Technology Development for the Biological Control of Invasive Native and Non-Native Plants
New Project Proposal

1. **PROJECT TITLE**: Leveraging Commercial and Agro-Forestry Expertise to Identify New Agents for Biological Control of Albizia (*Falcataria moluccana*)

2. **PRINCIPAL INVESTIGATORS**:

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3. **COOPERATORS AND OTHER PARTICIPATING INSTITUTIONS:**

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4. **AMOUNT REQUESTED**

$66,000 FY 2015

$32,000 FY 2016

$98,000 Total

Project Leveraging

This proposal expands upon a project newly funded by the State of Hawaii initiating exploration in albizia's native range for biocontrol agents ($100K). With additional funds we propose to expand the area of study, incorporating commercial and agroforestry knowledge to potentially fast-track albizia enemies for biocontrol.

5. **PROJECT GOALS**

The goal of this study is to find biological control organisms for albizia (*Falcataria moluccana*) from non-traditional sources in areas adjoining the target plant's native range. This project will demonstrate the effectiveness of utilizing knowledge gained by commercial and agroforestry practitioners in the expanded range to quickly identify safe and effective biocontrol agents for this highly destructive invasive tree species in Hawaii and other Pacific islands.

Supporting Objectives:

Damaging insect herbivores identified from albizia will be evaluated for non-target impacts on related plant species (Fabaceae) and agricultural crop plants in surveys of the areas around plantations and agroforestry plots to establish initial suitability for biological control.

6. PROJECT JUSTIFICATION/URGENCY

Urgency

Albizia has been identified as a significant invader on numerous lists, including a recent compilation of biocontrol targets identified at the Pacific Biocontrol Strategy Workshop (Dodd and Hayes 2009). Simulation models predict that the distribution of albizia in Hawaii will nearly double by the end of the century under projected climate conditions (Vorsino et al., 2014). Albizia is also a severe threat in the U.S. affiliated Pacific island countries of Palau, American Samoa, Guam and Federated States of Micronesia, and other tropical islands throughout the Pacific. Acute loss of native forests and biodiversity in Hawaii and the Pacific can be expected from *F. moluccana* invasion if biological control work is not initiated. As populations expand and grow quickly to their maximum heights (up to 250 ft), the risk for damage to roadways, utility infrastructure and properties increases as well. The prospects for catastrophic damage on an island-wide or even statewide scale increase steadily with the populations of mature trees because these weak giants are so vulnerable to wind storms, as recently demonstrated by hurricane Iselle on Hawaii Island: (http://www.youtube.com/watch?v=tRZriynYNCA&feature=youtu.be).

Project Justification

Falcataria moluccana (Fabaceae) is a large, fast-growing tree planted widely in Pacific Islands over the past century for reforestation and agroforestry (Nelson, 1965). It was formerly known as *Albizia falcataria* and *Paraserianthes falcataria*. It is referred to as "falcata" by the forestry industry and is commonly called "albizia" in Hawaii (used hereafter). Native to the Moluccas (eastern Indonesia), New Guinea, New Britain, and the Solomon Islands (Wagner et al., 1999), *F. moluccana* was introduced to Hawaii in 1917 (Rock, 1920). Albizia is valued for its rapid growth by commercial foresters, and shade and nitrogen fixing capacity in agroforestry settings, particularly on tropical islands of the Indo-Malayan biogeographic region. However, *F. moluccana* has become invasive in forests and developed landscapes on several Pacific islands where it is not widely utilized commercially. Albizia has naturalized widely, demonstrating adaptation to a broad range of tropical habitats between sea level and 1500 m in the Hawaiian, Fijian and Samoan archipelagos and elsewhere. Where significant infestations have developed, impacts of this tree can be severe, dramatically increasing inputs of nitrogen, and facilitating invasion by other weeds such as *Psidium cattleianum* while suppressing native plant species (Hughes and Denslow, 2005). Albizia has also been reported to reduce native biodiversity (IUCN, 2008) and adversely impact aquatic ecosystems in riparian areas (Atwood et al., 2010).

In addition to negative effects on native ecosystems, in Hawaii *F. moluccana* is a roadside and urban forest pest of major significance (Hughes et al., 2013). Immediately following hurricane Iselle on August 7, 2014, millions of dollars were expended by Hawaii State and County agencies, power utilities, and individuals to deal with damage from albizia trees felled by the high storm winds (http://news.mongabay.com/2014/0822-storm-damage-from-invasives-in-hawaii.html; Stewart, 2014). The trees grow rapidly to 40 m tall, with shallow roots that leave them susceptible to uprooting. Their massive but weak branches break easily in storms or with age. As demonstrated in the lower Puna District on Hawaii Island, large mature trees that formed closed canopies over hundreds of hectares created significant hazards to nearby power lines, road traffic and buildings. Similar closed canopies and "tree tunnels" remain in populated areas of Hilo on the Big Island of Hawaii, in central Oahu gulches, and in Kalihiwai and Kahili Mountain Park on Kauai, and are spreading widely to other developed areas. In urban settings removal of individual problem trees can cost several thousand dollars. Millions more will be required to control and eliminate albizia stands along transportation corridors and in Forest Reserves from which albizia populations originated. With its prolific seed production there is also the risk that this pioneer species will experience a population explosion in response to increased light availability and soil disturbances caused by severe storms and volcanic activity, setting the stage for recurring invasions in the future. These concerns have resulted in a request from

Hawaii's congressional delegation to the USDA/USDI Secretaries to assist Hawaii with current and future problems posed by albizia. In order to find a long-term solution to this invasive tree, both the State of Hawaii Department of Transportation and Department of Agriculture have shown interest in collaborating in the development of biological control of this tree.

The commercial production of albizia is widespread throughout the humid tropics, particularly in the Indo-Malayan region. Industrialized production of albizia in its native range in the eastern Indonesian archipelago, New Guinea and the Solomon Islands was limited until relatively recently due to lack of infrastructure and abundance of virgin forests but has increased as these resources are depleted. In contrast, there is a well-developed commercial albizia forestry industry in the adjacent expanded range of western Indonesia, Malaysia and the southern Philippines, with over 200,000 ha of albizia plantations in production (Cossalter and Pye-Smith, 2003). In addition, several thousand hectares of albizia are grown in mixed agroforestry plots, with the logs being sold to the timber industry for the production of a variety of soft wood and pulp products. This fast growing tree is typically on a 7-12 year rotation and makes up a large proportion of the annual timber harvests, especially in places like the Philippines where native forests have gained new regulatory protections (Eusebio & Lapitan, 2012).

The advantage of thriving commercial operations in other countries for Hawaii's proposed biological control program is that significant resources have already been put into identifying and controlling albizia pests, especially for younger trees. A large number of pest species have been identified in exotic albizia plantations (Nair, 2001) including several insects and fungal diseases that cause major damage and mortality to young trees within the expanded range. For example, four insect species, *Xystocera festiva* (Coleoptera), and *Eurema blanda, E. hecabe*, and *Pteroma plagiophleps* (Lepidoptera) (Nair, 2001, Krisnawati et al., 2011) and the gall rust fungus have recently swept through *F. moluccana* plantations in the Philippines, Malaysia and Indonesia (Rahayu, et al., 2010). These may be prime candidates for early evaluation as biocontrol agents. We expect that potential biocontrol species will also be more abundant, and therefore easier to detect, in large commercial plantations than on individual trees or small patches of trees in the native forest ecosystem. In addition, several of the related plants of concern for non-target impacts can be found in close proximity to agroforestry plots, so we will be able to quickly eliminate putative agents lacking host specificity. Very few pest reports have been found from the nascent commercial production of albizia in its native range, but as there are several close relatives of albizia across the native and expanded ranges, it is likely that insect species with near genus-level specificity can be found in both ranges. In at least a few cases, life history studies of the most destructive insects and diseases have been initiated by forestry companies in order to better control these organisms and mitigate any damage they may cause (cited in Nair, 2001). This knowledge is useful for biological control as well since it allows us to select potential agents with impacts most suited to conditions in Hawaii. For example, an insect that substantially reduces reproduction could be used to limit spread of albizia beyond current infestations without risking immediate damage to infrastructure near large trees.

Our lab group has received limited funding for conventional foreign exploration for biocontrol agents in albizia's native range and development of a host test list. Searching within the native range can provide a selection of highly coevolved herbivores with the strict host specificity required for widespread use in a variety of introduced habitats. This proposal expands on the conventional search within the native range to adjacent areas where albizia has been introduced as a forest crop species. In this expanded range albizia may have encountered new pest species from congeneric tree species as well as a subset of their native insect herbivores that migrated naturally or with human assistance to these plantations. Safe biological control of albizia in Hawaii will be possible with agents that are not strictly monospecific, because albizia belongs to the tribe Ingeae, which has no native Hawaiian representatives and only one other weedy alien species in the state.

Combining this proposed project with native range studies will allow us to greatly expand the area

searched for natural enemies of albizia and its close relatives, maximizing our chances of finding effective and suitably host-specific agents. By tapping the resources and knowledge of the commercial industry, this work has the potential to fast track suitable insects for testing. In the event that suitable agents are not immediately found, through this project we will have built contacts with collaborators within industry, universities, extension and regulatory agencies that can provide critical facilitation of more detailed studies in areas found to be most promising.

7. APPROACH:

1. Collect and collate pest records from published literature, "gray" literature, unpublished reports, direct correspondence and on-site interviews with commercial forestry companies, agricultural universities, and regional government agencies to provide and a list of insects and pathogens affecting growth of *F. moluccana* so that putative agents can be prioritized.

2. Explore reported host ranges of the most destructive species reported from the surveys using published and unpublished literature sources. Follow up with on-site investigation of commercial plantation areas for related plants also found in the invaded Hawaiian range that might be susceptible to non-target attack.

3. Investigate life history traits and bionomics of the most host specific insect species. Measure the effectiveness of putative biocontrol agents within plantations, agroforestry and natural settings to further assess the best candidate species.

4. Bring populations of the most likely candidate species to the quarantine facilities in Hawaii for additional screening of host specificity. Facilities include USDA Forest Service Quarantine Facility in Hawaii Volcanoes National Park and the Hawaii Department of Agriculture Pathogen Quarantine in Honolulu.

8. EXPECTED PRODUCTS AND OUTCOMES:

This project will produce data needed to complete the first phase in development of biocontrol for *Falcataria moluccana*, to be followed by a later phase in which the most promising biocontrol agents will be evaluated in detail. Products from this proposal:

1. Identification of potential biocontrol agents for *F. moluccana* from commercial plantations sources within the native and expanded range in the Indo-Malayan region.

2. Summary of preliminary information on the expected host ranges and impacts of the most damaging commercial- and agro-forestry pests. This product will allow prioritization of agents for further evaluation, including future rearing and host specificity screening.

3. Establishment of collaborations with industries and scientists within the native and expanded range of *F. moluccana* who can carry out or assist with additional detailed evaluations of particular biocontrol agents. Careful studies based in the area where insects naturally occur have been shown repeatedly to be critical for developing successful weed biocontrol.

BUDGET

Budget: FY 2015			
	Proposed	**Hawaii Match**	**FS-PSW Match**
Salary and Fringe			
Entomologist Postdoc (5 months - this proposal)	$35,000	21,000	
PI Research Entomologist Johnson			10,000
Supplies (collecting gear, specimen prep)	0	670	
Equipment	0	0	
Travel			
International travel postdoc/PI (native range surveys)		14,000	4,000
International travel postdoc/PI (expanded range)	12,000		
Other			
Contract with collaborators PNG/Solomon/Indonesia		24,000	
Assistance from collaborators in expanded range	19,000		
Permits, Museum bench fees, Identifications		2,000	
Indirect USFS (in-house 15%)	0	5,650	7,000
Indirect USFS (pass-through 2%)	0	480	
FY 2015 Total	$66,000	$67,800	$21,000

Budget: FY 2016			
	Proposed	**Hawaii Match**	**FS-PSW Match**
Salary and Fringe			
Entomologist Postdoc (4 months - this proposal)	$28,000	21,000	
PI Research Entomologist Johnson			10,000
Supplies (collecting gear, specimen prep)	0	0	
Equipment	0	0	
Travel			
International travel postdoc/PI (native range surveys)		6,000	
International travel postdoc/PI (expanded range)	4,000		
Other			
Permits, Museum bench fees, Identifications		1,000	
Indirect USFS (in-house 15%)	0	4,200	4,500
Indirect USFS (pass-through 2%)	0	480	
FY 2016 Total	$32,000	$32,200	$14,500
Totals FY15 + FY16	$98,000	$100,000	$35,500

TIMETABLE

FY 2015/2016	
March-May	Establish contacts with forest/paper industry experts, government officials and university researchers in Indonesia, Malaysia and Papua New Guinea to identify study areas with Albizia plantations and agroforestry plots. Organize permits for insect collections.
June	Travel to Indonesia/Malaysia/PNG to meet with collaborators and initiate surveys for biocontrol agents during early dry season.
July - September	Identify insect collections and compile host literature for promising agents. Write initial findings report.
October	Travel to Indonesia/Malaysia/PNG for second survey of putative agents during late dry season.
November - December	Identify insect collections and compile host literature for promising agents. Write final report.
January	Submit final report for review and publication.

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CURRICULUM VITAE – KENNETH P. PULIAFICO

Summary
Kenneth Puliafico came to Hawai'i in 2012 and has travelled to Costa Rica several times in the last two years to find and test potential insect agents for the biocontrol of *Miconia*. He has broad experience working on insect and weed surveys in a variety of tropical and temperate climates. His graduate studies and professional research has focused on weed biocontrol, insect ecology and taxonomy, and invasive species biology.

Education

PhD, Entomology, 2008. University of Idaho. Moscow, ID.

Influence of insect herbivory, plant competition and plant defense on the invasion success of hoary cress (*Lepidium draba* L. (Brassicaceae)).

MS, Entomology, 2003. Montana State University. Bozeman, MT.

Molecular taxonomy, bionomics, and host specificity of *Longitarsus jacobaeae* (Waterhouse) (Coleoptera: Chrysomelidae). The Swiss population revisited.

BS with Honors, Biology, 1992. Montana State University. Bozeman, MT.

Professional Experience

Research Entomologist, 2012-Present, USDA Forest Service, Pacific Southwest Research Station, Institute of Pacific Islands Forestry, Invasive Species Team. Biological control of weeds in Hawaiian forests, Pre-release screening of biocontrol agents,, Insect ecology.

Research Associate, 2010 – 2012, Natural History Museum of Denmark, Zoological Museum, Copenhagen, Denmark. Lead insect survey team to Qatar, Ecological assessment of Al Zubarah UNESCO World Heritage Site, Tropical insect collection in Costa Rica, Taxonomy, digital photography and curation of Coleoptera type specimens,

Entomologist, 2010, Landcare Research – Biosystematics Team, Auckland, New Zealand.

Coleoptera systematics project support. Digital photography and data collection.

Volunteer Curator, 2009-2010, Auckland War Memorial Museum, Entomology Department, Auckland, New Zealand. – Entomology Department.. Database management, digitalization and curation of Diptera collection.

Entomologist – Seasonal, 2009, Montana Department of Agriculture – Pest Management Bureau, Helena, MT. Statewide survey for adventive insect biocontrol of weeds agents. Coordinated Japanese beetle (*Popillia japonica*) surveillance, monitoring and eradication projects in two Montana counties in conjunction with USDA-APHIS.

Publications

Puliafico, K.P., M. Schwarzländer, W.J. Price, B.L. Harmon, H.L. Hinz. 2011. Competition between hoary cress (*Lepidium draba*) and *Festuca* and *Poa* grasses. Invasive Plant Science and Management. 4 (1): 38-49.

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CURRICULUM VITAE – M. TRACY JOHNSON

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Education

Ph.D., 1995, Entomology, North Carolina State University. Thesis: The role of natural enemies in ecology and evolution of *Heliothis virescens* on transgenic plants.

M.S., 1990, Entomology, North Carolina State University. Thesis: Combined effects of genetically engineered host plant resistance and natural enemies on *Heliothis* populations.

A.B., 1984, Biology, University of California - Berkeley

Work Experience

Research Entomologist, 2000-Present, USDA Forest Service, Pacific Southwest Research Station, Institute of Pacific Islands Forestry, Invasive Species Team

Biological control of weeds in Hawaiian forests, Insect ecology, Post-release monitoring of biocontrol, Non-target impacts of biocontrol, Plant-herbivore-enemy interactions.

Junior Researcher, 1997-2000, Dept. Entomology, University of Hawaii - Manoa

Quantifying the off-target effects of biological control on the native Hawaiian koa bug, and surveying parasitism of an alien leafhopper invading native forests.

Fulbright Fellow, 1996-1997, International Centre of Insect Physiology and Ecology, Kenya

Assessing the risk that African maize stemborers may evolve resistance to transgenic maize expressing toxins of *Bacillus thuringiensis*.

Recent Publications

Hughes, R.F., M.T. Johnson, and A. Uowolo. 2013. The invasive alien tree *Falcataria moluccana*: its impacts and management. Pp. 218-223 *in* Proceedings of the XIII International Symposium on Biological Control of Weeds; Wu, Y., Johnson, T., Sing, S., Raghu, S., Wheeler, G., Pratt, P., Warner, K., Center, T., Goolsby, J., and Reardon, R., (eds). USDA Forest Service, FHTET-2012-07.

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