KISC KAUAI INVASIVE SPECIES COMMITTEE	*Kauai Status*	*KISC Status*	*HPWRA*	*Invasive Impacts Score*	*Feasibility Score*	*Combined Score*
Hiptage benghalensis (hiptage)	**NATURALIZED**	**EARLY DETECTION**	**HIGH RISK (8)**	**8**	**4**	**12**

Initial prioritization report completed: November 2017
PFC report updated as of: N/A
Current Recommendation for KISC: pending scoring rank and committee review
Knowledge Gaps and Contingencies:

1) Delimiting surveys surrounding known locations are required to gain knowledge of the extent of populations.
2) Early detection surveys should be conducted in herbarium voucher locations.
3) Outreach efforts are crucial to increase detection by citizens on private land.
4) An understanding of partnership roles may increase the likelihood/rate of success.
5) Landowners must be contacted to assess cooperation
6) A plan for control along waterways is necessary

Background

Hiptage benghalensis (Malpighiaceae), or "hiptage", is a large, woody vine that is cultivated throughout the tropics as an ornamental (Staples and Herbst 2005). *H. benghalensis* has been considered for control by KISC in the past, but due to the size and density of the population, it was regarded as infeasible to eradicate at the time and not given "Target" status or controlled. However, this plant has since been included in the 2016 Kauai Pono Endorsement program to limit its dispersal through the nursery trade. The purpose of this prioritization assessment report is to consider the potential invasive impacts of *H. benghalensis* and evaluate whether KISC should attempt eradication (i.e. accept "Target" status) or joint control with partnering agencies (i.e. accept as "Partnership" species status). This will be informed by scoring and comparing *H. benghalensis* to other "Early Detection" species known to Kauai (See Table 5 in KISC Plant Early Detection Report for status terminology).

Detection and Distribution

H. benghalensis was first vouchered on Kauai in 2004 (T. Flynn 7117, PTBG), although it has been known on the island at least since the 1990's when herbicide trials were conducted in Huleia (Motooka 2001). Across the state, it is known as naturalized on Kauai and Oahu (Imada 2012). Currently, it is known from 3 locations, including 3 districts (Koloa, Lihue and Kawaihau) and 3 watersheds (Lawai, Kapaa, Huleia; Figure C25- 1). The largest population is located in Puhi/Huleia area, covering an area of at least 410 ha (~1000 acres) within the Huleia watershed. Herbarium vouchers indicate that there is a small population present in Lawai valley (D. H. Lorence 9636 and 10178, PTBG) and 2015-2017 surveys detected another small population in Kapaa.

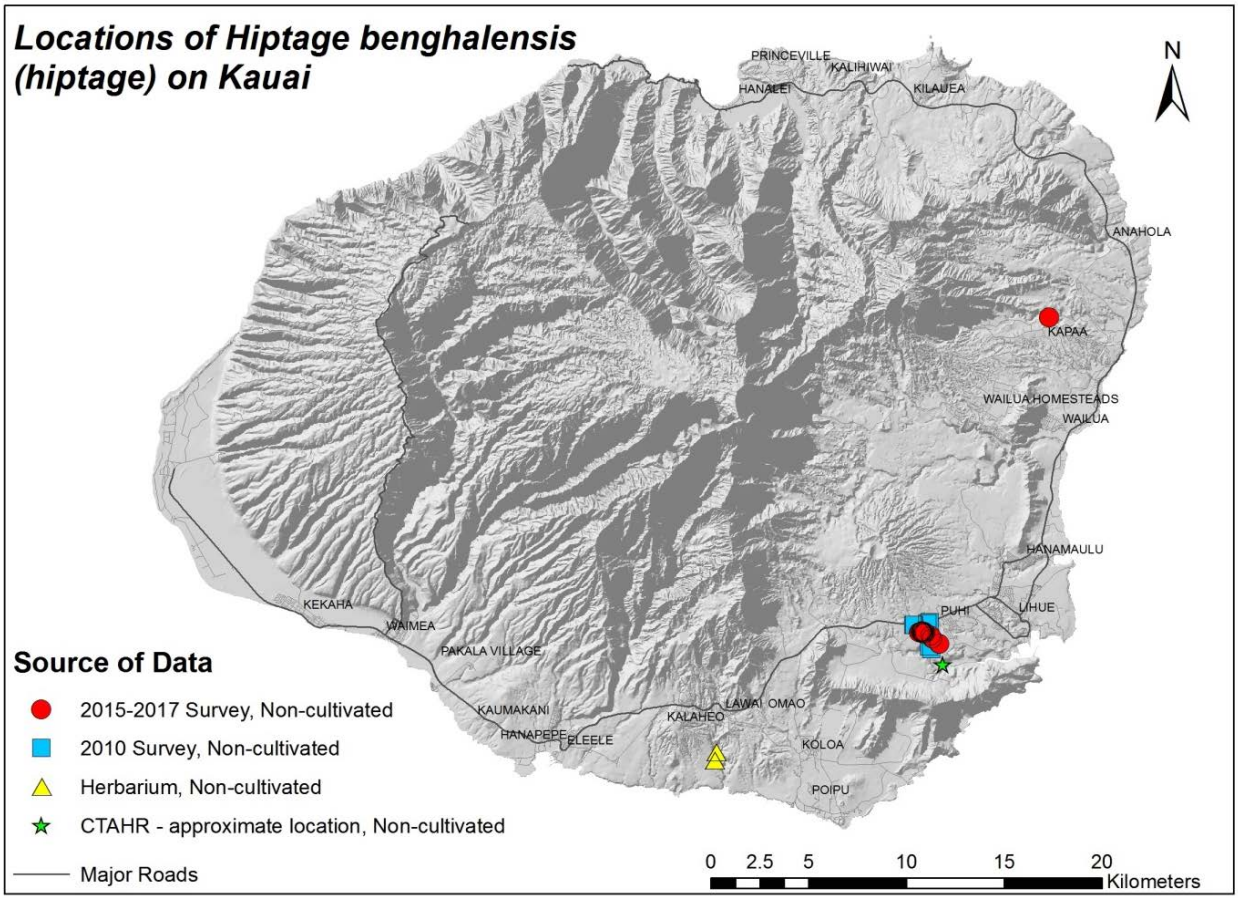

Figure C25- 1. Locations of *H. benghalensis* on Kauai. Locations where presence of the plant was confirmed during 2015-2017 surveys are denoted by red circles.

Hawaii Pacific Weed Risk Assessment (HPWRA) Score

H. benghalensis is designated as "High Risk", receiving a score of 8 (Daehler et al. 2004, HPWRA 2012). Traits contributing to this status are listed below according to whether they pertain to the likelihood a plant will invade vs. the consequences of the invasion, according to Daehler and Virtue (2010). Categorization of traits in this manner more accurately informs invasive impact potential scoring and prioritization of species that are already established on Kauai.

Likelihood of Invasion	*Consequences of Invasion*
• Well suited to climates in Hawaii • Naturalized in areas with comparable climates • Tolerate a wide range of soil conditions • Produces viable seed • Reproduction by vegetative fragmentation • Propagules dispersed intentionally and unintentionally by people • Tolerates or benefits from mutilation	• A weed of native ecosystems • Climbing and smothering growth habit forms dense thickets

Refer to the full Weed Risk Assessment for *H. benghalensis*, including how these traits and characteristics traits affect HPWRA scoring, at https://sites.google.com/site/weedriskassessment/assessments/Download-Assessments.

Invasive Impacts Score

1. Impact on natural community structure and/or composition

Score: 3 = Major impacts

H. benghalensis was assigned a score of 3 because reports from other invaded areas including La Reunion island, Mauritius island, and Australia, as well as field observations from Kauai, indicate clear negative impacts due to its spread. It is considered as one of the "100 worst invasive species" globally by The Global Invasive Species Database due to its ability to form impenetrable thickets, smother native vegetation and choke large trees (Lowe et al. 2000). A semi-quantitative study ranked *H. benghalensis* 1st of 26 of La Reunion island's most invasive plants, where it has been present on the island for 39 years, based on its impacts on native ecosystems (Baret et al. 2006, Tassin et al. 2006). Notably, this plant was rated ahead of some well-known ecosystem transforming weeds in Hawaii including *Acacia mearnsii, Ulex europeus, Psidium cattleianum, Clidemia hirta, Leucaena leucocephala* and *Lantana camara* (Tassin et al. 2006). Although it readily occupies disturbed sites including canopy gaps, eroded soil, and river banks, it is known to invade a variety of habitats including invaded lowlands, open woodlands, lowland rainforests, semidry forests, windward submountain rainforests, and submountain mesic forest ecosystems of La Reunion Island (Strasberg et al. 2005, Baret et al. 2006). *H. benghalensis* disperses vegetatively as well as by winged, wind-dispersed seeds, indicating that the edges of known populations will likely advance rapidly in ideal habitat. On Kauai, it was observed forming a thick smothering layer over trees while simultaneously dominating the understory during 2015-2017 surveys, indicating its potential to affect forest ecosystems by altering canopy structure (Figure C25- 2). Additionally, the largest population of *H. benghalensis* lies within a POPREF polygon (Huleia - HUL) also containing PEP plants.

Figure C25- 2. Photo of the Puhi/Huleia *H. benghalensis* population, smothering tall trees.

Figure C25- 3. Photo of the Puhi/Huleia *H. benghalensis* population, forming dominant understory along a slope.

2. Impacts to Agriculture, Culture and other Human Systems

Score: 3 = Major impacts

H. benghalensis received a score of 3 because it grows very rapidly and persists atop tall tree canopies (>15 m) for several decades, resulting in tree death or deformity (Vitelli et al. 2009). Additionally, woody lianas regularly connect 3-9 trees in a stand; thus, if one tree falls, multiple trees could be damaged, resulting in a large canopy gap that is rapidly dominated by *H. benghalensis* (Vidal et al. 1997, Vitelli et al. 2009). This phenomenon is especially damaging to forestry operations, as it precludes selective logging practices unless vines are manually cut and treated months before harvest (Vidal et al. 1997). Additionally, rapid growth and easy dispersal allow it colonize human-controlled systems including residential areas, gardens/landscapes, forestry plantations and orchards. Particularly, the climbing habit and exceptional weight of this woody vine would pose a significant issue for utility lines. Damage to utility lines along Highway 50 in Puhi, where the largest population is located, is expected if left uncontrolled. Repeated control and monitoring are likely required to prevent damage.

3. Impacts to biotic and abiotic processes

Score: 2 = Major Impacts

H. benghalensis was assigned a score of 2 because although little is known about how its invasion affects abiotic factors, the incredibly dense thickets formed by this plant are likely to cause significant alterations. High above and below ground biomass consumes large quantities of water and nutrients, thereby affecting soil moisture and fertility. Additionally, the ability of this plant to form a smothering canopy as well as the dominant understory significantly affects light conditions, altering habitat for both plants and animals. The largest population of *H. benghalensis* is present in Huleia National Wildlife Refuge, which provides important habitat for native water birds (Motooka 2001).

TOTAL INVASIVE IMPACTS SCORE: 8

Feasibility of Control Score

Feasibility of Control Scoring and rationale for *H. benghalensis* is presented below. Refer to Appendix A for details regarding the Invasive Impact Score.

Delimiting Survey:

Score: 1 = Signifcant Effort

Feasibility of a delimiting survey for *H. benghalensis* was given a score of 1 because although there are only three known sites of occurrence on Kauai, the Puhi/Huleia site is very large. Based on aerial imagery of ideal habitat and estimates of seed dispersal distances, approximately 1300 hectares (~3200 acres) would need to be surveyed to establish the extent of the Puhi/Huleia population for eradication goals. Aerial technology (helicopter or drone) may be used during certain times of the year to obtain a rough idea of extent, as canopy-covering vines can be identified aerially by the presence of dull orange-red new growth. Reports indicate that the population in Lawai valley may only consist of a few plants (or possibly may have been controlled recently), but the extent of the population in Kapahi is unknown. Surveys between 2015-2017 detected only 3 small individuals at this site, although the area wasn't searched extensively and many more plants may exist. As this plant was likely introduced as an ornamental, significant outreach efforts are necessary to increase the likelihood that citizens will report locations on private property that cannot be detected from roadsides.

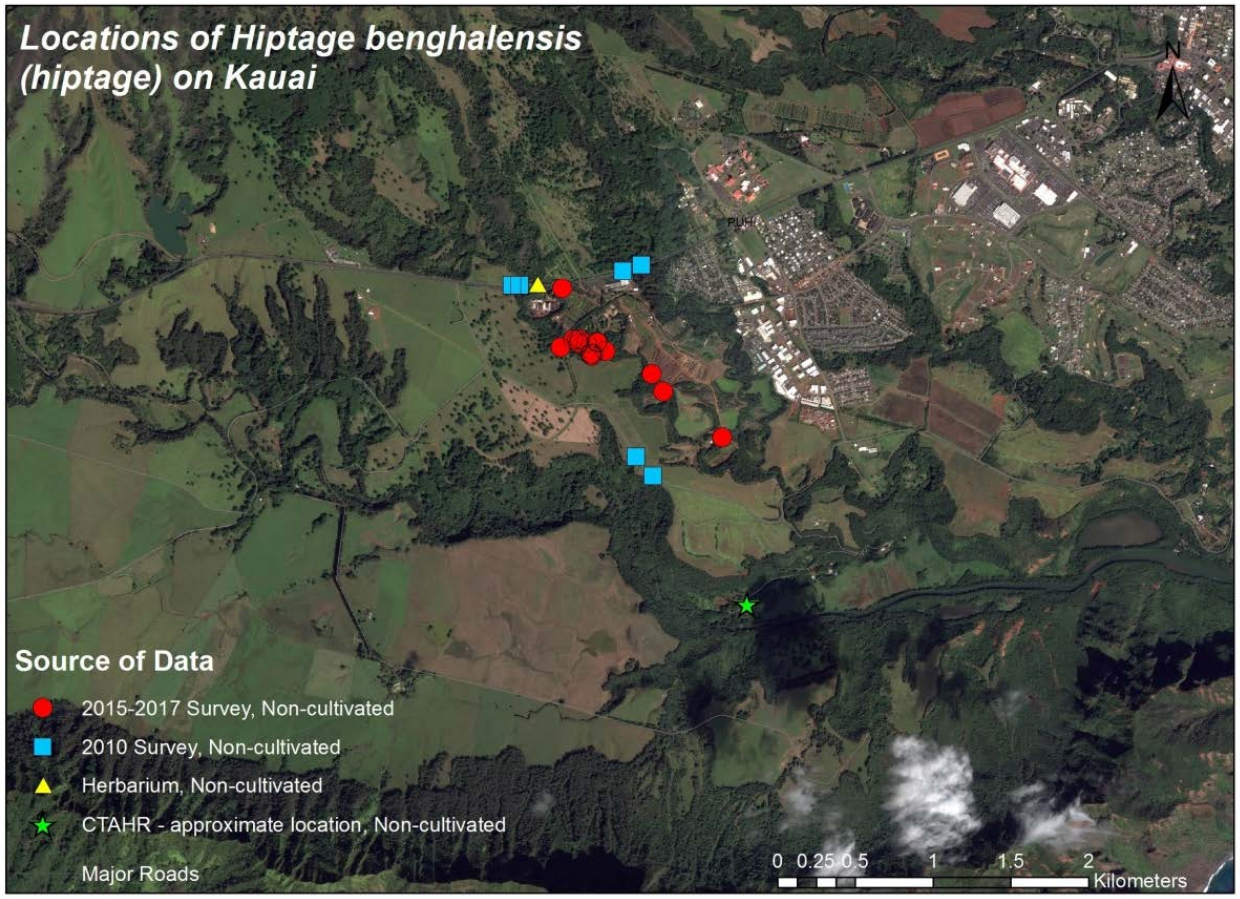

Figure C25- 4. Map of the Puhi/Huleia *H. benghalensis* population, with red circles denoting locations found during 2015-2017 surveys.

Initial control:

Score: 1 = Significant Effort

Feasibility of initial control for *H. benghalensis* was given a score of 1 because the extent of the Puhi/Huleia site is large relative to other KISC target sites and very dense. Field observations and GPS data indicate that the known population is approximately 410 ha (~1000 acres), although this number also includes intensely cultivated areas where the plant is likely not present in large numbers. The area of densely infested stands is likely closer to 100-200 ha (~250-500 acres). Additionally, most plants are located along tributaries leading into the Huleia river, which presents issues regarding the use of herbicide along waterways and as well as steep slopes that are difficult to navigate by field crews. In some patches, *H. benghalensis* is extremely dense, providing approximately 60-70% of overstory cover and >85% of understory cover. These areas will require extensive effort and herbicide application, and successful removal of these plants will provide large bare areas that will be rapidly colonized by other alien species. As the Puhi/Huleia site contains a large nursery with diverse stock, it is possible that this disturbance may provide a foothold for invasive ornamental plants that may otherwise be considered incipient to Kauai. Re-seeding with hardy native species or non-invasive alien species should be considered to prevent this from occurring (Cordell et al. 2016). Additionally, herbicide trials indicate that foliar application of herbicide is not very effective on adult plants, although it may be used to kill seedlings (Motooka 2001, Vitelli et al. 2009). Cut-stump method using picloram, glyphosate or fluroxypyr is necessary for mature plants, killing >95% of individuals. Once the Puhi/Huleia population is investigated in detail and other sites have been delimited, a study by Vitelli et al. may be referenced to approximate the cost of control based on the invasion of *H. benghalensis* in northern Queensland, Australia (2009). The authors estimate the cost of hiptage removal to be between $2,676 - $14,324 per hectare, excluding labor, depending on the method and herbicide used. Nonetheless, initial control of *H. benghalensis* is the most hindering factor affecting its eradication and likely requires a partnership or other resources outside of normal KISC operations. Landowners (comprising at least 7 TMKS) have not yet been consulted for their cooperation.

Monitoring:

Score: 2 = Moderate Effort

Feasibility of monitoring for *H. benghalensis* was given a score of 2 because a study of seed persistence in the soil suggests that this plant may form a very short-term seed bank (Vitelli et al. 2009). Seeds have a high germination rate in 12 months and no viability in laboratory-stored fruit after 2 years. Thus, intensive monitoring after all initial plants have been controlled is only required for approximately 3 years. However, a score of 2 is still warranted because the infested area is large enough that multi-day revisits are necessary to treat regenerating seedlings.

FEASIBILTY OF CONTROL SCORE: 4

COMBINED SCORE= 8 + 4 = 12

Literature Cited

Baret, S., M. Rouget, D. M. Richardson, C. Lavergne, B. Egoh, J. Dupont, and D. Strasberg. 2006. Current distribution and potential extent of the most invasive alien plant species on La Reunion (Indian Ocean, Mascarene islands). Austral Ecology **31**:747-758.

Cordell, S., R. Ostertag, J. Michaud, and L. Warman. 2016. Quandaries of a decade-long restoration experiment trying to reduce invasive species: beat them, join them, give up, or start over? Restoration Ecology **24**:139-144.

Daehler, C. C., J. S. Denslow, S. Ansari, and H. C. Kuo. 2004. A risk-assessment system for screening out invasive pest plants from Hawaii and other Pacific Islands. Conservation Biology **18**:360-368.

Daehler, C. C., and J. G. Virtue. 2010. Likelihood and consequences: reframing the Australian weed risk assessment to reflect a standard model of risk. Plant Protection Quarterly **25**:52-55.

HPWRA. 2012. Hiptage benghalensis. Hawaii Pacific Weed Risk Assessment.
Imada, C. T. 2012. Hawaiian native and naturalized vascular pland checklist (December 2012 update). , . Bishop Museum Technical Report 60/ Hawaii Biological Survey Contrib. 2012-021: 29 pp. + 27 appendices.
Lowe, S., M. Browne, S. Boudjelas, and M. De Poorter. 2000. 100 of the World's Worst Invasive Alien Species -A Selection from the Global Invasive Species Database. The Invasive Species Specialist Group (ISSG) a specialist group of the Species Survival Commission (SSC) of the World Conservation Union (IUCN).
Motooka, P. 2001. Summaries of Herbicide Trials for Pasture, Range and Non-Cropland Weed Control—2000 College of Tropical Agriculture and Human Resources -Cooperative Extension Service., University of Hawaii at Manoa, Honolulu, Hawaii.
Pappert, R. A., J. L. Hamrick, and L. A. Donovan. 2000. Genetic variation in Pueraria lobata (Fabaceae), an introduced, clonal, invasive plant of the southeastern United States. American Journal of Botany **87**:1240-1245.
Staples, G., and D. Herbst. 2005. A tropical garden flora: plants cultivated in the Hawaiian Islands and other tropical places. Bishop Museum Press., Honolulu, HI.
Strasberg, D., M. Rouget, D. M. Richardson, S. Baret, J. Dupont, and R. M. Cowling. 2005. An assessment of habitat diversity and transformation on La Reunion Island (Mascarene Islands, Indian Ocean) as a basis for identifying broad-scale conservation priorities. Biodiversity and Conservation **14**:3015-3032.
Tassin, J., J. N. Riviere, M. Cazanove, and E. Bruzzese. 2006. Ranking of invasive woody plant species for management on Reunion Island. Weed Research **46**:388-403.
Vidal, E., J. Johns, J. J. Gerwing, P. Barreto, and C. Uhl. 1997. Vine management for reduced-impact logging in eastern Amazonia. Forest Ecology and Management **98**:105-114.
Vitelli, J. S., B. A. Madigan, P. E. Van Haaren, S. Setter, and P. Logan. 2009. Control of the invasive liana, Hiptage benghalensis. Weed Biology and Management **9**:54-62.