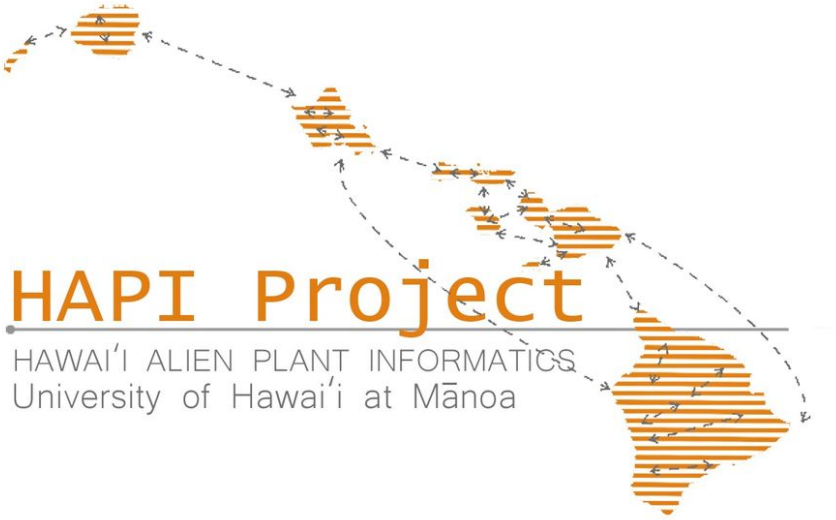
Summary Report for the Hawai‘i Invasive Species Council for FY19

The Hawaii Alien Plant Informatics Project: Informing Invasive Plant Prioritization and Management Decisions with Interconnected Data



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Overview

The Hawai‘i Alien Plant Informatics (HAPI) project aims to compile non-native plant biodiversity information while working to improve data infrastructure and provide decision support tools for invasive species managers in Hawai‘i. This report summarizes the efforts completed in this project's second year with funding provided by the Hawai‘i Invasive Species Council (HISC), beginning April 1st,2019, and ending March 31st, 2020. The entirety of funds allocated to this project in FY19 went towards funding the graduate student research assistantship of Kelsey Brock, a PhD student in School of Life Sciences (Botany Program) at the University of Hawai‘i-Mānoa. FY18 focused on compiling data and feedback from managers as well as taking the initial steps toward a status tracking system, and FY19 built upon these efforts, including:

1. Vetting of existing and proposed systems for tracking the entire non-native flora based on a synthesis of peer-reviewed literature and statewide plant data, including the submission of two manuscripts for peer-review and publication.
2. Continued compilation and cleaning of non-native plant data statewide, including the construction of semi-automated "pipelines" to retrieve and process data from multiple sources.
3. Integrating the HAPI decision-support tool into the Bishop Museum's new online "Plants of Hawai‘i" information platform.
4. Compiling a list of plants with uncertain statuses (e.g. "questionably naturalized") to promote field revisits at the island-specific level for our most data deficient species.

1.0 Reporting and Tracking Hawaii's Non-native Flora

1.1 Guidelines to Increase Reporting Consistency

Much progress has been made in the field of invasion biology to describe and categorize the invasion process, but few have attempted to apply these concepts to real-world field data, which is often complex and sometimes uncertain. As first reports of a plant's behavior outside of cultivation can influence downstream management decisions and analyses, we identified this lack of Hawaii-specific guidance as a necessary first step to improving data infrastructure. We summarized best practices from peer-reviewed literature to guide Hawai‘i's field botanists and improve consistency and accuracy when applying terminology to describe plant invasions. Additionally, we outline population description data that could be included in new naturalized species reports to better inform invasive plant management and research. This information was formatted to guide submissions to the *Records of the Hawai‘i Biological Survey*, as this has been an effective and popular forum for past naturalization reports. The following manuscript was submitted February 2020:

> Brock, K.C., Daehler, C.C, Imada, C.T., Kennedy, B.H., Flynn, T.W. *Submitted.* **Recommendations for reporting records of non-native plant species in the Hawaiian Islands.** *Bishop Museum Occasional Papers.*

1.2 Proposed System for Tracking Species Statuses

A practical method to track entire non-native floras according to their invasion status is currently lacking. However, Hawaii's invader-rich landscape emphasizes the urgent need for such a system, as uncertainty of impacts from hundreds of non-native species severely complicates management strategies. We conducted a study applying a generalized invasion framework by Blackburn et al. (2011) to categorize Hawaii's non-native plant checklist and identified uses and drawbacks of the system for species tracking and invasion management. We found some limitations in applying Blackburn's framework to Hawaii's data, highlighting the need for a modified categorization scheme that describes invasion phases relevant to managers and accommodates available data. For species whose naturalization status is uncertain and cannot be accurately categorized (e.g. just beginning to naturalize), we investigated whether scores from the Hawaii-Pacific Weed Risk Assessment (WRA) can predict naturalization. We conclude that the WRA information could be used to help prioritize on-the-ground monitoring for data-deficient species that may be in the early stages of naturalization. Finally, a categorization system for tracking statuses of an entire non-native flora is proposed that requires limited investments in additional data collection while following the rationale of Blackburn et al.'s scheme. This new categorization system may be used to reveal overall invasion patterns and trends in a region, leading to insights that can inform strategies for invasive species management. This study was summarized for discussion at a workshop on frameworks used in invasion science in Stellenbosch, South Africa in November 2019, and the following manuscript was submitted in March 2020:

> Brock, K.C., Daehler, C.C. *Submitted*. **Applying an invasion and risk framework to track non-native island floras and inform management: a case study of challenges and solutions in Hawaii**. *NeoBiota.*

2.0 Compiling, Cleaning and Supplementing Non-native Plant Data

2.1 Summary of Data Sets Being Compiled

This project relies on the compilation of statewide non-native plant data, which we have categorized into three types that are critical for informing management decisions: Taxonomy / Status, Ecology and Geospatial. Each of these data types are compiled separately and are continuously being cleaned and updated, with FY19 efforts focused on improving the Taxonomy / Status data set in alignment with the Bishop Museum. A summary of these data sets is presented in Table 1, and an overview of the importance of these data to inform management is shown in Figure 1. Each data set contains metadata describing the origin of the data alongside any potential sources of error as well as a universally unique identifier to facilitate cross-referencing between data sets.

Table 1. Summary of compiled data sets

Data Set	Description	Amount of Data Compiled So Far
Taxonomy / Status	Accepted taxon names reported in the Hawaiian islands and their status along the introduction - naturalization - invasion continuum. Taxonomy follows Bishop Museum (Imada, 2019) when available, and Kew's Plants of the World when no recent taxonomic treatment exists for Hawaii. Statuses are assigned following Brock & Daehler (submitted; see section 1.2 above).	8985 taxa, including 7481 taxa cultivated in Hawaii for which no recent taxonomic summary exists.
Ecology	Taxa for which ecological information has been compiled, including data from the Hawaii-Pacific Weed Risk Assessment that was considered useful to invasive species management and research (e.g. dispersed by birds, fire hazard).	2012 taxa, with 35 traits/characteristics for each plant
Distribution	Locations of non-native plant species compiled from herbaria and conservation groups and the number of watersheds invaded.	284868 occurrences

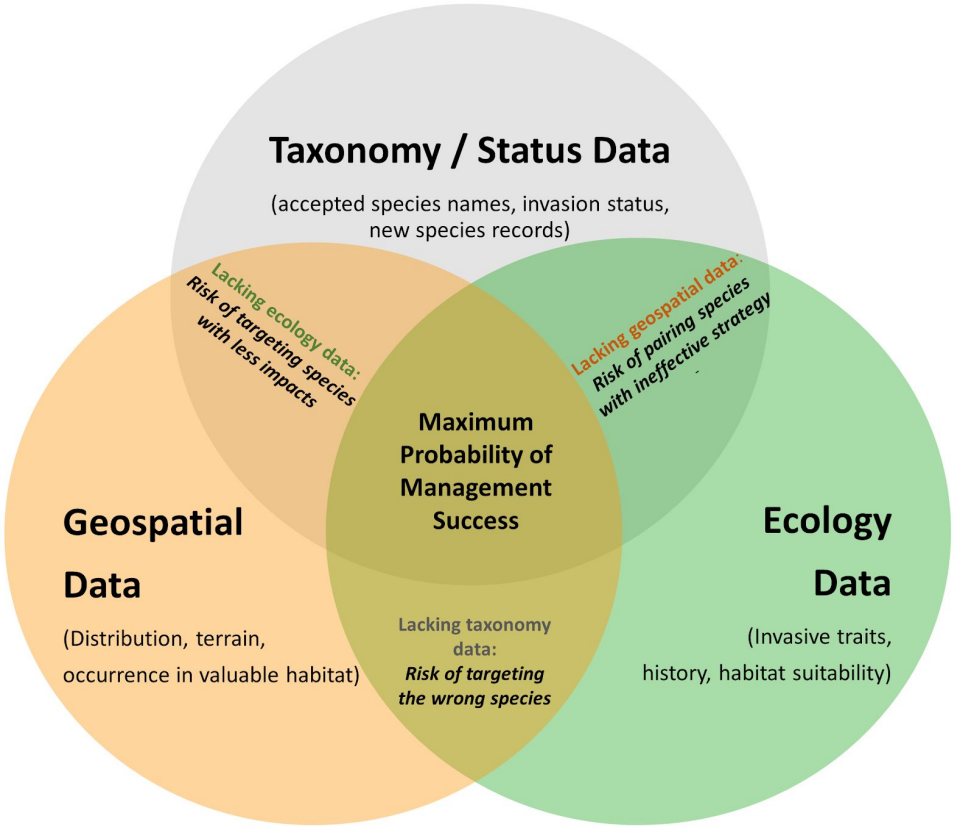

Figure 1. Conceptualization of three data types compiled for the HAPI project and their usefulness for informing management strategies.

2.2 Semi-Automated Data Pipelines

To minimize the labor necessary to manually compile data and avoid transcription or manipulation errors, we are developing semi-automated methods to continuously integrate data. These methods rely on free biodiversity data sets and libraries to manipulate data when available, but prompt the data manager for human input when necessary. The code for these pipelines is written in R and python programming languages and stored on a github site so they are accessible to other researchers. The creation of these data pipelines will help ensure that the HAPI project is updateable without requiring enormous labor demands as more data is compiled. The following links summarize pipelines that are currently in use for the HAPI project:

- A R script that automatically retrieves a plant's accepted name according to Kew's Plants of the World database, International Plant Name Index identification number, and associated taxonomic information (taxonomic rank, plant family, author).
- A python script that scrapes data from Hawaii-Pacific Weed Risk Assessment reports, both old and new file formats (excel file and pdf).
- A python script that cleans HPWRA data and translates variation in answer formats produced by different assessors (e.g. "Yes" versus "Y") into binary data (0, 1).
- A python script that cleans occurrence data by removing duplicate occurrences (e.g. duplicate specimens that were sent to more than one herbaria), and flags unlikely locations (e.g. GPS point falls in ocean).

3.0 Integrating HAPI with Bishop Museum's Platform

The ultimate goal of the HAPI project is to launch the compiled data as an interactive online resource. Managers interface with the data by filtering criteria to present plants with particular traits, risks or statuses, and they can download occurrence data and species lists for their management area. To prevent this online resource from meeting the fate of neglected biodiversity databases (Blair et al., 2020), we have partnered with the Bishop Museum to curate the HAPI project into the future by nesting it within their new Plants of Hawaii online platform. FY19 efforts on this front include data sharing and curation (e.g. privacy issues) and input on the user interface design through the Plants of Hawaii platform, which is also supported with HISC funds. A user interface has been developed and we will begin testing its utility with a set of sample data in FY20.

4.0 Promoting Field Revisits for Data Deficient Records

We have compiled a list of data-deficient species in need of field revisits in collaboration with Clyde Imada at the Bishop Museum. These species have often been considered "questionably naturalized" because insufficient data exists to determine whether a self-sustaining population has formed with multiple generations outside of cultivation. In reality, this designation lumps plants with radically different statuses and behavior, including:

- remnants of cultivation, such as long-lived species that were planted some time ago, but where growth of surrounding vegetation masks evidence of it being a former cultivation site,

- casual species, where immature or a few mature individuals originating from cultivated plants exist outside of cultivation, but for which multiple generations are not produced (i.e. population not self-sustaining),
- recently introduced invaders that will eventually naturalize, but have not had sufficient time to do so,
- species that have naturalized, but only a few individuals have been detected, and
- possibly extirpated species, for which historical records indicate that they existed in the wild at one time, but have not been observed for many decades.

A list of these species has been divided per island, annotated with a specific question (e.g. is this species now extirpated?) and mapped at the watershed level. While a permanent solution to displaying this information is being developed with Bishop Museum (See Section 4.0), we intend to launch a temporary method to communicate this information so we can recruit the help of Hawaii's botanical community to update statuses as quickly as possible. A sample web map has been designed including a subset of species, and we are exploring the best options to present the data and promote field revisits for Hawaii's data deficient species.

References

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