FINAL REPORT

ESTABLISHMENT OF BASELINE MONITORING

December 2012

Prepared for:

Naval Facilities Engineering Command Marianas
Guam 96915

Contract Number N62742-11-D-1825-JQ03

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LIST OF ABBREVIATIONS AND ACRONYMS

AFB	Air Force Base
cm	Centimeters
DoD	Department of Defense
GPS	Global Positioning System
HACCP	Hazard Analysis Critical Control Point
HIES	Hawaii International Environmental Services, Inc.
I&M	National Park Service Inventory and Monitoring Program
Hrs	Hours
JGPO	Joint Guam Program Office
m	Meters
m^2	Square meters
NAVFAC	Naval Facilities Engineering Command
NAVFACMAR	Naval Facilities Engineering Command Marianas
PVC	Polyvinyl Chloride
SESC	Spatial Environmental Solutions Corporation
USGS	United States Geological Survey
USDA	United States Department of Agriculture
UV	Ultraviolet
UXO	Unexploded Ordnance
WP	Work Plan

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EXECUTIVE SUMMARY

Spatial Environmental Solutions Corporation (SESC) has prepared this project report for Naval Facilities Engineering Command Marianas (NAVFACMAR) in accordance with the scope of work. This work plan documents the procedures that were followed to develop and implement a baseline study of terrestrial vegetation, invertebrates and vertebrates in select locations of Andersen Air Force Base (AAFB) to document the effectiveness of Hazard Analysis and Critical Control Point (HACCP) implementation at construction sites and provide a protocol and basis of comparison for future long-term monitoring efforts.

A HACCP plan is a tool created by examining activities in a five step process to determine if, when and how invasive species might be moved or released (Britton *et al.* 2011). The most effective ways to prevent, minimize or control this risk are then developed. Implementation of HACCP plans is new to construction management and natural resources management on Guam, and this study is designed to aid in evaluating the success of HACCP plans in preventing the incursion of invasive species. SESC has developed a long-term monitoring protocol and conducted a baseline study of existing species around three construction areas before disturbance from construction activities has begun.

The baseline monitoring protocol was developed for construction projects on Department of Defense (DoD) lands. The baseline monitoring protocol monitored vegetation that was adjacent to or contiguous with recovery habitat. Recovery habitat is a term defined in the Biological Opinion for the Joint Guam Program Office Relocation as "the habitat that is currently suitable to support the recovery of listed species." In accordance with the Conservation Measures in the Biological Opinion, monitoring efforts were focused within a 98.4 ft (30 m) buffer into the habitat surrounding the proposed construction sites. Three sites on Andersen Air Force Base (AFB) were identified for this project (Appendix 1).

Field work began in March 2012 and concluded in July 2012. A total of 3000 meters (m) of transect were surveyed, resulting in identification of approximately 115 plant species, 2 large mammals, 8 birds, 8 small vertebrates and over 80 invertebrates.

SECTION 1 - INTRODUCTION

1.1 Background

Invasive species are a concern world-wide, and are particularly damaging on islands with unique, isolated ecosystems that have little or no natural predators, competitors or pathogens to keep the introduced species in check (Fritts and Rodda 1998, Mooney and Cleland 2001, Reaser *et al.* 2007). Invasive species can cause severe ecological and economic damage, as well as carry disease (Britton *et al.* 2011). Guam has been particularly impacted by invasive species, with at least 131 known non-native species identified on the island (Global Invasive Species Database). One well-known example that demonstrates how damaging the introduction of a new species can be is the brown tree snake (*Boiga irregularis*), introduced to Guam in the 1950's (Fritts and Rodda 1998). Subsequent to this introduction most of Guam's native vertebrates, including birds, mammals and lizards, are either endangered, extirpated, or in the case of endemics such as the Guam Flycatcher (*Myiagra freycineti*), extinct. The introduction of new species continues to be a problem on Guam, with more recent introductions, such as the Coconut Rhinoceros Beetle (*Oryctes rhinoceros*), causing significant damage (Moore 2007).

One method to aid in prevention of introduction of invasive species is Hazard Analysis and Critical Control Point (HACCP) planning, which was originally developed for the food industry and later modified by the United States Fish and Wildlife Service for application to natural resource management actions (Britton *et al.* 2011). Development of a HACCP plan is a process used to identify which activities create a high risk of invasive species introduction and implement the most efficient methods (control measures) to reduce that risk. HACCP plans also include a monitoring protocol and establish corrective actions if control measures have failed.

The intent of this project was to establish a baseline of both native and non-native plants, vertebrates and invertebrates present prior to the beginning of planned construction activities. This baseline will serve as a reference for subsequent monitoring efforts conducted concurrently with construction in order to aid in evaluating the success of implemented HACCP plans. The baseline will also provide a basis of comparison for relative abundances of invasive species during construction, as well as whether any species detected during long-term monitoring are newly introduced or were present prior to the beginning of construction.

In developing this monitoring protocol, every effort has been made to reference studies based on Guam or other Pacific Islands with relevant methodologies already tested in the ecosystems and environments that will be encountered during this baseline study. Recommendations for developing long-term multi-species monitoring programs from both the federal Government and the Government of Guam natural resources agencies have been incorporated to fit the needs and scope of this project.

1.2 Site Location and Setting

This baseline monitoring plan and protocol were developed for construction projects coordinated through the Joint Guam Program Office (JGPO) on Department of Defense (DoD) lands on Guam. A total of ten transects were placed around three separate DoD construction sites, all located on Andersen Air Force Base (Appendix 1). Transects were placed within a buffer of 30 m of the perimeter of each planned construction site.

1.3 Health and Safety

While no unexploded ordinances (UXO) were discovered by the field team directly, site access to transects 5, 6, 8 and 10 (Appendices 2, 3 and 4) was restricted at varying times during field work to allow UXO teams to sweep those areas and remove discovered UXOs. These sweeps were executed by various companies associated with separate projects in or adjacent to the survey sites established for this project. These companies included Unitek Environmental Guam and Hansel Phelps-Granite Joint Venture. In addition, the original methodology for this project was modified to accommodate the restriction on digging or inserting objects into the ground to comply with UXO safety standards.

SECTION 2 – METHODS

2.1 Sampling Units, Placement and Frequency

The design of this project was based on multiple references with an emphasis on the National Park Service Inventory and Monitoring Program (I&M) protocols for the Pacific Islands Network or other park systems where necessary (Ainsworth *et al.* 2011, Busteed *et al.* 2011, Camp *et al.* 2011), and the United States Department of Agriculture (USDA) Multiple Species Inventory and Monitoring Technical Guide (Manley *et al.* 2006). These protocols were modified to fit the needs and scope required for this project. The I&M protocol recommends using belt transects with sampling points nested within each transect (Appendix 5). I&M protocol also recommends a two panel design with approximately half of the belt transects in a fixed location, and the other half in new locations for each sampling cycle (Ainsworth *et al.* 2011, Camp *et al.* 2011). Due to the limited space in which transects can be placed for this project, only fixed transects were recommended to avoid spatial auto correlation.

The scientific method dictates that transects be placed randomly within the sampling area to avoid bias. However, the intent of this project is to detect any invasive species that may be introduced as a result of construction activities. To meet the intent of the project, and remain scientifically sound, the baseline monitoring protocol was designed to focus on areas where newly introduced species were most likely to occur, which was determined to be the construction staging areas for each site (outlined in Appendices 1 and 2), while providing a representative sample of the entire construction area. Sampling was conducted in a 30 m wide zone around the perimeter of the construction site. Transect locations within this zone are referred to as the sampling area in this document.

As recommended by I&M protocol, each transect contained sampling points where intensive biological surveying and sampling took place. Each point was spaced at intervals of 150 m as

recommended in a previous survey (Camp *et al.* 2011), making each transect 300 m long with three sampling points each (Appendix 5). Field observers set traps and/or conducted vegetation surveys at each point, and surveyed 5 m on either side of the entire transectto record any additional species not encountered at the points. The radius of each sampling point was variable depending on the type of sampling being conducted. Every effort was made to place transects only in undeveloped or vacant land with a focus on areas that were predominately vegetation; however, due to the additional requirements of being close to the planned construction staging areas and within the 30 m buffer zone, some transects crossed open field or paved areas. Care was taken to ensure that points did not fall in these areas. The sampling points within each transect were marked at the center with rebar. A GPS location was collected for each point at the rebar. Biodegradable flagging tape was placed between points along the transect for use during sampling and removed after sampling was complete.

Sampling methods were designed for a minimum of two samplers working as a team to collect data and set traps. For the first four transects sampled, a larger team was used to train all field personnel on the methods employed as well as to complete transects in a timely manner regardless of lack of familiarity with the specific methodology and sites. Once all personnel were trained, a two person field team was used for sampling the remaining transects. Each transect took one week to fully complete. Most transects were sampled consecutively within a single week; however, due to site access complications with concurrent UXO sweeps being conducted, transects 5, 6, 8 and 10 were sampled across more than one week each.

Most of the methods described below are presence/absence studies. Both active and passive sampling methods were employed. Active sampling included methods that require a sampler present for the duration of data collection, while passive sampling methods did not have continuous monitoring.

Baseline monitoring establishes a time zero control prior to a potential disturbance. Therefore, descriptive statistics were calculated to show which species were most common, and additional calculations of relative abundance, species richness and proportion of invasive species to native species were also calculated. Over time, continued monitoring will determine any significant changes in these areas when compared to the baseline data.

2.2 Vegetation Monitoring Protocol

One 5 m by 20 m vegetation plot was placed at the center of each sampling point within each transect, making a total of three vegetation survey plots per transect. Within the each plot, all plant species were recorded. Rope was strung along the length of the plot at 1 m intervals to ensure plants were not surveyed more than once, and to keep within the boundaries of the 5 m by 20 m area. A 1 m by 1 m quadrat was created using ½ inch polyvinyl chloride (PVC) pipe and this was moved along each row of the plot until the entire area had been surveyed. This equaled 100 quadrats for each vegetation plot. In some cases a quadrat was miscounted, leaving fewer than 100 quadrats for a vegetation plot. Because area was not a factor in the data analysis and any unusual species were noted even if considered outside the vegetation plot, it was determined that going back to add additional quadrats would provide little benefit to the baseline study and only cause the likely pseudo-replication of individual plants that had already been surveyed. After the vegetation plots were completed for a given transect, the field observers walked the

entire transect between points and recorded invasive species and species that were not found within in the vegetation plots. When a new species was encountered, samples were collected, and in most cases photographs were taken for later identification purposes. These photos were included with the survey data.

For ease of identification and data entry while in the field, most plants were given field nicknames. Some species were not able to be identified with the specimens and reference resources available for this project. These plants have kept their field identification names in the database. Most species also have notes on morphology, which were also included in the database.

2.3 Invertebrate Monitoring Protocol

Multiple sampling techniques were used to sample invertebrates. Sampling methods are described according to target taxa. A layout of the sampling design can be seen in Appendix 6. Arthropod survey methods were modified from what was described in the final work plan due to digging restrictions within the sites. The shallow pan trap was changed so that digging was not required, and pit fall traps were removed.

Gastropods – Hopper and Smith (1992) was the basis of the sampling techniques used for gastropods. A visual survey of each vegetation plot (5 m by 20 m) was conducted for 20 minutes. The field observer looked between 1-3 m off the ground, searching trunks, the undersides of leaves, and looking for empty shells on the ground. Leaf litter was not disturbed while looking for shells to avoid spending effort on sites where snails were historically, but not currently, present. If no snails were found after 20 minutes of searching efforts, the survey for that point was concluded. If live native snails had been found, the search would have continued until no more specimens were sighted for 10 minutes after the last sighting. Due to the low number of live snails observed, and no live native snail observations, the searches did not expand outside the vegetation plot perimeter or beyond 20 minutes. These surveys were conducted once for each transect. It was determined that snails were more likely to be visible early in the day while it was cooler and moister. Therefore, surveys were generally conducted early in the morning.

Arthropods – To sample the wide array of arthropods, techniques similar to those used in the Pagan Island Arthropod Survey (Evenhuis *et al.* 2010) were used; modifications to this method are outlined. One randomly assigned point per transect was sampled for arthropods. Random point assignment was conducted by having one field member blindly select a point out of a hat. Both active and passive trapping occurred over a 72 hour period. Passive traps were checked every 24 hours to replenish chemicals and remove specimens as necessary. Ultraviolet (UV) light traps were employed one night of the sampling period. Collection methods are described in detail below.

Malaise traps – These tent-like traps are particularly successful in catching flying insects. The trap used in this study was a Townes style and covered an area of approximately 2.4 m^2. The mesh panels directed the insects to the top collection head, filled with a 90 percent ethanol or ethylene glycol solution. One malaise trap was situated near the center of the randomly chosen

invertebrate point. This trap was deployed for 72 hrs. Kill jars were checked and refreshed every 24 hrs.

Yellow pan traps – The pans used for this trap were 9 in by 9 in baking dishes spray painted neon yellow and filled with a 70 percent ethanol solution with a few drops of liquid dish detergent to break the surface tension (Missa *et al.* 2008). Five pans were situated in a circle within 5 m to 10 m from the point center and outside the vegetation plot. The final work plan stated that one shallow pan trap would be placed underneath the malaise trap to catch any falling insects; however, it was determined that this was not a successful trapping location, so it was moved to the outer circle with the other four traps. During the planning phase, the pans were to be buried with the top rim of the pan flush with the ground; however, digging was prohibited. Therefore, to increase capture rate, wooden ramps were attached to each side of the pan, enabling insects to crawl into the trap. Shallow pans were checked and refreshed with new ethanol solution every 24 hours for three days. Because it was discovered that feral pigs were drinking from these traps, as a result only ethanol, and not propylene glycol, was used in the trapping solution.

Ultraviolet light traps – Light traps were used at night to sample nocturnal insects that would otherwise not be captured during daytime sampling. An ultraviolet light trap was used for this sampling effort. This trap consisted of a UV light to attract nocturnal insects and a small fan to suck insects into a kill jar containing 90 percent ethanol or ethylene glycol solution. A few drops of liquid dish detergent broke the surface tension of the solution so that insects could not float. This trap was battery powered and had a light sensor that turned the UV light bulb on at dusk and off at dawn. The fan remained on after dawn to keep insects inside the kill jar. This method enabled nocturnal trapping to last approximately 12 hrs; a longer sampling period than would have been possible with the active sampling technique proposed in project the work plan.

Aerial sweep nets – Whereas the methods described above are ideal for mobile arthropods, they are less likely to attract or trap arachnids, particularly web-dwelling species (Sorensen *et al.* 2002). To sample these insects heavy duty, conical sweep nets with a 38 cm diameter net and 1 m handle were used. The net was swung between knee and just above the head of the sampler within the entire 5 x 20 m vegetation plot. It was determined that a higher sweep was warranted because many spiders were located at the sampler's head or higher. Nets were emptied frequently into containers to avoid damage to captured specimens. The material in the container was then carefully searched and all collected specimens were then placed into a jar of 90 percent ethanol or ethylene glycol solution. It was also determined through the sampling process that spiders were notably present at the beginning of surveying a particular point, but after multiple days of being knocked down as the samplers moved through to check traps and conduct surveys, they were no longer as prevalent. Therefore, sweep net sampling was conducted on the first day of starting a new transect. Additionally transects 1 and 2, the first two completed, were re-sampled with sweep nets after a few weeks of not being disturbed to account for this observation.

Peanut butter bait – These traps were successful at attracting both oil and sugar loving ants that may not be sampled by other methods. Four large index cards (approximately 13 cm by 18 cm) were spread with peanut butter and set out on the ground evenly around the point. They were then allowed to attract insects for a minimum of 20 minutes and a maximum of one hour. All insects attracted to these traps were pooled into the same collection jar as a single sample. One sample was collected for each transect.

Other Invertebrates – It was anticipated that other invertebrates would also be caught in the traps outlined above and below. Additionally, observations of invertebrates encountered throughout the sampling process or caught in other traps were noted and added to the species list.

2.4 Vertebrate Monitoring Protocol

Sampling methods were created for three vertebrate categories: birds, small vertebrates, and large vertebrates or mammals. Small vertebrates were trapped at one, randomly chosen point within each transect. Vertebrate and invertebrate sampling points were never the same to avoid complications in trap overlap. A layout of the sampling methodologies is provided in Appendix 7. Sampling methods are as follows:

Birds – Point counts were conducted to sample the avifauna of each site. Counts were completed first thing in the morning because it was observed that this is the time when birds are most active and likely to vocalize. An 8 minute observation period was conducted at each point along the transect. During this period, all specimens seen or heard for the first time were recorded, along with estimated distance from the point center. It was planned that observers would be stationed at the center of the point (Camp *et al.* 2011); however, it was determined that the best use of multiple observers was to have them move quietly about the point during the sampling period, increasing both visual and audio encounters. This was particularly beneficial on AAFB, because the frequent aircraft traffic made observations more challenging. Care was taken not to count the same animal twice, and there was no distance limit to observations. Binoculars were used to identify species that were visually observed at a far distance. While moving between points, samplers recorded any new observations and included distance estimates to the nearest point.

It should be noted that aircraft traffic was very high during the sampling period for this project. While no additional species were noted during times in between flight take-offs and landings, the calculated abundances may be somewhat depressed from actual numbers.

Small Vertebrates – Small vertebrates were sampled using three methods of live traps, line traps, funnel traps and glue boards. The original protocol outlined in the work plan was to use line fall traps, in which a bucket would be placed in a hole where the top rim was flush with the ground. Due to the digging restrictions, modified line traps were employed where funnel traps replaced the buckets (Manley *et al.* 2006, Busteed *et al.* 2006). The line trap used a 5 m silt fence to direct small animals into the funnel traps, placed at both ends and the center of the fence. The bottom of the fence was secured tightly to the ground with short nails to prevent animals from running underneath it. The funnel traps were cylindrical in shape with cone shaped openings on both ends. The large opening of the cone faced outwards. Animals entered the large opening, but were not able to exit the trap through the smaller opening inside. Boards were placed over the funnel traps to increase the likelihood that small vertebrates would seek shelter within them. Leaf litter and sticks found nearby were wedged into the crevice between the side of the round trap and the ground to ensure that animals would not be able to run between the trap and the fence, evading capture. Three line traps were placed evenly around the point with the closer end approximately 5-7 m from the point center and the other end 10-12 m away (Appendix 8). Five additional funnel traps were placed around the point at a distance of 5 m from the center and between the line traps.

To allow for the most efficient use of time, fencing for the line traps was installed the week prior to sampling a particular transect. The morning that sampling began all funnel traps were put in place and secured. After being installed, traps were checked once every 24 hours over a 72 hour period. Baiting was attempted using sardines and a mixture of peanut butter and honey in different traps to determine whether or not this increased capture rate. When no captured specimens were found in baited traps, this practice was discontinued.

To capture small reptiles and amphibians, glue board traps have been recommended as the most successful method (Rodda *et al.* 2005), and the methodology outlined in Rodda *et al.* (1993) was used for this survey. Twelve glue board traps were placed in a circle around the center of the sampling point, with approximately 7 m between each trap. An additional 12 traps were then stapled to tree trunks or large limbs at chest height and as near as possible to the corresponding trap on the ground (Appendix 9). Once placed, traps were checked approximately every two hours and taken down when field work was completed for that day. New traps were put out every morning over a 72 hour period.

Large vertebrates – It was beyond the scope of this project to trap large vertebrates such as feral hogs and deer. However, evidence of large vertebrates was noted during other sampling efforts around the points and during a survey walk of the entire transect. Indicators of large vertebrates noted were tree scrapings, tree rubs, disturbed ground from digging, scat, bedding grounds, antler sheds, and live sightings. Large mammal signs were ubiquitous throughout the sampling sites. Comparisons to later sampling efforts would be extremely difficult.

2.5 Data Analysis

During sampling, each transect was treated as a single unit, independent of all other transects. For analysis and the presentation of results, the transect data were pooled by project sites J001, P100 and P101. Because the purpose of this survey was to provide a baseline reference for three independent construction sites, no comparative analyses among sites or on all ten transects pooled together were conducted.

All of the species detected were compiled into a comprehensive dataset to allow the ability to look at data by transect or project site. Errors that occurred during data collection were addressed by site re-visits to determine the correct information when possible. There were a very small number of plant entries (approximately 20 out of nearly 150,000 total) where re-visits were not sufficient to determine the identity of the specimen. None of these entries were new species, therefore these entries were struck from the dataset prior to analysis.

Species richness and composition were determined, including a comparison of native and non-native species for all taxa except insects, the nativity of which were too complex to address. The native range of some plant species was difficult to determine, either due to difficulty with species identification or lack of references specific to Guam. There were several sources used to determine the identification and nativity of plant species (McConnel and Guitierrez 2006; Moore and McMakin 1979; Raulerson and Rinehart 1991, 1992; Reddy 2011; Yoshioka 2008). All native and non-native plants confirmed by these sources were identified in the database, and were used for native versus non-native species comparisons for each site. It should be noted that

mosses were counted as native species based on the moss key used to identify to genera (Miller 1968). This may not be accurate for all species of mosses, but few sources for moss native ranges exist for Guam. Other species which were of uncertain native range were considered non-native for the purposes of determining the ratio of native to non-native species.

Insects were consistently identified to Order, therefore diversity indices and descriptive statistics analyses were conducted at this level. Because many species were also identified to Family, richness at this level was also calculated. In cases where Family could not be identified, richness is a conservative estimate where each unique higher order was counted as having one Family. For example, if the lowest order of identification was Super Family, two unique Super Families within the same Order would be counted as having one Family each.

The community descriptive statistics calculated were Species Richness (S), Relative Abundance (p_i), Shannon-Wiener Diversity Index (H'), Simpson's Diversity Index (D), and Evenness (E). Species richness is a count of how many species were observed (Colwell 2009). Relative abundance is calculated by dividing the number of observations for a single species (n) by the total number of observations for the population (N). Shannon-Wiener Diversity Index ($H' = -\sum p_i \ln(p_i)$) measures the probability of incorrectly predicting which species or group a randomly selected specimen would come from (Zar 1999). The measure of this index approaches 0 when there are only a few abundant species (even if there are many rare species) and increases as the abundance of each species becomes more equal. The maximum that this measure can reach (H'_{max}), when probability of an incorrect prediction is highest, equals the natural log of species richness (lnS). Simpson's diversity index ($D = \sum(p_i)^2$) measures the probability that two randomly selected individuals in a population will be from the same species (Colwell 2009), or whatever category is being used to group the individuals (in the case of insects for this project, Order). The range of this index is from 0, representing infinite diversity, to 1, representing no diversity (every specimen belongs to one species or group). Evenness ($E = H'/\ln(S)$) is a measure of how equally each species, or group, is represented. When all species are equally abundant, this measure equals 1. As the abundances become more dissimilar (some abundant species and some rare) this measure decreases to 0. Due to the low species richness and encounter rates for gastropods and large mammals, diversity indices were not calculated for these taxa.

Because there were multiple sampling methods applied to sample invertebrates and small vertebrates, all species from each trap type were combined to determine total species richness and create a master species list. The capture success of individual trapping methods was also analyzed to determine whether or not each method is essential to future sampling efforts. Sampling methods that had multiple units per transect (i.e. shallow pan traps, glue boards, line traps) were pooled and treated the same as methods which had only one sampling unit per transect (i.e. malaise trap, UV light, sweep net), where only one value of species richness was generated for each transect, but a mean was calculated for the overall project site. Due to normality assumption violations and small sample size, standard deviations were not calculated for every site. Mean species richness and standard deviation was calculated for the vegetation plots of each transect, but it should be noted that P100 was the only site that did not violate normal distribution assumptions (determined with species richness histograms).

The bird sampling techniques used in this protocol were based on audio-visual detection only, as opposed to capture and release. Some species of birds were more vocal or active and so better

detected by this method. Even within the same species, variations in behavior, weather condition or observer bias affected detectability. In order to observe trends in species richness of birds over time, a detection history for each species at each sampling point would need to be determined. Therefore, a list of detectable species (i.e. species richness) for each sampling period was produced from the surveys conducted during this study. These values, however, will not be comparable to future sampling periods due to variation in detectability among species (from varying behavior and abundance) and among years (due to weather and observer turnover). However, the presence or absence of both existing and new species can be determined in future sampling efforts, as well as a comparison of the ratio of native to non-native species over time.

SECTION 3 - RESULTS

Surveying all ten transects, including post survey site re-visits, took place from 15 March, 2012 to 31 July, 2012. It took five days to fully complete the field work for a transect, with enough time on the fifth day to set up the next transect for the following week of sampling. This allowed the weekend for the disturbance at the site from installing traps to settle before sampling began. This did not include the considerable amount of additional time required to identify plants and insects collected during sampling and data entry and analysis. The results are presented by project site.

3.1 Project Site J001

Project site J001 was represented by transects 6, 7 and 8 (Appendix 2). These transects bracketed the construction staging area provided by construction drawings. A complete species list for this project site can be seen in Appendix 10.

This site was primarily limestone forest habitat. The overall vegetation species richness for this site was 104 species (Table 3.1.1). Of these, less than half (approximately 0.45 of total) were native species. One native species (*Oplismenus compositus*) ranked in the top five most abundant species (Appendix 11), and a second (*Nephrolepis hirsutula*) ranked in the top ten. However, the most abundant species (*Phyla nodiflora*) outnumbered the second most abundant by more than 15,000 individuals. Species richness was similar among the three transects, with an average species richness per site of approximately 32 (±11) species. Each transect had an individual mean within standard deviation of the overall mean. The Shannon-Wiener Diversity Index (H') was measured to be 2.51. Simpson's Diversity Index was 0.19, while overall evenness (E) was 0.54.

Table 3.1.1 Vegetation Descriptive Statistics Results for Project J001

Number of records: 56,693
Species richness in Vegetation Plots: 92
Species richness without fungus and cyanobacteria: 88
Richness including additional observations from transect walk: 104
Richness including additional observations without fungus and cyanobacteria: 99
Richness native: 47
Richness non-native: 52
Mean species per transect:
Transect 6: 37
Transect 7: 34.3
Transect 8: 31.7
Overall (±st. dev): 34.33 (±11.15)
Shannon-Wiener (H'): 2.51; H'_{max}: 4.58
Simpson's (D): 0.19
Evenness (E): 0.54

Birds, gastropods and large mammals were represented by relatively few species at site J001. The results for these three taxa are presented in Table 3.1.2. Six species of birds were detected, and only one was native to Guam. The Black Francolin (*Francolinus francolinus*) and native Yellow Bittern (*Ixobrychus sinensis*) were the most abundant, representing over half of the individuals surveyed. Overall diversity and evenness measures were as follows: H' 1.32; D 0.31; E 0.74. Two species of land snails were observed, neither of which were native. All observations of one species, the Giant African Snail (*Achatina fulica*) were in the form of shells, and not live specimens. For large mammals, signs such as trails, tree rubs and scrapes and scat were ubiquitous throughout the project site. Direct visual observations of the feral pig (*Sus scrofa*) and feral dog (*Cannis lupis familiaris*) were also made.

Table 3.1.2 Bird, Gastropod and Large Mammal Descriptive Statistics Results for Project J001.

Birds	**Gastropods**	**Large Mammals**
Number of records: 41	Number of records: 132	Number of records: 34
Species richness: 6	Species richness: 2	Species richness: 3
Richness native: 1	Richness native: 0	Richness native: 0
Richness non-native: 5	Richness non-native: 2	Richness non-native: 3
Relative abundances (natives in bold):		
Dicrurus macrocercus: 0.15		
Francolinus francolinus: 0.39		
Gallus gallus: 0.02		
Ixobrychus sinensis: 0.37		
Passer montanus: 0.05		
Streptopelia bitorquata: 0.02		
Shannon-Wiener (H'): 1.32; H'_{max}: 1.79		
Simpson's (D): 0.31		
Evenness (E): 0.74		

Small vertebrates had relatively low diversity, with only one native species represented in the total catch (Table 3.1.3). A large majority (0.97 of the total catch) of the specimens were either the Curious Brown Skink (*Carlia fusca*) or the native Blue-tailed Skink (*Emoia caeruleocauda*). The small vertebrate traps also caught the native coconut crab (*Birgus latro*), which was not represented in any other sampling methods. Diversity indices were calculated as follows: H' 0.76; D 0.51; E 0.47.

Table 3.1.3 Small Vertebrate Descriptive Statistics Results for Project J001

Number of records: 268
Species richness: 5
Richness native: 1
Richness non-native: 4
Relative abundances (natives in bold):
Carlia fusca: 0.35
Eleutherodactylus planirostris: 0.01
Emoia caeruleocauda: 0.62
Gekkonidae: 0.003
Rhinella marinus: .007
Non-vertebrate Catch: ***Birgus latro***
Shannon-Wiener (H'): 0.76; H'_{max}: 1.61
Simpson's (D): 0.51
Evenness (E): 0.47

Insects were by far the most diverse animal taxa sampled. A total of 3035 individuals were caught for this site. These individuals represented 15 Orders and an estimated 56 Families (Table 3.1.4). Relative abundances of most Orders were low, with 0.85 of the total abundance accounted for by flies (Diptera), wasps and ants (Hymenoptera) and two-pronged bristletails (Class Diplura). The diversity indices for this taxon were as follows: H' 1.55; D 0.26; E 0.57.

Table 3.1.4 Insect Descriptive Statistics Results for Project J001

Number of records: 3,035		
Order richness: 15		
Family richness: 56		
Order (*number of Families is an estimate)	**Number of Families**	**Relative Abundance**
Actinedida	1	0.00066
Araneae	4	0.00230
Blattodea	2	0.0020
Coleoptera	14	0.018
Diptera*	12	0.20
Hemiptera	3	0.0033
Hymenoptera*	8	0.31
Lepidoptera*	2	0.079
Orthoptera	4	0.0020
Poscoptera	1	0.038
Pseudoscorpiones*	1	0.001
Spirobolida	1	0.00033
Thysanoptera	1	0.0023
Diplura (Class)*	1	0.34
Tardigrada (Phylum)*	1	0.0023
Mean number of Orders (± st. dev): 11.3 (±2.31)		
Mean number of Families (±st. dev): 32 (±5.57)		
Shannon-Weiner (H'): 1.55; H'_{max}: 2.71		
Simpson's (D): 0.26		
Evenness (E): 0.57		

3.2 Project Site P100

Project site P100 was the largest and most spread out of the three projects and so covered the most habitat types. The site was sampled with transects 1, 2, 3, 4, and 5, which were placed as close to the off-base staging area as possible, and along the route that heavy equipment and supplies would take to access the construction area (Appendix 3). A complete species list for this project site can be seen in Appendix 12.

These transects were located in a mix of open, grassy areas, Tangan-tangan (*Leucaena leucocephala*) scrub forest, and limestone forest. The overall vegetation species richness for this site was 131 species (Table 3.2.1). Of these, less than half (approximately 0.40 of total) were

native species. One native, the Scaly Swordfern (*Nephrolepis hirsutula*) ranked in the top five most abundant species (Appendix 11), while a total of four ranked in the top ten. The gap between the top two most abundant species was approximately 2,500 individuals. Species richness was similar among the three transects, with an average species richness per site of approximately 33 (±9) species. Each transect had an individual mean within standard deviation of the overall mean. The Shannon-Wiener Diversity Index (H') was measured to be 3.34. Simpson's Diversity Index was 0.07, while overall evenness (E) was 0.70.

Table 3.2.1 Vegetation Descriptive Statistics Results for Project P100

Number of records: 36,006
Species Richness in Vegetation Plots: 114
Species Richness without fungus & cyanobacteria: 108
Richness including additional observations from transect walk: 131
Richness including additional observations without fungus & cyanobacteria: 121
Richness native: 52
Richness non-native: 69
Mean Species Per Transect:
Transect 1: 27
Transect 2: 32.7
Transect 3: 37.3
Transect 4: 37.3
Transect 5: 30.3
Overall (± st. dev): 32.9 (±8.84)
Shannon-Wiener (H'): 3.34; H'_{max}: 4.77
Simpson's (D): 0.07
Evenness (E): 0.70

Despite the additional transects and placement in different habitat types, birds, gastropods and large mammals had overall low species diversity for site P100 (Table 3.2.2). Eight species of birds were detected, three of which were native to Guam. The Black Drongo (*Dicrurus macrocercus*) and Eurasian Sparrow (*Passer montanus*) were the most abundant, representing over half of the individuals surveyed. Overall diversity and evenness measures were as follows: H' 1.69; D 0.22; E 0.81.

Eight species of land snails were recorded; the shells of one native species (*Pythia sp.*) were observed at transects 3 and 4. Of the 509 snail observations recorded for this site, only 39 total observations were of live snails. Because most of these observations are based on shells littered on the forest floor, some of which were very weathered, additional analysis was not conducted. For large mammals, signs such as trails, tree rubs and scrapes and scat were again ubiquitous throughout the project site. Direct visual observations of the Philippine Deer (*Cervus mariannus*) were also made during transect walks.

Table 3.2.2 Bird, Gastropod and Large Mammal Descriptive Statistics Results for Project P100

Birds	**Gastropods**	**Large Mammals**
Number of records: 135	Number of records: 509	Number of records: 77
Species richness: 8	Species richness: 8	Species richness: 2
Richness native: 3	Richness native: 1	Richness native: 0
Richness non-native: 5	Richness non-native: 7	Richness non-native: 2
Relative abundances (natives in bold):		
Dicrurus macrocercus: 0.21		
Francolinus francolinus: 0.16		
Gallus gallus: 0.01		
Gygis alba: 0.01		
Ixobrychus sinensis: 0.11		
Passer montanus: 0.34		
Pluvialis dominica: 0.03		
Streptopelia bitorquata: 0.13		
Shannon-Wiener (H'): 1.69; H'_{max}: 2.08		
Simpon's (D): 0.22		
Evenness (E): 0.81		

Small vertebrates had a relatively low diversity, but three native species were represented in the total (Table 3.2.3). The majority (0.94 of the total catch) of the specimens were either the Curious Brown Skink (*Carlia fusca*) or the native Blue-tailed Skink (*Emoia caeruleocauda*). The only small mammal recorded in this baseline study, the Asian musk shrew (*Suncus murinus*) was caught at this site. The small vertebrate traps also caught the native coconut crab (*Birgus latro*) and an invasive flatworm (*Platydemus manokwari*), which were not present in any other sampling methods. Diversity indices were calculated as follows: H' 0.88; D 0.48; E 0.42.

Table 3.2.3 Small Vertebrate Descriptive Statistics Results for Project P100

Number of records: 425
Species richness: 8
Richness native: 4
Richness non-native: 4
Relative abundances (natives in bold):
Carlia fusca: 0.33
Eleutherodactylus planirostris: 0.03
Emoia caeruleocauda: 0.61
Gehyra mutilata: 0.005
Hemidactylus frenatus: 0.007
Lepidodactylus lubugris: 0.002
Rhinella marinus: .01
Suncus murinus: .002
Non-vertebrate catches: ***Birgus latro***, *Platydemus manokwari*, *Veronicella cubensis*
Shannon-Wiener (H'): 0.88; H'_{max}: 2.08
Simpson's (D): 0.48
Evenness (E): 0.42

Insects were the most diverse animal taxa sampled. A total of 4,799 individuals were caught for this site. These individuals represented 13 Orders and an estimated 75 Families (Table 3.2.4). Relative abundance of most Orders was low. The total abundance (0.83) was accounted for by flies (Diptera), wasps and ants (Hymenoptera) and moths and butterflies (Lepidoptera). The diversity indices for this taxon were as follows: H' 1.61; D 0.26; E 0.63.

Table 3.2.4 Insect Descriptive Statistics Results for Project P100

Number of records: 4,799		
Order richness: 13		
Family richness: 75		
Order (*number of Families is an estimate)	**Number of Families**	**Relative Abundance**
Actinedida	1	0.0019
Araneae	4	0.018
Coleoptera*	17	0.018
Diptera*	17	0.28
Hemiptera	7	0.018
Hymenoptera*	15	0.39
Lepidoptera*	4	0.16
Mantodea	1	0.00021
Orthoptera*	5	0.0065
Poscoptera	1	0.036
Thysanoptera	1	0.0033
Diplura (Class)*	1	0.065
Tardigrada (Phylum)*	1	0.0015
Mean number of Orders (±st. dev): 11.2 (±1.64)		
Mean number of Families (±st. dev.): 52.8 (±15.43)		
Shannon-Weiner (H'): 1.61; H'_{max}: 2.56		
Simpson's Reciprocal (D): 0.26		
Evenness (E): 0.63		

3.3 Project Site P101

Project site P101 encompasses a small area adjacent to site P100 It was represented by two transects around the perimeter of the site, transects 9 and 10 (Appendix 4). A complete species list for this site can be seen in Appendix 13. Means were calculated for vegetation plots, but not for other taxa due to a sample size of 2.

The transects for this site were located in open, grassy areas with little to no forest cover. The overall vegetation species richness for this site was 90 species (Table 3.3.1). Of these, less than half (approximately 0.46 of total) were native species. One native (*Pilea microphylla*) ranked in the ten most abundant species for the site (Appendix 11), though there was a gap of 10,000 individuals between the two most abundant species. Species richness was similar between the two transects, with an average species richness per site of approximately 35 (±15) species. Each transect had an individual mean within standard deviation of the overall mean. The Shannon-Wiener Diversity Index (H') was measured to be 2.33. Simpson's Diversity Index was 0.22, while overall evenness (E) was 0.54.

Table 3.3.1 Vegetation Descriptive Statistics Results for Project P101

Number of records: 47,005
Species richness of Vegetation Plots: 77
Richness without fungus & cyanobacteria: 73
Richness including additional observations from transect walk: 90
Richness including additional observations without fungus & cyanobacteria: 85
Richness native: 41
Richness non-native: 44
Mean species per transect:
Transect 9: 35.3
Transect 10: 35.3
Overall Mean (±St. Dev): 35.3 (±14.85)
Shannon-Wiener (H'): 2.33; H'_{max}: 4.34
Simpson's (D): 0.22
Evenness (E): 0.54

Birds, gastropods and large mammals had overall low species diversity for site P101 (Table 3.3.2). Six species of birds were detected during the point counts, two of which were native to Guam. One record of an additional native species was detected during the final transect walk, the Micronesian Starling (*Aplonis opaca*). The Eurasian Sparrow (*Passer montanus*) was the most abundant, representing over half of the individuals surveyed. Overall diversity and evenness measures were as follows: H' 1.45; D 0.31; E 0.81. Two species of land snails were observed, none of which were live specimens. The shell of one native species was found (*Pythia sp.*). For large mammals, signs such as trails, tree rubs and scrapes and scat were again ubiquitous throughout the project site. No direct visual observations of large mammals were made at this site.

Table 3.3.2 Bird, Gastropod and Large Mammal Descriptive Statistics Results for Project P101

Birds	**Gastropods**	**Large Mammals**
Number of records: 97	Number of records: 6	Number of records: 24
Species richness: 6	Species richness: 2	Species richness: 2
Richness including additional observations from transect walk: 7	Richness native: 1	Richness native: 0
Richness native: 2	Richness non-native: 1	Richness non-native: 2
Richness non-native: 4		
Relative abundance (natives in bold):		
Dicrurus macrocercus: 0.12		
Francolinus francolinus: 0.14		
Gygis alba: 0.07		
Ixobrychus sinensis: 0.07		
Passer montanus: 0.51		
Streptopelia bitorquata: 0.08		
Shannon-Wiener (H'): 1.45 H'_{max}: 1.79		
Simpson's (D): 0.31		
Evenness (E): 0.81		

Small vertebrates also relatively low diversity. Two native species were represented in the total catch (Table 3.3.3). A large majority (0.91 of the total catch) of the specimens were either the Curious Brown Skink (*Carlia fusca*) or the native Blue-tailed Skink (*Emoia caeruleocauda*). The small vertebrate traps also caught the native coconut crab (*Birgus latro*) and another native land crab (*Cardisoma carnifex*), which were not present in any other sampling methods. Diversity indices were calculated as follows: H' 0.91; D 0.49; E 0.57.

Table 4.3.3 Small Vertebrate Descriptive Statistics Results for Project P101

Number of records: 92
Species richness: 5
richness native: 2
richness non-native: 3
Relative abundances (natives in bold):
Carlia fusca: 0.65
Eleutherodactylus planirostris: 0.03
Emoia caeruleocauda: 0.26
Gekkonidae: 0.04
Rhinella marinus: 0.01
Non-vertebrate catches: ***Birgus latro***, ***Cardisoma carnifex***, *Veronicella cubensis*
Shannon-Wiener (H'): 0.91; H'_{max}: 1.61
Simpson's (D): 0.49
Evenness (E): 0.57

Insects were the most diverse animal taxa sampled. A total of 1,265 individuals were caught for this site. These individuals represented 15 Orders and an estimated 38 Families (Table 3.3.4). Relative abundances of most Orders were low, with 0.85 of the total abundance accounted for by flies (Diptera), wasps and ants (Hymenoptera) and two-pronged bristletails (Class Diplura). The diversity indices for this taxon were as follows: H' 1.51; D 0.31; E 0.56.

Table 3.3.4 Insect Descriptive Statistics Results for Project P101

Number of records: 1,265		
Order richness: 15		
Family richness: 38		
Order (*number of Families is an estimate)	**Number of Families**	**Relative Abundance**
Actinedida	1	0.003
Araneae	3	0.00230
Blattodea	1	0.0020
Coleoptera	4	0.018
Diptera*	8	0.20
Hemiptera	4	0.0033
Hymenoptera*	8	0.31
Lepidoptera*	2	0.079
Mantodea	1	0.00079
Neuroptera	1	0.00079
Orthoptera	1	0.0020
Poscoptera	1	0.038
Thysanoptera	1	0.0023
Diplura (Class)*	1	0.34
Tardigrada (Phylum)*	1	0.0023
Shannon-Weiner (H'): 1.51; H'_{max}: 2.71		
Simpson's (D): 0.31		
Evenness (E): 0.56		

3.4 Trap Efficacy

Both invertebrate and small vertebrate sampling methodologies employed more than one trapping technique. Additional analysis was conducted to assess the efficacy of each trap in providing unique information and whether or not it should be included in future sampling efforts.

For small vertebrates, the methods compared were glue boards vs. line and funnel traps. The breakdown of catch per trap type for each project site is shown in Table 3.4.1. As shown in the table, glue boards accounted for the majority of small vertebrate catches at each site. Nevertheless, funnel traps contributed unique species to the overall species list that were not caught using any other method.

Table 3.4.1 Efficacy of Small Vertebrate Traps

	Number of Individuals Caught	Proportion of Total Catch	Number of Species Caught	Proportion of Total Species Caught[a]	Number of Unique Species[b]
Project Site J001					
Glue boards	244	0.91	2	0.4	0
Funnel/Line Traps	24	0.09	5	1	4
Project Site P100					
Glue boards	378	0.89	5	0.63	1
Funnel/Line Traps	47	0.11	7	0.88	5
Project Site P101					
Glue boards	76	0.83	2	0.4	0
Funnel/Line Traps	16	0.017	4	0.8	2

[a]Some species caught in both trap types; [b] including invertebrates not recorded in any other sampling effort

The insect trapping methods compared were malaise, peanut butter, shallow pan, sweep net and UV. Malaise traps caught the most individuals at each site. However, comparing proportions of total catch for each trap is not as meaningful for these data, as each trap was intended to catch a different type of insect. A more pertinent question is whether or not each trap contributed unique catches to the overall species list. The results showed that every trap contributed at least one unique specimen at each site except for peanut butter traps. Only one species was unique to the peanut butter trap at site P101. At the other two locations, peanut butter did not contribute any unique specimens; however, this trap type did provide the most ant (Family Formicidae) catches for any single trap at all sites.

Table 3.4.2 shows how many individuals were caught from each order by each trap type. For the order Hymenoptera, an additional comparison of how many ants were caught by each trap can be seen.

3.4.2 Number of Individual Insects Caught in Each Trap Type by Order

Project J001					
Order	**Malaise**	**Peanut Butter**	**Shallow Pan**	**Sweep Net**	**UV Trap**
Actinedida	--	--	--	2	--
Araneae	--	--	1	6	--
Blattodea	5	--	--	--	1
Coleoptera	20	--	7	3	24
Diptera	251	--	22	6	323
Hemiptera	2	--	2	5	1
Hymenoptera[a]	262 (69)	229	187 (136)	168 (164)	93 (2)
Lepidoptera	149	--	1	--	91
Orthoptera	3	--	2	1	--
Poscoptera	101	--	2	2	11

Project J001 (cont.)					
Order	**Malaise**	**Peanut Butter**	**Shallow Pan**	**Sweep Net**	**UV Trap**
Pseudoscorpiones	1	--	--	2	--
Spirobolida	--	--	--	1	--
Thysanoptera	3	--	1	2	1
Diplura (Class)	1025	--	--	5	3
Tardigrada (Phylum)	7	--	--	--	--
Project P100					
Order	**Malaise**	**Peanut Butter**	**Shallow Pan**	**Sweep Net**	**UV Trap**
Actinedida	4	--	--	5	--
Araneae	1	--	1	43	41
Coleoptera	21	--	13	27	23
Diptera	633	--	392	79	227
Hemiptera	31	--	39	7	7
Hymenoptera[a]	661 (23)	708	219 (100)	76 (69)	216 (59)
Lepidoptera	603	--	22	12	144
Mantodea	1	--	--	--	--
Orthoptera	8	--	8	16	--
Poscoptera	131	--	16	14	13
Thysanoptera	2	--	8	6	--
Diplura (Class)	311	--	2	1	--
Tardigrada (Phylum)	4	--	--	2	--
Project P101					
Order	**Malaise**	**Peanut Butter**	**Shallow Pan**	**Sweep Net**	**UV Trap**
Actinedida	--	--	--	4	--
Araneae	2	--	6	34	1
Blattodea	1	--	--	--	--
Coleoptera	8	--	1	1	2
Diptera	95	--	29	2	101
Hemiptera	10	--	5	10	--
Hymenoptera[a]	54 (19)	226	103 (91)	168 (165)	79 (36)
Lepidoptera	98	--	--	1	119
Mantodea	--	--	--	1	--
Neuroptera	--	--	1	--	--
Orthoptera	--	--	1	--	--
Poscoptera	50	--	--	10	6
Thysanoptera	1	--	2	3	--
Diplura (Class)	23	--	--	--	--
Tardigrada (Phylum)	1	--	1	4	--

[a]numbers in parentheses show how many ants (Family Formicidae) were caught by this trap type. Peanut butter traps caught only ants.

SECTION 4 – DISCUSSION

4.1 Baseline Data

Among the three sites, a variety of habitat types was covered, from open grassy areas to limestone forest. Some sites were highly disturbed, and others were less so. Despite these differences, the overall results at each site were very similar for each taxa. Therefore, results are discussed by taxa rather than by site.

It should be noted that Evenness measures how equally abundant each species was, and was calculated by dividing the Shannon-Wiener index by the maximum possible Shannon-Wiener index for a site. Therefore, discussion of Evenness is also taking into account the Shannon-Wiener index for each taxa.

Vegetation – A review of species richness at each site revealed that the number of native species accounted for less than half of the total species richness. The most abundant species were always non-natives (Appendix 11). Nevertheless, at least one native ranked in the top ten most abundant species at all sites. When looking at relative abundance overall, every site had a few abundant species and many rare. This observation was confirmed when looking at the diversity indices. The Evenness measure for each site was greater than 0.5, with the highest being 0.70 for site P100. An evenness measure of this magnitude indicates that species were somewhat equally abundant with some either very abundant or very rare species. This could then be determined by looking at the Simpson's index for each site, the largest of which was 0.22 for P101. As Simpson's approaches 0, the fewer abundant species there are, indicating that there were many rare plant species at all three sites. This could also be confirmed by looking at the abundance ranking of plant species in Appendix 11, which shows that the number of individuals quickly drops off within the first ten species.

Birds – As could be expected on Guam, where the Brown Tree Snake (*Boiga irregularis*) has decimated the bird populations, the overall species richness and diversity of birds in this study was very low. Few species of birds were observed, and most were non-native. Of the native species detected, only one, the Yellow Bittern (*Ixobrychus sinensis*) was considered a resident, nesting species (*Fact Sheet*). The Lesser Golden Plover (*Pluvialis dominica*) was a migratory sea bird that did not nest on Guam, while the White Tern (*Gygis alba*) was also a sea bird and no longer considered to nest on the main island of Guam. Looking at the diversity indices for birds in this study, the range of Evenness across sites was from 0.74 to 0.81. This would indicate that most species were fairly equally represented. This is confirmed by looking at the Simpson's index, which ranged from 0.22 to 0.31, indicating that most species were equally rare.

Gastropods – Most gastropod records in this study were from shells. The most common species of shell found was the Giant African Snail (*Achatina fulica*). Some very small live snails were observed in the mosses, however collection and identification beyond genus and quantification was considered unrealistic for the timeframe and scope of this study. When observed, they were noted and added to the species list. Few native species were observed, and no live natives were found. At site P101, no live specimens and very few shells were observed. One possible reason for the low occurrence of snails is that this study was undertaken during the dry season when the weather was very hot and dry. Though efforts were made to search for

snails in the morning, it was still dry at this that time of day. This effect was exacerbated at site P101, which was located primarily in open, grassy areas. If further surveys were conducted during the rainy season, more live gastropod encounters may be possible.

Large Mammals – Signs of both the Philippine deer (*Cervus mariannus*) and feral pig (*Sus scrofa*) were ubiquitous throughout all study sites. Game trails were frequently encountered as well as other signs and actual sightings. Though quantification of these animals was not possible from the survey methods used in this study, it is possible to say that both are common and spread through all three sites. The only other species observed was the feral dog (*Canis lupis familiaris*). No native mammals were observed.

Small vertebrates – The most common small vertebrates encountered at all three sites were the Curious Brown Skink (*Carlia fusca*) and the native Blue-tailed Skink (*Emoia caeruleocauda*). Though relatively few Greenhouse Frogs (*Eleutherodactylus planirostris*) were caught, many were heard chirping at sites with native limestone forest (such as transects 3 and 4). One reason fewer were caught than vocalizations indicated were present may be because glue boards are less effective at catching amphibians, whose wet skin and other defense mechanisms are more able to resist becoming trapped by the glue (Rodda *et al.* 1993).

Geckos had a relatively low capture rate, and this may be for two reasons. Funnel traps were on the ground, lessening the likelihood that a gecko would encounter it. Additionally, glue boards were not deployed at night, when geckos are most active.

Diversity indices for each site show that Evenness ranged from 0.42 to 0.57, indicating that some species were more common and others were equally rare. This is reflected in the Simpson's index, which ranged from 0.48 to 0.51, demonstrating that some species were more common than others, but no one species was vastly more abundant. Project site P100 consistently had low index measures, due to the high occurrence of rare catches for that site, including the only small mammal, the Asian musk shrew (*Suncus murinus*).

Insects – As was found with most other taxa, insects demonstrated a few common Orders, and many that were rare. This is shown in the diversity index measures, where Evenness ranged from 0.56 to 0.63, indicating a few common Orders and more that were equally rare. Simpson's index was relatively low for all three sites, ranging from 0.26 to 0.31, indicating that there were more equally rare Orders than there were abundant ones.

The shallow pan traps would most likely have been more effective had they been dug into the ground as the methodology intended; however, catch rates were still fairly high, particularly for ants and wasps (Hymenoptera) that were likely attracted by the yellow color (Mazon and Bordera 2008). The most common order for sites P100 and P101, and second most common for J001, was Hymenoptera, and over half of this Order was represented by ants for each site, showing the abundance of ants at these sites.

4.2 Trap Efficacy

When looking at the catch rate and proportion of catch for the small vertebrate traps, it is clear that the glue boards provided the bulk of the data. Glue boards were inexpensive, and did not require large amounts of personnel time to set-up. Checking the traps and removing captured animals was more time consuming, but even the time needed for these tasks was feasible within a work day and decreased as field personnel gained experience. Because glue boards were not deployed overnight, due to access and therefore trap checking issues, most of the specimens caught were diurnal.

While they did not catch as many individuals, funnel traps proved to be valuable in catching nocturnal and other unique specimens. Funnel and line traps were the most time consuming trap to construct and deploy; however, they caught the majority of unique vertebrates and small crustaceans. Also, after initial set up these traps were also low maintenance until the 72 hour trapping period was complete. The funnel traps that were part of the line trap, where fencing directed the animals, were more successful than the stand alone funnel traps. One issue encountered with the funnel traps along the fencing was ensuring that no gaps were allowed between the trap and fencing where small animals could pass through. This was achieved by packing the gap with detritus, such as leaf material or sticks. Square shaped traps may be more effective than the round traps used in this study.

Where the small vertebrate traps were generic in their catch, each insect trap was used to target particular types of insects, i.e. malaise traps targeted flying insects, while shallow pans targeted crawling insects. Each insect trap contributed unique specimens to the overall species list. The one exception to this was the peanut butter traps for sites J001 and P100, where all the species caught by this trap were also caught in other traps. Nevertheless, peanut butter traps caught the most ants of any trap for all three sites, providing more accurate relative abundance estimates for this Family than the other traps. None of the insect traps were high maintenance after initial set up. The most time consuming aspect of the insect survey was sorting and identifying specimens after field surveying and sampling were complete.

SECTION 5 – RECOMMENDATIONS AND CONCLUSION

The methodology used in this baseline study could easily be adapted for other locations and situations, as well as for a long-term monitoring protocol for the areas sampled in this baseline study. Long-term monitoring results could then be compared to this baseline and subsequent sampling periods to determine changes in species richness over time. All of the sampling methods employed for this study were successful in adding information that was not otherwise collected to the overall species list or community picture presented. However, in the event that this protocol is used for future monitoring efforts, some minor changes and recommendations can be made.

For birds and gastropods, sampling should be conducted in the early morning. This increases the likelihood of encountering the dawn chorus for the birds, and cooler, moister conditions for the snails. For small vertebrate and insect traps, the linefall and shallow pan traps were meant to be flush with ground level. In areas where digging restrictions are not imposed, it is strongly recommended that this original methodology be employed. Funnel traps create much more

opportunity for specimens to avoid being caught. Additionally, though building round traps is easier, square shaped funnel traps are recommended to avoid the necessity of stopping gaps between the fencing and rounded side of the funnel trap. Also, it was determined during the course of this study that spiders will relocate if their webs are disturbed frequently and consistently over the course of a few days. Therefore, it is recommended to do sweep net sampling as soon as possible to get an accurate picture of the spiders present. And finally, the mortality rate caused by the glue boards was fairly high for this study. This was in part due to the very hot and dry weather during sampling periods. One recommendation for alleviating this effect somewhat is to place glue boards in shady areas. This does not affect capture rate, but does keep trapped specimens from becoming hyperthermic (Rodda *et al.* 2003).

The design of the transects in this study, with nested points, is very flexible to the location of the sampling. For example, in the event sampling areas are developed or landscaped, a single point can be placed to avoid unnecessary waste of effort and resources on pavement, where it is unlikely that invasive species will establish themselves. The placement of points should be where native vegetation is concentrated. In areas where native vegetation is not available, lawns or landscaped areas can be used.

The number and frequency of transects for this study were limited by time, funding and the number of projects required to be sampled. Sampling was focused around the construction staging areas, where the introduction of new invasive species was most likely to occur. However, given the potential mobility of many invasive species, a more comprehensive sampling effort around one site would be recommended for future baseline studies.

Ideally a baseline would sample around the entire site and in both rainy and dry seasons, to account for most life cycles and increase the likelihood of a comprehensive baseline from which to compare future monitoring efforts. It is recommended that long-term monitoring sampling occur twice during the rainy season and twice during the dry season, or if this is not possible, at least once during each season to enable the detection of newly introduced species before they become a problem, while also allowing changes to be significant enough to be detected.

Conclusions **–** The overall picture of the habitats at all three sites was one of moderate diversity with a few abundant species and many rare species. Native species were present for all taxa for which nativity could be determined, and some in relatively high abundance. However, the only case in which a native species was the most abundant for that taxa, was with the Blue-tailed Skink at sites J001 and P100. Additionally some plant species surveyed are on the International Union for the Conservation of Nature (IUCN) list of top 100 most invasive species (Invasive Species Specialist Group). These findings demonstrate the stronghold that invasive and non-native species have on Guam, confirming the necessity of preventative endeavors such as the implementation of HACCP plans.

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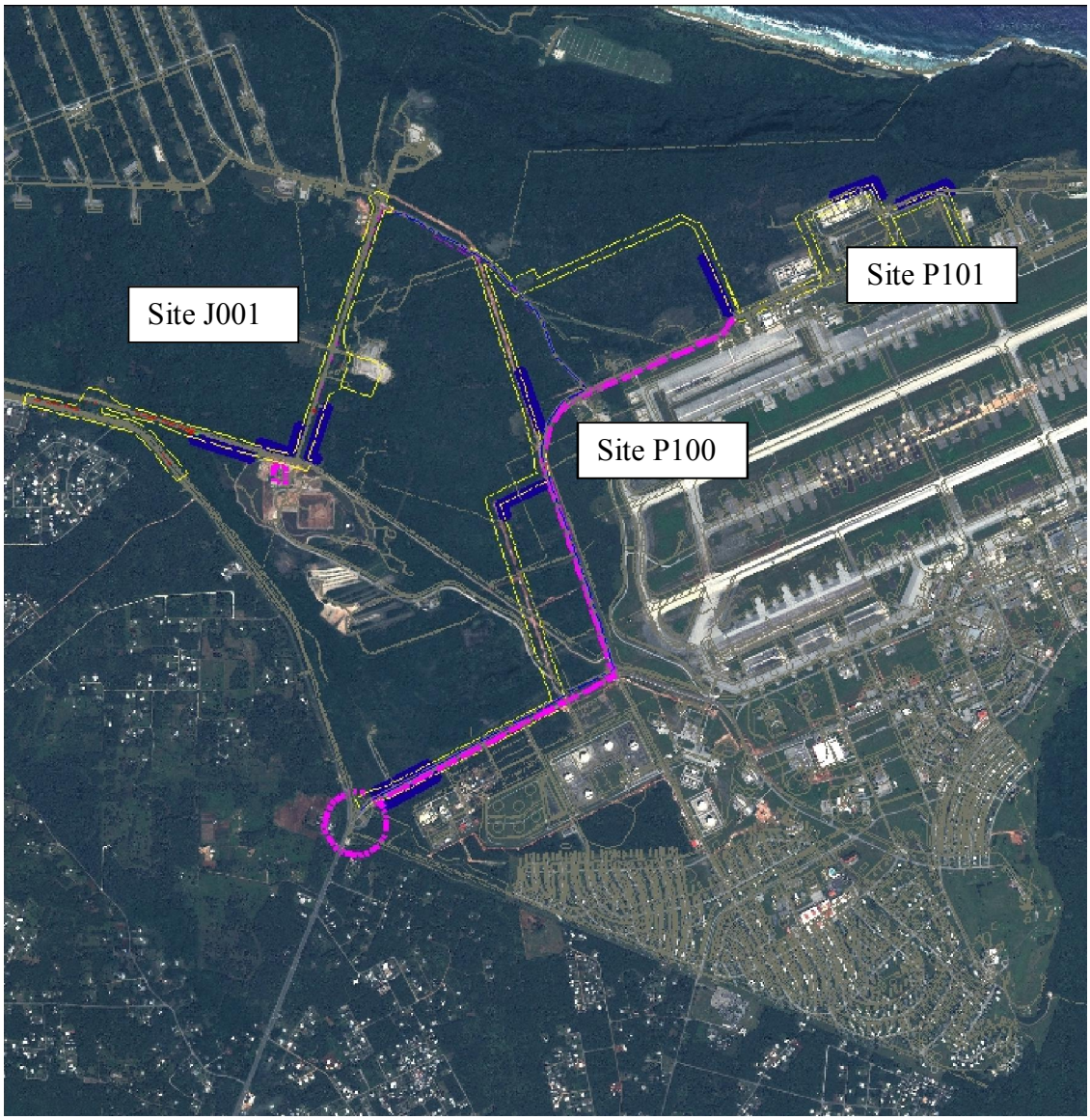
Appendix 1

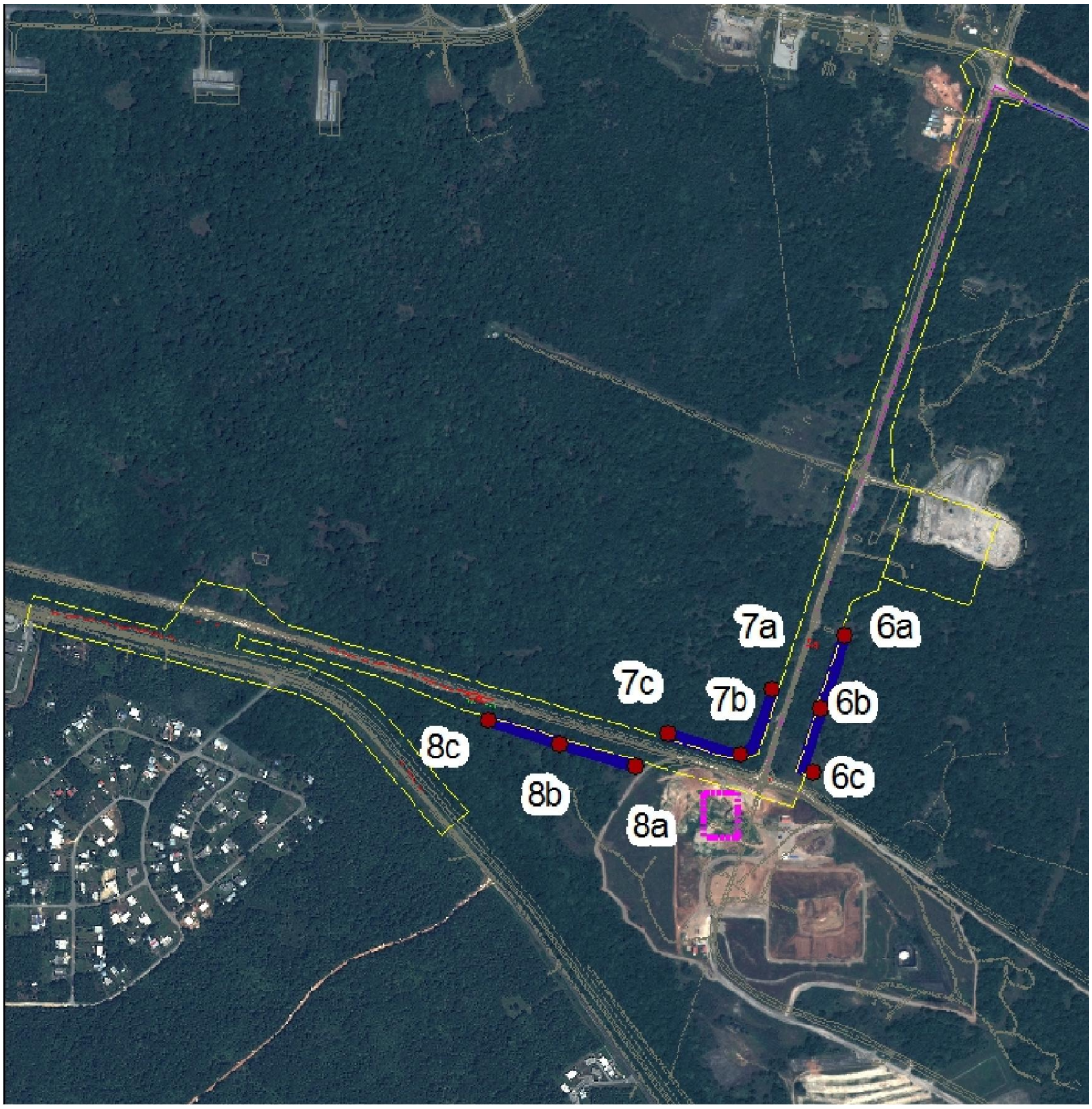
Overview of Project Site Locations on Andersen Air Force Base



Blue lines show labeled transect locations. Yellow dashed lines outline the project footprints and the pink dashed line shows staging areas and the path of equipment from staging area to construction site.

Appendix 2

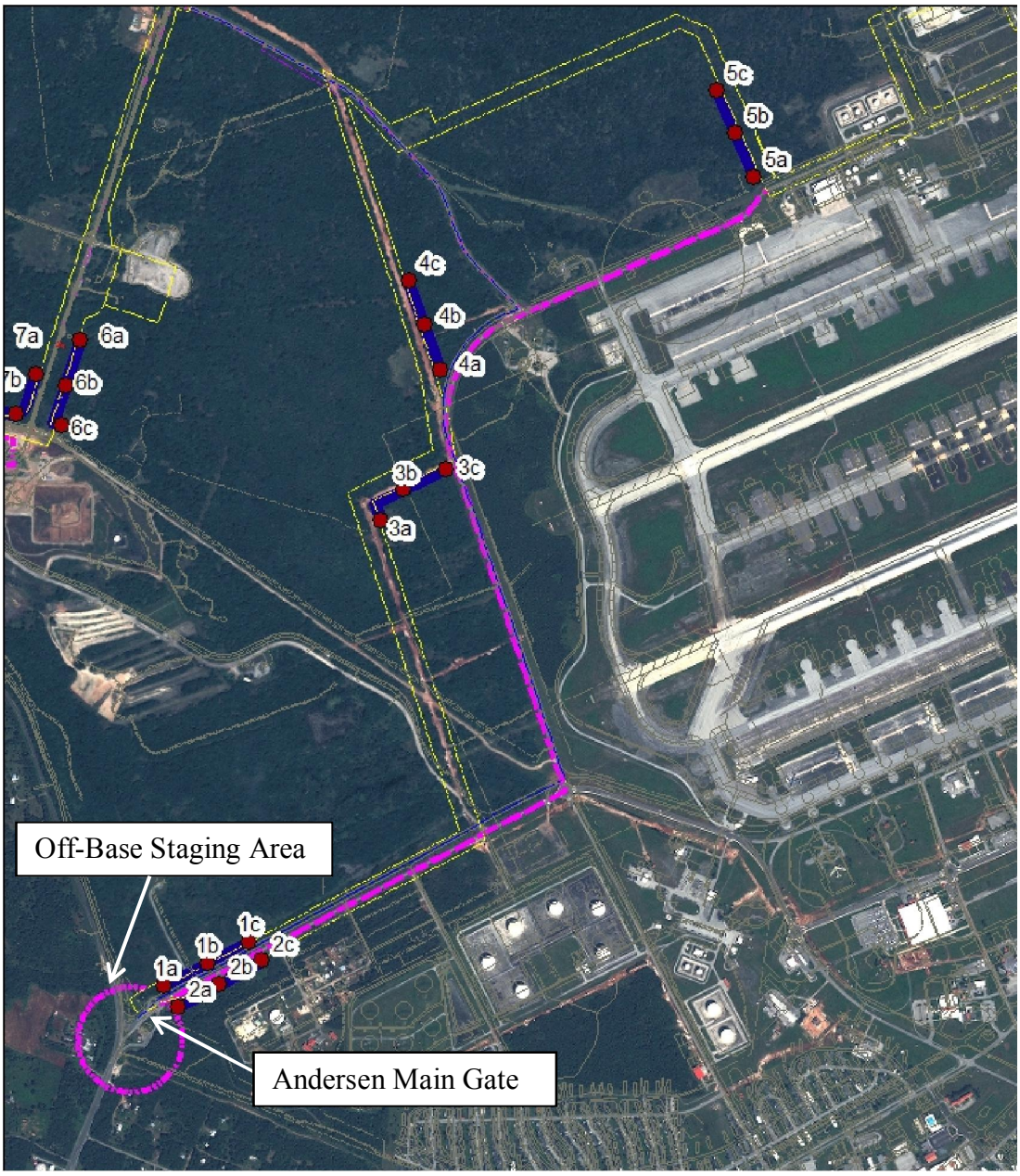
Site J001 Transect Placement



Transects are in blue with red dots indicating points. Yellow dashed line outlines the project footprint. Pink dashed lines indicate construction staging area.

Appendix 3

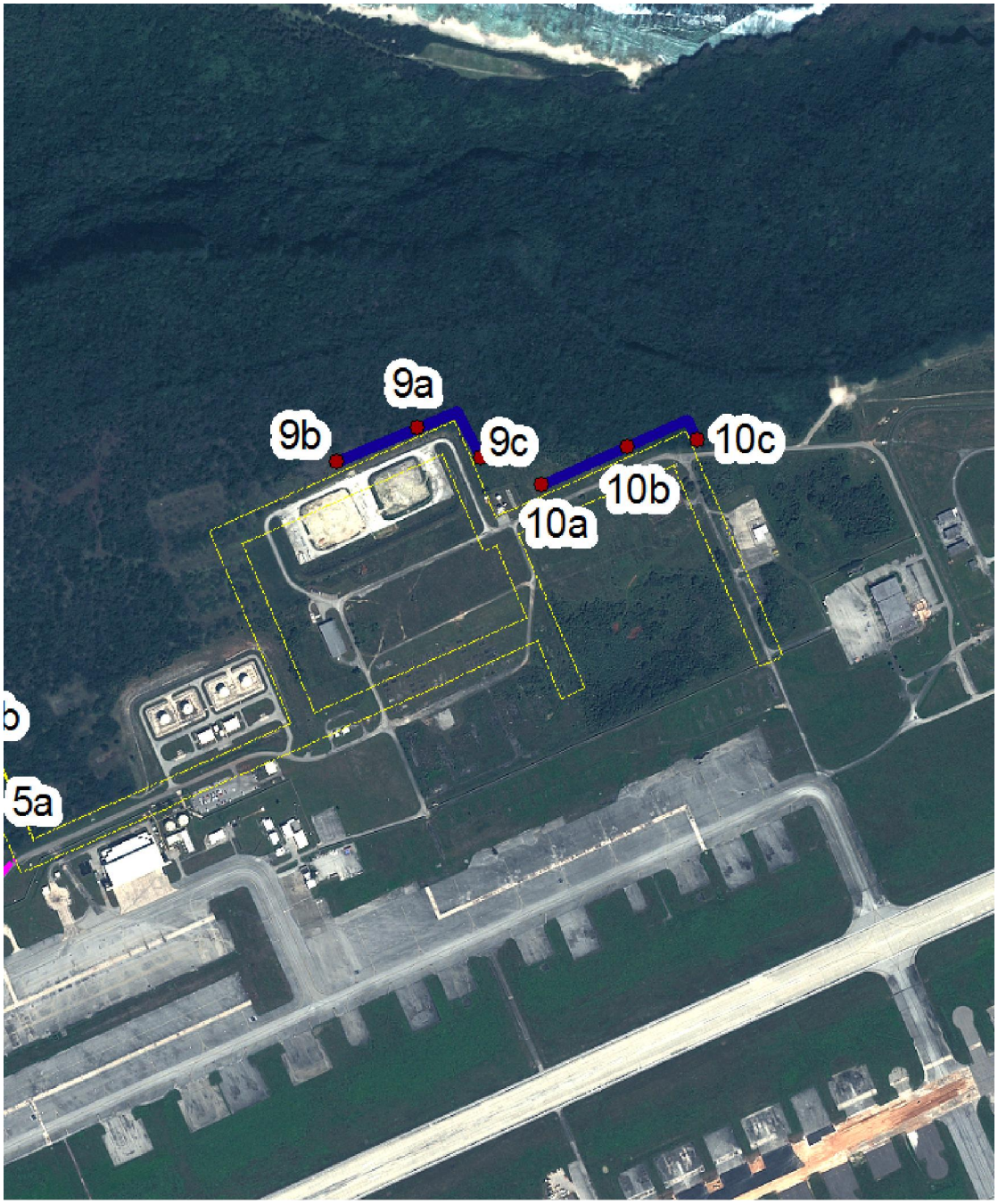
Site P100 Transect Placement



Transects are in blue with red dots indicating points. Yellow dashed line outlines the project footprint. Purple dashed lines indicate construction staging area and path of equipment to construction site.

Appendix 4

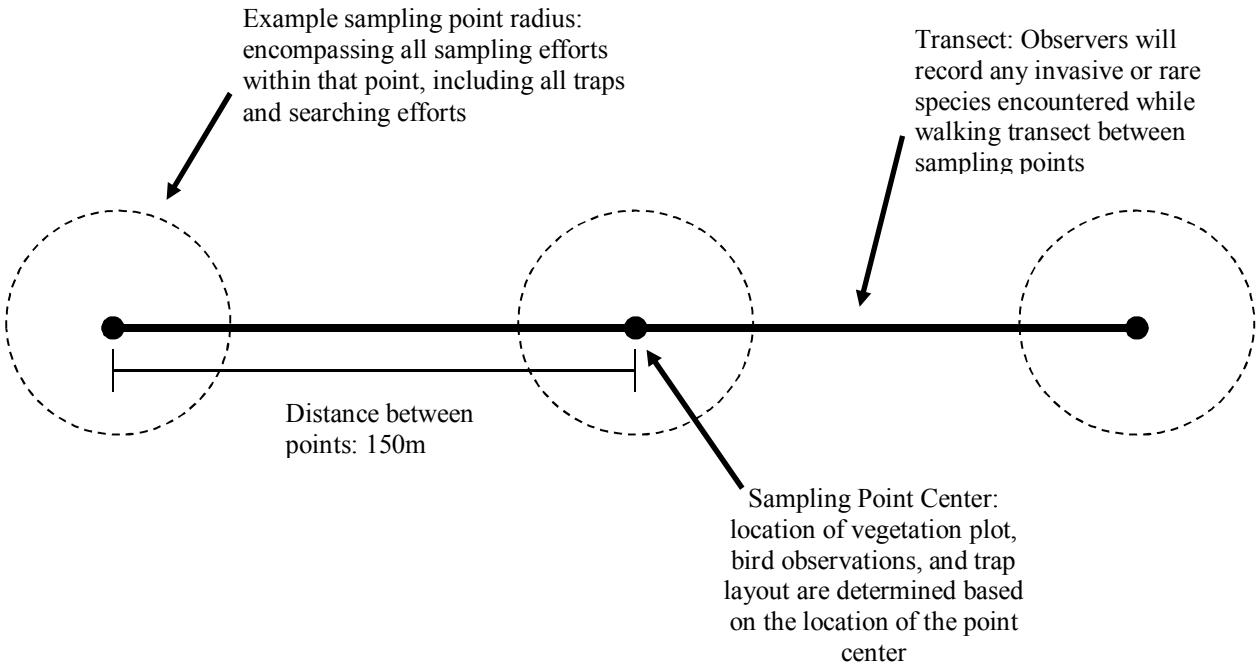
Site P101 Transect Placement



Transects are in blue with red dots indicating points. Yellow dashed line outlines the project footprint. This project uses same staging area as project P100, seen in Appendix 3.

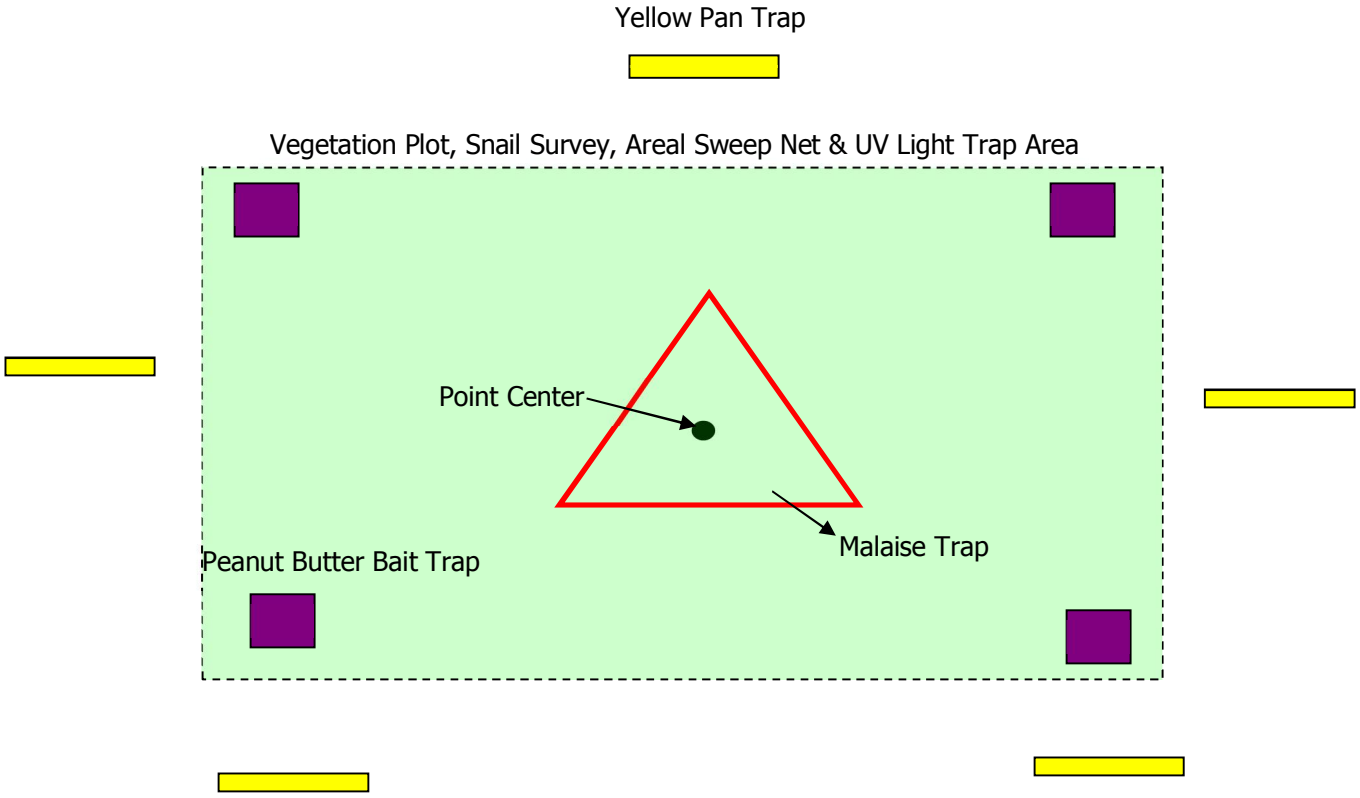
Appendix 5

Example 300m Transect Design



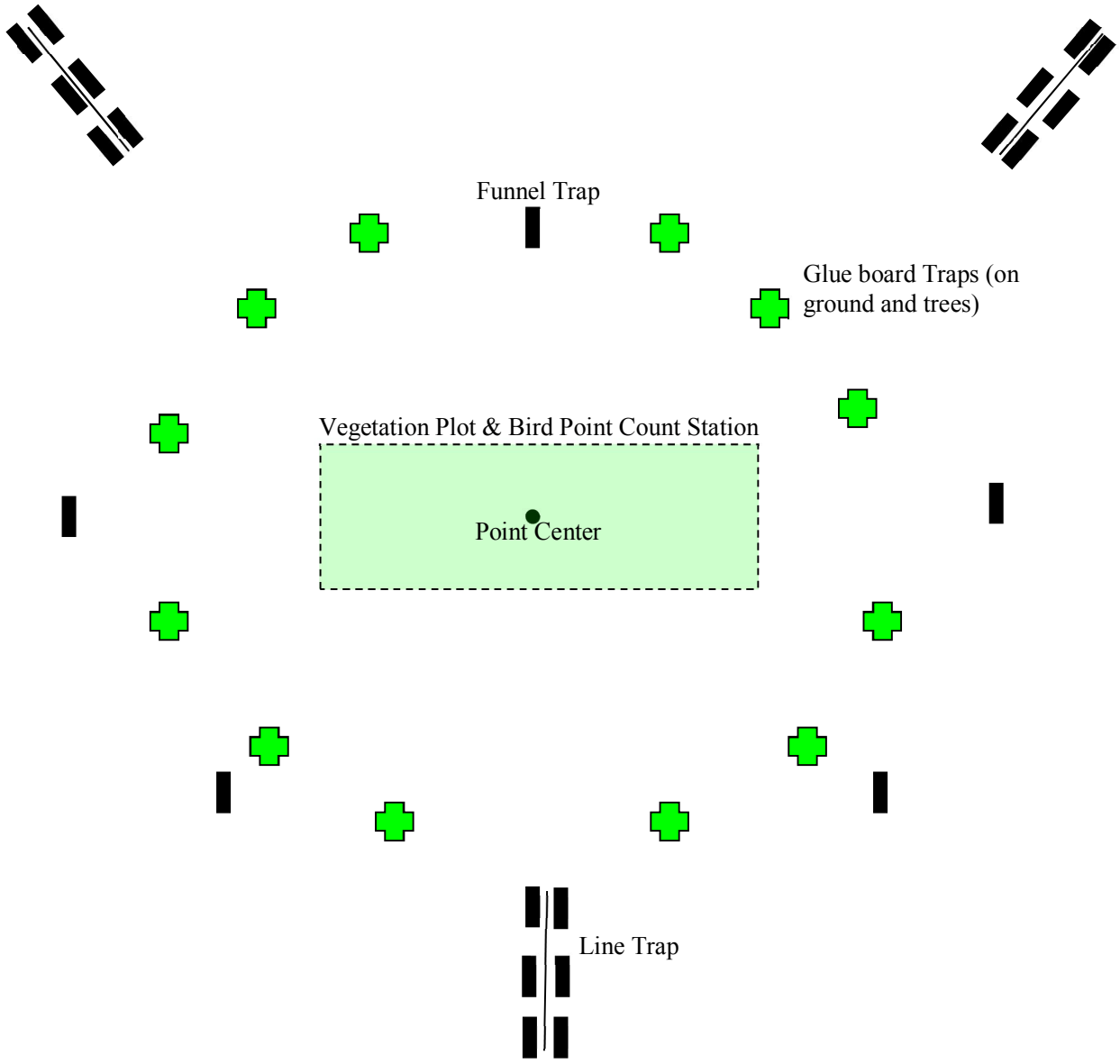
Appendix 6

Invertebrate Point Layout



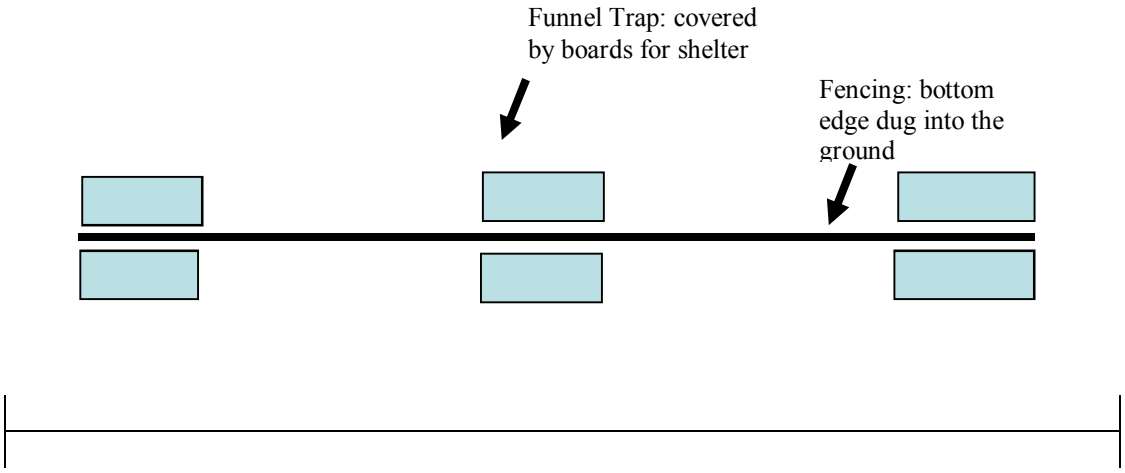
Appendix 7

Vertebrate Point Layout



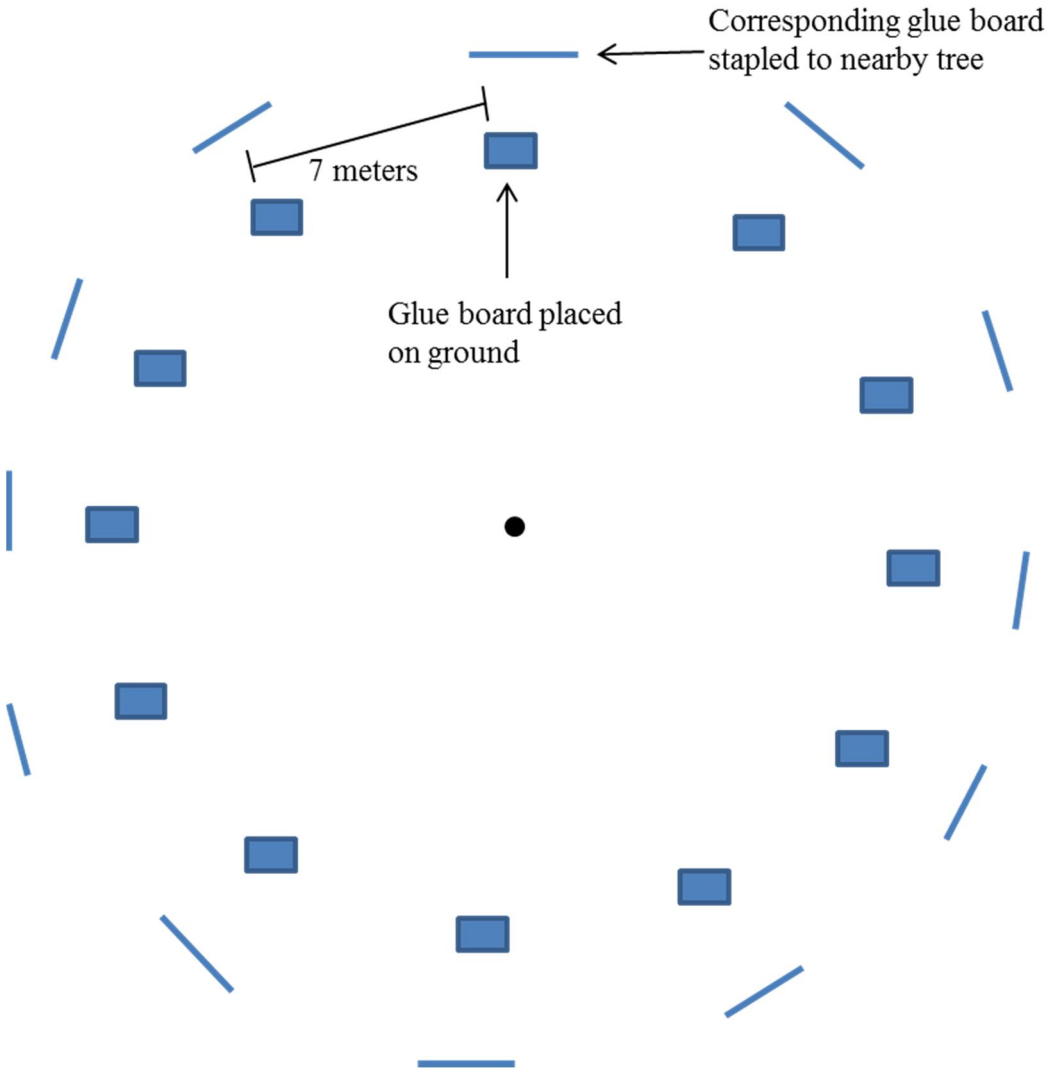
Appendix 8

Line Trap Design



Appendix 9

Glue Board Trap Layout



Appendix 10

Project Site J001 Species List
(native species are in bold)

Vegetation (including species from transect walk)

Ageratum conyzoides
Aglaia mariannensis
Alysicarpus vaginalis
Anhoceros agrestis
Antrophyum plantagineum
Asplenium nidus
Auricularia sp.
Averrhoa bilimbi
Axonopus compressus
Bidens alba
bluegreen algae
Caesalpinia major
Calymperes sp. 1
Calymperes sp. 2
Carica papaya
Cestrum diurnum
Chamaesyce hirta
Chamaesyce hypericifolia
Chlorophyta sp.
Chromolaena odorata
Chrysopogon aciculatus
Conyza canadensis
Coprinus plicatilis
Cuscuta campestris
Cynodon dactylon
Cyperus ligularis
Cyperus polystachyos
Cyperus rotundrus
Davallia solida
Desmodium triflorum
Didymoplexis fimbriata
Distichophyllum sp.
Eleaocarpus joga
Eragrostis cilianensis
Eugenia reinwardtiana
Euphorbia cyathophora
Euphorbia heterophylla
Eustachys petraea
unknown fern
unknown fern 2
Fimbristylis dichotoma
Flagellaria indica
unknown grass
unknown grass 2
Guamia mariannae
Hedyotis corymbosa
unknown herb
Hibiscus tiliaceus
Hookeria sp.
Ipomoea triloba
Jasminum sp.
Leucaena leucocephala
Macromitrium sp.
Macroptilium lathyroides
Malvaceae sp. 2
Malvaceae sp. 3
Merremia peltata
Mikania micrantha
Mimosa pudica
Miscanthus floridulus
Momordica charantia
Morinda citrifolia
Neckeropsis sp. 1
Neckeropsis sp. 2
Neisosperma oppositifolia
Nephrolepis hirsutula
Nervilia aragoana
Nostoc commune
Operculina ventricosa
Ophioglossum nudicaule
Oplismenus compositus
Pandanus dubius

Pandanus sp.
Parasola plicatilis
Parmelia sp. 1
Parmelia sp. 2
Paspalum setaceum
Passiflora foetida
Passiflora suberosa
Phyla nodiflora
Phymatosorus grossus
Pilea microphylla
Piper guahamense
Polygala paniculata
Polyporales sp.
Polypremum procumbens
Prasiolaceae sp.
Pteris tripartita
Pteris vittata
Pyrrosia lanceolata
unknown moss
Spermacoce assurgens
Sphagneticola trilobata
Sporobolus diander
Stachytarpheta jamaicensis
Taeniophyllum mariannense
Tillandsia usneoides
unknown tree
unknown tree 2
Trichomanes brevipes
Triphasia trifolia
Vittaria incurvata
Vitex parviflora
Wikstroemia elliptica

Birds

Dicrurus macrocercus
Francolinus francolinus
Gallusgallus
Ixobrychus sinensis
Passer montanus
Streptopelia bitorquata

Gastropods

Achatina fulica
Coniglobus spp.

Large Mammals

Cannis lupis familiaris
Cervus mariannus
Sus scrofa

Small Vertebrates

Carlia fusca
Eleutherodactylus planirostris
Emoia caeruleocauda
Gekkonidae sp.
Rhinella marinus

Invertebrates

Insects (Order)
Actinedida
Araneae
Blattodea
Coleoptera
Diptera
Hemiptera
Hymenoptera
Lepidoptera
Orthoptera
Poscoptera
Pseudoscorpiones
Spirobolida
Thysanoptera
Diplura (Class)
Tardigrada (Phylum)

Other Invertebrates

Birgus latro

Appendix 11

Vegetation Relative Abundances by Project Site (native species within the ten most abundant are in bold)

Project Site J001		
Species Name	**Number of Specimens**	**Relative Abundance**
Phyla nodiflora	23894	0.400274734
Sphagneticola trilobata	7172	0.120146078
Fimbristylis dichotoma	6515	0.109139947
unknown grass	2810	0.047073408
Oplismenus compositus	2597	0.04350521
Stachytarpheta jamaicensis	1825	0.030572587
Axonopus compressus	1796	0.030086776
Nephrolepis hirsutula	1423	0.023838242
Conyza canadensis	890	0.014909371
Alysicarpus vaginalis	693	0.011609207
Eustachys petraea	679	0.011374678
Hookeria sp.	528	0.00884511
Chrysopogon aciculatus	508	0.008510068
Cyperus polystachyos	506	0.008476564
Chamaesyce hypericifolia	453	0.007588702
Prasiolaceae sp.	445	0.007454686
unknown fern	397	0.006650585
Pandanus sp.	396	0.006633833
Mikania micrantha	376	0.00629879
Chromolaena odorata	315	0.005276912
Flagellaria indica	313	0.005243408
Chamaesyce hirta	307	0.005142895
Morinda citrifolia	305	0.005109391
unknown grass 2	282	0.004724093
Spermacoce assurgens	267	0.004472811
Hedyotis corymbosa	264	0.004422555
Antrophyum plantagineum	253	0.004238282
Parmelia sp. 1	232	0.003886488
Passiflora suberosa	228	0.003819479
Vitex parviflora	213	0.003568198
Macromitrium sp.	207	0.003467685
unknown herb	200	0.00335042
Phymatosorus grossus	193	0.003233156
Wikstroemia elliptica	179	0.002998626
Neckeropsis sp. 1	151	0.002529567
Trichomanes brevipes	147	0.002462559

Project Site J001 (cont.)		
Species Name	**Number of Specimens**	**Relative Abundance**
Pteris tripartite	137	0.002295038
Cynodon dactylon	122	0.002043756
Nostoc commune	118	0.001976748
Macroptilium lathyroides	116	0.001943244
Guamia mariannae	112	0.001876235
Parmelia sp. 2	98	0.001641706
Triphasia trifolia	92	0.001541193
Desmodium triflorum	70	0.001172647
Neckeropsis sp. 2	60	0.001005126
Asplenium nidus	59	0.000988374
Aglaia mariannensis	56	0.000938118
Paspalum setaceum	54	0.000904614
Polygala paniculata	51	0.000854357
Calymperes sp. 2	47	0.000787349
bluegreen algae	44	0.000737093
Calymperes sp. 1	42	0.000703588
Pilea microphylla	39	0.000653332
Distichophyllum sp.	35	0.000586324
Polyporales sp.	31	0.000519315
Eragrostis cilianensis	30	0.000502563
Ipomoea triloba	30	0.000502563
Davallia solida	24	0.00040205
Malvaceae sp. 2	24	0.00040205
Averrhoa bilimbi	22	0.000368546
Taeniophyllum mariannense	20	0.000335042
unknown moss	17	0.000284786
Mimosa pudica	16	0.000268034
Merremia peltata	15	0.000251282
Pyrrosia lanceolata	15	0.000251282
Momordica charantia	14	0.000234529
Hibiscus tiliaceus	13	0.000217777
Bidens alba	12	0.000201025
Chlorophyta sp.	12	0.000201025
Polypremum procumbens	10	0.000167521
Tillandsia usneoides	9	0.000150769
Sporobolus diander	8	0.000134017
Cuscuta campestris	7	0.000117265
Jasminum sp.	7	0.000117265
Neisosperma oppositifolia	6	0.000100513
unknown tree	6	0.000100513

Project Site J001 (cont.)		
Species Name	**Number of Specimens**	**Relative Abundance**
Ophioglossum nudicaule	5	8.37605E-05
Pteris vittata	5	8.37605E-05
Auricularia sp.	4	6.70084E-05
Pandanus dubius	4	6.70084E-05
Piper guahamense	3	5.02563E-05
Euphorbia heterophylla	2	3.35042E-05
Miscanthus floridulus	2	3.35042E-05
Ageratum conyzoides	1	1.67521E-05
Coprinus plicatilis	1	1.67521E-05
Cyperus ligularis	1	1.67521E-05
Cyperus rotundrus	1	1.67521E-05
Didymoplexis fimbriata	1	1.67521E-05
Euphorbia cyathophora	1	1.67521E-05
Malvaceae sp. 3	1	1.67521E-05
Nervilia aragoana	1	1.67521E-05
unknown fern 2	1	1.67521E-05

Project Site P100		
Species Name	**Number of Specimens**	**Relative Abundance**
Tabebuia pallida	6973	0.193662167
unknown grass 5	2455	0.068183081
Mikania micrantha	2249	0.062461812
Nephrolepis hirsutula	2205	0.061239793
Leucaena leucocephala	1937	0.053796589
Chrysopogon aciculatus	1890	0.052491251
Pilea microphylla	1754	0.048714103
Pteris tripartite	1661	0.0461312
Hookeria sp.	1157	0.032133533
Chromolaena odorata	1040	0.028884075
Passiflora suberosa	747	0.020746542
Phymatosorus grossus	693	0.019246792
Prasiolaceae sp.	673	0.018691329
Parmelia sp. 1	645	0.017913681
Oxalis corniculata	613	0.01702494
Centella asiatica	604	0.016774982
unknown grass 2	559	0.01552519
Pennisetum sp.	479	0.013303338
Spermacoce assurgens	470	0.01305338
Cassia occidentalis	465	0.012914514

Project Site P100 (cont.)		
Species Name	**Number of Specimens**	**Relative Abundance**
Flagellaria indica	459	0.012747875
Morinda citrifolia	430	0.011942454
Guamia mariannae	429	0.011914681
Triphasia trifolia	424	0.011775815
Stachytarpheta jamaicensis	359	0.00997056
Clerodendrum quadriloculare	312	0.008665222
Aglaia mariannensis	285	0.007915347
Wikstroemia elliptica	263	0.007304338
Conyza canadensis	257	0.007137699
Parmelia sp. 2	236	0.006554463
Pandanus sp.	235	0.00652669
Calymperes sp. 1	168	0.004665889
Pennisetum polystachion	166	0.004610343
Axonopus compressus	165	0.00458257
Pyrrosia lanceolata	164	0.004554796
Achyranthes aspera	153	0.004249292
Bidens alba	131	0.003638283
Chamaesyce prostrate	130	0.003610509
unknown grass 7	126	0.003499417
Ipomoea triloba	112	0.003110593
Tillandsia usneoides	108	0.0029995
Phyla nodiflora	93	0.002582903
Delonix regia	85	0.002360718
Taeniophyllum mariannense	84	0.002332945
Malvaceae sp.	76	0.002110759
unknown fern	75	0.002082986
Distichophyllum sp.	72	0.001999667
Chamaesyce hirta	68	0.001888574
bluegreen algae	67	0.001860801
Polyporales sp.	65	0.001805255
Averrhoa bilimbi	62	0.001721935
Macromitrium sp.	62	0.001721935
Vitex parviflora	53	0.001471977
Neckeropsis sp. 2	50	0.001388657
Cestrum diurnum	44	0.001222019
Merremia peltata	44	0.001222019
Mimosa pudica	41	0.001138699
Cyperus brevifolius	38	0.00105538
Momordica charantia	38	0.00105538
Neckeropsis sp. 1	38	0.00105538

Project Site P100 (cont.)		
Species Name	**Number of Specimens**	**Relative Abundance**
Hibiscus tiliaceus	31	0.000860968
unknown herb 2	31	0.000860968
Blechum pyramidatum	28	0.000777648
Davallia solida	27	0.000749875
Jasminum sp.	27	0.000749875
unknown herb 3	27	0.000749875
Sphagneticola trilobata	26	0.000722102
Paspalum setaceum	23	0.000638782
Auricularia sp.	21	0.000583236
Calymperes sp. 2	20	0.000555463
Cyperus polystachyos	20	0.000555463
Cyperus ligularis	17	0.000472144
Hedyotis corymbosa	16	0.00044437
unknown herb 4	15	0.000416597
Ageratum conyzoides	12	0.000333278
Alysicarpus vaginalis	12	0.000333278
Chamaesyce hypericifolia	12	0.000333278
Anhoceros agrestis	9	0.000249958
Fimbristylis dichotoma	8	0.000222185
Pteris vittata	8	0.000222185
unknown succulent	8	0.000222185
Chlorophyta sp.	7	0.000194412
unknown grass 3	5	0.000138866
unknown herb 5	5	0.000138866
unknown herb 6	5	0.000138866
Neisosperma oppositifolia	4	0.000111093
Nostoc commune	4	0.000111093
Vittaria incurvata	4	0.000111093
Acarospora sp.	3	8.33194E-05
Asplenium nidus	3	8.33194E-05
Maytenus thompsonii	3	8.33194E-05
Ophioglossum nudicaule	3	8.33194E-05
unknown moss	3	8.33194E-05
Syrrhopodon sp.	3	8.33194E-05
Nervilia aragoana	2	5.55463E-05
Peperomia mariannensis	2	5.55463E-05
Polypremum procumbens	2	5.55463E-05
Premna obtusifolia	2	5.55463E-05
Carica papaya	1	2.77731E-05
Cycas circinalis	1	2.77731E-05

Project Site P100 (cont.)		
Species Name	**Number of Specimens**	**Relative Abundance**
Eugenia thompsonii	1	2.77731E-05
unknown herb 7	1	2.77731E-05
Intsia bijuga	1	2.77731E-05
unknown fungus	1	2.77731E-05
Macaranga thompsonii	1	2.77731E-05
unknown tree 3	1	2.77731E-05
Parasola plicatilis	1	2.77731E-05
Piper guahamense	1	2.77731E-05
unknown herb 8	1	2.77731E-05
Scaevola sericea	1	2.77731E-05
unknown herb 9	1	2.77731E-05
unknown fungus 2	1	2.77731E-05
Trichomanes brevipes	1	2.77731E-05
unknown herb 10	1	2.77731E-05
Zeuxine fritzii	1	2.77731E-05

Project Site P101		
Species Name	**Number of Specimens**	**Relative Abundance**
unknown grass	19169	0.40780768
Fimbristylis dichotoma	9589	0.203999575
Axonopus compressus	2134	0.045399426
Conyza Canadensis	1554	0.033060313
Stachytarpheta jamaicensis	1504	0.031996596
unknown grass 5	1166	0.024805872
unknown grass 6a	1121	0.023848527
unknown grass 2	1100	0.023401766
Pilea microphylla	882	0.018763961
Chromolaena odorata	761	0.016189767
Cassia occidentalis	711	0.01512605
Phyla nodiflora	663	0.014104882
Saccharum spontaneum	575	0.012232741
Sporobolus diander	528	0.011232848
Chrysopogon aciculatus	523	0.011126476
Spermacoce assurgens	418	0.008892671
Wikstroemia elliptica	404	0.00859483
Hookeria sp.	372	0.007914052
Passiflora suberosa	369	0.007850229
Desmodium triflorum	336	0.007148176
Aglaia mariannensis	280	0.005956813
Prasiolaceae sp.	261	0.005552601

Project Site P101 (cont.)		
Species Name	**Number of Specimens**	**Relative Abundance**
Triphasia trifolia	244	0.005190937
Parmelia sp. 1	214	0.004552707
Alysicarpus vaginalis	194	0.004127221
Oxalis corniculata	172	0.003659185
Ipomoea triloba	171	0.003637911
Pteris tripartite	152	0.003233699
Tillandsia usneoides	141	0.002999681
Pennisetum polystachion	135	0.002872035
Indigofera suffruticosa	112	0.002382725
Calymperes sp. 1	101	0.002148708
Phymatosorus grossus	86	0.001829593
Ageratum conyzoides	85	0.001808318
Merremia peltata	80	0.001701947
Distichophyllum sp.	77	0.001638124
Mikania micrantha	75	0.001595575
Stylosanthes sp.	62	0.001319009
Chamaesyce hirta	61	0.001297734
Guamia mariannae	52	0.001106265
Asplenium nidus	31	0.000659504
Morinda citrifolia	31	0.000659504
Chlorophyta sp.	30	0.00063823
Vittaria incurvata	27	0.000574407
Auricularia sp.	21	0.000446761
Cestrum diurnum	21	0.000446761
Digitaria sp.	20	0.000425487
Parmelia sp. 2	20	0.000425487
Nostoc commune	17	0.000361664
Chamaesyce hypericifolia	15	0.000319115
Leucaena leucocephala	11	0.000234018
Polypremum procumbens	11	0.000234018
Neckeropsis sp. 1	10	0.000212743
Polyporales sp.	10	0.000212743
unknown moss	10	0.000212743
unknown fern	9	0.000191469
Nephrolepis hirsutula	8	0.000170195
Davallia solida	7	0.00014892
Euphorbia heterophylla	6	0.000127646
Hedyotis corymbosa	6	0.000127646
Hernandia nymphaeifolia	6	0.000127646
Mimosa pudica	6	0.000127646

Project Site P101 (cont.)		
Species Name	**Number of Specimens**	**Relative Abundance**
Oplismenus compositus	6	0.000127646
Cyperus ligularis	4	8.50973E-05
Momordica charantia	4	8.50973E-05
unknown grass 7	3	6.3823E-05
Neckeropsis sp. 2	3	6.3823E-05
Syrrhopodon sp.	3	6.3823E-05
unknown fungus 3	2	4.25487E-05
Cycas circinalis	2	4.25487E-05
Operculina verntricosa	2	4.25487E-05
Prasiolaceae lichen 2	2	4.25487E-05
Pyrrosia lanceolata	2	4.25487E-05
Macromitrium sp.	1	2.12743E-05
Macroptilium lathyroides	1	2.12743E-05
Neisosperma oppositifolia	1	2.12743E-05
Phyllanthus amarus	1	2.12743E-05
Psychotria mariana	1	2.12743E-05

Appendix 12

Project Site P100 Species List
(native species are in bold)

Vegetation (including species from transect walk)

Acarospora sp.
Achyranthes aspera
Ageratum conyzoides
Aglaia mariannensis
Alysicarpus vaginalis
Anhoceros agrestis
Asplenium nidus
Auricularia sp.
Averrhoa bilimbi
Axonopus compressus
Bidens alba
Blechum pyramidatum
bluegreen algae
Caesalpinia major
Calymperes sp. 1
Calymperes sp. 2
Carica papaya
Cassia occidentalis
Centella asiatica
Cestrum diurnum
Chamaesyce hirta
Chamaesyce hypericifolia
Chamaesyce prostrata
Chlorophyta sp.
Chromolaena odorata
Chrysopogon aciculatus
Clerodendrum quadriloculare
Conyza canadensis
Cycas circinalis
Cyperus brevifolius
Cyperus ligularis
Cyperus polystachyos
Davallia solida
Delonix regia
Desmodium triflorum

Distichophyllum sp.
Erigeron bellioides
Eugenia thompsonii
Euphorbia thompsonii
unknown fern
unknown fern 3
Ficus prolixa
Fimbristylis dichotoma
Flagellaria indica
unknown fungus
unknown fungus 2
unknown fungus 4
unknown grass 2
unknown grass 3
unknown grass 5
unknown grass 7
Guamia mariannae
Hedyotis corymbosa
unknown herb 2
unknown herb 3
unknown herb 4
unknown herb 6
unknown herb 7
unknown herb 8
unknown herb 9
unknown herb 10
unknown herb 11
unknown herb 12
Hibiscus tiliaceus
Hookeria sp.
Intsia bijuga
Ipomoea triloba
Jasminum sp.
Leucaena leucocephala
Macaranga thompsonii
Macromitrium sp.
Malvaceae sp.

Maytenus thompsonii
Merremia peltata
Mikania micrantha
Mimosa pudica
Momordica charantia
Morinda citrifolia
unknown moss
unknown moss 2
Neckeropsis sp. 1
Neckeropsis sp. 2
Neisosperma oppositifolia
Nephrolepis hirsutula
Nervilia aragoana
Nostoc commune
Operculina ventricosa
Ophioglossum nudicaule
Oxalis corniculata
Pandanus sp.
Parasola plicatilis
Parmelia sp. 1
Parmelia sp. 2
Paspalum setaceum
Passiflora suberosa
Pennisetum polystachion
Pennisetum sp.
Peperomia mariannensis
Phyla nodiflora
Phymatosorus grossus
Pilea microphylla
Piper guahamense
Polyporales sp.
Polypremum procumbens
Prasiolaceae sp.
Premna obtusifolia
Psychotria mariana
Pteris tripartite
Pteris vittata
Pycnoporus sp.
Pyrrosia lanceolata
Ruellia prostrate
Scaevola sericea
unknown shrub

Spermacoce assurgens
Sphagneticola trilobata
Stachytarpheta jamaicensis
Stylosanthes sp.
unknown succulent
Syrrhopodon sp.
Tabebuia pallida
Taeniophyllum mariannense
Tillandsia usneoides
unknown tree 3
Trichomanes brevipes
Triphasia trifolia
unknown vine
Vitex parviflora
Vittaria incurvata
Wikstroemia elliptica
Zeuxine fritzii

Birds

Dicrurus macrocercus
Francolinus francolinus
Gallus gallus
Gygis alba
Ixobrychus sinensis
Passer montanus
Pluvialis dominicana
Streptopelia bitorquata

Gastropods

Achatina fulica
Coniglobus sp.
little shell
Pythia spp.
small African looking
Subulina ocotona
unknown 1
unknown 2

Large Mammals

Cervus mariannus
Sus scrofa

Small Vertebrates

Carlia fusca
Eleutherodactylus planirostris
Emoia caeruleocauda
Gehyra mutiliata
Hemidactylus frenatus
Lepidodactylus lugubris
Rhinella marinus
Suncus murinus

Invertebrates

Insects (Order)
Actinedida
Araneae
Coleoptera
Diptera
Hemiptera
Hymenoptera
Lepidoptera
Mantodea
Orthoptera
Poscoptera
Thysanoptera
Diplura (Class)
Tardigrada (Phylum)

Other Invertebrates

Birgus latro
Platydemus manokwari
Veronicella cubensis

Appendix 13

Project Site P101 Species List
(native species are in bold)

Vegetation (including species from transect walk)

Acalypha indica
Aidia cochinchinensis
Ageratum conyzoides
Aglaia mariannensis
Alysicarpus vaginalis
Asplenium nidus
Auricularia sp.
Axonopus compressus
Calymperes sp. 1
Cassia occidentalis
Cestrum diurnum
Chamaesyce hirta
Chamaesyce hypericifolia
Chamaesyce prostrate
Cheilanthes tenuifolia
Chlorophyta sp.
Chromolaena odorata
Chrysopogon aciculatus
Conyza Canadensis
Cycas circinalis
Cyperus ligularis
Davallia solida
Desmodium triflorum
Digitaria sp.
Distichophyllum sp.
Euphorbia heterophylla
unknown fern
Ficus tinctoria
Ficus prolixa
Fimbristylis dichotoma
unknown fungus 3
unknown grass
unknown grass 2
unknown grass 5
unknown grass 6a
unknown grass 7
Guamia mariannae
Hedyotis corymbosa
unknown herb 13
Hernandia nymphaeifolia
Hookeria sp.
Indigofera suffruticosa
Intsia bijuga
Ipomoea triloba
Leucaena leucocephala
Macaranga thompsonii
Macromitrium sp.
Macroptilium lathyroides
Merremia peltata
Mikania micrantha
Mimosa pudica
Momordica charantia
Morinda citrifolia
unknown moss
Neckeropsis sp. 1
Neckeropsis sp. 2
Neisosperma oppositifolia
Nephrolepis hirsutula
Nostoc commune
Ochorosia mariannensis
Operculina verntricosa
Oplismenus compositus
Oxalis corniculata
Pandanus sp.
Parasola plicatilis
Parmelia sp. 1
Parmelia sp. 2
Passiflora suberosa
Pennisetum polystachion
Phyla nodiflora
Phyllanthus amarus
Phymatosorus grossus

Pilea microphylla
Polyporales sp.
Polypremum procumbens
Prasiolaceae sp.
Premna obtusifolia
Psychotria mariana
Pteris tripartite
Pyrrosia lanceolata
Saccharum spontaneum
Spermacoce assurgens
Sporobolus diander
Stachytarpheta jamaicensis
Stylosanthes sp.
Syrrhopodon sp.
Tillandsia usneoides
Triphasia trifolia
Vittaria incurvata
Wikstroemia elliptica

Birds

Aplonis opaca (from transect walk)
Dicrurus macrocercus
Francolinus francolinus
Gygis alba
Ixobrychus sinensis
Passer montanus
Streptopelia bitorquata

Gastropods

Coniglobus spp.
Pythia spp.

Large Mammals

Cervus mariannus
Sus scrofa

Small Vertebrates

Carlia fusca
Eleutherodactylus planirostris
Emoia caeruleocauda
Gekkonidae sp.
Rhinella marinus

Invertebrates

Insects (Order)
Actinedida
Araneae
Blattodea
Coleoptera
Diptera
Hemiptera
Hymenoptera
Lepidoptera
Mantodea
Neuroptera
Orthoptera
Poscoptera
Thysanoptera
Diplura (Class)
Tardigrada (Phylum)

Other Invertebrates

Birgus latro
Cardisoma carnifex
Veronicella cubensis