# 5-YEAR REVIEW

Short Form Summary

**Species Reviewed**: *Solanum incompletum* (pōpolo kū mai)

**Current Classification**: Endangered

**Federal Register Notice announcing initiation of this review:**

[USFWS] 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 88(83): 20088–20092, May 7, 2018.

**Lead Region/Field Office:**

Interior Region 12/Pacific Islands Fish and Wildlife Office (PIFWO), Honolulu, Hawai‘i

**Name of Reviewer:**

Cheryl Phillipson, Biologist, PIFWO
Lauren Weisenberger, Plant Recovery Coordinator, PIFWO
Megan Laut, Conservation & Restoration Team Manager, PIFWO

**Methodology used to complete this 5-year review:**

This review was conducted by staff of the Pacific Islands Fish and Wildlife Office (PIFWO) of the U.S. Fish and Wildlife Service (Service) beginning in October 2019. The review was based on a review of current, available information since the last 5-year review for *Solanum incompletum* (USFWS 2015). The evaluation by Cheryl Phillipson, Biologist, was reviewed by Lauren Weisenberger, Plant Recovery Coordinator, and Megan Laut, Conservation and Restoration Team Manager.

**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*).

**Review Analysis:**

Please refer to the previous 5-year reviews for *Solanum incompletum* published in the Federal Register on January 18, 2008 and August 6, 2015 (available at *https://ecos.fws.gov/docs/five_year_review/doc1809.pdf* and *https://ecos.fws.gov/docs/five_year_review/doc4561.pdf*) for a complete review of the species' status, threats, management efforts, and references cited. We are not aware of any significant new information regarding the species' biological status since listing to warrant a change in the Federal listing status of *S. incompletum*.

This short-lived perennial shrub in the Solanaceae (nightshade) family is endangered and found on the island of Hawai‘i, with historic occurrences on Lāna‘i and Maui. The current status and trends for *Solanum incompletum* are provided in the tables below.

New Status Information:

- At the time of the 5-year review in 2015 there were estimated to be 86 wild individuals of *Solanum incompletum* at three locations: Pōhakuloa Training Area (PTA), Puʻuanahulu, and Puʻuwaʻawaʻa. Currently, there are three populations on PTA at Puʻu Leilani-Puʻu Hukilau and Mixed Tree West, and two populations on State land at Puʻuanahulu and Puʻuwaʻawaʻa, that total between 73 to 113 individuals (Department of Land and Natural Resources (DLNR) 2017, p. 60; U.S. Army Garrison 2020, pp. 13, 26–28). Seedlings (natural recruitment) have been observed (U.S. Army Garrison 2020, pp. 26–28).
- In 2016, the critical habitat designation for *S. incompletum* was revised for the island of Maui (five units totaling 7,577 hectares (ha), 18,724 acres (ac)) (81 FR 17790, March 30, 2016). Critical habitat was excluded on Lānaʻi because the benefits provided to the species from conservation actions by the landowner outweighed the benefits of designation.
- In November, 2019, an endangered Blackburn's sphinx moth caterpillar (BSM, *Manduca blackburni*) was found on *Solanum incompletum* in PTA (Bogardus 2019, in litt.). Species in the plant family Solanaceae (nightshade) are host plants for the larval stage of the moth, and the moth larvae (instar stages) are commonly found on the widespread nonnative *Nicotiana glauca* (tree tobacco) (DLNR 2017, p. 2). Clearing of tree tobacco and other nonnative plants from PTA and the adjacent Puʻuanahulu and Puʻuwaʻawaʻa is essential to provide fuel breaks for fire suppression but may impact the BSM (DLNR 2017, p. 2). However, fire suppression would provide an overall benefit to the BSM and to native host plants such as *S. incompletum* (DLNR 2017, p. 102).

New Threats:

- Climate change loss or degradation of habitat—Climate change may pose a threat to this species. Fortini *et al.* (2013) conducted a landscape-based assessment of climate change vulnerability for native plants of Hawaiʻi 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 by Fortini *et al.* (2013) concluded that *Solanum incompletum* is vulnerable to the impacts of climate change, with a vulnerability score of 0.308 (on a scale of 0 being not vulnerable to 1 being extremely vulnerable to climate change). Therefore, additional management actions may be needed to conserve this taxon into the future, such as locating key microsites that overlap with current and future climate envelopes for outplanting efforts.

New Management Actions:

- Surveys and inventories—Field surveys to monitor and confirm the status of wild and reintroduced populations of *Solanum incompletum* are conducted within PTA, Puʻuanahulu, and Puʻuwaʻawaʻa (DLNR 2017, entire; U.S. Army Garrison 2020, pp. 6, 13). Threats and their impacts are monitored (DLNR 2017, pp. 120, 162, 165; U.S. Army Garrison 2020, pp. 26–28).

- Ungulate monitoring and control—The Department of Land and Natural Resources (DLNR) plans on construction of a larger exclosure (7 hectares (ha), 18 acres (ac)) to protect nine *S. incompletum* currently in eight small emergency fences at the Solanum Kīpuka (DLNR 2017, pp. 111, 115–117). The DLNR also manages another proposed fence unit, Kīleo (216 ha, 533 ac), for the protection of *S. incompletum* and four other endangered plant species (DLNR 2017, pp. 115–117).
- Rodent monitoring and control—Rats and mice and their impacts on *S. incompletum* are monitored at PTA (U.S. Army Garrison 2020, pp. 26–28).
- Captive propagation for genetic storage and reintroduction—
    - At the end of 2019, PTA reported a total of 81 cuttings taken from 16 founders for propagation (produced 39 propagules), and collection of 594 seeds representing eight founders from two locations for storage (U.S. Army Garrison 2020, pp. 35, 40; U.S. Army 2018-2019). The overall totals for seed and fruit collections include 3,390 seeds collected for wild individuals, 8,363 fruit from greenhouse plants, and 21 fruit collected from reintroduced plants (U.S. Army Garrison 2020, p. 37).
    - The DLNR reported propagation from 21 cuttings from wild and nursery plants at Puʻuwaʻawaʻa and Puʻuanahulu (Puʻuwaʻawaʻa 2018).
    - The Volcano Rare Plant Facility (VRPF) reported propagation of a total of 38 *S. incompletum* between 2015 and 2019, with nine individuals currently in refugia (VRPF 2015–2019).
- Reintroduction—
    - From 2004 to 2015, PTA reintroduced *S. incompletum* in seven locations. Currently, 214 mature and 195 immature plants survive (U.S. Army Garrison 2020, pp. 48–49). In 2019, PTA reported reintroduction of two plants at the installation's garden; however, both plants died (U.S. Army 2020, p. 190).
    - The National Tropical Botanical Garden (NTBG) reported one individual of *S. incompletum* planted at the Southshore Garden as a living collection (NTBG 2019).
    - VRPF reported reintroduction of 11 propagated plants at Puʻuwaʻawaʻa (VRPF 2015–2019).
- Population biology—PTA conducted 30 seed germination trials using 1,587 seeds that produced 166 seedlings (approximately 10 percent germination rate) (U.S. Army 2020, p. 40).

**Table 1. Status and trends of *Solanum incompletum* from listing through current 5-year review**.

| Date | No. wild individuals | No. outplanted | Stabilization Criteria identified in Recovery Plan | Stabilization Criteria Completed? |
|---|---|---|---|---|
| 1994 (listing) | 2 | 0 | All threats managed in all 3 populations | No |

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|---|---|---|---|---|
| | | | Complete genetic storage | No |
| | | | 3 populations with 50 mature individuals each | No |
| 1999 (recovery plan) | ca 40 | 0 | All threats managed in all 3 populations | Partially |
| | | | Complete genetic storage | Partially |
| | | | 3 populations with 50 mature individuals each | No |
| 2003 (critical habitat) | ca 35 | 527 | All threats managed in all 3 populations | Partially |
| | | | Complete genetic storage | Partially |
| | | | 3 populations with 50 mature individuals each | No |
| 2008 (5-year review) | 63 mature<br>20 immature | 1,085<br>921 survived 3 years | All threats managed in all 3 populations | Partially |
| | | | Complete genetic storage | Partially |
| | | | 3 populations with 50 mature individuals each | No |
| 2015 (5-year review) | 86 | 554<br>(189 natural recruits) | All threats managed in all 3 populations | Partially |
| | | | Complete genetic storage | Partially |
| | | | 3 populations with 50 mature individuals each | No |

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|---|---|---|---|---|
| 2016 (critical habitat Maui, Lānaʻi CH excluded) | 0 (Maui, Lānaʻi) | 0 | All threats managed in all 3 populations | No |
| | | | Complete genetic storage | No |
| | | | 3 populations with 50 mature individuals each | No |
| **Date** | **No. wild individuals** | **No. outplanted** | ***Preventing Extinction Criteria identified by HPPRCC** | ***Preventing Extinction Criteria Completed?** |
| 2020 (5-year review) | 73–113 | 214 mature 195 immature survive | All threats managed in all 3 populations | Partially, 5 populations in exclosures |
| | | | Complete genetic storage | Partially |
| | | | Reproduction (i.e. viable seeds, seedlings) at all 3 populations | Partially, natural recruitment at 2 populations |
| | | | 3 populations with 50 mature individuals each | No |

* The Preventing Extinction Stage was established in 2011. Prior to 2011, the Interim Stabilization Stage was the first stage towards recovery (now it is the second stage after Preventing Extinction).

**Table 2. Threats to *Solanum incompletum* and ongoing conservation efforts**.

| Threat | Listing factor | Current Status | Conservation/ Management Efforts |
|---|---|---|---|
| Ungulate destruction and degradation of habitat and herbivory | A, C, D | Ongoing | Partial, 5 populations in exclosures |
| Established ecosystem altering invasive plant species degradation of habitat and competition | A, E | Ongoing | Partial, some nonnative plant control at PTA, planned for other areas |

| | | | |
|---|---|---|---|
| Drought destruction and degradation of habitat | A | Ongoing | Partial, some supplemental water at PTA 2010 |
| Fire destruction and degradation of habitat | A | Ongoing | Partial, nonnative plant control efforts and firebreaks at PTA |
| Climate change degradation and loss of habitat | A | Ongoing | None |
| Collection and vandalism impacts | B | Ongoing | None |
| Rodent predation and herbivory | C | Ongoing | Partial, PTA monitoring |
| Military training activities | E | Ongoing | Partial, management at PTA following ESA consultation |
| Loss of vigor due to low numbers | E | Ongoing | Partial, germination and propagation trials, reintroduction |

**Synthesis:**
Currently, between 73 and 113 wild individuals of *Solanum incompletum* occur within PTA, Puʻuanahulu, and Puʻuwaʻawaʻa on the island of Hawaiʻi. A landscape-based assessment of climate change vulnerability for native plants of Hawaiʻi using high resolution climate change projections was made by Fortini *et al.* (2013) and their analysis showed that *S. incompletum* is vulnerable to the effects of climate change. Currently, of the previously reintroduced individuals at PTA, 214 mature and 195 immature individuals survive. Five wild and reintroduced populations are provided protection from feral ungulates by fencing and ungulate control at PTA and Puʻuwaʻawaʻa, with some nonnative plant management. Fewer than 20 individuals have been reintroduced at Puʻuwaʻawaʻa. Natural recruitment has been reported at two populations. Germination trials and propagation from cutting trials are ongoing. Rat or mouse control efforts have not been reported recently.

Stabilizing (interim), downlisting, and delisting objectives were provided in the Recovery Plan for the Multi-Island Plants (USFWS 1999), and have been updated according to the draft revised recovery objective guidelines developed by the Hawaiʻi and Pacific Plants Recovery Coordinating Committee (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.

*Solanum incompletum* is a short-lived perennial shrub. 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. In addition, a minimum of three populations should be documented on the islands of Hawai‘i and at least one other island (Maui, Lāna‘i) where they now occur or occurred historically and each of these populations must be naturally reproducing *(i.e.,* viable seeds, seedlings, saplings), with a minimum of 50 mature, reproducing individuals per population.

The preventing extinction goals for this species have not been met. There are not three populations with 50 reproducing individuals each (there may be one); however, natural recruitment is reported at two populations. Genetic representation is complete for only eight founders (Table 1). All threats, including nonnative plant competition, rodent predation, and vandalism, are not being managed (Table 1, Table 2). Therefore, *Solanum incompletum* meets the definition of Endangered as it remains in danger of extinction throughout its range.

**Recommendations for Future Actions:**
We are not aware of any new threats or significant new information regarding the species' biological status since the last 5-year review in 2015. Thus, the following recommendations for future actions are reiterated for the 5-year review for 2020.

- Surveys and inventories—Continue to conduct thorough surveys of all current and historical range for an assessment of the species' status.
- Ungulate monitoring and control—Continue to construct and maintain fenced exclosures to protect individuals from the negative impacts of habitat destruction and degradation, and browsing and trampling by ungulates.
- Established ecosystem-altering invasive plant monitoring and control—Control established ecosystem-altering nonnative invasive plant species, and those that compete with *Solanum incompletum* at all populations.
- Fire management—Continue to develop and implement fire management plans.
- Habitat protection—Continue to implement effective measures to reduce the impacts of military training.
- Climate change adaptation strategy—Assess the modeled effects of climate change on this species and use to determine future landscape needed for the recovery of the species.
- Captive propagation for genetic storage and reintroduction—Continue collection and propagation efforts for maintenance of genetic stock and for reintroduction into protected suitable habitat within historical range.

- Reintroduction and translocation—Determine optimal sites for reintroduction and continue to reintroduce individuals into these areas that are managed for known threats.
- Population biology research—Continue germination and propagation research and implement best practices.
- Alliance and partnership development—Continue to work with the U.S. Army Garrison, Department of Land and Natural Resources, and other partners and land managers in planning and implementation of ecosystem-level restoration and management to benefit this species.

**References:**


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[HPPRCC] Hawaiʻi and Pacific Plants Recovery Coordinating Committee. 2011. Revised recovery objective guidelines. 8 pp.

[NTBG] National Tropical Botanical Garden. 2019. Report on controlled propagation of listed species, as designated under the U.S. Endangered Species Act. Unpublished report submitted to the U.S. Fish and Wildlife Service, Pacific Islands Fish and Wildlife Office, Honolulu, Hawaiʻi.

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U.S. Army Garrison. 2020. 2019 annual report for Pōhakuloa Training Area, Hawai‘i Island, Hawai‘i. Recovery Permit TE-40123A-2. Prepared by Colorado State University, Center for Environmental Management and Military Lands. 190 pp.

[VRPF] Volcano Rare Plant Facility. 2015-2019. Summary of reports on controlled propagation of listed species, as designated under the U.S. Endangered Species Act. Unpublished report submitted to the U.S. Fish and Wildlife Service, Pacific Islands Fish and Wildlife Office, Honolulu, Hawai‘i.

**U.S. FISH AND WILDLIFE SERVICE**
SIGNATURE PAGE for 5-YEAR REVIEW of *Solanum incompletum* (pōpolo kū mai)

**Pre-1996 DPS listing still considered a listable entity?** N/A

**Recommendation resulting from the 5-year review**:

_____ Delisting
_____ Reclassify from Endangered to Threatened status
_____ Reclassify from Threatened to Endangered status
X Reclassify from Threatened to Endangered status
_____ No Change in listing status

For **Field Supervisor, Pacific Islands Fish and Wildlife Office**

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