

# White-tailed Deer Selection of a Travel Route when Dispersing in an Agricultural Environment

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## ABSTRACT

Both sexes of white-tailed deer (*Odocoileus virginianus*) traveled about twice as far before selecting a new home range when dispersing through agricultural fields compared to travel through a forested corridor. Travel (km/day) was somewhat greater through agricultural fields, but selection of a travel route did not significantly affect survival or permanent cover selected on the new home range. Corn planting dates and maturation did not influence the timing of a dispersal movement. Selection of a travel route was influenced by the location on the natal range (whether on the edge or center of the area), mother's movements, and the social position of the family group. Subsequent survival after reaching the new home range was dependent more upon hunting pressures on the new range, a factor not readily apparent in late spring-early summer when most dispersal behavior occurs in Illinois.

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## INTRODUCTION

In Illinois and elsewhere in the lower Midwest, white-tailed deer live in a mosaic of habitats dominated by agricultural fields. Agricultural uses dominate the landscape in much of central and northern Illinois with permanent cover relegated to isolated patches along rivers and streams, hedgerows, or small woodlots (Iverson et al. 1989). More than 50% of the state is devoid of year-round cover for deer (Roseberry and Wolf 1998).

Dispersal behavior (a one-way movement from a natal range to a new range greater than 5 km away) is common for both sexes in the lower Midwest (Nixon et al. 1991, Vercauteren and Hygnstrom 1994). Deer dispersing in late spring in central and northern Illinois have two choices as to a travel route, either to remain entirely within a forest dominated landscape located primarily as corridors along rivers and streams or to travel through agricultural fields largely devoid of cover prior to corn maturation. Landscape structure often influences dispersal distance among vertebrates, and searching for a suitable home range might be more difficult within an agriculture dominated matrix (South et al. 2002, Bowler and Benton, 2005). Intuitively, deer remaining within forest dominated land-

scapes would be more likely to settle within an area offering more permanent cover and protection from hunters and vehicles. In contrast, agriculture dominated landscapes are usually privately owned farms where hunting is encouraged, woodland patches are often small and isolated, and human intrusions into the landscape are frequent. This paper attempts to determine what environmental or social factors affect the selection of a travel route and the costs in inclusive fitness to the individual deer, if any, as a result of this decision.

## STUDY AREAS

We used 2 study areas to investigate the selection of a travel route during a dispersal movement (Fig. 1). The 2,953-ha Piatt study area lies within Piatt County in east-central Illinois, which was nearly covered with tall grass prairie prior to settlement by Europeans. In 1985, Piatt county was 2.7% forested, with forests restricted to areas too rough or wet to farm (Iverson et al. 1989). The Piatt study area consisted of 64% row crops (corn [*Zea maise*] and soybeans [*Glycine max*]) and 36% forest and included the 600-ha Robert Allerton Park, a refuge from all hunting. The area was bisected by the Sangamon River with narrow upland and bottomland forests stretching NE–SW across and beyond the study area (Fig. 1). Except for an occasional hedge row, usually only a single tree in width, there was no woody cover for 8–11 km north and south of this study area.

The 1,648-ha DeKalb study area, located in DeKalb County in northeast Illinois, and centered on the Shabbona Lake Recreation Area, lay at the headwaters of a tributary of the Fox River and was surrounded with agricultural fields and urban sprawl (Fig. 1). Row crops covered 59% of the area, while 14% was hardwood forest, 7% was reconstructed tall grass prairie, 6% mixed species pine plantations, and 5% savanna. The remaining 9% included a small suburb, a golf course, and a 128-ha lake. There was no permanent cover available for at least 16 km north and west and 10–13 km east of the study area. There was a small woodlot 5 km due south and 2–3 0.5–1.0 ha woodlots SW of the study area. DeKalb County was only 1.6% forested in 1985 (Iverson et al. 1989).

Hardwood forests on both study areas were generally understocked mixtures of previously pastured or cutover hardwoods. Corn and soybeans were planted from April to early June. Soybean harvests began in late September and corn harvest was completed by early November. Most corn fields were disked or chisel-plowed each fall.

## METHODS

Deer were captured using rocket-propelled or drop nets (Hawkins et al. 1968) during 1980–1985 (Piatt County) and 1990–1993 (DeKalb County). Fawns were aged on the basis of tooth replacement (Severinghaus 1949). For this paper we only used deer aged as fawns when captured that dispersed between aged 10–14 mos old, ignoring deer that were migrators.

Males ( $N = 43$ ) were marked with ear streamers or numbered cattle-type plastic ear tags (Y-Tex Corp., Cody, WY) while females ( $N = 39$ ) were marked with plastic collars bearing reflective numbers. Radio collars (Wildlife Materials, Carbondale, IL; Teleonics, Inc., Mesa, AZ) were placed on 4 of the 43 males and 20 of the 39 females that became

dispersers. Deer were radio-tracked using 2 truck-mounted 8-element yagi antennas aligned in a null configuration. Each radio location was derived from 2–4 bearings taken from fixed locations generally < 400 m apart. Radio marked deer that dispersed were located by truck or aircraft and then periodically radio tracked during a dispersal movement or after settling on a new home range.

Most dispersal travels were nearly straight line movements based on radio locations taken along the route. We used topographic maps depicting these routes to determine the percentage of forest and row crops traversed during travel.

The minimum distance traveled to a permanent home range was measured as a straight line from the capture location to the center of radio locations or observations on the new home range (mean =  $4.9 \pm 1.4$  SE locations/deer) or to a death location if there were no other observation/radio locations. Daily movements (km/day) were available for 10 females and 5 males (4 with radios, 1 male observed frequently) that dispersed through a forested corridor and for 6 females and 2 males (both through observations) using agricultural fields.

### **Data Analysis**

We used a nominal logistic fit with the travel route (agricultural fields vs. forested corridors) as the dependent variable using 82 fawns that dispersed (43 males, 39 females) and provided sufficient data for each variable. Preliminary independent variables considered for analysis included sex of fawns, social group status (dominant or subordinate), natal range location (edge or center of the study area), fawn age when dispersing (mos.), fawn condition (chest girth taken posterior to the posterior edge of the scapular with the legs perpendicular to the spine and hind foot length taken from the calcanium to the tip of the longest hoof), mother's survival status (alive or dead), mother's movements (sedentary—remained on the study area, migratory—leave and return each year, dispersed—permanently left the study area), percent of corn planted, height of corn maturation (cm) at the time of deer dispersal (Annual Weather and Crop Reports, Illinois Department of Agriculture), and direction of travel during dispersal (NE, SE, NW, SW). Because some variables were extremely skewed, only 7 of these variables were adequate for describing travel route selection in the final logistic regression analysis (mother's survival status, fawn age, location of natal range, direction of travel, percent corn planted, height of corn, and travel distance). Means are reported with standard errors.

To develop Akaike's information criterion (AIC<sup>c</sup>) adjusted for small sample sizes (Burnham and Anderson 1998), we tested which environmental and social (mother and other relationships) factors may influence the travel route selection (agricultural fields vs. forested corridors). AIC models used categorical and continuous covariates relating to this selection and used 39 deer (21 males, 18 females) for which we had a complete data set for all variables.

Five environmental models were compared using combinations of the variables: percent of permanent cover present on the new home range (using a 256-ha section centered on radio fixes/observations), the percent of the corn crop planted when dispersal began, the average height of corn (cm) on the date each deer began dispersing, the location on the natal range from which each deer began dispersing (actually left the study area), the path

taken by dispersing fawns (across the study area or from the edge of the study area), general habitat in each natal range (forest, prairie, row crops, pasture), and direction of the dispersal movement (NE, SE, SW, NW).

Five mother models were compared using the variables: mother's range (on the edge or centered on each study area), the dominant land use present on the natal range (forest, prairie, row crops, pasture), mother's age, mother's movements after tagging (sedentary, migratory, dispersed), and mother's social position (dominant or subordinate). The mother's social position was developed on an average of  $49 \pm 6.1$  observations of these deer and was based on aggressive encounters won or lost, leadership among related deer, leadership of large groups of deer in winter, duration of location of a stable home range, and movement behavior after tagging.

Four relationship models were compared using the variables: sex of siblings, number of siblings, the movement history of any siblings (sedentary, migratory, or dispersed), mother's survival status (alive or dead when fawn dispersal began), social group size (number of deer in the social group when dispersal began), and known birth progression for each fawn (first born or later).

Models chosen for inference included the 95% likelihood set based on AIC weights (Burnham and Anderson 1998). The best model from each of the 3 model types (environmental models, mother models, and relationship models) was compared with each other to determine the overall best model. We then used analysis of variance and Chi-square likelihood ratio tests ( $\alpha = 0.10$ ) (Sokal and Rohlf 1995) to examine how sexes might differ in the importance of variables within each model.

## RESULTS

Deer that used agricultural fields for dispersal traveled significantly farther before settling on a new range compared with deer using forested corridors to disperse. Females using agricultural fields traveled  $48.3 \pm 3.6$  km, while those using forested corridors traveled  $25.1 \pm 4.4$  km ( $F = 16.5$ ,  $df = 1,38$ ,  $P = 0.0002$ ,  $N = 39$ ). Males using agricultural fields traveled  $54.8 \pm 5.2$  km, while those using forested corridors traveled  $25.8 \pm 5.6$  km ( $F = 14.4$ ,  $df = 1,42$ ,  $P < 0.0004$ ,  $N = 43$ ). Both sexes moved about double the distance over agricultural fields to a final location compared with those who dispersed through forest cover. Ten females averaged  $5.3 \pm 1.5$  km/day moving through a forested corridor and 6 females averaged  $7.3 \pm 1.9$  km/day through agricultural fields ( $P = 0.42$ ). Six males (4 radio tracked, 2 marked and observed each day) averaged  $6.9 \pm 1.8$  km/day through forest cover and 2 males  $9.3 \pm 2.9$  km/day traveling through agricultural fields (sample sizes too small to test.).

For radio marked deer that used forested corridors as travel routes, the landscape traversed by these deer averaged  $80 \% \pm 1.8$  forested habitat for females ( $N = 5$ ) and  $75.8 \% \pm 5.0$  forested for males ( $N = 3$ ). For females ( $N = 15$ ) traveling through agricultural fields, row crops dominated averaging  $95.1 \% \pm 1.6$  of the terrain. The corridors used by male deer ( $N = 2$ ) using agricultural fields averaged  $95.2 \% \pm 2.6$  row crop fields.

Using the nominal logistic fit allows the use of a larger sample ( $N = 82$ ), and the 7 variables selected to describe travel route selection in the final regression analysis were collectively significant for affecting selection of a travel route (females— $N = 39$ ,  $X^2 = 33.4$ ,  $P = 0.0001$ ; males— $N = 43$ ,  $X^2 = 32.2$ ,  $P = 0.0002$ ). However, a stepwise analysis of these 7 variables did not show any 1 variable as significantly associated with travel route selection.

The AIC models separated out 5 variables influencing route selection with the relationship model providing the best fit (Table 1). For females, only the location of the natal range (edge vs. the center of the study areas) significantly affected route selection as 19 of 23 females whose natal range was on the edge of the study areas dispersed through agricultural fields ( $X^2 = 5.4$ ,  $df = 1,36$ ,  $P = 0.01$ ). For males, there were 2 variables affecting travel cover type selection; (1) the direction of travel: 13 of 21 males moved NE (3 through agricultural fields, 10 through forests) ( $P = 0.002$ ) and (2) group size: 14 of 21 males from the larger social groups led by dominant females (average 5.1 deer/year vs. 3.2 deer for groups led by subordinates) selected a forested corridor for dispersal travel ( $P = 0.03$ ).

Mother's movements did not have a significant effect on selection by fawns of a travel route, but this may have been the result of a small sample size. All 4 female fawns of migrating mothers dispersed through agricultural fields. Males were not influenced by their mother's movement to disperse through either landscape type. Selection of permanent cover at the end of a dispersal movement was not significantly different between travel routes for either sex.

Moving farther through agricultural fields did not affect survival for either sex (43 males lived 1.8 yrs using the agriculture fields vs. 1.7 yrs using the forested corridors ( $P = 0.68$ ); 39 females lived 2.5 yrs using agriculture fields vs. 3.0 yrs using forested corridors ( $P = 0.74$ ).

If dispersal through agricultural fields is a more risky travel option, impending parturition might force some females to select this travel route. We knew the initial reproductive history for 20 primiparous females. Based on observations before and after reaching the new range, 9 females (5 pregnant) dispersed through a forested corridor while 11 females (9 pregnant) dispersed through agricultural fields ( $X^2 = 1.6$ ,  $df = 1,18$ ,  $P = 0.20$ ). There were 11 weaned fawns known alive 1 October for the 14 breeding dispersing female fawns, but only 3 of these fawns were known alive at 1 year. However, 6 (43%) of the 14 breeders were killed during the fall and as their fawns were unmarked, once orphaned, their fate was unknown.

## DISCUSSION

Considering the general landscape of east-central and northern Illinois, dispersing deer seem to be able to find diurnal cover during agricultural field crossings using somewhat longer daily movements. The marked deer from the Piatt study area did not move at random, as more emigration was initiated along the forested river corridor (Fig. 1). However, several dispersing deer then left the river and traveled extensively through agricultural fields. Crop maturation did not appear important in controlling the timing of dispersal as

most dispersals occurred before corn plants were high enough to shelter deer, even when lying down. However, very large fields, common in Illinois, offer diurnal protection by their very size and deer could spend daylight hours in these fields well away from more permanent cover. In eastern South Dakota, deer routinely cross wide expanses of open fields to locate permanent cover (Sparrowe and Springer 1970).

Selection of agricultural fields for dispersal travel was not related to the amount of permanent cover found on the new home range, the survival likelihood of dispersing deer, or survival of fawns produced by these dispersing females at least until 1 October. The inclusive fitness of the dispersing females was not compromised by travel through agriculture fields. Once settled on a new range, the odds of further survival were a product of other factors than cover per se, as deer mortality in Illinois is primarily a result of hunting pressures not apparent when the deer selects a new home range in late spring-summer (Nixon et al. 2001).

Edge-located females were usually part of a subordinate social group on our study areas (Nixon et al. 2010). These young females were subjected to harassment by older residents on our trapping sites and when feeding on agricultural fields surrounding the study areas. Such harassment would also be present during dispersal movements which may account for the long distances traveled by these females when dispersing (Gladfelter 1978, Kernohan et al. 1994, Vercauteren and Hygnstrom 1994, Nixon et al. 2007). Unlike males who can select any site containing conspecifics and who often search out such sites that may offer enhanced breeding opportunities, females must find sites that provide an exclusive parturition site not available on the crowded natal ranges found on our study areas. Because dominant females typically inhabit the preferred permanent cover of contiguous woodlands, harassment by more dominant females toward subordinate fawns is much less likely in agricultural fields and small woodlots. In addition, many small woodlots are vacated in the fall because of hunting or inadequate winter cover and thus available for colonization by less experienced subordinate females (Nixon and Hansen 1992).

Travel direction was undoubtedly biased for males on the Piatt study area because the Sangamon River corridor ran NE-SW, and males often followed the river to a new range. The dominant social groups that produced these dispersing males were located on the most stable home ranges near the center of our study area where more extensive forest cover would have been familiar and attractive as dispersal cover to these males. Familiarity with natal landscapes appears to provide one of the cues for dispersers in selecting a new home range (Stamps 2001, Andressen et al. 2002, Stamps et al. 2009).

Subordinates of both sexes appear more likely to select agricultural fields as a travel route compared with members of a dominant social group. Whether due to harassment by dominants or merely a movement from the nearest edge of permanent cover is not known.

These results confirm the ability of white-tailed deer to adapt to an array of fragmented landscape characteristics. Deer, especially those from subordinate social groups (Nixon et al. 2010), are forced to leave the natal range to find mating or parturition sites. Because so much of the present landscape is dominated by agriculture, use of crop fields for travel becomes a necessity. Use of these fields did not significantly affect survival or fawn recruitment per se as deer settled in landscapes providing adequate cover. Future research

should further examine how the juxtaposition of landscape elements governs travel direction and selection of a final home range.

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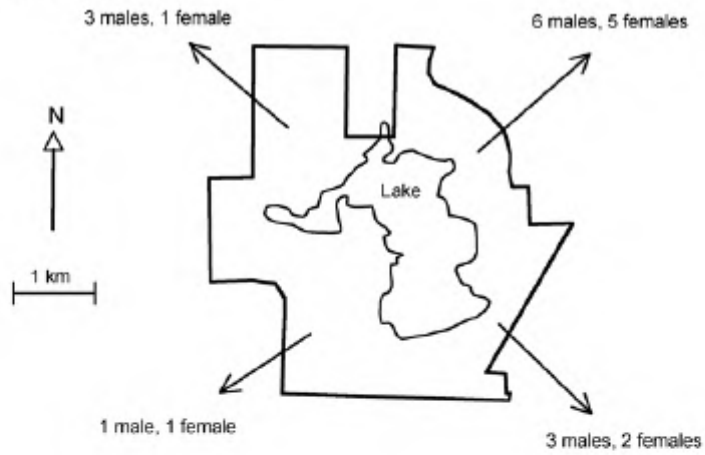
Table 1. White-tailed deer models tested with AIC variables for travel route selection for deer dispersing from sites in northern (DeKalb) and east-central (Piatt) Illinois, 1980–1993.

Model	Variables <sup>a</sup>	N	Log-Likelihood	AICc	DeltaAICc	exp AIC
Environment	%Cover, NR, DT	39	-14.55	40.92	30.19	0.000
Mother	MM, NR	39	-2.46	14.00	3.37	0.185
Relationship	Group size	39	-2.02	10.73	0.00	1.000

<sup>a</sup>%Cover (percent permanent cover), NR (natal range location—edge or center of a study area), DT (direction of travel—NE, SE, NW, SW), MM (mother's movement—sedentary, migratory, disperse), Group size (number of deer in the social group when dispersal began).

Figure 1. Boundaries of white-tailed deer study areas in northern (A) (DeKalb) and east-central (B) (Piatt) Illinois, 1980–1993. Arrows indicate the direction of initial travel and the number of dispersing male and female deer from both areas.

A) DeKalb Study Area



B) Piatt Study Area

