permit and reporting requirements and implement ecosystem management goals, sustainable training, and objectives is being drafted (JRM 2019).

- Other Natural or Manmade Factors - Recreation – The Guam's Department of Agriculture, Division of Aquatic Wildlife Resources (DWAR) has the authority to enforce laws (5 GCA, Chapter 63, PL-6-85) to protect native flora and fauna. Their Conservation Land areas include Cotal with 552 acres (223 ha) and Bolanos area with 2,830 acres (1145 ha). Cotal is primarily savanna, badlands, and some secondary forests and Bolanos consists of both savanna and forest. The Bolanos Conservation area is dominated by swordgrass and efforts are being made to rehabilitate the area by enforcing public use permits.

Table 1. Status and trend of *Hedyotis megalantha* from listing through 5-year review.

Date	No. wild individuals	Preventing Extinction Criteria identified by HPPRCC	Preventing Extinction Criteria Completed?
2015 (listing)	<1,000	All threats managed in three populations	No
		Complete genetic storage	No
		3 populations with 50 mature, reproducing individuals each	Partial – census of population numbers and sizes is incomplete
2020	~ 800	All threats managed in three populations	No
		Complete genetic storage	No
		3 populations with 50 mature, reproducing individuals each	Partial – census of population numbers and sizes is incomplete

Table 2. Threats to *Hedyotis megalantha* and ongoing conservation efforts.

Threat	Listing factor	Current Status	Conservation/ Management Efforts
Loss and degradation of habitat due to development	A	Ongoing	Partial. Efforts to assure conservation of native savanna vegetation initiated.
Invasive animal destruction and degradation of habitat	A	Ongoing	Partial. Local collaborations to develop and implement brown treesnake control measures to conserve native savanna vegetation on Guam.
Ecosystem altering invasive plant species degradation of habitat	A	Ongoing	Partial. Research ongoing on how to restore savanna habitats.
Fire	A	Ongoing	Partial. Interagency efforts to reduce wildfire threat to native diverse savanna

			vegetation occur on Guam. Guam Forestry personnel cut firebreaks and do public outreach and education to reduce wildfire ignitions (FSRD 2020).
Typhoons and climate change degradation or loss of habitat	A	Ongoing	None
Inadequate existing regulatory mechanisms	D	Ongoing	None
Direct impact from off-road vehicles	E	Ongoing	Partial, legislation to limit some activities.

2.4 Synthesis

Hedyotis megalantha is endemic to the savanna habitat of southern Guam. This endangered perennial herb is often found growing in the *Dimeria* community and erosion scar community within the savanna habitat, frequently in patches with the native fern *Dicranopteris linearis* (Gawel et al. 2013, in litt.; Demeulenaere, 2020, in litt.). An estimated 800 individuals of this endangered plant remain in the wild (Demeulenaere 2020 in litt.). Because surveys of the distribution and abundance of *H. megalantha* are incomplete, the number of populations of *H. megalantha* and total population sizes are unknown (Demeulenaere 2020 in litt.). The Guam Plant Extinction Prevention Program has found it difficult to propagate the plant (GPEPP 2018).

The remaining individuals are not protected from threats and are vulnerable to loss and habitat degradation by non-native animals (including ungulates, rodents, the brown treesnake, and invertebrates), invasive plants (including wildfire-mediated habitat conversion to grass and direct loss of plants due to wildfire), typhoons, and effects due to climate change. Individuals and their habitat area also vulnerable to loss due to off-road recreational vehicles.

We assess the status of *Hedyotis megalantha* in relation to Preventing Extinction, Interim Stabilization, and Delisting recovery objective guidelines developed by the Hawai‘i and Pacific Plants Recovery Coordinating Committee (HPPRCC 2011). Life history traits such as breeding system, population size fluctuation or decline, and reproduction type (sexual or vegetative), are included in the calculation of the number of populations and reproducing individuals needed to meet each recovery 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.

Hedyotis megalantha is a short-lived perennial herb. 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 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 should be documented throughout their historic range and each of these

populations must be naturally reproducing (i.e., viable seeds, seedlings) with a minimum of 50 mature, reproducing individuals per population.

The preventing extinction goals for this species have not been met. There has not been sufficient surveys to determine if there are at least three populations each with a minimum of 50 mature, reproducing individuals, there is a limited genetic storage collection and the goals have not been met (Table 1), and threats to these populations are not controlled (Table 2). Therefore, *Hedyotis megalantha* 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** (Indicate reasons for delisting per 50 CFR 424.11
__X__ No change is needed

3.2 New Recovery Priority Number, N/A

Brief Rationale:

3.3 Listing and Reclassification Priority Number, N/A

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

- Determine population status and current distribution—Determine the distribution and number of all individuals on each island. Identify priority sites for species conservation. Assess the status and threats to each population to inform prioritization of conservation effort.
- Conduct research to clarify life history information and threats to the populations and their habitat—Conduct research to determine the best way to control the brown treesnake, rodents, and invasive invertebrates. Assess development and land designation and zoning threats to conservation of habitat needed for recovery.
- Ungulate monitoring and control—Continue to construct and maintain fenced exclosures to protect wild and reintroduced individuals from the negative impacts of feral ungulates.
- Invasive plant monitoring and control—Continue to control ecosystem-altering

nonnative invasive plant species and those that compete with *H. megalantha* at all populations.

- Captive propagation for genetic storage and reintroduction—Continue to collect seeds and other propagative materials for storage and reintroduction.
- Reintroduction and translocation—Augment populations and increase numbers of populations and individuals in suitable habitat to build resiliency and redundancy and reduce the impacts of predation and typhoons, and climate change.
- Reduce human disturbance from military activities mortality and reduced viability—increase population resiliency by mitigating threats from military activities.
- Fire prevention and control—Implement more effective fuel load control.
- Develop regulations and policy essential to recover the species and their habitats—Encourage the development of legislation to ensure protection of the listed species under Commonwealth or Territorial law. Develop and support the implementation of biosecurity plans to prevent the influx of new pests and invasive species into the Territory and inter-island movement of pests and invasive species.
- 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 *Hedyotis megalantha*

Current Classification: Endangered

Recommendation resulting from the 5-Year Review:

____ Downlist to Threatened
____ Uplist to Endangered
____ Delist
__X__ No change needed

Appropriate Listing/Reclassification Priority Number, if applicable: N/A

Review Conducted By:
Dawn Bruns, Biologist, Pacific Islands Fish and Wildlife Office (PIFWO)
Lauren Weisenberger, Plant Recovery Coordinator, PIFWO
Megan Laut, Conservation and Restoration Team Manager, PIFWO

FIELD OFFICE APPROVAL:

for MEGAN LAUT Digitally signed by MEGAN LAUT Date: 2020.12.15 11:03:05 -10'00' _____ Date _____

Lead Field Supervisor, Fish and Wildlife Service