Final Report

# Semi-annual Indigenous Waterbird Surveys: An examination of seasonal variation in population size and dispersal of indigenous waterbirds on St. Croix, U.S. Virgin Islands

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**2009**

**Summary:**

Indigenous waterbirds were surveyed during an intense five day period at 149 sites during the dry season and 145 sites during the wet season using the area search method. All accessible sites on St. Croix were surveyed. During the dry season, 1402 indigenous waterbirds were observed including 390 Black-necked Stilts, 58 American/Caribbean Coots, 457 White-cheeked Pintails, 2 Rudy Ducks, 100 Green Herons, 49 Pied-billed Grebes, 23 Least Grebes, and 323 Common Moorhen. During the wet season, 989 indigenous waterbirds were observed including 261 Black-necked Stilts, 60 American/Caribbean Coots, 457 White-cheeked Pintails, 7 Ruddy Ducks, 111 Green Herons, 51 Pied-billed Grebes, 18 Least Grebes, and 228 Common Moorhen. Although some variation was expected in the populations counts between the two seasons, it is unknown if this was normal seasonal population fluctuations or a result of the hurricane that hit St. Croix shortly before surveys occurred. Data on area, salinity and surrounding habitat was also collected at each wetland site.

A positive linear relationship between area and total indigenous waterbirds was found at freshwater sites year round, while at brackish sites this relationship held true only during the wet season. A positive linear relationship between area and species richness was found for freshwater sites, but not for brackish sites. This indicates that large ponds should be targeted for wetland conservation and monitored for degradation due to development and introduction of aquatic invasive species.

Ephemeral wetlands that were dry during the dry season but contained water during the wet season were used by a large number of birds during the wet season. This indicates that these ephemeral sites are important to the ecology of indigenous waterbirds and should be considered in conservation planning.

## Introduction

St. Croix has lost substantial wetland area in the last century, largely due to development. Currently the construction of several large scale resorts has been proposed, threatening many more acres of valuable wetlands. The use of these wetland sites by waterbirds for feeding and breeding has been well documented (Beatty 1930, Knowles 1997, McNair 2005 (1-3), 2006, 2008), but not necessarily well understood. A 2005 study identified freshwater ponds as an overlooked but quite important habitat for waterbirds (McNair et al 2005(2)); previous research focused primarily on saline wetlands. The Division of Fish and Wildlife is now trying to parse out the details of indigenous waterbird use of both freshwater ponds and brackish wetlands to better guide management and conservation.

The Comprehensive Wildlife Conservation Plan of the U.S. Virgin Islands lists reliable population estimates of indigenous waterbirds as an item of the highest priority (Platenberg 2005). Previous studies of waterbirds on St. Croix have involved censusing waterbirds on a per site basis. However, these surveys could not provide an estimate of the island-wide population of these birds. Without information on the movement of these birds among ponds, it is impossible to tell how many of the same birds are being resighted and therefore, double counted at different ponds. By conducting intensive surveys throughout the island in a short period of time, we can approach an island wide population estimate of the indigenous waterbirds. This information will allow for better monitoring of the status of waterbirds in St. Croix and re-evaluation of species' statuses on the local endangered species list. Additionally, indigenous waterbird abundance has been used as a tool for prioritizing saline wetlands for conservation in St. Croix (McNair et al 2006). These priority rankings were based on multiyear survey data but have not examined the annual changes in distribution by season. Some sites that are seemingly less important overall may provide a dry season refuge when the "best" sites are unavailable. It is also important to determine how this distribution among ponds changes seasonally.

There is substantial seasonal variation in available wetlands on tropical islands such as St. Croix. During the dry season many freshwater and salt ponds have low water levels, or in many cases, dry up completely. There are fewer sites available overall and

the salt ponds that do retain some water may have higher salinity making them potentially less suitable for occupation by waterbirds. The resident waterbirds that rely on these wetlands for feeding and breeding may have to occupy sub-optimal sites during the dry season.

It is unknown how the indigenous waterbirds of St. Croix disperse seasonally. A study in Hawaii found that waterbirds dispersal patterns could be partially explained by annual rainfall patterns (Engilis and Pratt 1993). The populations of some species such as coots, moorhens, and stilts fluctuated with climatic events and the birds were found to disperse to ephemeral wetlands among nearby islands. The migration of coots was especially tied to major rainfall events. The birds of St. Croix may follow similar patterns. By conducting intense island-wide surveys during the dry and wet seasons, patterns of intraisland movements may be detected and interisland movements may be inferred by differences in population size.

A variety of factors contribute to the selection of sites by waterbirds. In many cases, increasing area of a pond results in increasing waterbirds. One study of tidal marsh birds found that species that were habitat specialists were found in larger numbers in larger areas of that habitat, while species that were habitat generalists were equally frequent on plots in marshes of different areas (Benoit and Askins 2002). Another theory is that during the dry season, lowering water levels and receding surface tend to concentrate prey in small areas making for valuable foraging sites (Russell et al. 2002). In a previous study of waterbirds at freshwater sites in St.Croix, generally more species were found at larger ponds, but many other factors may have affected this relationship such as shoreline vegetation, invasive aquatic vegetation, and disturbance (McNair 2005(2)). The relationship between area of brackish sites and waterbird abundance on St. Croix is examined for the first time in this study.

## Methods

*Study Area*

The study area consisted of all accessible freshwater and saline ponds on St. Croix. A total of 125 freshwater ponds and 29 saline sites were surveyed. The vast majority of freshwater ponds on St. Croix are manmade and consist of agricultural ponds, golf course ponds, or water treatment areas.

Information on the area of each pond was based on a GIS analysis of aerial photos. Most ponds were measured by the Conservation Data Center (2001) but several were not included in this analysis and had to be measured in GIS from aerial photos. Pond names are based on McNair et al. 2005 (2) and (3). A list of all ponds and their areas is included in Appendix 3.

Although the dry season was typical, the wet season surveys were conducted in atypical conditions. Hurricane Omar brushed St. Croix as a Category 3 hurricane just two weeks before the wet season surveys began. High winds knocked down many trees and rain caused flooding, including causing many of the study sites to overflow. On October 15 and 16 (the day before and day of the storm) 16 inches of rain fell on St. Croix (Weather Station KVICHRIS5 – Buccaneer Resort). St. Croix received several inches of rain during the previous week as well when Omar passed over the island for the first time as a tropical storm.

*Indigenous Waterbirds*

The indigenous waterbirds included in this study are the Black-necked Stilt (*Himantopus mexicanus*), Least Grebe (*Tachybaptus dominicus*), Pied-billed Grebe (*Podilymbus podiceps*), White-cheeked Pintail (*Anas bahamensis*), Common Moorhen (*Gallinula chloropus*), Green Heron (*Butorides virescens*), Ruddy Duck (*Oxyura jamaicensis*), and the Caribbean (*Fulica caribea*) and American Coot (*F. americana*) complex. Caribbean and American Coots can not always be distinguished from each other and so for analysis purposes, were combined into one Coot complex. Indeed, there

is likely interbreeding between the two species and so there may be hybrids in the survey area

*Surveys*

Surveys were conducted during a five day period from 2 June 2008 to 6 June 2008 during the dry season and 1 November 2008 to 6 November 2008 during the wet season. Surveys started between sunrise and 15 minutes thereafter. Birds were surveyed using the area search method (McNair et al. 2006, Dieni and Jones 2002). In this method, observers thoroughly search a defined area and record all birds seen. The area searched consisted of the wetlands up to the high-water line. Any birds observed beyond the high water line were counted, notes taken on their location (distance from pond and general habitat) and any other relevant information included.

Sites were divided among five primary observers plus three other observers surveyed sites on the cays that required extra travel time. In most cases, a single observer visited each site, however at very large sites or at sites in which safety was a factor, two observers surveyed the site. Surveys started on the eastern end of the island and moved west. Sites were grouped for ease of travel but also to ensure that observers were covering the same general area in the same day. This was done in an attempt to further limit the possibility of double counting birds that might be traveling between different sites. Surveys started at the eastern end of the island and progressed westward.

When necessary, sites were surveyed by walking or kayaking around the perimeter to the greatest extent practicable or if observers could see the entire shoreline and into the associated vegetation from points across the pond, observations were taken from those points. Where appropriate, the surveyor walked, waded or kayaked into the interior of the site to count waterbirds not likely to be seen from the site's perimeter. In heavily vegetated areas where observers were not able to survey the entire area, observers would start with an initial perimeter count, if possible, and then walked one or two paths through the designated area. The primary goal was to count the birds that were associated with the pond.

Each bird was classified into an age group category (adult, immature, juvenile, downy young), but only adult and immature birds were included in the population counts.

Supplementary information on water level, salinity (at applicable sites), vegetation surrounding the pond, vegetation in the pond, and the presence of aquatic invasive vegetation was recorded at each pond. Photographs were taken at each pond to document water levels.

*Data Analysis*

Other than descriptive statistics, analyses included chi square tests, regression analysis and rank sum tests. Data was log transformed when necessary (area, total birds, diversity).

A Chi-square test was used to compare population size between seasons. Regression analysis was used to assess the relationship between area and total birds, area and species richness, salinity and total birds, and salinity and species richness. The rank sum test was used to compare species richness and total birds between seasons and between freshwater and saline sites. Results were judged significant at $p \leq 0.05$.

**Results**

During the dry season surveys in June 2008, 149 sites were surveyed totaling 909.6 acres. Of these, 120 sites were freshwater totaling 104.3 acres, and 29 sites were brackish totaling 805.3 acres. During the wet season surveys in November 2008, 145 sites were surveyed totaling 859 acres. Of these, 119 sites were freshwater totaling 104.1 acres, and 26 sites were brackish totaling 754.9 acres. Differences in survey numbers between seasons was largely due to accessibility issues. Appendix 1 shows the survey sites and relative areas.

*Seasonal differences in total birds*

During the dry season a total of 1402 indigenous waterbirds were observed versus a total of 989 indigenous waterbirds observed during the wet season. If the birds observed at sites surveyed during only one season are removed from the totals there were 1388 total birds observed during the dry season and 986 during the wet season, a significant difference $c^2(644, N= 141) = 1512$, $p<.005$. The 17% decrease in birds in the wet season can likely be attributed to Hurricane Omar which passed over St. Croix on the night of October 15, just two and a half weeks before the wet season surveys were conducted. When appropriate, between-season comparisons are made in percentages of total birds rather than raw bird numbers to account for this.

During the dry season, 32 ponds were dry (25 freshwater, 7 brackish). Despite this, 39 total indigenous waterbirds were observed at these sites, although most of these were part of a flock of 28 Black-necked stilts observed at the Altona Lagoon Salt Flats. During the wet season, all but one of these sites (Skov Little Pond) had water. During the wet season surveys, 20% (total of 197 birds) of the birds observed were found at sites that were dry during the dry season. By species, 26% (69 birds) of the Black-necked Stilts, 3% (2 birds) of the Coots, 17% (43 birds) of the White-cheeked Pintails, 29% (32 birds) of the Green Herons, 8% (4 birds) of the Pied-billed Grebes, 22% (4 birds) of the Least Grebes, and 19% (43 birds) of the Common Moorhen observed during the wet season were at ponds that were dry during the dry season surveys.

*Seasonal differences in totals at brackish and freshwater sites*

During the dry season 68% (955 total) of the indigenous waterbird species were found at freshwater sites and 32% (447 total) were found at brackish sites. During the wet season 58% (573 total) of the focal species were found at freshwater sites and 42% (416 total) were found at brackish sites. Table 1 gives the totals by species, season and water type. Distributions of total birds and species can be found in Appendix 2.

Table 1. Total numbers and percentages of birds of each species and numbers and percentages of sites at which each species was observed by season and water type.

**Black Necked Stilts**

| Season/pond type | Number of birds | Percentage of total for season | Number of sites | Percentage of total for season |
|---|---|---|---|---|
| Dry/Fresh | 94 | 24% | 30 | 67% |
| Dry/Brackish | 296 | 76% | 15 | 33% |
| Wet/Fresh | 31 | 12% | 7 | 37% |
| Wet/Brackish | 230 | 88% | 12 | 63% |

**Coot Complex**

| | | | | |
|---|---|---|---|---|
| Dry/Fresh | 33 | 57% | 8 | 80% |
| Dry/Brackish | 25 | 43% | 2 | 20% |
| Wet/Fresh | 16 | 27% | 9 | 75% |
| Wet/Brackish | 44 | 73% | 3 | 25% |

**White Cheeked Pintail**

| | | | | |
|---|---|---|---|---|
| Dry/Fresh | 380 | 83% | 30 | 77% |
| Dry/Brackish | 77 | 17% | 9 | 23% |
| Wet/Fresh | 185 | 73% | 22 | 61% |
| Wet/Brackish | 68 | 27% | 14 | 39% |

**Ruddy Duck**

| | | | | |
|---|---|---|---|---|
| Dry/Fresh | 1 | 50% | 1 | 50% |
| Dry/Brackish | 1 | 50% | 1 | 50% |
| Wet/Fresh | 0 | 0% | 0 | 0% |
| Wet/Brackish | 7 | 100% | 1 | 100% |

**Green Heron**

| | | | | |
|---|---|---|---|---|
| Dry/Fresh | 75 | 75% | 44 | 83% |
| Dry/Brackish | 25 | 25% | 9 | 17% |
| Wet/Fresh | 84 | 76% | 49 | 82% |
| Wet/Brackish | 27 | 24% | 11 | 18% |

**Pied-bill Grebe**

| | | | | |
|---|---|---|---|---|
| Dry/Fresh | 47 | 96% | 23 | 92% |
| Dry/Brackish | 2 | 4% | 2 | 8% |
| Wet/Fresh | 47 | 92% | 27 | 93% |
| Wet/Brackish | 4 | 8% | 2 | 7% |

| | | | | |
|---|---|---|---|---|
| **Least Grebe** | | | | |
| Dry/Fresh | 21 | 91% | 11 | 92% |
| Dry/Brackish | 2 | 9% | 1 | 8% |
| Wet/Fresh | 14 | 78% | 6 | 86% |
| Wet/Brackish | 4 | 22% | 1 | 14% |
| **Common Moorhen** | | | | |
| Dry/Fresh | 304 | 94% | 78 | 96% |
| Dry/Brackish | 19 | 6% | 3 | 4% |
| Wet/Fresh | 196 | 86% | 84 | 93% |
| Wet/Brackish | 32 | 14% | 6 | 7% |

Overall, during the dry season a mean of 9.47 birds were found per site (SD = 31.49) compared to 6.68 birds per site during the wet season (SD = 15.01). By species during the dry season, the mean number of birds per site were as follows: Black-necked stilts: 2.64 (SD = 11.863), Coots: 0.39 (SD = 2.47), White-cheeked Pintail: 3.09 (SD = 23.59), Green Heron: 0.68 (SD = 1.4), Pied-billed Grebe: 0.33 (SD = 1.05), Least Grebe: 0.16 (SD = 0.56), and Common Moorhen: 2.18 (SD = 3.47).

Ruddy Ducks were only detected at two sites: Southgate Pond (brackish) during both the dry and wet seasons and Fredensborg Pond (fresh) during the dry season. This limited distribution meant that no conclusions could be drawn as to its seasonal distribution pattern. For a description of the breeding status of the Ruddy Duck on St. Croix see McNair et al 2005 (1).

Black-necked Stilts were the only birds that were found in greater numbers at brackish sites than at freshwater sites during both seasons. Although the number of Black-necked Stilts found at brackish sites was greater, they were found at a greater number of freshwater sites. During the dry season they were found at 30 different freshwater sites, but only 7 freshwater sites during the wet season. They were found at 15 brackish sites during the dry season and 12 brackish sites during the wet season.

During the dry season more coots were found at freshwater sites (57%), but during the wet season more coots were found at brackish sites (73%). Southgate Pond (brackish) is the primary breeding site for coots on St. Croix (McNair and Cramer-Burke 2006) and during this study accounted for 96% of the coots counted at brackish sites

during the dry season and 91% of the coots counted at brackish sites during the wet season.

All other species of indigenous waterbird species (Least Grebe, Pied-billed Grebe, Common Moorhen, White Cheeked Pintail, Green Heron) were found at much higher numbers at freshwater sites than brackish sites during both seasons.

*Seasonal differences in species richness at brackish and freshwater sites*

Species richness, the number of species present, was examined between seasons and between fresh and brackish sites. During the dry season only two brackish sites had four or more indigenous waterbird species indicating high species richness (Southgate, UVI Wetlands), but during the wet season four sites had four or more indigenous waterbird species (Altona Lagoon Salt Flats, Mannings Bay East, Southgate Pond, and UVI Wetlands). Interestingly, there were 18 freshwater sites that had four or more indigenous waterbird species during the dry season but only seven during the wet season. Only three of these freshwater ponds had four or more indigenous waterbird species in both seasons (Carambola Golf Course Upper Pond, Frangipani East Pond, Granard South).

There was a significant positive relationship between area and species richness at freshwater ponds during both seasons (Dry: $r^2$ =0.21, F(1,86) = 17.56, p<0.0001, Wet: $r^2$ =0.20, F(1,97) = 27.01, p<0.0001). This did not hold true for the brackish sites. During the dry season, there was no significant relationship between area and species richness at brackish sites ($r^2$ =0.27, F(1,16) = 0.2048, p=0.657). Although not significant, during the wet season there appeared to be a trend towards a positive relationship between area and species richness at brackish ponds ($r^2$ =0.26, F(1,20) = 3.52, p=0.08). Further study may establish this relationship fully.

*Area*

A regression analysis was performed to evaluate the relationship between area and the total number of indigenous waterbirds counted, and between area and diversity of

waterbirds. A significant positive linear relationship was found between area and total indigenous waterbirds at freshwater sites during both the dry and wet season (Dry: $r^2$ =0.31, F(1,86) = 43.71, p<0.0001, Wet: $r^2$ =0.25, F(1,96) = 31.98, p<0.0001). At brackish sites however, there was only a significant relationship during the wet season and not during the dry season. This pattern held true even when dry ponds were removed from the analysis.

There was no significant relationship between salinity and either total number of birds ($r^2$ =0.003, F(1, 23) = 0.088, p=0.77) or species richness ($r^2$ =0.02. F(1, 24) = 0.5353, p=0.4715). Rather than a linear relationship, there may be a threshold at which birds no longer use saline sites. Our salinity meter maxed out at 100ppt and at ponds that reached this reading, there were a number of indigenous waterbirds present.

*Priority Sites*

The top sites in terms of total number of indigenous waterbirds during the dry season were, in descending order: Buccaneer Hotel Hole 8 Pond (freshwater: 332 birds), Southgate Pond (brackish: 174 birds), Great Pond (brackish: 60 birds), Renaissance Mangrove Pond (brackish: 49 birds) and Fredensborg Pond (freshwater: 47 birds). During the wet season the results were very similar, confirming the year-round importance of some of these ponds: Buccaneer Hotel Hole 8 Pond (freshwater: 129 birds), Southgate Pond (brackish: 85 birds), Great Pond (brackish: 64 birds), Altona Salt Flats (brackish: 60 birds) and Renaissance Mangrove Pond (brackish: 33 birds).

In terms of species richness, the top ponds were very similar. During the dry season the top ponds were: Southgate Pond (brackish: 7 species), Fredensborg Pond (freshwater: 7 species), Buccaneer Hotel Hole 8 Pond (freshwater: 6 species), Longford West Pond (freshwater: 6 species) and Sight South Pond (freshwater: 6 species). During the wet season the top ponds in terms of species richness were: Southgate Pond (brackish: 7 species), Mannings Bay East (brackish: 5 species), Sight North Pond (freshwater: 5 species).

**Discussion**

Hurricane Omar confounded our attempt to obtain a reliable population count for the wet season. We found significantly less birds in the wet season than the dry season but cannot attribute this solely to wet season dispersal to ephemeral wetlands on other islands. Numerous studies have found that hurricanes cause declines in waterbird populations (Waide 1991, Wiley and Wunderle 1993, Wunderle and Wiley 1996). Indeed, there appeared to be far less birds on island than in normal wet seasons as confirmed by other bird observers (Lisa Yntema, Carol Cramer-Burke, Sheelagh Fromer, pers. comm. And see Christmas Bird Count 2008). White Cheeked Pintails, Common Moorhen and Black-necked Stilts showed especially large decreases in population size in the wet season. It is possible that our counts of the other species (Least Grebe, Pied-billed Grebe, Green Heron, Coot complex) have indeed approached an accurate estimate of the number of these species on the island. There was very little variation in population size for these four species between the seasons indicating that they may have not been affected by the hurricane. Nevertheless, we hope to conduct more surveys during the wet season to sort out what amount of the change in population was due to the hurricane and what amount was due to normal intraisland dispersal.

The importance of salt ponds to waterbirds has been well documented (Craig and Beal 1992, Warnock et al 2002, McNair 2005(1, 3, 6)) Indeed, we found that a higher percentage of indigenous waterbirds were found in brackish sites in the wet season when more saline sites were available, than the during the dry season when saline sites are limited. However, during the wet season, 20% of the birds dispersed to sites that were dry during the dry season, half of which went to freshwater sites meaning that a substantial number of birds are indeed using these ephemeral wetlands, both freshwater and saline. This has two very important conservation and management implications. First, freshwater sites are very important to indigenous waterbirds. This was recently brought to light through surveys of freshwater ponds on St. Croix (McNair 2005 (2)) and is reiterated in our study. Second, ephemeral pond that are often dismissed in the conservation planning process play an important role in the ecology of the indigenous waterbirds of St. Croix.

Only Black Necked Stilts preferred saline sites over freshwater sites. This is consistent with the findings of other studies (McNair et al 2005(2)) in which breeding populations of Black necked Stilts on St. Croix were almost entirely found at saline sites. The dramatic decrease in their population size from the dry season to the wet season may be partially attributed to the hurricane, but some seasonal interisland movement is also likely. The seasonal movement of Black-necked Stilts was found to be closely tied to seasonal changes in rainfall in Hawaii where stilts regularly dispersed among islands to take advantage of ephemeral wetlands (Engilis and Pratt 1993).

Only coots changed preference between seasons and this was largely due to one site, Southgate Pond, their most important breeding site in St. Croix. During the dry season, Southgate was less than 50% full, decreasing the amount of space available, and the salinity was 42 ppt during the dry season vs. 1 ppt during the wet season. It appears that during the dry season a large number of coots moved to a nearby fresh pond (Buccaneer Hotel Hole 8 Pond), however further surveys are necessary to confirm this.

Least Grebes and Pied Billed Grebes were both found occupying the same pond at only one site (Sight South Pond during dry season). This provides further evidence that these birds do not co-exist and Pied-billed Grebes competitively exclude Least Grebes (see Storer 1976, McNair et al 2008).

White-cheeked Pintails showed a fairly substantial reduction in population numbers in the wet season surveys. White-cheeked Pintails are known to disperse among the Virgin Islands and Puerto Rico for breeding (Norton et al. 1986, Collazo and Bonilla-Martinez 2001). Unfortunately, we are not able to determine whether the reduction in population during the wet season is due to normal dispersal or in response to the hurricane.

We confirmed the findings of many other studies, that there is a positive relationship between area and total number of birds, with one exception. During the dry season, brackish ponds did not follow this pattern. One possible explanation for this is that the water level on many of the salt ponds was reduced, making one of the most valuable aspects of theses sites, the surrounding mangroves, inaccessible for birds.

The additional finding that there is a positive relationship between area and species richness at freshwater ponds reinforces the importance of protecting large

freshwater ponds. A number of these large ponds, such as Castle Burk are now being threatened by the introduction of a variety of invasive aquatic plants that cover the pond and can eventually dry up the pond completely. Regular visits for bird monitoring and inspection for invasive aquatic plants should be conducted at these ponds regularly.

We did not find a relationship between salinity and total number of birds or species richness in this study. It may be that the indigenous waterbirds do not react to salinity in a linear fashion but rather there may be a threshold salinity value at which waterbirds no longer use saline sites. In this study however, indigenous waterbirds were observed even at sites with very high salinity reading (100+ ppt).

This study confirmed that Southgate Pond is probably the single most important pond on St. Croix for indigenous waterbirds (see McNair 2005(3)). It had the highest species richness during both seasons and had the second largest total number of birds during both seasons. Southgate has fortunately been protected by the St. Croix Environmental Association as part of the Southgate Coastal Reserve. Other brackish sites that were especially important based on species richness and total birds were Great Pond, the Renaissance Mangrove Pond, Altona Salt Flats and Mannings Bay East. Unfortunately, Great Pond is threatened by a large resort that has been proposed to be constructed adjacent to the wetlands. Both Great Pond and Southgate Pond are listed as Important Bird Areas by Birdlife International.

Two freshwater ponds stood out as being especially important to indigenous waterbirds: Buccaneer Hotel Hole 8 Pond and Fredensborg Pond. The Buccaneer Hotel Hole 8 Pond had the highest total number of waterbirds during both seasons' surveys and had high species richness during the dry season surveys. Fredensborg pond, the largest freshwater pond on St. Croix, hosted a very high number of indigenous waterbirds and had high species richness during the dry season. Other freshwater sites of note include Longford West Pond, Sight South Pond, Sight North Pond, Carambola Golf Course Upper Pond, Frangipani East Pond and Granard South Pond..

Despite our inability to obtain a reliable wet season population count for a typical year, we were able to determine some of the patterns of seasonal dispersal of the indigenous waterbirds of St. Croix. Specific movement studies such as through banding

or radio tracking may give further insight into more specific dynamics of this movement and should be considered for future research.

**Acknowledgements**

Lisa Yntema, Carol Cramer-Burke, Sheelagh Fromer and Claudia Lombard provided valuable help in planning and carrying out the bird surveys. Other bird observers included Mike Treglia, Chris Neibuhr, and Zandy Hillis-Starr. Douglas McNair originally conceived of and proposed the idea for this study. Russell Slatton provided assistance with GIS. We are very grateful to all the landowners that allowed us access to their property for the bird surveys.

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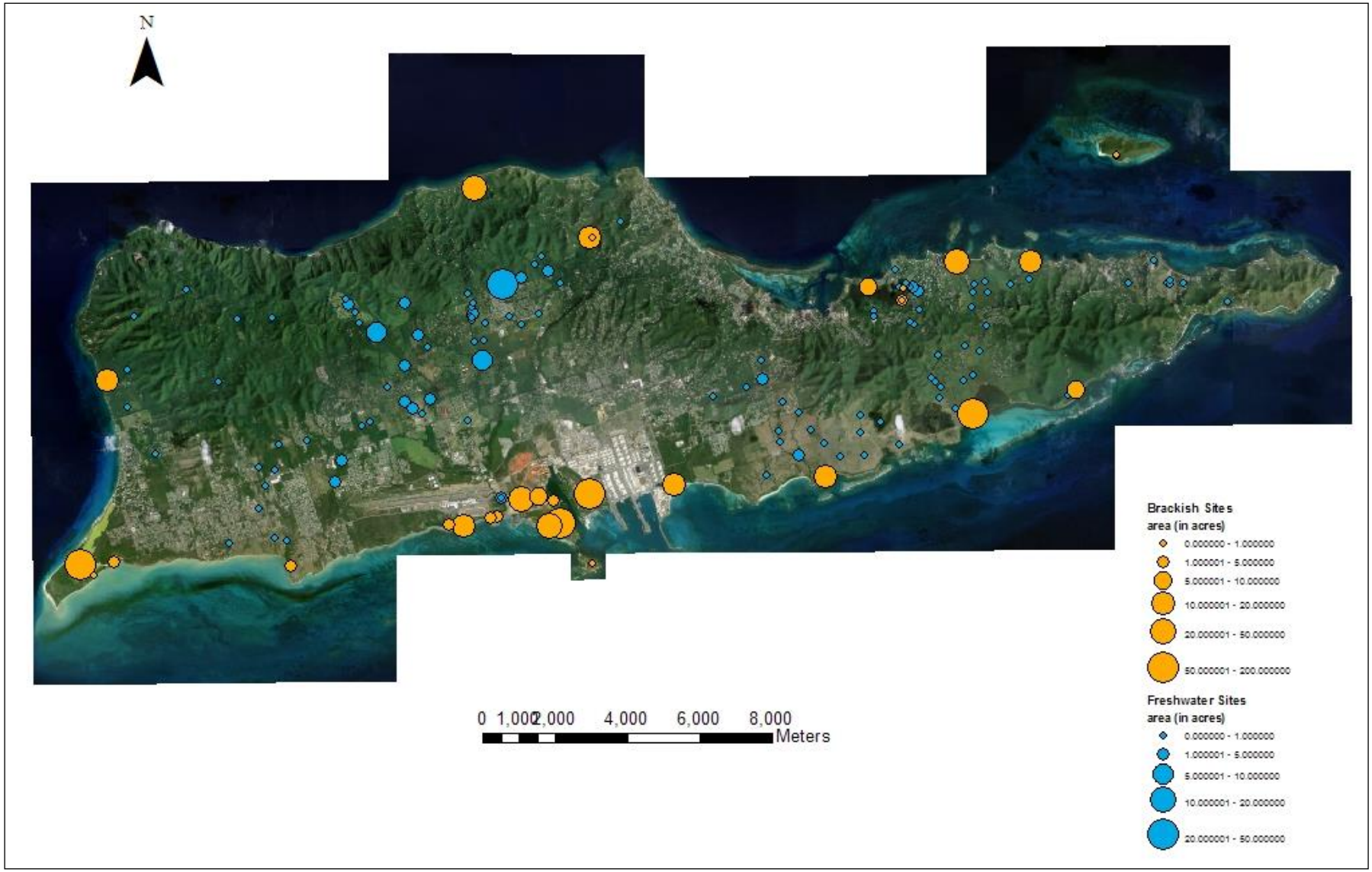
# Appendix 1.

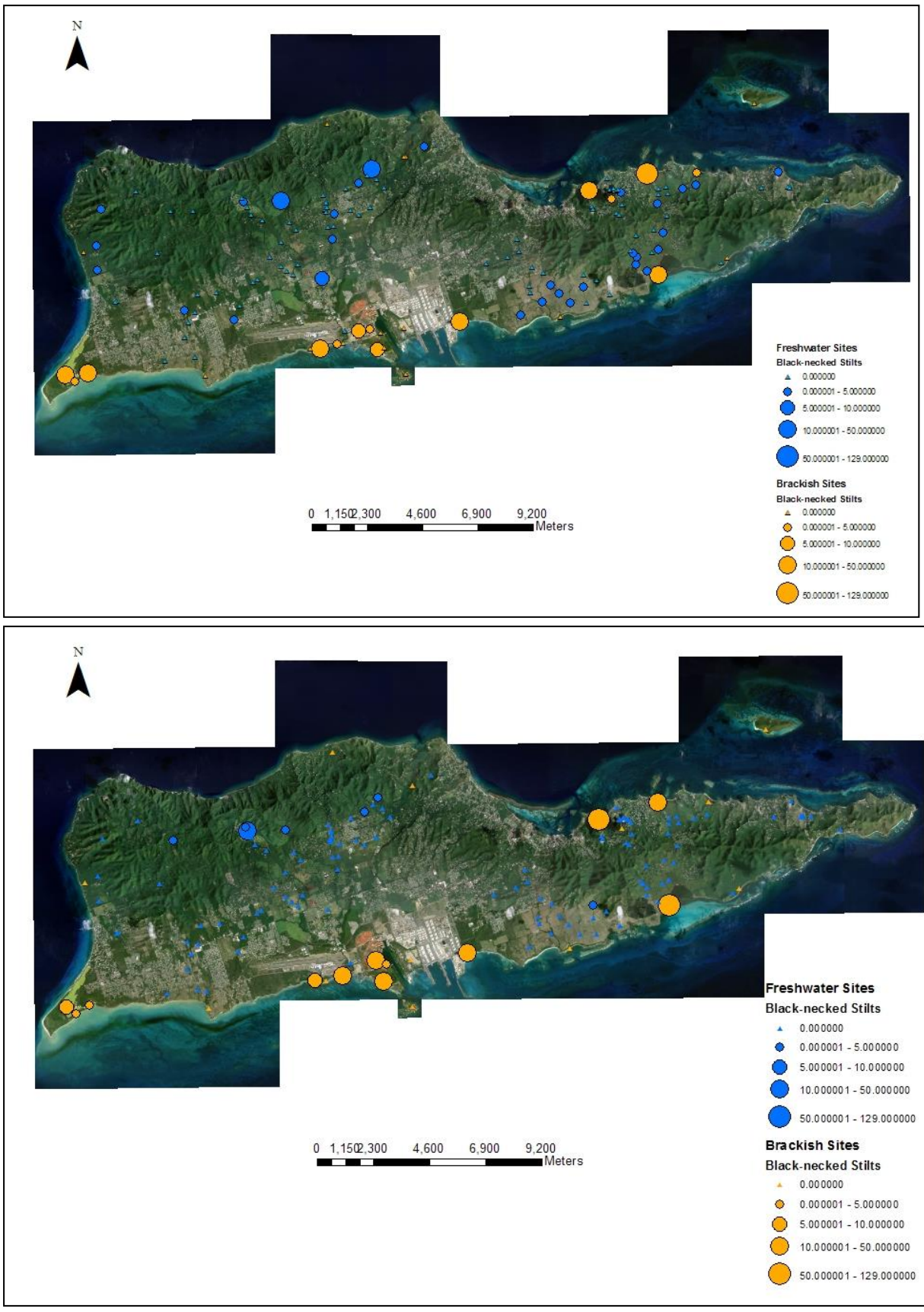
## Wetland Sites Surveyed




All of the wetlands sites that were surveyed for indigenous waterbirds, divided by fresh and brackish sites. Size of the circle indicates total area of the wetland.

Appendix 2.

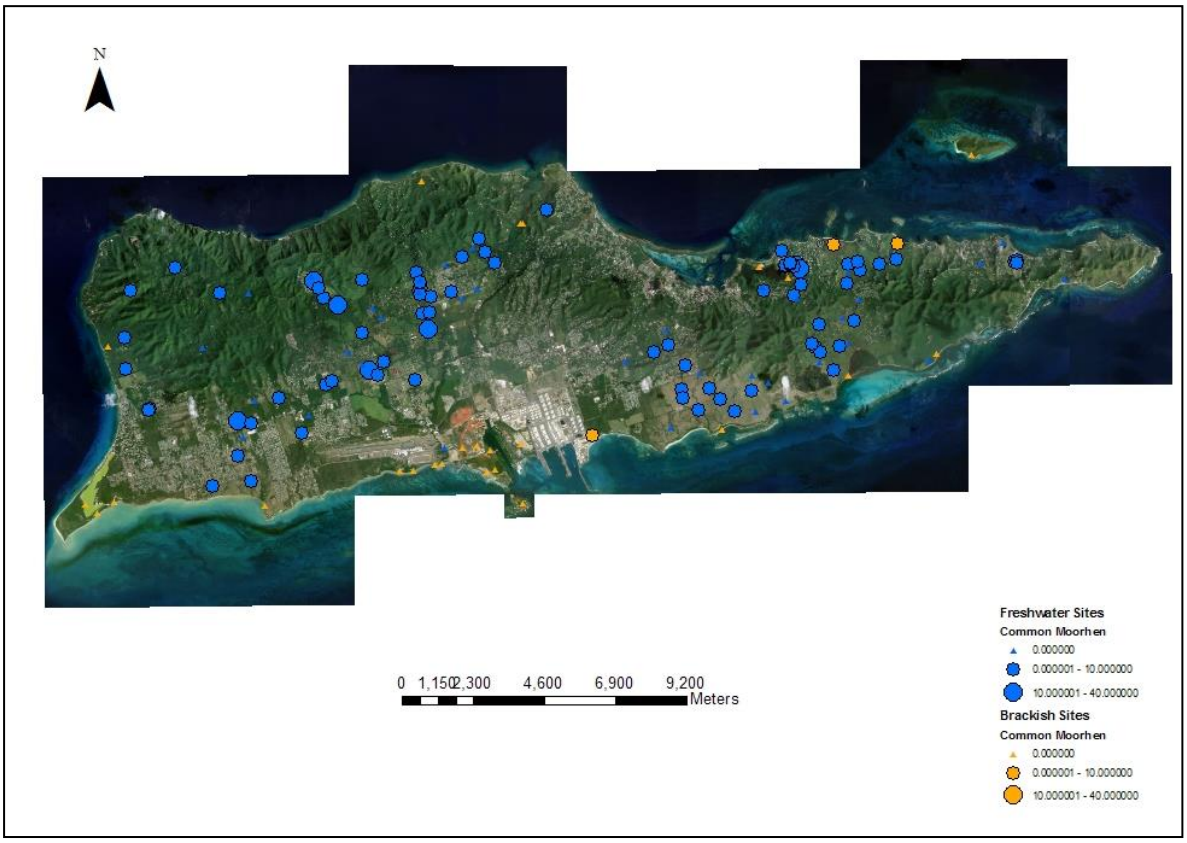
Distribution of total birds at freshwater and brackish sites during wet and dry seasons, and by species

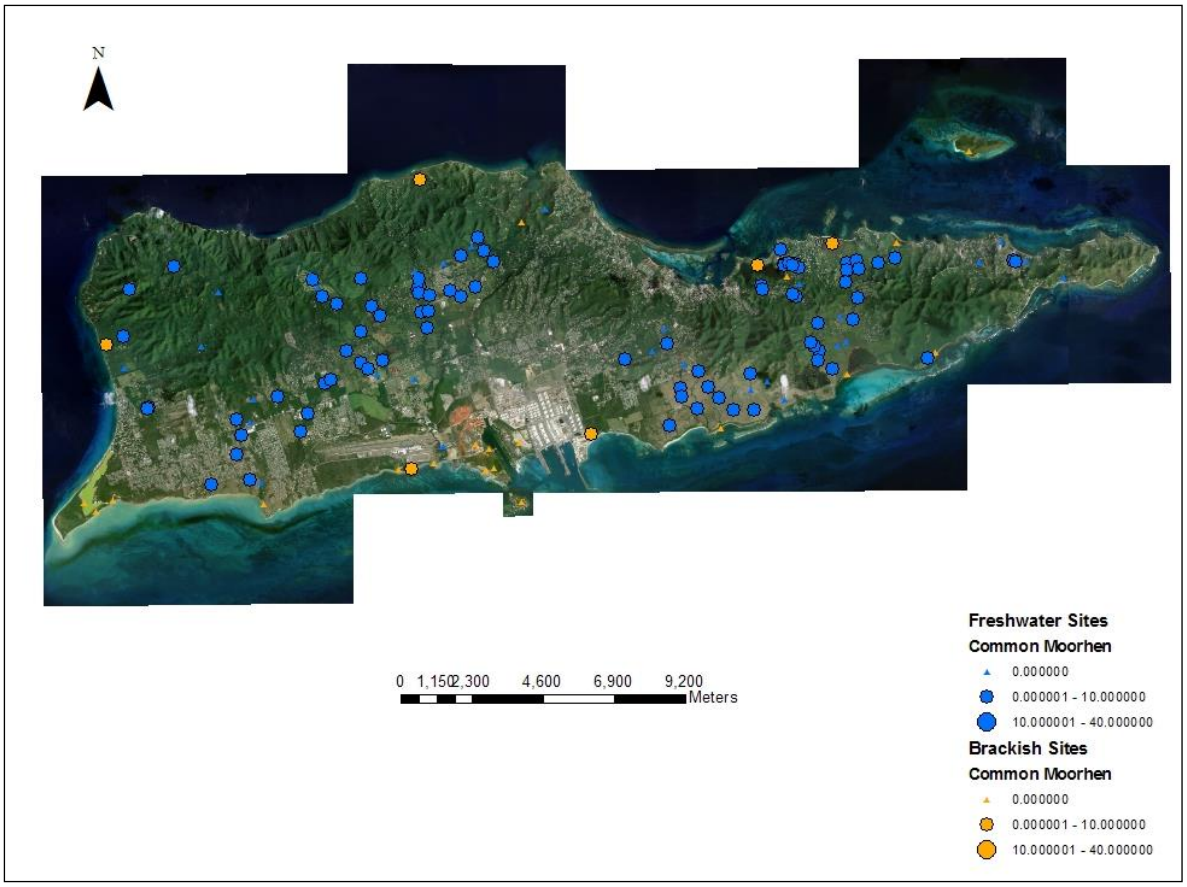




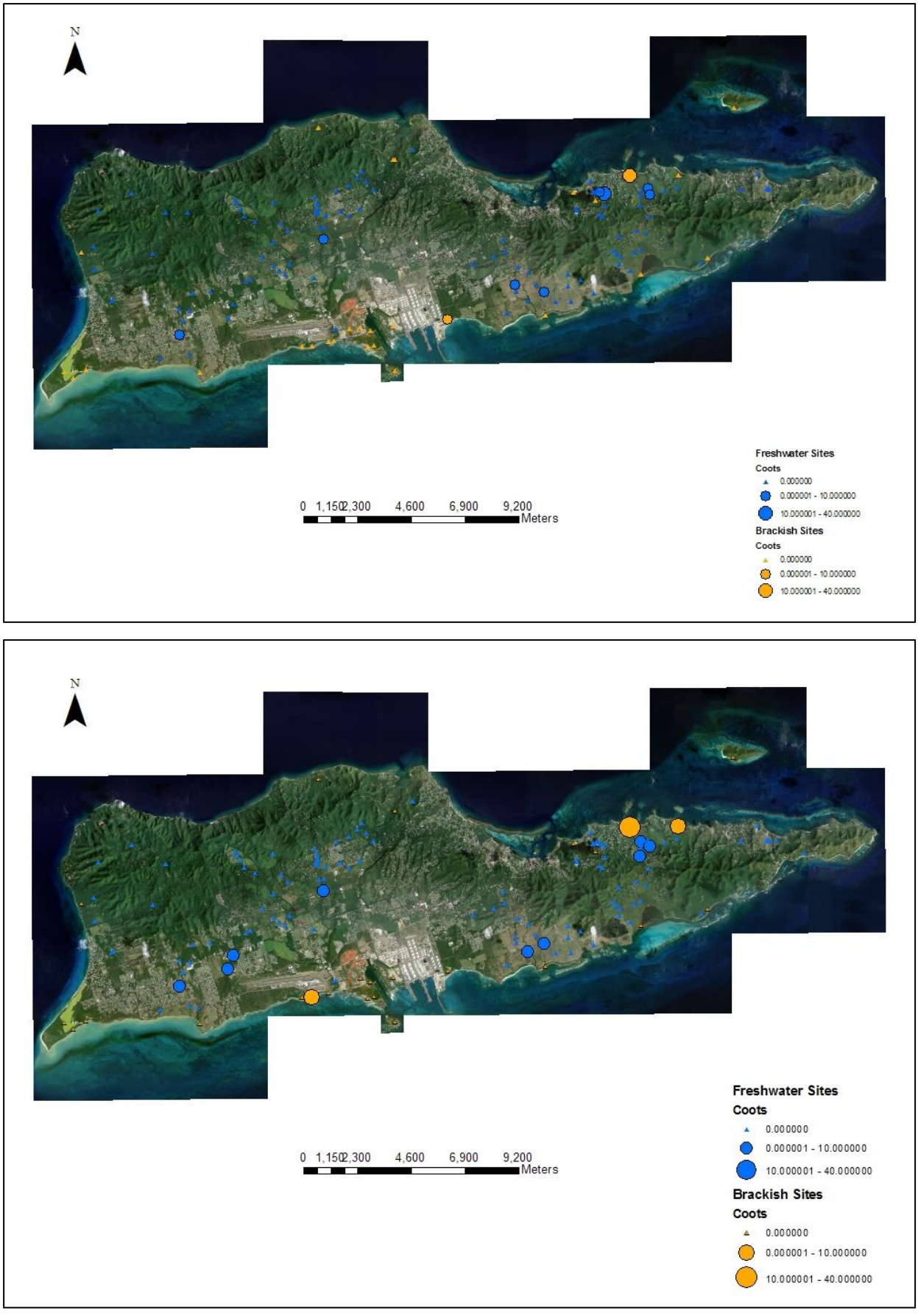


Distribution and total numbers of Black-necked Stilts during the dry season (top) and wet season (bottom)

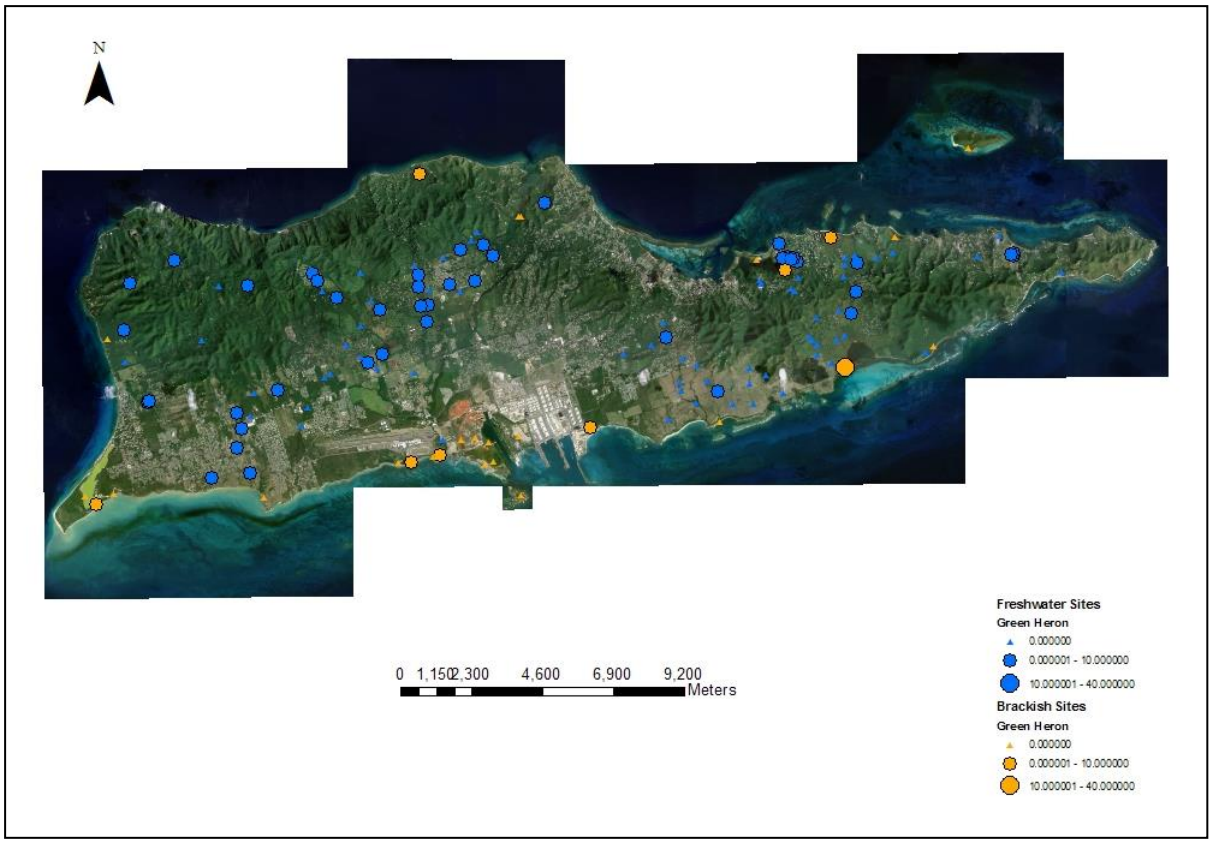


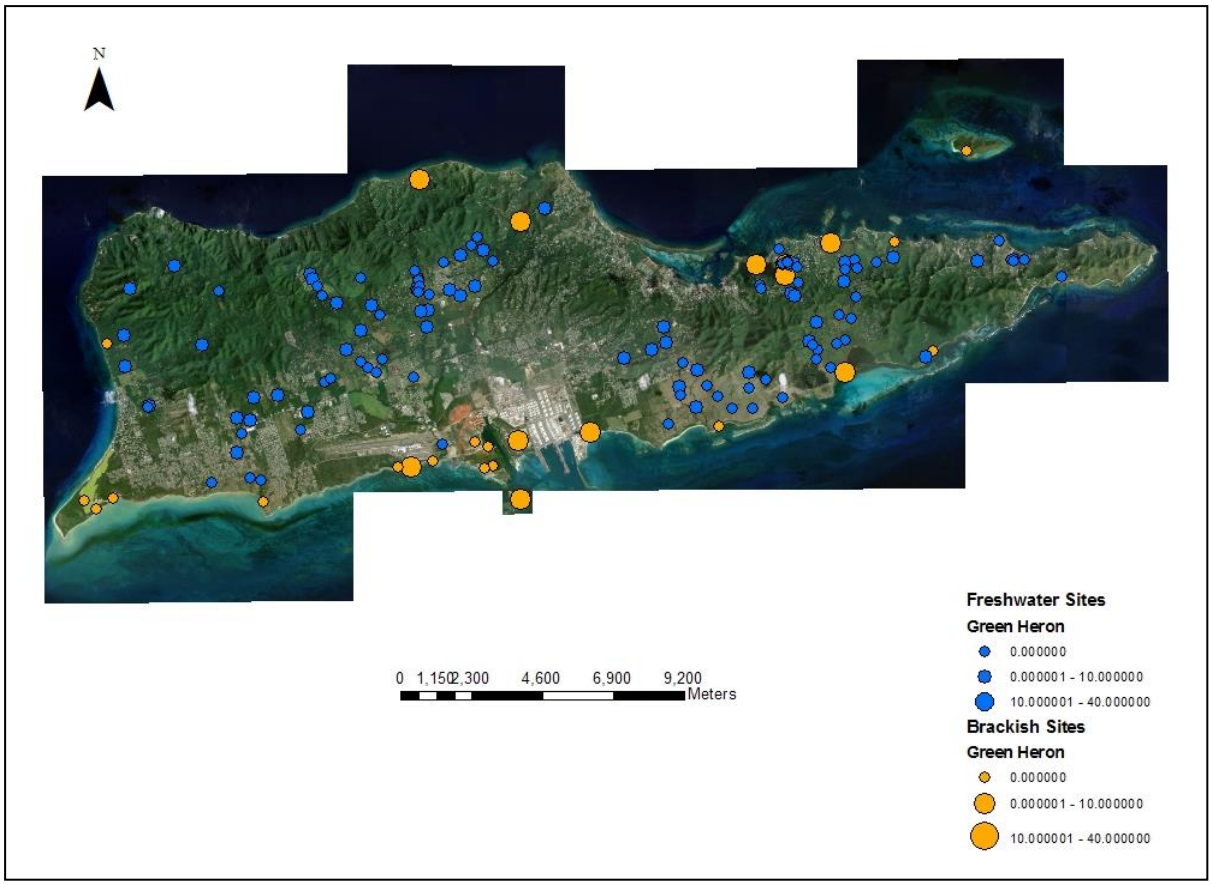




Distribution and total numbers of Common Moorhen during the dry season (top) and wet season (bottom)

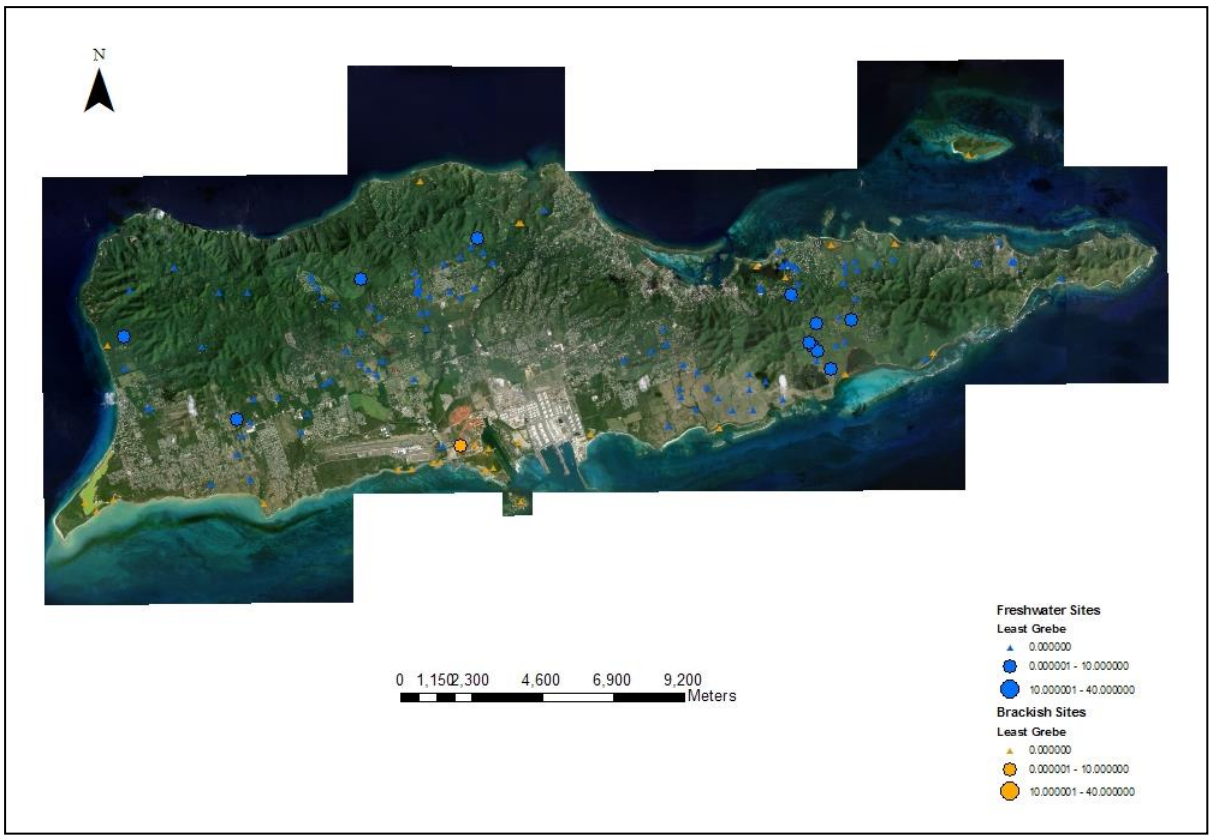


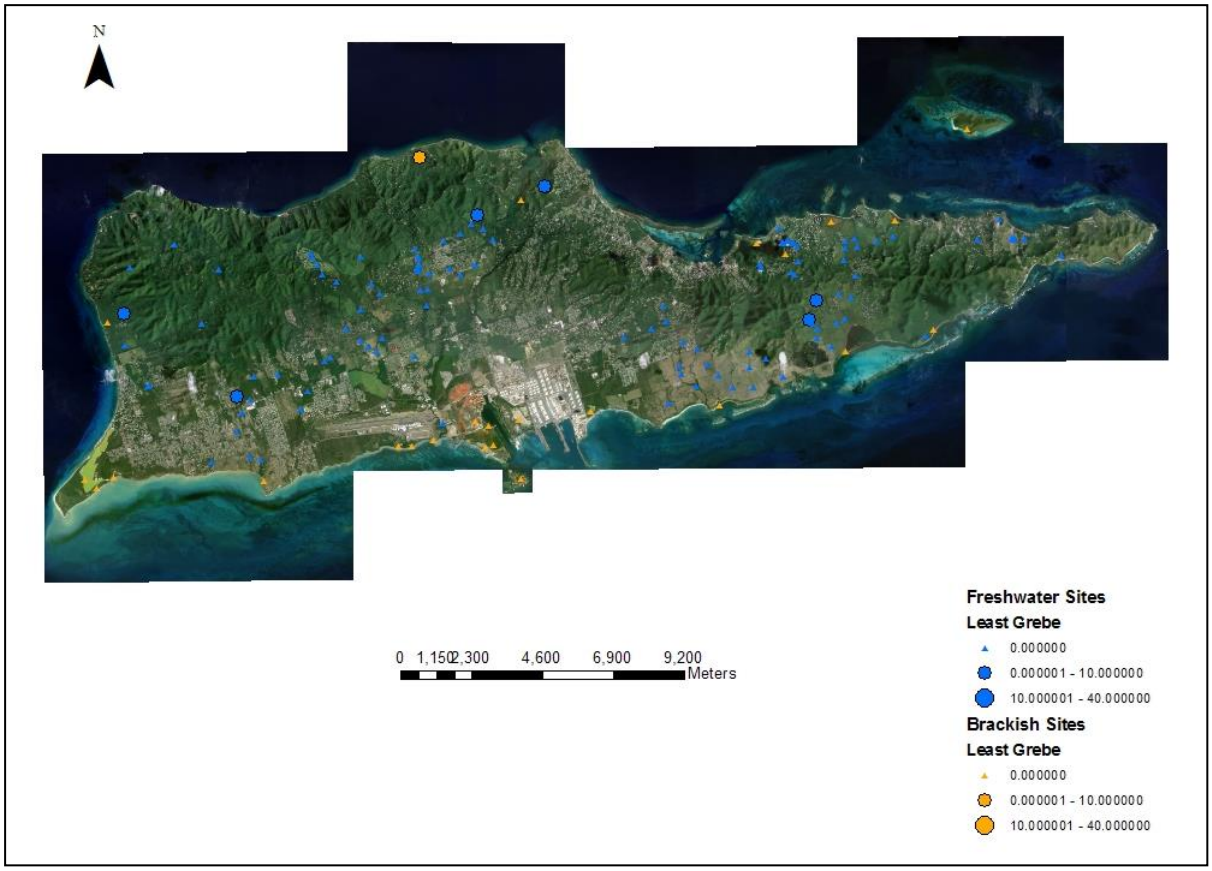

Distribution and total numbers of Coots during the dry season (top) and wet season (bottom)



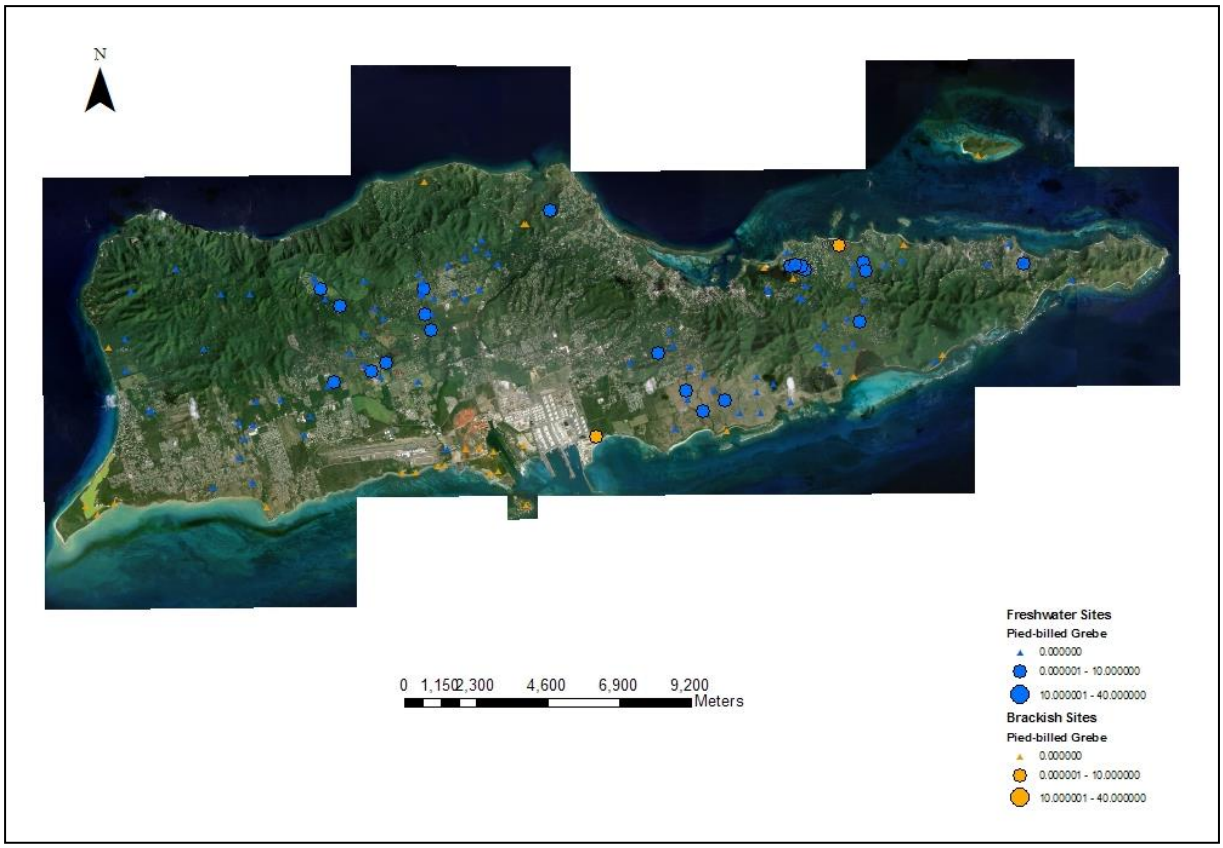



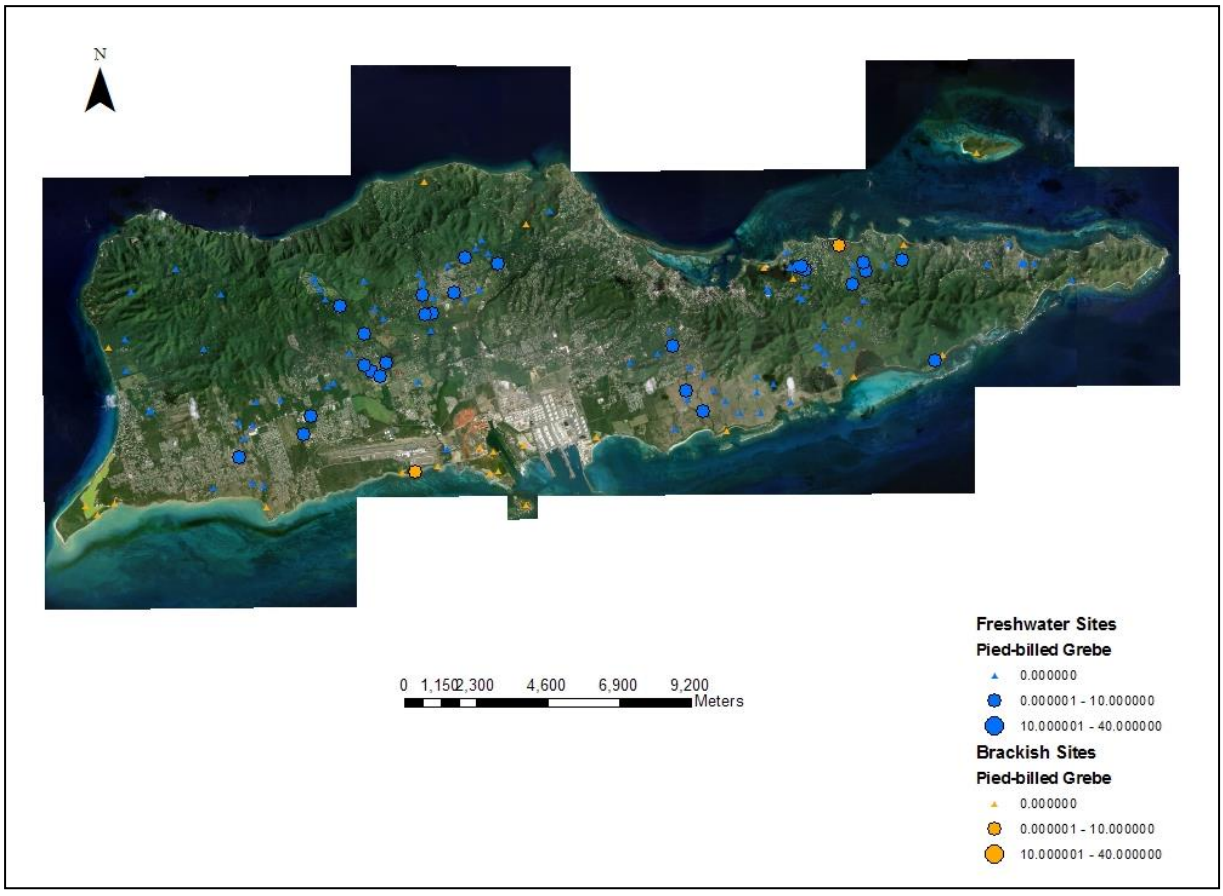

Distribution and total numbers of Green Herons during the dry season (top) and wet season (bottom)



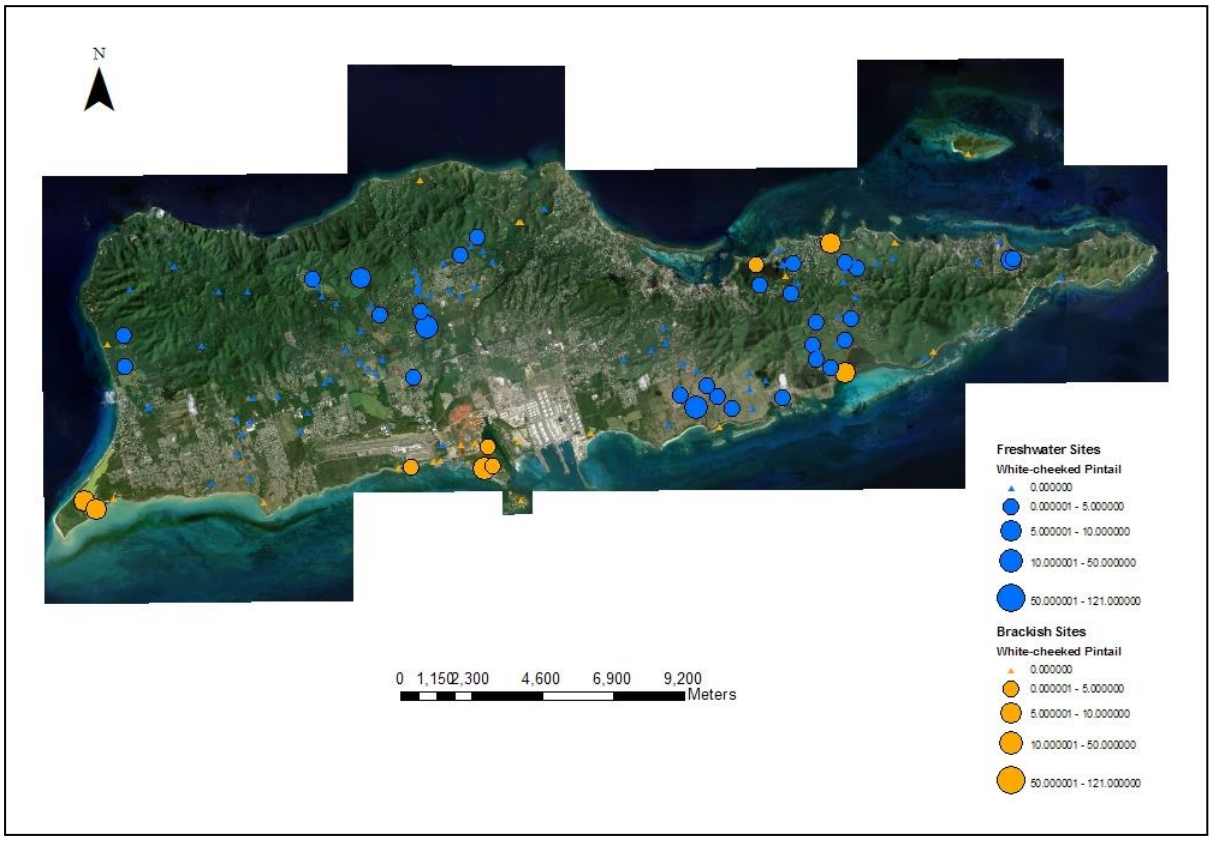



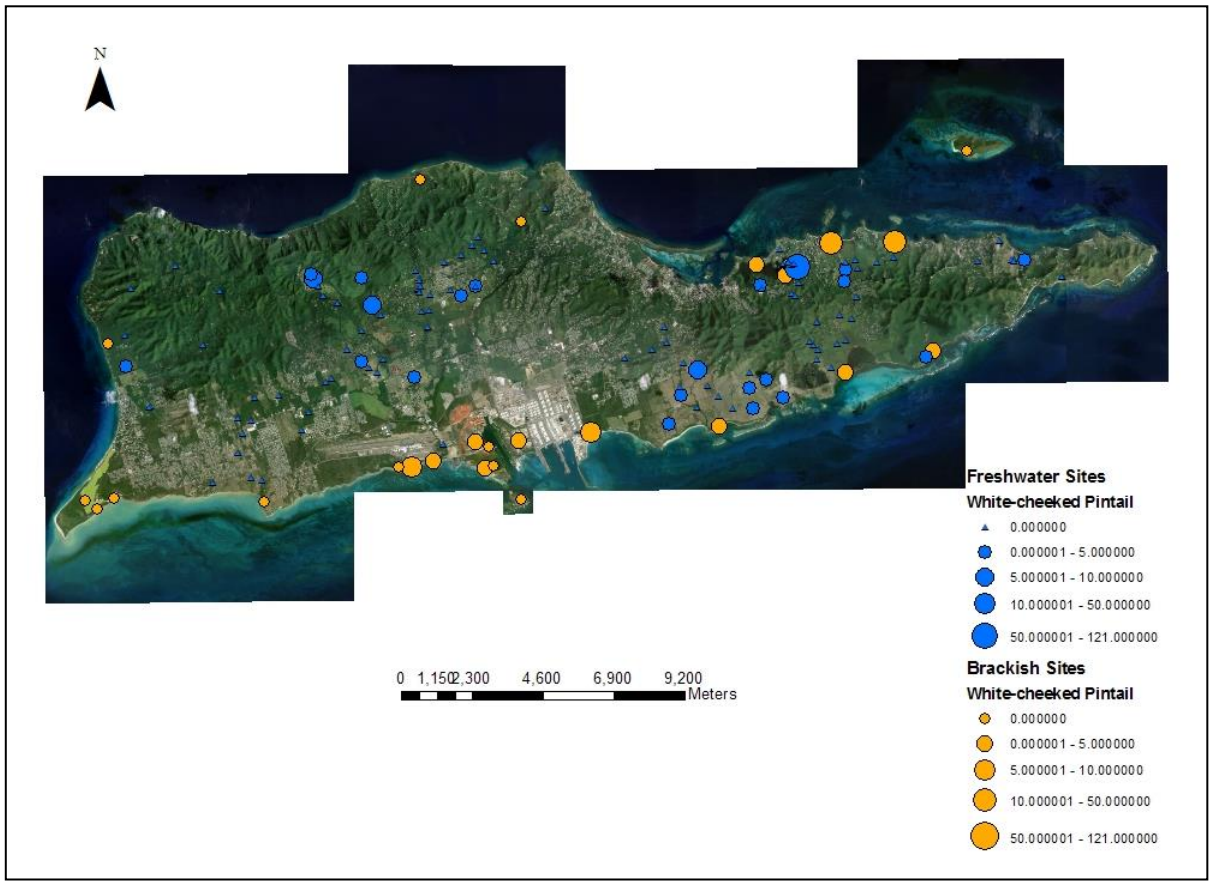

Distribution and total numbers of Least Grebes during the dry season (top) and wet season (bottom)




Distribution and total numbers of Pied-billed Grebes during the dry season (top) and wet season (bottom)




Distribution and total numbers of White-cheeked Pintails during the dry season (top) and wet season (bottom)

Appendix 3.

List of wetland sites surveyed, locations and areas.

# Locations and areas of all sites surveyed for indigenous waterbirds

| site | longitude | latitude | area in hectares |
|---|---|---|---|
| Aermotor North Pond | -64.79138 | 17.74984 | 0.066 |
| Aermotor South Pond | -64.79149 | 17.74900 | 0.291 |
| Altona Lagoon Salt Flat | -64.68792 | 17.75296 | 2.607 |
| Anguilla Landfill Water Treatment Plant | -64.78440 | 17.70087 | 0.950 |
| Annaly Farms East Pond | -64.78440 | 17.70087 | 0.253 |
| Annaly Farms West Pond | -64.80928 | 17.73445 | 0.435 |
| Annaly Pond | -64.85276 | 17.74646 | 0.183 |
| Bethlehem Cattail Marsh | -64.78845 | 17.74034 | 0.307 |
| Brookshill Pond | -64.85791 | 17.73057 | 0.064 |
| Buccaneer Hotel Hole 10 | -64.67983 | 17.75291 | 0.118 |
| Buccaneer Hotel Hole 16 Pond | -64.67996 | 17.75303 | 0.066 |
| Buccaneer Hotel Hole 17 Pond | -64.67844 | 17.75388 | 0.082 |
| Buccaneer Hotel Hole 6 Pond | -64.67831 | 17.75336 | 0.119 |
| Buccaneer Hotel Hole 8 Pond | -64.67532 | 17.75192 | 0.802 |
| Buccaneer Hotel Hole 9 Pond | -64.67736 | 17.75277 | 0.208 |
| Buccaneer Hotel Parking Mangrove | -64.67887 | 17.75262 | |
| Buccaneer Hotel Putt Hole 4 Pond | -64.67931 | 17.74942 | 1.134 |
| Buccaneer Hotel Water Lily Pond | -64.68110 | 17.75743 | 0.072 |
| Buccaneer Hotel Water Treatment Pond | -64.67660 | 17.75299 | 0.443 |
| Buck Island Salt Pond | -64.62297 | 17.78508 | 0.264 |
| Cane Pond | -64.84588 | 17.70441 | 0.175 |
| Cane Valley South Pond | -64.84225 | 17.71490 | 0.117 |
| Carambola GC Horseshoe Pond | -64.82106 | 17.74496 | 0.080 |
| Carambola GC Lower Ponds | -64.81641 | 17.74278 | 2.205 |
| Carambola GC Middle Pond | -64.82222 | 17.74775 | 0.264 |
| Carambola GC North Marsh | -64.82451 | 17.75116 | 0.194 |
| Carambola GC Upper Pond | -64.82390 | 17.74981 | 0.540 |
| Carlton North Pond | -64.84763 | 17.69872 | 0.310 |
| Carlton Slough | -64.84028 | 17.69068 | 0.056 |
| Carlton South Pond | -64.84367 | 17.69141 | 0.339 |
| Castle Burk Pond | -64.80282 | 17.72585 | 0.708 |
| Castle Nugent Lower Pond | -64.68033 | 17.71346 | 0.054 |
| Catherine's Rest North | -64.71077 | 17.72422 | 0.077 |
| Coakley Pond | -64.64603 | 17.75455 | 0.152 |
| Coakley Salt Pond | -64.64560 | 17.75897 | 4.943 |
| Cobel | -64.80578 | 17.74181 | 0.424 |
| Cockpit Pond | -64.77418 | 17.74718 | 0.109 |
| Corn Hill Pond | -64.77418 | 17.74718 | 0.100 |
| Cotton ValleyPond | -64.62037 | 17.75331 | 0.181 |
| Creque Dam Reservoir | -64.87976 | 17.74738 | 0.092 |
| Cruzan Rum Distillery Pond | -64.82781 | 17.70540 | 0.418 |
| Diamond Keturah Pond | -64.71526 | 17.70608 | 0.140 |
| Diamond Pond | -64.82582 | 17.71056 | 1.379 |
| Eulalie Rivera Pond | -64.82057 | 17.71938 | 0.087 |
| Fairplane Gut Entrance | -64.78546 | 17.69636 | 1.847 |
| False Schuster | -64.65115 | 17.75324 | 0.094 |
| Forbes Street Pond | -64.68692 | 17.74695 | 0.094 |
| Frangipani East Pond | -64.77867 | 17.75630 | 0.562 |
| Fredensborg Pond | -64.78894 | 17.73540 | 2.952 |
| Glynn South Pond | -64.76842 | 17.75475 | 0.062 |
| Grapetree Cattail Pond | -64.59446 | 17.74836 | 0.154 |

| | | | |
|---|---|---|---|
| Great Pond | -64.66097 | 17.72077 | 40.050 |
| Great Pond East Little Pond | -64.66097 | 17.73051 | 0.081 |
| Grenard Middle Pond | -64.71165 | 17.71449 | 0.366 |
| Grenard North Pond | -64.71176 | 17.71699 | 0.366 |
| Grenard South Pond | -64.70666 | 17.71084 | 0.510 |
| Ha'Penny Mangrove Swamp | -64.69975 | 17.70539 | 6.269 |
| Head Start Pond | -64.72880 | 17.72578 | 0.215 |
| Herman Hill Middle | -64.71592 | 17.73013 | 0.436 |
| Herman Hill North | -64.71641 | 17.73482 | 0.091 |
| Hermitage Pond | -64.80922 | 17.75003 | 0.451 |
| Hogensborg East Pond | -64.84353 | 17.70835 | 0.132 |
| Hogensborg West Pond | -64.84744 | 17.70917 | 0.113 |
| Hope and Carlton Pond | -64.85537 | 17.69014 | 0.221 |
| IRQA Cattail Pond | -64.83485 | 17.71583 | 0.118 |
| Jealousy Pond | -64.80336 | 17.73910 | 0.158 |
| Krause Lagoon | -64.76132 | 17.70161 | 77.715 |
| LaGrange East Pond | -64.87436 | 17.71283 | 0.049 |
| LaGrange West Pond | -64.87463 | 17.71263 | 0.058 |
| Little Fountain Pond | -64.79248 | 17.75214 | 0.143 |
| Long Point Salt Pond | -64.83938 | 17.68443 | 0.595 |
| Longford East Pond | -64.69050 | 17.71666 | 0.169 |
| Longford Lower Pond | -64.69569 | 17.71060 | 0.054 |
| Longford Southeast Pond | -64.68956 | 17.71063 | 0.054 |
| Longford Upper Northeast Pond | -64.68535 | 17.71900 | 0.123 |
| Longford Upper Pond | -64.69064 | 17.72100 | 0.107 |
| Longford West Pond | -64.69997 | 17.71403 | 0.156 |
| Lowry Hill North Pond | -64.67744 | 17.74417 | 0.206 |
| Lowry Hill South Slough | -64.67626 | 17.74348 | 0.336 |
| Mannings Bay East | -64.79409 | 17.69410 | 5.342 |
| Mannings Bay East Flats | -64.78739 | 17.69580 | 1.000 |
| Mannings Bay West | -64.79813 | 17.69419 | 1.214 |
| Many Paws Pond | -64.70360 | 17.71728 | 0.098 |
| Mon Bijou North | -64.78202 | 17.74638 | 0.146 |
| Mon Bijou South Pond | -64.77858 | 17.74441 | 0.125 |
| Mon Bijou Waterway | -64.78370 | 17.75437 | 10.607 |
| Mount Fancy Pond | -64.63641 | 17.72535 | 0.318 |
| Mount Fancy Salt Pond | -64.63399 | 17.72677 | 3.363 |
| Mount Pleasant West Pond | -64.67502 | 17.74728 | 0.096 |
| Mount Stewart Pond | -64.84380 | 17.74651 | 0.095 |
| Mount Victory Pond | -64.86605 | 17.75395 | 0.149 |
| Mountain Mint Dairy Lower Pond #1 | -64.66353 | 17.72938 | 0.076 |
| Mountain Mint Dairy Lower Pond #2 | -64.66553 | 17.72218 | 0.187 |
| Mountain Mint Dairy Upper Pond #1 | -64.66933 | 17.72775 | 0.089 |
| Mountain Mint Dairy Upper Pond #2 | -64.67098 | 17.72896 | 0.285 |
| Mountain Mint Dairy Upper Pond #3 | -64.67186 | 17.73014 | 0.160 |
| Mountain Mint Dairy Upper Pond #4 | -64.66967 | 17.72487 | 0.059 |
| Mrs. Harvey's Pond | -64.70642 | 17.72182 | 0.135 |
| Nolan's Tavern Pond | -64.68673 | 17.74564 | 0.074 |
| Old Works Pond | -64.79098 | 17.74002 | 0.097 |
| Out-of-Sight Pond | -64.66290 | 17.73788 | 0.084 |
| Petronella Pond | -64.66992 | 17.73582 | 0.158 |
| Pig Pen Pond | -64.72010 | 17.72823 | 0.200 |
| Plessen Pond | -64.81851 | 17.72043 | 0.031 |
| Prosperity Pond | -64.88158 | 17.72437 | 0.164 |

| | | | |
|---|---|---|---|
| Reef Condo Pond #1 | -64.60926 | 17.75402 | 0.092 |
| Reef Condo Pond #2 | -64.61003 | 17.75339 | 0.377 |
| Reef Condo Pond #3 | -64.60938 | 17.75303 | 0.151 |
| Renaissance: Bottom Ash Pond | -64.77457 | 17.70125 | 2.757 |
| Renaissance: East Pond | -64.77060 | 17.70005 | 0.571 |
| Renaissance: Lower Cooling Pond | -64.76908 | 17.69441 | 48.398 |
| Renaissance: Mangrove Pond | -64.77180 | 17.69373 | 17.208 |
| Renaissance: Upper Cooling Pond | -64.77911 | 17.70066 | 11.413 |
| Rust-Op-Twist | -64.79072 | 17.77866 | 10.379 |
| Ruth Island Salt Pond | -64.76076 | 17.68428 | 0.288 |
| Schuster Little Pond | -64.66089 | 17.75127 | 0.088 |
| Schuster Lower Pond | -64.65773 | 17.75405 | 0.329 |
| Schuster Upper Pond | -64.65691 | 17.75132 | 0.341 |
| Sight North Pond | -64.66117 | 17.74763 | 0.198 |
| Sight South Pond | -64.65924 | 17.73655 | 0.253 |
| Skov Little Pool | -64.79181 | 17.74630 | 0.015 |
| Skov Middle Pond | -64.79186 | 17.74660 | 0.197 |
| Skov North Pond | -64.79123 | 17.74732 | 0.407 |
| Skov South Pond | -64.79153 | 17.74552 | 0.374 |
| Skov Southeast Pond | -64.78804 | 17.74482 | 0.280 |
| Slob Pond | -64.60583 | 17.75331 | 0.093 |
| Southgate Plantation Pond | -64.66061 | 17.75336 | 0.213 |
| Southgate Pond | -64.66502 | 17.75904 | 9.528 |
| SPNWR Plover Pits | -64.89071 | 17.68244 | 0.069 |
| SPNWR Stilt Pond | -64.88568 | 17.68572 | 2.017 |
| Sugar Bay Catchment Pond | -64.75985 | 17.76617 | 0.123 |
| Sugar Bay Mangrove Forest | -64.76082 | 17.76602 | 7.189 |
| Teague Bay Pond | -64.61368 | 17.75909 | 0.143 |
| Tipperary Pond | -64.65735 | 17.74302 | 0.147 |
| Triton Bay Pond | -64.75277 | 17.77010 | 0.176 |
| Upper Love Pond | -64.81381 | 17.72886 | 0.176 |
| USDA Exp Sta Water Treatment Pond | -64.79302 | 17.72050 | 0.253 |
| UVI Wetlands | -64.73940 | 17.70374 | 4.662 |
| VI Agri Station Lower Pond | -64.80467 | 17.72217 | 0.332 |
| VI Agri Station Middle Pond | -64.80727 | 17.72356 | 1.028 |
| VI Agri Station Upper Pond | -64.80920 | 17.72516 | 0.943 |
| West End Salt Pond | -64.89421 | 17.68514 | 58.847 |
| Williams Pond | -64.88170 | 17.73382 | 0.127 |
| Williams-Prosperity Marsh | -64.88693 | 17.73132 | 6.372 |
| Windsor Marsh | -64.77519 | 17.75935 | 0.233 |
| Windsor North Pond | -64.77341 | 17.76152 | 0.233 |
| Windsor South Pond | -64.77155 | 17.75775 | 0.450 |