Control of Invasive Species through Management – Demonstration: *Falcataria moluccana* in the Republic of Palau

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In order for land managers across the Pacific to effectively protect their forest resources, Pacific Islanders need information to allow them to effectively evaluate, prioritize, and execute management actions to control the invasive species that pose the greatest threat to their resources. *Falcataria moluccana* is an exotic nitrogen-fixing tree (Figure 1) that has invaded native forests throughout the Pacific (Figure 2), and it has been shown to create profound and persistent changes in forest composition, structure, and function in Hawaii (Hughes and Denslow 2005, Hughes and Uowolo 2006). and American Samoa (Hughes et al. unpublished data). While this species threatens native forests on many other Pacific Islands (PIER 2010), implementing control efforts is complicated by an underestimation of its threat and by the value some sectors of society have placed on the services it provides. Significant outreach efforts over the next several years are needed to inform resource managers across the Pacific regarding the impacts of *F. moluccana* on native forests as well as how to successfully control it.

Native to the Moluccas, New Guinea, New Britain, and the Solomon Islands (Wagner et al. 1999), *Falcataria moluccana* (Miquel) Barneby and Grimes (formerly known as *Albizia falcataria* (L.) Fosberg and *Paraserianthes falcataria* (L.) Nielsen) is believed to have been introduced to Palau during the Japanese occupation of Palau in the early 1900's to provide shade for agricultural plantations (Anne Marie LaRosa pers. com.). As a nitrogen-fixing tree, it has commonly been planted in the Pacific with the intention of capitalizing on its fast growth and nitrogen fixation capacity for short-rotation forestry applications (Binkley and Giardina 1997, DeBell et al. 1997). *F. molucanna,* commonly known as albizia, grows well on a variety of soil types, including degraded sites (Otsamo 2000) and acidic or nutrient-poor soils (DeBell et al. 1989, Panjaitan et al. 1993). It is among the fastest growing trees in the world (Walters 1971), exhibiting growth rates up to 4.5 meters per year and the ability to reach heights over 30 meters with single canopy spread of over 50 meters (Little and Skolmen 1989). Albizia trees produce abundant seeds that are wind dispersed and can be carried great distances, both up and down slope. Due to its very rapid growth rate and prolific seed production, albizia can take advantage of local disturbances to become established across a landscape.

Figure 1. *F. moluccana* trees invading native forest of Babeldaop Island, Palau.

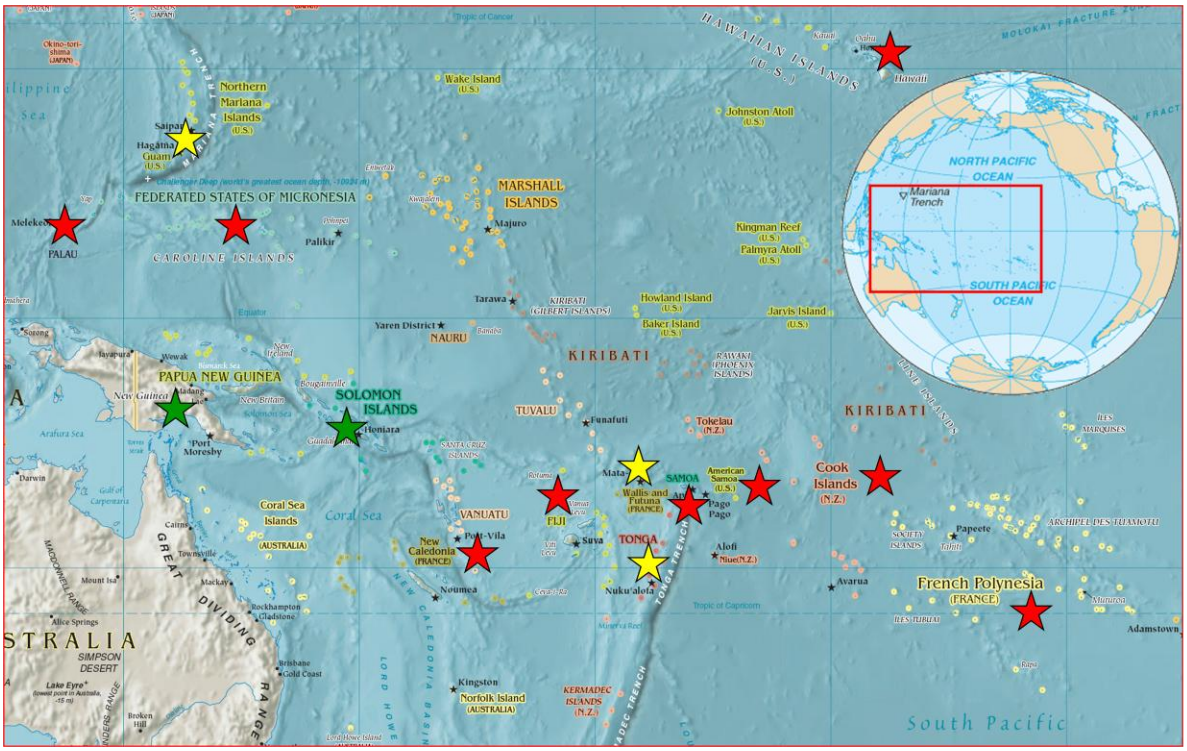

Figure 2. Map of the distribution of albizia across the Pacific. Green stars indicate the native range in the Pacific, yellow stars indicate where it is present but not considered a problem, and red stars indicate where it is present and considered to be an invasive species.

Project Objectives

1.) Communicate research findings from Hawaii and American Samoa to government land managers and conservation organizations in Palau to allow them to be more informed of current knowledge and techniques to aid in their invasive species control programs and conservation programs.
2.) Demonstrate various methods for the control of albizia that have been successful in Hawaii and American Samoa.
3.) Increase understanding of the impacts of albizia invasion, and its subsequent removal on the composition, structure and function of native forest ecosystems in the Republic of Palau.
4.) Educate local land managers regarding proper data collection methods and the concepts behind the techniques in conducting forest monitoring work so that Palau could independently quantify change in their forest resources that may arise in the future.

Project Outcomes

<u>Meetings with Land Managers & Conservation Organizations</u>

In June 2010, we began our outreach efforts in the Republic of Palau (Appendix 1), where we conducted a series of presentations with the Palau Forestry, Babeldaop Watershed Alliance, Palau Conservation Society, Ngeremenglui State governor liaison, Ngeremenglui Conservation Area Coordinating Committee representative, Ngatpang State governor liaison, Ngatpang Conservation Area Coordinating Committee representative, and the Belau National Museum. In these presentations, we discussed the impacts of *F. moluccana* in native forests of Hawaii and American Samoa, the current distribution of albizia in Palau and the threat it may pose in Palau if left alone. We presented a successful model developed by Mr. Tavita Togia of the National Park of American Samoa for the control

of albizia across forested landscapes through the involvement and collaboration with not-for-profit conservation organizations, government agencies, and individual villages where the infestations occur.

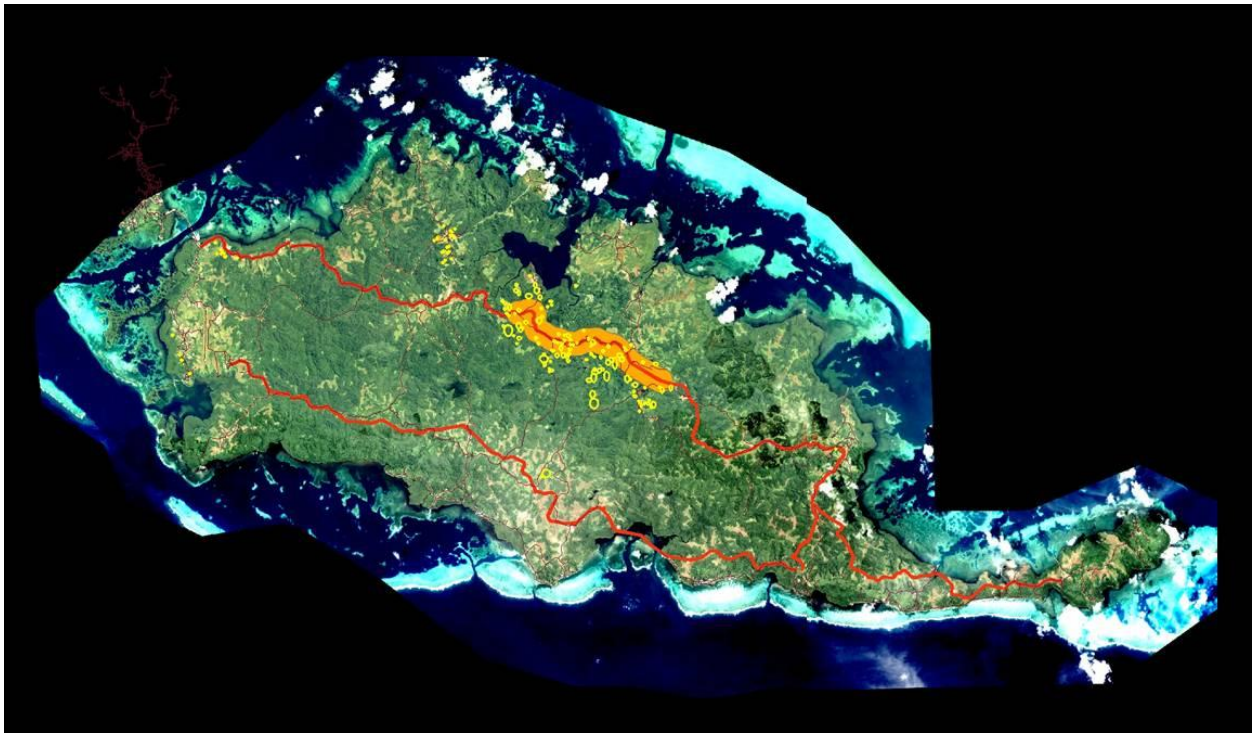

Figure 3. Map of Babeldaop Island, Palau showing the current distribution of *F. moluccana* across 6 states in yellow and the previous known extent of *F. moluccana* in 3 states in orange.

Mapping of Albizia

Prior to the work of our project, the extent of albizia was thought to be limited to 3 states of Babeldaop Island (Aimeliik, Ngeremenglui, and Ngatpang). Through the use of remotely sensed data and ground surveys, we were able to detect populations across the island in 3 additional states (Melekeok, Airai, and Ngardmau) (Figure 3). Geographic Information System (GIS) maps were developed for the partners in Palau so they could determine the exact locations of the populations detected.

Outreach through the Media

The Palau Conservation Society requested the members of our project to participate in a one hour radio "talk show" program hosted by the Palau Conservation Society on Palau Paradise Eco-Radio 87.8 FM (Figure 4). During this program, we informed the public of the impact this species has had elsewhere, the threat it may pose to the native forests of Palau, and how control efforts have been funded to control albizia elsewhere which have provided employment opportunities for individual villages to control the invasive species on their own village lands. All comments made during the interview were translated into the local Palauan language in order to reach a broader audience of non-English speaking listeners.

Figure 4. EcoRadio interview with the Palau Albizia Project participants

A hands-on demonstration and training seminar (Figure 5) covering successful methods for controlling albizia was conducted for the local Forestry staff, Babeldaop Watershed Alliance, and the local Conservation Area Coordinating Committee members. Participants were taught how to control albizia trees with only simple hand tools.

Figure 5. OTV interviews about the Palau Albizia Project

The demonstration by Tavita Togia of the National Park of American Samoa was filmed by the Palau Conservation Society. In addition Joe Tiobech from Palau Forestry and Amanda Uowolo from the USDA Forest Service were interviewed during the filming; they spoke about the impact this species has had elsewhere, the threat it may pose to the native forests of Palau, and the current forest monitoring work in Palau. The program was hosted by Palau Conservation Society and aired throughout each day of a one-week period as part of the local news program on Oceania Television Channel 23 for an anticipated audience of 22,000 people.

Demonstration & Monitoring

Through hands on demonstrations, we were able to train local people on the control method used successfully in American Samoa that involves only simple hand tools. Through our partnerships with Palau Forestry of the Bureau of Agriculture, the Belau National Museum, and the Babeldaop Watershed Alliance we successfully established long term demonstration and forest monitoring plots in native dominated forests, *F. moluccana* invaded forests, and stands where *F. moluccana* would be controlled to determine levels of infestation, the nature and impacts of such infestations, and the response of the forest once *F. moluccana* is removed.

Figure 6. Demonstration of a method to control albizia trees

Technical Transfer & Training

Local forestry staff and botanists at the Belau Museum (Figure 7) were trained on the data collection methods, use of geographic positioning systems (GPS) and ArcGIS software, as well as the concepts behind the techniques in conducting the forest monitoring work so that Palau could independently conduct this type of work in the future in order to quantify change in forest resources that may arise.

Figure 7. Palau Forestry staff collecting seedling density data in one of the permanent forest monitoring plots

USDA Forest Service-International Programs funding and this project provided for a successful ten week internship for Mr. Victor Nestor, a student from the Republic of Palau (Figure 8) through the Pacific Internship Program for Exploring Science (PIPES) of the University of Hawaii at Hilo. The internship was supported through a collaboration between the USDA Forest Service and Palau Forestry and provided an opportunity for this Palauan student to learn about communicating science to the public, establishing and conducting forest monitoring work, and how invasive species control programs are conducted in Palau and elsewhere across the Pacific.

Figure 8. Victor Nestor, USDA FS & Palau Forestry intern collecting GPS data in one of the permanent forest monitoring plots

Forest Monitoring Activities

<u>Research Questions</u>

1. What are the impacts of *F. moluccana i*nvasion on the native forest communities of Palau?
2. To what extent does native forest recover following *F. moluccana* control?
3. What changes occur with respect to forest community composition, growth, and biomass when *F. moluccana* invades the forests of Palau?

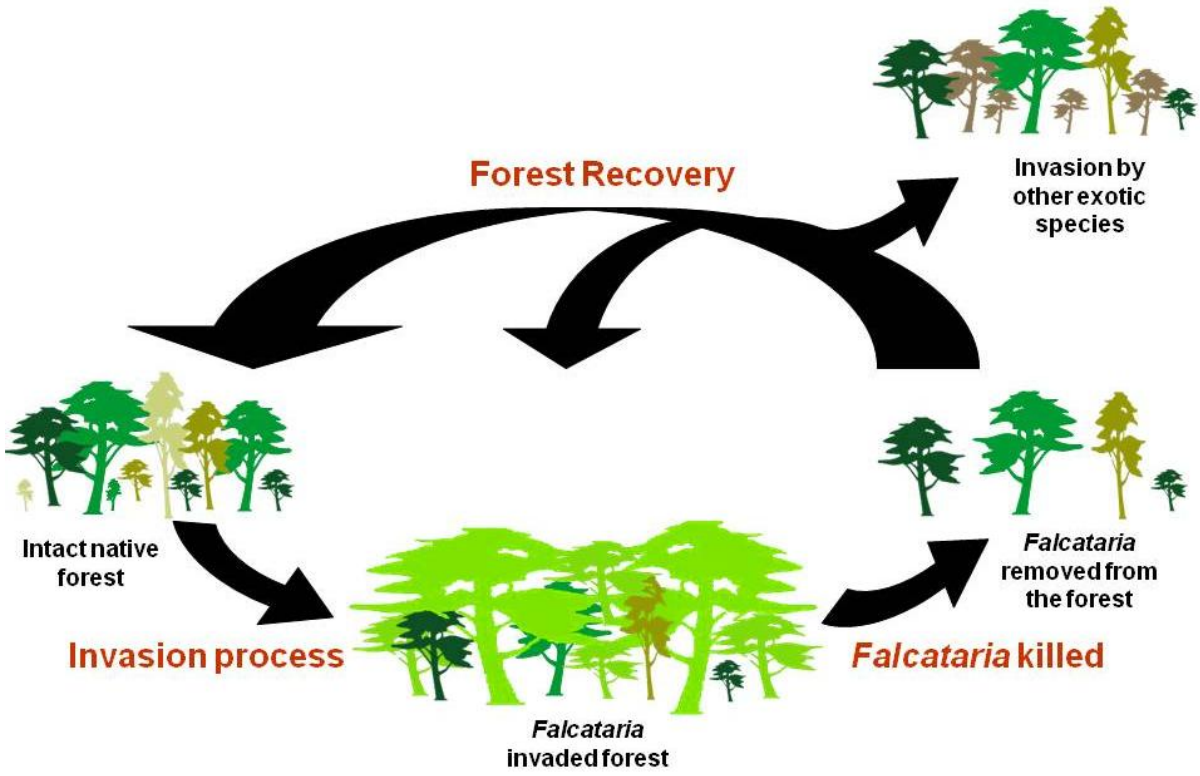

Figure 9. Forest recovery trajectories for *F. moluccana* -invaded forests of Palau

We established long-term monitoring plots in the three "treatments" of interest (i.e., intact native forest, *F. moluccana* -invaded forest, and forests in which the F. moluccana has been killed). We measured species composition and forest structure within plots of each treatment and will compare these parameters among the three treatments to document the impact of both *F. moluccana* invasion and its subsequent control within native forests of Palau (Figure 9).

Forest Monitoring Plot Design

Sets of study plots were arrayed across designated forest types of interest (i.e., intact native dominated forest, *F. moluccana* –invaded forest, and *F. moluccana* -controlled forest). We established five 18 m radius circular plots in each forest type of interest, with appropriate modifications to meet the specific objectives of the study and the size and shape of the respective forest-types. Aboveground plant biomass, tree/sapling/seedling density, as well as angiosperm species richness will be quantified at various scales in each of the individual nested subplots (Figure 10). Plots were permanently marked using metal rebar posts encased in PVC sleeves. Any and all potential archaeological features were avoided.

Within each 18 m radius plot, all trees greater than 10 cm diameter at breast height (1.3m height, DBH) were tagged with a numbered tag, identified to species, and the DBH measured. The DBH of all stems greater than 2 cm at breast height was measured and identified to species in nested 9 m radius subplots. The DBH of all stems less than 2 cm at breast height was measured and identified to species in nested 6 m radius subplots. Biomass and Carbon mass will be determined for all stems measured using a variety of appropriate allometric models that predict aboveground biomass with DBH. A series of eight 0.25 m^2 quadrats were used to measure seedling and sapling density for all stems < 1.3 m in height. Quadrats were located 5, 10, 5, and 10 m North, East, South, and West, respectively, from the center point of the nested subplots.

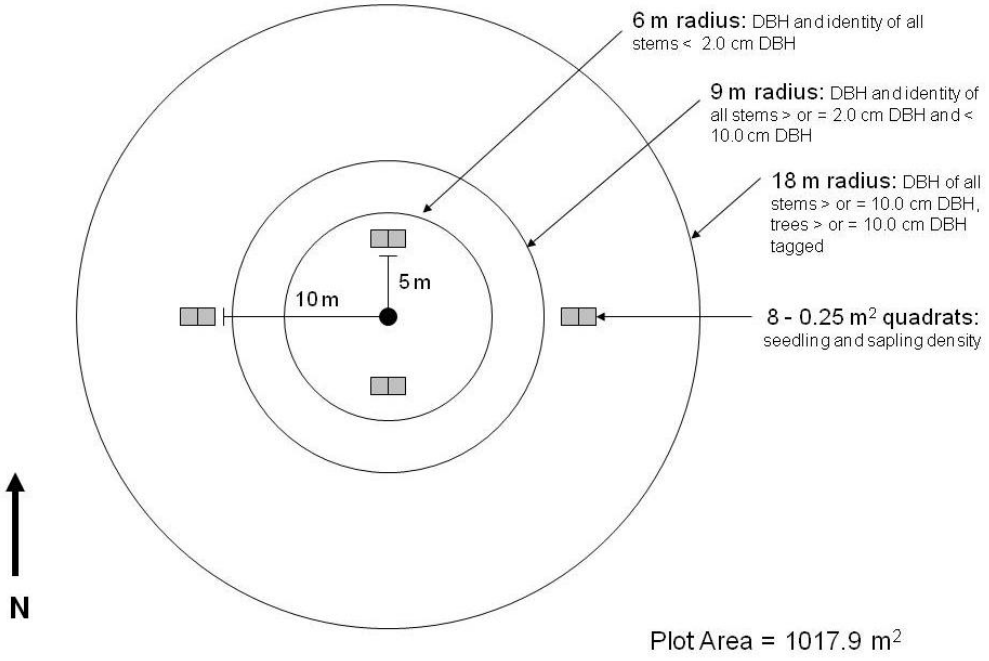

Figure 10. The nested subplot design to be used for sampling aboveground plant biomass and tree/sapling/seedling density.

Literature Cited

Binkley, D., and C. Giardina. 1997. Nitrogen fixation in tropical forest plantations. Chapter 9 *in* E. K. S. Nambiar and A. G. Brown, editors. Management of soil, nutrients, and water in tropical plantation forests. Australian Centre for International Agricultural Research, ACIAR/CSIRO/CIFOR. Monograph No. 43, Canberra, Australia.

DeBell, D. S., C. D. Whitesell, and T. H. Schubert. 1989.Using N2-fixing *Albizia* to increase growth of *Eucalyptus* plantations in Hawaii. Forest Science **35**:64–75.

DeBell, D. S., T. G. Cole, and C. D. Whitesell. 1997. Growth, development, and yield in pure and mixed stands of *Eucalyptus* and *Albizia*. Forest Science **43**:286–298.

Hughes, R. F., and J.S. Denslow. 2005. Invasion by a N_2-fixing tree alters function and structure in wet lowland forests of Hawaii. Ecological Applications **15**(5):1615–1628

Hughes, R. F., and A. L. Uowolo. 2006. Impacts of Falcataria moluccana invasion on decomposition in Hawaiian lowland wet forests: the importance of stand-level controls. Ecosystems **9**: 1-16.

LaRosa, A.M., personal communication, June 8, 2010.

Little. E.L., and R.G.Skolmen. 1989. Common Forest Trees of Hawai'i. Agriculture Handbook No. 679. United States Department of Agriculture, Washington DC.

Otsamo, R. 2000. Secondary forest regeneration under fast growing forest plantations on degraded *Imperata cylindrical* grasslands. New Forests **19**:69–93.

Panjaitan, M., W. W. Stur, and R. Jessop. 1993. Growth of forage tree legumes at four agro-climatic sites in Indonesia. Journal of Agricultural Science **120**:311–317.

PIER - Pacific Islands Ecosystems at Risk. *Falcataria moluccana* Species Profile. 4 APR 2009 Web. 27 Aug 2010. <http://www.hear.org/pier/species/falcataria_moluccana.htm>

Wagner, W. L., D. R. Herbst, and S. H. Sohmer. 1999. Manual of the flowering plants of Hawai'i. University of Hawaii Press, Honolulu, Hawaii, USA.

Appendix 1: Education & Outreach Activities in Palau for Albizia Project

6/7/10 Amanda Uowolo and Tavita Togia gave a 30 minute presentation to the Palau Forestry staff on the impacts of Albizia in Hawaii and American Samoa, the management approach for Albizia in American Samoa, and the extent of the current albizia invasion in Palau based on aerial data. Anne Marie LaRosa led a discussion on how to begin to think about albizia control in Palau, identifying the next steps to take, and the role that Palau Forestry envisions having in this process.

Present: Amanda Uowolo, Ecologist, USDA Forest Service
Tavita Togia, Terrestrial Ecologist, National Park of American Samoa
Anne Marie LaRosa, Forest Health Coordinator, USDA Forest Service
Pua Michael, Head Forester, Palau Forestry
Joe Tiobech, Invasive Plants Eradication Coordinator, Palau Forestry
Dino Mesubed, Invasive Plants Eradication Assistant , Palau Forestry
Victor Nestor, USDA-FS and Palau Forestry intern

6/10/10 Anne Marie LaRosa, Pua Michael, and Joe Tiobech gave a brief introduction and overview of our proposed forest monitoring work and the context within the current work with invasive species in Palau. Amanda Uowolo and Tavita Togia gave a 30 minute presentation on the impacts of Albizia in Hawaii and American Samoa, the management approach for Albizia in American Samoa, and the extent of the current albizia invasion in Palau based on aerial data. Anne Marie LaRosa led a discussion on how to begin to think about albizia control in Palau and identifying the next steps to take.

Present: Amanda Uowolo, Ecologist, USDA Forest Service
Tavita Togia, Terrestrial Ecologist, National Park of American Samoa
Anne Marie LaRosa, Forest Health Coordinator, USDA Forest Service
Pua Michael, Head Forester, Palau Forestry
Joe Tiobech, Invasive Plants Eradication Coordinator, Palau Forestry
Dino Mesubed, Invasive Plants Eradication Assistant, Palau Forestry
Director, Palau Conservation Society
Anu Goopta, Palau Conservation Society
Joyce Beouch, Babeldaop Watershed Alliance Coordinator
Samil Beouch, Ngeremenglui Conservation Area Coordinating Committee
Ngeremenglui Governor Representative
Ngatpang Conservation Area Coordinating Committee Representative
Ngatpang Governor Representative
Victor Nestor, USDA-FS and Palau Forestry intern

6/15/10 Joe Tiobech, Anne Marie LaRosa, Amanda Uowolo, and Tavita Togia participated in a one hour radio talk show sponsored by the Palau Conservation Society on Palau Paradise Eco-Radio Station 87.8FM. We discussed the impacts of albizia in native forests in Hawaii and American Samoa, the presence of this species in forests of Palau, and the forest monitoring demonstration plots we were establishing in collaboration with Palau Forestry and the Belau Museum to better understand the impact this species is having in forests of Palau.

6/18/10 Amanda Uowolo, Anne Marie LaRosa, and Tavita Togia were invited to attend the Palau Conservation Society (PCS) annual meeting. Amanda Uowolo and Tavita Togia were introduced at the meeting and a brief introduction of the work we were doing with the forest

monitoring demonstration plots. Amanda and Tavita met with Yalap Yalap, the Communications and Outreach coordinator for PCS, and Umai Basilus, the Education coordinator of PCS, to discuss PCS's desire for us to participate in a radio interview and a television interview about the project work.

6/19/10 Tavita Togia conducted a hands-on demonstration & training with Palau Forestry Staff, Palau Conservation Society, Babeldaop Watershed Alliance, and community members from Ngeremenglui village on the technique for killing Albizia that has been effective in American Samoa. The demonstration and training was filmed to be used later to train local Palauans on how to effectively kill Albizia using simple tools (i.e., machetes and sticks) and no herbicide. Tavita Togia was interviewed by the local news television program OTV Channel 23 on the field technique that has been used in American Samoa to control albizia. Tavita was interviewed on the field technique and important safety considerations in conducting this type of work that were taught during the demonstration. Joe Tiobech and Amanda Uowolo were interviewed as well on the impacts of Albizia in native forests in Hawaii and American Samoa, the presence of this species in forests of Palau, and the forest monitoring demonstration plots that were being establishing in collaboration with USDA Forest Service, Palau Forestry, and the Belau Museum in order to better understand the impact this species is having in forests of Palau. The news program was aired multiple times a day over one week to an anticipated audience of approximately 22,000 people.

Present: Amanda Uowolo, Ecologist, USDA Forest Service
Tavita Togia, Terrestrial Ecologist, National Park of American Samoa
Yalap Yalap, Palau Conservation Society and OTV interviewer
Pua Michael, Head Forester – Palau Forestry
Joe Tiobech, Invasive Plants Eradication Coordinator – Palau Forestry
Dino Mesubed, Invasive Plants Eradication Assistant – Palau Forestry
Bungellong Tebelak, Palau Forestry
Joyce Beouch, Babeldoap Watershed Alliance Coordinator
Samil Beouch, Ngeremenglui Conservation Area Coordinating Committee
Van Ray Tadao, Belau Museum
Victor Nestor, USDA-FS and Palau Forestry intern

6/28/10 At the request of Palau Forestry, Amanda Uowolo conducted a 2 hour Geographic Positioning System (GPS) training for the Palau Forestry Staff, Local High School student summer interns, and staff from the Belau Museum. Participants were taught how to operate a GPS: to collect individual map coordinates, to average the data collection of coordinate points for better results, to collect points around a perimeter area, to enter coordinates into the GPS, and to navigate to a point entered into the GPS with the aid of a compass. Participants were also taught various ways to change units and name items in the GPS. A competition was made to apply the skills acquired during the training which all the participants enjoyed.

Present: Amanda Uowolo, Ecologist, USDA Forest Service
Pua Michael, Head Forester – Palau Forestry
Joe Tiobech, Invasive Plants Eradication Coordinator – Palau Forestry
Bungellong Tebelak, Palau Forestry
Pamela Kaluu, Palau Forestry Stewardship Intern
Stephanie Andrews, Palau Forestry
Aleyna Ngrengkoi, USDA-FS and Palau Forestry intern
Lia Ngiramolau, Palau Forestry Intern

Jay Kodep, Palau Forestry Intern
Jeracie Oiterong, Palau Forestry Intern
Van Ray Tadao, Belau Museum
Victor Nestor, USDA-FS and Palau Forestry intern

At the request of Palau Forestry, Amanda Uowolo also conducted a 4 hour ArcView-GIS training for the Palau Forestry staff. Participants were shown basic functions for using GIS to map invasive species for presentations and to calculate area of invasion. We used the data collected in the GPS training exercise to do a hands on exercise on how to apply the skills learned.

Present: Amanda Uowolo, Ecologist, USDA Forest Service
Pua Michael, Head Forester – Palau Forestry
Joe Tiobech, Invasive Plants Eradication Coordinator – Palau Forestry
Bungellong Tebelak, Palau Forestry
Pamela Kaluu, Palau Forestry Stewardship Intern
Van Ray Tadao, Belau Museum
Victor Nestor, USDA-FS and Palau Forestry intern

6/29/10 Amanda Uowolo gave a 60 minute presentation to the Belau Museum staff and the Palau Forestry Staff on the research findings of the impacts of Albizia in Hawaii and American Samoa, the management approach for Albizia in American Samoa, and the extent of the current Albizia invasion in Palau based on aerial data.

Present: Amanda Uowolo, Ecologist, USDA Forest Service
Ann Kitalong, Botanist & Botanical Collection Manager, Belau Museum
Van Ray Tadao, Assistant Manager of Botanical Collection, Belau Museum
Pua Michael, Head Forester – Palau Forestry
Joe Tiobech, Invasive Plants Eradication Coordinator – Palau Forestry
Dino Mesubed, Invasive Plants Eradication Assistant – Palau Forestry
Victor Nestor, USDA-FS and Palau Forestry intern