ADVANCING A 24-HOUR TIME-ACTIVITY BUDGET FOR WINTERING ATLANTIC FLYWAY CANADA GEESE: CONSIDERATION OF NOCTURNAL BEHAVIOR

by

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ABSTRACT

Canada geese (*Branta canadensis*), both resident and migratory, utilize many areas in New Jersey as wintering and breeding grounds. Biologists and wildlife managers are interested in establishing time-activity budgets for geese and other waterfowl to help determine carrying capacities, daily energy needs, and other ecological information. In order to accurately create these budgets, it is important to observe behaviors over a complete 24 hr period, a task not easily achievable due to constraints of nighttime observation. Therefore, nocturnal activity is often dismissed. My objectives in this study were to 1) examine whether various Canada goose behaviors differed between the four time periods of a day (morning crepuscular, diurnal, evening crepuscular, and nocturnal) and 2) explore the effects of environmental variables and human hunting disturbance on goose behavior comparatively between diurnal and nocturnal periods. The behavioral observations for this study took place in coastal habitats in New Jersey. Observations included 7 behaviors (feeding, resting, comfort, swimming, alert, flying, and walking), 6 environmental variables (temperature, wind speed, cloud cover, tide, ice coverage and precipitation), and whether or not sites fell within hunting areas and open hunting season. I analyzed behavioral observations across time periods using multiple analysis of variance (MANOVA, $\alpha \leq 0.05$). I further analyzed individual behavioral differences between observation periods using univariate analysis of variance (ANOVA, $\alpha \leq 0.05$) with Tukey's post-hoc pair-wise comparisons. To analyze environmental variables and hunting, I used backwards stepwise regression to find the best-fitting model. Feeding, resting, and swimming were the most common behaviors. I found that behavior proportions differed across observation periods (MANOVA, $F_{21, 2777} = 6.32$, $P < 0.01$). Further univariate ANOVA with Tukey's post-hoc pair-wise comparisons indicated individual behavioral differences existed between observation periods. Additionally, I found that environmental variables and hunting lead to differences in the 3 most common behaviors (feeding, resting, and swimming) between diurnal and nocturnal periods. The results of this study show that Canada geese are far more active nocturnally than previously assumed. Further, it showed that environmental variables and human hunting disturbance have an effect on behavior and can cause birds to be more or less active during certain time periods. This information can be valuable for future wildlife researchers and managers in considering time-energy budgets for Canada geese and acknowledging that nocturnal behavior should be incorporated into 24 hr budgets.

Chapter 1

INTRODUCTION

Sites along the east coast of the United States, and notably areas of New Jersey, serve as both wintering and breeding grounds for resident and migratory Canada geese (*Branta canadensis*) (United States Department of Agriculture [USDA] 2003). According to the United States Fish and Wildlife Service's Migratory Bird Program, migratory wintering goose populations in the Atlantic Flyway have shown declines, while resident breeding populations have increased exponentially, resulting in higher levels of crop damage and increased instances of nuisance complaints (Serie and Hindman 1997). As of 2002, the USDA Animal and Plant Health Inspection Service (APHIS) estimated the population of resident geese in New Jersey at ~97,000, while the total resident population in the Atlantic Flyway was estimated at around 1.1 million. The mid-winter migrant population is comprised of approximately 190,000 geese. These migrant birds are members of the Atlantic and North Atlantic populations of Canada geese, considered to be the subspecies *Branta canadensis canadensis*, or the Atlantic Canada goose (USDA 2003).

Across waterfowl species there has been a long-term interest in quantifying time-activity budgets to monitor behavioral responses to habitat loss and changes in diet, estimate carrying capacities, determine optimal placement of hunting seasons, and identify and protect habitats (Paulus 1988). To accurately assess time-energy budgets, it is important researchers quantify behaviors over a 24 hr period;

however, observing nocturnal behaviors is historically difficult (Paulus 1988). Jorde and Owen (1988) noted this limitation has been primarily due to 1) lack of sufficient equipment needed to collect data nocturnally, 2) limited information describing effective methodology, and 3) the reluctance or inability of biologists to conduct field research at night. Through a handful of waterfowl research projects, there has been indication that different species, using a diversity of habitats, are active at night and vary their behavior under a variety of environmental and physiological stimuli (Tamisier 1974, Tamisier 1976, Pedroli 1982, Albright 1981, Paulus 1984, Morton et al. 1989, Anderson and Smith 1999, Guillemain et al. 2002, Rizzolo et al. 2005). To partially address this lack of information, Miller and Eadie (2006) designed an allometric equation to estimate a daily (24 h) energy expenditure based on a mass proportionality coefficient but they could not account for variability due to environmental and habitat stochasticity.

Wintering Canada geese normally feed diurnally, flying from roosting sites to foraging areas during morning and late afternoon hours while returning midday and at night (Raveling et al. 1972). Alert behaviors are increased while foraging to monitor for predators and other threats, namely in the form of hunters (Gawlik and Slack 1996). Geese also spend time loafing at foraging areas. Upon returning from foraging areas, midday activities most often include loafing and swimming, depending on the circumstances. Geese prefer to be on the water when predator threats are nearby, but prefer to remain on land when stormy or rough water conditions are present (Raveling et al. 1972). Raveling et al. (1972) also reported that Canada Geese spend approximately 13% of their time feeding diurnally during winter months with the remainder of the day dominated by these more comfort-based activities. Raveling et al. (1972) suggested that during nocturnal periods, geese spend much of their time sleeping, often on the water, but they could show some tendency to feed when disturbances (hunting or adverse weather conditions), occurred diurnally. Raveling et al. (1972) further found that geese fed nocturnally when certain criteria were met, specifically when there was majority snow cover with a clear sky and full moon, leading to an increase in nocturnal light conditions.

Despite these qualitative observations, there has not yet been a concerted effort to quantify Canada goose nocturnal behavior to build a comprehensive time-activity budget. The goal of this research is to better quantify the behavioral dynamics of Canada geese within nocturnal periods as compared to diurnal and crepuscular periods. Additionally, if gross differences exist, I will determine the effects of environmental and anthropogenic variation and disturbance on the behavioral dynamics within nocturnal and diurnal periods.

STUDY AREA

Behavioral observations took place in the coastal ecosystem of southern New Jersey inclusive of Great, Reeds, Grassy, and Absecon Bays and Little Egg Harbor; areas that are either wholly or partly contained within the general confines of lands owned by Edwin B. Forsythe National Wildlife Refuge (EBFNWR, Oceanville, NJ) and the New Jersey Division of Fish and Wildlife (Figure 1). The entirety of this area is roughly outlined by the Atlantic City Expressway to the south, the Garden State Parkway to the west and Great Bay Boulevard to the north in Atlantic, Burlington and Ocean counties. The region contains over 47,000 acres of protected habitat consisting of coastal salt marsh, barrier beaches, woodlands and freshwater swamps and impoundments. Salt marsh in this region is dominated by cordgrasses (*Spartina spp.*) and submerged aquatic vegetation (SAV) most abundantly in the form of sea lettuce (*Ulva spp*.).

Chapter 2

METHODS

Data Collection

A team of biologists collected Canada goose behavioral data as part of two greater projects focusing on 24 hr activity of American black ducks (*Anas rubripes*) and Atlantic brant (*Branta bernicla hrota*) wintering in New Jersey. While behavioral observations focused on activities of black ducks and brant, scans of all incidental waterfowl species in the study area were collected to provide additional useful information to wildlife managers.

Behavioral observations of waterfowl were conducted between the third week of Oct and the third week of Feb 2009–2010 and 2010–2011, effectively capturing the core of the winter period in coastal New Jersey. Observations occurred over a series of paired hunting and non-hunting periods. Canada goose hunting periods for the 2009–2010 coastal zone season were from 26 Nov–5 Dec and 8 Dec–18 Jan. Non-hunting periods in the coastal zone were from 23 Oct–25 Nov, 6 Dec–7 Dec, and 19 Jan–21 Feb. For the 2010–2011 season in the coastal zone, hunting periods were from 25 Nov–4 Dec and 7 Dec–17 Jan. Non-hunting periods spanned from the third week of October to 24 Nov, 5 Dec–6 Dec, and 18 Jan–21 Feb.

Observation sites were selected within the study area and focused on the natural salt marsh system, however a handful of sites included upland habitats; e.g. lawns and fields. Fifteen locations were selected that were representative of the various salt marsh microhabitats and 2–3 observation locations were chosen for a total of 44 actual observation points (Figure 1). Observations took place out of portable pop-up blinds, permanent elevated blinds, or vehicles. Daily observation locations were selected at random.

Behavioral observations were divided into four 6 hr blocks centered around morning crepuscular, diurnal, evening crepuscular, and nocturnal periods to effectively cover the full 24 hr time period. Core nocturnal and diurnal periods ran from 2100–0300 and 0900–1500, respectively. Morning and evening crepuscular periods ran from 0300–0900 and 1500–2100, respectively, although the actual crepuscular periods only occurred for 1 hr during these periods (30min before and after sunrise or sunset) with observations before and after this period being added to the respective nocturnal and diurnal data.

Instantaneous scan samples were conducted during nocturnal periods using Generation 3 Morovision 6X night vision scopes and during diurnal periods using 8–10X binoculars. On alternating weeks, paired diurnal/nocturnal or morning/evening crepuscular observations took place 12 hr apart to match observation periods with tide stage. To attempt to avoid observer bias, a 30 min acclimation period was allowed before the scheduled start of observations. Instantaneous scan samples were then conducted every 10 min for the 6 hr period, recording the behavior of all individuals and species. Behaviors were recorded into the following 7 categories: feeding, resting (which contained both sleeping and loafing), comfort, swimming, alert, flying, and walking.

The selection to scan a flock from left or right was made at random and the start of an individual scan began with checking the 200 m observation radius for birds in flight. After initially checking for birds in flight, the instantaneous scan then focused on birds present on the ground or water. When large flocks ($n \geq 500$) were present, we counted groups of birds exhibiting the same behavior in multiples of 10 individuals to expedite the process of recording behavior for the entire flock. We recorded environmental conditions of temperature, wind speed, cloud cover, and precipitation hourly. Temperature and wind speed were measured using a handheld anemometer (Kestrel 1000 series). Hourly water equivalent precipitation rate, recorded by Atlantic City International Airport, was incorporated into each observation to the nearest scan(s) (National Climatic Data Center 2011). Tide height was determined utilizing the New Jersey Tide Telemetry System (USGS), which records tidal height readings at 6 min intervals at various locations within the study area, and was incorporated into the dataset to the nearest scan. The observation location, hunting season designation (open/closed), hunting area designation (observation location open/closed to hunting), ice coverage, and sunrise/sunset times were also recorded.

Data Analysis

To specifically test the hypothesis that behavioral data would differ between time periods, I tested for a difference between all recorded behaviors across time periods using multiple analysis of variance (MANOVA, $\alpha \leq 0.05$). I further analyzed individual behavioral differences between observation periods using univariate analysis of variance (ANOVA, $\alpha \leq 0.05$) with Tukey's post-hoc pair-wise comparisons. To investigate the effects of continuous temporal variables of temperature, ice cover, hunting season, wind speed, tide height, precipitation, and cloud cover on the analyzed behavior data across observation periods, I used backwards stepwise regression to find the best-fitting model. I report all significant Beta values for significant environmental variables for each behavior.

Chapter 3

RESULTS

Canada goose behavior data were recorded in a total of 977 individual 10 minute instantaneous scans encompassing the morning crepuscular (n=53), diurnal (n=394), evening crepuscular (n=52), and nocturnal (n=478) time periods. Feeding, resting, and swimming were the most common behaviors with comfort, alert, flying, and walking occurring <10% of the time each (Figure 2).

Observation Period Effects on Behavior

In testing the hypothesis that Canada goose behavior proportions would be similar across observation periods, I found that behavior differed (MANOVA, $F_{21,\,2777}$ = 6.32, $P < 0.01$). Further univariate ANOVA with Tukey's post-hoc pair-wise comparisons indicated individual behavioral differences existed between observation periods, denoted by like letters in Table 1. Univariate analysis indicated feeding behavior varied across observation periods ($F_{3,\,973}$ = 19.36, $P < 0.01$) with pair-wise comparisons only showing lower feeding during nocturnal periods ($P < 0.01$) when compared to diurnal and evening crepuscular periods. Resting behavior varied across observation periods ($F_{3,\,973}$ = 16.81, $P < 0.01$), only showing higher rates during nocturnal periods ($P < 0.01$) when compared to diurnal and evening crepuscular periods. Comfort behavior varied across observation periods ($F_{3,\,973}$ = 19.36, P = 0.05); however, post-hoc tests did not reveal any pair-wise differences between periods (P > 0.11). Swimming behavior did not vary across observation periods ($F_{3,\,973}$

= 1.02, P = 0.38) and thus there was no difference between pair-wise observation period combinations. Alert behavior varied across observation periods ($F_{3, 973}$ = 3.78, P = 0.01), with rates during the diurnal period lower when compared to the nocturnal period (P = 0.03). Flying behavior varied across observation periods ($F_{3, 973}$ = 2.78, P =0.04); however, as with comfort behavior, post-hoc tests did not reveal any pair wise differences between periods, with the exception of slightly increased flight during evening crepuscular as compared to nocturnal (P = 0.06). Walking behavior varied across observation periods ($F_{3, 973}$ = 9.40, P < 0.01), being higher only during the diurnal period when compared to morning crepuscular (P = 0.02) and nocturnal (P < 0.01) periods.

Environmental Variable Effects on Behavior

I further examined the effects of environmental variables and hunting on behaviors (Table 2). To assure adequate sample size for analysis, I limited analysis only to behaviors that occurred more than 10% of the time (i.e. Feeding, Swimming and Resting) and during diurnal and nocturnal periods. Higher tide decreased diurnal feeding, while increasing resting and swimming. Conversely, higher tide decreased nocturnal swimming, while increasing feeding. Ice coverage had no effect on Canada goose diurnal and nocturnal behaviors. Increased wind diurnally caused increased resting and decreased feeding. Increasing wind nocturnally increased swimming and also decreased feeding. Increasing precipitation increased resting and decreased feeding during the diurnal period, while having no effect on the nocturnal period. Increasing cloud cover decreased diurnal resting and increased feeding while having no nocturnal effect. Increasing temperatures increased diurnal feeding and reduced resting during both periods. Lastly, during the hunting season, diurnal feeding decreased and swimming increased, while nocturnal resting decreased and swimming increased.

Chapter 4

DISCUSSION

Canada geese are one of the most numerous and readily recognizable migratory bird species in the northeastern United States. They play an important role as migrants, as a hunted species, and, more recently, as a nuisance species (Serie and Hindman 1997). In order to gather as much information as possible on the behavior of this species, as well as other waterfowl, it is important to view them from a complete 24 hr perspective (Paulus 1988).

Results of this study showed some differences from previously published materials in relation to behaviors across time periods. In 1972, Raveling et al. found that geese spend approximately 13% of their time feeding during the day. I found that geese observed in this study were found to be feeding more than double that, spending over 36% of their time feeding diurnally. Nocturnally, I found that they spent close to 20% of their time feeding. This figure, higher even than Raveling's diurnal estimate, may suggest that geese are more active foraging for food nocturnally than previously thought. I found behavior rates for alert behaviors to be higher during the nocturnal period than the diurnal period. Gawlik and Slack (1996) reported that alert behaviors most often accompany foraging, which further suggests that this behavior may be more common at night than prior studies assumed. As would be expected, I found that geese have a higher rate of resting during the nocturnal period. Interestingly, I found that swimming does not vary across time periods. This could perhaps be explained by Raveling et al.'s (1972) findings, noting that geese prefer to be swimming when predator threats are nearby and that they often prefer to sleep on the water nocturnally. While flying was higher during the evening crepuscular period, it otherwise remained fairly constant across the day, including the nocturnal period. As one of the more energetically costly behaviors (e.g. 13.4 x basal metabolic rate as compared to ~2 x for other behaviors estimated for Atlantic brant, Ladin et al. 2011), this could be important to consider when incorporating nocturnal behavior into a complete 24 hr time-activity budget.

This study also considered the effect of environmental variables, along with hunting, on goose behavior across time periods. Raveling et al. (1972) proposed that nocturnal feeding might be more likely when certain environmental criteria are met, specifically reduced cloud cover and full moon. While this study failed to show results for those variables, other relationships were found. An increase in temperature seems to make birds more active at any time period, as it led to decreased resting both diurnally and nocturnally. This suggests that geese are more active during the nocturnal period with warmer temperatures. Feeding was reduced both diurnally and nocturnally with an increase in wind speed and was also reduced diurnally as precipitation increased. This may suggest that geese tend to avoid feeding during stormy conditions and instead rest, which increased diurnally for each of these variables. Feeding behavior increased and resting decreased with greater cloud cover, however. Interestingly, higher tides caused less feeding diurnally with higher swimming but caused an increase feeding and reduced swimming nocturnally.

In addition to environmental variables, I considered the effects of hunting on goose behavior during the various time periods. Hunting reduced feeding during the day, but increased swimming. Raveling et al. (1972) stated that geese prefer to be on the water when a predator threat is nearby, which explains swimming replacing feeding during the day. Nocturnally, resting was decreased and swimming increased. Because hunting takes place only during the day, it is feasible that geese reallocated feeding activity at night to compensate for energy needs.

Chapter 5

MANAGEMENT IMPLICATIONS

Information on the behavior of Canada geese during a complete 24 hr period, in addition to the effects of environmental variables and hunting on these behaviors, can be important tools in determining what size population an area can support, predicting how weather events may affect the population, deciding what bag limits and season parameters should be allowed for hunting, and learning more about the ecology of the species. Our research indicated Canada geese are much more active than previously thought, especially at night. Additionally, the behaviors are being actively influenced by environmental variables as well as hunting disturbance. Therefore, for future managers to build more accurate time-energy budgets to assess potential carrying capacity, we encourage future researchers to allow for variability in estimates rather than assuming constant allometric daily energy expenditure.

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Appendix A

TABLES

Table 1 Average percentages (x ± S.E.) of wintering Canada geese behavior during four observation periods between October 2009-February 2010 and October 2010-February 2011, New Jersey, USA. Like-letters denote a significant difference ($\propto = 0.05$) in the behavior between observation periods.

	Observation Period									
	Morning Crepuscular		Diurnal		Evening Crepuscular		Nocturnal		ANOVA Results	
Behavior	X	S.E.	X	S.E.	X	S.E.	X	S.E.	$F_{3,973}$	P
Feeding	29.79	0.05	36.41_a	0.02	38.93_b	0.05	19.81_{ab}	0.01	19.36	<0.01
Resting	28.01	0.05	21.22_a	0.02	15.69_b	0.04	38.68_{ab}	0.02	16.81	<0.01
Comfort	8.56	0.03	5.72	0.01	2.99	0.01	4.00	0.01	2.61	0.05
Swimming	26.58	0.05	23.07	0.02	23.25	0.05	27.20	0.02	1.02	0.38
Alert	2.22	0.01	3.39_a	0.01	8.47	0.02	6.41_a	0.01	3.78	0.01
Flying	4.60	0.03	5.11	0.01	9.62_a	0.04	2.66_a	0.01	2.78	0.04
Walking	0.24_a	0.00	5.07_{ab}	0.01	1.07	0.01	1.22_b	0.00	9.4	<0.01

Morning crepuscular (n = 53); Diurnal (n = 394); Evening crepuscular (n = 52); Nocturnal (n = 478)

Table 2 Comparison of 3 behaviors of wintering Canada geese, 2009–2011, in coastal New Jersey, analyzed for effects of environmental variables by time period.

Behavior	Time	R^2	Variable	Variable Beta (B)	Variable SE	Sig
Feeding	Diurnal	0.331	Temp	0.033	0.008	0.000
			Hunt	-0.169	0.087	0.053
			Wind	-0.013	0.005	0.018
			Tide	-0.075	0.025	0.003
			Precip	-2.609	0.822	0.002
			Cloud	0.054	0.026	0.040
	Nocturnal	0.038	Wind	-0.005	0.002	0.007
			Tide	0.035	0.016	0.030
Resting	Diurnal	0.261	Temp	-0.020	0.009	0.026
			Wind	0.013	0.005	0.016
			Tide	0.070	0.027	0.011
			Precip	2.549	0.894	0.005
			Cloud	-0.091	0.025	0.000
	Nocturnal	0.035	Temp	-0.012	0.007	0.085
			Hunt	-0.139	0.051	0.007
Swimming	Diurnal	0.058	Hunt	0.089	0.051	0.084
			Tide	0.044	0.019	0.024
	Nocturnal	0.087	Hunt	0.169	0.051	0.001
			Wind	0.012	0.003	0.000
			Tide	-0.052	0.021	0.012

Appendix B

FIGURES

Figure 1	Study Area where behavioral observation of wintering Canada geese occurred, 2009–2011, New Jersey, USA

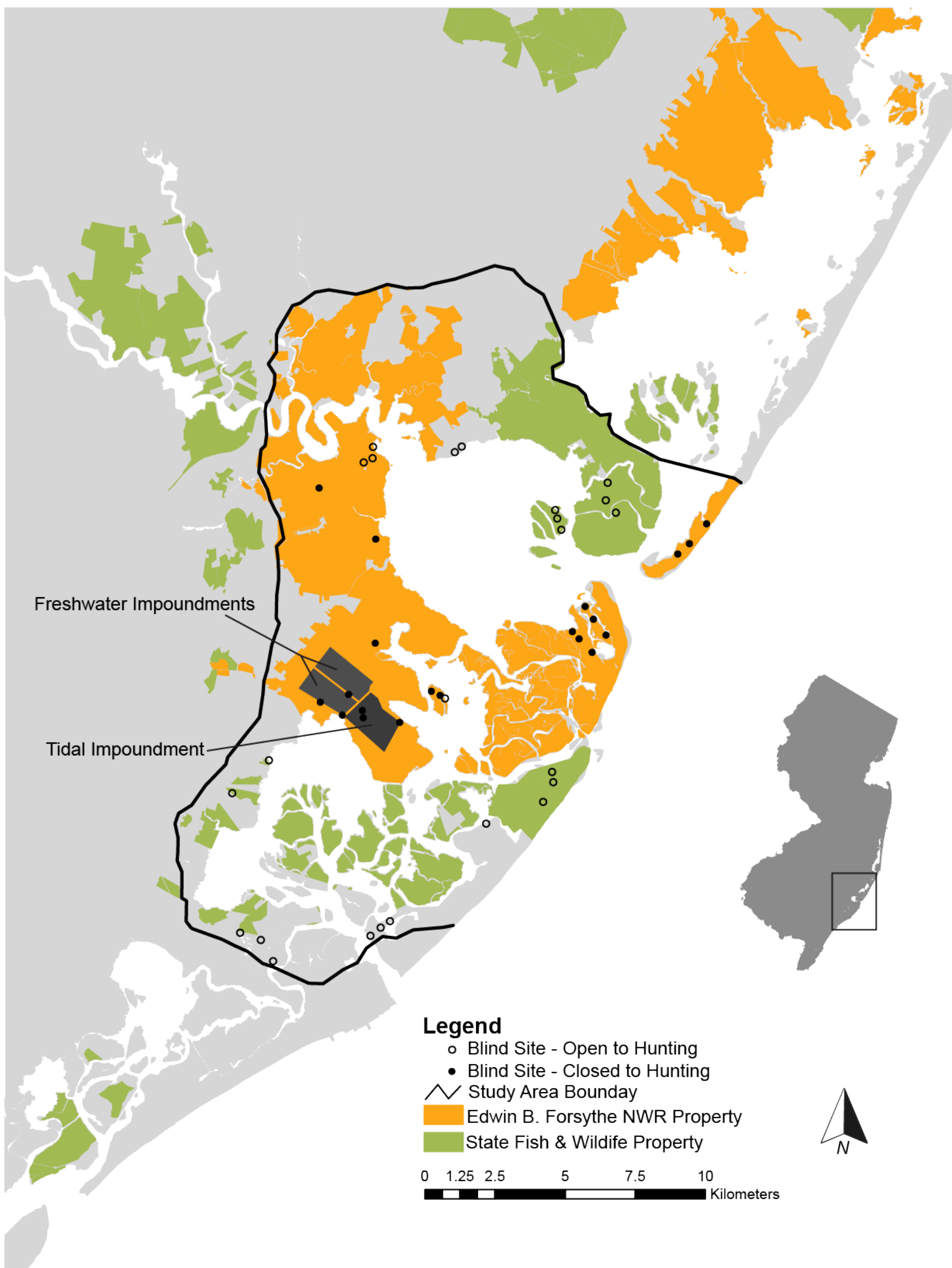

Figure 2 Time-activity budget of wintering Canada geese in coastal New Jersey in 2009–2011, depicting percentage of observed behavior across the four time periods, morning crepuscular, diurnal, evening crepuscular, and nocturnal