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Moonlight and Suburban White-Tailed Deer Movements

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Abstract. *Seventeen white-tailed deer* (Odocoileus virginianus) *were monitored in a land preserve adjacent to suburban Bryn Athyn College. Deer were fitted with radio-collars that transmitted spatial and temporal data at 5-minute interval fixes. Intersections of deer within four types of habitat (field, forest, suburban and industrial) were calculated within ArcGIS®, based on whether the moon was above or below the horizon. The deer appear to prefer fields when the moon is above the horizon, and forested habitat when the moon is below the horizon. The preference for open fields during moonlight periods may be determined by predator avoidance behavior in deer.*

Key Words: white-tailed deer, spatial analysis, GPS/GSM telemetry.

INTRODUCTION

The Bryn Athyn College (BAC) deer study documented regular shifts in the timing of deer visits to trap location sites that roughly aligned with whether there was moonlight present or not. During moonlit periods, deer stopped visiting the forested trapping locations, preferring to arrive either before sunset, or after the moon disappeared from the night sky. The study utilizes high frequency signals from collars on deer that transmit acquired coordinates via a cellphone network (GPS/GSM collars). The purpose of the BAC deer study is to increase understanding of the distribution and movement of a suburban population of white-tailed deer. The objective of this student project was to address the question of whether the lunar cycle has a definable influence on suburban deer habitat selection. More specifically, this study is focused on an analysis of the presence or absence of suburban white-tailed deer in four habitat types in the study area, in response to moonlight.

It has been shown that the moon is a key stimulator of spawning and tidal feeding events in marine organisms (Korringa, 1947; Loosanoff and Nomejko, 1951), as well as increased predator avoidance activity in marine birds and nocturnal rodents (Bowers, 1988; Gannon and Willig, 1997; Penteriani et al., 2010; Yamamoto et al., 2008). Budde (1983) claims that daylength and lack of moonlight is important in triggering puberty, as well as ovulation activities, in female white-tailed deer *(Odocoileus virginianus)*. If moon cyclicity affects the physiology of deer, it could be hypothesized that it also affects the behavior of deer.

MATERIALS AND METHODS

All study animals were trapped in the Pennypack Ecological Restoration Trust (PERT) land preserve, located approximately 25 km northeast of central Philadelphia (Fig. 1). During the years 2007–2010, seventeen mature (4 female and 13 male), white-tailed deer were trapped using a corn-baited, modified Clover trap (Clover, 1956) with a manual trigger. The trapping team physically restrained the deer (covering the eyes to reduce stress), keeping the animal from injuring itself during the 5-minute period when deer were fitted with a Tellus GPS/GSM collar (Followit, Sweden). No sedatives were used under Pennsylvania Game Commission (PGC) special use permit number 30-2010. The collars collected GPS locations, along with time and date, at five-minute intervals for each study animal. A total of 216,720 location fixes were used in this study (average 12,748 fixes or ~44 days per deer), collected on different dates and times within the years of the study.

A GIS coverage map was created for a rectangular study area that includes the outmost locations of all study deer positions using techniques similar to Stocker et al. (1977). The study area was classified as field, forest, suburban and industrial polygons using Google Earth imagery version 5.0 (Google Inc., 2010) and a one meter resolution. These areas were ground-truthed, and ratios were calculated to represent the percentage of each habitat type to the total available habitat.

The timing of sunrise and sunset, as well as moonrise and moonset, were calculated for each day of the study in Excel using National Oceanic and Atmospheric Administration's (NOAA) solar formula (http://www.srrb.noaa.gov/highlights/sunrise/sunrise.html) for the coordinates (75°04′W, 40°08′N) that represents a point in the middle of the study area. These two sets of data were combined to provide when the moon rose and set overlapping with sunrise/sunset periods.

Deer location data were imported into an ArcGIS 10 project, where the location fixes were converted into lines, preserving their time stamps, and then intersected with the study area habitat-classified map. Shapefiles of the data were made, showing movements of the deer by day and night with the moon above the horizon, and by day and night with the moon below horizon. The selection of habitat under various moon position was accomplished using logical functions in Excel.

Habitat preference, based on the position of the moon, was analyzed by summing the number of trajectory sections located in each

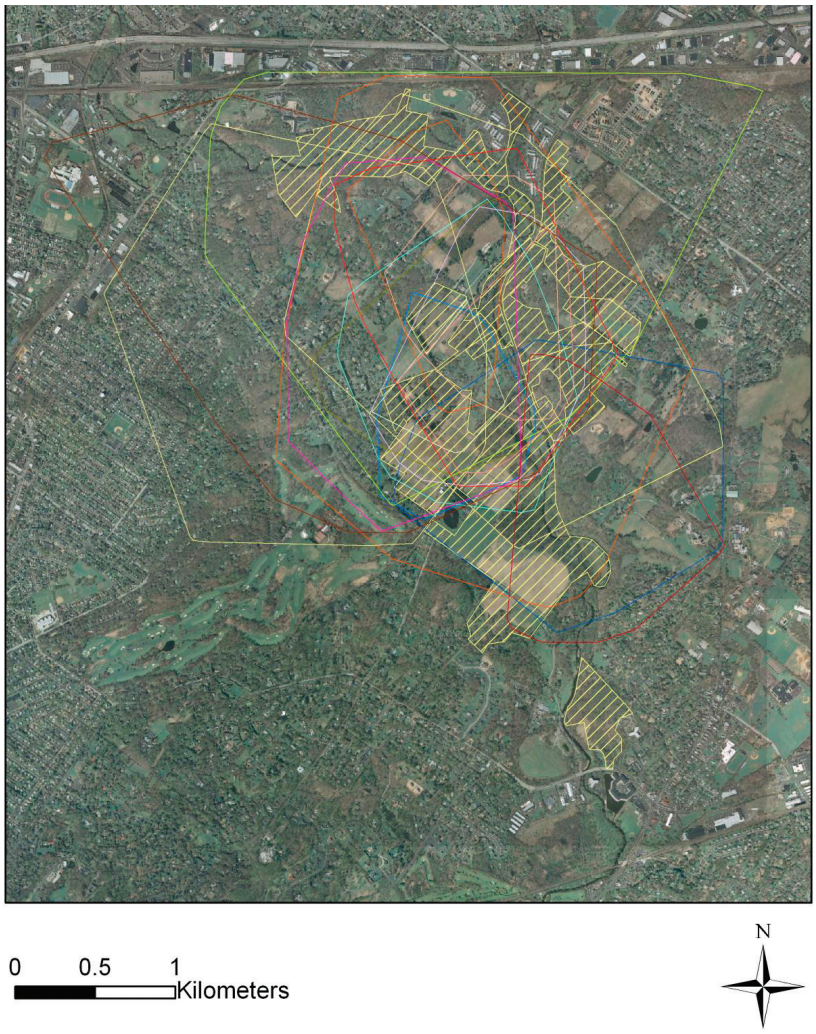

Figure 1. Pennypack Ecological Restoration Trust lands (yellow highlights), and surrounding habitat where deer movements were monitored. Home ranges of individual deer are outlined by different colors

habitat type. This method was new for the high-frequency data collected. The percentages of habitat use by the deer were compared to percentage of habitat available (Fig. 2). ANOVA and T-test after arcsine transformation was used $\Psi = \arcsin\sqrt{(\%)}$ (McDonald, 2009).

RESULTS AND DISCUSSION

White-tailed deer use of field habitat, tested on the presence or absence of the moon at night, scored a p value of 0.001 in the ANOVA test (Fig. 3), indicating that deer are more likely to be found in field habitat when the moon is above the horizon at night. All other habitat types did not show any statistically significant shift in usage by deer in response to the moon. The study area consisted of 19.7% open field, 27.3% forest, 44.0% suburban, and 9.0% industrial habitat. Fourteen of the deer favored forest and field habitat, while actively avoiding the suburban and industrial plots, while three others remained almost exclusively in heavily planted suburban areas. During the day, all deer utilized protective vegetation communities (forest and shrub ≥4 feet), with forest being preferred. During the night, use of open habitats, especially field, increased dramatically (Fig. 2).

Our results indicate that when the moon is above the horizon, white-tailed deer prefer open field environments. By comparing field use by deer based on presence or absence of the moon, study deer utilized open grassland habitat the most during periods of moonlight, $p = 0.001$. The data on deer habitat usage suggest that deer prefer habitat in proximity to browse, with hiding areas close by. Many research groups have suggested a similar habitat use pattern (Beier and McCullough, 1990; DeNicola et al., 2000; Koerth and Kroll, 1996). The results of this and previous studies show that the majority of deer avoid anthropogenic interactions through a decreased use of public access areas within PERT (Potapov et al., 2008).

It is important to note that corrections for environmental factors such as age, dominance, light pollution, cloud cover and predator avoidance were not taken into account in this study due to time constraints. The fact remains that the 17 study animals showed a statistically significant indication that the moon does play a role in habitat selection. Other factors involved that may dilute any lunar impact include the fact that the study covers multiple seasons. The transition from summer into winter in a deciduous habitat, and the resulting loss of leaves, could affect what deer might consider open habitat.

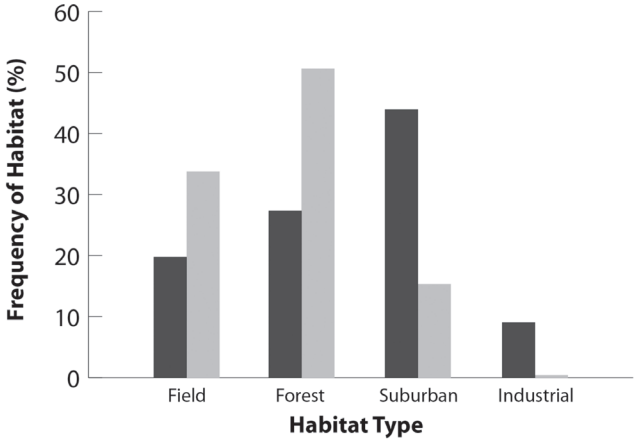

Figure 2. White-tailed deer realized habitat use (gray) vs. available habitat within the study area (black), calculated from summing all trajectory sections for each habitat type for every study animal. Data includes pooled day and night deer activity and shows overall selectivity in deer habitat preferences.

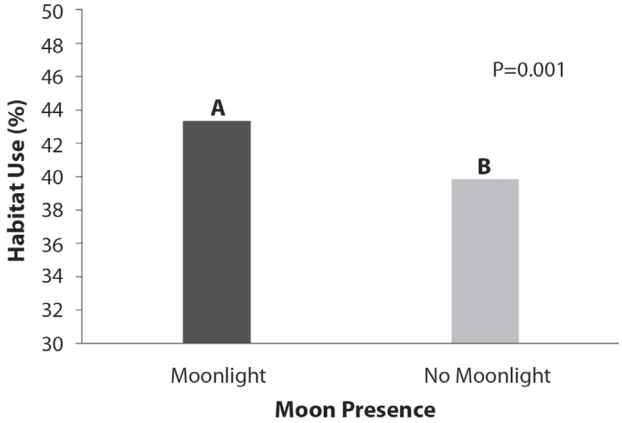

Figure 3. White-tailed deer nocturnal use of field habitat when the moon is above the horizon (black) vs. use of field habitat when the moon is below the horizon (gray)

A possible explanation for why the deer utilize open fields during moonlit nights can be found in literature discussing other ungulate species. Kie (1999) indicates that deer, being a prey animal, become uncomfortable under increased light levels, which can increase exposure to predation due to increased visibility. By limiting their normal nocturnal foraging activity and moving to open habitat, white-tailed deer would reduce their potential exposure to any predators waiting to ambush them from the shadows.

Our data suggest that deer did not alter their daytime habitat use in response to presence or absence of the moon, which is in agreement with the non-invasive camera analysis presented by Koerth and Kroll (1996). Furthermore, our data do not support that deer are affected by moon-induced gravitational pull, as suggested by some (Murray, 2001). This study suggests that it is the luminosity of the moon that affects deer movement and habitat preference.

While environmental impacts such as rut, seasonal change, and predator avoidance could all take precedence over the lunar influence on deer, nocturnal luminosity appears to be a factor in habitat selection. Being crepuscular animals, peak activity times for deer are the low light periods of dusk and dawn, which can be effectively extended by the presence of the moon. The moon may not dictate where a deer is going to be, but it appears to play a role in predicting what habitat a deer is going to prefer.

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