KISC KAUAI INVASIVE SPECIES COMMITTEE	Kauai Status	KISC Status	HPWRA	Invasive Impacts Score	Feasibility Score	Combined Score
Acacia mangium (brown salwood)	**NATURALIZED**	**EARLY DETECTION**	**HIGH RISK (8)**	**8**	**5**	**13**

Initial PFC report completed: October 2017
PFC report updated as of: N/A
Current Recommendation for KISC: Consider eradication 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 – if populations prove significantly larger than currently known, the feasibility score will likely drop to 3.
2) Partnerships should be explored to conduct delimiting surveys in a more timely manner.
3) Land access to forestry plantings west of Puhi is necessary to determine whether this species is being cultivated in forestry plantings.

Background

Acacia mangium, or "brown salwood", is a tree commonly used a forestry species, especially in south-east Asia, where it is mainly harvested for paper pulp (Kull and Rangan 2008). It is also occasionally used as a nitrogen-fixing tree to improve soil condition. *A. mangium* has not been considered for control by KISC in the past, although it was first detected during surveys in 2010. Thus, the purpose of this prioritization assessment report is to 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 *A. mangium* to other "Early Detection" species known to Kauai (see Table 5 in KISC Plant Early Detection Report for status terminology).

Detection and Distribution

The first herbarium voucher of *A. mangium* was collected in 2007, when it was deemed naturalized on Kauai (N. Tangalin 1273, PTBG). However, the earliest known voucher statewide is from 1986 at the Waimanalo Experimental Research Station (University of Hawaii College of Tropical Agriculture and Human Resources, CTAHR) on Oahu (M.F. Ziegler s.n., BISH). Additionally, *A. mangium* is planted at two agricultural research stations on Maui (Starr et al. 2003) and some appear to have been cultivated at the agricultural research station on Kauai. This indicates that this plant was likely introduced to Kauai via a statewide research project by at least the mid 1980's, although this hasn't been confirmed. Statewide, it is considered naturalized on Kauai, Oahu and Hawaii Island (Imada 2012). On Kauai, there are three known sites of *A. mangium*, although no trees were found at the third site when it was resurveyed in 2016. Combined, these data indicate that *A. mangium* is distributed across Kawaihau, Lihue and Hanalei district and occupies 3 watersheds. The largest known population is located within and near the Kauai Agricultural Station in Wailua homesteads, home of KISC's office and base yard (Figure C2- 1). At least 40 trees are located on the Kauai Agricultural Research Station, at least some of which are large and appear to have been planted. However, the population is known to extend 3 km southwest of the station to Hanahanpuni crater. More than 100 trees are present at this location, and mature trees are found occasionally along Kuamoo Rd between the crater and the research station. The infestation at the Hanahanapuni crater site is quite dense in some locations, forming a near monotypic stand in some spots (Figure C2- 2). As this population is already known to be 3 km in diameter with numerous mature individuals, it is likely that this population is much larger than what was enumerated during 2015-2017 surveys (approximately 160 trees) because the prolific seeds can be dispersed by birds (Richardson et al. 2011).

Much less is known about the second site near Halfway Bridge on Highway 50 (Figure C2- 3), as survey access was limited by private property. One tree was detected during the 2015-2017 surveys, and 3-5 trees were detected during surveys in 2010. Large areas of agroforestry plantations comprised of many different species exist in this area of Kauai. Because *A. mangium* is a common forestry tree, it is possible that the few trees detected from the roadside may represent escapes from a much larger forestry plantation beyond view of the roadside. A third site consisting of a single tree in a pasture was detected during 2010 surveys near Lumahai Beach Park and Wainiha, with notes that the tree was naturalized, not cultivated. A second survey from the roadside was conducted in 2016, but the tree was not detected. However, the area was not surveyed thoroughly by foot, and surveys of sections that cannot be seen from the roadside (eg. pasture edges) are necessary to determine whether an established population exists in this area.

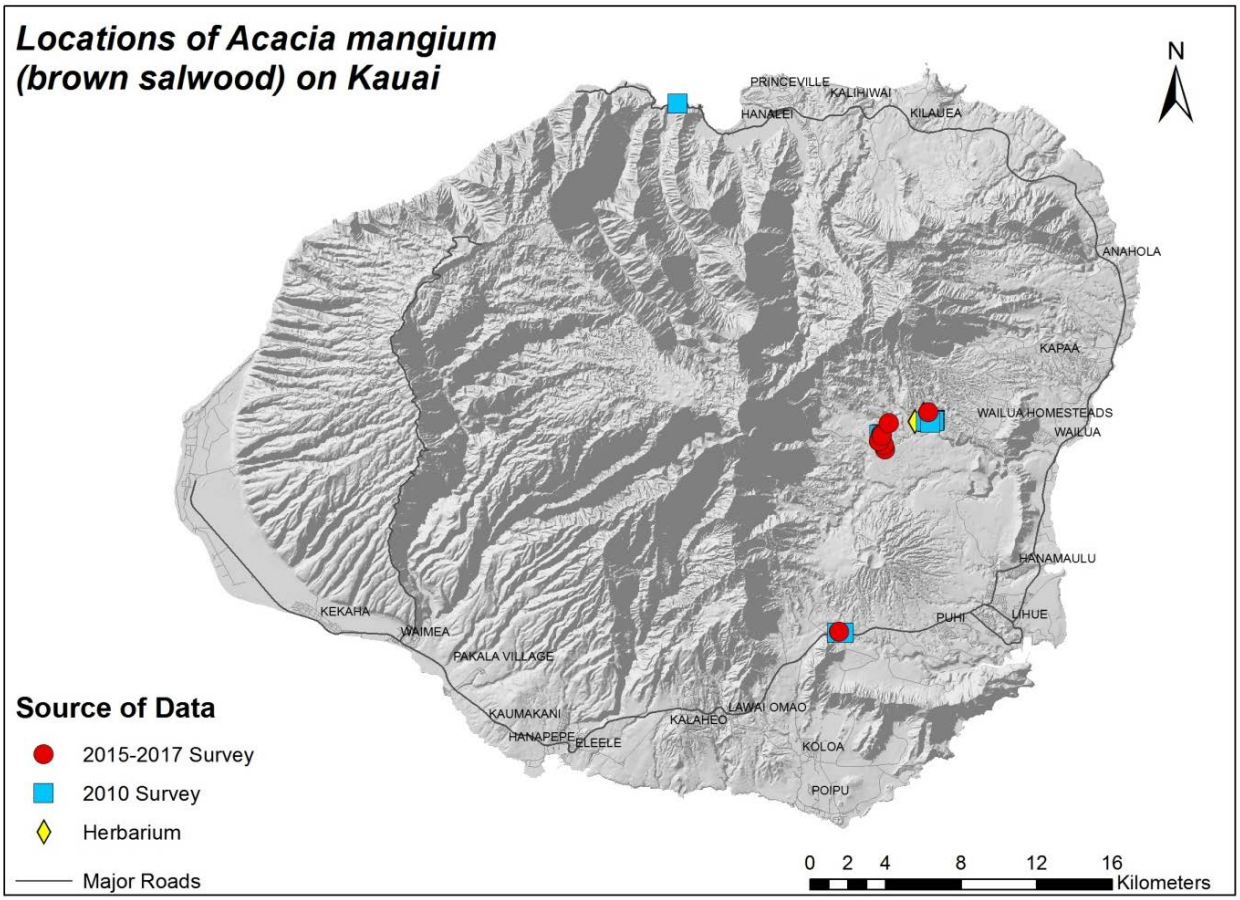

Figure C2- 1. Locations of *A. mangium* on Kauai. Locations where presence of the plant was confirmed during 2015-2017 surveys are denoted by red circles (in Hanamaulu)

Hawaii Pacific Weed Risk Assessment (HPWRA) Score

A. mangium is designated as "High Risk", receiving a score of 8 (Daehler et al. 2004, HPWRA 2006). 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 • Repeatedly introduced and naturalized in areas with comparable climates • Allelopathic • Tolerate a wide range of soil conditions • Produces viable seed • Hybridizes naturally • Propagules dispersed intentionally by people • Propagules bird dispersed, surviving passage through the gut • Forms a persistent seed bank • Benefits from disturbance	• A weed of gardens/amenity/disturbed areas • A congeneric weed, sharing a genus with known invasive trees (i.e. implies inheritance of tendencies to inflict invasive impacts) • Allelopathic • Unpalatable to grazing animals • Nitrogen fixer

Refer to the full Weed Risk Assessment for *A. mangium,* including how these traits and characteristics 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: 2 = Moderate impacts

A. mangium was assigned a score of 2 because recent studies are beginning to communicate the invasive reputation of this tree escaping forestry plantations. A study of behavior, distribution and life history traits of acacias commonly used and distributed by humans placed *A. mangium* in the "Extremely High" invasive potential category alongside other acacias known as invasive in Hawaii, including *A. mearnsii* and *A. melanoxylon* (Wilson et al. 2011). The authors recommend that populations in climatically suitable areas are removed. Field observations of the population at Hanahanapuni crater and from other places across the globe indicate that formation of monotypic stands on Kauai is likely (Kull and Rangan 2008, Delnatte and Meyer 2012). Infestation of this species is rapid, with studies showing that the lag time to naturalization is only 10 years (Wilson et al. 2011), and a study from Brazil demonstrated that the invasion front from a plantation advances 1 km every 8-9 years via bird dispersal (Aguiar et al. 2014). However, *A. mangium* received a score of 2 instead of 3 because it is a lowland species requiring adequate light and moisture conditions. Its rapid growth and high light requirements allow it to invade disturbed habitats, but it may be less likely to invade stable native climax communities, especially those at higher elevations (Osunkoya et al. 2005). However, many disturbances including invasive animals, human impacts and climate change impact Kauai's native habitats, so this score may change in the future based on field observations. Nonetheless, it is likely to out-compete both alien and native plant species in moist, lowland environments.

Figure C2- 2. An almost pure stand of *A. mangium* at Hanahanapuni crater near Wailua Homesteads, showing multiple age classes.

2. Impacts to Agriculture, Culture and other Human Systems

Score: 3 = Major Impacts

A. mangium received a score of 3 because this plant is known to rapidly colonize disturbed areas and spread rapidly via bird dispersal. These traits allow it to colonize human-controlled systems including residential areas, gardens/landscapes, forestry plantations and any agricultural crops that have multi-year turn overs (Osunkoya et al. 2005, Kull and Rangan 2008, Delnatte and Meyer 2012, Aguiar et al. 2014). Additionally, *A. mangium* can become 30 meters tall (Starr et al. 2003) and can grow as rapidly as 5 m/year (Krisnawati et al. 2011). Thus, trees may become problematic or hazardous and expensive to remove if growing under utility lines and next to buildings or highways. *A. mangium* has become a common sight on roadside landscapes in Asian countries where is it planted as a forestry species (Kull and Rangan 2008, Richardson et al. 2011, Delnatte and Meyer 2012). Left unchecked on Kauai, *A. mangium* could become a major component of lowland alien-dominated ecosystems in moist-mesic disturbed areas..

3. Impacts to biotic and abiotic processes

Score: 3 = Major Impacts

A. mangium was assigned a score of 3 because this plant is likely to influence soil nutrient cycling via nitrogen fixation and the release of allelopathic chemicals. *A. mangium* is often used in multi-species forestry crops because of its nitrogen fixing capability. A study assessing soil nitrogen stores after *A. mangium* was planted on a *Eucalyptus* plantation showed that soil nitrogen increased by 86% in 6 years (Voigtlaender et al. 2012). Some effort has been made to sterilize this species so it can be planted to increase soil nitrogen on forestry lands without subsequently becoming invasive (Harbard et al. 2012). Although it's not exactly clear how increased soil nitrogen will affect nutrient cycling and plant growth on Kauai, it is possible that nitrogen fixation will facilitate invasions by other quick-growing alien species that can take advantage of high soil nitrogen stores. Furthermore, studies have shown that the fallen leaves of *A. mangium* release chemicals that significantly affect the germination and growth of other plants, especially in acidic soil. In one study, the germination rate of other weed species, including *Mimosa pudica*, was as low as 2% when subjected to chemicals released by *A. mangium* (Luz et al. 2010). However, it is important to note that the chemicals were extracted from leaves in a lab and the dosage of allelopathic compounds in the study may not accurately reflect amounts leached from leaf litter in nature. Field surveys on Kauai have noted small, but nearly pure stands of *A. mangium* with only one other species, *Clidemia hirta*, present in the understory amongst large amounts of leaf litter.

TOTAL INVASIVE IMPACTS SCORE: 8

Feasibility of Control Score

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

Delimiting Survey:

Score: 2 = Moderate Effort

Feasibility of a delimiting survey for *A. mangium* was given a score of 2 because although there are only 3 known sites within 5 TMKs, they are situated in areas where bird-dispersed seeds have likely spread the population from known sites, and a buffer area of at least 1000 m must be searched for other trees and hard-to-see saplings. Furthermore, terrain in these areas is difficult, especially along the Wailua river valley, which will make surveying slow, or perhaps impossible in very steep areas. However, the largest population overlaps with the miconia search buffer zone, so reconnaissance surveys in this area could search for both species. The detection of a single plant on Kauai's north shore, as well as a few individuals near forestry plantations west of Puhi is especially worrisome, because it hints that large

populations exist on Kauai away from view of routes surveyed during Early Detection Surveys. Thus, a downgrade of this score to a 1 or 0 is likely if populations prove to be substantially larger than detected in early detection surveys.

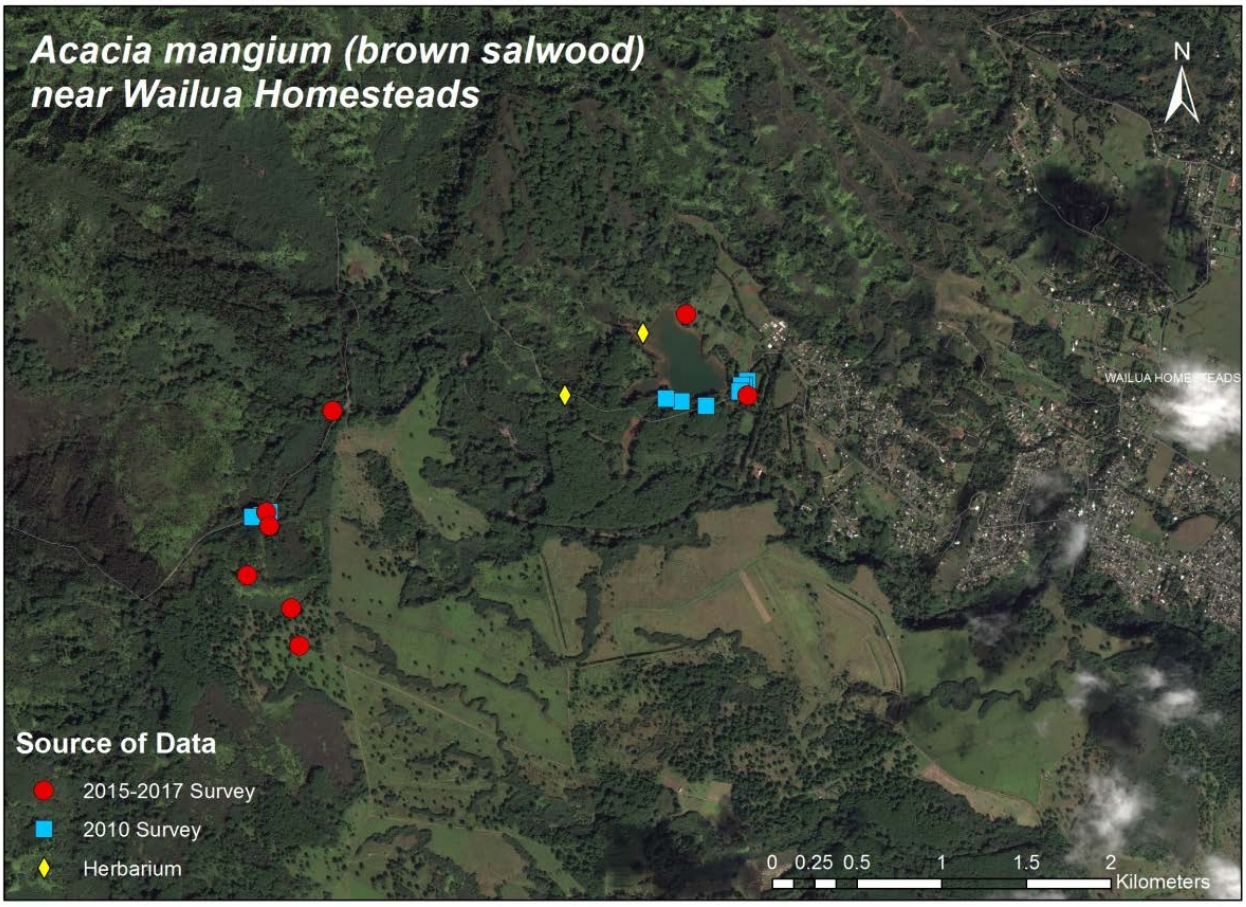

Figure C2- 3. Map of *A. mangium* locations near Wailua Homestead. Locations where presence of the plant was confirmed during 2015-2017 surveys are denoted by red circles.

Initial control:

Score: 2 = Moderate Effort

Feasibility of initial control for *A. mangium* was given a score of 2 because control by herbicide is known to be very effective for most acacias (Kull and Rangan 2008). Unlike many other alien plants on Kauai, *A. mangium* isn't dominant in the nursery trade and therefore hasn't spread amongst many private landowners. However, this scoring assumes that the population is around 200 mature trees, which may be a large underestimate (see Detection/Distribution and Delimiting Survey sections). If delimiting surveys detect larger/additional populations of this plant, which is likely, this score should be downgraded accordingly.

Monitoring:

Score: 1 = Substantial Effort

Feasibility of monitoring for *A. mangium* was given a score of 1 because acacias are known to form persistent seed banks (Marchante et al. 2011, Erkovan et al. 2013, Aran et al. 2017, Liyanage and Ooi 2017, Strydom et al. 2017). Although the seed bank of *A. mangium* hasn't been specifically studied, the seed bank of many acacias decline by about 80% in less than 10 years, but some viable seeds can persist for greater than 50 years (Milton and Hall 1981). This

indicates that a long-term monitoring schedule is necessary to eradicate *A. mangium* from Kauai. Furthermore, trees can produce seed within the first 1.5 years of their life (Krisnawati et al. 2011), meaning that short revisit intervals are necessary for multiple decades.

FEASIBILTY OF CONTROL SCORE: 5

COMBINED : 8 + 5 = 13

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