Monitoring Avian Diversity and Abundance in the Odello West Restoration Site, Carmel, California

Prepared For:
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INTRODUCTION

Riparian areas and wetlands together comprise important habitat for a wide range of species, including fish, amphibians, and a wide range of bird species (CCC 1987). These habitats provide rich food resources, secure nesting, roosting and staging areas, and prime stopover habitat for migratory songbirds, shorebirds and waterfowl, particularly in western North America (Donovan et al. 2002). Riparian and wetland areas also play important roles in maintaining water quality and controlling seasonal flood events (Naiman et al. 2000). These habitats are seriously imperiled by watershed development, heavy water usage and residential and commercial development (Knopf et al. 1988). Preservation and restoration of these habitats has become the priority for many conservation and natural resource management organizations.

In California, at least 85% of historical riparian areas have been lost (Mitsch and Gosselink 1993), and the remaining areas are under constant threat by development and increased water use. Effective restoration of riparian habitats in California is essential in order to protect and sustain populations of endangered, threatened, declining, and healthy populations of riparian-associated species (Naiman et al. 2000, Knopf et al. 1988). The assessment and monitoring of restoration projects provides clear information about the efficacy of the restoration, and allows resource managers to improve the quality of their resource management programs based on information garnered from monitoring efforts, a practice referred to as adaptive management (Ruiz-Jaen and Aide 2005, Elliot et al. 2005). Ecosystems are dynamic processes rather than discrete entities, and adaptive management facilitated by regular monitoring will ensure successful restoration efforts.

The use of focal species is a widely accepted method for monitoring the effectiveness of restoration projects. Birds are sensitive and accurate indicators of habitat quality because they respond quickly and observably to perturbations in the environment (Marzluff and Sallabanks 1998). They are also a very cost-effective measure of habitat quality because they are easy to monitor using a minimum of equipment and personnel (Ralph et al. 1993).

In 2004, California Department of Parks and Recreation (CDPR) initiated the Carmel River State Beach Lagoon Restoration Project on a 10 ha site at the mouth of the Carmel River. The land was originally comprised of brackish and freshwater wetlands and a wide riparian zone but was converted to agriculture during the late 1700's (CDPR 2003). The land was acquired by CDPR in 1979, but was used for agriculture continuously until 1998. After extensive flooding of the Carmel River in 1998, the fields were left fallow in order to provide an adequate floodplain for the river. The goal of this restoration project is to restore the historic habitat and associated wildlife including many sensitive and endangered species and to improve the hydrologic function of the Carmel River (CDPR 2003).

In spring 2005, Ventana Wildlife Society (VWS) was contracted to assess and monitor avian use of the Carmel River State Beach Lagoon Restoration Project. The purpose of the avian assessment and monitoring at the site was to provide essential information about current habitat use and to begin monitoring the effectiveness of restoration efforts to the resource agencies involved with the project. Avian monitoring at the Carmel River Lagoon will provide conservation and resource management personnel with the opportunity to track the effects of habitat restoration on bird

populations, and practice adaptive management strategies to continue to provide optimal habitat for a variety of plant and animal species.

I used area search censuses to determine the diversity, abundance and community assemblages of birds using the restoration site, in order to develop an understanding of how birds use the restoration site, and to provide baseline data with which to compare data gathered during subsequent monitoring efforts. This report details the baseline data obtained from those surveys, and presents recommendations for future assessment and monitoring efforts.

METHODS

Study Area

The portion of the Carmel River State Beach Lagoon Restoration Project currently being implemented is known as the Odello West restoration site. This area comprises approximately 10 ha of fallow artichoke fields which are overgrown with predominately non-native annual vegetation including poison hemlock, black mustard and wild radish. The restoration site also includes a newly dredged lagoon channel as well as portions of the existing lagoon and surrounding wetland vegetation.

Restoration efforts thus far have focused on the establishment of vegetation along the edge of the new lagoon channel and the suppression of hemlock and mustard in the upper reaches of the project area by mowing portions of the site and planting sterile wheat. Several areas within the restoration site remained unaltered during the avian survey period, allowing the restoration site to be divided into six plots representing both restored and unaltered habitats. One plot included the new arm of the lagoon, one plot comprised the previously existing upper portion of the lagoon with some vegetation restoration along the banks, one plot was centered on an unaltered site planned as a native American agriculture site, and three plots were located in the upper reaches of the restoration site where the vegetation ranged from mowed hemlock and planted wheat to unaltered mustard, hemlock and grassland patches (Appendix 1).

Area search

The area search is a technique used to census avian populations in a given plot over the course of a 20-minute sampling period. The benefit of this method for censusing bird populations is that it allows the observer to move freely within the sample plot in order to track down inconspicuous, quiet or unfamiliar birds. Each study plot was searched twice per season in summer, fall and winter for twenty minutes, by an experienced observer. Every bird seen or heard was recorded on a standardized data sheet (Appendix 2).

Data presentation and analysis

Species richness (total number of species) and abundance were tabulated for each plot in each season by taking the average count of species and individuals, respectively. Overall relative abundance and the relative abundance of each species were calculated for each plot in each season by dividing the total number of individuals of each species by the area of the plot.

Species diversity was calculated for each plot in each season using the Simpson Diversity Index, D, which combines estimates of species richness and species evenness to

arrive at a relative diversity value. The Simpson Diversity index is an accurate measure of diversity for nonrandom sampling of limited populations (Brower et al. 1997). A high Simpson Diversity Index indicates relatively high diversity. The Simpson Diversity Index is calculated as

$$D = \frac{1}{\sum_{i=1}^{s} P_i^2}$$

where S equals the total number of species detected, and P is the proportion of the *i*th species (Begon et al. 1996). I calculated a Simpson Diversity Index for each plot in each season.

The degree of community similarity between plots was evaluated using the Bray-Curtis measure of dissimilarity. The Bray-Curtis measure is a robust measure of dissimilarity that has been used to evaluate a wide range of ecological data (Faith et al. 1987). I used this measure to calculate the degree of dissimilarity between the six study areas. The Bray-Curtis measure is calculated as

$$I_{BC} = \mathbf{1} - \frac{\Sigma \left| x_i - y_i \right|}{\Sigma (x_i + y_i)}$$

where x_i and y_i represent the abundances of the *i*th species in sample x and sample y. The values generated by the Bray-Curtis coefficient range from "0" to "1", with values closer to "0" indicating areas that have a high degree of similarity (many species in common) and values closer to "1" representing areas that have low similarity (few species in common).

RESULTS

I detected 3170 birds of 56 species over all survey periods. During the spring surveys, I detected 792 birds of 29 species. During the summer surveys I detected 1002 birds of 33 species, and during the fall surveys I detected 1376 birds of 31 species. Plot two contained the greatest abundance of birds in spring (128) and summer (113.5), while plot five had the highest abundance of birds in the fall (181). Plot two had the highest species richness R in all seasons (R = 17, 16 and 12 respectively). Species diversity was highest in plot three in the spring (D = 0.873), and in plot six in summer (D = 0.786) and fall (D = 0.755). Tables 1 through 6 show the species detected, abundance and species diversity index for each sampling plot in each season.

Bray-Curtis analysis of dissimilarity showed that in the spring, plots two and six had the least community overlap, while plots five and six showed the greatest community overlap (Table 7). In the summer, plots three and four showed the least community overlap and plots one and six showed the highest degree of community overlap (Table 8). In the fall, plots one and two were least similar, and plots four and six were the most similar (Table 9).

DISCUSSION AND RECOMMENDATIONS

This study evaluated current avian use patterns in the Odello West Restoration Site. The area search surveys revealed that plot two, a sample plot incorporating portions of the newly dug lagoon as well as some adjacent newly restored riparian edge, consistently supported the highest number of species in all seasons. This likely reflects the structural heterogeneity of this plot compared to the others, which were either entirely lagoon habitat, or unrestored grassland or shrub habitat. Overall abundance was also highest in plot two during the spring and summer surveys, owing to the presence of several flocking species, including Canada Geese and Mallards. In the fall, however, species abundance was highest in plot five, which again reflects the presence of flocking birds, in this case sparrows and Western Meadowlarks.

An analysis of community similarity confirmed that avian community composition was organized according to major habitat type. The lagoon plots, two and three, were always more similar to each other than to any of the upland plots. Likewise, all of the upland plots exhibited a high degree of similarity with each other. None of the upland plots have undergone any substantial restoration activities as yet, but as restoration efforts are carried forward at the restoration site, we should expect to see increasing stratification of avian communities amongst all of the sample plots.

These surveys have provided important baseline information about bird abundance and diversity in the habitats being established and enhanced at the Odello West Restoration Site. The avian use data collected during 2005 will provide an effective means to judge the effects of the restoration process on bird populations in the area, as well as a measure by which to gauge the success of the restoration project once it is completed. In 2005, only limited restoration activities took place during the avian survey periods. Vegetation was planted around areas of open water in plots two and three. Plot six was planted with sterile wheat in portions of the plot, but was mostly unaltered. Plots one, four, and five remained largely unaltered. The fact that only minor vegetation restoration activities had occurred during the first avian survey season will allow for effective pre- and post-restoration comparisons of bird diversity and abundance measures if monitoring continues.

Future monitoring efforts will provide an understanding of how bird populations react to habitat restoration actions and the maturation of restored vegetation. The following monitoring actions are recommended:

- Continued area search censuses will provide biologists with the data necessary to track the response of bird populations to restoration efforts by evaluating the short-term effects of restoration actions and the long-term response of bird populations to the maturation of restoration efforts.
- A minimum of 5 years of post-restoration monitoring is recommended in order to effectively evaluate the success of the restoration (Ruiz-Jaen and Aide 2005).
- Expanding the current monitoring program to include surveys in all four seasons will provide a clearer picture of the effects of the restoration on bird populations during all portions of the annual cycle.

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Table 1. Abundance, species richness and species diversity of birds detected in plot 1, Carmel River State Beach Lagoon Restoration Project (Odello West Restoration Site), Carmel, CA, in 2005

Species	Spring	Summer	Fall
American Kestrel	0	0	0.5
Barn Swallow	5.5	3	0
Brewer's Blackbird	2.5	0	6.5
Brown-headed Cowbird	0	0.5	2
Black Phoebe	0	1.5	0
California Towhee	0	1	3
California Quail	6	16.5	5
Cliff Swallow	5	0	0
European Starling	0	0	83
Golden-crowned Sparrow	0	0	9
House Finch	0	7.5	3.5
Lesser Goldfinch	0	2	0
Mallard	1	0	0
Mourning Dove	0.5	0	9.5
Oregon Junco	0	3.5	0
Red-winged Blackbird	2	0	7.5
Song Sparrow	14.5	26	12
Western Scrub-jay	0.5	0	0
White-crowned Sparrow	0	0	7
Overall Abundance	**37.5**	**61.5**	**148.5**
Species Richness	**9**	**9**	**12**
Simpson Diversity Index	**0.777**	**0.727**	**0.664**

Table 2. Abundance, species richness and species diversity of birds detected in plot 2, Carmel River State Beach Lagoon Restoration Project (Odello West Restoration Site), Carmel, CA, in 2005

Species	Spring	Summer	Fall
American Coot	0	0	63.5
American Goldfinch	0	2	0
Anna's Hummingbird	0	0	1
Barn Swallow	5	5	0
Black Phoebe	0	0.5	2
Brewer's Blackbird	3	9	0
Canada Goose	54.5	56.5	0
California Quail	0.5	0	0
Cliff Swallow	5.5	3	0
Common Merganser	0	1	0
Dunlin	0	1.5	0
Elegant Tern	0	0.5	0
European Starling	0.5	0	0
Great Blue Heron	0.5	0.5	1
Great Egret	0	0.5	0
Greater Yellowlegs	0	0	1
Horned Grebe	0	0	1
House Finch	5	0	0
Killdeer	7	5.5	8
Lesser Yellowlegs	0.5	0	0
Mallard	29.5	9	7.5
Mourning Dove	2	0	0
Northern Rough-winged Swallow	1	1	0
Pied-billed Grebe	0	0	2
Red-winged Blackbird	2.5	0	0
Rock Pigeon	0	8	0
Ruddy Duck	0	0	5
Song Sparrow	5.5	10	3.5
Spotted Sandpiper	0.5	0	0
Violet-green Swallow	5	0	0
Western Meadowlark	0	0	22
Total Count	**128**	**113.5**	**117.5**
Species Richness	**17**	**16**	**12**
Simpson Diversity Index	**0.753**	**0.721**	**0.661**

Table 3. Abundance, species richness and species diversity of birds detected in plot 3, Carmel River State Beach Lagoon Restoration Project (Odello West Restoration Site), Carmel, CA, in 2005

Species	Spring	Summer	Fall
American Coot	1.5	1.5	58.5
Barn Swallow	2.5	2.5	0
Belted Kingfisher	0	0.5	0.5
Brewer's Blackbird	3	4.5	14.5
Brown-headed Cowbird	0	0.5	0
Black Phoebe	0	0.5	1
Canada Goose	14.5	3.5	0
California Quail	1	0	0
Cliff Swallow	2	0	0
Common Merganser	1	0	0
Common Yellowthroat	1	0	0
Double-crested Cormorant	0.5	0.5	0
European Starling	1	0	0
Great Egret	0	0.5	0
Golden-crowned Sparrow	0	0	1.5
Green-winged Teal	0	0	3
Killdeer	8.5	2.5	2
Mallard	3.5	7.5	38.5
Pied-billed Grebe	0	1	0
Redhead	0	0	1
Red-winged Blackbird	5.5	82	2
Snowy Egret	0	0.5	0
Song Sparrow	0.5	4	8
Tree Swallow	5.5	0	0
Violet-green Swallow	5.5	1.5	0
Total Count	**57**	**113.5**	**130.5**
Species Richness	**16**	**16**	**11**
Simpson Diversity Index	**0.873**	**0.468**	**0.695**

Table 4. Abundance, species richness and species diversity of birds detected in plot 4, Carmel River State Beach Lagoon Restoration Project (Odello West Restoration Site), Carmel, CA, in 2005

Species	Spring	Summer	Fall
Allen's Hummingbird	1	0	0
Anna's Hummingbird	0	0	0.5
Barn Swallow	1	0	0
Bewick's Wren	0	0	0.5
Brewer's Blackbird	1	0	0
California Towhee	0	0.5	0
California Quail	5.5	12	0
California Thrasher	0	0.5	0
Cliff Swallow	0.5	0	0
European Starling	0.5	0	0
Golden-crowned Sparrow	0	0	5
House Finch	5	9.5	5
Killdeer	0.5	0	0
Mourning Dove	5.5	20.5	5.5
Red-winged Blackbird	8.5	0	0
Rock Pigeon	0	32.5	0
Rufous-crowned Sparrow	0	0	0.5
Song Sparrow	23.5	27	22
Violet-green Swallow	1	0	0
Western Scrub-jay	3.5	2	1.5
White-crowned Sparrow	0	0	4.5
Total Count	**57**	**104.5**	**45**
Species Richness	**13**	**8**	**9**
Simpson Diversity Index	**0.776**	**0.776**	**0.710**

Table 5. Abundance, species richness and species diversity of birds detected in plot 5, Carmel River State Beach Lagoon Restoration Project (Odello West Restoration Site), Carmel, CA, in 2005

Species	Spring	Summer	Fall
Barn Swallow	3	0.5	0
Brewer's Blackbird	2.5	0	0
California Quail	4.5	2	0
Cliff Swallow	5	0	0
European Starling	1	0	0
Golden-crowned Sparrow	0	0	9.5
House Finch	0.5	3	80
Killdeer	0.5	0	0
Lesser Goldfinch	0.5	0	0
Lincoln's Sparrow	0	0	0.5
Mourning Dove	1.5	2	2
Red-winged Blackbird	9.5	0	0
Savannah Sparrow	0	0	3
Say's Phoebe	0	0	4
Song Sparrow	23	17	29
Violet-green Swallow	3	0	0
Western Meadowlark	0	0	35
Western Scrub-jay	0	0.5	0
White-crowned Sparrow	0	0	18
Total Count	**54.5**	**25**	**181**
Species Richness	**12**	**6**	**9**
Simpson Diversity Index	**0.767**	**0.510**	**0.728**

Table 6. Abundance, species richness and species diversity of birds detected in plot 6, Carmel River State Beach Lagoon Restoration Project (Odello West Restoration Site), Carmel, CA, in 2005

Species	Spring	Summer	Fall
Anna's Hummingbird	0	1	2
Barn Swallow	0.5	9.5	0
Brown-headed Cowbird	0.5	0	0
Bushtit	0	10	0
California Towhee	0.5	1.5	1.5
California Quail	5.5	10.5	0
Chestnut-backed Chickadee	1.5	0	0
Cliff Swallow	5	0	0
Golden-crowned Sparrow	0	0	9
House Finch	3	17.5	16.5
Mourning Dove	1.5	2.5	2.5
Northern Rough-winged Swallow	0.5	0	0
Rock Pigeon	1.5	0	0
Red-shouldered Hawk	0	0	0
Red-winged Blackbird	13	0	0
Say's Phoebe	0	0	1
Song Sparrow	28.5	29	25.5
Sharp-shinned Hawk	0	0	0.5
Violet-green Swallow	0	1	0
Western Scrub-jay	0.5	0	1.5
White-crowned Sparrow	0	0	5.5
Total Count	**62**	**82.5**	**65.5**
Species Richness	**13**	**9**	**10**
Simpson Diversity Index	**0.726**	**0.786**	**0.755**

Table 7. Bray-Curtis Community Dissimilarity Matrix for 6 area search plots at the Odello West Restoration Site, spring 2005.

	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6
Plot 1	0.000					
Plot 2	0.734	0.000				
Plot 3	0.672	0.643	0.000			
Plot 4	0.460	0.784	0.719	0.000		
Plot 5	0.304	0.726	0.650	0.238	0.000	
Plot 6	0.427	**0.800**	0.748	0.269	**0.236**	0.000

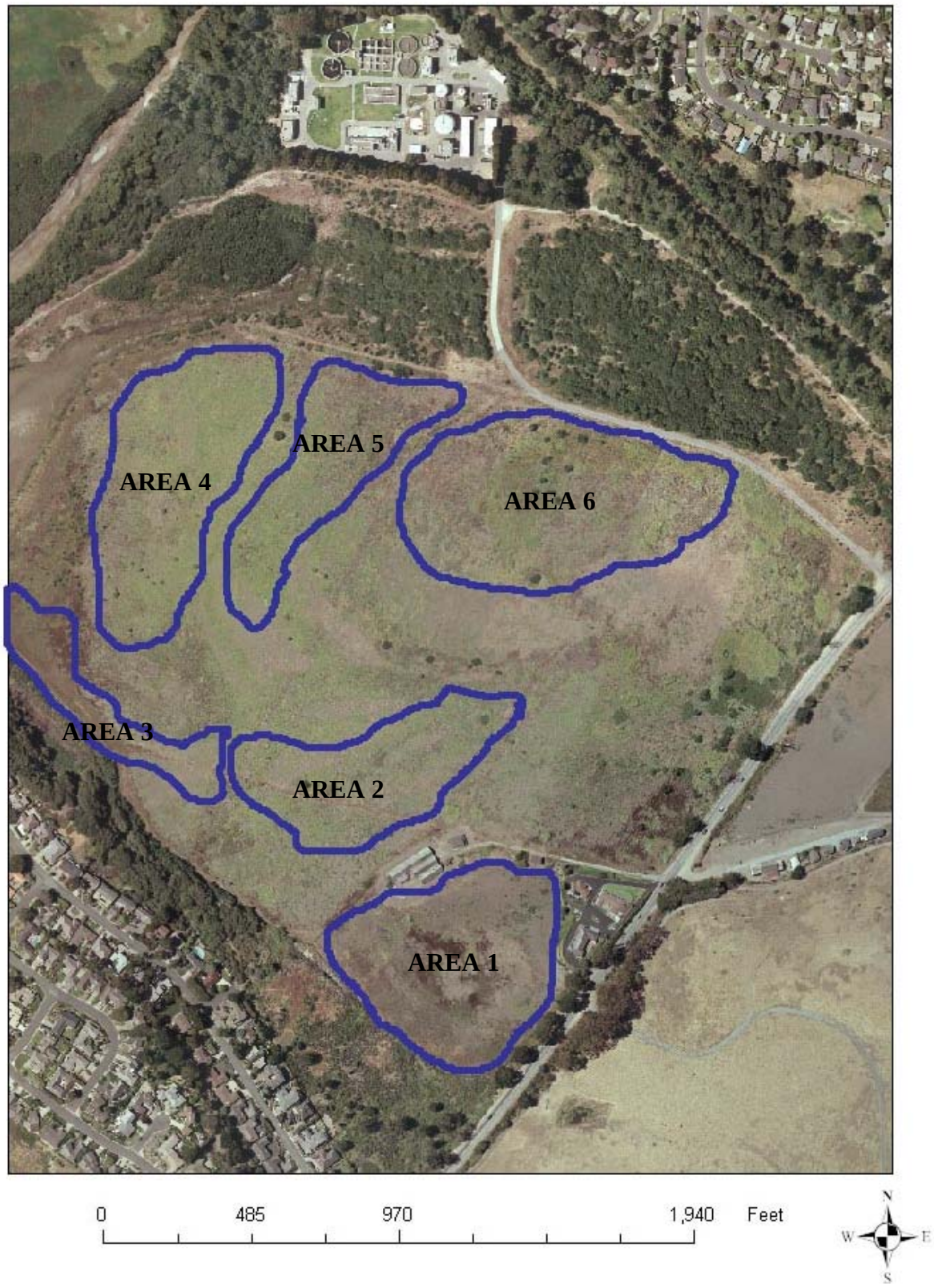
Table 8. Bray-Curtis Community Dissimilarity Matrix for 6 area search plots at the Odello West Restoration Site, summer 2005.

	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6
Plot 1	0.000					
Plot 2	0.846	0.000				
Plot 3	0.914	0.775	0.000			
Plot 4	0.446	0.835	**0.963**	0.000		
Plot 5	0.480	0.848	0.935	0.622	0.000	
Plot 6	**0.333**	0.847	0.923	0.465	0.544	0.000

Table 9. Bray-Curtis Community Dissimilarity Matrix for 6 area search plots at the Odello West Restoration Site, fall 2005.

	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6
Plot 1	0.000					
Plot 2	**0.974**	0.000				
Plot 3	0.871	0.415	0.000			
Plot 4	0.688	0.951	0.893	0.000		
Plot 5	0.797	0.829	0.939	0.659	0.000	
Plot 6	0.682	0.951	0.903	**0.271**	0.518	0.000

Appendix 1. Area search plots at the Carmel River State Beach Lagoon Restoration Project (Odello West Restoration Site) 2005.



Appendix 2. Area search data sheet used for avian monitoring at the Carmel River State Beach Lagoon Restoration Project (Odello West Restoration Site) 2005.

AREA SEARCH DATA FORM

Area # _____ **Visit #** _____ **Date:** _____
Start Time: _____ **End Time:** _____
Temperature _____**°C** **Cloud Cover** _____**%** **Wind Speed** _____ **(BFT)**
Observers: _____
Explanation if Start Time to End Time is not 20 min:

Species				**Tally of Individuals** **S**ong, **V**isual, **C**all, one letter per individual	*Total*	*Behavior* (check if applicable)*								
						FO	*FL*	*CO*	*DI*	*PA*	*CM*	*CF*	*NE*	*FLE*

FO-foraging, FL-flock, CO-copulation, DI-territorial display, PA-par, CM-carrying material, CF-carrying food, NE-nest, FLE- fledgling

Notes and flyovers:

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_____
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