

# MOVEMENT, HABITAT SELECTION, AND BASELINE CONDITION OF DEER ON BALD HEAD ISLAND, NORTH CAROLINA

JANUARY 2008 – DECEMBER 2010

Dr. Anthony Snider<sup>1</sup>  
Brandon Sherrill<sup>2</sup>  
Douglas Noonan<sup>1</sup>  
Dr. Chris Deperno<sup>2</sup>

1 – Department of Environmental Studies, University of North Carolina at Wilmington, 601 S. College Rd., Wilmington, NC 28403

2 – Fisheries and Wildlife Sciences Program, North Carolina State University, Turner House, Box 7646, Raleigh, NC 27695

## INTRODUCTION

The Smith Island Complex is located at the mouth of the Cape Fear River in North Carolina. It is comprised of approximately 1,882 acres of uplands and almost 13,000 acres of marsh. At over 2,700 acres, Bald Head Island (BHI) is the largest landmass in the Smith Island Complex and constitutes Cape Fear. The Bald Head Woods North Carolina Coastal Reserve (Woods) accounts for approximately 190 acres of the island's total acreage, is situated in the center of BHI, and acts as an ecological pivot for the island's ecosystems. BHI is characterized by a unique barrier island maritime forest ecosystem.

The Woods comprise the only maritime forest component in southeastern North Carolina with access to both the marsh and the sea. The Woods also represent the best example of intact maritime forest in the southeastern portion of North Carolina, and the only large intact North Carolina maritime forest in the Carolinian biogeographic region. Maintenance of the integrity in this Reserve is important for barrier island research. In recognition of these unique attributes, the Woods were formally dedicated as a preserved area for research purposes by the North Carolina Council of State in 1994.

In recent years, the population of white-tailed deer on the island has expanded. Growth in the number of deer has raised public concern over their impact on the vegetation of the maritime forest, especially within the Woods. In an effort to control the size of the deer population, the Village of Bald Head (Village) has engaged in periodic culling. At the request of BHI residents, the Village has begun considering immunocontraception as an alternate means of population control.

Immunocontraception requires a relatively closed target population. Assessing the movements of a particular herd is necessary to determine the degree to which immunized deer remain on site and the degree to which contraceptive control is practical. Loss of deer to migration reduces the cost-efficiency of immunization. If the female white-tailed deer in a population remain in the area, immunocontraception may be a viable means of population control.

Our primary project objective of this study was to assess deer movement on Bald Head Island, North Carolina. This report documents our efforts at meeting that objective.

## MATERIALS AND METHODS

Beginning 05 January 2008, female white-tailed deer were tranquilized with Telazol and xylazine HCL using injection darts delivered from CO<sub>2</sub> powered and charge-powered rifles. Ketamine was used as a secondary tranquilizer if needed. Yohimbine was used as a reversal agent to bring animals out of sedation following field procedures. Animals were darted either from fixed locations (trees, decks, or a hunting stand) using a night vision scopes or from golf carts using spotlights. Targeted deer were

tracked using a transmitter attached to the tranquilizer dart until the animals succumbed to the tranquilizer.

Sedated deer were fitted with radio collars, each emitting a unique frequency. While sedated, deer were continuously monitored for respiration, heart rate, blood oxygen saturation, and temperature. Body length, leg length, chest girth, and body weight were measured for each captured animal. Yellow cattle tags and piglet tags were placed in the ears of each captured deer for ease in later field identification. Blood samples were also drawn from each deer for subsequent analysis. Blood samples were centrifuged, frozen, and shipped to two labs for screening.

Blood samples were tested for leptospirosis, a serious bacterial infection, normally found in tropics, which can transmit to humans, causing fever, headaches, nausea, and vomiting. It can result in liver damage and kidney failure, meningitis, and in rare cases death. It normally produces flu-like symptoms, but if untreated may have more severe implications. Samples were also tested for *Borrelia burgdorferi*, which is associated with lyme disease. *Anaplasma phagocytophilum*, carried by deer ticks, may be transmitted to humans. This pathogen can cause fever, swollen joints, painful joints, lethargy, and if untreated, other implications (Dumler, et al., 2005). We analyzed all blood samples for this pathogen as well.

Darting initially continued for two months without obtaining the minimum number of deer for statistical analysis. Darting was curtailed in the first year due to the onset of the fawning season on 31 March 2008. Deer darted in the first darting season were tracked using radio telemetry every two weeks beginning with the first darted deer. Darting resumed 02 January 2009 and the requisite number of animals was obtained by 31 January 2009. Telemetry tracking of collared animals continued through the end of December 2009.

Each semi-monthly telemetry session consisted of collecting at least two deer locations, separated by a 24-hour period. Animals were tracked to sight, or when this was not possible, triangulated using multiple compass bearings and telemetry vectors. GPS locations and habitat information were collected at each animal location. Telemetry was conducted by the darting technician and students from the graduate programs at NCSU and UNCW. This part of the project was also used to teach basic field methods to the field methods class at UNCW.

Data taken from spotlight counts were used to calculate deer herd size for 2008 and 2009 using the Lincoln-Peterson approach. Citizen sightings of tagged deer were incorporated into the data set. Information was gathered from citizens via email and a web-based data collection system.

Mean centers of geographic distribution for each animal were calculated by averaging the latitude and longitude from GPS data gathered for each (Taylor, 1977). Individual and group standard distances of geographic distribution were calculated using the following formula:

$$SD = \sqrt{\frac{\sum r_{ic}^2}{n}}$$

where  $r$  is the distance from each observation,  $i$ , to the mean center,  $c$ . Similar to the statistical concept of standard deviation, standard distances are measured in actual units, in this case meters. Relative dispersion was calculated from the standard distance for each animal by applying the formula:

$$RD = \frac{SD_x}{SD_p}$$

where  $SD_x$  is the standard distance of each deer and  $SD_p$  is the standard distance of the population. Statistical significance of shifts in standard distances (reflecting significant increases or contractions of

standard distances) was tested using a modified form of the Student's t-test designed for geographic data (Taylor, 1977). Data were grouped into seasons, seasons by year, and pre-cull and post-cull sets for comparative analysis. Additionally, we investigated changes in deer locations in proximity to roads related to culling. We also incorporated spatial data in cluster analysis to determine if individual, distinct herds existed on BHI. Several approaches were used in consultation with both a statistician and an ecological modeler.

At the end of the study, it was decided, in consultation with the Bald Head Island Conservancy, to forego the recapture of tagged animals. Instead, the animals will continue to be used for research and teaching endeavors. Allowing the collars to remain on the test animals causes no adverse effects and is less traumatic to individuals than re-darting.

## RESULTS

Over the two darting periods in 2008 and 2009, 12 females and one male white-tailed deer were successfully captured and fitted with radio collars. The male succumbed to natural mortality during the monitoring period. Two of the female deer died from trauma, apparently associated with vehicle collisions. During the study, the overall survival rate (male and female combined) for radiocollared white-tailed deer on BHI was 0.83.

Of the 11 remaining deer, one moved into the marsh adjacent to BHI during the fawning season. During the last month of monitoring we were unable to relocate this animal, despite checking several off-island sites. White-tailed deer normally exhibit high levels of site fidelity, unless extenuating circumstances (predation, food shortage, etc.) precipitate movement. As all other deer remained on island, external pressures were not extant during the study period. Consequently, we believe the radio collar on the missing animal malfunctioned. The transmitter of the collar on the male deer experienced a similar malfunction during the study period, lending credence to this hypothesis.

Spotlight surveys were conducted from May through August, 2008 (27 total, 11 pre-fawn and 16 post-fawn) and May through September, 2009 (34 total, 15 pre-fawn and 19 post-fawn). Lincoln-Peterson indices and reconstruction models for the two years yielded estimates for BHI's deer population of 144 deer post-fawn in 2008 and 99 deer post-fawn in 2009. Details of the approach used may be found in separate reports submitted to the Bald Head Island Conservancy (Sherrill, Snider, & DePerno, 2008, 2009).

The majority of home ranges for individual white-tailed deer overlapped the maritime forest habitat on BHI (Table 1). The 90% home range (defined as the area in which an animal spends 90% of its time) for BHI deer averaged 60.73 ha and the 50% core areas averaged 15 ha. No seasonal changes in movement were detected for the deer on BHI. Distribution variances both collapsed and expanded for individual deer throughout the study period, undermining any overall pattern with regard to season. Relative dispersion exhibited the same lack of overall seasonal pattern.

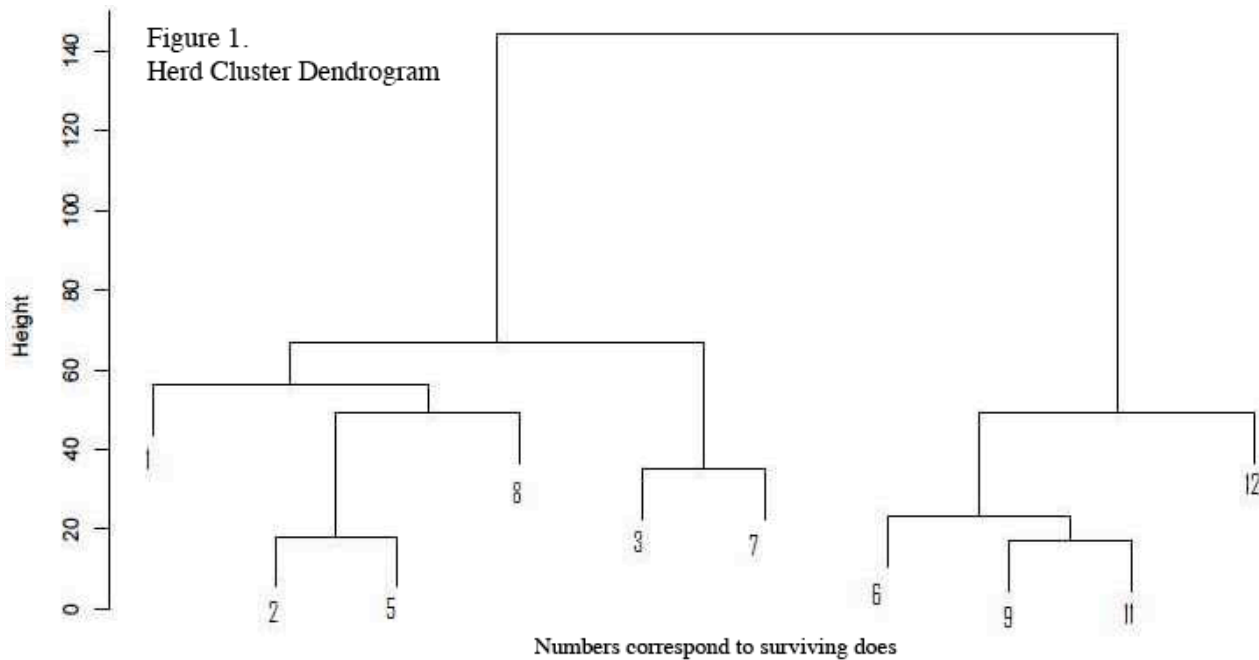
Significant shifts in mean center and standard distances did occur in relation to culling for three deer, two of whom exhibited a collapse in dispersion ( $t=4.32$ ,  $df=86$ ,  $p=0.0001$ ,  $t=5.98$ ,  $df=82$ ,  $p=0.001$ ), while a third showed an increase in standard distance ( $t=2.47$ ,  $df=76$ ,  $p=0.0158$ ). Deer showed no changes in their proximity to roads following culling. Cluster analysis using mean centers separated the deer into two distinct herds with some overlap geographically (Figs. 1 and 2). The height of the vertical lines in Figure 1 separating the two herds relative to the vertical lines from individual animals indicates a clear distinction between the herds.

Habitat Type	Avg. %	Range
Open Water (Brackish/Salt)	0.9	0.0-3.9
Developed Open Space	4.4	0.5-8.4
Low Intensity Developed	3.6	0.0-11.8
Medium Intensity Developed	0.4	0.0-1.7
Atlantic Coastal Plain Central Maritime Forest	66.5	43.9-91.1
Successional Shrub/Scrub (Other)	0.3	0.0-1.0
Atlantic Coastal Plain Southern Dune and Maritime Grassland	10.3	0.0-26.6
Clearcut - Grassland/Herbaceous	1.0	0.0-3.8
Atlantic Coastal Plain Southern Tidal Wooded Swamp	3.8	0.5-7.8
Atlantic Coastal Plain Central Fresh-Oligohaline Tidal March	0.1	0.0-0.4
Atlantic Coastal Plain Central Salt and Brackish Tidal Marsh	8.7	0.1-23.8

\* See Appendix A for habitat descriptions

Deer in this study had an average chest girth of 81.3 cm (range 71.4-87.5). Their hind leg length averaged 40.7 cm (range 38.3-42.5) and their overall body length averaged 122.4 cm (range 107.0-128.3). The average weight for deer sampled was 40 pounds (range 26.3-43.5).

All blood laboratory tests returned negative indications for leptospirosis. One deer tested positive for antibodies related to *Borrelia burgdorferi*. Two deer returned positive results for antibodies related to *Anaplasma phagocytophilum*.





## DISCUSSION

Our results indicate that radiocollared deer do not emigrate from BHI. The survival rate of 0.83 on BHI is relatively high compared to deer populations at other locations. Work by DePerno et al. (2000) conducted in the Black Hills of South Dakota and Wyoming estimated annual female survival to range from 50.3 to 62.1%. The lack of hunting and the relatively hospitable and stable environment likely contribute to the high survival rate.

Morphological features of white-tailed deer can vary by location. Typically, deer are larger at higher latitudes. Also, deer on the mainland are typically larger than deer on islands (likely related to the quality of habitat and food). Average chest girth for BHI deer was larger than that found on Blackbeard Island, GA, but the range of measurements on BHI is close to the upper end of the range for Blackbeard (Osborne, et al., 1992) (Table 2). The same is true for hind leg length. Body length is comparable to that found on Ossabaw Island, SC (Brisbin & Lenarz., 1984). The measurement for Blackbeard Island body length is from snout to tip of tail. If tail length is excluded, the values for Blackbeard would be smaller than the measurements from comparable locations. The weights for deer on BHI were quite variable, but the average weight for BHI deer was higher than that found on Ossabaw Island.

Deer on BHI routinely selected the maritime forest habitat. Deer on the western side of the island exhibited larger home ranges than those on the eastern side of the island, due to the increased level of development and the consequent need to cover more territory to obtain sufficient food. The home ranges observed on the island fall within the range sizes observed in other studies (Etter, et al., 2002; Grund, McAninch, & Wiggers, 2002; Kilpatrick & Spohr, 2000), and are consistent with ranges for other urban deer populations.

<b>Table 2. Morphological Comparisons (females only)</b>					
<b>Location</b>		<b>Chest Girth (cm)</b>	<b>Hind Leg Length (cm)</b>	<b>Body Length (cm)</b>	<b>Weight (lbs)</b>
<b>NC</b>				tip of snout to base of tail	
BHI Deer Study	Average	81.3	40.7	122.4	40.0
	Range	71.4-87.5	38.3-42.5	107.0-128.3	26.3-43.5
<b>SC</b>				tip of snout to base of tail	
Ossabaw Isl.	Average	N/A	N/A	120.3	33.1
	Range	N/A	N/A	117.7-122.9	31.3-34.9
Mainland	Average	N/A	N/A	129.2	46.1
	Range	N/A	N/A	127.3-131.1	44.2-48.0
<b>GA</b>				tip of snout to tip of tail	N/A
Blackbeard Isl.	Average	68.7	37.3	136.8	N/A
	Range	48.3-82.5	33.0-45.7	108-177.2	N/A

Other researchers have noted an increase in deer movement associated with hunting (Henderson, Warren, Cromwell, & Hamilton, 2000; Root, Fritzell, & Giessman, 1998). The BHI deer that showed an increase in movement following culling had the largest home range and standard distance of any deer monitored in this study. The home range included the Bald Head Creek marshes and adjacent marsh islands. The previous year this deer moved into the marsh hammocks adjacent to BHI to fawn. Of the 8 deer we were able to analyze for changes in movement related to culling, 5 showed a reduction in standard distance and two of these showed a significant reduction. Additional research is necessary to determine the relationship between white-tailed deer home range size and hunting pressure in barrier island environments.

There appears to be little incidence of disease for the vectors considered in this study. Evidence of *Anaplasma phagocytophilum* was found in two deer. Our analysis found antibodies associated with *Borrelia burgdorferi* in only one animal. None of the deer tested on BHI showed evidence of leptospirosis.

## CONCLUSIONS

With regard to the main objective of this study, we believe the lack of emigration of female white-tailed deer from BHI makes immunocontraception a viable management option to control population size. We estimated the white-tailed deer population to be between 100-150 animals. Culling does not appear to cause a shift in habitat selection but does appear to have some effect on home range size, resulting in a contraction of range in some animals, and an expansion in others. Further research in this area would prove valuable for understanding herd dynamics in barrier island systems.

Deer selected the maritime forest habitat on BHI, further underpinning the importance of this ecosystem. Survival appears to be high and continuous monitoring of radiocollared deer will provide additional information on long-term mortality. Blood tests indicated a low exposure for the diseases we evaluated. Deer on BHI are of average to above average weight and size, and in excellent physical condition.

## ACKNOWLEDGEMENTS

We would like to express our gratitude to the Village of Bald Head and the Bald Head Island Conservancy for their financial and logistical support throughout this entire project. We would also like to thank the many citizens of the island who offered us housing and transportation and general encouragement. Doug Oakley deserves special recognition for his willingness to facilitate interactions with island residents and for graciously offering the use of his home and carts during the darting. George and Martha Hayworth also offered housing, as did many others. Several people provided access to deer congregation areas for darting purposes, including Suzanne Confoy, Jeffrey and Janice Monsein, Vivian Smith, William Sanders, Stan Werb and Meredith Schuman, and many others. The ability to use multiple sites for darting drastically reduced the time involved in that phase of research and the overall cost of the project.

Finally, we wish to remember and honor Anne Pickering. Anne sat in silence, in the cold and dark, for many, many nights with us as we waited for deer to make their rounds. She exhibited a joy and sensitivity to life that we have seldom seen; coming out in the small hours of the morning just to get close to deer we had sedated. She brought us blankets in the depths of winter, and when she could not join us for darting, left hot food for us on our return. She was an amazingly giving person and we miss her greatly.

## WORKS CITED

- Brisbin, I. L., Jr., & Lenarz., M. S. (1984). Morphological comparisons of insular and mainland populations of southeastern white-tailed deer. *Journal of Mammalogy*, 65, 44-50.
- DePerno, C. S., Jenks, J. A., Griffin, S. L., & Rice, L. A. (2000). Female survival rates in a declining white-tailed deer population. *Wildlife Society Bulletin*, 28, 1030-1037.
- Dumler, J. S., Choi, K.-S., Garcia-Garcia, J. C., Barat, N. S., Scorpio, D. G., Garyu, J. W., et al. (2005). Human Granulocytic Anaplasmosis and *Anaplasma phagocytophilum*. *Emerging Infectious Diseases*. Retrieved 09 April, 2010, from <http://www.medscape.com/viewarticle/518524>
- Etter, D. R., Hollis, K. M., Deelen, T. R. V., Ludwig, D. R., Chelsvig, J. E., Anchor, C. L., et al. (2002). Survival and movements of white-tailed deer in suburban Chicago, Illinois. *Journal of Wildlife Management*, 66, 500-510.
- Grund, M. D., McAninch, J. B., & Wiggers, E. P. (2002). Seasonal movements and habitat use of female white-tailed deer associated with an urban park. *Journal of Wildlife Management*, 66, 123-130.
- Henderson, D. W., Warren, R. J., Cromwell, J. A., & Hamilton, R. J. (2000). Responses of Urban Deer to a 50% Reduction in Local Herd Density. *Wildlife Society Bulletin*, 28(4), 902-910.
- Kilpatrick, H. J., & Spohr, S. M. (2000). Movements of female white-tailed deer in a suburban landscape: a management perspective. *Wildlife Society Bulletin*, 28, 1038-1045.
- Osborne, J. S., Johnson, A. S., Hale, P. E., Marchinton, R. L., Vansant, C. V., & Wentworth., J. M. (1992). *Population ecology of the Blackbeard Island white-tailed deer* (Bulletin No. 26). Tallahassee, FL: Tall Timbers.
- Root, B. G., Fritzell, E. K., & Giessman, N. F. (1998). Effects of Intensive Hunting on White-Tailed Deer Movement. *Wildlife Society Bulletin*, 16(2), 145-151.
- Sherrill, B., Snider, A., & DePerno, C. (2008). Estimates of white-tailed deer population on Bald Head Island, North Carolina. Unpublished Deer Project Interim Report. NC State University.
- Sherrill, B., Snider, A., & DePerno, C. (2009). 2009 white-tailed deer population estimate on Bald Head Island, North Carolina. Unpublished Deer Project Interim Report. NC State University.
- Southeast Gap Analysis Project (2001). NCLD 2001 Land Cover Class Definitions Retrieved 06 June, 2010, from <http://www.basic.ncsu.edu/segap/>
- Taylor, P. J. (1977). *Quantitative Methods in Geography* (1st ed.). Prospect Heights, IL: Waveland Press.

## **Appendix A**

Descriptions derived from the National Land Cover Dataset (Southeast Gap Analysis Project, 2001)

### **Open Water (Brackish/Salt)**

All areas of open water, generally less than 25% cover of vegetation or soil. Specifically, coastal and near-shore estuarine and/or marine waters.

### **Developed Open Space**

Developed open areas that are primarily herbaceous (i.e. golf courses, road sides, parks, air fields).

### **Low Intensity Developed**

Includes areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 20-49 percent of total cover. These areas most commonly include single-family housing units.

### **Medium Intensity Developed**

Includes areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 50-80 percent of the total cover. These areas most commonly include single-family housing units.

### **Atlantic Coastal Plain Central Maritime Forest**

This system encompasses most woody vegetation of barrier islands and similar coastal strands, from Virginia Beach to central South Carolina. It includes forests and shrublands whose structure and composition are influenced by salt spray, extreme disturbance events, and the distinctive climate of the immediate coast.

### **Successional Shrub/Scrub (Other)**

Areas dominated by shrubs; less than 5 meters tall with shrub canopy typically greater than 20% of total vegetation. This class includes true shrubs, young trees in early successional stage or trees stunted from environmental conditions. Specifically, this class refers to anthropogenically altered shrub/scrub areas other than utility swaths or clear-cuts.

### **Atlantic Coastal Plain Southern Dune and Maritime Grassland**

This system consists primarily of grasslands of Atlantic Coastal Plain barrier islands and related near-coastal areas from North Carolina southward to northern Florida. Upland plant communities and non-flooded wetlands are included in this system as embedded or "inclusional" shrublands. The environment of this system is highly dynamic. Reworking of sand by storms or by slower eolian processes may completely change the local environment in a short time, and portions of the system may occupy sites fairly early in the process of primary succession. The combined effects of chronic and extreme salt spray and ocean overwash prevent or dramatically inhibit woody plant growth.

### **Clearcut - Grassland/Herbaceous**

Areas dominated by herbaceous ground cover following a disturbance event such as clearcutting or catastrophic fire.

### **Atlantic Coastal Plain Southern Tidal Wooded Swamp**

This system encompasses the tidally flooded areas in lower river floodplains

and edges of estuaries of the Atlantic Coastal Plain that have fresh enough water and short enough flooding to be able to support tree canopies. *Taxodium*, *Nyssa*, or *Fraxinus* generally dominate. Swamps may be either regularly flooded by lunar tides or irregularly flooded by wind tides.

#### **Atlantic Coastal Plain Central Fresh-Oligohaline Tidal Marsh**

This system represents tidally influenced fresh marsh and tidal shrublands ranging from approximately Morehead City, NC, southward to St. Johns River, FL [see Montague and Wiegert (1990)]. This system occurs where there is adequate river flow and discharge to maintain fresh to oligohaline conditions, while still within tidal range. These marshes most often occur well inside the mouths of tidal creeks and rivers. Elevation differences within the marsh correspond to the occurrence of different vegetation types.

#### **Atlantic Coastal Plain Central Salt and Brackish Tidal Marsh**

This system encompasses the brackish to salt intertidal marshes of the Atlantic Coast, from south of the Embayed Region of North Carolina to northern Florida. It is dominated by medium to extensive expanses of *Spartina alterniflora*, flooded twice daily by lunar tides. *Juncus roemerianus* and other brackish marshes occur upstream in tidal creeks, and a variety of small-patch associations occur near the inland edges.