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Variables Influencing Nest Success of Eastern Wild Turkeys in Connecticut: Nesting Habitat, Home Range-Scale Fragmentation, and Nest Attentiveness

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VARIABLES INFLUENCING NEST SUCCESS OF EASTERN WILD TURKEYS IN CONNECTICUT: NESTING HABITAT, HOME RANGE-SCALE FRAGMENTATION, AND NEST ATTENTIVENESS

By

Shelley M. Spohr

B.S. University of Massachusetts, 1994

A THESIS

Submitted in Partial Fulfillment of the
Requirements for the Degree of
Master of Science
(in Wildlife Ecology)

The Graduate School
The University of Maine
December, 2001

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VARIABLES INFLUENCING NEST SUCCESS OF EASTERN WILD TURKEYS IN CONNECTICUT: NESTING HABITAT, HOME RANGE-SCALE FRAGMENTATION, AND NEST ATTENTIVENESS

By Shelley M. Spohr

Thesis Co-Advisors: Dr. Daniel J. Harrison and Dr. Frederick A. Servello

An Abstract of the Thesis Presented
in Partial Fulfillment of the Requirements for the
Degree of Master of Science
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December, 2001

Nest success is the most important demographic parameter influencing rates of population change of eastern wild turkeys (*Meleagris gallopavo silvestris*) and many variables operating at multiple spatial and temporal scales may influence whether a nest is successful. Most studies of nest success and survival of turkeys have occurred in forested or agricultural landscapes; variables influencing nest success have not been studied in suburban landscapes. My objectives were to: 1) quantify survival and reproductive parameters of eastern wild turkey hens in the suburban environment of southeastern Connecticut and compare results to studies conducted in other northeastern states; 2) determine which within patch- and within home range-scale variables were most important in determining the success of turkey nests; and 3) quantify nest attentiveness of hens.

Fifty-nine hens were equipped with back-pack transmitters during 1996 and 1997. Survival rate of hens during the reproductive period (0.60) and success rate of nests (0.35)

were lower in Connecticut than rates reported in most neighboring states. Predation during the reproductive period appeared to be greater on my study sites than on more forested study sites elsewhere in the eastern U.S., possibly due to increased densities of nest predators in suburban environments.

Landscape and cover variables were measured at 38 nests (14 successful, 16 destroyed by predators, 8 abandoned). Multiple linear regression modeling was used to determine relationships between home range-scale fragmentation and cover variables and the number of days each nest survived, and logistic regression modeling was used to compare home range-scale fragmentation and cover characteristics of successful and destroyed nests. The most parsimonious logistic regression model included number of trees and height of ground vegetation as significant descriptor variables. Variables that significantly influenced duration of nest success were number of trees within 10 m of the nest, number of nonwoody stems per 10 m^2, and amount of forest within 225 m of nests. These variables probably had indirect influences on wild turkey nest success by influencing detection and encounter rates of predators.

Attentiveness data were obtained for 15 nesting hens. Mean values of attentiveness variables did not differ between hens of successful and destroyed nests; however, small sample sizes resulted in high probability of type II error. Hens whose nests were destroyed were more likely to leave nests from 1200-1459 hr and successful birds were more likely to leave nests from 1500-2100 hr. Although it is reported that turkeys have 2 distinct daily periods of intense feeding activity - mid-morning and mid-afternoon, I found that 1200 – 1459 hr was the most frequent time for hens to leave their nests.

Predation may be the proximate factor influencing nest success of turkey hens, but the ultimate cause may be habitat related. Despite the ability of hens to decrease the probability of nest predation by placing nests in forested areas with dense herbaceous or woody understories, fragmentation may have contributed to higher predator densities and subsequent nest predation in this suburban landscape. Thus, long-term studies will be necessary to determine whether incremental increases in forest fragmentation will decrease productivity of turkeys in increasingly suburban environments.

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CHAPTER 1

SURVIVAL AND REPRODUCTION OF WILD TURKEY HENS IN A SUBURBAN ENVIRONMENT

INTRODUCTION

Winter severity is an important variable influencing eastern wild turkey (*Meleagris gallopavo silvestris*) populations in the northcentral and northeastern United States (Porter et al. 1983). Mortality of turkeys in winter can significantly reduce population growth at the northern extent of their range, but may not be limiting where winters are less severe (N.Y.: Austin and DeGraff 1975, Pa.: Wunz and Hayden 1975, Minn.: Porter et al. 1980, 1983). Furthermore, food such as waste corn in silage bunkers and manure spreads can alleviate effects of severe winters and reduce annual variation in survival rates (Porter et al. 1980, Vander Haegen et al. 1988, Roberts et al. 1995). Overwinter survival of turkeys was 93% in western Massachusetts (Vander Haegen et al. 1988), where waste corn from dairy farms (22% of the study site) provided abundant winter food, and 87% in south central New York, where 15% of the study area was agricultural (Roberts et al. 1995). Thus, populations inhabiting mixed agricultural and forested environments with infrequent severe winters are less affected by winter mortality (Roberts et al. 1995).

In areas where overwinter mortality is reduced because of anthropogenic food sources, turkey populations are most responsive to annual variation in reproductive success (Roberts et al. 1995), and nest success is the most important demographic variable influencing rates of population change (Roberts and Porter 1996). Highly variable annual nest success has been documented in New York (26–58%; Roberts et al. 1995), Maine

(51–74%; Treiterer 1987), and Missouri (14–47%; Vangilder et al. 1987), yet little is known about the factors affecting this variable (Roberts et al. 1995: 444).

Landscape characteristics of habitats used by hens may influence nest success (Badyaev et al. 1996, Palmer et al. 1996). For instance, survival and reproductive rates have been reported to differ between agricultural and forested landscapes (e.g., Treiterer 1987, Vander Haegen et al. 1988, Roberts and Porter 1996). Although turkeys were originally considered to require forested or farmed landscapes (Wunz 1971, Little 1980), turkeys are now considered habitat generalists (Healy 1992). Turkeys are becoming a nuisance species in some suburban areas (S. M. Spohr, H. J. Kilpatrick, M. A. Gregonis, unpubl. rep., Conn. Dep. Env. Prot., Wildl. Div.), exemplifying their ability to persist in human-altered environments. Most studies of nest success and survival of turkeys have occurred in forested (Treiterer 1987, Vander Haegen 1987, Thomas and Litvaitis 1993, Roberts et al. 1995, Miller 1997, Roberts and Porter 1998) or agricultural (Kurzejeski et al. 1987, Miller 1990, Miller 1993, Wright et al. 1996) areas and may not be representative of turkey populations occupying suburban landscapes. Therefore, my primary objective was to quantify nest success, survival, and reproductive parameters of eastern wild turkey hens in the suburban environment of southeastern Connecticut, and to compare these results to results of studies in forested and agricultural regions of northeastern U.S. Also, I examined biological aspects of reproductive and survival characteristics of hens by evaluating patterns across biological seasons because survival rates of hens may be lowest during specific seasons (winter; Wunz and Hayden 1975) or biological periods (nesting; Vander Haegen et al. 1988). Lastly, I evaluated whether weight of hens was associated with reproductive success (Porter et al. 1983) to gain further insight into the potential influences of winter food availability on reproductive performance of turkeys in a suburban landscape.

STUDY SITE

The study area comprised three distinct study sites within 9 towns in Middlesex and New London counties in southeastern Connecticut. Study sites were defined from trap locations used to capture turkeys and the movements of radio marked hens; sites were 58.8, 68.2, and 77.2 km^2 based on concave polygons around all locations of birds marked in 1996 and 1997. Altitude at the 3 sites ranged from 13 - 183 m above sea level and median population density for the 9 towns was 97 humans/km^2 (250 humans/mi^2; range 34 – 461 humans/km^2; Secretary of the State 1996).

Forested land composed 67% of Middlesex and New London counties in 1985, and 85% of the forested land was privately owned (Dickson and McAfee 1988). Forests were dominated by oak/hickory (*Quercus* spp./*Carya* spp.) stands with yellow-poplar (*Liriodendron tulipifera*), elm (*Ulmus* spp.), and red maple (*Acer rubrum*). Common understory species included blueberry (*Vaccinium* sp.), witch hazel (*Hamamelis virginiana*), dogwood (*Cornus* spp.), common spicebush (*Lindera benzoin*), mountain laurel (*Kalmia angustifolia*), raspberry (*Rubus* sp.), maple-leaved viburnum (*Viburnum acerifolium*), poison ivy (*Rhus radicans*), and greenbriar (*Smilax* spp.) (Dickson and McAfee 1988). Forests were highly interspersed with human development (Brooks et al.

1993) and forest-development edges were the dominant ecotone after transportation right-of-ways (Dickson and McAfee 1988). Agricultural land in Connecticut steadily declined from 498,000 acres in 1950 to 225,000 acres in 1982, which coincided with an increase in housing units (Brooks et al. 1993). In addition, much of the recent development of residential housing has occurred in rural, forested areas (Brooks et al. 1993).

I considered the turkey population in this study to be predominately suburban. Hens were captured in suburban settings and most (92%) nested in suburban areas. I defined a suburban area as a town with > 80 people/km^2. Only 4 birds in this study nested in two towns that had < 80 people/km^2 (population density = 34 and 45 people/km^2). Thirty-three of 48 (69%) nesting attempts occurred in towns with > 100 people/km^2, and 21 of 48 (44%) occurred in towns with > 200 people/km^2. In addition, 29 of 43 hens (67%) nested within 300 m of development and 79% nested within 500 m of development. I classified the entire study population as being in a suburban setting because radioed hens were prevalent in suburban sites during this study. Other studies of wild turkeys in New England have not occurred in such human-dominated environments as in this Connecticut study area. Hens studied by Vander Haegen (1987) did not use urban/suburban areas and < 14% of the study area had that classification (W. M. Vander Haegen, Washington Department of Fish and Wildlife, personal communication). Thomas (1989) studied turkeys at a predominantly forested study site in New Hampshire. The county had a human population density of 184 humans/km^2, but turkeys appeared to avoid development and nested in undeveloped tracts of forest and not in subdivisions associated with houses

(G. Thomas, personal communication). Thomas did not consider this turkey population to be in a suburban setting (G. Thomas, personal communication).

Mean winter (December–March) temperatures at a weather station located in the study area were -3.2°C (26.2°F) in 1996 and 0°C (32.0°F) in 1997 (National Oceanic and Atmospheric Administration). Depths of snow exceeded 15.2 cm (6 inches) during 39 of 123 days in the winter of 1996, but never exceeded 15.2 cm in 1997. Total precipitation during April-May was 31.0 cm in 1996, which was 7.6 cm (33%) greater than the 30-year average, and 22.3 cm in 1997. Mean daily temperatures for April and May were 8.4°C (47.1°F) and 13.2°C (55.7° F) in 1996 and 7.4°C (45.4°F) and 12.2°C (54° F) in 1997.

After being extirpated in Connecticut in the early 1800's, eastern wild turkeys were reintroduced to northeastern Connecticut during the 1970's. By 1981, the turkey population had increased to 2,300–2,500 statewide (S. M. Spohr, H. J. Kilpatrick, M. A. Gregonis, Connecticut Department Environmental Protection, unpublished report). Through reintroduction and management efforts, Connecticut's turkey population increased to 18,000–25,000 birds in 1998 (2.4–3.4 turkeys/km^2; S. M. Spohr, H. J. Kilpatrick, M. A. Gregonis, Connecticut Department Environmental Protection, unpublished report). The population appears to be stabilizing in northwestern regions and continues to increase in eastern regions of the state where the most recent reintroductions occurred (M. A. Gregonis, Connecticut Department Environmental Protection, personal communication).

METHODS

Capture and Telemetry

I captured turkeys from January to April in 1996 and 1997 with rocket nets at sites baited with corn. After capture, each hen was weighed, aged, leg banded, and equipped with a back-pack transmitter with a mortality sensor on a 12-hr time delay (Advanced Telemetry Systems, Isanti, Minn.). Transmitters had a life expectancy of 3 years and were attached to hens with 0.32 cm (1/8") diameter elastic 'bungi' cord. All hens weighed ≥ 3.2 kg (7 lbs) and weights of transmitter packages ranged from 89-93 grams amounting to an average of 1.95% of body weight (range 1.4 – 2.4%). I classified hens as yearlings (<1 yr old) or adults based on plumage characteristics (Petrides 1942). Capture and handling procedures were approved by the Institutional Animal Care and Use Committee at the University of Maine, Orono.

I monitored hens weekly during non-reproductive periods (August - March) and ≥ 4 days/week and 3 times/day from April - July to determine initiation of incubation and to document dates and causes of mortality of hens and destruction of nests. Locations of turkeys were obtained from the ground by triangulation of ≥ 2 bearings with intersecting angles from 30–150°. I assumed that incubation was occurring when a hen was inactive and in the same general location for 3 readings during 2 days of monitoring; I subsequently determined approximate locations of nests by radiotelemetry. I flagged at least 2 trees approximately 15 m from the estimated nest location and recorded compass bearings to the nest to minimize the chance that hens would be accidentally flushed from nests. After hatching or nest loss, I searched the flagged areas for nests and used a Geographic Positioning System (Garmin 45XL) to obtain Universal Transverse Mercator coordinates of nests. I determined nest success, hatching success, and clutch size by examining eggshells and by searching for broods after nesting was completed by following radio-marked hens.

Survival and Reproductive Parameters

I located transmitters when mortality sensors indicated that a hen had not moved in >12 hrs. The area was searched for evidence of cause of death (e.g., fur, tracks, scats, or feathers). I also examined the carcass, if found, for evidence of canine punctures or disease. Canid kills were identified by measuring width of canine punctures on the carcass or transmitter (Hodgman et al. 1997). Kills by avian predators were identified by owl feathers at the kill site or when the turkey carcass had been decapitated and the breast meat had been removed (J. Victoria, Connecticut Department of Environmental Protection, personal communication; Thogmartin and Schaeffer 2000). If I lost radio contact with a turkey and was unsure of its fate, I censored the hen on the date after she was last located (Vangilder and Sheriff 1990).

I estimated survival of hens using the Heisey and Fuller (1985) method. I divided the year into five intervals during which daily survival rates were assumed constant: fall (5 July – 30 November), winter (1 December – 5 April), pre-nesting (6 April – 5 May), nesting (6 May – 4 June), and post-nesting (5 June – 4 July). To evaluate whether it was justifiable to pool data, I analyzed daily survival rates between years of study, age of hens, and among study sites with Z-tests (Heisey 1985) and Bonferroni adjustments, as necessary. If differences were not detected, data were pooled across years, sites, and hen ages. Survival rates of hens were then estimated for pre-nesting, incubation, and post-nesting phases of the reproductive period. These phases were determined with the median incubation date for each year as the beginning of the incubation period and 30 days before and after this date as the initiation of pre-nesting and post-nesting phases, respectively (Table 1.1). To determine if a difference existed in daily survival rates among the non-reproductive, pre-nesting, nesting, and post-nesting periods, I first had to determine if fall and winter data could be pooled to obtain a survival rate for the entire non-reproductive period. I used a Z-test (Heisey 1985) to compare daily survival rates during the fall and winter periods; if no differences were observed, data were pooled. I then compared daily survival rates of hens among 4 biological periods – non-reproductive, pre-nesting, incubation, and post-nesting periods - using Bonferroni adjusted Z-tests (Heisey 1985).

I calculated nesting rates (proportion of hens that attempted to nest), clutch size, median incubation date, hatching success (proportion of eggs that hatched in a successful nest), renesting rates (proportion of hens not successful on the first nesting attempt that renested), and renesting success (proportion of renests from which at least one live poult hatched). I estimated when incubation was initiated for each nest by backdating from the date of hatching (Bailey and Rinell 1967) or by backdating embryos from eggs not destroyed (Stoll and Clay 1975), in conjunction with telemetry data. Instead of conducting

Table 1.1. Pre-nesting, nesting, and post-nesting phases of the reproductive period of female eastern wild turkeys in southeastern Connecticut, 1996–1997. Phases were determined with the median date of incubation initiation as the beginning of the incubation period and 30 days before and after this date as the initiation of pre-nesting and post-nesting phases.

Year	Dates		
	Pre-nesting	Nesting	Post-nesting
1996	11 April – 10 May	11 May – 9 June	10 June – 9 July
1997	6 April – 5 May	6 May – 4 June	5 June – 4 July

biologically irrelevant statistical tests (Johnson 1999), I computed 95% confidence intervals for all estimates of reproductive performance.

I calculated nest success as the proportion of nesting females that hatched at least one egg (Vangilder et al. 1987). Given that my primary objective was to compare my turkeys' reproductive estimates to other studies, I evaluated uniformity of nest success between years, ages, and among study sites with Z-tests to determine if these data could be pooled. To determine if nests were more likely to be destroyed the longer they were available to predators, I used the Kaplan-Meier method (Pollock et al. 1989) to produce a survival curve of nests during the 30-day incubation period. To determine if visual cues related to seasonal cover influenced predation, I used a Z-test to compare the proportion of successful nests initiated before and after the estimated date of spring green-up (1 May).

I examined whether heavier hens were more likely to nest and to nest successfully than lighter hens. For this analysis, I used hens that survived up to the pooled median date of incubation (6 May) and nesting data were used only during the year each bird was captured (because weights were only recorded the year of capture). I used a 2-factor analysis of variance on ranked data to examine weights of adults and yearlings that did not nest, successfully nested, and unsuccessfully nested.

RESULTS

I radio-marked 59 hens (17 yearlings, 42 adults) during 1996 and 1997 (Table A.1). Thirty-three hens (6 yearlings, 27 adults) died during the monitoring period and 5 turkeys (2 yearlings, 3 adults) with unknown fates were censored after the date of last location. Survival rates did not differ by year ($Z = 1.57$, 1 df, $P = 0.11$), age ($Z = 0.63$, 1 df, $P = 0.54$), or among study sites (Site 1 vs. Site 2: $Z = 1.25$, $P = 0.21$; Site 1 vs. Site 3: $Z = 1.66$, $P = 0.09$; Site 2 vs. Site 3: $Z = 1.08$, $P = 0.26$; Table 1.2); however, comparisons were limited by small sample sizes (1996 = 22 hens; 1997 = 37 hens). Given that no overriding evidence existed of strong year-specific differences in survival, I pooled data to maximize statistical power. The annual survival rate of hens pooled across years, hen age, and sites was 0.43 (95% CI 0.32–0.59; Table 1.3).

Daily survival rates of hens were 0.998 during the non-reproductive period, 0.996 for the pre-nesting period, 0.991 for the incubation period, and 0.996 for the post-nesting period (Figure 1.1, Table 1.3). Most deaths of hens (76%) occurred during the reproductive period; 6 of 9 in 1996 and 19 of 24 in 1997. Furthermore, most deaths (52%) were caused by mammalian predators such as coyotes, foxes, and raccoons; 12% were attributed to avian predators, likely great horned owls, 18% were undetermined, and the remaining deaths were attributed to vehicles (6%), disease (6%), and poaching (6%).

Forty-four of 54 females (81%; 95% CI 0.69–0.9) attempted to nest (Table 1.4). Average clutch size was 10.5 eggs (SE = 0.51, $n = 25$). The median incubation date was 11 May in 1996 (range 24 April – 9 June) and 6 May in 1997 (range 22 April – 5 June; Table 1.4). Hatching rate for eggs from successful nests for both years pooled was 89% (95% CI 0.82–0.94; Table 1.4). None of the 5 yearlings that failed in their initial nesting

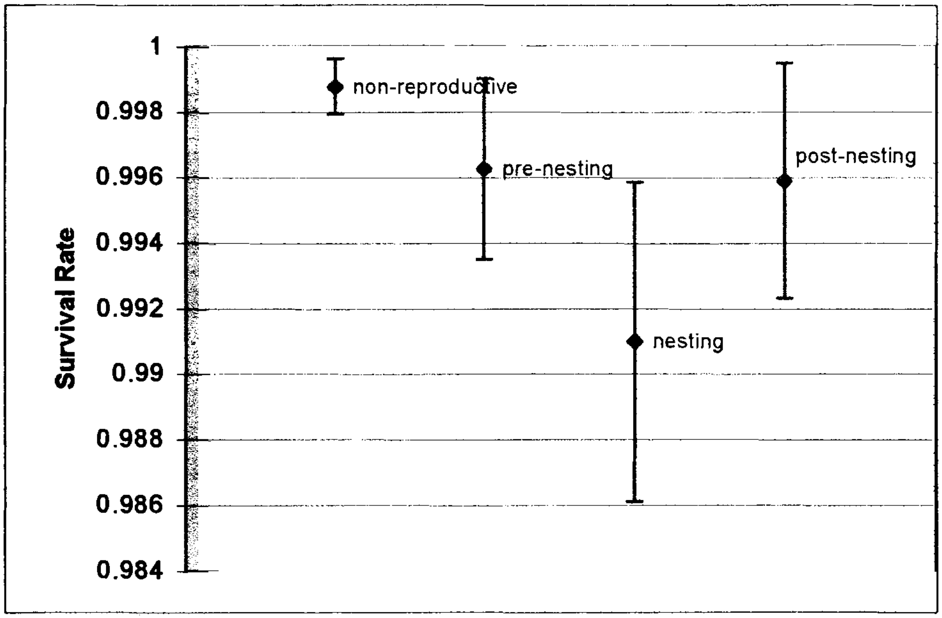
Table 1.2. Survival rates for radio-marked turkey hens by year, age of hen, and study site in southeastern Connecticut using program MICROMORT (Heisey and Fuller 1985).

			Daily Rates		Interval Rates	
	N days in interval	N turkey-days	Survival	95% CI	Survival	95% CI
Site 1	526	4603	0.998	0.997-0.999	0.357	0.182-0.699
Site 2	501	5265	0.997	0.995-0.998	0.198	0.092-0.427
Site 3	177	1233	0.994	0.990-0.999	0.365	0.173-0.769
Yearling	365	1551	0.996	0.993-0.999	0.297	0.112-0.784
Adult	365	9550	0.997	0.996-0.998	0.442	0.325-0.602
1996	313	4428	0.998	0.997-0.999	0.529	0.349-0.802
1997	213	6673	0.996	0.995-0.998	0.464	0.341-0.631

Table 1.3. Survival rates by biological periods for radio-marked turkey hens in southeastern Connecticut, using program MICROMORT (Heisey and Fuller 1985).

			Daily Rates		Interval Rates	
Interval	N days in interval	N turkey-days	Survival	95% CI	Survival	95% CI
Fall	149	2752	0.999	0.998-1.0	0.897	0.772-1.0
Winter	126	3809	0.998	0.997-0.999	0.819	0.669-0.961
Fall/Winter (Non-reproductive)	275	6561	0.999	0.998-0.999	0.715	0.567-0.902
Pre-nesting	30	1876	0.996	0.994-0.999	0.894	0.823-0.971
Nesting	30	1444	0.991	0.986-0.996	0.762	0.658-0.883
Post-nesting	30	1220	0.996	0.992-0.999	0.884	0.793-0.985
				Annual rate:	0.431	0.317-0.586

Figure 1.1. The 95% confidence intervals on estimates of daily survival rates (Heisey and Fuller 1985) for eastern wild turkey hens during four biological periods (non-reproductive, pre-nesting, nesting, and post-nesting) in southeastern Connecticut, 1996-1997.



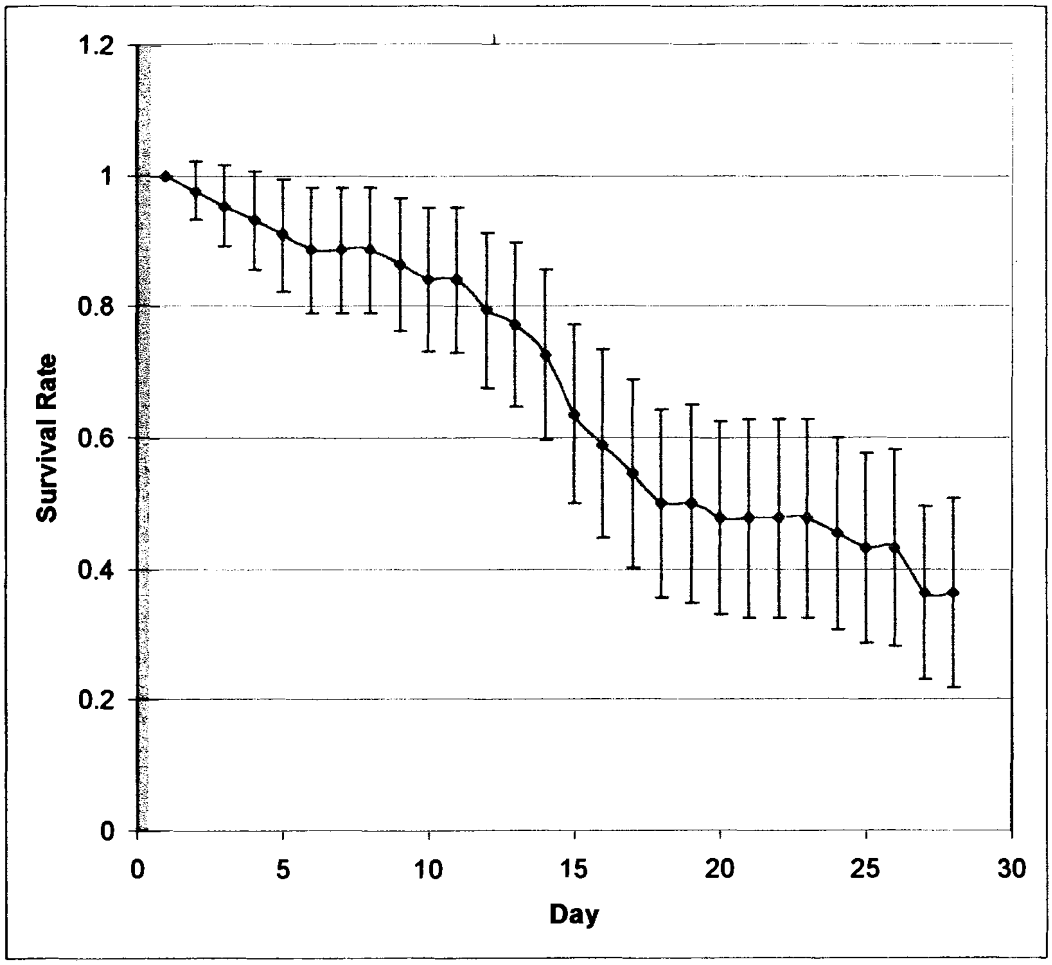
Age	Year	Median (range) Incubation Date	Nesting Rate[a]	Mean ± SE Clutch Size	Nest Success Rate[b]	Hatching Success Rate[c]	Mean ± SE Days of Incubation	Renesting Rate[d]	Success Rate of Renests[e]
Adult	1996								
	Estimate (n)	11 May (24 April - 9 June) (9)	0.75 (12)	10.3 ± 1.0 (8)	0.33 (9)	0.95 (19)	18.7 ± 2.9 (9)	0.13 (8)	0.0 (1)
	95% CI		0.42-0.95	7.9-12.6	0.08-0.7	0.74-0.99	12.14-25.26	0-0.53	
	1997								
	Estimate (n)	6 May (22 April - 5 June) (27)	0.90 (30)	10.4 ± 0.5 (11)	0.41 (27)	0.95 (58)	20.0 ± 1.7 (27)	0.33 (9)	0.33 (3)
	95% CI		0.73-0.98	9.29-11.5	0.22-0.62	0.86-0.99	16.51-23.48	0.08-0.7	0-0.91
	Pooled								
	Estimate (n)	6 May (22 April - 9 June) (36)	0.86 (42)	10.3 ± 0.5 (19)	0.39 (36)	0.95 (77)	19.7 ± 1.5 (36)	0.24 (17)	0.25 (4)
	95% CI		0.71-0.95	9.25-11.34	0.23-0.56	0.87-0.99	16.66-22.74	0.07-0.49	0-0.81
Yearling	1996								
	Estimate (n)	14 May (3 May - 25 May) (2)	0.40 (5)	10.0 ± 4.0 (2)	0.00 (2)		16.5 ± 10.6 (2)	0.0 (2)	
	95% CI		0.05-0.85	0-27.2			0-62.1		
	1997								
	Estimate (n)	2 May (23 April - 22 May) (6)	0.86(7)	12.5 ± 0.7 (2)	0.33 (6)	0.72 (25)	20.3 ± 2.6 (6)	0.0 (3)	
	95% CI		0.42-0.99	9.48-15.51	0.08-0.77	0.5-0.88	7.58-26.66		
	Pooled								
	Estimate (n)	4 May (23 April - 25 May) (8)	0.67 (12)	11.3 ± 1.8 (4)	0.25 (8)	0.72 (25)	19.4 ± 2.8 (8)	0.0 (5)	
	95% CI		0.35-0.9	6.3-16.29	0.03-0.65	0.5-0.88	12.94-25.86		
All females	1996								
	Estimate (n)	11 May (24 April - 9 June) (11)	0.65 (17)	10.2 ± 1.0 (10)	0.27 (11)	0.95 (19)	18.3 ± 2.8 (11)	0.10 (10)	0.0 (1)
	95% CI		0.38-0.86	7.97-12.43	0.06-0.61	0.74-0.99	12.14-24.46	0-0.45	
	1997								
	Estimate (n)	6 May (22 April - 5 June) (33)	0.89 (37)	10.8 ± 0.5 (12)	0.39 (33)	0.88 (83)	20.1 ± 1.5 (33)	0.25 (12)	0.33 (3)
	95% CI		0.75-0.97	9.71-11.89	0.23-0.58	0.79-0.94	17.05-23.15	0.06-0.57	0-0.91
	Pooled								
	Estimate (n)	6 May (22 April - 9 June) (44)	.81 (54)	10.5 ± 0.5 (23)	0.36 (44)	0.89 (102)	19.6 ± 1.3 (44)	0.18 (22)	0.25 (4)
	95% CI		0.69-0.9	9.46-11.53	0.22-0.53	0.82-0.94	16.98-22.22	0.05-0.4	0-0.81

[a] Proportion of hens that attempted to nest
[b] Proportion of nesting females that hatched at least one egg in their initial nest
[c] Proportion of eggs that hatched in a successful nest
[d] Proportion of hens not successful on the first nesting attempt that renested
[e] Proportion of renests from which at least one live poult hatched

attempt renested. Four of 17 unsuccessful adults renested, but only one renest attempt was successful. One hen that successfully hatched a first nest renested after the poults from that first nesting attempt died.

I pooled nest success data across years and sites for subsequent analyses because no evidence existed that nest success differed between years ($Z = 0.37$, 1 df, $P = 0.67$) or among study sites (Site 1 vs. Site 2: $Z = 0.09$, $P = 0.89$; Site 1 vs. Site 3: $Z = 0.04$, $P = 0.97$; Site 2 vs. Site 3: $Z = 0.59$, $P = 0.52$). Also, nest success did not differ between adults (39%; 95% CI 0.23 – 0.56; $n = 36$) and yearlings (25%; 95% CI 0.03–0.65; $n = 8$), likely because n was small ($Z = 0.35$, 1 df, $P = 0.73$). Nest success data were pooled to maximize sample size in subsequent analyses. Twenty-seven percent of nests were successful in 1996 ($n = 11$) and 39% in 1997 ($n = 33$); the success rate for both years combined was 36% (95% CI 0.22–0.53; Table 1.4). Including renesting attempts, 17 of 48 nests (35%) were successful (95% CI = 22.0 – 50.0%; Table 1.4). Of 28 initial nests that were unsuccessful, 20 were attributed to predation of the eggs ($n = 13$) or the hen ($n = 7$), and 8 were abandoned. Raccoons, coyotes, and foxes were the most commonly identified nest predators. Four of 20 nests were destroyed by predators within 10 days of incubation initiation, 11 were destroyed between days 11 – 20 of incubation and 5 were lost after day 20. The survival curve of nests documents that nest loss was distributed over the entire

Figure 1.2. The 95% confidence intervals on estimates of cumulative survival rates of nests of wild turkey hens in southeastern Connecticut, 1996-1997, based on the Kaplan-Meier survival function (Pollock et al. 1989).



28-day incubation period (Figure 1.2). Nest success between hens that nested pre- (success = 47%; 95% CI 0.23 – 0.72; *n* = 17) or post- (success = 29%; 95% CI = 0.14 – 0.49; *n* = 27) spring green-up (May 1) were not statistically different ($Z = 0.91$, 1 df, $P = 0.36$).

Body weights at capture averaged 4.45 kg for adults (*n* = 33) and 3.86 kg for yearlings (*n* = 15) ($F = 17.85$, $P = 0.000$). No differences were detected in weights of hens that did not nest, successfully nested, or unsuccessfully nested ($F = 1.488$, $P = 0.238$). The average weight of hens that did not nest (*n* = 13) was 4.05 kg; hens that were successful averaged 4.39 kg (*n* = 12), and hens that did not successfully nest averaged 4.35 kg (*n* = 23; Figure 1.3). In addition, no differences were detected in weights of hens that nested and did not nest ($F = 1.705$, $P = 0.198$). Average weight of hens that nested was 4.36 kg (*n* = 35).

DISCUSSION

The mean annual survival rates of turkey hens in Connecticut were similar to rates reported in neighboring states (Table 1.5). As in other regions of the United States, hen survival was lowest during the reproductive period (Speake 1980, Vander Haegen et al. 1988, Seiss 1989, Palmer et al. 1993, Roberts et al. 1995, Vangilder and Kurzejeski 1995, Wright et al. 1996, Miller et al. 1998). Survival during the reproductive period, however, tended to be lower in Connecticut than other northeastern states (Table 1.5). Only 33% of deaths in Maine occurred during the reproductive period (Treiterer 1987), whereas 76% of the deaths in Connecticut occurred during this period (Table 1.5). Winter mortality in

Figure 1.3. The 95% confidence intervals on mean weights (kilograms) of hens that did not nest, successfully nested, or unsuccessfully nested in southeastern Connecticut, 1996-1997.

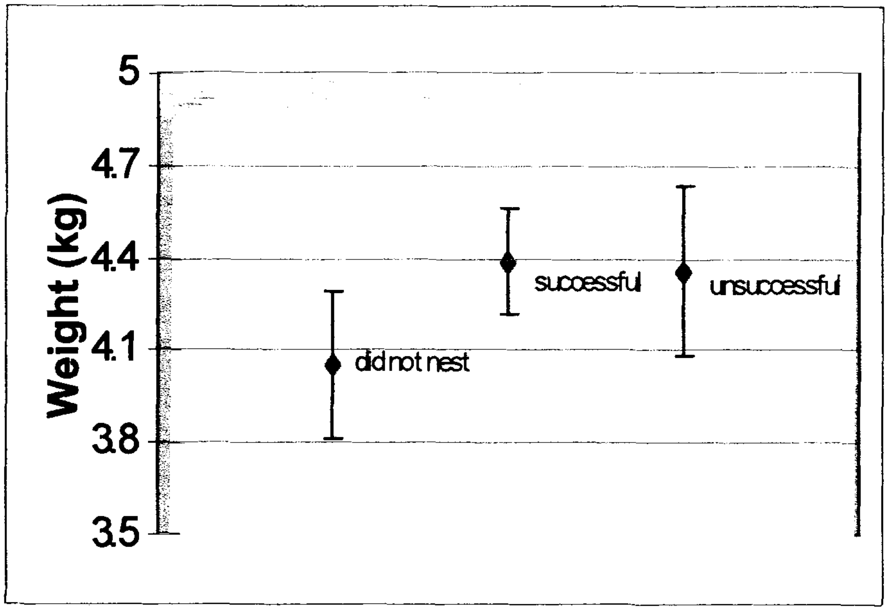


Table 1.5. Mortality and reproductive parameters for eastern wild turkeys in the northeastern U.S.

Reproductive Metric	CT (this study)	MA (Vander Haegen 1987)	NY (Roberts et al. 1995)	NH (Thomas and Litvaitis 1993)	ME (Treiterer 1987)
Hen Survival Rate					
Annual	0.43[1]	0.66[2]	0.49[3]	-	0.37[4]
Reproductive period	0.60[5]	0.78[6]	0.83[7]	-	0.67[8]
Deaths during reproductive period (%)	76[5]	75[6]	46[7]	-	33[8]
Deaths during nesting phase (%)	48	25	-	12	-
Nest success (%; includes renests)	35	55	38	55	57
Nest loss from predators (%)	71	57[9]	-	86	33[10]
Rate of abandonment (%)	17	24	-	6	29

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[1] Heisey-Fuller method; 2 years pooled.

[2] Used specific formula (# hens alive at end of period divided by # hens alive at beginning of period)

[3] Kaplan-Meier method (Pollock et al. 1989); 4 years pooled.

[4] Mayfield estimate (Bart and Robson 1982); 2 years averaged.

[5] 6 April – 4 July

[6] 1 April – 31 August

[7] 15 April – 31 July

[8] 1 May – 31 August

[9] Specific cause not determined for 8 nests.

[10] Specific cause not determined for 4 nests.

states with severe winter weather, such as Maine and New York, may compensate for the high rates of mortality documented in Connecticut during the reproductive period, resulting in similar annual survival rates.

Similar to this study, other researchers have reported predation as the principle cause of mortality of wild turkeys (Treiterer 1987, Vander Haegen 1987, Thomas and Litvaitis 1993). Predation during the reproductive period tended to be greater, however, on my study site than has been observed elsewhere in the eastern U.S. Although predation rates in New Hampshire were lowest during the incubation phase (Thomas 1989), I observed that the highest predation rates (i.e. lowest daily survival rates) occurred during the incubation phase. Higher density of predators (Schinner and Cauley 1973, Harris 1977, Hoffman and Gottschag 1977, Wilcove 1985, Riley et al. 1988) or high density of ecotones (Paton 1994) as a result of suburbanization, could be contributing to the relatively high predation rates observed during my study.

High rates of predation on hens and nests during the reproductive period resulted in lower success rates of nests during my study (35%) than reported for most neighboring states (Table 1.5). Only one study reported nest success that was within the 95% confidence interval for nest success in this study; nest success in New York was 38% (Roberts et al. 1995). Overall nest success was 55% in Massachusetts (Vander Haegen et al. 1988) and New Hampshire (Thomas and Litvaitis 1993), 50% in Rhode Island (Pringle 1988), 67% (Porter et al. 1983) in New York, and 57% in Maine (Treiterer 1987). Predation was the leading cause of nest loss in all of these studies; however, I observed a higher proportion of nests lost from predation (71% of total nest losses) than reported for Massachusetts or Maine (Table 1.5).

Mammalian, not avian, predators are responsible for the majority of nest losses, and most nest predators such as raccoons, opossum, and fox, rely on olfactory cues more than visual cues for locating nests (Grant and Morris 1971, Bowman and Harris 1980, Paton 1994). Scent cues may be prevalent the longer a nest is active because of scent trails left by the hen. Hence, as a nest gets closer to hatching, its chances of being detected may increase. As an index of whether olfactory cues played a role in nesting and nest predation, I examined survival rates during the incubation period. Although I hypothesized that the probability of predation would increase with time since initiation of incubation, the survival curve of nests did not depict this. Instead, the trajectory of the curve appeared to be fairly consistent, suggesting that nests are at comparable risk throughout the 28-day incubation period. Similarly, predation on 27 turkey nests in Florida was distributed evenly throughout the incubation period (Williams and Austin 1988). Because most nest losses did not occur late in incubation and the nest survival curve was constant, it is unlikely that olfactory cues related to nest age and cumulative hen movements were primary variables influencing risk of predation.

It has been reported that coyotes primarily rely on visual cues, with audition and olfaction being less important (Wells and Lehner 1978). I theorized that vegetative characteristics around nests would be less likely to provide adequate cover for concealment (Wunz and Pack 1988) during the pre-spring green-up period. Hence, eggs laid in the spring before green-up or in sparse, homogeneous vegetation (Bowman and Harris 1980) may be more likely to be detected by predators. No significant difference in success rates between birds that nested before or after spring green-up was detected, perhaps a result of small sample sizes and large confidence intervals. This result suggests that timing of nesting may not substantially influence success. There may be several reasons for this: 1) variables other than vegetative cover at the nest influence nest success, 2) hens that nest before spring green-up choose sites where green vegetation is unimportant to nest concealment, such as thickets or downed trees, or 3) hens may camouflage nests in leaves. I found that hens that nested before spring green-up tended to locate their nests in hardwood forests with little understory (6 of 16 nests), but nests were difficult to locate in the dead, brown leaves. Other hens that nested before spring green-up chose thickets (n = 4), downed trees (n = 4), or tall grass or *Phragmites* (spp.) (n = 2) to nest. Downed trees also provided nesting cover to turkeys in Maine early in incubation when herbaceous cover was not available (Treiterer 1987).

I observed that the nesting rate of hens in Connecticut (81%) tended to be lower than reported in Massachusetts (92%; Vander Haegen et al. 1988) and New Hampshire (91%; Thomas and Litvaitis 1993); those researchers used the same methods to define a nesting attempt. Roberts and Porter (1996) attributed differences in nesting rates between sites in northern Missouri (Vangilder et al. 1987), New York (Glidden 1977, Roberts et al. 1995), and Massachusetts (Vander Haegen et al. 1988) and a site in southern Missouri (Roberts and Porter 1996: L. D. Vangilder, Mo. Dep. Conserv., pers. commun.) to habitat differences. Studies that documented little variation and high nesting rates occurred in agricultural environments (northern Missouri, New York, Massachusetts), whereas the study that documented much variation and low nesting rates was in a primarily forested area (southern Missouri). Perhaps the mixed forested-suburban environment of southeastern Connecticut contributed to lower nesting rates because of reduced availability of agriculturally related foods (e.g., manure spreads) during winter.

Nesting chronology differs across the United States depending on latitude (Vangilder et al. 1987), with more northerly populations having later nest initiation dates associated with later onset of spring (Welty 1982). Because Connecticut weather is milder than most New England states, hens in Connecticut would be expected to nest earlier than hens in northern New England. As expected, the two-year median incubation date for Connecticut birds was 6 May; New Hampshire was 16 May (Thomas and Litvaitis 1993) and southern Massachusetts was 15 May, 8 May, and 7 May (Vander Haegen et al. 1988). The median incubation dates in Maine, however, were 4 May and 7 May (Treiterer 1987), which was counter to the expected trend of earlier nest initiation dates with decreasing latitude. The median date of incubation also can vary in response to annual weather fluctuations; in Missouri initiation of incubation was delayed during springs with low average temperatures and renesting rates were lower during years with harsh spring weather (Vangilder et al. 1987).

One hen unsuccessfully renested after losing poults from a successful clutch. According to Williams (1981), hens do not renest in the same year a brood is hatched;

however, reports of hens renesting after losing a brood are becoming more common. A hen in Alabama and 2 hens in North Carolina were observed renesting after hatching a clutch (Harper and Exum 1999) and a hen initiated a second nest after losing her >2-week-old brood in Arkansas (Thogmartin and Johnson 1999). Apparently this nesting strategy is rare and likely depends on the viability of the sperm stored in a hen's oviduct and the number of days poults from the initial nest survive (Harper and Exum 1999).

Weights at capture were similar to winter weights reported in Maine (Treiterer 1987), Massachusetts (Vander Haegen 1987), and New Hampshire (Thomas and Litvaitis 1993). Therefore, the differences in nesting rate and nest success between Connecticut and other states were likely not caused by differences in weights of hens. Without evaluating body fat composition (Morton et al. 1991), conclusions can not be made about hen condition. Porter et al. (1983) reported that light weight females (<4.3 kg) in Minnesota were less likely to survive to breed and less likely to nest; however, Vangilder and Kurzejeski (1995) and Vander Haegen et al. (1988) reported no relationship between winter weights and subsequent reproductive parameters. Although it has been suggested that lighter weight hens may not have energy reserves necessary to initiate nesting (Drent 1975), winter body weights may not influence productivity during mild winters (Vander Haegen et al. 1988, Vangilder and Kurzejeski 1995). Although I found that weights did not influence whether a hen would nest or whether the nest was successful, the potential for a type II error was strong, given the sample sizes. In fact, hens that did not nest were 0.32 kg lighter than hens that nested.

Predation was the most influential proximal variable influencing nest success and hen survival during my study. Perhaps predation on turkey nests may be greater in suburban than forested environments because densities of some species of nest predators increase in suburban environments (Schinner and Cauley 1973, Harris 1977, Hoffman and Gottschag 1977, Wilcove 1985, Riley et al. 1988). Behavioral and landscape influences may interact with predation risk to determine the ultimate productivity and survival of turkeys inhabiting environments where winter severity does not severely compromise body condition and survival of hens (Chapters 2 and 3).

CHAPTER 2

EFFECTS OF HOME RANGE-SCALE FRAGMENTATION AND COVER CHARACTERISTICS ON NEST SUCCESS OF EASTERN WILD TURKEYS IN SOUTHEASTERN CONNECTICUT

INTRODUCTION

Nest success is the most important demographic variable influencing annual population change of eastern wild turkeys (*Meleagris gallopavo silvestris*) in northern environments (Roberts et al. 1995, Roberts and Porter 1996, 1998). Predators are consistently responsible for most nest failures (Vangilder et al. 1987, Vander Haegen et al. 1988, Thomas and Litvaitis 1993, Vangilder and Kurzejeski 1995) and most mortality of hens occurs during the reproductive period (April -July; Porter et al. 1983, Vander Haegen et al. 1988, Palmer et al. 1993, Roberts et al. 1995, Vangilder and Kurzejeski 1995, Wright et al. 1996, Miller et al. 1998) when they are stationary and on the ground at night.

Within-patch characteristics may influence rates of predation on wild turkey nests as reported for other ground-nesting birds (Schranck 1972, Klimstra and Roseberry 1975, Bowman and Harris 1980). Vegetative cover close to the nest may affect vulnerability (Leopold 1933, Holling 1965) by providing concealment from predators (Dwernychuk and Boag 1972, Wunz and Pack 1988). Vegetative cover has been positively associated with nest success in sage grouse (*Centrocercus urophasianus*) (Gregg et al. 1994, DeLong et al. 1995), lesser prairie chickens (*Tympanuchus pallidicinctus*) (Riley et al. 1992, McKee et al. 1998), waterfowl (Schranck 1972), and turkeys (Seiss et al. 1990, Badyaev et al.

1996, Palmer et al. 1996, Miller 1997). Additionally, success of wild turkey nests may be influenced by broad-scale landscape patterns, based on studies with artificial nests (Wilcove et al. 1986, Burger 1988, Linder and Bollinger 1995, Marini et al. 1995).

Although turkeys in Connecticut were extirpated by the early 1800s (Schorger 1966), populations rebounded after reintroductions began in the 1970's. Once thought to be associated with semi-wilderness (Wunz 1971), turkeys in Connecticut are now established in forested, agricultural, and suburban areas. In fact, the incidence of human/turkey conflicts in suburban Connecticut has recently increased (S. M. Spohr, H. J. Kilpatrick, M. A. Gregonis, Connecticut Department Environmental Protection, unpublished report) and is expected to continue as urban development proceeds.

Turkeys nest on the ground, and thus are more susceptible to predators than birds that nest above the ground (Wilcove 1985). Further, average rates of predation on ground nests in general are greater in suburban woodlots than in rural woodlots (Wilcove 1985) and rates of predation are sensitive to the percent of non-forested habitat within 5 and 10 km of nests (Hartley and Hunter 1998). Densities of nest predators, especially crows and raccoons (*Procyon lotor*), increase in suburban environments (Schinner and Cauley 1973, Hoffman and Gottschag 1977, Riley et al. 1988). These species, as well as coyotes (*Canis latrans*), red fox (*Vulpes vulpes*), opossum (*Didelphis virginiana*), and skunk (*Mephitis mephitis*) are responsible for most losses of turkey nests (Miller and Leopold 1988). Therefore, greater rates of predation on turkey nests may occur in suburban than rural areas.

Success of turkey nests in suburban areas may be dependent on a combination of within-patch and landscape-scale variables. Because landscape features have been reported to influence success rates of artificial nests (Wilcove et al. 1986, Burger 1988, Linder and Bollinger 1995, Marini et al. 1995), success of wild turkey nests may also be influenced by home range-scale patterns. Habitat fragmentation and reduced patch size have been associated with higher rates of predation on songbird nests (Robbins 1980, Ambuel and Temple 1983, Wilcove 1985, Burger 1988, Small and Hunter 1988, Askins 1994, Paton 1994) and turkeys have been shown to select larger patches than typically available (Thogmartin 1999). Likewise, rates of predation on songbird nests may increase near permanent edges (Paton 1994) and often are higher in fragmented areas than in forest-dominated regions (Robbins 1980, Ambuel and Temple 1983, Wilcove 1985, Burger 1988, Hartley and Hunter 1998). One possible reason for greater predation on songbird nests in fragmented habitats is that populations of avian predators such as blue jay (*Cyanocitta cristata*), American crow (*Corvus brachyrhynchos*), and common grackle (*Quiscalus quiscula*) often occur at elevated densities because of human-induced changes in the landscape (Robbins 1980, Wilcove 1985, Rosenberg et al. 1999). Likewise, mammalian predators that prey on turkeys and turkey nests, such as coyotes, have been reported to concentrate foraging activity along edges (Harrison and Famous 1991) and roadsides (Schranck 1972).

Three studies have examined relationships between landscape characteristics and productivity in turkeys; however, none of these studies was conducted in a suburban area.

Porter and Gefell (1995) examined long-term effects of land use on turkey population dynamics, and Miller (1997) determined whether nest success was linearly dependent on landscape characteristics in turkey home ranges. Thogmartin (1999) attempted to associate reproductive success with habitat features at the patch and landscape scales in a southwestern pine forest. No studies have simultaneously examined the relative within-patch influences of cover at the nest and within home range-scale habitat characteristics on the fate of wild turkey nests in fragmented, suburban landscapes. My objectives were to determine variables at the patch and home range scale that were important in determining the success of turkey nests in southeastern Connecticut where turkeys inhabit a mosaic of suburban areas, state-owned forest lands, and agricultural lands.

STUDY SITE

The study area comprised 9 towns in Middlesex and New London counties in southeastern Connecticut. The study area was delineated based on locations of sites used to capture turkeys and movements of radiomarked hens. The study area was defined as a concave polygon around all locations of birds marked in 1996 and 1997 and was 204.1 km^2 in area. Altitude at the study area ranged from 13 – 183 m above sea level. Median population density for towns in the study area was 97 humans/km^2 (250 humans/mi^2; range 34 – 461 humans/km^2; Secretary of the State 1996). Majority of development within the study area was residential with small businesses.

Forested land composed 67% of Middlesex and New London counties in 1985, and 85% of the forested land was in private ownership (Dickson and McAfee 1988).

Forests were dominated by oak/hickory (*Quercus* spp./*Carya* spp.) stands, which were commonly associated with yellow-poplar (*Liriodendron tulipifera*), elm (*Ulmus* spp.), and red maple (*Acer rubrum*). Common understory species included blueberry (*Vaccinium* spp.), witch hazel (*Hamamelis virginiana*), dogwood (*Cornus* spp.), common spicebush (*Lindera benzoin*), mountain laurel (*Kalmia angustifolia*), raspberry (*Rubus* spp.), maple-leaved viburnum (*Viburnum acerifolium*), poison ivy (*Rhus radicans*), and greenbriar (*Smilax* spp.) (Dickson and McAfee 1988). Forests were highly interspersed with developed lands (Brooks et al. 1993), which were the second leading contributors to edge density after transportation right-of-ways (Dickson and McAfee 1988). Agricultural land in Connecticut steadily declined from 498,000 acres in 1950 to 225,000 acres in 1982 (Brooks et al. 1993), which has coincided with substantial development of rural, forested areas (Brooks et al. 1993).

Mean winter (December – March) temperatures at a local weather station were -3.2°C (26.2°F) in 1996 and 0°C (32.0°F) in 1997 (National Oceanic and Atmospheric Administration). Snow depths exceeded 15.2 cm (6 inches) during 39 of 123 days in winter of 1996 but never exceeded 15.2 cm in 1997. Total precipitation during April – May was 31.0 cm in 1996, which was 7.6 cm more than normal, and 22.3 cm in 1997. Mean daily temperatures in April and May were 9.8°C (49.7°F) in 1996 and 8.8°C (47.9°F) in 1997.

METHODS

Capture and Telemetry

I captured turkeys from January to April in 1996 – 1997 with rocket nets at sites baited with corn. After capture, each hen was equipped with a back-pack transmitter with a 12-hr mortality sensor (Advanced Telemetry Systems, Isanti, Minn.). Transmitters had a life expectancy of 3 years and were attached to hens with 0.32 cm (1/8") diameter elastic 'bungi' cord. All captured hens weighed ≥ 3.2 kg (7 lbs) and weights of transmitter packages ranged from 89-93 grams. Transmitters averaged 1.95% of body weight (range 1.4 – 2.4%). I classified hens as yearlings (<1 yr old) or adults based on plumage characteristics (Petrides 1942). Capture and handling procedures used in this study were approved by the Institutional Animal Care and Use Committee at the University of Maine, Orono.

I monitored hens weekly during non-reproductive periods (August – March) and ≥ 4 days/week and 3 times/day from April – July to determine when incubation was initiated. Locations of turkeys were obtained from the ground using triangulation of ≥ 2 bearings with intersecting angles from 30 – 150°. I determined nest locations by radiotracking hens that were inactive and in the same general location for 3 readings during 2 days of monitoring. To avoid research-induced nest abandonment, I flagged at least 2 trees approximately 15 m from the estimated nest location and recorded compass bearings to the nest to locate the nest after hatching, nest loss, or abandonment. A Geographic Positioning System (Garmin 45XL) was used to obtain Universal Transverse Mercator coordinates of nests after nesting was completed. I determined nest success by examining egg shells and searching for broods via radio tracking of the female. A nest was considered to be successful if at least one egg hatched (Vangilder et al. 1987). I estimated the number of days each nest survived as the period from the date of nest initiation to the date eggs were destroyed by predators or abandoned.

Angular error of telemetry bearings was estimated as the median difference between true and estimated bearings to hidden test transmitters. I included angular error in program TRIANG to estimate error polygons for each location (White and Garrott 1984). I excluded readings with error polygons > 10% of the median home range area (White and Garrott 1990). I determined temporal independence by plotting time and distance between readings (Harrison and Gilbert 1985) and identifying asymptotes. I also examined distances between independent consecutive readings (Harrison and Gilbert 1985, White and Garrott 1990). Any distances > 90th percentile were examined to determine if movements were dispersal or normal movements within the spring home range based on the boundaries of the home range and annual telemetry locations. I calculated 95% minimum convex polygon (MCP) home range areas for the spring period (6 April – 9 July) with the program CALHOME (Kie et al. 1996). I used area-observation curves to determine the minimum number of locations required per individual to compute spring home range areas that were independent of sampling intensity (Odum and Kuenzler 1955; Figure A.2). At least 10 locations were needed to derive asymptotic indices to home range area. I calculated circles around first nests based on the radius of the 75th, 50th, and 25th percentile of observed distances that hens left the nest during the day to quantify relevant scales of evaluating home range-scale variables that might influence fate of nests.

Home Range-Scale Measurements

I delineated spring home ranges and 75% activity circles of each hen on mylar overlays to the scale of 1995 aerial photographs (1:12000) and overlaid them on aerial photographs of each nest site. Circular areas that were centered on the nest and represented the mean spring (6 April – 9 July) home range size of birds with ≥ 10 locations were used to approximate the home ranges for 4 birds with < 10 locations during the spring period. I delineated 4 patch types on the mylar overlays: forest, development (nonforested land with human-built structures), agriculture/open land (including fields, cemeteries, and Christmas tree farms), and water. I also mapped roads (dirt and paved), human-made trails, powerlines, and streams. Mylar overlays were scanned and hand-digitized into a vector-based geographic information system (MapInfo 4.1, MapInfo Corporation, Troy, N.Y., and Arc/Info Version 7.03, Environmental Systems Research Institute, Redlands, Calif.). I then used FRAGSTATS (McGarigal and Marks 1995) to quantify landscape metrics within spring home ranges and 75% activity circles. Landscape variables with potential biological significance were predetermined by referring to previous studies that examined ground-nesting birds and landscape patterns (Porter and Gefell 1995, Miller 1997, Thogmartin 1999) and were evaluated for autocorrelation with a Pearson correlation matrix. For pairs of metrics with $r > 0.7$, the metric with the higher univariate $\underline{P}$-value, suggesting lower relative influence on the fate of nests, was removed from further analyses (Brennan et al. 1986). The resulting metrics that were retained for further analyses were patch density (number of patches per unit area), area-weighted mean shape index (AWMSI; average perimeter to area ratio for a patch type [(e.g.; forest, agriculture, water, development)], weighted according to patch size), and percentages of each patch type (Table 2.1). Metrics were calculated at 4 spatial scales including the 95% MCP home range and the 75%, 50%, and 25% activity circles. I also determined distance from each nest to the nearest trail (human-built dirt travel lane), road (any paved travel lane), powerline, water, development, agriculture, any path or road, and any edge. Because FRAGSTATS is designed for landscape analysis of large areas, metrics in 25 and 50% activity circles were obtained with MapInfo. These metrics included amount of edge (m), number of patches, and amount of forest (ha) (Table 2.1). In determining the amount of edge in 25 and 50% activity circles, I defined an edge as any boundary between any of the 4 patch types.

Cover Measurements

I measured 11 cover variables around each nest immediately after nesting was completed (Table 2.1). Canopy closure was measured with a densiometer held at chest height directly above the nest and 1 m from the nest in each cardinal direction; these 5 readings from each nest were averaged. Number of trees (≥ 5 cm dbh, ≥ 1 m tall) was counted in a 10-m radius (area = 314 m^2) circle around each nest. Number of downed or dead trees also was tallied in a 10-m radius around each nest.

Table 2.1. Cover and landscape variables measured at eastern wild turkey nest sites in southeastern Connecticut, 1996–1997.

Variable	Unit of measure	Abbreviation
canopy closure	mean % at nest and at 4 points located in 4 cardinal directions	canopy
trees (≥ 5 cm dbh, ≥ 1 m tall)	no. per 314 m^2 circular plot	trees
woody stems (< 5 cm dbh, ≥ 1m tall)	total no. in 4, 2.5 m^2 plots	wstem
nonwoody stems (< 5 cm dbh, ≥ 1m tall)	total no. in 4, 2.5 m^2 plots	nwstem
total stems (< 5 cm dbh, ≥ 1m tall)	total no. in 4, 2.5 m^2 plots	tstem
shrub cover (< 5 cm dbh, ≥ 1m tall)	% above nest	shrub
total ground cover (<1m tall)	mean % of 4, 0.8 m^2 plots	%total
volume ground cover (<1m tall)	mean % of 4, 0.8 m^2 plots	%vol
height of ground vegetation (<1m tall)	mean height (cm) in 4, 0.8 m^2 plots	grht
ground stems (<1m tall)	total no. in 4, 0.8 m^2 plots	grstem
downed or dead trees	no. per 314 m^2 plot	dead
patch density in 75% activity circles[a]	number of patches per unit area	pd75
area weighted mean shape index in 75% activity circles[a]	average perimeter to area ratio for a patch type weighted according to patch size	awmsi75
patch density in home ranges[a]	number of patches per unit area	pdhr
area weighted mean shape index in home ranges[a]	average perimeter to area ratio for a patch type weighted according to patch size	awmsihr
% forested land in 75% activity circles	%	%for75
% developed land in 75% activity circles	%	%dev75
% agricultural land in 75% activity circles	%	%agr75
% forested land in home ranges	%	%forhr
% developed land in home ranges	%	%devhr
% agricultural land in home ranges	%	%agrhr
distance from nest to nearest trail	m	dtrail
distance from nest to nearest road	m	droad
distance from nest to nearest powerline	m	dpowerline
distance from nest to nearest water	m	dwater
distance from nest to nearest development	m	ddevelop
distance from nest to nearest agriculture	m	dagr
distance from nest to nearest path or road	m	dpathroad
distance from nest to nearest edge	m	dedge
perimeter of edge in 25% circles	m	edge25
perimeter of edge in 50% circles	m	edge50
number of patches in 25% circles	no.	patch25
number of patches in 50% circles	no.	patch50
amount of forest in 25% circles	ha	forest25
amount of forest in 50% circles	ha	forest50

[a]McGarigal and Marks 1995

I recorded the number of woody, nonwoody, and total understory stems (< 5 cm dbh, ≥ 1m) in 4 transects in each cardinal direction from the nest. Transects were 5 m long and 0.5 m wide (area = 10 m^2). Percent shrub cover directly above the nest was measured with a densiometer held 30 cm above the nest.

I determined ground cover (< 1 m tall) in four, 1-m diameter circular plots (area = 3.1 m^2) positioned 1 m from the nest in each cardinal direction. Percent live vegetative ground cover was ocularly estimated within each plot as the percent of ground covered by vegetation (Thomas 1989). Percent of each plot filled with vegetation to a height of 1 m was ocularly estimated and recorded as percent volume ground cover (Thomas 1989). Height of ground vegetation and number of ground stems also were recorded in each plot.

Statistical Analyses

Differences in cover variables at nest sites were tested between yearling and adult hens using a Mann-Whitney U test. I pooled data if cover variables did not differ (P > 0.05) between age class of nesting hens. Because the study area was disjunct and composed of 3 distinct study sites, landscape variables were compared among study sites with a Kruskal-Wallis test. Landscape data were pooled if no differences (P > 0.05) were apparent among the 3 sites. I examined nest success with 2 criteria: 1) successful versus destroyed nests, and 2) the number of days a nest survived.

I used multiple linear regression (SYSTAT 7.0) to determine relationships between landscape and cover variables and the number of days each nest survived. The number of abandoned nests (n = 8) was small; therefore, they were excluded. First, I used a univariate Kruskal-Wallis analysis to select among the 35 variables that were considered to have the greatest potential relationships to nest survival. I separated the incubation period into 3 periods (0–12, 13–22, or 23–28 days) and examined univariate tendencies among time periods. Variables exhibiting differences at a liberal $\underline{P} < 0.2$ were retained, tested for normality (Wilkinson et al. 1992), and transformed (arcsine or $\log_{10}$) if necessary. Next, the retained subset of variables was screened for autocorrelation with Pearson's correlation; if $\underline{r} > 0.7$ for a pair of variables, the variable with the greater $\underline{P}$-value was omitted from further analyses. An automatic, forward selection process was used to select the most appropriate regression model and variables remained in the model if $\underline{P} < 0.10$. Model fit was determined by the adjusted squared multiple $\underline{\mathrm{R}}$ value and analysis of variance on the residuals. Regression assumptions were graphically verified by plotting residuals and estimated values to ensure that errors were normally distributed, independent, and had constant variance. (SPSS Inc. 1997: 277–280).

I also explored principal components analysis (PCA) as an alternate means of data reduction. New, composite variables were made by multiplying raw values of each variable by the loadings from the significant axes (eigenvalues ≥ 1.00). I formed a second group of composite variables by multiplying raw values by significant components (loadings > 0.50) (Table A.2). These partial and whole components were then run in a Pearson correlation to determine if they were similar. Because they were highly correlated, a forward automatic multiple regression was calculated with the partial components as independent variables and the number of days each nest survived as the response variable. The screening process with PCA resulted in 8 composite variables being entered into the regression. The final linear regression model included 2 principal components (PC3 and PC6; Table A.2), but was extremely weak ($R^2 = 0.125$), and was not significant ($P = 0.12$). Also, the variables included in significant axes did not have intuitive biological meaning. Based on those results, results from PCA analyses were not considered in subsequent modeling exercises.

I also compared landscape and cover characteristics of successful and destroyed nests with logistic regression. Normality of each response variable was verified with Lilliefor's test (Wilkinson et al. 1992) on residuals from ANOVA. Univariate tests were used to reduce the number of variables used in model building. I used Mann-Whitney U tests (Conover 1980: 216–223) for nonnormal (Lilliefor's $P < 0.05$) variables that could not be transformed by log-rank, square root, or arcsine transformation, and t-tests to compare all other variables between successful and destroyed nests. Variables with univariate $P \leq 0.2$ were retained and all possible pairs were evaluated for autocorrelation with Pearson's r. If $r > 0.7$ for a pair of variables, the variable with the greater P-value was omitted from further analyses. Remaining variables were entered into a forward, stepwise logistic regression. Variables selected were retained in the final model if the 95% confidence interval for the odds ratio did not include 1.0. Significance of the final model was assessed with a G statistic that compared the model to a constant-only model. Model performance was evaluated with McFadden's rho-squared statistic, concordance values, and an acceptable goodness of fit score ($\underline{P} > 0.05$) (SPSS, Inc. 1997: 86–87) evaluated with a Pearson Chi Square (Hosmer and Lemeshow 1989).

To determine if abandoned nests would be classified by models as successful or destroyed nests, I incorporated abandoned nests ($n = 8$) in the models. I grouped abandoned nests with destroyed nests and reran the final logistic model. I then compared results to the original model and compared overall model fit. Raw data from abandoned nests were similarly added to the final multiple linear regression equation and the significance and r^2 of the models were compared. Further, I compared the number of days that abandoned nests survived to the number of days predicted by the multiple regression model equation using a paired $\underline{t}$-test.

To determine if model variables were interchangeable, I substituted variables that were significant in the logistic regression model into the multiple linear regression model and vice versa. To determine if independent variables were acting as surrogates to describe similar effects, I also substituted potential surrogate variables measured at the same spatial scale into the final linear regression model and compared model fit and adjusted r^2 values.

RESULTS

Telemetry and Home Range

I radio-marked 59 hens (17 yearlings, 42 adults) during 1996 and 1997. Thirty-three (6 yearlings, 27 adults) died during the monitoring period and 4 (2 yearlings, 2 adults) were censored beginning on the midpoint between the last location and the first unsuccessful attempt to locate. Most deaths of hens (52%) were attributed to mammalian predators such as coyotes, fox, and raccoons; 12% were attributed to avian predators, likely great horned owls, 18% were undetermined, and the remaining deaths were attributed to vehicles (6%), disease (6%), and poaching (6%).The median incubation date was 11 May in 1996 (range 24 April – 9 June) and 6 May in 1997 (range 22 April – 5 June). Twenty-seven percent of nests were successful in 1996 (n = 11) and 39% in 1997 (n = 33); the 2-year average was 36% (n = 44).

Median angular telemetry error was 6.24°, which resulted in the omission of 193 (22%) telemetry locations that had error polygons > 10% (15.52 ha) of the mean area (1.55 km^2) of home ranges of hens. Telemetry locations < 4 hours apart were determined to be temporally dependent based on graphs of time and distance between locations and, as a result, 46 locations separated by < 4 hours were omitted from analyses. Consecutive locations of turkeys that were separated by > 1625 m (90th percentile of all separation distances) were visually examined to determine if they were within or outside the boundaries of spring home ranges. Seventeen locations from 5 birds were judged to be excursions outside the 95% minimum convex polygon and consequently, were omitted from analyses. At least 10 locations were needed to define a home range.

Mean home range area for 39 hens during spring was 135.05 ha (SE = 16.04 ha) based on an average of 19.4 locations per individual hen (range 10–41). The median distance that hens were located off nests during absences was 389.6 m (SE = 30.21 m;

area = 47.7 ha); whereas the radii based on 75th and 25th percentile of distances from nests were 634.3 m (area = 126.0 ha) and 225.4 m (area = 15.96 ha), respectively.

Landscape and Cover Effects on Nest Success

Cover variables were measured at 38 of 43 nests (14 successful, 16 destroyed, 8 abandoned); exact locations of 5 nests were not determined. Mean values for cover variables did not differ between yearlings and adult hens (Table A.3); therefore, all cover data were pooled across age classes to test for differences between successful and destroyed nests. Of 7 landscape variables compared among the 3 study sites, only percent agriculture differed among sites ($P < 0.001$; Table A.4). Additionally, sample sizes of radio-marked birds within sites were low ($n = 8-19$), thus I pooled data across sites for subsequent analyses.

Multiple Regression Analyses - Seventeen of 35 cover and landscape variables met the univariate criteria ($\underline{P} < 0.2$) for evaluating a probable influence on length of nest survival (Table 2.2). Six of these 17 variables were omitted from regression analyses (percent developed land in home ranges, edge in 25% and 50% activity circles, number of patches in 25% activity circles, forest in 50% activity circles, and percent volume of ground cover) because pairwise correlation coefficients with other significant variables were > 0.70 (Table 2.3). The remaining 11 variables were entered into a multiple regression analysis including only successful and destroyed nests. Independent variables that significantly influenced duration of nest success were number of trees within 10 m of the nest, number of nonwoody stems/10 m^2, and amount of forest in 25% activity circles

($R^2 = 0.496$, $\underline{P} < 0.001$). Number of trees explained 32% of the variance in duration of nest success, number of nonwoody stems explained an additional 8% of the variance, and amount of forest in 25% circles explained an additional 9.6% of the variance in the number of days that nests survived compared to the number of trees and number of nonwoody stems model.

Logistic Regression Analyses - In the initial screening process for logistic regression, 9 of 35 cover and landscape variables met my univariate criteria ($\underline{P} < 0.20$) suggesting a possible influence on whether a nest was successful or destroyed (Table 2.4). Significant ($\underline{P} < 0.20$) cover variables included percent volume of ground cover, height of ground vegetation, and number of trees, understory stems, woody stems, nonwoody stems, and ground stems (Table 2.4). Significant landscape variables were percentage of agriculture in 75% activity circles and in spring home ranges (Table 2.4). No landscape variables in 25 and 50% activity circles and no metrics based on distance measurements had univariate P-values < 0.2 (Table 2.4). Pairwise correlation coefficients for all significant variables were ≤ 0.60 (Table A.5), except height of ground vegetation vs. % volume of ground cover ($\underline{r} = 0.70$), total understory stems vs. nonwoody stems ($\underline{r} = 0.98$), and % agriculture in 75% activity circles vs. % agriculture in spring home ranges ($\underline{r} = 0.76$). Based on results of univariate tests, percent volume of ground cover, nonwoody stems, and percent agriculture in 75% activity circles were omitted. The 6 variables (height of ground vegetation, number of trees, number of understory stems, number of woody stems, number of ground stems, and percent agriculture in spring home ranges) were subsequently modeled with logistic regression to evaluate their influence on whether a nest was successful or destroyed.

The most parsimonious logistic regression model included number of trees and height of ground vegetation as significant descriptor variables (Table 2.5). The model was significant ($G = 11.89$, 2 df, $P = 0.003$), fit the data well (McFadden's rho-squared = 0.287), and correctly predicted outcome for 67% of the nests upon which it was based. The Pearson chi-squared goodness of fit test indicated little evidence that the model did not fit the data ($P = 0.472$) (Hosmer and Lemenshow 1989).

Abandoned Nests

Fit decreased when abandoned nests were added to destroyed nests in a logistic regression model evaluating successful versus unsuccessful (abandoned and destroyed) nests (McFadden's rho-squared = 0.242). Using the original model comparing destroyed versus successful nests, however, 4 of the 5 abandoned nests were classified as destroyed. Fit of the linear regression model also decreased compared to the original model ($R^2 = 0.496$, $P < 0.001$), when abandoned nests were pooled with destroyed nests ($R^2 = 0.385$, $P = 0.002$). Additionally, the number of days that abandoned nests survived ($\bar{x} = 11.88$) was less than the number of days predicted by the model ($\bar{x} = 20.27$, $t = -3.353$, $P = 0.012$). This suggests that abandoned nests differ in sub-stand and home range-scale habitat characteristics from either successful or destroyed nests.

Table 2.2. Median values (*n*) of landscape and cover variables that influenced ($P < 0.20$; Kruskal Wallis test) length of nest survival at eastern wild turkey nests in southeastern Connecticut, 1996–1997.

Variable[a]	P-value	Days of nest survival		
		1-12	13-22	23-28
ddevelop	0.062	25.0 (6)	200.0 (9)	90.0 (20)
dwater	0.082	120.0 (6)	330.0 (9)	235.0 (20)
%dev75	0.109	0.18 (6)	0.04 (9)	0.05 (20)
%devhr	0.187	0.12 (6)	0.04 (9)	0.06 (20)
%agrhr	0.148	0.09 (6)	0.02 (9)	0.03 (20)
edge25	0.030	2847.0 (6)	1804.15 (9)	2065.94 (20)
patch25	0.069	3.0 (6)	1.0 (9)	1.5 (20)
forest25	0.030	13.24 (6)	15.87 (9)	15.33 (20)
edge50	0.134	7479.0 (6)	4397.43 (9)	5306.99 (20)
forest50	0.126	39.89 (6)	45.18 (9)	44.95 (20)
trees	0.059	5.0 (6)	9.0 (7)	17.0 (17)
grht	0.153	32.59 (6)	16.9 (7)	33.0 (17)
grstem	0.060	172.5 (6)	57.0 (7)	64.0 (17)
%vol	0.201	0.37 (6)	0.69 (7)	0.29 (17)
%total	0.107	0.76 (6)	0.19 (7)	0.55(17)
nwstem	0.029	5.0 (6)	0.0 (7)	13.0 (17)
wstem	0.124	17.0 (6)	13.0 (7)	8.0 (17)

[a]See variable definitions in Table 2.1.

Table 2.3. Pearson rank correlation coefficients from pairwise comparisons of 17 landscape and vegetative cover variables[a] measured at successful and destroyed nests of eastern wild turkeys in southeastern Connecticut, 1996-1997. All variables included in this matrix were significant ($\underline{P} \leq 0.2$) in a Kruskal-Wallis analysis based on length of nest survival (1–12, 13–22, or 23–28 days).

	ddevel	dwater	%dev75	%devhr	%agrhr	edge25	patch25	forest25	edge50	forest50	trees	grht	grstem	%vol	%total	nwstem	wstem
ddevelop	1.0																
dwater	0.545	1.0															
%dev75	-0.541	-0.559	1.0														
%devhr	-0.476	-0.429	0.713	1.0													
%agrhr	-0.122	0.118	-0.101	-0.150	1.0												
edge25	-0.558	-0.537	0.529	0.346	0.224	1.0											
patch25	-0.549	-0.519	0.334	0.197	0.165	0.801	1.0										
forest25	0.460	0.487	-0.494	-0.445	-0.315	-0.770	-0.392	1.0									
edge50	-0.600	-0.632	0.757	0.585	0.091	0.847	0.638	-0.759	1.0								
forest50	0.516	0.546	-0.645	-0.557	-0.219	-0.602	-0.360	0.832	-0.758	1.0							
trees	-0.222	-0.046	-0.356	-0.255	0.032	0.030	0.184	0.021	-0.029	0.138	1.0						
grht	-0.070	0.118	0.079	0.134	0.095	0.190	0.064	-0.321	0.251	-0.275	0.032	1.0					
grstem	-0.117	-0.107	0.446	0.174	0.064	0.369	0.090	-0.264	0.309	-0.135	-0.370	0.166	1.0				
%vol	-0.227	-0.081	0.251	0.377	-0.087	0.221	0.204	-0.147	0.232	-0.175	-0.299	0.703	0.232	1.0			
%total	-0.083	-0.078	0.229	0.300	-0.162	0.161	0.117	-0.103	0.198	-0.059	-0.366	0.617	0.486	0.866	1.0		
nwstem	-0.296	-0.300	0.398	0.423	0.117	0.286	0.231	-0.488	0.396	-0.647	-0.241	0.541	-0.040	0.602	0.427	1.0	
wstem	-0.009	-0.122	0.486	0.438	-0.157	0.138	-0.052	-0.281	0.294	-0.344	-0.451	0.123	0.207	0.130	0.167	0.090	1.0

[a] Refer to Table 2.1 for abbreviations.

Substitution of Variables in Analysis

I substituted potential surrogate variables measured at the same spatial scale into the final linear model to determine if independent variables were acting as surrogates to describe similar effects. Substituting distance to development for amount of forest in 25% activity circles did not appreciably alter the fit of the multiple regression model ($R^2 = 0.483$, $P = 0.001$). Substituting percent development in 75% circles ($R^2 = 0.420$, $P = 0.002$) or percent agriculture in home ranges ($R^2 = 0.409$, $P = 0.003$) as alternate landscape variables, however, reduced the fit of resulting linear regression models.

When I entered the significant independent variables from the linear regression model into the logistic model, the amount of forest in 25% circles had an odds ratio that included 1.0. Therefore, that variable was excluded from the final logistic model. The resulting logistic model with the number of trees and nonwoody stems fit the data well (McFaddens rho-squared = 0.295), was significant ($G = 12.21$, 2 df, $\underline{P} = 0.002$), and correctly predicted nest outcome for 67% of the observations upon which it was based. Variables identified in the multiple regression model were surrogates for variables selected during the logistic modeling approach; fit and predictive accuracy of the logistic model were similar when stand and sub-stand variables from the multiple linear regression model were included. Substituting the original logistic variables (trees and ground height) in a linear regression, reduced model fit ($R^2 = 0.36$, $P = 0.002$) because the patch-scale variable that had contributed significantly to the multiple regression model was not significant in logistic regression analyses.

Table 2.4. Mean (SE) values of vegetative cover variables[a] and landscape metrics[b] measured at wild turkey nests in southeastern Connecticut, 1996–1997. Standard errors of distance measurements are followed by the number of nests sampled in parentheses.

Variable[c]	**P-value**[d]	**Successful nests**		**Destroyed nests**	
		x	SE	x	SE
canopy	0.236[e]	70.05	2.96	53.69	7.81
trees[f]	0.018	18.43	2.22	11.88	2.44
wstem[f]	0.176	11.29	3.14	16.5	3.95
nwstem[g]	0.146	47.71	16.41	27.56	19.15
tstem[f]	0.139	59.0	17.96	44.06	19.43
shrub[f]	0.845	32.05	9.50	31.08	7.18
%total[h]	0.295	50.38	4.83	40.02	8.01
%vol[h]	0.197	27.75	3.92	20.75	5.6
grht	0.071	35.59	4.36	25.49	3.11
grstem[f]	0.122	81.79	16.49	131.88	26.79
dead[f]	0.396	5.71	1.24	6.31	1.63
%dev75[h]	0.406	6.48	1.91	10.22	2.11
%for75[h]	0.352	87.44	2.91	84.81	2.02
%agr75[h]	0.128	4.35	1.54	2.19	0.76
pd75	0.630	11.85	1.85	10.66	1.62
awmsi75	0.548	2.17	0.164	2.31	0.165
%devhr[h]	0.718	6.65	1.87	8.07	1.64
%forhr[h]	0.634	84.16	2.54	85.71	1.83

Table 2.4 Continued

Variable[c]	**P-value**[d]	**Successful nests**		**Destroyed nests**	
		x	SE	x	SE
%agrhr[h]	0.077	6.86	1.92	3.95	1.03
pdhr	0.710	15.69	1.55	14.88	1.51
awmsihr	0.380	2.89	0.22	2.65	0.16
edge50[g]	0.580	5373.62	603.75	5753.61	476.06
patch50	0.872	5.93	1.02	5.7	0.98
forest50	0.317[e]	43.15	1.39	42.89	0.74
edge25	0.456	2135.4	170.48	2330.1	193.56
patch25	0.771[e]	1.93	0.46	2.0	0.37
forest25	0.617[e]	14.79	0.48	14.82	0.33
dtrail[g]	0.484	119.43	36.66 (14)	82.05	22.72 (20)
droad	0.686	309.33	48.42 (15)	280.5	51.45 (20)
dpowerline	0.456	310.83	2.45 (6)	485.5	173.82 (10)
dwater[g]	0.657	400.0	81.08 (14)	358.00	52.58 (20)
ddevelop[g]	0.281	268.00	0.46 (15)	397.5	84.49 (20)
dagr[e]	0.397	323.33	54.26 (15)	513.33	135.29 (15)
dpathroad	0.676[e]	67.47	20.39 (15)	62.8	21.58 (20)
dedge	0.525[e]	49.93	11.25 (15)	43.80	10.79 (20)

[a] Cover was measured at 14 successful nests and 16 nests destroyed by predators.

[b] Landscape metrics were measured at 15 successful nests and 20 nests destroyed by predators.

[c] Refer to Table 2.1 for variable definitions.

[d] T-test

[e] Mann-Whitney U test

[f] Log transformed

[g] Square root transformed

[h] Arcsine transformed

Table 2.5. Coefficient estimates, P-values, and odds ratios from a logistic regression model describing differences in landscape and vegetative cover variables between successful and destroyed nests of eastern wild turkeys in southeastern Connecticut.

Variable	Coefficient (SE)	P-value	Odds ratio (95% C.I.)
Constant	20.896 (8.40)	0.013	
Number of trees per 314 m^2 plot	-3.570 (1.58)	0.024	0.028 (0.001 - 0.622)
Height of ground vegetation (cm) in 4, 0.8 m^2 plots	-2.854 (1.35)	0.034	0.058 (0.004 - 0.805)

DISCUSSION

Number of nonwoody stems per 10-m^2 plot, number of trees within a 10-m radius, and amount of forest within 225 m of nests probably had indirect influences on wild turkey nest success. The correlation and interchangeability of these variables to other variables of similar scale suggests that vegetative characteristics at 2 spatial scales may influence nest success. Two within patch-scale variables, overstory cover (e.g., number of trees) and understory cover (e.g., number of nonwoody stems), and whether the patch containing the nest was forested (e.g., amount of forest within 225 m) seemed to influence nest success most significantly.

The PCA procedures resulted in a weak regression model because components included correlated variables (probably within a single spatial scale) that grouped as a single component. The regression model could not determine one principal component that was responsible for a substantial percentage of the variation in the number of days that nests survived because variation was being influenced simultaneously at 2 different spatial scales.

The number of trees around nests explained the highest variation in the number of days that nests survived and had the greatest influence in determining whether nests were successful or not. Successful nests and nests that survived > 23 days had a greater number of trees within 10 m than destroyed nests. Number of trees was positively associated with canopy cover above nests ($r = 0.77$). Although increased canopy cover may reduce nest predation by avian predators, mammals were the major predators and the significance of overstory cover probably related to whether the area around nests was forested. Destroyed nests were more likely to be found in open areas such as fields and edges where overhead cover was sparse. Nest success often declines in these (i.e., open and edge) habitats (Gates and Gysel 1978) perhaps because they often serve as hunting areas for mammalian predators (Schranck 1972, Harrison and Famous 1991). Lazarus and Porter (1985) in Minnesota also reported that canopy cover was an important variable in nest site selection by turkeys. In contrast, Thomas (1989) in New Hampshire reported that hens selected nest sites in open areas with little canopy cover and nest success was relatively high (Chapter 1). Because mammalian predators are often more abundant in urban and suburban areas than in rural areas (Schinner and Cauley 1973, Harris 1977, Hoffman and Gottschag 1977, Riley et al. 1988), hens in rural New Hampshire may face less of a risk of predation when nesting than in a suburban landscape such as on my study site (Chapter 1).

Understory cover also was important in predicting nest success. Height of ground vegetation (< 1m tall) was a significant variable in the logistic model and the number of nonwoody stems around nests was a significant variable in the multiple linear regression model; both could be substituted in either regression model without appreciably altering model fit. A number of other similar variables were correlated with height of ground vegetation and number of nonwoody stems (percent volume ground vegetation, percent total ground vegetation, and number of nonwoody stems) suggesting that density of understory and ground cover was important in determining nest success. In general, nests in areas with dense ground cover and nonwoody stems in the understory were less likely to be destroyed by predators. This is consistent with several studies of other species of avian ground nesters (Yahner and Scott 1988, Martin 1992, Rudnicky and Hunter 1993) and with previous reports for wild turkeys (Cook 1972, Healy 1981, Treiterer 1987, Thomas and Litvaitis 1993).

Tall, dense understory vegetation near nests may reduce predator foraging efficiency by providing visual and scent barriers and impeding movement (Schranck 1972, Duebbert and Lokemoen 1976, Bowman and Harris 1980, Hines and Mitchell 1983, Crabtree et al. 1989). Because coyotes rely on visual cues while hunting (Wells and Lehner 1978) and were one of the major predators on hens and nests, dense understory at successful nest sites may have inhibited their ability to locate nests. Although raccoons use olfactory and tactile senses to locate nests, increased spatial heterogeneity also may inhibit the ability of predators to find nests (Bowman and Harris 1980).

The proportion of area within 225 m from the nest (amount of forest in 25% activity circles) that is forest also may influence nest success. This suggests that patch-scale features within 225 m of turkey nests may be more important in determining nest outcome than home range-scale features and supports the idea that nests in forested areas are more likely to be successful. In addition, this likely relates to whether a nest was near either an open patch or edges between open and forested patches.

In this study, nests destroyed by predators were generally located in open areas surrounded by less forest than successful nests. Predators likely select these areas to forage or are more efficient at detecting prey in these areas. Because forested land in my study area was fragmented by suburban development and had much edge, predator populations may have been more dense than in other areas where turkeys have been studied (Hoffman and Gottschag 1977, Robbins 1980). Furthermore, fragmentation may have contributed to high mortality and nest predation rates (Chapter 1). Bowman and Harris (1980) reported that high rates of predation are more a function of prey vulnerability (a correlation of spatial heterogeneity) than prey density. Therefore, if habitat within small patches is homogeneous and prey density is elevated within small patches, then vulnerability of turkey nests to predators may be increased relative to landscapes with larger mean patch areas and fewer anthropogenic influences.

Amount of forest in 25% activity circles was interchangeable with distance to development in the multiple linear model, suggesting that distance to development may have influenced nest success. Densities of nest predators often increase in suburban environments (Schinner and Cauley 1973, Harris 1977, Hoffman and Gottschag 1977, Wilcove 1985, Angelstam 1986, Riley et al. 1988), which also may decrease success of nests located near development. Although no other studies have examined distance to development of successful versus destroyed turkey nests, successful ground nests have been reported to be farther from edges than destroyed nests (Burger et al. 1994, Johnson and Temple 1986) probably because carnivores used roads and other corridors for hunting (Miller 1997). Thogmartin (1999) concluded that turkey nest success in pine forests of Arkansas was low because of high densities of predators associated with a fragmented, heterogeneous environment with small patches.

Abandoned nests probably were influenced by variables other than those influencing destroyed nests, as indicated by the reduced fit of the logistic model when abandoned nests were included, and by the overestimation of the number of days that abandoned nests were predicted to survive based on the multiple linear regression model. These variables could include hen inexperience, hen condition, and disturbance by predators or humans. All abandoned nests (n = 5) were located in small patches with an open canopy and thick understory, which was usually composed of greenbriar or Rubus thickets. Also, humans (i.e., researchers) could have influenced nest abandonment independent of a nest's vulnerability to predation.

CONCLUSIONS AND MANAGEMENT IMPLICATIONS

Predation may be the proximate variable influencing nest success, but the ultimate cause may be habitat related. Wild turkeys were once thought to be associated only with semi-wilderness (Wunz 1971). In 1971, however, Wunz reported that turkeys had become established in small wooded areas near urban regions, suggesting a greater tolerance to human disturbance than was previously observed. Today, turkeys are considered generalists and persist in many habitat types (Healy 1992). As the interspersion of land use increases, landscapes become more complex and fragmentation of forestland increases (Brooks et al. 1993). In the selection of nesting sites, turkeys seem to make patch-level and within patch-level choices that minimize the influences of fragmentation. This may be one reason turkeys are able to adapt and thrive in human-altered environments and have become a nuisance species in some locations.

Whether or not turkeys nested in forests directly influenced nest success. Forest lands in Connecticut are highly interspersed within developed lands and Connecticut's land-use interspersion index is higher than Rhode Island and Massachusetts (Brooks et al. 1993), perhaps explaining the lower nest success rates observed in my study compared to studies conducted in those 2 states (Pringle 1988, Vander Haegen et al. 1988). Turkeys in Connecticut commonly nest in small patches of forest where predator densities may be greater (Gates and Gysel 1978, Robbins 1980, Ambuel and Temple 1983, Wilcove 1985). Additionally, because mammalian predators are more likely to intensively search areas of dense cover in isolated clumps (Bowman and Harris 1980), nests in small patches may be more susceptible to predators (Wiens 1976). Despite the seeming ability of turkeys to adapt, habitat quality for turkeys may be declining in eastern Connecticut because of human encroachment (Bailey et al. 1981). As forested land is destroyed for human purposes, forest patches decrease in size. Long-term studies will be necessary to determine whether incremental increases in forest fragmentation will decrease survival and productivity of turkeys in increasingly suburban and urban environments, and whether some suburban habitats might become population sinks (Pulliam 1988) for turkeys.

CHAPTER 3

NEST ATTENTIVENESS AND ITS ASSOCIATION WITH NEST SUCCESS OF EASTERN WILD TURKEYS

INTRODUCTION

Nest success is the most important demographic variable influencing annual population change of eastern wild turkeys (*Meleagris gallopavo silvestris)* in northern environments (Roberts et al. 1995, Roberts and Porter 1996, 1998). Hen behavior during incubation, such as how long a hen is absent from her nest, timing of absences, and how many absences a hen takes in a day, may influence nest success. Incubating hens also may protect their clutches from predators (Williams and Austin 1988), and unattended nests may be vulnerable to visual detection by predators (Williams and Austin 1988) because hens do not cover eggs with leaves or vegetation during incubation (Williams et al. 1971). Hens that leave the nest frequently also may leave scent trails, which may increase predator effectiveness (Erckmann 1981). Conversely, Roberts et al. (1995) hypothesized that if a hen remained on the nest when wet, she could attract mammalian predators by facilitating olfactory detection.

Nest attentiveness in turkeys has been examined (Green 1982, Williams and Austin 1988), but has not been related to nest success. Additionally, previous studies occurred in forested areas (Green 1982) or subtropical cypress and pine forests (Williams and Austin 1988). The potential for nesting hens to be disturbed may be greater in southeastern Connecticut with its high human density and suburbanization than in predominately forested areas. Also, climate may influence behavior of nesting hens, resulting in differing nest attentiveness patterns among regions. My objectives were to quantify nest attentiveness of turkey hens in southeastern Connecticut where a high occurrence of suburban development exists, and to compare nest attentiveness of hens with successful nests versus hens whose nests were destroyed by predators.

STUDY SITE

The study area was comprised of 9 towns in Middlesex and New London counties in southeastern Connecticut. Turkeys were monitored on 3 study sites that were approximately 59, 68, and 77 km^2. Altitude ranged from 13 – 183 m above sea level. Median population density for towns in the study area was 97 humans/km^2 (250 humans/mi^2; range 34 – 461 humans/km^2; Secretary of the State 1996).

Forested land composed 67% of Middlesex and New London counties in 1985, and 85% of the forested land was in private ownership (Dickson and McAfee 1988). Forests were dominated by oak/hickory (*Quercus* spp./*Carya* spp.) stands, which were commonly associated with yellow-poplar (*Liriodendron tulipifera*), elm (*Ulmus* spp.), and red maple (*Acer rubrum*). Common understory species included blueberry (*Vaccinium* spp.), witch hazel (*Hamamelis virginiana*), dogwood (*Cornus* spp.), common spicebush (*Lindera_benzoin*), mountain laurel (*Kalmia angustifolia*), raspberry (*Rubus* spp.), maple-leaved viburnum (*Viburnum acerifolium*), poison ivy (*Rhus radicans*), and greenbriar (*Smilax* spp.) (Dickson and McAfee 1988). Forests were highly interspersed with developed lands (Brooks et al. 1993), and this interspersion was the second leading contributor to edge density after transportation right-of-ways (Dickson and McAfee 1988). Agricultural land in Connecticut steadily declined from 498,000 acres in 1950 to 225,000 acres in 1982 (Brooks et al. 1993), which has coincided with substantial development of rural, forested areas (Brooks et al. 1993).

Of the 15 hens whose attentiveness patterns were monitored, 8 (53%) nested in towns with a human population density > 250 people/km^2. Two hens nested in towns with human population densities of 99 humans/km^2 and three hens nested in towns with 56 humans/km^2. All 3 of the latter birds nested behind houses or directly off roads being built for new developments. One hen nested in a 15,682-acre state forest in a town with a human population density of 81 humans/km^2. Finally, one bird nested in a town with a human population density of 45 humans/km^2 and, although the nest was approximately 60m from a road, it was in an undeveloped area. Therefore, of 15 monitored hens, thirteen would be considered to have nested in a suburban area, whereas 2 would be considered rural nesters.

Mean winter (December – March) temperatures at a weather station located in the study area were -3.2°C (26.2°F) in 1996 and 0°C (32.0°F) in 1997 (National Oceanic and Atmospheric Administration). Snow depths exceeded 15.2 cm (6 inches) during 39 of 123 days in winter 1996, but never exceeded 15.2 cm in 1997. Total precipitation during April-May was 31.0 cm in 1996, which was 7.6 cm greater than the 30-year average, and 22.3 cm in 1997. Mean daily temperatures for April and May were 8.4°C (47.1°F) and 13.2°C (55.7° F) in 1996 and 7.4°C (45.4°F) and 12.2°C (54° F) in 1997.

METHODS

Capture and Telemetry

I captured turkeys from January to April in 1996 - 1997 with rocket nets at sites baited with corn. Each hen was weighed, aged, leg banded, and equipped with a back-pack transmitter with a 12-hour mortality sensor (Advanced Telemetry Systems, Isanti, Minn.). Transmitters had a life expectancy of 3 years and were attached to hens with 0.32 cm (1/8 inch) diameter elastic 'bungi' cord. All captured hens weighed $\geq$ 3.2 kg (7 lb) and weights of transmitter packages ranged from 89-93 g. Transmitters averaged 1.95% of body weight (range 1.4 – 2.4%). I classified hens as yearlings (<1 yr) or adults based on plumage characteristics (Petrides 1942). Capture and handling procedures used in this study were approved by the Institutional Animal Care and Use Committee at the University of Maine, Orono.

I located hens weekly during non-reproductive periods (August – March) and $\geq$ 4 days per week and 3 times per day from April – July to determine when incubation was initiated. Locations of turkeys were obtained from the ground with triangulation of $\geq$ 2 bearings with intersecting angles from 30 – 150°. I determined nest locations by radiotracking hens that were inactive and in the same general location for 3 readings during 2 days of monitoring. To avoid research-induced nest abandonment I did not closely approach nests. I flagged at least 2 trees approximately 15 m from estimated nest locations and recorded compass bearings to the nest to facilitate locating the nest after hatching or abandonment. I determined nest success by examining eggshells and searching for broods via radiotracking of the female. A nest was considered to be successful if at least one egg hatched (Vangilder et al. 1987).

Attentiveness

I recorded hen activity at nests with remote-monitoring units composed of coaxial cables stripped at one end to function as antennas, a Telonics TR-2 receiver, a Telonics TDP-2 digital signal processor, a 12v battery, and a Rustrak chart recorder operating at a chart speed of 15 cm/hr. After hens initiated incubation, I placed the antenna end of coaxial cables within 7 m of the nest and located monitoring units approximately 40 m from nests. Hens were sampled depending on feasibility of transporting equipment to nests. Length of recording period differed for each hen and depended on the availability of other nests to monitor.

Analyses

I calculated five attentiveness variables: incubation constancy (percent of the monitored time that hens spent on the nest), number of absences per day, absence duration (min), total time off the nest per day (min), and the percentage of monitored days an absence from the nest occurred. Attentiveness patterns of the hen that abandoned her nest appeared to differ from other monitored hens (Table A.6); therefore, I excluded data from this hen from analyses. Only data collected from sunset to sunrise were included in analyses. I examined attentiveness during the nocturnal period separately because absences initiated after sunset are likely in response to disturbance by predators instead of active foraging by the hen.

I used average values for number of absences/day, absence duration, and total time off the nest for each hen and used a Mann-Whitney test to compare between successful and destroyed nests for each of the 5 attentiveness variables. If differences between successful and destroyed nests were not detected ($P > 0.5$), I pooled all data for subsequent analyses. Additionally, I determined the time each absence began and compared the time distribution of absence initiations between successful and destroyed nests using a Kolmogorov-Smirnov 2-sample test.

RESULTS

Attentiveness data were obtained for 15 hens during 1996–1997 (11 adults, 4 yearlings). Four nests were destroyed by predators, 10 were successful, and one nest was abandoned (Table A.6). Total monitoring time for all hens was 2,360 hrs and averaged 157.3 hrs per bird. The number of days each bird was monitored ranged from 4–14. I recorded 102 days of data and 114 absences (99 during daylight hours) for these hens. Sixty-nine absences were recorded for successful hens, and 45 were recorded for hens whose nests were destroyed. Most (10) hens were monitored during the third week of incubation, 3 were monitored during the fourth week, and 1 hen was monitored during each of the first and second weeks of incubation.

Mean values of attentiveness variables did not differ between hens of successful ($n = 10$) and destroyed ($n = 4$) nests (Table 3.1); however, small sample sizes resulted in high probability of type II error. Mean number of absences per day for monitored hens was 0.94; hens left nests 0 – 4 times daily. Mean length of absences during daylight (after sunrise and before sunset) was 77.2 min and ranged from 7 – 638 min. Fifty of 99 (51%) absences during daylight were ≥ 1 hour in length. Total time off the nest each day during daylight hours averaged 76.5 min (range 0 – 869 min). Hens spent 94% of the incubation period on the nest and left the nest at least once during 75% of the days when they were monitored.

The distribution of absence initiations differed between hens of successful and destroyed nests ($D = 0.282$, $P = 0.027$; Figure 3.1). Hens whose nests were destroyed by predators were more likely to leave nests from 1200–1459 and successful birds were more likely to leave nests from 1500–1759 (Figure 3.1). Nine of 15 birds initiated 15 absences after sunset for periods ranging from 20 – 677 min. Five of these hens had successful nests, 3 nests were destroyed, and 1 hen abandoned her nest. Mean duration of absences between sunset and sunrise was 212.4 min; 11 of 15 (73%) absences during the night were ≥ 1 hour in length. Length of absences was greater at night than during the day ($\bar{x}$ = 81.76; $U = 442.5$, $P = 0.012$, $n = 99$).

DISCUSSION

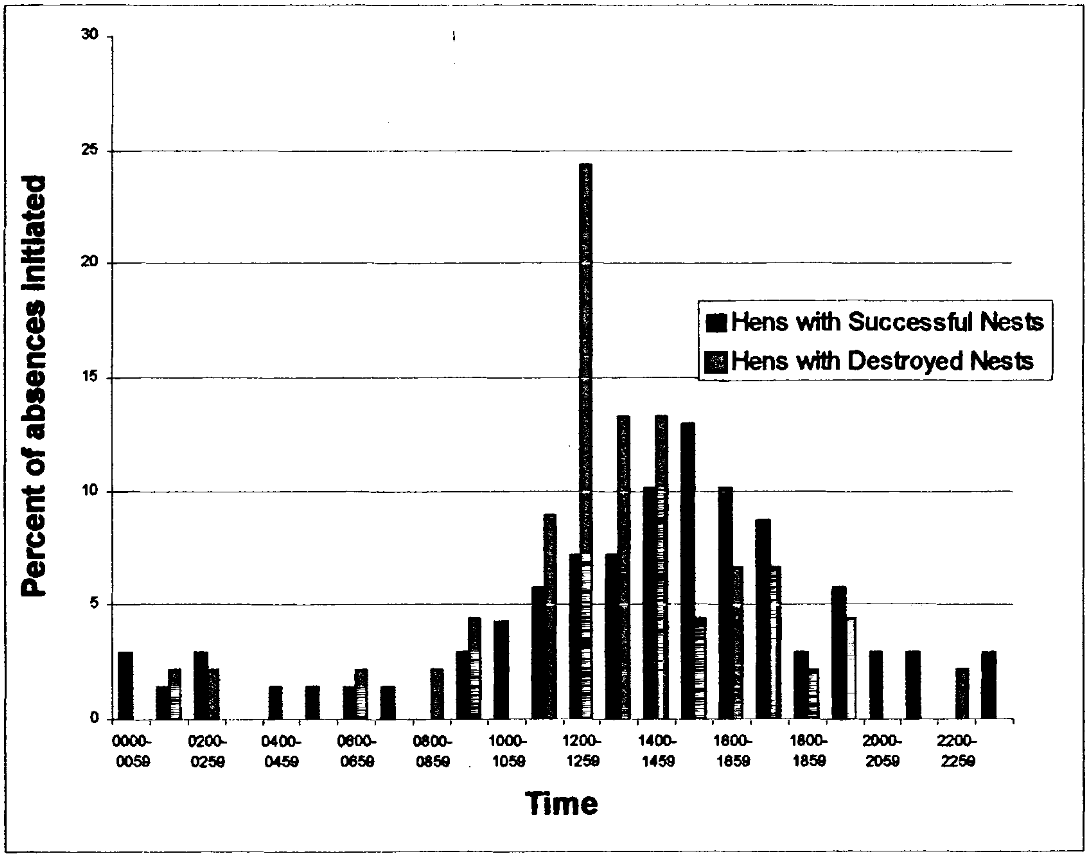
Attentiveness patterns of hens in this study were considerably different from those reported in previous studies. Mean length of absences (93 min) by hens in Connecticut was greater than mean absence length (53 min) by 5 hens in Michigan (Green 1982). Conversely, mean absence length (121 min) was greater for 8 hens in Florida (Williams and Austin 1988). These regional differences in absence length could be temperature

Table 3.1. Nest attentiveness variables[a] (mean ± SE) of incubating eastern wild turkey hens in southeastern Connecticut, 1996–1997.

Variable	**Hens of Successful Nests ($n = 10$)**	**Hens of Destroyed Nests ($n = 4$)**	***P* value**
Incubation constancy, %	93 ± 2	96 ± 1	0.48
Absences/day, no.	0.88 ± 0.08	1.07 ± 0.22	0.26
Absence duration, min.	88.4 ± 16.1	49.1 ± 6.8	0.26
Time off nest/day, min.	85.6 ± 20.6	53.8 ± 13.4	0.48
Days absence occurred, %	72 ± 4	83 ± 14	0.26

[a] Does not include absences that were initiated after sunset.

Figure 3.1. Percent of absences initiated in 1-hour intervals by hens incubating successful or destroyed nests in southeastern Connecticut, 1996–1997.



related. Higher temperatures in Florida may allow hens to take longer absences without affecting embryo development (Green 1982).

The timing of nest absences in this study also differed from reports from other regions. It has often been reported that turkeys have 2 distinct daily periods of intense feeding activity - mid-morning and mid-afternoon (Mosby and Handley 1943, Davis 1949, Burger 1954, Raybourne 1968). Green (1982) also reported that absences of nesting hens occurred in late morning or late afternoon and only 1 of 5 hens was observed to leave her nest between 1200 -1455. Hens in Florida exhibited similar patterns with most absences occurring from 1000–1100 and 1800–1900 (Williams and Austin 1988). I found that 1200 – 1459 was the most frequent time for hens in Connecticut to leave their nests. Hens at my study site were least likely to leave the nest in the morning suggesting that feeding patterns for nesting hens may be different from those previously reported.

Temperature may be a variable influencing the time hens recess from nests. Hen turkeys monitored in Michigan (Green 1982) and Florida (Williams and Austin 1988) remained on their nests during the hottest part of the day and recessed before and after temperatures had peaked. In contrast, I found that hens in Connecticut left the nest most often when temperature and solar radiation were usually highest (1200 – 1500). This suggests that minimizing egg-cooling (Cartar and Montgomerie 1987) may be more important to hens in Connecticut than shading eggs during peak solar radiation (Maclean 1967). Midday may be the best time for absences to occur because air temperatures are probably closest to required incubation temperatures (Hillestad 1970).

Although it is generally believed that hens do not go to roost while incubating a clutch (Williams and Austin 1988), I found that 13% of absences by nesting hens occurred after sunset. Williams et al. (1971) reported that hens may roost in trees during the night, even after incubating for several days. It has not been determined if roosting at night is a response to disturbance by predators or some other stimuli. I hypothesized that nests that were left at night were more likely to be detected by predators; however, 5 of 9 (56%) nests that were left unattended at night were successful, suggesting that leaving the nest at night may not increase its susceptibility to predators.

I did not find differences in 5 of the attentiveness patterns (incubation constancy, the number of absences per day, absence duration, time off the nest per day, and the percent of days that absences occurred) between hens of successful and destroyed nests, in contrast to reports for herring gulls (Fox et al. 1978) and hummingbirds (Baltosser 1996); however, small sample sizes resulted in a high probability of type II error. There have been several proposed explanations for the influence of attentiveness on the nest success of turkeys. Thogmartin and Johnson (1999) hypothesized that turkey hens that take many absences from the nest increase the risk of predation to the nest and themselves. Additionally, Williams and Austin (1988) hypothesized that attentiveness by the female minimizes the risk of nest predation by decreasing the time the nest is exposed to predators. However, I found little evidence to support either hypothesis.

The distribution of absence initiation differed between hens of successful and destroyed nests in this study. Hens of destroyed nests were more likely to take absences from 1200–1459 whereas successful hens were more likely to take absences from 1500–2159. With the small number of nests destroyed by predators, however, it is uncertain if this is a general pattern. Perhaps being on a nest around dusk, when mammalian predators are most likely to hunt (Williams and Austin 1988), increases vulnerability to predators by providing olfactory cues while incubating eggs.

MANAGEMENT IMPLICATIONS AND FUTURE RESEARCH

In Connecticut, spring turkey hunting is allowed until noon and only bearded birds can be legally harvested. When turkey populations were first reestablished, hunting until noon was required to decrease the risk of a hunter shooting a hen because it was thought that hens were more likely to be off the nest in the afternoon. My findings support this assumption; 1200–1800 is the most likely time period for hens to be off the nest. Therefore, to minimize potential for accidental take of turkey hens in areas where populations are low, requiring hunting to cease at 1200 is a valid management strategy.

Temperature and precipitation probably are important variables that influence behavior of incubating hens. Temperature affects the cooling rates of eggs (Drent 1970), adult metabolic rates (Norton 1973), and foraging success of adults (Bryant and Westerterp 1983). Hens in Michigan remained on the nest and panted during midday when temperatures were highest; further, hens left the nest either in late morning or late afternoon (Green 1982). This strategy likely protects eggs from solar radiation (Weathers and Sullivan 1989) during the hottest part of the day. In contrast, black ducks nesting in wetlands in Maine had longer absences during high temperatures (Ringelman et al. 1982), suggesting that temperature likely influences when hens take recesses from nests. Weather, including rain and humidity, could affect the behavior of incubating hens and may have caused the duration and timing of absences observed in this study to differ from other regions.

Videography could be used to determine if weather or concealment from predators is more important in determining when hens are absent from nests. Remote videography at nests would also provide insight into whether nests are more likely to be destroyed by predators when hens are attending or absent. The circadian timing of nest predation could also be evaluated using videography and may be useful for understanding optimal strategies of nest attentiveness.

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Appendix

Tables and Figures Depicting Capture Information, Home Range Estimates, and Survival and Reproductive Data

Table A.1. Capture, mortality, and reproductive data for radio-tagged wild hen turkeys in southeast Connecticut, 1996–1998.

	Capture				Mortality		Reproduction	
Band	Date	Site	Age^a	Weight (lb)	Date	Cause	Nest initiation dates	Nest Outcome
T700	2/22/96	Essex	A	8.50	5/25/97	Mammalian predator	5/9/97	Hen killed
T699	2/22/96	Essex	A	10.25	6/16/96	Unknown	5/6/96	Abandoned
T698	2/22/96	Essex	Y	7.75	--	Alive	5/3/96	Abandoned
							5/6/97	Destroyed
T697	2/22/96	Essex	A	9.75	5/16/96	Unknown predator	None	
T696	2/22/96	Essex	Y	8.00	5/25/98	Coyote	None	
T654	3/25/96	Essex	Y	7.75	5/8/96	Vehicle	None	
T655	3/25/96	Essex	Y	7.75	6/16/96	Disease	None	
T656	3/25/96	Essex	A	9.75	7/31/97	Disease	4/29/96	Successful
							4/29/97	Successful
T650	3/18/96	Salem	A	9.75	1/27/98	Owl	4/24/96	Successful
							4/23/97	Successful
T651	3/18/96	Salem	A	10.50	--	Censored 3/19/96		
T652	3/18/96	Salem	A	8.75	4/17/96	Mammalian predator	None	
T653	3/18/96	Salem	A	10.25	5/23/98	Mammalian predator	5/11/96	Destroyed
							5/10/97	Successful
T657	3/26/96	Franklin	A	8.75	4/1/96	Poached	None	
T658	3/26/96	Franklin	A	10.75	12/21/96	Poached	5/11/96	Destroyed
T659	3/26/96	Franklin	Y	8.25	5/9/97	Mammalian predator	4/22/97	Hen killed
T660	3/26/96	Franklin	Y	8.50	5/11/96	Unknown	None	
T661	3/26/96	Franklin	Y	7.75	5/17/98	Mammalian predator	5/25/96	Destroyed
							4/26/97	Successful
T662	3/26/96	Franklin	A	10.75	12/21/96	Mammalian predator	5/21/96	Successful
T663	3/26/96	Franklin	A	11.00	3/29/97	Unknown predator	5/26/96	Vehicle
							6/9/96	Abandoned
T664	3/26/96	Franklin	A	8.75	4/24/97	Unknown	None	

Table A.1. Continued

	Capture				Mortality		Reproduction	
Band	Date	Site	Age[a]	Weight (lb)	Date	Cause	Nest initiation dates	Nest Outcome
T665	3/26/96	Franklin	A	10.75	4/25/9	Mammalian predator	5/15/96	Destroyed
							4/22/97	Destroyed
T666	4/08/96	Franklin	A	13.00	6/27/9	Mammalian predator	6/9/96	Abandoned
							5/21/97	Abandoned
T671	1/18/97	Essex	A	8.25	5/26/9	Mammalian predator	5/6/97	Destroyed
T672	1/18/97	Essex	A	9.00	– –	Censored - 5/29/98	6/5/97	Destroyed
T673	1/18/97	Essex	A	8.50	4/19/9	Vehicle	5/15/97	Abandoned
							6/5/97	Abandoned
T674	1/18/97	Essex	A	8.75	– –	Alive	5/1/97	Successful
T675	1/18/97	Essex	A	9.25	5/17/9	Unknown	None	
T677	1/18/97	Essex	A	9.75	– –	Alive	5/13/97	Successful
T678	1/18/97	Essex	A	9.75	5/25/9	Mammalian predator	4/23/97	Successful
T679	1/18/97	Essex	Y	7.50	5/13/9	Mammalian predator	4/23/97	Hen killed
T680	1/18/97	Essex	A	10.00	9/6/97	Unknown	6/5/97	Successful
T681	1/18/97	Essex	A	9.25	11/13/	Poached	4/29/97	Abandoned
							5/18/97	Successful
T682	1/18/97	Essex	A	8.50	– –	Censored 4/2/97	None	
T683	1/18/97	Essex	A	9.50	7/28/9	Vehicle	5/6/97	Destroyed
T676	1/18/97	Essex	A	9.50	– –		5/19/97	Destroyed
T684	1/22/97	Franklin	Y	8.75	5/5/97	Fox	None	
T686	1/22/97	Franklin	A	10.00	6/15/9	Raccoon	None	
T687	1/22/97	Franklin	A	12.50	5/4/97	Mammalian predator	4/30/97	Hen killed
T688	1/22/97	Franklin	A	10.50	1/25/9	Great-horned owl	None	
T689	1/22/97	Franklin	A	10.00	– –		4/28/97	Successful
T691	2/6/97	Killingworth	Y	8.75	5/19/9	Mammalian predator	4/28/97	Destroyed
T545	2/6/97	Killingworth	A	10.25	5/13/9		None	
T546	2/14/97	Franklin	A	9.50	– –		5/17/97	Successful
T547	2/14/97	Franklin	A	9.75	5/5/97	Mammalian predator	5/2/97	Hen killed

Table A.1. Continued

	Capture				Mortality		Reproduction	
Band	Date	Site	Age[a]	Weight (lb)	Date	Cause	Nest initiation dates	Nest Outcome
T548	2/14/97	Franklin	A	10.25	3/24/97	Mammalian predator	None	
T549	2/14/97	Franklin	A	10.25	6/26/97	Mammalian predator	5/28/97	Successful
T550	2/14/97	Franklin	A	11.25	4/10/97	Mammalian predator	None	
T599	3/19/97	Killingworth	A	8.75	5/11/97	Unknown predator	4/25/97	Hen killed
T598	3/19/97	Killingworth	A	10.00	5/6/97	Mammalian predator	None	
T597	3/19/97	Killingworth	A	10.00	5/19/97	Great-horned owl	4/30/97	Destroyed
							5/13/97	Hen killed
T600	3/19/97	Killingworth	A	10.50	6/3/97	Great-horned owl	5/10/97	Hen killed
T588	3/21/97	Killingworth	Y	9.00	9/20/98		5/6/97	Successful
T589	3/21/97	Killingworth	Y	8.50	2/14/98	Coyote	5/22/97	Abandoned
T590	3/21/97	Killingworth	A	10.50	4/18/97	Mammalian predator	None	
T591	3/21/97	Killingworth	Y	8.75	6/4/98	Unknown predator	5/11/97	Successful
T592	3/21/97	Killingworth	Y	7.75	--	Censored 5/10/97	None	
T593	3/21/97	Killingworth	Y	8.75	--	Censored 5/10/97	None	
T594	3/21/97	Killingworth	Y	9.00	8/7/98		4/29/97	Destroyed
T595	3/21/97	Killingworth	Y	9.25	--		None	

[a] A = adult, Y = yearling

Figure A.1. The 95% confidence intervals on estimates of daily survival rates (Heisey and Fuller 1985) for radio-marked wild turkey hens by month during the non-reproductive period in southeastern Connecticut, 1996-1997.

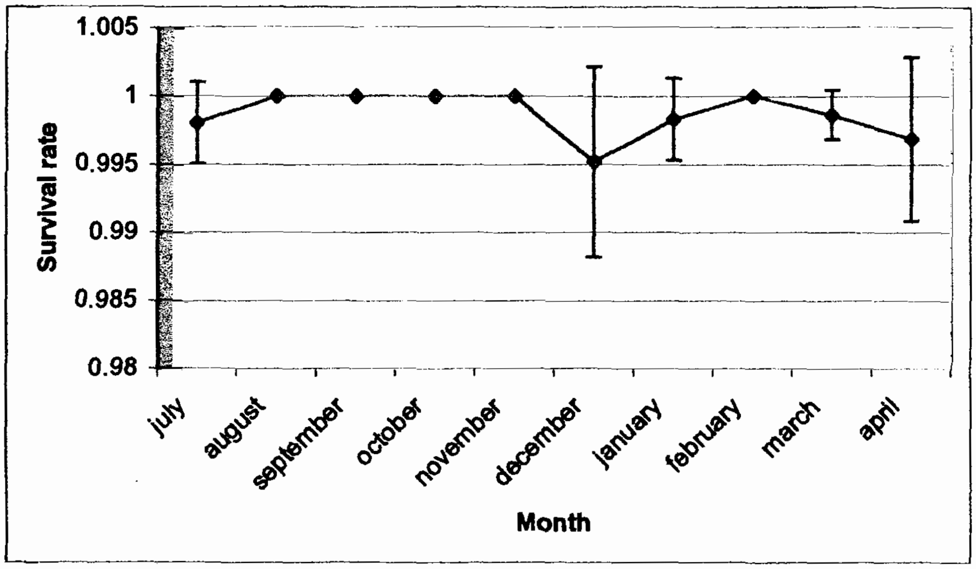

Figure A.2. Effect of number of radio locations on spring (April – July) home range estimates for 7 turkeys in southeastern Connecticut, 1996–1997.

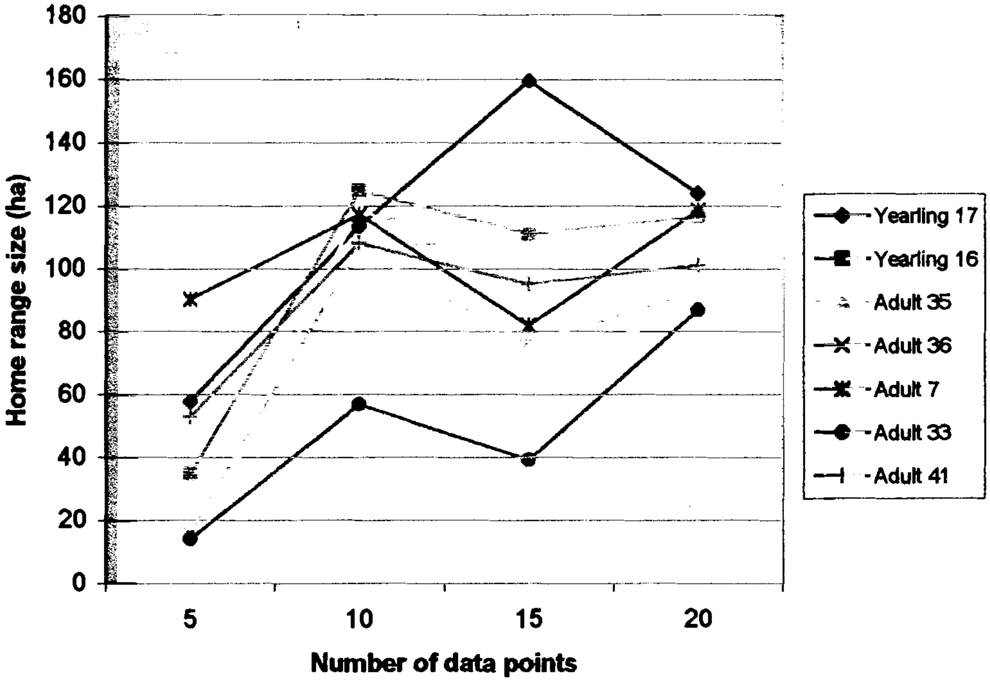

Table A.2. Component loadings of 8 significant principal components for landscape and vegetative cover variables[a] measured at wild turkey nests in southeastern Connecticut during 1996 and 1997.

Variable	**PC1**	**PC2**	**PC3**	**PC4**	**PC5**	**PC6**	**PC7**	**PC8**
%forhr	-0.943	0.264	0.028	0.038	-0.164	0.011	-0.056	0.073
shrub	0.937	-0.189	-0.185	0.108	-0.039	0.028	0.086	0.074
forest50	-0.842	0.362	0.140	0.153	-0.273	0.019	-0.136	0.001
forest25	-0.838	0.309	-0.074	-0.328	-0.221	0.041	0.004	0.030
%dev75	0.830	-0.242	0.066	-0.040	-0.226	-0.072	-0.038	-0.330
ddevelop	-0.808	-0.159	0.242	-0.011	0.495	-0.044	0.116	0.046
edge50	0.769	-0.176	0.546	0.030	-0.032	0.096	-0.003	-0.241
tstem	0.767	0.125	-0.283	-0.307	0.165	-0.104	0.385	0.112
%for75	-0.762	0.296	-0.029	0.530	-0.067	-0.010	-0.010	0.173
%devhr	0.746	-0.329	-0.212	0.023	-0.194	-0.404	-0.227	0.059
awmsi75	0.724	0.182	0.597	0.009	-0.045	-0.181	-0.043	-0.211
nwstem	0.722	0.187	-0.280	-0.350	0.172	-0.066	0.399	0.125
canopy	-0.695	-0.242	0.253	0.119	0.173	-0.462	0.246	-0.191
%agr75	0.667	0.396	0.105	-0.467	0.313	0.023	0.116	-0.225
%vol	0.653	0.634	-0.119	-0.193	0.211	0.044	-0.046	0.264
trees	-0.651	0.157	0.586	-0.070	0.216	-0.378	0.064	-0.004
%total	0.645	0.599	0.021	0.020	-0.094	0.011	-0.133	0.373
wstem	0.626	-0.534	-0.118	0.300	-0.015	-0.376	-0.015	-0.086
dagr	-0.607	-0.458	-0.151	-0.181	0.213	-0.142	0.025	0.534
edge25	0.602	-0.188	0.504	0.060	0.052	0.531	-0.074	0.066
dedge	0.577	-0.208	-0.106	0.545	0.406	-0.352	0.069	0.134
grht	0.551	0.428	0.346	-0.175	0.535	-0.236	0.084	0.058

Table A.2. Continued

dpath	-0.511	-0.571	0.108	-0.593	0.184	0.075	-0.027	0.031
dpowerline	-0.511	-0.571	0.108	-0.593	0.184	0.075	-0.027	0.031
droad	0.017	0.737	-0.417	0.141	0.406	0.162	0.052	-0.032
dead	-0.404	0.539	-0.339	-0.065	-0.095	0.018	0.075	-0.343
pd75	0.068	0.395	0.817	0.019	-0.126	-0.278	0.216	0.145
patch50	0.144	0.001	0.754	0.034	-0.547	0.030	0.304	0.104
patch25	0.048	-0.103	0.527	-0.268	-0.140	0.616	0.455	0.148
%agrhr	-0.007	-0.176	-0.039	0.508	0.488	0.588	0.184	-0.215
grstem	0.461	-0.005	0.386	0.505	-0.058	0.271	-0.462	0.300
dpathroad	-0.346	-0.130	0.209	0.459	0.687	0.257	0.091	-0.051
awmsihr	0.277	-0.122	0.388	-0.325	0.427	-0.111	-0.618	0.148
dwater	-0.304	0.422	0.330	-0.252	0.252	-0.032	-0.593	-0.285
pdhr	-0.334	0.151	0.365	0.353	0.089	-0.414	0.337	0.019

[a] Refer to Table 2.1 for variable definitions.

Table A.3. Median (range) values of vegetative cover variables measured at 38 eastern wild turkey nests in southeastern Connecticut, 1996–1997.

Variable[a]	***P*-value**[b]	**Adult (n=31)**	**Yearling (n=7)**
canopy	0.235	65.9 (0 - 91.4)	71.9 (59.5 - 85.4)
trees	0.418	11 (0 - 35)	17 (6 - 33)
wstem	0.910	10 (0 - 63)	16 (0 - 38)
nwstem	0.382	8 (0 - 305)	0 (0 - 60)
tstem	0.749	26 (0 - 315)	32 (3 - 60)
shrub	0.833	27 (0 - 100)	35 (0 - 70)
%total	0.836	55 (3 - 100)	47 (19 - 79)
%vol	0.865	27 (1 - 77)	31 (1 - 46)
grht	0.292	32.7 (9.4 - 78)	30.6 (10.3 - 35)
grstem	0.267	98 (15 - 1000)	57 (40 - 273)
dead	1.00	4 (0 - 20)	3 (1 - 7)

[a] Refer to Table 2.1 for variable definitions

[b] Mann-Whitney U test

Table A.4. Median (range) values of landscape metrics measured in spring home ranges and 75% activity circles of nesting eastern wild turkey hens at 3 study sites in southeastern Connecticut, 1996–1997.

Metric[a]	**P-value**[b]	**Essex** (*n*=16)	**Franklin** (*n*=19)	**Killingworth** (*n*=8)
pd75[c]	0.466	9.18 (1.6 - 27.4)	12.62 (3.1 - 27.6)	9.22 (2.4 - 19.8)
awmsi75[c]	0.104	1.9 (1.4 - 2.9)	2.84 (1.3 - 3.5)	2.16 (1.4 - 3.4)
pdhr[c]	0.941	16.37 (3.9 - 31.7)	13.9 (4.2 - 34.4)	16.96 (2.5 - 23.5)
awmsihr[c]	0.345	2.45 (1.5 - 3.8)	2.75 (1.9 - 4.0)	3.46 (1.4 - 4.6)
%for75	0.060	86.9 (78.4 - 96.7)	75.6 (64.5 - 98.9)	94.4 (81.1 - 96.2)
%dev75	0.330	8.7 (0 - 18)	7.8 (0.2 - 26.4)	4.4 (0 - 18.3)
%agr75	0.000	0.2 (0 - 4.5)	4.1 (0.1 - 28.5)	0.9 (0 - 3.4)

[a] Refer to Table 2.1 for metric definitions.
[b] Kruskal-Wallis Test
[c] McGarigal and Marks 1995

Table A.5. Pearson rank correlation coefficients among nine landscape and vegetative cover variables[a] measured at eastern wild turkey nests in southeastern Connecticut, 1996–1997. Variables were significant ($P \leq 0.2$) in a univariate T-test between successful and destroyed nests.

	%agr75	%agrhr	trees	tstem	nwstem	wstem	%vol	grht	grstem
%agr75	1.0								
%agrhr	0.76	1.0							
trees	0.11	0.18	1.0						
tstem	0.58	0.33	-0.32	1.0					
nwstem	0.60	0.36	-0.24	0.98	1.0				
wstem	-0.02	-0.11	-0.45	0.28	0.09	1.0			
%vol	0.15	0.04	-0.29	0.61	0.60	0.13	1.0		
grht	0.47	0.42	0.03	0.55	0.54	0.12	0.70	1.0	
grstem	-0.09	0.00	-0.37	0.00	-0.04	0.21	0.23	0.17	1.0

[a] Refer to Table 2.1 for variable definitions.

Table A.6. Means ± SE (*n*) of nest attentiveness variables (not including night data) for 15 hens monitored during incubation in southeastern Connecticut, 1996–1997.

Band No.	**Year**	**No. Days Monitored**	**Week of Incubation**	**Nest Result**	**Incubation Constancy (%)**	**Days Left Nest/Total Days**	**No. of Absences/Day**	**Total Min. Off/Day**	**Absence Duration (min)**
T661	1996	14	3	Destroyed	93.8	14/14	1.14 ± 0.09 (14)	78.14 ± 8.22 (14)	68.38 ± 7.37 (16)
T662	1996	11	3	Successful	91.0	8/11	0.92 ± 0.24 (11)	134.54 ± 76.75 (11)	148.0 ± 51.78 (10)
T665	1996	8	3	Destroyed	95.4	8/8	1.38 ± 0.18 (8)	67.25 ± 12.32 (8)	48.91 ± 6.89 (11)
T650	1997	6	3	Successful	97.6	6/6	0.83 ± 0.17 (6)	25.333 ± 7.28 (6)	30.4 ± 6.41 (5)
T600	1997	7	1	Destroyed	98.4	4/7	0.43 ± 0.20 (7)	16.86 ± 9.52 (7)	39.3 ± 13.87 (3)
T589	1997	5	2	Abandoned	73.0	5/5	1.6 ± 0.25 (5)	379.6 ± 135.27 (5)	237.25 ± 57.39 (8)
T588	1997	6	3	Successful	97.6	4/6	0.67 ± 0.21 (6)	34.33 ± 11.2 (6)	51.5 ± 4.35 (4)
T591	1997	6	3	Successful	94.8	6/6	1.17 ± 0.17 (6)	73.5 ± 29.16 (6)	63.0 ± 22.82 (7)
T677	1997	6	3	Successful	75.7	5/6	1.33 ± 0.62 (6)	224.83 ± 117.14 (6)	168.63 ± 70.0 (8)

Table A.6. Continued

Band No.	Year	No. Days Monitored	Week of Incubation	Nest Result	Incubation Constancy (%)	Days Left Nest/Total Days	No. of Absences/Day	Total Min. Off/Day	Absence Duration (min)
T681	1997	5	3	Successful	98.6	3/5	0.6 ± 0.25 (5)	22.6 ± 11.95 (5)	37.67 ± 13.86 (3)
T546	1997	4	4	Successful	97.4	3/4	0.75 ± 0.25 (4)	30.25 ± 13.54 (4)	40.33 ± 12.79 (3)
T689	1997	5	4	Successful	91.1	4/5	1.0 ± 0.32 (5)	117.6 ± 57.61 (5)	117.6 ± 29.78 (5)
T549	1997	8	3	Successful	95.1	5/8	0.63 ± 0.26 (8)	66.25 ± 33.74 (8)	106.0 ± 30.67 (5)
T672	1997	9	4	Destroyed	95.9	8/9	1.33 ± 0.29 (9)	53.11 ± 12.05 (9)	39.83 ± 5.75 (12)
T680	1997	7	3	Successful	90.9	5/7	1.0 ± 0.31 (7)	126.57 ± 41.01 (7)	126.57 ± 35.85 (7)

BIOGRAPHY OF THE AUTHOR

Shelley M. Spohr was born in Middletown, Connecticut on 29 December, 1972. She was raised in Essex, Connecticut and graduated in 1990 from Valley Regional High School, Deep River, Connecticut. Shelley attended the University of Massachusetts, Amherst and graduated with a Bachelor of Science degree in Wildlife Biology in February 1994 and was named the "Outstanding Senior in Fisheries and Wildlife". Upon graduation, Shelley was employed by the Connecticut Department of Environmental Protection, Wildlife Division, and conducted research on suburban deer herds. She entered the graduate program in the Department of Wildlife Ecology at the University of Maine in the fall of 1995. Since April of 1999, Shelley has been the wildlife biologist for the Office of Natural Resources Protection of the Mashantucket Pequot Tribal Nation, Connecticut. Shelley is a candidate for the Master of Science degree in Wildlife Ecology from The University of Maine in December, 2001.