

	<i>Kauai Status</i>	<i>KISC Status</i>	<i>HPWRA</i>	<i>Invasive Impacts Score</i>	<i>Feasibility Score</i>	<i>Combined Score</i>
<i>Ficus religiosa</i> (Bo tree)	Adventive	TARGET	HIGH RISK (7)	6	5	11

Initial Prioritization Assessment Report completed: April 2017

Report updated as of: N/A

Current Recommendation for KISC:

Knowledge Gaps and Contingencies:

- 1) Early detection surveys need to be completed at likely sites, including large gardens and the Wailua Hindu Monastery. Additional occurrences found in the future will likely decrease the monitoring score.
- 2) Feasibility of delimiting surveys and initial control hinge on landowner permission and thus, tactful conversations need to be conducted before proceeding. Scores in both of these sections may drop to 0, (or may already warrant a 0 due to Na Aina Kai's refusal) if permission cannot be gained.
- 3) Need to inquire regarding the cost of hiring a certified arborist for 6 mature trees or explore landowner cooperation.

Background

Ficus religiosa (Moraceae) is a large tree that grows to 25m and is widely cultivated throughout the world (Staples and Herbst 2005). Non-human dispersal includes frugivorous birds and possibly rats that eat the figs (HPWRA 2012). Unlike several other *Ficus* species, *F. religiosa* does not form aerial roots and therefore does not exhibit a typical strangling habit; however, young saplings often germinate as epiphytes and can split the trunk of the host tree (or human made structure) as the penetrative roots grow (Galil 1984). This species is universally regarded as a spiritually and culturally important tree, being sacred to both Buddhists and Hindus (Sitaramam et al. 2009). In Buddhism, the Buddha is said to have attained enlightenment underneath a *F. religiosa* and in Hinduism, Vishnu was born under and embodies *F. religiosa* trees. Religious followers may use the trees as a place to practice meditation (Sitaramam et al. 2009). No species-specific data on minimum time until maturity exists but two years observation of fruitless adventive *F. religiosa* specimens by KISC including multiple age classes and a 7m tall (thought to be F1 generation) tree suggests that the minimum time until maturity is greater than three years. It is not known whether *F. religiosa* seeds can persist to form a seed bank. Observations from seed conservation studies have noted that *F. religiosa* seeds stored under ideal conditions can remain viable for three years, but this does not mean that seeds will remain this long in the soil as moisture tends to greatly affect long term viability (Galil and Meiri 1981).

Prior to 2007, spread of *F. religiosa* in Hawaii was not considered likely as it is typically thought to require its fig wasp pollinator, *Platyscapha quadraticeps*, to produce viable seeds. However, in 2007, saplings were noticed for the first time occurring under the *F. religiosa* at Foster Garden in Honolulu (Frohlich and Lau 2007). Since then, saplings have also been observed on Molokai (Fox Strohecker 2013), Kauai (Williams pers. comm., 2015) and Hawaii (Parker and Parson 2011) islands. As of 2012, it has been documented as naturalized on Hawaii and Oahu (but then demoted to adventive status) (Imada 2012). From these observations, it was assumed that the normal fig wasp pollinator arrived in 2007 as well, but evidence that *F. religiosa* can be pollinated by other fig wasps in the absence of *P. quadraticeps* has been documented in the Americas where it can be pollinated by native *Pegoscaphus* wasps and in Florida by the usual pollinator of *F. aurea* (Cook and Segar 2010). As pollinator efficacy and ultimately production of viable seed may be dependent on the presence of the normal wasp pollinator vs. a host-shifting pollinator, a study was conducted by KISC and National Tropical Botanical Garden (NTBG) to investigate the mode of pollination. The identity of the normal fig wasp pollinator (*P. quadraticeps*) was confirmed morphologically (vouchered J. Bernard, 2017) from Kauai *F. religiosa* figs and percent germination was as high as 100% in some samples. The method of arrival for the pollinator wasp to Hawaii is unknown, although van Noort et al. hypothesize that trade of bonsai, where plants can reach maturity and bear fruits while remaining small, may be responsible for the increasingly global distribution of *P. quadraticeps* (2013). Once introduced, the wasp is known to rapidly spread hundreds of kilometers by wind throughout the range of its host (Ahmed et al. 2009).

Detection and Distribution

On Kauai, *F. religiosa* was first recorded (herbaria voucher) in Lihue in 1988 (T. Flynn 2001, PTBG) but has likely been present in Hawaii’s horticultural trade for longer—the famous “Bodhi tree” specimen at Foster Garden in Honolulu that was gifted by monks from Sri Lanka arrived sometime before Mary Foster’s death in 1930. 2015-2017 early detection surveys located 6 occurrences of this plant (Figure C19- 2). These occurrences are somewhat widespread amongst the island, being located in all house districts, all judiciary districts except Kawaihau but present in only 6 out of 74 watersheds (Paua, Hanapepe, Lawai, Huleia, Nawiliwili and Kilauea watersheds). The occurrences consist of 6 mature cultivated trees, of which 4 were found to be producing saplings. An exception to this is the Kilauea location where a single sapling was found near the perimeter of Na Aina Kai Garden, implying that the parent plant is located on the garden’s property. Six or less individual saplings shorter than 1m tall were found at all locations except the occurrence in Kekaha, where approximately 20 saplings of multiple age classes ranging from 1m to 7m were observed surrounding a large cultivated tree. A review of herbarium records did not reveal any additional trees not located during the 2015-2017 Early Detection surveys. However, most Early Detection surveys have taken place on roads or trails, while *F. religiosa* is widely sought after for public gardens. Thus, additional trees may be found when more gardens and nurseries on Kauai (eg. the Wailua Hindu monastery) are surveyed.



Figure C19- 1 *Ficus religiosa*

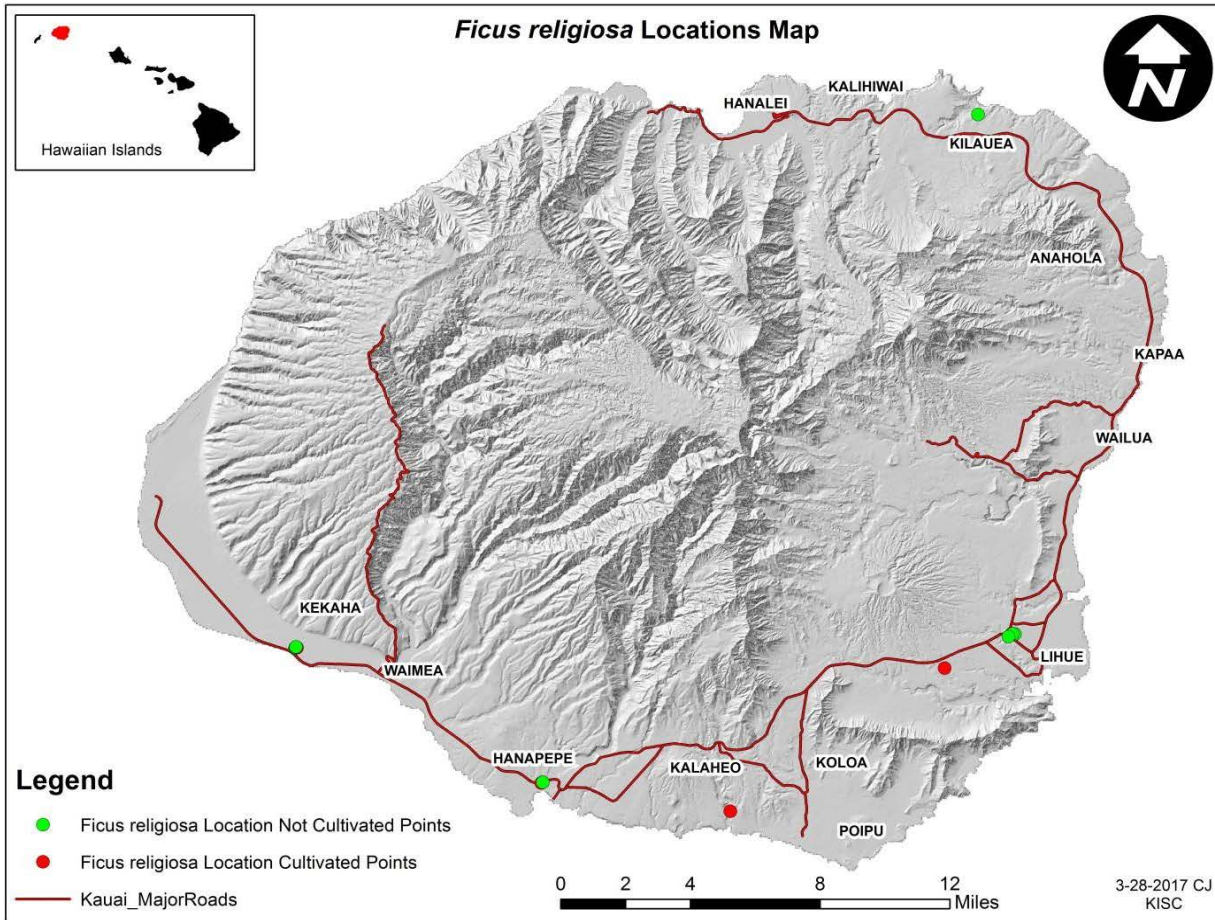


Figure C19- 2. Known locations of *F. religiosa* on Kauai with green circles representing non-cultivated individuals and red circles indicating cultivated individuals. Note: At this map scale, not-cultivated points overlap cultivated points; however, cultivated parent plants were found at all occurrences except in Kilauea.

Hawaii Pacific Weed Risk Assessment (HPWRA) Score

Ficus religiosa is designated as “High Risk” (HPWRA 2012), listing the following biological traits as contributors to its high risk status:

<i>Likelihood of Invasion</i>	<i>Consequences of Invasion</i>
<ul style="list-style-type: none"> · Naturalized within Hawaii and elsewhere in the world · Tolerates a wide range of climates and soil conditions · Seeds easily dispersed by animals · Often epiphytic when young 	

Refer to the full Weed Risk Assessment for *F. religiosa* at <https://sites.google.com/site/weedriskassessment/assessments/Download-Assessments>.

Invasive Impacts Score

1. Impact on natural community structure and/or composition

Score: 1 = Minor impacts

F. religiosa received a score of 1 in the “Impacts to Natural Communities” because of its ability to grow as an epiphyte and persist at high elevations, where it could cause damage to native trees (Galil 1984, HPWRA 2012). It is considered naturalized in the Mediterranean, Israel, Australia, South Africa, Brazil, Florida and now Hawaii, but there are no observations of *F. religiosa* threatening native ecosystems (Nadel et al. 1992, Corlett 2006, van Noort et al. 2013, Vianna-Filho et al. 2017). Contrarily, van Noort et al. report that despite naturalization of this plant in Africa after the arrival of *P. quadraticeps* at least 22 years earlier, there is no indication yet that *F. religiosa* is environmentally problematic (2013).

2. Impacts to Agriculture, Culture and other Human Systems

Score: 3 = Major impacts.

F. religiosa received a score of 3 in the “Impacts to Agriculture, Culture and other Human Systems” due to its known impacts to buildings and other infrastructure in urban environments. *F. religiosa* seeds readily germinate on buildings and compromise their structural integrity (Corlett 2006, van Noort et al. 2013, Vianna-Filho et al. 2017). In Kauai, saplings have been observed on the roof of the post office in Lihue (although they appear to be periodically removed), growing in cracks of a restaurant’s wall in Hanapepe and on an abandoned sugar mill in Kekaha. Additionally, *F. religiosa* is considered a major urban weed in Tel Aviv, where, prior to the arrival of the pollinator wasp, *F. religiosa* was considered an ideal street tree – but landscapers later realized that pollination results in the ripening of fruits (Lori 2004). Now, prolific fruit production coats sidewalks and buildings, changes the color of stonework to dark purple, and forms a smelly, slippery hazard to pedestrians. These observations indicate that long term establishment of *F. religiosa* would likely have long-term impacts on human infrastructure and tourism.

3. Impacts to Biotic and Abiotic Processes

Score: 2 = Moderate Impacts

F. religiosa was assigned a score of 2 in the “Impacts to Biotic and Abiotic Processes” because of its potential to produce large quantities of high-sugar fruits, possibly during off seasons for other species (Kannan and James 1999), if Kauai populations establish and grow. This trait is characteristic of many *Ficus* species and they are frequently considered a keystone food resource for frugivorous animals, particularly birds (Compton et al. 1996, Thornton et al. 1996, Kannan and James 1999, Korine et al. 2000, Kattan and Valenzuela 2013). On Kauai, this has the potential to bolster alien animal populations including lowland bird species, rats and pigs. On Maui, Starr et al. (2003) have observed foraging of several birds on *Ficus* species, including mynah birds (*Acridotheres tristis tristis*), blue faced doves (*Geopelia striata*), lace necked doves (*Streptopelia chinensis*), Japanese white-eye (*Zosterops japonicus*), Northern cardinals (*Cardinalis cardinalis*), and house sparrows (*Passer domesticus*). Scoring for this section based on large *F. religiosa* fruit-crops, assumes that *F. religiosa* populations on Kauai will grow, which seems likely based on the confirmation of the normal pollinator and reports of established urban populations elsewhere in the world (van Noort et al. 2013). However, to my knowledge, no second generation fruit-bearing individuals have ever been reported in Hawaii.

TOTAL INVASIVE IMPACTS SCORE: 6

Feasibility of Control Score

Feasibility of Control Scoring and rationale for *F. religiosa* is presented below. Refer to Appendix A for details regarding the Effect on System Score.

Delimiting Survey:

Score: 1 = Substantial Effort.

Feasibility of a delimiting survey for *F. religiosa* was given a score of 1 because despite a small number of known occurrences, land access issues have already arisen. When a sapling was found on the perimeter of Na Aina Kai Gardens, it was assumed that the parent tree was located on the garden's property. However, permission to survey the garden to confirm this and look for additional saplings was denied in August 2016. Additionally, *Ficus* are known to have a large "seed shadow" and long-distance dispersal by birds (Laman 1996), necessitating a large search buffer around fruit-bearing plants. This section may be rescored after land access permission requests (including Na Aina Kai Garden). Currently, known plants fall within 8 TMKs (Tax Map Keys).

Initial control:

Score: 1 = Substantial Effort

Feasibility of initial control for *F. religiosa* was given a score of 1 because of the enormous religious value of this plant, which is particularly important when considering that a large, well-tended individual currently exists at the Zen Soto Temple in Hanapepe. In addition to our inability to gain access to the supposed mature individual within Na Aina Kai Garden, the large tree outside of the state building in Lihue provides shade and aesthetic value and people may be reluctant to remove it. One individual is located within the living collection at NTBG, which provides multi-purpose value for science and conservation. Furthermore, the KISC crew cannot control large trees that are adjacent to roadsides, buildings, utility lines or high people-traffic areas. Unfortunately, all mature individuals on Kauai are adjacent to high-risk areas, requiring a certified arborist or partnership with the landowner. This section may be rescored after future discussions with landowners (including Na Aina Kai Garden).

Monitoring:

Score: 3 = Minimal Effort

Feasibility of monitoring for *F. religiosa* was given a score of 3 because few known occurrences exist on Kauai. Efficacy of control for this species is not well known, but it is thought that cut-stump application of triclopyr should kill trees entirely (Starr et al. 2003). However, physical removal alone is thought to result in resprouting. This section may be rescored after a trial herbicide application or if new occurrences are found via additional early detection surveys.

FEASIBILITY OF CONTROL SCORE: 5

COMBINED SCORE: 6 + 5 = 11

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