Survey of *Tabernaemontana rotensis* on Andersen Air Force Base

Contract #FA5240-04-P-0099

Submitted by: University of Guam

Final Report

February 2007

Table of Contents

1. Summary

More than 21,000 *Tabernaemontana* individuals were found throughout Andersen Air Force Base during this systematic survey. These individuals occurred in an aggregated spatial distribution, revealing a clumped pattern within 265 specific sites. The average number of individuals at each site was approximately 80, with one site containing 850 individuals. Analysis of the population structure revealed an excellent representation of emerging seedlings, young juveniles, and reproductive mature individuals with an immense range in canopy size. Disregarding the issue of the clumped pattern, recruitment is not a current conservation concern.

Tabernaemontana habitat was located on relatively flat terrain, with 96% of the sites on slopes of less than 15%. Soils in these sites were largely represented by the closely related Guam series and the Ritidian-Rock Outcrop Complex (93%), with the remaining 7% of the sites located on the Yigo soil series. Co-occurring species were overwhelmingly native species, especially for the emergent canopy species. Most of the alien species associated with *Tabernaemontana* were forb or woody shrub species. Forest habitats within Andersen Air Force Base that were dominated by alien tree species were devoid of *Tabernaemontana* trees. The most abundant co-occurring species was *Cycas micronesica*, which was Red-listed by the IUCN as endangered in 2006.

The Guam population of *Tabernaemontana* trees exhibited vegetative growth throughout the year. Surprisingly, 40% to 80% of the mature population also produced some flowers throughout the year. Despite the presence of flowers, fruit set was minimal from January through June. The percentage of trees with orange fruit was greatest from October through February. *Tabernaemontana* fruits reached full size in about 30 days following flowering, exhibited a color break from green to light orange at about 60 days, and split open to expose seeds at about 90 days. These data may inform conservation decisions if seed harvest becomes a component of a conservation plan. Allometric relations indicate the Guam *Tabernaemontana* exhibits significantly shorter stature for a given trunk diameter than tree species in general. This scaling pattern improves tree biomechanics for withstanding typhoon-force winds.

Poor seed germination of < 3% occurred in 9 of the 11 seed studies we conducted. The two successful studies with germination in excess of 90% used seeds that were harvested from mast fruiting events that followed forest damage by typhoons. In one of the successful studies, germination and seedling emergence were maximized in full sun conditions, which indicated *Tabernaemontana* behaves like a pioneer species at this phase of development. However, early plant growth was maximized in shade. Even severe shade of approximately 80% elicited equal or greater seedling growth than full sun conditions. *Tabernaemontana* leaves exhibited facultative responses that allowed them to function in a range of light conditions. Shade leaves were more efficient than sun leaves at utilizing absorbed light energy for photosynthetic processes, but were unable to reach maximum photosynthesis rates as high as full sun leaves. Moreover, respiration of shade leaves was lower than sun leaves. These facultative physiological responses are crucial for allowing a *Tabernaemontana* individual to respond to changes in light conditions as the forest canopy goes through ephemeral changes in cover.

This field survey suggests a widely distributed extant population of healthy, reproductively viable and resilient *Tabernaemontana* plants with an admirable population structure represented

by mature, young reproductive, juvenile, and seedling recruits. Thus, population structure is not a current conservation concern. Unfortunately the spatial distribution is a major concern, as so many individuals are growing in close proximity within only 265 sites throughout the Base. This aggregated pattern increases the vulnerability of the population, especially to the threat of habitat loss. This threat is exacerbated by the fact that almost all of the *Tabernaemontana* trees on Andersen AFB are located in sites with less than 15% slope, which is also terrain suitable for human development.

Current and ongoing threats to the population are mostly conversion of forested areas to non-forest use, habitat fragmentation, limited seed dispersal, and the potential for Guam to acquire a new invasive arthropod species with the ability to infest *Tabernaemontana*. The extent to which the first two threats are realized will depend on future development plans for Andersen AFB.

2. Introduction

Tabernaemontana rotensis was proposed for listing under the Endangered Species Act in June 2000 (Fish and Wildlife Service, 2000), and the decision on this proposal was pending when funding was identified in 2004 to conduct this botanical survey of Andersen AFB. Effective 10 May 2004, the Fish and Wildlife Service published the decision to refrain from listing the Mariana Island *Tabernaemontana* taxa on the basis of a 1991 taxonomic classification that lumped *T. rotensis* and many other recognized *Tabernaemontana* species into a single widespread species (Fish and Wildlife Service, 2004). The Fish and Wildlife Service now recognizes the Guam and Rota *Tabernaemontana* populations to be a local form of *T. pandacaqui*.

This sort of confusion over the precise nomenclature of local plant populations is routine in conservation biology. However, there is no confusion about the fact that local plant populations are genetically and morphometrically distinct on some level. Therefore, the need for conservation of locally rare plants is not diminished by human debates concerning the range of recognized names attributed to plant populations by humans. For example, the Fish and Wildlife Service's published decision acknowledged the importance of local *Tabernaemontana* plants as a critical natural resource of Guam and Rota, and they urged local authorities to conserve the local populations despite the lack of protection under the Endangered Species Act of 1973.

No systematic survey has been conducted to determine the census and distribution of Guam's *Tabernaemontana* population. Similarly, no formal studies have been conducted to increase the understanding of appropriate conservation measures for this taxa.

Federal Regulations

- Endangered Species Act (16 U.S.C. 1531 et seq.)
- Fish and Wildlife Coordination Act (16 U.S.C. 661 et seq.)
- Endangered and Threatened Wildlife and Plants (50 CFR 17.11-17.12 et seq)

Department of Defense Regulations and Guidelines

- Conservation & Management of Natural Resources, 36 ABWI 32-7003

Applicable State and Local Regulations

- Fish, Game, Forestry and Conservation (5 Guam Code Annotated, Chapter 63)

3. Background

The contemporary understanding of *Tabernaemontana* distribution on Guam and Rota began in 1998 with the discovery of several trees on Andersen Air Force Base. Prior to this discovery, local biologists were unable to find the locations of any of the three trees previously reported. Conservation efforts at the time were operating under the belief that the only remaining trees of the taxa were on Rota. The first of currently known existing *Tabernaemontana* trees was unexpectedly observed in Area 50 in the spring of 1998. The conspicuous orange fruit with showy, exposed red pulp tissue caught the eye of biologists, who were able to confirm the plant's identity. We now know that *Tabernaemontana* trees respond to typhoons with a synchronized flowering pulse. Thus, the copious fruit set that led to the initial tree's discovery was a direct response to the effects of Typhoon Paka on 16 December 1997. This tree would have likely gone unnoticed in 1998 were it not for the flowering/fruiting response to the typhoon. Several more *Tabernaemontana* trees were later found within Andersen Air Force Base, and by the time the proposal for listing the taxa was published in June 2000 the number of known trees was between 30 and 40.

The Mariana Island *Tabernaemontana* occurs on the islands of Rota and Guam. It occurs on Andersen Air Force Base, Ritidian, and private lands on Guam, and on private lands on Rota. According to the literature, the species and its habitat have been affected by one or more of the following: habitat degradation or destruction by feral pigs and deer; competition for space, light, water, and nutrients with introduced vegetation; road construction and maintenance activities; recreational activities; natural disasters or random environmental events; fire; vandalism; development of agricultural homesteads; resorts and golf courses; limited reproductive vigor; and potential insect, mouse, or rat predation.

4. Methods

4.1. Survey methods.

Phase I. (Reconnaissance Survey) - This work was planned as the initial phase of the contract. It involved starting with the list of *Tabernaemontana* sites that were known to then Project Manager Dana Lujan at the beginning of the contract period. The Project Manager was to provide that list in accordance with the Statement of Work and the Work Plan. The Project Manager was also required to augment this list by accompanying the Contractor on site visits to these known individuals. We attempted to obtain these obligations from the Project Manager for several months, but were unsuccessful. We have never been provided this list of previously known *Tabernaemontana sites*. Thus, the contract has been fulfilled without an ability to begin with Phase I.

Phase II: (Meander Survey) - Delineate the outlines of all potential *Tabernaemontana* habitats as search units. We used various maps of Andersen Air Force Base to define the areas for search

units. The boundaries for these search areas follow roads or construction, powerline access ways and natural topographical features such as the cliffline. General macro habitat descriptions will be developed for each search unit defined in Phase II.

Phase III: (Patterned Survey) - Pattern searches were conducted within each of the specific habitats defined in Phase II. All plant locations were documented as point locations.

We defined the pattern for transects within each search unit based on the most readily accessible base line. For example, if the baseline for the patterned search grid is north-south then the patterned search transects were east-west. Search transects were at 90 degree angles from the baseline. Nearly all search areas have at least one accessible linear feature from which to establish the initial baseline. The distance between search transects were set at 5 meters. Along each access baseline and the parallel baseline, GPS waypoints were established at 5 meter intervals.

4.2. Habitat determination.

Micro-habitat descriptions for *Tabernaemontana* individuals were developed from Guam Soil Survey (SCS 1984) narrative descriptions. SURGO GIS soils layers were used to map general edaphic conditions for the micro-sites of each individual. The SURGO soil layer was over-laid with established GEODATA road and topographic features to form a base layer to support Phase II and III field surveys. Topographic characteristics were recorded at each site and based on direct observation. Co-occurring species were defined and recorded. The general percentage of native versus introduced species was calculated from the list of co-occurring species.

4.3. Allometry methods.

Allometric information will add to our understanding of the general population characteristics of this important species. These measurements focus primarily on canopy height and stem size. Regression analysis was used to determine the size relationships among the entire population of plants. We added the regression comparisons of other known woody perennial tree species to determine how *Tabernaemontana* trees on Guam scale in comparison with a general population of many species.

4.4. Propagation methods.

4.4.a. Seed propagation.

Storage conditions: We stored seeds in humidified chambers versus air-conditioned room conditions for 7 months. We planted at monthly intervals to determine germination percentage as a function of storage conditions.

Mechanical scarafication: We used 120 grit sandpaper to scratch the surface of *Tabernaemontana* seeds.

Hot water scarification: We plunged *Tabernaemontana* seeds into hot water (170-210 degrees F) for 3 minutes, followed by rinsing with cold water. Volume of water was 10 times the volume of seed.

Chemical scarification: *Tabernaemontana* seeds were scarified in sulfuric acid for 20, 40, 60, or 120 minutes.

Water soak: We used 12, 24, 36, and 48 hour pre-sowing water soak treatments to determine the most appropriate duration.

Gibberellic acid infusion: GA is a plant hormone that acts as a germination promoter. We used 100, 300, or 500 ppm GA for these studies. We infused seeds for 1 hour.

Ethephon: This chemical decomposes within plant tissues to generate the plant hormone ethylene. We infused ethephon for 1 or 12 hours at 1, 5, or 10 mM for these studies.

Nitric oxide: Sodium nitroprusside is a nitric oxide donor. This donor has been used to break seed dormancy in some species. We used 25, 100, or 300 μM for these studies, and infused for 1 hour.

Liquid smoke: Commercially available liquid smoke flavorings have been instrumental for breaking dormancy and improving germination of seeds from a variety of species. We used 1, 12, or 24 hour soak treatments to infuse chemicals found in liquid smoke flavoring.

4.4.b. Vegetative Propagation.

The methods used in developing a protocol for stem cutting propagation are even more straight-forward than for seed propagation.

1. Stem age – We used distance from the stem tip as a surrogate for stem age. Tip cuttings contained healthy leaves, stem sections basal to the tip cuttings contained older leaves, and stem sections basal to these cuttings generally exhibited no leaves. All cuttings were 6 inches in length.

2. Air drying – Stem cuttings of some members of the Apocynaceae are easily rooted, but only if cuttings are allowed to air dry for several days after being removed from the parent plant. We used this pre-treatment with the older stem sections that lacked leaves. Air dry treatments were 1 or 2 days prior to planting.

3. Rooting hormone – Indolebutyric acid (IBA) was applied to *Tabernaemontana* stem cuttings in commercially available powder form.

4.4.c. In-situ establishment methods.

We conducted transplant studies of seedlings from habitat. For comparison purposes, we included Guam's other Apocynaceae species. Thus, seedlings of *Tabernaemontana, Cerbera*

dilitata, Ochrosia mariannensis, and *Neisosperma oppositifolia* were transplanted and nurtured using standard horticultural approaches.

4.5. Phenology methods.

General phenology observations were conducted to document major vegetative and reproductive events in the population of *Tabernaemontana* on Andersen AFB. We recorded timing of flowering, fruiting, vegetative growth, and any observed herbivory. Data were recorded as percentage of canopy involved in each of these categories. We also attempted to document the source of herbivory and any other general plant community interactions that were observable at the time of the visits. These observations were made on monthly intervals.

Additionally, measurements of developing fruiting structures were made from the time of flowering until seed dispersal. This information will allow resource managers to accurately predict the date of seed collection whenever a flowering cycle is noticed in the *Tabernaemontana* population.

5. Results

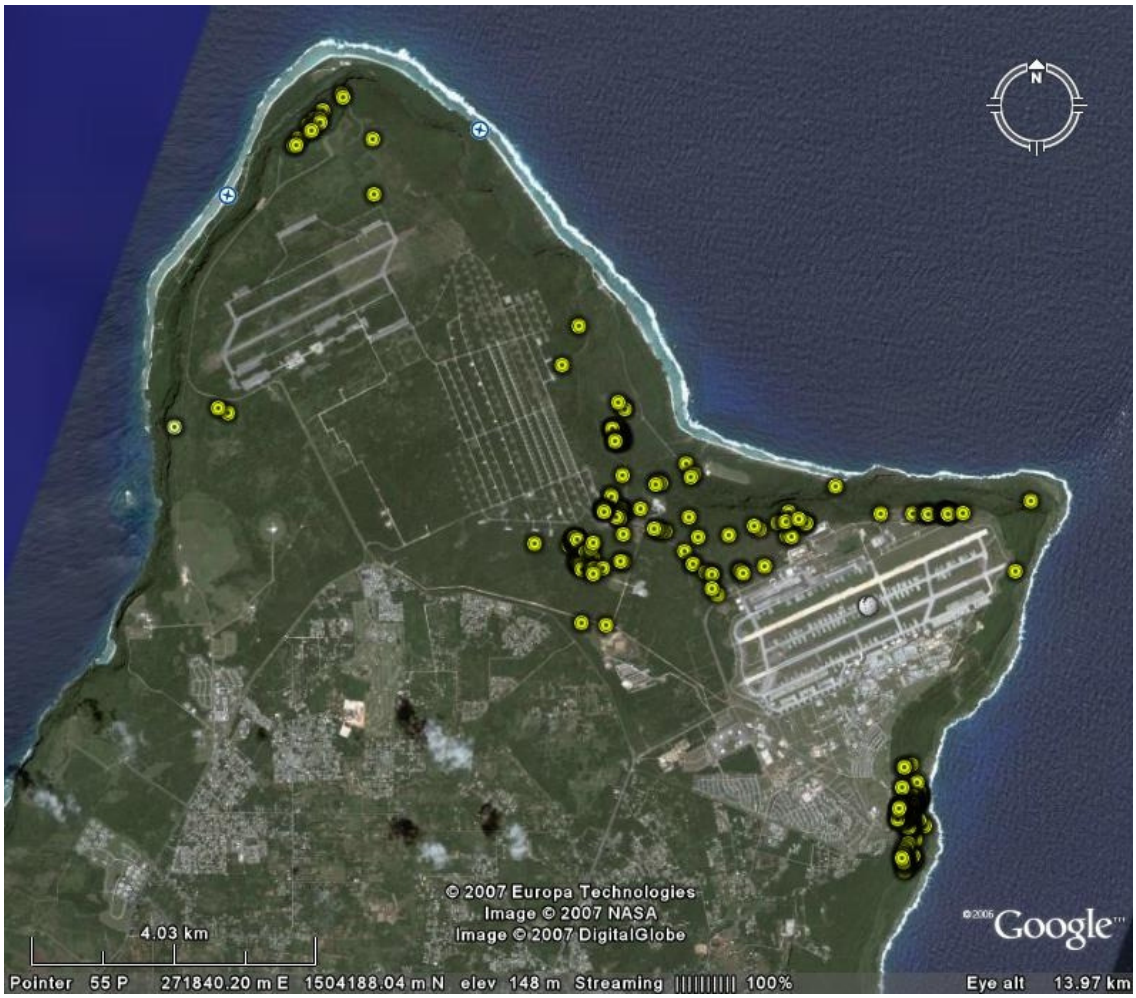
5.1. Survey results.

We located 21,669 *Tabernaemontana* individuals throughout Andersen AFB. This large population of individuals revealed an aggregated spatial pattern, with the entire population clumped in only 265 sites (see Appendix 7.1 for UTM of each site). Almost all of these sites contained more than one tree. In fact, the average number of individuals at each of these 265 sites was approximately 80, with one site comprised of 850 individuals. In every case, the original progenitor of each "grove" was easily identified based on tree size. However, the robust range of tree sizes and the occurrence of so many reproductive individuals within each grove support the contention that several generations comprise the population within each grove. In other words, every individual is not a direct offspring of the one individual that is the obvious original progenitor.

This field survey suggests Andersen AFB is home to a widely distributed extant population of healthy, reproductively viable and resilient *Tabernaemontana* plants with excellent population structure represented by mature, young reproductive, juvenile, and seedling recruits. About 35% of the population is greater than 1.5 m in height. Unfortunately the spatial distribution whereby so many individuals are clumped in close proximity increases the vulnerability of the population, especially to the threat of habitat loss.

Graphical representation of the *Tabernaemontana* localities is provided in an image that covers the entire Base (Fig. 1). Each marker represents one of the sites in the spreadsheet. Thus, on average, each marker represents 80+ individuals. Close-up images of concentrated areas with appropriate scale to reveal individual locations are presented in Appendix 7.2.

Figure 1. Image of Andersen Air Force Base showing location of 265 sites containing *Tabernaemontana* trees.



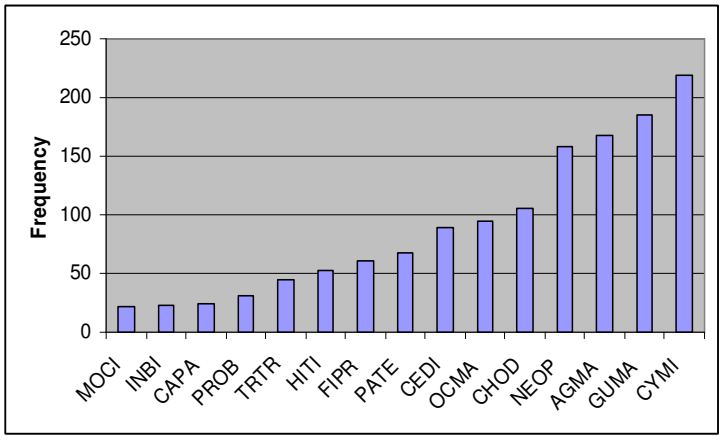
5.2. Habitat description.

5.2.a. Soils. *Tabernaemontana* trees were located in three of the four soils found within Andersen Air Force Base. The exception was Shioya sand substrates along the coast. Ritidian-Rock Outcrop soils contained 48% of the Base-wide population, Guam soils contained 45% of the population, and Yigo soils contained the remaining 7% of the population. While *Tabernaemontana* trees were located in the littoral forests, these individuals were growing in Ritidian Rock-Outcrop soil pockets within or near the Shioya sand substrates.

5.2.b. Slope. The *Tabernaemontana* population was largely restricted to fairly flat terrain. We used three categories of slope to reveal that 75% of the sites occurred in terrain less than 7% slope, 21% of the sites were in terrain between 7% and 15% slope, and only 4% of the sites were in terrain characterized by slope of greater than 15%.

5.2.c. Co-occurring species. One of the most important characteristics to quantify when attempting to more fully understand the habitat of a rare plant species is the other species that occur in close proximity. The 15 most common species that co-occur with the Guam *Tabernaemontana* were largely represented by natives (Fig. 2a). In fact, only 2 of the top 10 species were exotic species. Furthermore, the exotic species that do show up in close association with *Tabernaemontana* plants are forb or woody shrub species, indicating all of the tree species in close association with *Tabernaemontana* at the majority of sites were native.

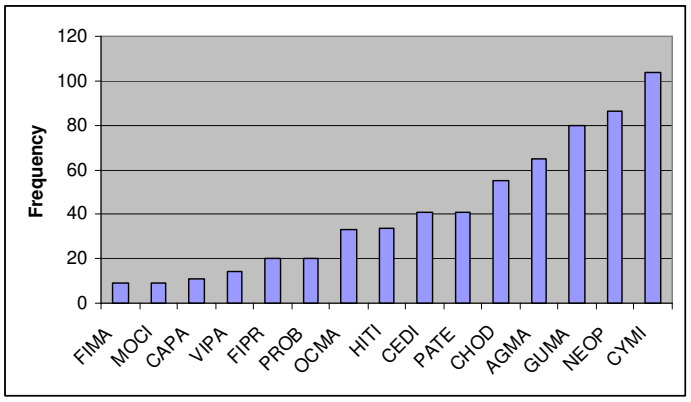
Figure 2a. Frequency of occurrence for the 15 most common co-occurring species throughout the 265 *Tabernaemontana* sites on Andersen Air Force Base.



CYMI – Cycas micronesica
GUMA – Guamia mariannae
AGMA – Aglaia mariannensis
NEOP – Neisosperma oppositifolia
CHOD – Chromolaena odorata
OCMA – Ochrosia mariannensis
CEDI – Cestrum diurnum
PATE – Pandanus tectorius
FIPR – Ficus prolixa
HITI – Hibiscus tiliaceus
TRTR – Triphasia trifolia
PROB – Premna obtusifolia
CAPA – Carica papaya
INBI – Intsia bijuga
MOCI – Morinda citrifolia

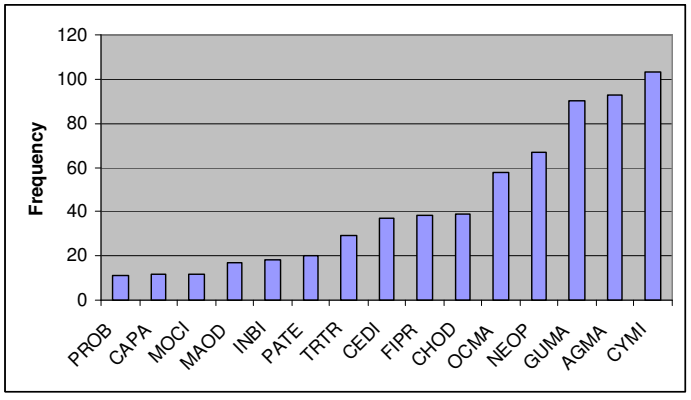
The co-occurring species in the sites located on Ritidian-Rock Outcrop soils (Fig. 2.b.; Clayey-skeletal gibbsitic, nonacid, isohyperthermic Lithic Ustorthents) were similar to those found on Guam soils (Fig. 2.c.; Clayey, gibbsitic, nonacid, isohyperthermic Lithic Ustorthents). However, the list and ranking of co-occurring species at the sites located on Yigo soils (Clayey, gibbsitic, isohyperthermic Tropeptic Eutrustox) were slightly different (Fig. 2.d.). Although *Cycas micronesica* was bumped to a tie for the second most abundant species in these soils, top ranked *Guamia mariannae* was also a native tree species.

Figure 2.b. Frequency of occurrence for the 15 most common co-occurring species in the *Tabernaemontana* sites located on Guam soil series.



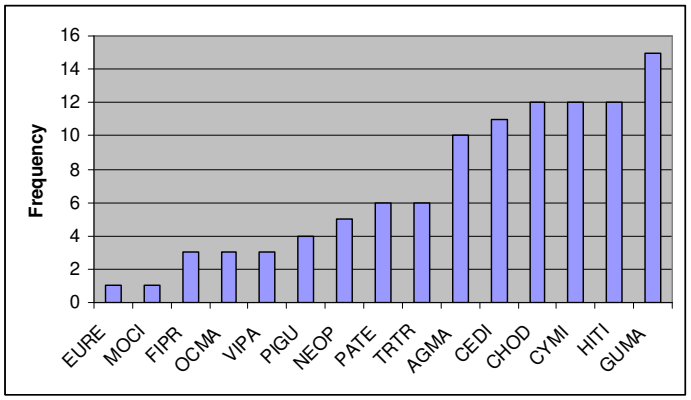
CYMI – Cycas micronesica
NEOP – Neisosperma oppositifolia
GUMA – Guamia mariannae
AGMA – Aglaia mariannensis
CHOD – Chromolaena odorata
PATE – Pandanus tectorius
CEDI – Cestrum diurnum
HITI – Hibiscus tiliaceus
OCMA – Ochrosia mariannensis
PROB – Premna obtusifolia
FIPR – Ficus prolixa
VIPA – Vitex parviflora
CAPA – Carica papaya
MOCI – Morinda citrifolia
FIMA – Ficus tinctoria

Figure 2.c. Frequency of occurrence for the 15 most common co-occurring species in *Tabernaemontana* sites located on Ritidian-Rock outcrop complex soils.



CYMI – Cycas micronesica
AGMA – Aglaia mariannensis
GUMA – Guamia mariannae
NEOP – Neisosperma oppositifolia
OCMA – Ochrosia mariannensis
CHOD – Chromolaena odorata
FIPR – Ficus prolixa
CEDI – Cestrum diurnum
TRTR – Triphasia trifolia
PATE – Pandanus tectorius
INBI – Intsia bijuga
MAOD – Mammea odorata
MOCI – Morinda citrifolia
CAPA – Carica papaya
PROB – Premna obtusifolia

Figure 2.d. Frequency of occurrence for the 15 most common co-occurring species in *Tabernaemontana* sites located on Yigo soil series.



GUMA – Guamia mariannae
HITI – Hibiscus tiliaceus
CYMI – Cycas micronesica
CHOD – Chromolaena odorata
CEDI – Cestrum diurnum
AGMA – Aglaia mariannensis
TRTR – Triphasia trifolia
PATE – Pandanus tectorius
NEOP – Neisosperma oppositifolia
PIGU – Piper guahamense
VIPA – Vitex parviflora
OCMA – Ochrosia mariannensis
FIPR – Ficus prolixa
MOCI – Morinda citrifolia
EURE – Eugenia reinwardtiana

The most abundant co-occurring species during this survey was *Cycas micronesica*. This species is now red-listed as endangered by the IUCN (Marler et al. 2006). Two issues are relevant to these results. First, if this same survey were conducted beginning 2007, fewer *Cycas micronesica* individuals would have been found because of plant mortality that began in 2005 as a result of the Cycad aulacaspis scale epidemic. We have one permanent transect in Ritidian, and the census of *Cycas micronesica* has declined from 686 individuals in 2004 (before the Cycad aulacaspis scale entered the habitat) to only 87 of the original plants in January 2007. Second, from a conservation perspective these data indicate that any decision to protect a *Tabernaemontana* site will inadvertently protect a *Cycas micronesica* site. The fact that so many native species are in close association with *Tabernaemonta*, and that other rare species such as *Intsia bijuga* and *Elaeocarpus joga* are among those species, lends further credibility to the importance of protecting *Tabernaemontana* sites from habitat loss. The entire list of species found during this survey is presented in Appendix 7.3.

5.2.d. Recruitment dynamics. A characteristic found at most of the habitats was the high density of *Tabernaemontana* individuals (Fig. 3). This high plant density is beneficial for keeping many invasive plant species away from the typical *Tabernaemontana* micro-site. Indeed, we did not find as much vine competition within the *Tabernaemontana* groves as we did within surrounding vegetation. For example, *Mikania micrantha* did not make it into the top ten co-occurring species. On the other hand, this high plant density leads to acute con-specific light competition as the seedlings attain height. This fosters attrition from the high density population and reduced numbers of individuals over time.

We believe these pulses of high density seedling emergence and subsequent growth can be used as a core component of a conservation plan. Based on the fact that *Tabernaemontana* seedlings may be successfully transplanted (see Section 5.4) and that many of the young seedlings will die from competition if left in such high plant density, we believe there are no negative consequences to digging up small seedlings within the high density sites for transplanting to other targeted sites. The mandatory season for conducting a transplantation operation such as this is early in the rainy season.

Figure 3. Typical development of high density *Tabernaemontana* stands in Andersen Air Force Base.

***Tabernaemontana* seeds emerge from the soil line with a bent hypocotyl emerging first (left). This is epigeal germination behavior. Seedlings typically emerge in high population density situations beneath or near the mother tree. After several months of growth, the high density causes crowding and con-specific competition for light (right).**

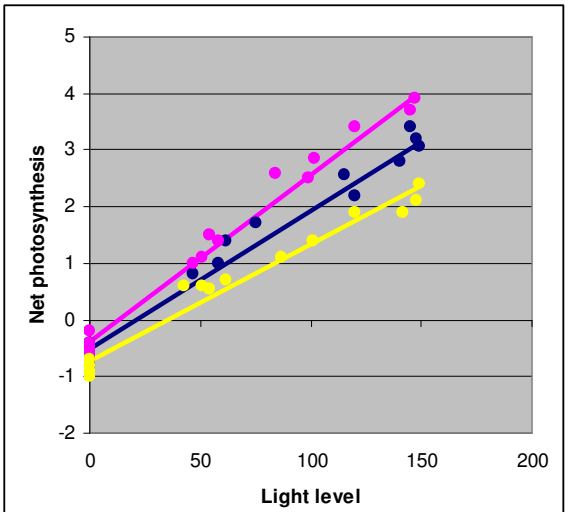
5.2.e. Light conditions. The light environment among the habitats containing *Tabernaemontana* trees was highly variable. Some trees were in full sun conditions, others were in limited light conditions beneath the forest canopy. These heterogeneous light conditions suggest *Tabernaemontana* plants are highly "plastic" in their ability to tolerate a wide range of available light. We conducted several studies in controlled conditions to quantify this *Tabernaemontana* attribute.

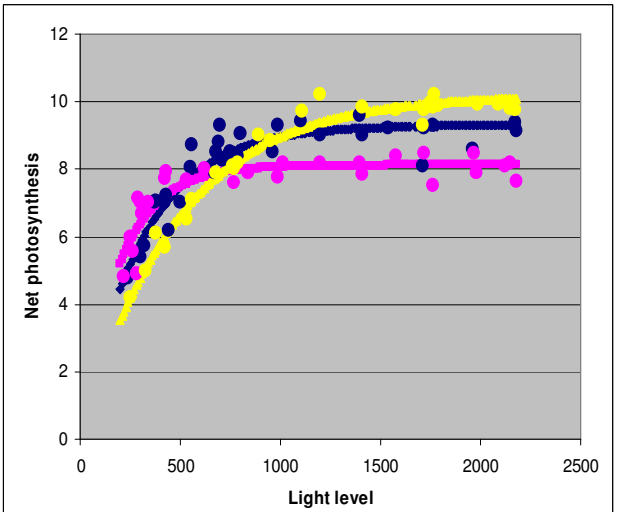
In very limited light conditions, a shade-grown *Tabernaemontana* leaf is more efficient at using light energy than is a full sun leaf. As light is increased at the very low level near darkness, shade leaves are able to capture and use more of the limited energy for net photosynthesis (Fig. 4 left, indicated by greater slope). Moreover, dark respiration of the shade leaves (y intercept) is greater for sun leaves than for shade leaves, indicating full sun leaves burn more energy just to maintain normal daily function. However, as light continues to increase the shade leaves saturate to a maximum net photosynthesis at a lower light threshold than do sun leaves (Fig. 4 right). Additionally, the sun leaves are equipped with physiological machinery to exhibit a maximum photosynthesis that exceeds that of shade leaves.

These changes in leaf physiology that result from varied light conditions allow a *Tabernaemontana* tree to develop leaves that burn up less carbohydrates for normal respiratory

function when light is highly limited. These same leaves are able to maximize the conversion of limited light energy into carbohydrates available for growth. Alternatively, a *Tabernaemontana* tree can develop leaves that are able to reach a greater maximum photosynthesis in full sun forest conditions, even though these leaves are less efficient in limited light conditions.

Figure 4. Developmental light level influences the ability of *Tabernaemontana* leaves to utilize light energy. Full sun is 2300-2400.





Left figure: Light level below about 7% of full sun where leaf use of the energy causes a linear response in photosynthesis.
Pink: Deep shade leaf. Photosynthesis = -0.377 + 0.030*light; r^2 = 0.99.
Blue: Medium shade leaf. Photosynthesis = -0.522 + 0.025*light; r^2 = 0.98.
Yellow: Full sun leaf. Photosynthesis = -0.725 + 0.021*light; r^2 = 0.96.

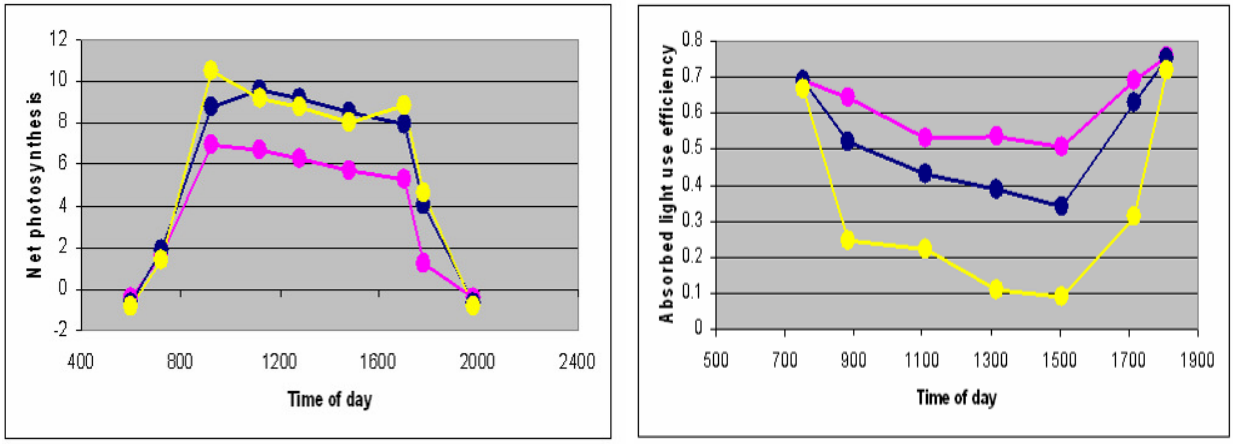
Right figure: Light level above about 7% of full sun where leaf photosynthetic use of light energy reaches a maximum.
Pink: Deep shade leaf. Photosynthesis = 8.121* (1-$e^{-0.0051*light}$); r^2 = 0.84.
Blue: Medium shade leaf. Photosynthesis = 9.309 * (1-$e^{-0.0033*light}$); r^2 = 0.93.
Yellow: Full sun leaf. Photosynthesis = 10.197 * (1-$e^{-0.0021*light}$); r^2 = 0.98.

These plastic developmental responses translate to differing patterns of physiology throughout a full day of typical light conditions (Fig. 5). In 80% shade the *Tabernaemontana* leaves (pink) are never able to reach their potential level of photosynthesis due to limitations of energy (Fig. 5 left compared with Fig. 4 right). Alternatively, the 60% shade leaves (blue) and full sun leaves (yellow) reach their photosynthetic potential throughout the day (Fig. 5 left).

We also measured the general ability of *Tabernaemontana* leaves to convert absorbed energy into reactions that support photosynthesis and growth (Fig. 5 right). All three leaf treatments were able to convert about 70% of absorbed light energy toward the reactions that support growth before sunrise and after sunset. However, all three leaf types declined in their ability to

carry out this important function during the day when they were actively photosynthesizing. The full sun leaves were much more impaired by excessive energy than were the shade grown leaves.

Figure 5. Physiological responses of *Tabernaemontana* leaves to developmental light level impart strong influence on the daily ability to utilize available light for growth.



Left: Net photosynthesis of *Tabernaemontana* leaves throughout a sunny day.
Right: The ability of *Tabernaemontana* leaves to efficiently use absorbed light energy throughout a sunny day.

Pink: Deep shade leaf. Blue: Medium shade leaf. Yellow: Full sun leaf.

These profound responses of *Tabernaemontana* leaves indicate this species has the ability to literally change its physiology in order to maximize the use of limited light when a plant is in deep shade, but to maximize the use of full sun conditions when a plant is grown in an open site. This "plastic" nature of *Tabernaemontana* leaf development partly explains why the plants are able to colonize sites that have such contrasting light conditions.

The net result is healthy *Tabernaemontana* plant growth can occur in full sun, but healthy growth can also occur in deep shade (at least to 80% shade) conditions (Fig. 6). Deep shade plants were the tallest and they also produced the longest internodes (Fig. 7 center). However, when defining growth as dry weight of the plant body (the most accurate measurement of growth), the medium shade plants grew more than the full sun or deep shade plants (Fig. 7 left). This indicates 80% shade limited growth by limiting available energy, but full sun limited growth by providing an excess of energy.

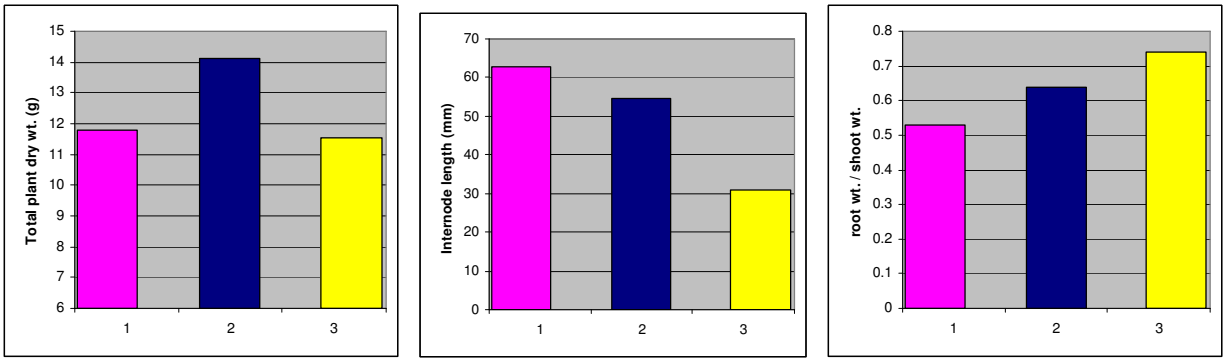
One more plant response indicates *Tabernaemontana* is not only adept at using physiological plasticity to capitalize on varied light environments, it also has the ability to alter allocational plasticity to maximize plant function. Under deep shade conditions, light is the most limiting resource, so more of the plant body is allocated to the shoot system (Fig. 7 right). Alternatively,

in full sun conditions light is not limiting but water acquisition becomes a limiting resource. Thus, more of the plant body is allocated to the root system (Fig. 7 right).

Figure 6. Appearance of *Tabernaemontana* plants grown from 16 Nov. 2005 until 18 Feb. 2006 under three levels of light.

Full sun plant on left. Medium shade plant (39% sunlight transmission) in center. Deep shade plant (18% sunlight transmission) on right. Full sun plant is shorter and leaves are smaller but thicker. Deep shade plant is tallest with large, thin leaves.

Figure 7. Important *Tabernaemontana* growth responses to development light level.

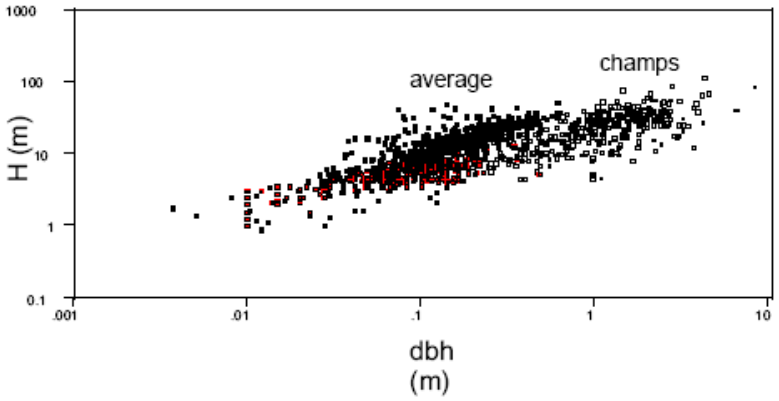


Pink: Deep shade plant. Blue: Medium shade plant. Yellow: Full sun plant.
Left: Medium shade plants grew more than deep shade or full sun plants.
Center: The length of internodes declined with increased exposure to sun.
Right: Full sun plants exhibited the greatest root wt / shoot wt. This indicates relatively more root growth at the expense of stem and leaf growth.

5.3. Allometric relations.

We compared the allometry of Guam's *Tabernaemontana* trees (Fig. 8, red data points) with the average size tree for many species (black) and record size trees of many species. The slope of the relationship between *Tabernaemontana* tree diameter and height is much less than that for all tree species in general. Therefore, Guam's *Tabernaemontana* tree is much shorter for any given trunk diameter than other trees. This is a function of the impact of trade winds on growth dynamics and periodic "pruning" by typhoons. These relations indicate *Tabernaemontana* biomechanics for withstanding typhoon force winds are improved in comparison to trees in general.

Figure 8. Log-log plot of height versus diameter at breast height of *Tabernaemontana* plants throughout Andersen Air Force Base, 2005-2006.



***Tabernaemontana*: log H versus log D slope = 0.553**
All average tree species: log H versus log D slope = 0.872

5.4. Propagation protocols.

5.4.a. Seed propagation.

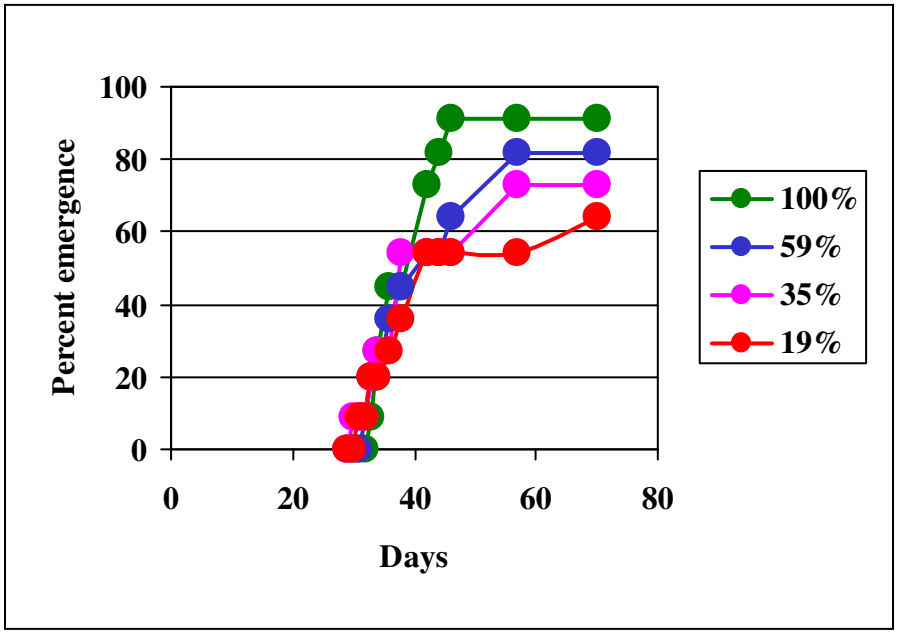
We conducted a total of 11 germination studies using seeds harvested in May 2004, October 2004, December 2004, December 2005, March 2006, and October 2006. The number of treatments in these studies ranged from 3 to 9, and in every case we used three replications of 15 seeds each. Thus, we harvested, cleaned, treated, and planted more than 2,400 seeds for these detailed studies.

The results have been very disappointing because of erratic germination that we assume is the result of erratic seed viability at harvest time. Indeed, only two of the studies resulted in

germination that could be considered acceptable for use in a conservation nursery (results below). The remaining studies resulted in germination percentages ranging from 0.5% to 3% even though each of these studies had a control treatment that did not differ from the seed treatment we used in the two successful studies. Thus, we are confident that the poor germination in the remaining studies was not a result of a change in how the seeds were handled or treated.

We used a 24 hour water soak prior to sowing in our initial studies and obtained up to 93% germination success under full sun conditions (Fig. 9). Germination began from 30-35 days after planting. Shade delayed germination and reduced germination percentage, as measured by the emergence of seedling hypocotyls.

Figure 9. The influence of shade on *Tabernaemontana* seedling emergence.



Seeds were harvested in October 2004, and planted on 26 December 2004. 100% represents full sun.

The 80% shade treatment not only delayed germination and reduced the percentage of seedlings that emerged, it also generated seedlings of inferior quality (Fig. 10). Many of the seedlings that emerged were deformed by persistent seed coat that would not allow the cotyledons to develop normally.

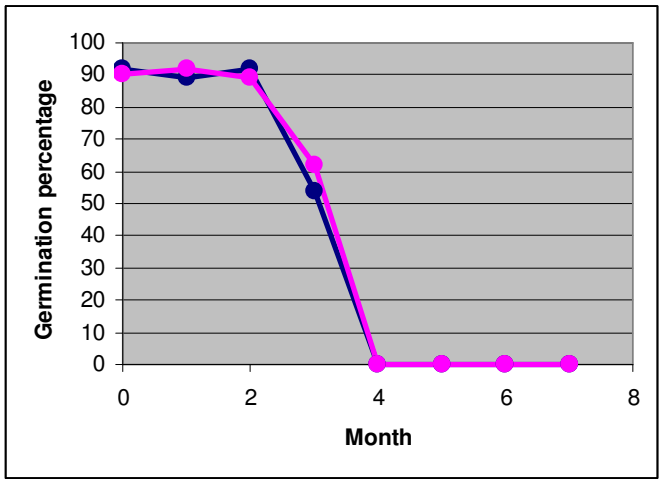
We also conducted a seed storage study to determine if storing in a humidified chamber would improve storability of the seeds. However, seeds in both air-conditioned and humidified conditions began to lose the ability to germinate by month 3 (Fig. 11). These tests do not indicate

the lack of germination that begins in month 3 is an indication of loss in seed viability. On the contrary, there may well be a physiological dormancy mechanism that develops whenever *Tabernaemontana* seeds are not sown immediately upon harvest.

Figure 10. The influence of deep shade (left) or full sun (right) conditions on *Tabernaemontana* seedling emergence and quality.

Germination percentage was poor in deep shade. Hypocotyls were stretched in deep shade. Seed coats tended to stick to cotyledons in deep shade.

Figure 11. Germination of *Tabernaemontana* seeds as a function of time since harvest.



Pink: Seeds stored in air-conditioned laboratory. Blue: Seeds stored in humidified chamber. Seeds harvested in December 2004.

The fruits that were harvested in October and December 2004 produced seeds with more than 90% germination success, yet the remainder of the fruit harvest dates between May 2004 and October 2006 produced seeds with germination success below 3%. Two general observations can be made from this series of studies. First, we still know nothing about the influence of common seed treatments on germination of healthy seeds following several months of storage. We had hoped the acid scarification, ethephon, GA, and smoke treatments would have helped promote germination, but we have not had a seed batch with acceptable viability to adequately evaluate these treatments since the harvests of 2004. This is not a horticultural question, it is a seed biology question. We believe a seed biologist should be approached to determine viability of freshly harvested seeds over a several year period in order to determine the cause of such erratic germination from one fruit harvest to another.

The second observation is developed by asking the question, what was different about the October and December 2004 harvests? These were the two seeds batches that produced excellent germination with nothing more than a 24 hour water soak prior to sowing. The answer is that both fruit harvest seasons were a direct result of the passage of typhoons 4 months prior. Typhoon Tingting affected Guam on 27-28 June 2004, and Typhoon Chaba affected Guam on 21 August 2004. Guam's *Tabernaemontana* trees responded to these storms with synchronized flowering events one month after each storm. The resulting fruits were mature in October and December 2004. Unfortunately, we have not been able to confirm this observation with any subsequent typhoons since Guam has not experienced the influence of a typhoon following Typhoon Chaba. Perhaps the copious number of *Tabernaemontana* trees that produce flowers and the copious flowering that occurs within each tree as a direct result of the passage of a typhoon leads to greater seed health and greater embryo viability. If this is the case, then conservation efforts should ensure the harvest of the mast seeding that occurs about 4 months after the passage of a typhoon on Guam.

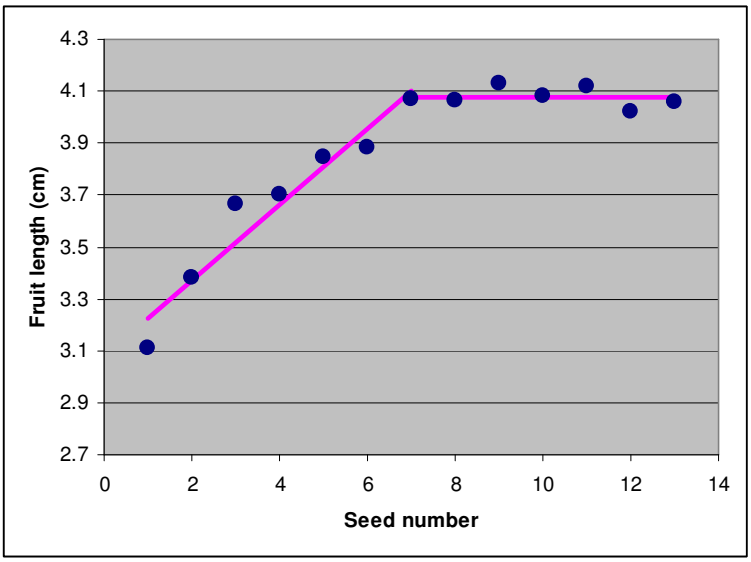
We conducted a study to determine the influence of fruit size on seed number. We included 250 fruits in this study, so are confident in the results shown in Fig. 12. The relationship followed a segmented model. Seed number increased with increased fruit length from about 3 cm to about 4 cm. At a mature fruit length of about 4 cm, seed number ranged from 7 to 13.

5.4.b. Stem cuttings.

Two studies were conducted using three age categories of stem sections within 18 inches of the stem tip. All three age categories did not respond with rooting. Use of IBA rooting hormone did not elicit rooting, nor did air-drying prior to planting the cuttings.

We did not use large, older stem sections for this portion of the work since the harvesting of larger stems would have damaged existing trees. In accordance with the Work Plan, we were ready to harvest older stem sections from toppled *Tabernaemontana* trees if a typhoon had caused major damage on Guam during the contract period. However, this was not the case. All of the typhoons that passed near Guam during the contract period were not strong enough to cause

Figure 12. The relationship between mature *Tabernaemontana* fruit length and the number of seeds per fruit.



Line equation: length = 3.08+0.146*seed; r^2 = 0.93.
This is about 1 seed for every 1.7 mm increase in fruit length.

toppling. We believe that the use of older stem sections and possibly air drying prior to planting may lead to an adequate protocol for using stem cuttings to propagate *Tabernaemontana*. However, if cuttings are needed to develop a worthy conservation plan, it would be difficult to endorse the harvesting of large stem sections from existing trees simply to increase the population. This is especially true in light of the information discussed in Section 5.4.c.

5.4.c. Transplant studies.

Methods for this portion of the contract were restricted to using typical horticultural procedures for transplanting established individuals. We transplanted 40-60 cm tall seedlings in the early part of the rainy season to find that all four native Apocynaceae species transplanted with ease. In order of success rate, we obtained 90% transplant success with *Cerbera dilitata,* 75% transplant success with *Ochrosia mariannensis*, 70% transplant success with *Neisosperma oppositifolia*, and 50% transplant success with *Tabernaemontana*.

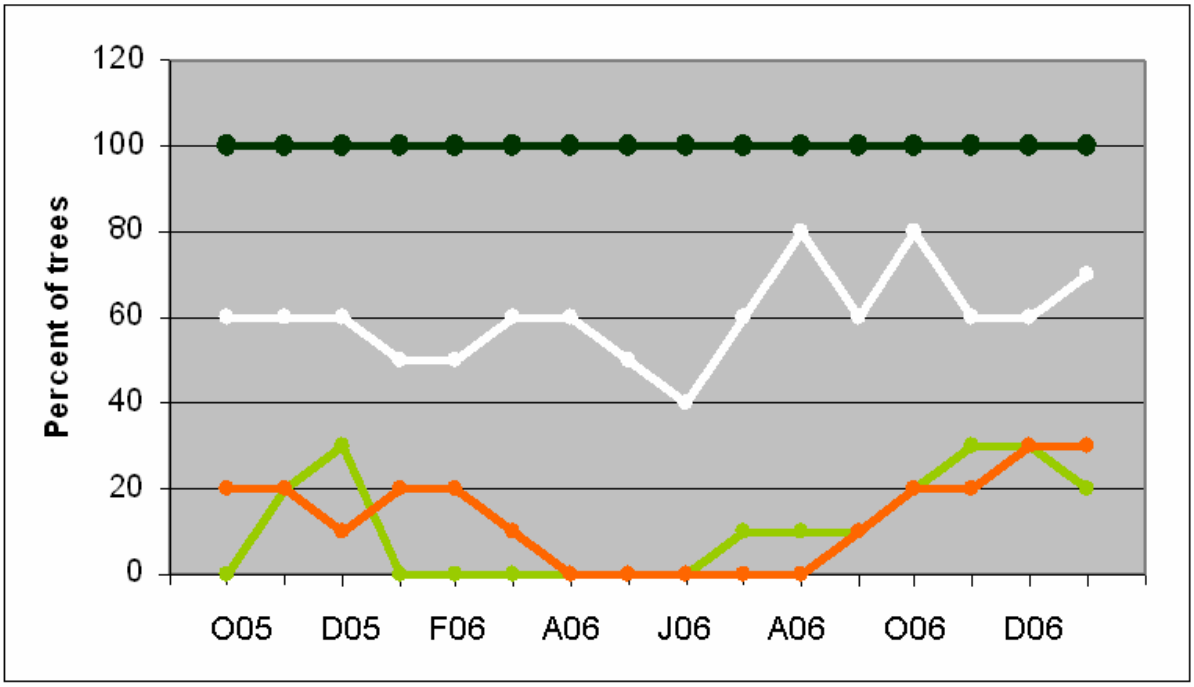
Copious seed germination and high density natural seedling establishment frequently occur within the vicinity of a mature *Tabernaemontana* tree whenever the forest canopy cover is affected by a typhoon (see Fig. 3 and accompanying text). These seedlings develop in extreme competition with each other because of the lack of seed dispersal, and many of them become stunted and some die from competition for light and/or edaphic resources. Resource managers would benefit from transplanting some of these seedlings prior to their death. This would expand

the distribution of the *Tabernaemontana* population into new habitat niches, niches that would have likely been naturally occupied by the *Tabernaemontana* population prior to the loss of seed dispersal on Guam. This approach would also thin out the crowded seedlings and possibly ensure more of them remain alive.

5.5. Phenology.

All of the *Tabernaemontana* trees that were measured to determine when vegetative growth occurred throughout the year had a portion of their canopy in active vegetative growth every month (Fig. 13). Our measurements also revealed that a surprising 40% to 80% of the trees had at least some flowering occurring every month that we measured growth. A typhoon did not pass close enough to Guam during the measurement period to be able to quantify the flowering and fruiting response. In the absence of typhoons, the population exhibited an increase in the number of trees that were flowering in August to October. The months following these months revealed the greatest percentage of trees with immature or orange fruit.

Figure 13. The percentage of *Tabernaemontana* trees exhibiting active growth throughout the year.



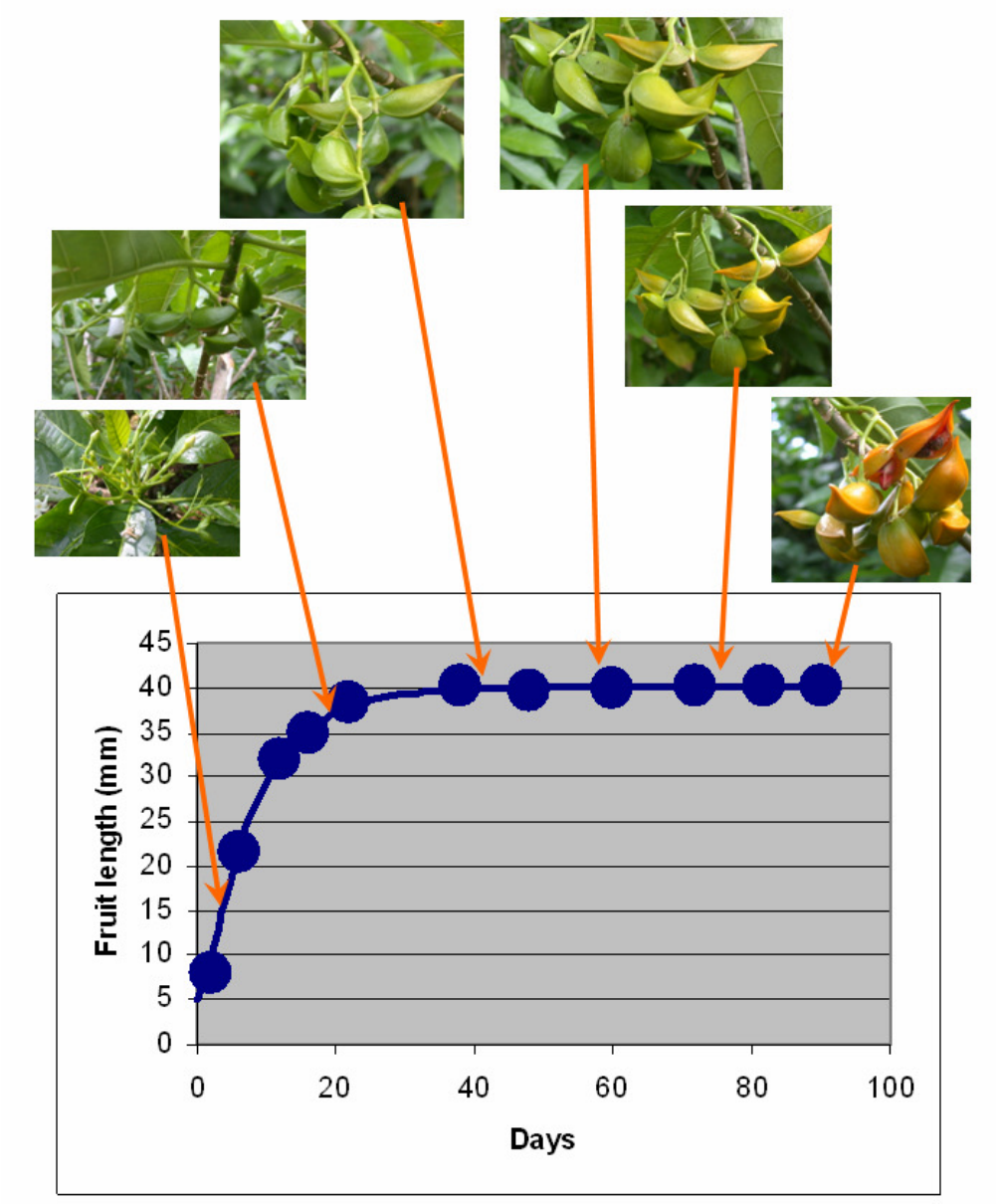
Dark green – vegetative growth **Lime green – immature fruit present**
White – active flowering **Orange – orange fruit present**

The data in Fig. 13 simply expose the number of trees that had at least one stem growing, one flower panicle active, or one green or orange fruit apparent. These data do not expose the percentage of each tree's canopy that is exhibiting the growth response. We believe the number of synchronized flowers determines the relative fruit set, and this is determined by the combination of percentage of trees in flower and the proportion of each tree's canopy that produces flowers. Many panicles produce copious numbers of flowers with no fruit set (e.g. Fig. 14). These panicles with hundreds of flowers may spread out the individual flower maturity over many weeks, which is probably why we were able to document at least some flowering on some trees during every month of the study.

Figure 14. A typical *Tabernaemontana* panicle with 100+ flowers that opened sequentially over a several week period. None of these flowers produced fruit, indicating poor pollination success.

The pattern of fruit size development followed an exponential function with an initial period of rapid linear extension rate, a slowing of extension, then a long period with no more measurable increase in size (Fig. 15). The ovary remains united until it reaches a length of about 8 mm. At this stage, the entire corolla tube falls off intact revealing one prominent style and stigma. The ovary splits into two distinct halves immediately following this event. The two halves spread farther apart as the days progress until they are oriented directly opposite each other on the pedicel by the time full fruit size is reached. This occurs in 30-35 days following flowering. Fruit color changes from bright green to dull green in the subsequent month, and a dull orange color break occurs in 50-60 days after flowering. Color development progresses during the final month of fruit growth until a bright orange phenotype characterizes the fruits as the split open about 90 days after flowering.

Figure 15. Ontogeny of fruit growth between the flower period and fruit maturity, as defined by splitting fruit.



Fruit length increased rapidly from the time of flowering until about day 30. Thereafter fruit size remained the same. The timing for color break from green to slightly orange ranged from 50-60 days following flowering. The time for fruit splitting ranged from 87-90 days following flowering.
Equation: Length = 40.1265 * (1-e $^{-0.1308*day}$); r^2 = 0.85.

5.6. Miscellaneous herbivore observations.

Unidentified mealy bug infestation on *Tabernaemontana* stem.

Hemispherical scale insect being tended by *Paratrechina longicornis* ants on lower surface of *Tabernaemontana* leaf.

Hemispherical scale insect on *Tabernaemontana* fruit.

Satsuma mercatorius **snail consumes the red pulp from** ***Tabernaemontana*** **seeds after fruits split open.**

A second unidentified species of armored scale infesting a ***Tabernaemontana*** **seedling.**

A third unidentified species of scale insect that favors the bottom of leaves.

5.7. Other survey observations.

The two years of reconnaissance allowed us to identify the location of other rare species. For example, *Heritiera longipetiolata* is currently red-listed as endangered by the IUCN (http://www.iucnredlist.org/search/details.php/32002/all). The areas around Pati Point and the south-east edge of Andersen AFB are two habitats that have many *Heritiera* trees (see Appendix 7.4). We also recorded any habitat characteristic that was unique to a location, such as a rare plant assemblage, unusual terrain, or signs of past unusual human activity (see Appendix 7.5).

5.8. Past and future threats.

5.8.a. Past threats leading to modern rarity.

The two years of observations in *Tabernaemontana* habitats indicate the list of past threats to the Guam population result from human activity.

5.8.a.1. Dispersal. Seedlings and juveniles are found beneath almost every mature *Tabernaemontana* plant on AAFB, indicating mature trees are admirably fulfilling their role in reproduction of the species through adequate seed production. Moreover, small seedlings or juveniles that are isolated from a mature *Tabernaemontana* are not a component of Guam's northern forests. These two characteristics of the northern Guam population indicate that seed production is likely adequate, but limited seed dispersal is an acute threat to the population health.

The recent loss of frugivore bird species on Guam has likely caused the decline or cessation of *Tabernaemontana* seed dispersal. In addition to the population patterns described above, we made one field observation that supports this contention. One of the only young *Tabernaemontana* seedlings (about 50 cm tall) that we found in the absence of a mature *Tabernaemontana* tree was at Anao Point. This plant was growing on a rock outcrop beneath the drip line of a mid-story *Barringtonia asiatica*. The location of this seedling beneath a typical bird perch and the absence of a nearby *Tabernaemontana* parent supports the suggestion that a bird was the vector responsible for seed dispersal.

5.8.a.2. Habitat loss and fragmentation. Clearing of forests to convert the land to non-forest use has also been a historical threat that has led to contemporary rarity of *Tabernaemontana*. These human activities reduce the absolute amount of forest area, but they also increases isolation and fragmentation of remaining forested areas. This activity is perhaps the greatest looming threat to the existing *Tabernaemontana* population.

Our habitat observations also support the contention that forested areas dominated by invasive alien tree species, such as the *Vitex* forests along the fence near Pott's Junction, do not support *Tabernaemontana* (see Section 5.2. for further discussion). Thus, the threat of habitat loss is not restricted to outright conversion to non-forest uses, but it also includes highly disturbed forested areas where exotic tree species dominate.

5.8.a.3. Forest emergent canopy dynamics. Loss of habitat, forest fragmentation, and loss of recruitment have been presented as probable causes for the decline in population census and health of Guam's emergent forest species. *Elaeocarpus joga* and *Artocarpus mariannensis* are two examples of species that comprised a large portion of the emergent canopy in historical limestone forests. We believe the drastic reduction in the population of these large emergent individuals without a replacement of an equally tall species has changed the nature of light dynamics in the sub-canopy and forest floor.

The discussion in Section 5.2 indicates ephemeral leaf loss of the forest canopy following typhoons is instrumental in causing a pulse of *Tabernaemontana* seedling emergence. Moreover, the gradual canopy closure during forest recovery after each typhoon is beneficial for *Tabernaemontana* seedling growth. Indeed, in our studies 80% shade elicited more growth in *Tabernaemontana* seedlings than did full sun conditions. Thus, the drastic changes in forest canopy dynamics over recent decades because of chronic and ongoing loss of individuals from native emergent canopy species may be removing the types of light conditions that *Tabernaemontana* seedlings need for successful recruitment.

5.8.a.4. Alien arthropods. We documented several arthropods feeding on *Tabernaemontana* stems, leaves, and fruits. However, we do not consider any of these herbivores to be a serious threat at this time. Thus, we are not capable of speculating if an alien arthropod was instrumental in the historic reduction in *Tabernaemontana* population on Guam.

5.8.a.5. Feral ungulates. Feral ungulate damage was also documented on *Tabernaemontana* plants, but not to the level of comprising a major threat. The primary ungulate damage is a result of feral pigs rooting beneath the cool shade of a *Tabernaemontana* grove. We have seen some deer browse of young seedlings and damage to the soft new bark of young seedlings (1.0-2.0m height class) presumably from rubbing of antlers. However, most of the damaged seedlings recover from these isolated events. Thus, we do not believe feral ungulates have been a major historical component in what has caused the rarity of *Tabernaemontana* on Guam.

5.8.a.6. Invasive vine species. Invasive vines and other herbaceous and woody invasive weeds may limit growth of isolated *Tabernaemontana* individuals. Due to the high stem density of most current *Tabernaemontana* groves, we believe these invasive alien plant species pose less of a threat to *Tabernaemontana* than to other rare native tree species. The competitive nature of the mono-specific group of plants is not the kind of environment that is conducive to vine growth. It is difficult to speculate retrospectively, but we do not believe that invasive plant competition has been a major component in the historic decline of the *Tabernaemontana* population.

5.8.a.7. Soil disturbance. This plant seems to grow well in previously disturbed soils, such as along road construction areas. Many of the groves that we located were situated with obvious signs of past land clearing and disturbance. Moreover, mechanical injuries to *Tabernaemontana* stems in urban landscape settings do not appear to damage the plants or impair continued growth. These observations lead us to believe that short-term soil disturbance does not impair growth of this plant or restrict recruitment in the disturbed areas. However, permanent conversion of forested areas obviously inhibits access of *Tabernaemontana* to those areas for recruitment.

5.8.a.8. Typhoon damage. While individual *Tabernaemontana* trees may be damaged by the passage of a typhoon, we do not believe the population is hurt in any appreciable manner. On the contrary, the typhoon conditions cause *Tabernaemontana* to develop a synchronized pulse of flowering about one month after the typhoon. This pulse of flowering leads to a mast seeding event about four months after the typhoon.

Native tree species utilize various approaches to tolerating the impact of typhoons. *Tabernaemontana* trees use the approach that is evident in *Artocarpus mariannensis*. The

medium sized limbs of these and other species break during typhoon winds. This reduces the stature and the wind drag of the canopy, and the result is minimal toppling of the trees. *Tabernaemontana* trees regrow quickly following this form of damage. Almost every one of the oldest trees within each of our 265 sites show signs of upper stem breakage.

Even toppling of the progenitor tree within each grove does not seem to hurt the population appreciably. In a typical grove, one single tree could be identified as the oldest. The sites that were an exception to this generality were sites with several large trees of similar stature. In these sites where several trees took over as the largest within the grove, we could find the toppled original progenitor deep within the grove.

5.8.b. Current threats.

From the list of potential threats, we believe only two are of major concern in the immediate future. First, continued conversion of forest land to non-forest use is the greatest ongoing threat. Second, lack of seed dispersal is limiting recruitment in new habitats. All of the seedlings that emerge and grow are in close proximity to the parent plants.

The combination of these two threats is worse than each individual threat taken alone. To explain, when a habitat containing one *Tabernaemontana* tree is converted into non-forest use, the number of lost individuals cannot typically be limited that one individual. The average number of con-specific individuals in close proximity to each mature tree found in the survey is greater than 80. Thus, the conversion of a forested area containing one mature *Tabernaemontan*a tree would effectively eliminate 80+ individuals, on average, from the current population.

The decline in forest health due to habitat loss of other critical species should also be acknowledged. For example, one of the most common co-occurring species we found at each *Tabernaemontana* site was *Cycas micronesica*. This species is currently red-listed as endangered by the IUCN (Marler et al., 2006), thus every attempt to preserve *Tabernaemontana* habitat will inadvertently preserve *Cycas micronesica* habitat. The benefits of appropriate *Tabernaemontana* conservation decisions are therefore magnified.

5.8.c. Past and future threats.

In the absence of a newly introduced invasive species at some point in the future, the two current threats will likely remain the major *Tabernaemontana* threats for the foreseeable future. However, the sheer number of accidental introductions of invasive arthropod species into Guam demands respect for the fact that any new introduction may wreak havoc on a native plant species.

For example, we must keep the spotlight on one recent introduction, the Oleander Hawk Moth (*Daphnis nerii*). The primary plant host of this larvae is *Nerium oleander*, a common ornamental species on Andersen AFB and a member of the Apocynaceae family. We have conducted feeding trials in the laboratory to confirm these moth larvae will consume leaves of Guam's native Apocynaceae species, including *Tabernaemontana*. While this does not confirm that the

Oleander Hawk Moth will begin infesting *Tabernaemontana* plants in habitat, it does expose that possibility as this recently introduced alien pest becomes established on Guam.

Oleander Hawk Moth

6. References

Donnegan, J.A.; Butler, S.L.; Grabowiecki, W.; Hiserote, B.; Limtiaco, D. 2004. Guam's forest resources, 2002. Resour. Bull. PNW-RB-243. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 32 p.

Fish and Wildlife Service. 2000. Proposed endangered status for three plants from the Mariana Islands and Guam. Federal Register 65(106):35025-35033.

Fish and Wildlife Service. 2004. Determination of endangered status and prudency determination for designation of critical habitat for two plant species from the Commonwealth of the Northern Mariana Islands. Federal Register 69(68):18499-18507.

Marler, T., J. Haynes & A. Lindström. 2006. *Cycas micronesica*. In: IUCN 2006. *2006 IUCN Red List of Threatened Species.* www.iucnredlist.org.

Raulerson, L. Rinehart, A.F. 1992. Trees and Shrubs of the Northern Mariana Islands. American Printing Corp, Guam, US.

Young, Fred. Soil Survey: Territory of Guam. 1988. USDA, Soil Conservation Service (NRCS).

7. Appendices

Appendix 7.1. Locality information and census for each of 265 locations of *Tabernaemontana* trees on Andersen AFB.

ID SEQ	UTM East	UTM North	Count (-1.5m)	Count (+1.5m)	Count Total
1001	273061.30	1504437.93	165	80	245
1002	273103.58	1504395.68	10	15	25
1003	273518.44	1504482.45	65	15	80
1004	273530.83	1504486.55		1	1
1005	272404.00	1503475.00		1	1
1006	272424.00	1503463.00		1	1
1007	272581.25	1503716.00		1	1
1008	272579.66	1503712.00	157	5	162
1009	272154.00	1503594.00	170	50	220
1010	272126.00	1503523.00	20	36	56
1011	272147.00	1503392.00	60	65	125
1012	272148.00	1503361.00		1	1
1013	272086.00	1503250.00		1	1
1014	272317.00	1504039.00	30	35	65
1015	272312.00	1504045.00		1	1
1016	272296.00	1504078.00	100	25	125
1017	272311.00	1504087.00	100	150	250
1018	272284.00	1504083.00		1	1
1019	272288.00	1504087.00		1	1
1020	268376.00	1509652.00	350	150	500
1021	268513.00	1509748.00	75	150	225
1022	268509.00	1509730.00	40	35	75
1023	268518.00	1509797.00		1	1
1024	268557.00	1509847.00	165	25	190
1025	268677.28	1509888.95	1		1
1026	271744.00	1506089.00	160	60	220

1027	271980.82	1506644.14	1		1
1028	276564.47	1499573.32	325	175	500
1029	276574.77	1499564.23		1	1
1030	276660.54	1499550.05		1	1
1031	276473.37	1499558.98		1	1
1032	276590.43	1499534.69		1	1
1033	276593.95	1499540.05		1	1
1034	276595.00	1499542.78		1	1
1035	276609.07	1499554.81		1	1
1036	276643.77	1499577.65		1	1
1037	276841.99	1499539.94	1		1
1038	276686.87	1499360.30		1	1
1039	276640.75	1500417.63	0	1	1
1040	276539.98	1500389.11	0	7	7
1041	276536.53	1500385.35	0	1	1
1042	276551.46	1499658.28	375	125	500
1043	276531.38	1499685.24	90	10	100
1044	276513.95	1499702.07	75	25	100
1045	276526.03	1499752.22	45	25	70
1046	276524.27	1499753.76	45	35	80
1047	276546.49	1499758.86	225	125	350
1048	276584.28	1499767.01		2	2
1049	276583.53	1499760.92	20	2	22
1050	276610.87	1499786.96	1		1
1051	276609.23	1499811.35	65	25	90
1052	276492.86	1499573.68	1		
1053	274261.00	1503134.00		1	1
1054	274245.00	1503159.00	221	150	371
1055	274243.00	1503171.00		1	1
1056	274270.00	1503571.00		1	1
1057	274351.00	1503509.00	4	1	5

1058	268237.00	1509430.00	12	8	20
1059	268237.00	1509430.00	6	4	10
1060	268207.00	1509418.00	190	110	300
1061	276430.00	1499601.00		1	1
1062	276435.00	1499653.00		1	1
1063	276433.00	1499655.00	24	1	25
1064	276440.00	1499635.00	3	1	4
1065	276435.19	1499654.81	3	1	4
1066	276502.11	1499568.42		1	1
1067	276508.03	1499567.62		1	1
1068	276502.25	1496502.25		1	1
1069	276508.03	1499562.53		1	1
1070	276524.27	1499753.76		1	1
1071	276538.44	1499616.86	225	75	300
1072	276538.44	1499627.42		1	1
1073	276591.84	1499598.57	175	50	225
1074	276601.68	1499587.05	5	5	10
1075	276600.03	1499574.22		1	1
1076	276587.86	1499561.01		1	1
1077	276543.78	1499612.40		1	1
1078	276647.52	1499852.26		1	1
1079	276658.96	1499854.40	18	7	25
1080	276672.85	1499975.12			
1081	276659.38	1499856.36	175	50	225
1082	276648.43	1499867.76	75	175	250
1083	276655.13	1499912.19	4	1	5
1084	276654.31	1499977.29	35	65	100
1085	276511.40	1500087.52		1	1
1086	276532.21	1499614.33		1	1
1087	276484.50	1499613.04		1	1
1088	276448.92	1499688.72		1	1

1089	272046.83	1503466.70	100	50	150
1090	276493.19	1499780.99		1	1
1091	276489.51	1499802.01	100	75	175
1092	276472.99	1499816.39		1	1
1093	276472.46	1499820.16	85	95	180
1094	276447.57	1499783.29		1	1
1095	276459.54	1499812.41	185	65	250
1096	276478.18	1499841.52	150	50	200
1097	276485.30	1499837.27		1	1
1098	276492.16	1499838.99		25	25
1099	276512.86	1499837.31	25	1	26
1100	276580.31	1499826.62	1		1
1101	276696.27	1499850.92	10		10
1102	276698.48	1499860.84	10		10
1103	276697.89	1499901.71	1	10	11
1104	276691.21	1499922.53	8	2	10
1105	276760.26	1499910.49	1	11	12
1106	276772.37	1499961.96		1	1
1107	276747.58	1500037.43	35	15	50
1108	276752.67	1500049.63	15	10	25
1109	271926.19	1503319.93		1	1
1110	271926.14	1503314.08		1	1
1111	271936.58	1503352.13	25	150	175
1112	271981.44	1503370.09	50	25	75
1113	271978.83	1503421.75	75	25	100
1114	271911.56	1503604.97	250	125	375
1115	271909.85	1503605.59	225	275	500
1116	271935.42	1503608.39	325	125	450
1117	271899.78	1503650.21		1	1
1118	271900.72	1503646.81		1	1
1119	271901.56	1503648.01		1	1

1120	271890.22	1503646.68	450	300	750
1121	271898.12	1503668.87	150	200	350
1122	272048.99	1503469.33	225	25	250
1123	272061.37	1503462.41	350	150	500
1124	272050.84	1503445.77	225	25	250
1125	272041.28	1503426.78	125	75	200
1126	272022.38	1502269.55	225	125	350
1127	271971.96	1503331.18	35	15	50
1128	271960.10	1503292.58	105	45	150
1129	273012.67	1503782.20	160	65	225
1130	273056.16	1503778.27	58	8	66
1131	273634.44	1503661.25	200	65	265
1132	273170.99	1503746.91		1	1
1133	273508.30	1503941.15	150	100	250
1134	273102.00	1503696.00		1	1
1135	273002.00	1503766.00	263	275	538
1136	274067.84	1503686.27		1	1
1137	276497.90	1499803.57		1	1
1138	271968.97	1502462.68		1	1
1139	272324.25	1502437.62		1	1
1140	272143.62	1503161.89	65	15	80
1141	272072.99	1503225.45		1	1
1142	271995.94	1503228.58		1	1
1143	272006.29	1503254.61		1	1
1144	276583.93	1499310.03		1	1
1145	276651.00	1499139.00	100	75	175
1146	276649.48	1499059.66	100	25	125
1147	276748.23	1499628.39	1		1
1148	276673.85	1499181.33	75	10	85
1149	276504.15	1499087.24	8	2	10
1150	276514.55	1499055.92	4	1	5

1151	276520.01	1498986.32	200	51	251
1152	276530.98	1498921.40	1		1
1153	276565.04	1498961.48		1	1
1154	276598.73	1499010.44	3	1	4
1155	276540.71	1499030.14	1		1
1156	276542.02	1499071.74		1	1
1157	276532.63	1499095.90		1	1
1158	276501.93	1499156.25	5	1	6
1159	276634.10	1499316.78	75	20	95
1160	276527.93	1499052.35		1	1
1161	276541.48	1499119.68		1	1
1162	276503.77	1499200.10		1	1
1163	269100.00	1509278.00	325	125	450
1164	269085.00	1508545.00	10	5	15
1165	267113.60	1505470.00	1	1	2
1166	266227.00	1504551.00	75	3	78
1167	266223.00	1504554.00		1	1
1168	274877.00	1503059.00	200	3	203
1169	274893.00	1503878.00		1	1
1170	274866.00	1503722.00	225	125	350
1171	275145.00	1503802.00	28	7	35
1172	274801.00	1503830.00	110	16	126
1173	274762.00	1503848.00	50	350	400
1174	274990.00	1503821.00		1	1
1175	268340.00	1509530.00	7	4	11
1176	268340.00	1509550.00		1	1
1177	268369.00	1509658.00	375	225	600
1178	276402.00	1499800.00		1	1
1179	276402.00	1499180.00	1	1	2
1180	276534.00	1499690.00	225	175	400
1181	276168.35	1503236.16	315	28	343

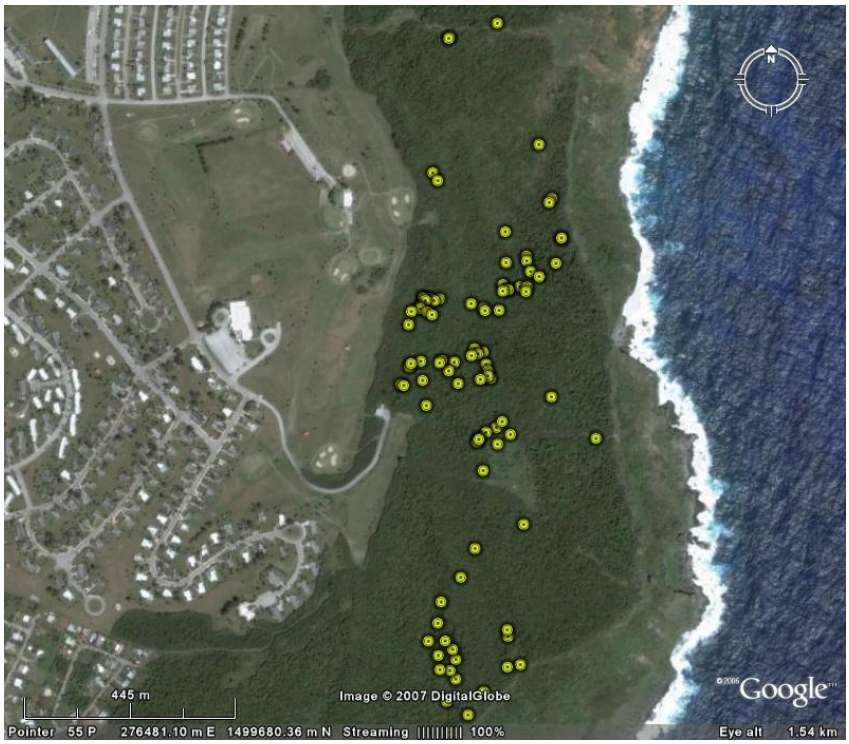
1182	272136.66	1503232.05	315	93	408
1183	272135.16	1503225.81	205	7	212
1184	272536.22	1503332.51	15	4	19
1185	272578.10	1503322.64		1	1
1186	271324.53	1503590.16		1	1
1187	271815.11	1503564.26	120	47	167
1188	271866.23	1503446.51		1	1
1189	272557.63	1504060.13	15	100	115
1190	272584.67	1504059.84		1	1
1191	272532.33	1505153.68	165	125	290
1192	272516.23	1505142.11		1	1
1193	272547.04	1503921.57		1	1
1194	272446.72	1505185.52		1	1
1195	272442.84	1505192.99		1	1
1196	272456.24	1505205.21	25	3	28
1197	272448.76	1505076.54	375	125	500
1198	272456.09	1505226.14		4	4
1199	272358.45	1505249.95		1	1
1200	272520.06	1505223.70		1	1
1201	272518.36	1505231.84	340	110	450
1202	272529.37	1505572.42		1	1
1203	272496.27	1505222.57	20	80	100
1204	272490.67	1505035.75	175	245	420
1205	272557.85	1505135.83	20	9	29
1206	272548.23	1505209.35	25	12	37
1207	272704.65	1505456.27		1	1
1208	272515.17	1505030.88		1	1
1209	272508.41	1505017.26	20	60	80
1210	272496.62	1505025.37		1	1
1211	272483.25	1505015.38		1	1
1212	272526.45	1505207.16	95	10	105

1213	272582.17	1505020.47	700	150	850
1214	272548.99	1505041.97		1	1
1215	272543.23	1505056.31		1	1
1216	272550.61	1505056.26		1	1
1217	276184.00	1503955.00		1	1
1218	276916.00	1503952.00	4	1	5
1219	276915.00	1504122.00		1	1
1220	276955.00	1504105.00		1	1
1221	276913.00	1503961.00	2	2	4
1222	277064.00	1503952.00	20	5	25
1223	272484.83	1505027.96		1	1
1224	272005.00	1503248.00		1	1
1225	274873.00	1503858.00		1	1
1226	274896.00	1503879.00		1	1
1227	275080.00	1503835.00		1	1
1228	275133.00	1503792.00	35	15	50
1229	273445.00	1503460.00		1	1
1230	271988.00	1502488.00		1	1
1231	277109.00	1503982.00		1	1
1232	275754.00	1504329.00	75	15	90
1233	277112.00	1503982.00		1	1
1234	277112.00	1503982.00		1	1
1235	277123.00	1503962.00		1	1
1236	277119.00	1503963.00		1	1
1237	277120.00	1503963.00		1	1
1238	277120.00	1503964.00		1	1
1239	277155.00	1503963.00		1	1
1240	277156.00	1503957.00	1	1	2
1241	277152.00	1503957.00		1	1
1242	277149.00	1503956.00		1	1
1243	277148.00	1503954.00		1	1

1244	277140.00	1503967.00		1	1
1245	277161.00	1503962.00		1	1
1246	277339.00	1503950.00		1	1
1247	274261.00	1503134.00		1	1
1248	272826.64	1504059.59	40	2	42
1249	274913.00	1504001.00		1	1
1250	273077.00	1503752.00	140	85	225
1251	276660.54	1499550.05		1	1
1252	276777.89	1500348.94	10	1	11
1253	271909.85	1503605.59		1	1
1254	271939.75	1503665.65		1	1
1255	271949.54	1503692.56		1	1
1256	271969.34	1503755.34		1	1
1257	271959.67	1503795.21		1	1
1258	271989.35	1503801.09		1	1
1259	271909.05	1503903.04		1	1
1260	271936.45	1503514.96		1	1
1261	276650.92	1499123.66	25	15	40
1262	276677.31	1499064.31	60	7	67
1263	272549.64	1504075.66		1	1
1264	272546.23	1504063.46		1	1
1265	267130.00	1505477.00	40	2	42
		Total	**14,176**	**7,493**	**21,669**

Appendix 7.2. Additional images depicting *Tabernaemontana* locations.

Pati Point Area



South-east edge of Andersen AFB

Ritidian Point Area

Central Area of Andersen AFB

Appendix 7.3. Alphabetical list of the main co-occurring species throughout the 265 sites within Andersen AFB containing *Tabernaemontana* trees.

Aglaia	mariannensis
Annona	reticulata
Barringtonia	asiatica
Bikkia	tetranda
Carica	papaya
Cestrum	diurnum
Chromolaena	odorata
Cocos	nucifera
Cycas	micronesica
Cynometra	ramiflora
Elaeocarpus	joga
Erythrina	variegata
Eugenia	reinwardtiana
Eugenia	thompsonii
Ficus	tinctoria
Ficus	prolixa
Guamia	mariannae
Guettarda	speciosa
Hibiscus	tiliaceus
Intsia	bijuga
Ixora	triantha
Leucaena	leucocephala
Mammea	odorata
Macaranga	thompsonii
Maesa	sp.
Mikania	micrantha
Morinda	citrifolia
Neisosperma	oppositifolia
Ochrosia	mariannensis
Pandanus	tectorius
Pipturus	argenteus
Piper	guahamense
Premna	obtusifolia
Psychotria	hombroniana
Procris	pedunculata
Pteris	tripartite
Stachytarpheta	jamaicensis
Triphasia	trifolia
Vitex	parviflora

Appendix 7.4. Additional images depicting other species identified in the survey.

South-east edge of AAFB

Red squares Heritiera longipetiolata

White stars Barringtonia asiatica

Pati Point Area

Heritiera longipetiolata locations

Tree location of other rare species. This is not a comprehensive listing of locations.

White Circle *Elaeocarpus joga*
Green Tree *Artocarpus mariannensis* breadfruit
White square *Cordia* forest
White sideways square *Erythrina variegata*
Red square *Heritiera longipetiolata*
White Star *Barringtonia asiatica*

Appendix 7.5. Various observations by locality.

A
Dense primary limestone forest along cliff line, complex karst karren topography with low flat "valleys"; Forest contains large over story canopy including Heritiera, Barringtonia, Erythrina, Ifit

B
Dense primary limestone forest throughout, complex karst karren topography, steep folds of rock. Very difficult terrain; hand held GPS does not function consistently

C
Lighthouse or WWII era structure; old hand cut trail to cliff line; see David Lotz report 1/2007

D
Major cultural site; pot shards and grinding stones, sling stones, various cave formations; see David Lotz report 1/2007

E
Extensive pottery scatter; see David Lotz report 1/2007

F
Too remote for safe access from cliff line or from gun range along beach; found no cliff side access this stretch apart from trail at Pati Point; don't anticipate many *Tabernaemontana* this habitat.

G
Extensive fago forest; sheltered in lee of cliff, trees tall, straight, little wind deformation of canopies; major cultural sites scattered throughout; many *Annona reticulata* trees scattered throughout this forest area.

H
Eight spot butterfly observed this location; very complex topography, cockpit karst deep, many fissures; extensive area with well established populations of *Procris pedunculata* scattered all along cliff line and in deep karst habitat; no browse from deer.

I
very complex topography, cockpit karst deep, many fissures; extensive area with well established populations of *Procris pedunculata* scattered all along cliff line and in deep karst habitat; no browse from deer; dangerous terrain.

J
Much evidence of prior disturbance clearing/roads extending in some locations to cliff line; degraded secondary forest with pockets of intact secondary forest and complex topography approaching cliff line.

K
Extensive *Cordia* forest below cliff line; many large specimens; multiple access points from basin to cliff line along this 1000 meters either side this point; extensive coconut plantation.

L
Pottery shards and scatters, isolated pockets of black soils; lots of deer and pig browse.

M
Old motor/engine with superstructure, 55 gallon drums and other 1960s era materials; old water line?; road from Scout Beach to this point still open in most sections for easy walking on even grade.

N
Major Trash site; signs of previous mapping completed, dangerous and very steep drop off below cliff line on east side of debris shoot, very loose; mix of military trash; some post 1970s trash; access to top of cliff possible.

O
Pottery shards and scatters, isolated pockets of black soils; lots of deer and pig browse.

P
Pottery shards and scatters, isolated pockets of black soils; lots of deer and pig browse.

Q
Annona reticulata scattered throughout forest; intact secondary/primary limestone forest throughout, complex topography with mix of exposed sites showing strong signs of wind damage and sheltered sites with large canopy trees and little canopy damage; lots of deer and pig sign; Japanese beer bottles.

R
Vitex dominated secondary/scrub; meander searches yielded no TARO locations; lots of deer and pig browse sign, few *Cycas.*

S
Vitex dominated forest; observations from perimeter road and short meander searches yielded no TARO locations.

T
Degraded secondary scrub; signs of prior military use, old cement pads, old road, bottle caches, etc.; Many large and a few intermediate *Elaeocarpus* trees in this area; many *Cycas* (area known historically as “Sabanon Fadang" Geology Map, Guam; mix of yigo soils, rock outcrop and guam soils.

U
Many old drums, asphalt patch?, extensive area; no TARO locations; lots of deer and pig browse.

V
Four major access trails (old roads) leading to cliff from this IRP site; birds heard in this forest; not seen.

W
Pocket of large canopy *Heritiera* along road; not all of them were mapped; observed pair of starlings in canopy of *Heritiera*; documented in report to J. Wald, February 2006.

X
Degraded scrub forest; transitions to open secondary limestone forest first at intermediate cliff line; much deer and pig browse/sign throughout the entire area; hunting stands in 3-4 locations; old roads and water lines present; bottle caches and other trash scattered throughout; much evidence of ifit harvest with flush cut stumps throughout.

Y
degraded scrub forest; dense thickets of *Hibiscus*; reduced indication of browse and trails in this area.

Z
degraded scrub forest; lots of evidence of past clearing in this area; soils appear to have been scraped or removed over large area.

1
Interesting disparity in forest physiognomy between top and bottom of an ancient reef face. Top is weather-beaten, bottom is lush. Many *Artocarpus* in this forest below; deep soils, *Vitex* dominated scrub, lots of deer and pig sign this area.

Appendix 7.6. Statement of Work.

STATEMENT OF WORK

SURVEY OF *TABERNAEMONTANA ROTENSIS*

ON

ANDERSEN AIR FORCE BASE

March 2004

1.0 GENERAL INFORMATION

1.1 Introduction

The purpose of this Statement of Work (SOW) is to survey, in a timely manner, the population and distribution of *Tabernaemontana rotensis* on Andersen Air Force Base.

1.2. Background

Tabernaemontana rotensis has been proposed for listing under the Endangered Species Act since June 2000 (65 FR 35025). *Tabernaemontana rotensis* occurs on the islands of Rota and Guam. It occurs on Andersen Air Force Base, Ritidian, and private lands on Guam, and on private lands on Rota. According to the proposed listing citation, the species and its habitat have been affected by one or more of the following: habitat degradation or destruction by feral deer and pigs; competition for space, light, water, and nutrients with introduced vegetation; road construction and maintenance activities; recreational activities; natural disasters or random environmental events; fire; vandalism; development of agricultural homesteads; resorts and golf courses; limited reproductive vigor; and potential insect, mouse, or rat predation. No systematic survey has been conducted to determine the population and distribution of *Tabernaemontana rotensis*. No formal studies have been conducted to increase the understanding of appropriate conservation measures for this species.

Federal Regulations

- Endangered Species Act (16 U.S.C. 1531 et seq.)
- Fish and Wildlife Coordination Act (16 U.S.C. 661 et seq.)
- Endangered and Threatened Wildlife and Plants (50 CFR 17.11-17.12 et seq)

Department of Defense Regulations and Guidelines

- Conservation & Management of Natural Resources, 36 ABWI 32-7003

Applicable State and Local Regulations

- Fish, Game, Forestry and Conservation (5 Guam Code Annotated, Chapter 63)

2.0 SCOPE OF WORK

Under provisions of this SOW, the contractor shall accomplish the tasks described below for Andersen AFB.

2.1 Survey Andersen Air Force Base for *Tabernaemontana rotensis*

This objective will be met in three phases. The first phase will begin by documenting the location of every known individual throughout the Base. Aerial photographs will be used to map habitats and *Tabernaemontana rotensis* individuals. Information will be gathered to describe the edaphic conditions and the surface geology of each habitat. Reconnaissance searches will be conducted in the immediate proximity of every individual within the limitations imposed by surface geology.

The second phase involves the use of "meander" searches as defined by the aerial maps. These searches will define the boundaries and general biotic patterns of specific habitats that will become individual search units. The search unit boundaries will probably be defined by road and other past construction activity and the top or bottom of the cliffline that surrounds the perimeter of the Base.

The third phase involves patterned searches of each search unit. These will be based on parallel transects throughout a search unit. Plant locations will be documented with GPS readings.

2.2 Characterize the micro-habitat of every Tabernaemontana rotensis located

Document the general edaphic and topographic characteristics, proximity to co-occurring specimens, species of co-occurring specimens at the subcanopy and canopy levels, quantity and quality of shade, and exposure to trade winds.

2.3 Determine allometric relations of each individual to develop a demographic survey

General size measurements will be made on every known individual at the beginning of the project. As new individuals are found and positioned, the same measurements will be made at the time of discovery. The entire population will be re-measured at the end of the project to obtain preliminary information on growth rates.

2.4 Determine propagation protocols within restrictions of seed availability

SEEDS. These methods will be limited by the availability of seeds, and the approval of a permit for collection of seeds if *T. rotensis* becomes listed during the project. The variables that will be studied will focus on planting depth and shade characteristics if seed quantity is limited. A storage variable will be added if enough seeds are available. These germination methods are straight-forward and will determine primary nursery protocols for propagation of this species.

CUTTINGS. Propagation trials will be conducted on leafy stem cuttings. If the species becomes listed during the project, this research will be dependent on approval of any appropriate permits for collection of vegetative material. An intermittent mist system will be constructed for these experiments. The two variables will be root-promoting hormone

applications and shade levels. Two formulations (powder and liquid) and various concentrations of indole-butyric acid and naphthalene acetic acid will be used. Both of these auxins are standard products used in the horticultural industry.

TRANSPLANTATION. The experiments for this phase of the study will be designed to try speed up active growth following transplanting.

2.5 Determine phenological patterns of the known population

Every known individual will be visited on a bi-monthly basis to observe any vegetative or reproductive growth patterns. Additionally, stems will be located and tagged, and stem extension will be measured during each visit.

2.6 Determine which of the proposed threats were most important in increasing the rarity of this species, and which are likely to be most important in the future

General analysis of the results and anecdotal observations obtained from meeting the other objectives. Proposed mitigation efforts will be offered within the context of what can be learned in such a short timeline.

2.7 Written Report

Prepare a written report presenting the results of the project. See below for topics, format, etc.

3.0 DELIVERABLES

3.1 Work Plan

The contractor shall develop a Work Plan that specially states the methodological approaches to the scope of work. The plan should link known information, goals, methods and regulatory guidance to required work. Also, included within the Work Plan should be a schedule/timeline of expected completion dates, work, activities, etc. for the completion of this Statement of Work. Since the document is to be developed early within the contract, electronic submittal via email or disk is acceptable. The work plan will be incorporated into the Written Report (see below), and as such, will not require multiple submittals. However, the work plan must be submitted to meet the approval of the Project Manager.

3.2 Written Report

3.2.1 Summary Report: The contractor shall prepare a formal report incorporating the below listed components at a minimum (not necessarily listed in order):

- Title Page

- Copy of the SOW and contract
- Table of Contents
- Executive Summary or Abstract
- Introduction
- Work Plan
- Background
- Methods
- Results, to include the following:
  - survey of *Tabernaemontana rotensis* on Andersen Air Force Base
  - maps indicating locations and habitat types (preferably using GPS)
  - characteristics of the micro-habitat of every individual in the population
  - allometric relations of each individual
  - propagation protocols
  - phenological patterns of the known population
  - which of the proposed threats were most important in increasing the rarity of this species, and which are likely to be most important in the future
  - management recommendations to include suggested research
- References
- Appendices

At a minimum, 3 submittals (Initial, Final, Revised) will be required to be submitted. Depending on the comments additional submittals might be required. Format for the submittals is to be decided by the Project Manager but it is not to exceed 6 hard copies. The document is to be in Microsoft Word for submittals and revised form. The revised form is to be in 3 ring white binders with professional tabs/section labels and a plastic sheet containing the revised electronic version of all deliverables. Disks should be labeled with contents, project name and number and date.

3.3 Deliverable Schedule

- Work Plan – NTP (Notice to Proceed) + 6 weeks (See 3.1 for details)

- Initial Written Report, Collections Database, Interim Collections Management Plan and Final PA/CA – NTP + 44 weeks

- Final Written Report, NTP + 50 weeks

- Final Revised Written Report, NTP + 52 weeks
  Project Complete

4.0 SUPPORTING INFORMATION

4.1 Responsibilities

4.1.1 The contractor shall provide the personnel (project director, field director, crew members) necessary to complete the tasks necessary to fulfill the requirements under this Statement of Work.

4.1.2 The contractor shall coordinate the research and field surveys with the Project Manager in support of the effort.

4.1.3 The contractor shall be available to participate in technical direction/interchange meetings with the Project Manager to develop methodologies, review progress, discuss problem areas, and exchange information. The contractor shall also be available to respond to technical issues presented by Andersen AFB. For costing purposes, it is assumed that these interchanges will take place via telephone conference calls at prearranged times except for one site visit for data collection and methodology development.

4.2 Special Considerations

4.2.1 Pre-coordination of data needs or data collection trips must be accomplished through the Project Manager. No contacts with federal, state, or other agencies/groups will be made without first requesting approval of the Project Manager.

4.2.2 All original materials, visual aids, software, and text developed or gathered in the performance of the tasks listed herein will be the property of Andersen AFB and will not be used, distributed, or published by the contractor without specific written permission of Andersen AFB.

4.2.3 The installation will provide all necessary safety and security briefings, base permits, passes, and escorts required to conduct work on Andersen AFB.

4.2.3.1 Contractor personnel will need base passes to access the base. The contractor will have to submit a letter on company letterhead with the following information:

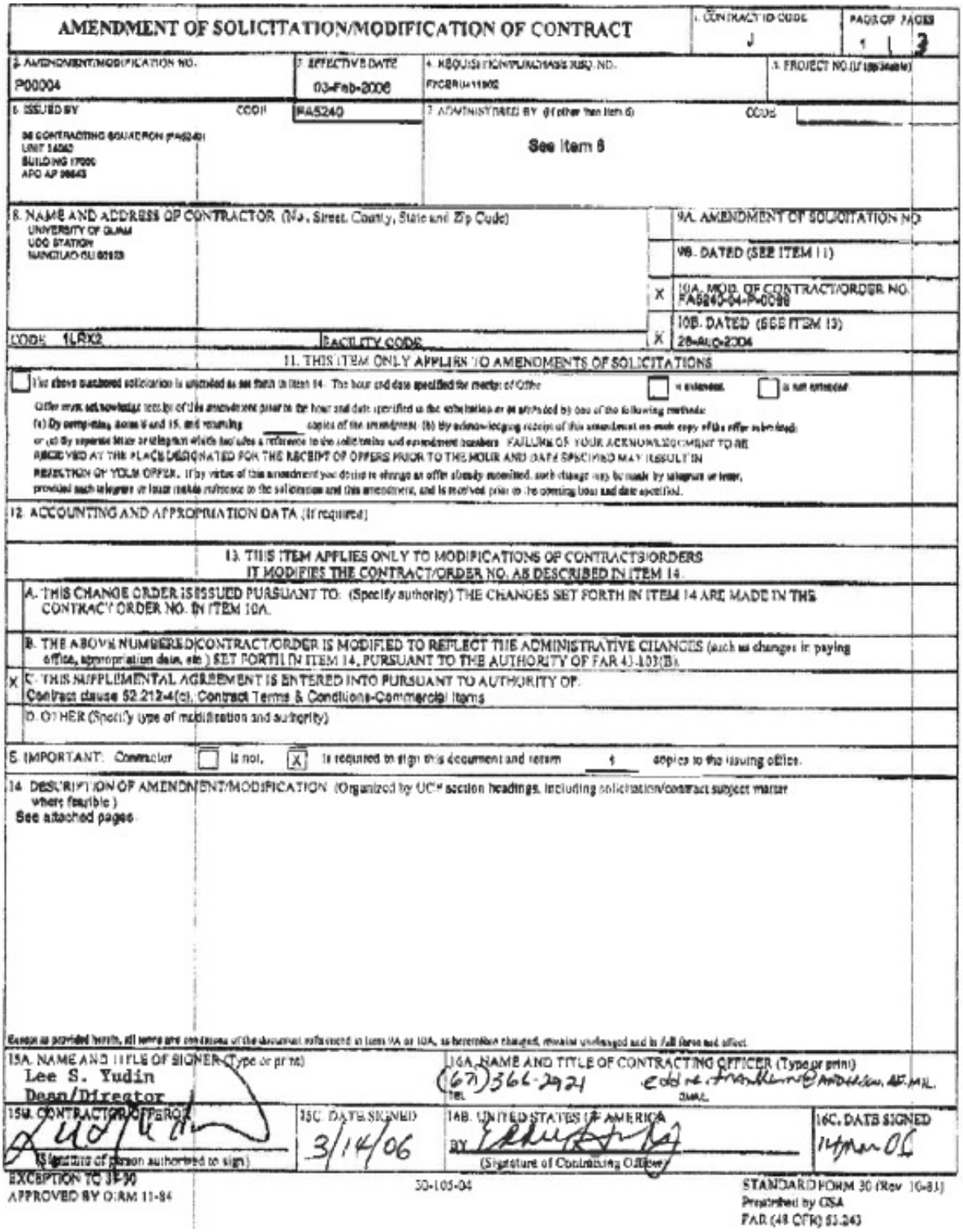
- Workers Names, Social Security Numbers, nationality, dates access required
- Prime Contractor Name (if subcontracted)
- Contract Number, Name, purpose and duration
- Project Manager's Name, Contact Number

The letter is to be submitted NLT 2 weeks prior to requested base access date. Base passes are not required for initial "scoping"/work plan meetings by the contractor and the Project Manager (no more than 2-3 contractor personnel involved); contractor personnel can be escorted during these times.

4.2.4 On-base data collection and associated activities must be pre-coordinated and approved by the Project Manager prior to commencement of activities.

Appendix 7.7. Contract.

Three page 2006 amendment.



AMENDMENT OF SOLICITATION/MODIFICATION OF CONTRACT

1. CONTRACT ID CODE	PAGE OF PAGES
J	1 | 3

2. AMENDMENT/MODIFICATION NO.	3. EFFECTIVE DATE	4. REQUISITION/PURCHASE REQ. NO.	5. PROJECT NO. (If applicable)
P00004	03-Feb-2006	FYCBR[illegible]1902	

6. ISSUED BY	CODE	7. ADMINISTERED BY (If other than Item 6)	CODE
96 CONTRACTING SQUADRON (PACAF) UNIT 14040 BUILDING 17000 APO AP 96543	FA5240	See Item 6	

8. NAME AND ADDRESS OF CONTRACTOR (No., Street, County, State and Zip Code)	9A. AMENDMENT OF SOLICITATION NO.
UNIVERSITY OF GUAM UOG STATION MANGILAO GU 96923	9B. DATED (SEE ITEM 11)
	X 10A. MOD. OF CONTRACT/ORDER NO. FA5240-04-P-0098
CODE 1LRK2 FACILITY CODE	X 10B. DATED (SEE ITEM 13) 28-AUG-2004

11. THIS ITEM ONLY APPLIES TO AMENDMENTS OF SOLICITATIONS

☐ The above numbered solicitation is amended as set forth in Item 14. The hour and date specified for receipt of Offer ☐ is extended, ☐ is not extended.

Offer must acknowledge receipt of this amendment prior to the hour and date specified in the solicitation or as amended, by one of the following methods: (a) By completing Items 8 and 15, and returning _____ copies of the amendment; (b) By acknowledging receipt of this amendment on each copy of the offer submitted; or (c) By separate letter or telegram which includes a reference to the solicitation and amendment numbers. FAILURE OF YOUR ACKNOWLEDGMENT TO BE RECEIVED AT THE PLACE DESIGNATED FOR THE RECEIPT OF OFFERS PRIOR TO THE HOUR AND DATE SPECIFIED MAY RESULT IN REJECTION OF YOUR OFFER. If by virtue of this amendment you desire to change an offer already submitted, such change may be made by telegram or letter, provided each telegram or letter makes reference to the solicitation and this amendment, and is received prior to the opening hour and date specified.

12. ACCOUNTING AND APPROPRIATION DATA (If required)

13. THIS ITEM APPLIES ONLY TO MODIFICATIONS OF CONTRACTS/ORDERS
IT MODIFIES THE CONTRACT/ORDER NO. AS DESCRIBED IN ITEM 14.

A. THIS CHANGE ORDER IS ISSUED PURSUANT TO: (Specify authority) THE CHANGES SET FORTH IN ITEM 14 ARE MADE IN THE CONTRACT ORDER NO. IN ITEM 10A.

B. THE ABOVE NUMBERED CONTRACT/ORDER IS MODIFIED TO REFLECT THE ADMINISTRATIVE CHANGES (such as changes in paying office, appropriation data, etc.) SET FORTH IN ITEM 14, PURSUANT TO THE AUTHORITY OF FAR 43.103(B).

X C. THIS SUPPLEMENTAL AGREEMENT IS ENTERED INTO PURSUANT TO AUTHORITY OF:
Contract clause 52.212-4(c), Contract Terms & Conditions-Commercial Items

D. OTHER (Specify type of modification and authority)

E. IMPORTANT: Contractor ☐ is not, ☒ is required to sign this document and return 1 copies to the issuing office.

14. DESCRIPTION OF AMENDMENT/MODIFICATION (Organized by UCF section headings, including solicitation/contract subject matter where feasible.)
See attached pages

Except as provided herein, all terms and conditions of the document referenced in Item 9A or 10A, as heretofore changed, remains unchanged and in full force and effect.

15A. NAME AND TITLE OF SIGNER (Type or print)	16A. NAME AND TITLE OF CONTRACTING OFFICER (Type or print)
Lee S. Yudin Dean/Director	(671) 366-2921 [illegible]@[illegible].edu TEL EMAIL

15B. CONTRACTOR/OFFEROR	15C. DATE SIGNED	16B. UNITED STATES OF AMERICA	16C. DATE SIGNED
(Signature of person authorized to sign)	3/14/06	BY (Signature of Contracting Officer)	14 Mar 06

EXCEPTION TO SF30
APPROVED BY OIRM 11-84

30-105-04

STANDARD FORM 30 (Rev. 10-83)
Prescribed by GSA
FAR (48 CFR) 53.243

SECTION SF 30 BLOCK 14 CONTINUATION PAGE

The purpose of this modification is to extend the period of performance and to incorporate the consideration offered by the contractor in exchange for the Government's agreement to the extension of performance.

SUMMARY OF CHANGES

SECTION SF 1449 - CONTINUATION SHEET

DELIVERIES AND PERFORMANCE

The following Delivery Schedule Item has been deleted from CLIN 0001:

DELIVERY DATE	QUANTITY	SHIP TO ADDRESS	UIC
02-FEB-2006	1	36 CES/CEVN - F5CEVN DANA LUJAN UNIT 14007 APO AP 96543 FOB: Destination	F5CEVN

The following Delivery Schedule item has been added to CLIN 0001:

DELIVERY DATE	QUANTITY	SHIP TO ADDRESS	UIC
POP 03-FEB-2006 TO 02-FEB-2007	N/A	36 CES/CEVN - F5CEVN DANA LUJAN UNIT 14007 APO AP 96543 FOB: Destination	F5CEVN

Following is information on (1) current status, (2) interpretation of the survey, and (3) considerations for the extension request.

1. Status.
Total *Tabernaemontana rotensis* count as of surveys through 15 January 2006 is 5,245 individuals. The growth habit and recruitment dynamics of this species leads to a clustered distribution. Very rarely is an isolated individual found. Of the 5,425 individuals we have located, only 49 are isolated single trees.

We have completed about 50% of the forested area of the base, on target with the original agreement to complete the entire survey in 24 months. Approximately 90% of the area inventoried to date has been in degraded scrub or secondary limestone forest sites. The largest areas of habitat left to inventory are cliff line or bench locations in the most remote and most irregular terrain.

2. Interpretation of survey.
a. Approximately 80% of the *T. rotensis* plants are located within disturbed plant communities. This new knowledge about edaphic and habitat restrictions of *T. rotensis* distribution will allow future Air Force conservation efforts to proceed in a more educated manner. We are receiving GPS data management training that will allow the contract final report to include a soil taxonomy overlay along with the plant locations. This will graphically reveal the propensity of this species to be restricted to certain habitat types.

b. The original need of the contract was conceived at a time that *T. rotensis* was being considered for listing as endangered. Our results to date will benefit the Air Force with hard data that indicate the species is quite abundant on Department of Defense lands. A gross extrapolation of the population based on a doubling of the census on 50% of the forested lands provides an estimate of more than 10,000 individuals. Moreover, this is only on AAFB proper, since the scope of the contract did not include portions of the Ritidian Wildlife Refuge Overlay that are technically on AAFB. Thus, the *T. rotensis* population on all Department of Defense lands in northern Guam would exceed this gross estimate. This result from the contract will allow the Department of Defense to proceed with development plans with minimal concern about impacts on the global population of this biological resource.

3. Considerations

a. Our field notes have allowed us to verify two important aspects of *T. rotensis* phenology in Guam's environment. Typhoon disturbances, even typhoon events that impose minimal damage to the vegetation, synchronize a flowering pulse among the population. Moreove, the period between flowering and fruit maturation is a stable ca 13 weeks regardless of season. Thus, a mast seeding event can be predicted with accuracy by Department of Defense resource managers desiring to propagate this species. Quick surveys of accessible *T. rotensis* trees shortly after any typhoon can be conducted to find flowering trees, then returning to those trees 13 weeks after the flowering pulse would provide copious seed yields.

b. This is the first comprehensive survey of this type. If your office plans to conduct similar surveys in the future, this knowledge base will allow more informed decisions on how to manage the biological resources on Andersen Air Force Base. The protocols being used are labor intensive and are providing valuable experience for defining methods or refining logistics of future biological assessments, environmental assessments or Environmental Impact Statements.

c. During the course of the surveys to date, we have identified 6 unique locations with the T&E species *Heritiera longipatiolata*. This beautiful tree is in the Sterculiaceae, and is endemic to the Mariana Islands. Nothing is known about the ecology of the species, or the current census. Moreover, we have identified 3 unique habitat locations with plants that support the T&E butterfly species (butterfly plants). These data will allow future EIS work or any other ecology efforts prior to future land use plans for these known locations. Following are GPS data for these findings.

Heritiera longipetiolata **endangered species -endemic**

HELO5	1504499	276132.6
HELO6	1504492	276114.7
HELO4	1504502	276138.2
HELO3	1503347	278052.6
HELO1	1503446	278003.9
HELO2	1503318	278059.7

Elatostema calcareum-host plant supporting GU endangered butterflies

ELCA	1504552	276214.7

Procris pedunculata-host plant supporting GU endangered butterflies

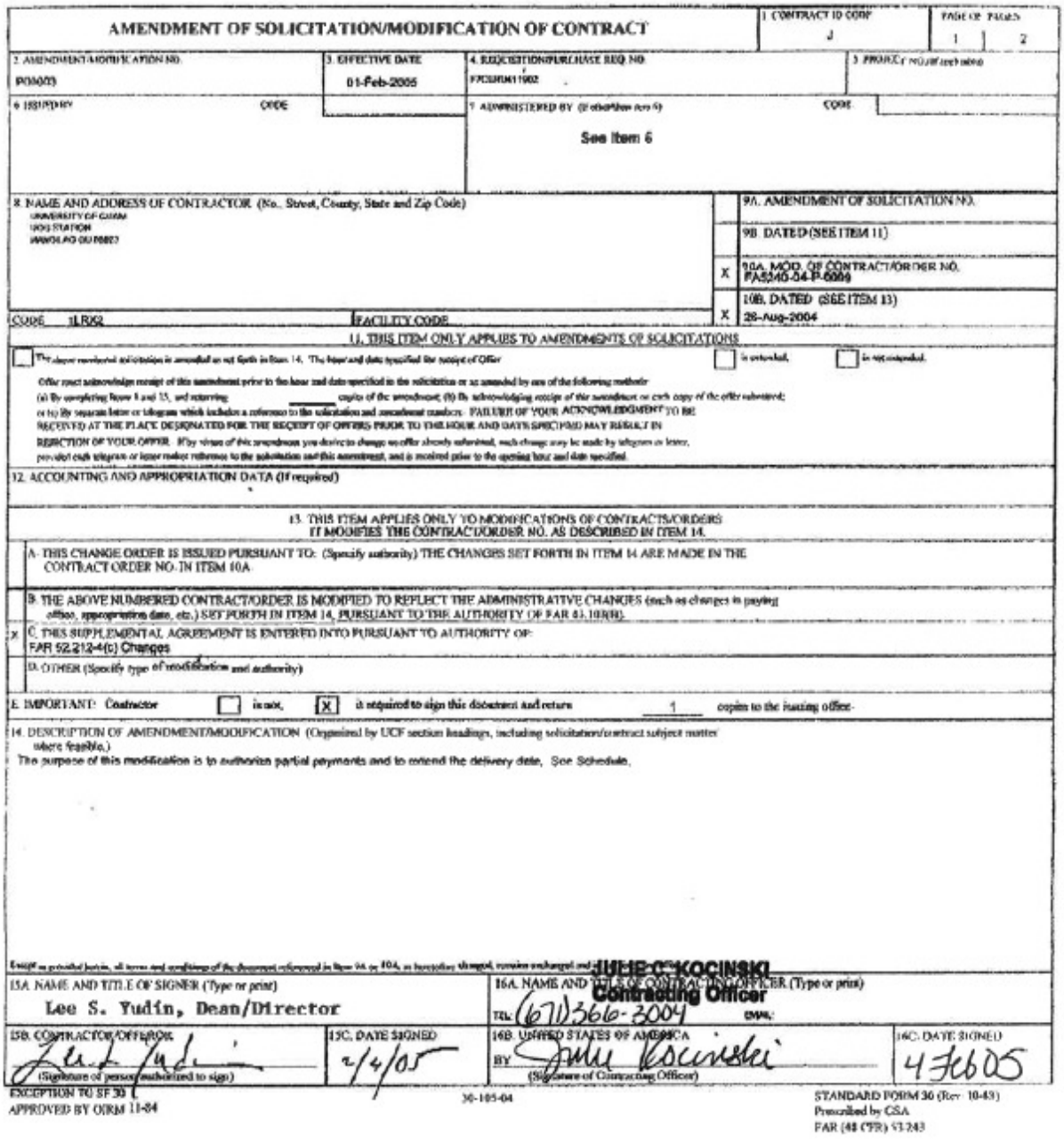
PRPE	1504492	276114.7

Maytenus thompsonii-host plant supporting GU endangered butterflies

MATH	1503441	277968

(End of Summary of Changes)

Two page 2005 amendment.



AMENDMENT OF SOLICITATION/MODIFICATION OF CONTRACT

1. CONTRACT ID CODE: J — PAGE OF PAGES: 1 | 2

2. AMENDMENT/MODIFICATION NO.: P00003 — 3. EFFECTIVE DATE: 01-Feb-2005 — 4. REQUISITION/PURCHASE REQ. NO.: FXSUNM11902 — 5. PROJECT NO. (If applicable)

6. ISSUED BY: CODE — 7. ADMINISTERED BY (If other than item 6): CODE — See Item 6

8. NAME AND ADDRESS OF CONTRACTOR (No., Street, County, State and Zip Code)
UNIVERSITY OF GUAM
UOG STATION
MANGILAO GU 96923

9A. AMENDMENT OF SOLICITATION NO.

9B. DATED (SEE ITEM 11)

X 10A. MOD. OF CONTRACT/ORDER NO. FA5240-04-P-0006

X 10B. DATED (SEE ITEM 13) 28-Aug-2004

CODE 1LR92 — FACILITY CODE

11. THIS ITEM ONLY APPLIES TO AMENDMENTS OF SOLICITATIONS

☐ The above numbered solicitation is amended as set forth in Item 14. The hour and date specified for receipt of Offer ☐ is extended, ☐ is not extended.

Offer must acknowledge receipt of this amendment prior to the hour and date specified in the solicitation or as amended by one of the following methods: (a) By completing Items 8 and 15, and returning _____ copies of the amendment; (b) By acknowledging receipt of this amendment on each copy of the offer submitted; or (c) By separate letter or telegram which includes a reference to the solicitation and amendment numbers. FAILURE OF YOUR ACKNOWLEDGEMENT TO BE RECEIVED AT THE PLACE DESIGNATED FOR THE RECEIPT OF OFFERS PRIOR TO THE HOUR AND DATE SPECIFIED MAY RESULT IN REJECTION OF YOUR OFFER. If by virtue of this amendment you desire to change an offer already submitted, such change may be made by telegram or letter, provided each telegram or letter makes reference to the solicitation and this amendment, and is received prior to the opening hour and date specified.

12. ACCOUNTING AND APPROPRIATION DATA (If required)

13. THIS ITEM APPLIES ONLY TO MODIFICATIONS OF CONTRACTS/ORDERS. IT MODIFIES THE CONTRACT/ORDER NO. AS DESCRIBED IN ITEM 14.

A. THIS CHANGE ORDER IS ISSUED PURSUANT TO: (Specify authority) THE CHANGES SET FORTH IN ITEM 14 ARE MADE IN THE CONTRACT ORDER NO. IN ITEM 10A.

B. THE ABOVE NUMBERED CONTRACT/ORDER IS MODIFIED TO REFLECT THE ADMINISTRATIVE CHANGES (such as changes in paying office, appropriation date, etc.) SET FORTH IN ITEM 14, PURSUANT TO THE AUTHORITY OF FAR 43.103(B).

X C. THIS SUPPLEMENTAL AGREEMENT IS ENTERED INTO PURSUANT TO AUTHORITY OF: FAR 52.212-4(c) Changes

D. OTHER (Specify type of modification and authority)

E. IMPORTANT: Contractor ☐ is not, ☒ is required to sign this document and return 1 copies to the issuing office.

14. DESCRIPTION OF AMENDMENT/MODIFICATION (Organized by UCF section headings, including solicitation/contract subject matter where feasible.)
The purpose of this modification is to authorize partial payments and to extend the delivery date. See Schedule.

Except as provided herein, all terms and conditions of the document referenced in Item 9A or 10A, as heretofore changed, remains unchanged and in full force and effect.

15A. NAME AND TITLE OF SIGNER (Type or print): Lee S. Yudin, Dean/Director

15B. CONTRACTOR/OFFEROR (Signature of person authorized to sign)

15C. DATE SIGNED: 2/4/05

16A. NAME AND TITLE OF CONTRACTING OFFICER (Type or print): JULIE C. KOCINSKI Contracting Officer
TEL: (671)366-3004 EMAIL:

16B. UNITED STATES OF AMERICA BY (Signature of Contracting Officer)

16C. DATE SIGNED: 4 Feb 05

EXCEPTION TO SF 30
APPROVED BY OIRM 11-84

30-105-04

STANDARD FORM 30 (Rev. 10-83)
Prescribed by GSA
FAR (48 CFR) 53.243

SECTION SF 30 BLOCK 14 CONTINUATION PAGE

SUMMARY OF CHANGES

SECTION SF 30 - BLOCK 14 CONTINUATION PAGE

The following have been added by full text:

PARTIAL PAYMENTS

PARTIAL PAYMENTS ARE AUTHORIZED. INVOICING SHALL NOT BE SUBMITTED MORE THAN ONCE PER MONTH.

RELEASE OF CLAIMS

The contractor agrees that the changes stated in this supplemental agreement constitute full and final agreement. The contractor releases the Government from any and all liability under this contract for further equitable adjustments attributable to the changes contained under this agreement.

SECTION SF 1449 - CONTINUATION SHEET

DELIVERIES AND PERFORMANCE

The following Delivery Schedule item for CLIN 0001 has been changed from:

DELIVERY DATE	QUANTITY	SHIP TO ADDRESS	UIC
19-AUG-2005	1	36 CES/CEVN - F5CEVN DANA LUJAN UNIT 14007 APO AP 96543 FOB: Destination	F5CEVN

To:

DELIVERY DATE	QUANTITY	SHIP TO ADDRESS	UIC
02-FEB-2006	1	36 CES/CEVN - F5CEVN DANA LUJAN UNIT 14007 APO AP 96543 FOB: Destination	F5CEVN

(End of Summary of Changes)

Original contract.

SOLICITATION/CONTRACT/ORDER FOR COMMERCIAL ITEMS
OFFEROR TO COMPLETE BLOCKS 12, 17, 23, 24, AND 30

1. REQUISITION NUMBER	PAGE 1 OF 14
F7CERU411902	

2. CONTRACT NO.	3. AWARD/EFFECTIVE DATE	4. ORDER NUMBER	5. SOLICITATION NUMBER	6. SOLICITATION ISSUE DATE
FA5240-04-P-0099	20-Aug-2004			

7. FOR SOLICITATION INFORMATION CALL:	a. NAME	b. TELEPHONE NUMBER (No Collect Calls)	8. OFFER DUE DATE/LOCAL TIME

9. ISSUED BY CODE FA5240

36 CONTRACTING SQUADRON (FA5240)
UNIT 14040
BUILDING 17000
APO AP 96543

TEL:
FAX:

10. THIS ACQUISITION IS
- [ ] UNRESTRICTED
- [X] SET ASIDE: 100 % FOR
  - [X] SMALL BUSINESS
  - [ ] HUBZONE SMALL BUSINESS
  - [ ] 8(A)

NAICS: 541990
SIZE STANDARD: $6M

11. DELIVERY FOR FOB DESTINATION UNLESS BLOCK IS MARKED
- [ ] SEE SCHEDULE

12. DISCOUNT TERMS
Net 30 Days

- [ ] 13a. THIS CONTRACT IS A RATED ORDER UNDER DPAS (15 CFR 700)

13b. RATING

14. METHOD OF SOLICITATION
- [ ] RFQ
- [ ] IFB
- [ ] RFP

15. DELIVER TO CODE F5CEVN
36 CES/CEVN - F5CEVN
DANA LUJAN
UNIT 14007
APO AP 96543

16. ADMINISTERED BY CODE

SEE ITEM 9

17a. CONTRACTOR/ OFFEROR CODE 1LRX2

UNIVERSITY OF GUAM
UOG STATION
MANGILAO GU 96923

TEL:
FACILITY CODE

18a. PAYMENT WILL BE MADE BY CODE F68300

DFAS- PC/FFVF
477 ESSEX ST
FORD ISLAND
PEARL HARBOR HI 96860-5806

- [ ] 17b. CHECK IF REMITTANCE IS DIFFERENT AND PUT SUCH ADDRESS IN OFFER

18b. SUBMIT INVOICES TO ADDRESS SHOWN IN BLOCK 18a. UNLESS BLOCK BELOW IS CHECKED [ ] SEE ADDENDUM

19. ITEM NO.	20. SCHEDULE OF SUPPLIES/ SERVICES	21. QUANTITY	22. UNIT	23. UNIT PRICE	24. AMOUNT
	SEE SCHEDULE				

25. ACCOUNTING AND APPROPRIATION DATA	26. TOTAL AWARD AMOUNT (For Govt. Use Only)
See Schedule	$30,000.00 EST

- [ ] 27a. SOLICITATION INCORPORATES BY REFERENCE FAR 52.212-1, 52.212-4, FAR 52.212-3, 52.212-5 ARE ATTACHED. ADDENDA [ ] ARE [ ] ARE NOT ATTACHED
- [ ] 27b. CONTRACT/PURCHASE ORDER INCORPORATES BY REFERENCE FAR 52.212-4, FAR 52.212-5 IS ATTACHED. ADDENDA [ ] ARE [ ] ARE NOT ATTACHED

28. CONTRACTOR IS REQUIRED TO SIGN THIS DOCUMENT AND RETURN 0 COPIES
- [ ] TO ISSUING OFFICE. CONTRACTOR AGREES TO FURNISH AND DELIVER ALL ITEMS SET FORTH OR OTHERWISE IDENTIFIED ABOVE AND ON ANY ADDITIONAL SHEETS SUBJECT TO THE TERMS AND CONDITIONS SPECIFIED HEREIN.

29. AWARD OF CONTRACT: REFERENCE
- [X] OFFER DATED . YOUR OFFER ON SOLICITATION (BLOCK 5), INCLUDING ANY ADDITIONS OR CHANGES WHICH ARE SET FORTH HEREIN, IS ACCEPTED AS TO ITEMS: SEE SCHEDULE

30a. SIGNATURE OF OFFEROR/CONTRACTOR

Lee S. Yudin 9/2/04

31a. UNITED STATES OF AMERICA (SIGNATURE OF CONTRACTING OFFICER)

Eddie Franklin

31c. DATE SIGNED
26-Aug-2004

30b. NAME AND TITLE OF SIGNER (TYPE OR PRINT)
Lee S. Yudin, Dean/Director
CNAS/UOG

30c. DATE SIGNED

31b. NAME OF CONTRACTING OFFICER (TYPE OR PRINT)
Eddie Franklin / Contracting Officer
TEL: [redacted] EMAIL: eddie.franklin@andersen.af.mil

AUTHORIZED FOR LOCAL REPRODUCTION
PREVIOUS EDITION IS NOT USABLE

STANDARD FORM 1449 (REV 4/2002)
Prescribed by GSA
FAR (48 CFR) 53.212

SOLICITATION/CONTRACT/ORDER FOR COMMERCIAL ITEMS (CONTINUED)					PAGE 2 OF 14
19. ITEM NO.	20. SCHEDULE OF SUPPLIES/ SERVICES	21. QUANTITY	22. UNIT	23. UNIT PRICE	24. AMOUNT
	SEE SCHEDULE				

32a. QUANTITY IN COLUMN 21 HAS BEEN

☐ RECEIVED ☐ INSPECTED ☐ ACCEPTED, AND CONFORMS TO THE CONTRACT, EXCEPT AS NOTED: _____

32b. SIGNATURE OF AUTHORIZED GOVERNMENT REPRESENTATIVE	32c. DATE	32d. PRINTED NAME AND TITLE OF AUTHORIZED GOVERNMENT REPRESENTATIVE
32e. MAILING ADDRESS OF AUTHORIZED GOVERNMENT REPRESENTATIVE		32f. TELEPHONE NUMBER OF AUTHORIZED GOVERNMENT REPRESENTATIVE
		32g. E-MAIL OF AUTHORIZED GOVERNMENT REPRESENTATIVE

33. SHIP NUMBER ☐ PARTIAL ☐ FINAL	34. VOUCHER NUMBER	35. AMOUNT VERIFIED CORRECT FOR	36. PAYMENT ☐ COMPLETE ☐ PARTIAL ☐ FINAL	37. CHECK NUMBER
38. S/R ACCOUNT NUMBER	39. S/R VOUCHER NUMBER	40. PAID BY		

41a. I CERTIFY THIS ACCOUNT IS CORRECT AND PROPER FOR PAYMENT		42a. RECEIVED BY (Print)	
41b. SIGNATURE AND TITLE OF CERTIFYING OFFICER	41c. DATE	42b. RECEIVED AT (Location)	
		42c. DATE REC'D (YY/MM/DD)	42d. TOTAL CONTAINERS

AUTHORIZED FOR LOCAL REPRODUCTION
PREVIOUS EDITION IS NOT USABLE

STANDARD FORM 1449 (REV 4/2002) BACK
Prescribed by GSA
FAR (48 CFR) 53.212

Section SF 1449 - CONTINUATION SHEET

ITEM NO	SUPPLIES/SERVICES	QUANTITY	UNIT	UNIT PRICE	AMOUNT
0001		1	Lump Sum	$30,000.00	$30,000.00 EST
	Survey Andersen AFB for Tabernaemontana FFP Survey Andersen AFB for Tabernaemontana rotensis MILSTRIP: F7CERU41190200 PURCHASE REQUEST NUMBER: F7CERU411902 SIGNAL CODE: A				
				NET AMT	$30,000.00
	ACRN AA Funded Amount				$30,000.00

FOB: Destination

INSPECTION AND ACCEPTANCE TERMS

Supplies/services will be inspected/accepted at:

CLIN	INSPECT AT	INSPECT BY	ACCEPT AT	ACCEPT BY
0001	Destination	Government	Destination	Government

DELIVERY INFORMATION

CLIN	DELIVERY DATE	QUANTITY	SHIP TO ADDRESS	UIC
0001	19-AUG-2005	1	36 CES/CEVN - F5CEVN DANA LUJAN UNIT 14007 APO AP 96543 FOB: Destination	F5CEVN

ACCOUNTING AND APPROPRIATION DATA

AA: 5743400 304 7447 464416 010000 53217 28853F 668300 F68300 WO:64186 ESP:PM
COST 000000000000
CODE:
AMOUNT: $30,000.00

BASE ACCESS REQUESTS

Andersen AFB Local Clause.

The Contracting Officer shall insert the local clause, Andersen-002: Background Checks for Contractor Personnel Requiring Entry/Access to Installations/Locations, in all solicitations and contracts meeting the following conditions:

(a) Performance will be in the United States or United States territorial possessions

Andersen-002: Background Checks for Contractor Personnel Requiring Entry/Access to Installations/Locations

As prescribed by Andersen AFB local policy, insert a clause substantially the same as the following clause in solicitations and contracts:

Background Checks for Contractor Personnel Requiring Entry/Access to Andersen Air Force Base, Guam (28 Jun 2004)

(a) Contractor and subcontractor personnel requiring entry/access to Andersen Air Force Base, Guam, cited in the contract shall be governed by the requirements of this clause. The below requirements and procedures are prerequisites to the issuance of any government identification (i.e., pass/badge) or the registration of a privately owned or commercial vehicle and the issuance of a pass/decal.

(b) Immediately upon contract award, the contractor shall submit the following documentation for personnel who will be performing work as a result of an awarded contracting instrument (contract, delivery order, purchase order, etc.) to the Contracting Officer/designee:

(1) "Listing of personnel requiring access/entry" (See Note 1).

(2) Completed consent forms (See Note 2).

(3) Favorable Criminal Background Histories (See Note 3).

This documentation shall be submitted no later than seven (7) calendar days prior to performance on the installation/location.

(c) Subsequent to the contractor accomplishing (b), contractor personnel may report to the badge issuing activity and follow local installation/facility procedures to obtain identification passes/badges and vehicle passes/decals.

(d) For contractor personnel to obtain entry to the installation/facility in order to request the issuance of government identification (i.e., pass/badge) or to register a privately owned/commercial vehicle and obtain a vehicle pass/decal, the contractor personnel shall report to the installation/location entry control point and badge issuing activity with a photo identification issued by a Federal/State activity.

(e) To register a privately owned/commercial vehicle and obtain a vehicle pass/decal, contractor personnel shall provide a valid driver's license, current vehicle registration, and valid vehicle insurance certificate.

(f) Contractor personnel shall follow local procedures for wearing and displaying government-issued identification passes/badges, vehicle passes/decals, and contractor-issued identification. In general, all identification passes/badges and vehicle passes/decals shall at all times be prominently worn/displayed in a visible manner to government personnel.

(g) During the performance period of the contract, the Contractor shall:

(1) Provide written notification of any additions to the "Listing of personnel requiring entry/access" and submit consent forms and criminal background histories for all new contractor personnel requiring entry/access to the Contracting Officer/designee.

(2) No later than five (5) calendar days after a change in status for contractor personnel requiring entry/access (e.g., the personnel no longer require entry/access or the contractor becomes aware of a negative screening criteria (i.e., "disqualifying factor"), provide written notification of deletions of personnel to the Contractor's "Listing of personnel requiring entry/access" to the Contracting Officer/designee. The Contractor shall return all government-issued identification passes/badges and vehicle passes/decals to the badge-issuing agency not later than one (1) work day after retrieval from the employee and obtain a proof of return. The proof of badge return shall be provided to the Contracting Office for inclusion in the contract file.

(3) Maintain a copy of all background checks for a 24-month period and ensure subsequently needed background checks are accomplished prior to the expiration of a 24-month period (See Note 3).

(h) Given a reasonable cause, condition, or reason, this clause does not circumvent an installation/location commander's unilateral authority to deny or withdraw any individual's entry/access to an installation/location.

(i) When work under this contract requires unescorted entry to controlled or restricted areas, the Contractor shall comply with AFI 31-101, The Air Force Installation Security Program, and AFI 31-501, Personnel Security Program Management, as applicable.

(j) Contractor personnel are not covered by FAR 52.222-3, Convict Labor, for the purposes of entry/access to entry/access to installations/locations. Contractor personnel are covered by FAR 52.222-3 for the purposes of performance outside of installations/locations.

(k) The Contractor shall insert this clause in any subcontract where the subcontractor will require entry/access to the installation(s)/location(s) cited in the contract.

Note 1: "Listing of personnel requiring access/entry." The Contractor shall provide a "Listing of personnel requiring entry/access" to the Contracting Officer or the Contracting Officer's designee(s). Contact information for the Contracting Officer's designee follows:

_____. (The contracting officer's designee may be personnel within Security Forces, inclusive of the badge issuing activity; or personnel within the organization that will be performing quality assurance functions for the contract.)

This listing shall be submitted on company letterhead and, as a minimum, contain the following data elements:

- Contract number.
- Work site(s) or location(s).
- Performance start and stop date(s).
- Time of day of performance (e.g. 7:30 a.m. – 4:30 p.m.)
- Days of the week of performance (e.g. Monday through Friday)
- As a minimum, the following information for Contractor personnel requiring entry/access: full name, social security number (or other identification number), and installation(s)/location(s) to be accessed.

No Contractor personnel shall be granted or authorized entry/access until identified on the "Listing of personnel requiring entry/access."

Note 2: Consent forms. Consent forms shall authorize the Air Force to fingerprint Contractor personnel and to conduct additional background checks. In general, the consent form will outline the following:

(1) The Contractor has briefed the contractor personnel for the purpose of the consent form.

(2) The information on the form is collected in accordance with 50 U.S.C. 797 and DoDD 5200.8 that permits installation commanders to limit access to installations for security reasons.

(3) Completion of the form is voluntary.

(4) Agreement to provide a specimen of fingerprints, if/when requested.

(5) Awareness of a list of "disqualifying factors" and/or access to the list.

(6) Consent and authorization for the Air Force to conduct additional background screening and to compare fingerprints against state and Federal criminal databases.

(7) Knowing and willful false statements on the form can be punished by a fine or imprisonment, or both (10 U.S.C. 1001).

(8) That the consent form shall remain valid for not less than a 24-month period.

In summary, the consent forms authorize the Government to conduct additional background checks that may result in the identification of negative screening criteria (i.e., disqualifying factor(s)). If negative screening criteria is identified, the affected Contractor personnel shall be denied entry/access and the Contracting Officer/designee will notify the Contractor. Furthermore, the Contractor shall be responsible for immediately returning all issued identification passes/badges and vehicle passes/decals to the badge-issuing office and obtain a proof of return.

Each background check shall be considered "current" for a 24-month period and valid for all contracts performed within the 24-month period of currency. Contractors shall ensure background checks are accomplished every 24 months to ensure no lapse in background check coverage. This requirement does not apply to Contractor personnel that have a favorable government personnel security background investigation that is valid for a period longer than 2 years.

Contractor personnel who have a current, favorable Government personnel security background investigation that is electronically accessible and immediately verifiable by the Government within the Joint Personnel Adjudication System (JPAS) are not required to obtain an additional background check for the purposes of complying with this clause (i.e., existing current, favorable security background investigations may be used in lieu of the requirements of this clause).

(End of Clause)

Appendix 7.8. Work Plan.

Work Plan

Survey of Tabernaemontana rotensis on Andersen Air Force Base

Contract #FA5240-04-P-0099

April 2005

BACKGROUND

Tabernaemontana rotensis (TR) was proposed for listing under the Endangered Species Act. Known locations of TR occur on the island of Guam and Rota, but these have not been mapped and many other locations likely exist. On Guam, TR is found in scattered locations within Andersen Air Force Base, in the forest around Ritidian Point and in forest enclaves on private lands.

TR in its native habitat has been severely affected over the past several centuries by the same threats as other native plants and animals: habitat loss, habitat degradation, the introduction of exotic and invasive plant and animals species, and the resulting loss of possible pollinators and seed dispersers. All of these threats are associated with human activity.

No formal studies have been conducted to increase the understanding of this species. This work plan addresses this paucity of information. We will be documenting the locality of TR individuals that comprise the AAFB population. Additionally, we will be defining population characteristics and general information to better inform resource managers and resource planners about conservation recommendations.

WORK PLAN

A. Survey Andersen Air Force Base for *Tabernaemontana rotensis*

General Methods

A Gamin Map76 GPS unit calibrated to Guam UTM zones will be used to document the location of every known and observed TR. All GIS layers will be saved and delivered in a format acceptable to Andersen Air Force Base. Other features of unique or special interest will be mapped. IKONAS imagery for northern Guam from 2001 is available from the Guam Department of Forestry, and will be used to map TR habitats.

Phase I. (Reconnaissance Survey) - Document location of known individuals or stands of *Tabernaemontana rotensis.* Early in this phase outings will be scheduled with the Project Manager and several other biologists who have observed TR plants within AAFB. Each of these plants will be recorded during these outings. Thereafter, reconnaissance searches will be made within a 50 meter radius search area surrounding each known individual and within limits imposed by topographical features and/or restricted access area perimeters.

Phase II: (Meander Survey) - Delineate the outlines of all potential *Tabernaemontana rotensis* habitats as search units. We will not be needing aerial photographs from AAFB as originally planned, since we are using maps available from detailed soil surveys for northern Guam. Using these base maps the areas for search units have been predetermined. The boundaries for these search areas follow roads or construction, powerline access ways and natural topographical features. These search areas will be measured to determine total search unit area in hectares. A time estimate and schedule will be developed for each search area. Initial recon estimates for a 700 meter traverse (approximately 7000 sq meters) for a single typical transect required

approximately 2 hours to complete. Phase II meander searches will be recorded as line data using the Garmin Map76 GPS unit. General macro habitat descriptions will be developed for each search unit defined in Phase II.

Phase III: (Patterned Survey) - Document location of observed *Tabernaemontana rotensis* plants. Phase III pattern searches of specific habitat defined in Phase II will be recorded as line data using the Garmin May 76 GPS unit. All plant locations will be documented as point locations.

The bearing of the patterned search transects will be determined after establishing the most readily accessible base line for each defined search area. For example, if the baseline for the patterned search grid is north-south then the patterned search transects will be east-west. Search transects will be at 90 degree angles from the baseline. Nearly all search areas have at least one accessible linear feature from which to establish the initial baseline. The distance between search transects will be set at 5 meters initially. Along each access baseline and the parallel baseline, GPS waypoints will be established at 5 meter intervals. This will be done in the field or preprogrammed into the GPS unit. This will provide 100% overlap with adjacent search transects. The effective view-shed in most forest cover situations on Andersen during the dry season is about 5 meters. Depending on vegetative cover (open scrub), the grid pattern may be expanded to 10 meters in specific locations.

The search unit defined by the air strips, the access road to Tarague Beach area, and the cliffline overlooking the shooting range will be the first search unit completed. We will use a distance of 5 m between parallel transects to determine the length of time needed to complete Phase III of this search unit. We will negotiate with the Project Manager thereafter to define the remainder of number of search units and distance between transects within remaining search units.

Transect methods

A. Set GPS to track to predetermine waypoint from baseline to baseline (initial 5 meter intervals).
B. During traverse, scan forward along the transect line 180 degrees.
C. During the traverse, stop along the search transect every 10 meters and complete a visual search in a 360 degree circle.
D. Collect specified data for each observed TR individuals along the transect (GPS waypoint, general vigor and condition, estimated height and canopy width, approximate count of individuals and percentage of each size/age class present, herbivory, phenology observations, co-occurring species, shade and wind exposure, etc. (see attached data sheet).
E. At the terminal end of each traverse note and described the general plant community along the traverse.

B. Characterize the micro-habitat of *Tabernaemontana rotensis*

The edaphic characteristics of Andersen Air Force Base are well-known. Micro-habitat descriptions for TR individuals will be developed from Guam Soil Survey (SCS 1984) narrative descriptions. SURGO GIS soils layers will be used to map general edaphic conditions for the micro-sites of each known and observed TR. The SURGO soil layer will be over-laid with established GEODATA road and topographic features to form a base layer to support Phase II

and III field surveys. Topographical characteristics will be observed on-site and recorded by direct observation. Co-occurring species will be defined and recorded, and the general percentage of native versus introduced species will be calculated from the list of co-occurring species for each TR individual. Contractor developed datasheets will be used to record site characteristics. The forest and plant micro habitat community descriptions will be developed using the Guam Soil Survey, Benjamin Stone's Flora of Guam and other Guam specific floristic references.

C. Allometric observations of *Tabernaemontana rotensis*

Allometric information will add to our understanding of the general population characteristics of this important species. These measurements focus primarily on canopy height and stem size, but we will also measure other characteristics such as canopy diameter and density. These will be made on TR plant as each plant is located during the searches. Regression analysis will be used to determine the size relationships among the entire population of plants by the end of the contract period.

D. Propagation protocols of *Tabernaemontana rotensis*

Evaluate and document appropriate propagation and seedling establishment protocols for *Tabernaemontana rotensis*.

Seed propagation methods

We have stored TR seeds for 7 months in ziploc bags under air-conditioned laboratory conditions. With these storage conditions, we obtained 91%-93% germination after 2 months of storage, but no germination following 7 months of storage. These initial studies reveal this issue requires detailed study, since conservation efforts will be more easily served if a protocol for storage will allow resource managers to be in better control of when seed sowing can occur after seed harvest.

One possible explanation is the seeds lose viability during this time period. This is highly unlikely, since TR is a pioneer species, and numerous seeds in the forest seed bank germinate and emerge following heavy canopy loss during major typhoons. These seeds are probably more than 7 months of age at the time of a typical Guam typhoon. A more likely possibility is some sort of physiological dormancy is initiated during this initial storage period.

We will address this critical issue with two approaches. Either of these approaches will allow an improved protocol for TR seed management to be developed.

1. Storage conditions. Loss of water content during our storage methods may have accounted for the poor germination following 7 months of storage. To address this, we will store seeds in humidified chambers to retain moisture. We will plant at monthly intervals to determine germination percentage as a function of storage time.

2. Several scarification treatments are used to improve germination speed and percentage with various species. We will use the standard treatments on TR seeds to determine if any of these commonly used methods improve germination of stored seeds.

(a) Mechanical: Several methods are used to break or weaken the seed coat. We will use a file, clippers or 120 grit sandpaper to achieve this mechanical scarification.

(b) Hot water: For HW scarification seeds are plunged into hot water (170-210 degrees F) for 2-5 minutes, following by immediate rinsing in cold water. Volume of water will be 10 times the volume of seed.

(c) Chemical scarification: Sulfuric acid and common household vinegar are used for chemical scarification treatments. We will use 20, 40, 60, or 120 minute treatment periods to determine if this method will improve TR seed germination.

(d) Water soak: We used a 24 hour water soak prior to sowing in our preliminary studies. This treatment led to 93% germination of 2 month old seeds. This is an admirable result, but there is no reason to believe that the 24 hour soak is optimum. Thus, we will use 12, 24, 36, and 48 hour pre-sowing water soak treatments to determine the most appropriate duration.

3. Other pre-plant chemical treatments have been shown to improve germination of many species. These treatments are not scarification treatments. Soaking for 2-24 hours allows these chemicals to infuse into the seed.

(a) gibberellic acid: GA is a plant hormone that acts as a germination promoter. We will use 100, 200, 300, 400, or 500 ppm GA for these studies.

(b) ethephon: This chemical decomposes within plant tissues to generate the plant hormone ethylene. We will infuse ethephon at 1, 5, or 10 mM for these studies.

(c) nitric oxide: Sodium nitroprusside is a nitric oxide donor. This donor has been used to break seed dormancy in some species. We will use 25, 50, 100, 200, or 300 μM for these studies.

Vegetative propagation methods

The methods used in developing a protocol for stem cutting propagation are even more straight-forward than for seed propagation. Three factors will be used to determine the feasibility of using stem cuttings for propagating TR.

1. Stem age – We will use distance from the stem tip as one source of variation. Tip cuttings will have healthy leaves, and will require intermittent mist to ensure cuttings do not desiccate during the propagation period. We will not use large, old stem sections since this will damage existing trees. However, if a typhoon impacts Guam's TR population during the contract period we will

harvest any large limbs that are broken from existing trees and attempt to develop a propagation protocol using these large stem sections.

2. Air drying – Some members of the TR plant family are easily rooted, but only if stems are allowed to air dry for several days after being removed from the parent plant. We will use this pre-treatment with the older stem sections that lack leaves. Air dry treatments will be 1-7 days prior to planting.

3. Rooting hormone – Treatment of stem cuttings with auxins are known to increase the percentage of cuttings that form roots, shorten the time needed to form roots, and increase the number of roots per cutting. Indolebutyric acid (IBA) is the best product to use because it is non-toxic over a wide range of concentrations and has been shown to be effective for a wide range of species. The product is applied to the base of a cutting as a quick soak in a concentrated solution. We will use concentrations of 500, 1000, 2500, 5000, or 10000 ppm IBA. Plumeria responds well to treatment with 2500 ppm IBA, so we anticipate TR will also respond well to this treatment.

In-situ establishment methods

Observations of the TR population dynamics following major canopy damage from typhoons have been made for several years. Copious seed germination within the vicinity of a mature TR individual occurs when the forest canopy cover is reduced. This reveals anecdotal evidence that TR behaves like a pioneer species, and that the mechanism of seed dispersal has been interrupted. Since these seedlings are in extreme competition with each other, many of them are stunted by the half-siblings that are able to reach the tallest positions in the mass of seedlings. Eventually many of these stunted seedlings die from competition for light and/or edaphic resources. Resource managers would benefit from learning more about methods to disperse some of these seedlings prior to their death.

Methods for this portion of the contract will be restricted to using typical horticultural procedures for transplanting established individuals. We will focus on the early part of the rainy season for initial attempts at transplanting. If transplanting these individuals is successful with no or very few follow-up visits, this will be an effective means of intervening to help the TR population find niches to occupy, niches that would have likely been occupied by the population prior to the loss of seed dispersal.

E. Characterize the phenological patterns of known *Tabernaemontana rotensis*

General phenology observations will document major vegetative changes in the population of known TR plants. This will primarily focus on timing of flowering, fruiting, vegetative growth, and any observed herbivory. Data will be recorded as percentage of canopy involved in each of these categories. We will also attempt to document the source of herbivory and any other general plant community interactions that are observable at the time of the visits. These observations will be made from 1 to 2 month intervals for the duration of the project.

Additionally, detailed phenology of developing fruiting structures will be made from the time of flowering until seed dispersal. This information will allow resource managers to accurately predict the date of seed collection whenever a flowering cycle is noticed in the TR population.

F. Characterize the importance of established threats to *Tabernaemontana rotensis*

This deliverable will be developed as a synthesis of all experimental and anecdotal information that is gleaned during the course of carrying out the contract. Thus, this deliverable will be an end product after Items A-E have been completed.

G. Reports

Initial summary report will be submitted 6 weeks prior to the termination of the contract period.
Final summary report will be submitted 2 weeks prior to the termination of the contract period.
Final Revised Written Report will be submitted at the termination of the contract period.