Survival of white-tailed deer in an intensively farmed region of Minnesota

Todd J. Brinkman, Jonathan A. Jenks, Christopher S. DePerno, Brian S. Haroldson, and Robert G. Osborn

Abstract Survival and cause-specific mortality of white-tailed deer (*Odocoileus virginianus*) have been well documented in forested habitat, but limited information has been collected in intensively farmed regions. The objectives of this study were to determine survival and cause-specific mortality of neonate, fawn female, and adult female white-tailed deer in an intensively farmed (>80% land cover) region of Minnesota. We captured and radiocollared 77 female deer >8 months old (61 adults, 16 fawns) and 39 neonates (17 male, 22 female). Hunting was the greatest cause of mortality among adult deer, with 43% of mortalities attributed to firearms hunters. Annual survival rate of all adult and fawn (≥8 months) radiocollared deer was 0.77 (n=58, SE=0.06). Overall (Jan. 2001–Aug. 2002) adult survival was 0.75 (n=77, SE=0.05) and was similar to survival rates reported elsewhere for female white-tailed deer. Natural causes (e.g., disease, predation) of mortality were minor compared to human-related causes (e.g., hunting, vehicle collision). In total, 67% of neonate mortalities were due to predators. Neonate summer survival rate pooled over years was 0.84 (n=39, SE=0.06) and was high compared to other studies. High neonate survival was likely associated with a low predator density, quality vegetation structure at neonate bed sites, and high nutritional condition of dams. Deer management in the highly fragmented and intensively farmed regions of Minnesota relies on hunter harvest to maintain deer populations at levels tolerable to landowners.

Key words agriculture, cause-specific mortality, Minnesota, *Odocoileus virginianus*, predation, survival, white-tailed deer

Knowledge of survival and cause-specific mortality is crucial to understanding white-tailed deer (*Odocoileus virginianus*) population dynamics. Common causes of mortality include human-related factors (e.g., legal hunting, poaching, vehicle collisions; Fuller 1990, Nixon et al. 1991), weather conditions (e.g., winter severity; DelGiudice et al. 2002), predation (Mech 1984), and disease (Matschke et al. 1984). Mortality varies spatially and temporally with sex, age, and density of deer (Gavin et al. 1984, Dusek et al. 1992, Whitlaw et al. 1998, DelGiudice et al. 2002). Deer population models designed to predict spatial and temporal changes in deer populations have stressed the importance of region-specific, sound empirical data (Grund 2001). Without such data, overexploitation of hunted populations is possible (Hoskinson and Mech 1976, Nelson and Mech 1986, Fuller 1989).

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Survival and cause-specific mortality of white-tailed deer have been well documented in forested habitats (Van Deelen et al. 1997, Whitlaw et al. 1998, DePerno et al. 2000, DelGiudice et al. 2002), but limited information has been collected in intensively cultivated regions. In the agricultural Midwest, farmland deer have adapted to the radically altered landscape, where food is abundant and permanent cover is limited (Gladfelter 1984, Nixon et al. 2001). In heavily farmed areas of Minnesota, data on the basic principles and concepts of deer population ecology are absent. The objectives of this study were to determine survival and cause-specific mortality of adult and fawn (≥8 months) female, and neonate white-tailed deer in the intensively cultivated area of southwest Minnesota.

Study area

The study was conducted in a 34,627-km² area of southwest Minnesota (43°29′N to 45°16′N–093°38′W to 096°27′W) containing 24 deer-permit areas (PAs; Figure 1). Topography of the region was flat to rolling, with elevation ranging from 229–608 m above mean sea level. Mean daily temperatures during July and January were 23.1°C and -9.8°C, respectively, and average annual precipitation and snowfall were 65.4 cm and 105.2 cm, respectively. Land cover was dominated by row-crop agriculture (85.6%), primarily corn and soybeans (Minnesota Department of Natural Resources 2000). Other land cover included grassland (Johnson and Larson 1999), forest (Minnesota Association of Soil and Water Conservation Districts Forestry Committee 1986), open water, and wetlands.

Deer populations in Minnesota are managed through allocation of limited hunting permits during the firearms season. Firearms harvest season during 2001 was held on 3–4 and 10–13 November, and mean number of antlerless permits allocated per PA was 549 (n=24, SE=55.8) in our study area. Corn and soybean harvest was generally completed by early November (Minnesota Agricultural Statistics Service 2002).

Methods

We captured female adult (>1 year old) and fawn (~8 months) white-tailed deer by helicopter net-gun and radiocollared them at 3 locations in southwest Minnesota during 22–24 January 2001 and 26

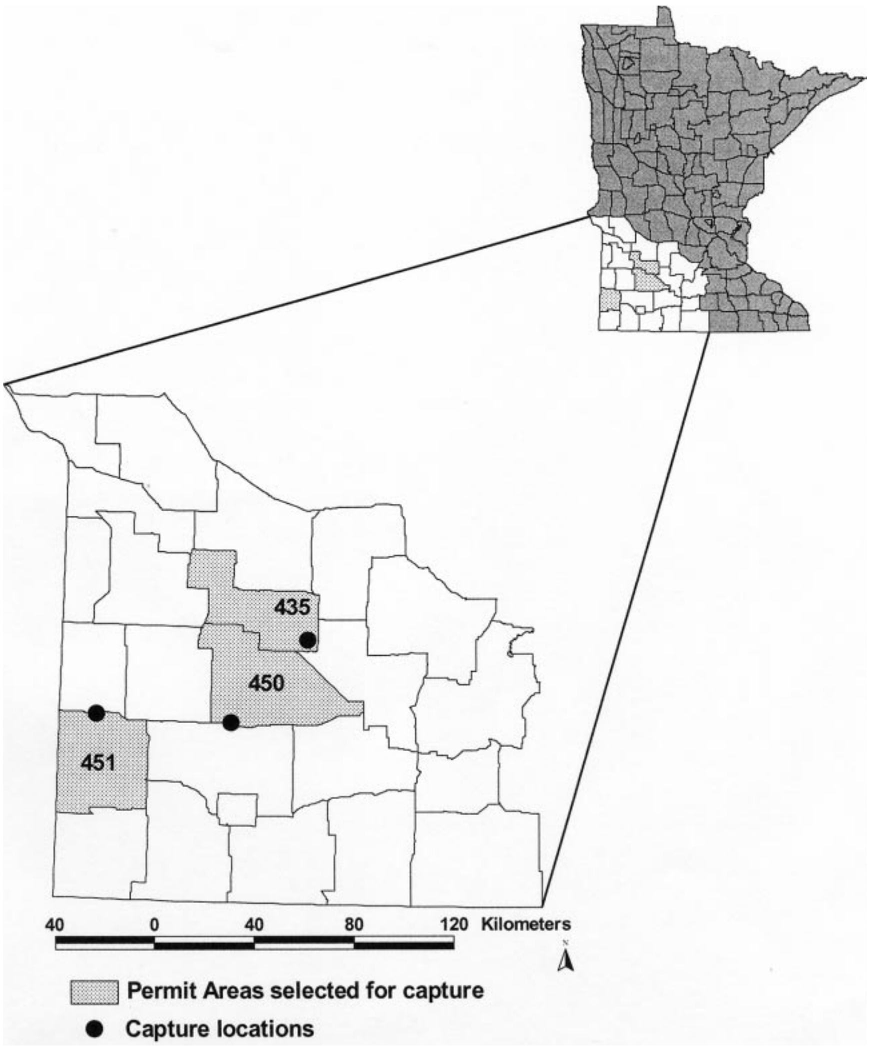

Figure 1. Study area and white-tailed deer capture locations in southwest Minnesota, 2001–2002.

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January 2002 (Figure 1). We captured neonate white-tailed deer by hand, using ground and vehicle searches (Downing and McGinnes 1969), and fitted them with expandable breakaway radiocollars during late May and early June 2001–2002. Captured neonates were sexed, and aged (in days) by hoof growth (Haugen and Speake 1958). Animal handling protocols were approved by the Institutional Animal Care and Use Committee at South Dakota State University (SDSU; Approval number 00–A038).

We monitored adult and fawn deer for mortality 2–3 times per week from January 2001 to August 2002. We determined status of collared neonates daily until approximately 9 weeks post-capture, and 2–3 times per week thereafter. Cause of death was determined from field necropsy and ancillary evidence at the site of the mortality (White et al. 1987). If we could not determine cause of death in the field, we transported carcasses to the SDSU Animal Disease Research Diagnostic Laboratory (ADRDL) for further investigation. We collected lower incisors of adult deer, post-mortem, for aging by counting cementum annuli (Gilbert 1966).

We calculated annual and seasonal survival and cause-specific mortality using the Kaplan-Meier procedure (Kaplan and Meier 1958) modified for a staggered-entry design (Pollock et al. 1989). Adult seasonal survival rates were calculated at 3 intervals: January–April (post-hunt); May–August (pre-hunt); and September–December (hunt). We calculated fawn survival only for the post-hunt interval. Thereafter, they were incorporated into the adult age class. We calculated neonate survival rates monthly from June through August and for the 3-month summer season. Program CONTRAST (Sauer and Hines 1989) was used for survival-rate comparisons by year, age, and season for fawns and adults and by year, sex, and month for neonates. CONTRAST uses a chi-square statistic to test the composite hypothesis. We performed other statistical analyses using SYSTAT (Wilkinson 1990). We set alpha at ≤ 0.05, and used Bonferroni correction factors to maintain the experiment-wide error rate when multiple chi-square and *t*-tests were performed (Neu et al. 1974).

Results

We captured and radiocollared a total of 77 female deer >8 months old (61 adults, 16 fawns) and 39 neonates (17 male, 22 female). Fourteen adult and fawn mortalities occurred, including 6 harvested by firearms hunters, 3 vehicle collisions, 1 train collision, 1 feline predation, 1 disease (*Clostridium perfringens*-induced enteritis), and 2 unknowns (Table 1). Median age at death was 2.0 years ($n=12$) and ranged from 0.5–8.5 years.

Post-hunt adult survival was similar to post-hunt fawn survival during 2001 ($\chi^2_1=0.116$, $P=0.733$), and adult post-hunt survival was similar across years ($\chi^2_1=0.641$, $P=0.424$; Table 1). Due to small sample sizes, no comparisons were made with post-hunt fawn survival in 2002. Pooled fawn survival during the post-hunt interval was 0.94 ($n=16$, SE= 0.06). In 2001, adult survival was lowest during the hunt interval ($\chi^2_2=18.815$, $P<0.001$; Table 1).

Overall, 6 neonate mortalities occurred: 4 killed

Table 1. Survival rates and cause-specific mortality (%) of radiocollared female fawn and adult white-tailed deer in southwest Minnesota, 2001–2002.

Age of deer	Year	Survival interval[a]	Number at-risk	Survival rate	95% CI	Mortality (%) Hunting[b]	Vehicle	Train	Disease	Predator	Unknown
Fawn (7–12 months)	2001	Post-hunt	14	0.93	± 0.12				1 (100)		
	2002	Post-hunt	2	1.00	± 0.00						
Adult (>12 months)	2001	Post-hunt	44	0.95	± 0.06			1 (50)			1 (50)
		Pre-hunt	53	1.00	± 0.00						
		Hunt	51	0.80	± 0.05	6 (60)	3 (30)			1 (10)	
		Annual	56	0.77	± 0.11	6 (50)	3 (25)	1 (8)		1 (8)	1 (8)
	2002	Post-hunt	58	0.98	± 0.03						1 (100)
		Pre-hunt	56	1.00	± 0.00						
	Pooled	Overall	74	0.75	± 0.10	6 (46)	3 (23)	1 (8)		1 (8)	2 (15)

[a] Survival intervals = Post-hunt (Jan–Apr), Pre-hunt (May–Aug), Hunt (Sep–Dec), Annual (Jan–Dec 2001), Overall (Jan 2001–Aug 2002).

[b] Hunting mortality was similar to vehicle but greater than other mortality causes at *P* £ 0.05.

Table 2. Monthly survival rates and cause-specific mortality (%) of radiocollared neonate white-tailed deer in southwest Minnesota, 2001–2002.

Year	Survival interval (month)	Number at-risk	Survival rate	95% CI	Mortality (%)		
					Predation	Disease	Vehicle
2001	June	21	1.00	± 0.00			
	July	19	0.95	± 0.10			1 (100)
	August	18	1.00	± 0.00			
	Overall	21	0.95	± 0.10			1 (100)
2002	June	18	0.78	± 0.17	3 (75)	1 (25)	
	July	13	1.00	± 0.00			
	August	13	0.92	± 0.14	1 (100)		
	Overall	18	0.72	± 0.21	4 (80)	1 (20)	

by predators (67%; 2 coyote [*Canis latrans*], 2 unknown), 1 vehicle collision (17%), and 1 disease (17%; enteritis; Table 2). Neonate survival pooled across years was 0.90 ($n=39$, SE=0.05) at 4 weeks and 0.84 ($n=39$, SE=0.06) at 12 weeks post-capture. Summer survival of neonates was greater during 2001 than 2002 ($\chi^2_1=3.790$, $P=0.052$; Table 2). There was no difference in survival across months ($\chi^2_2=1.972$, $P=0.373$) or between sexes ($\chi^2_1=0.302$, $P=0.583$; male: 0.88, female: 0.81).

Discussion

Annual survival of adult and fawn female deer (76%) was similar to survival rates reported elsewhere for female white-tailed deer (65%–80%, Gavin et al. 1984, Fuller 1990, Nixon et al. 1991, Whitlaw et al. 1998, DePerno et al. 2000). Natural causes of mortality such as predation and disease (14%) were low relative to human-related causes (71%). Hunting was the greatest cause of mortality (43%), which is consistent with other northern white-tailed deer studies with limited antlerless harvest systems. Annual mortality in southern New Brunswick was 13%, with most adult female mortalities resulting from hunting (Whitlaw et al. 1998). Fuller (1990) reported hunting-related female mortality of 19% in north-central Minnesota, with other causes of mortality (e.g., illegal harvest, predation) minor relative to hunting. Dusek et al. (1992) noted that 74% of female deaths in Montana were attributed to hunting and only 8% were due to natural causes. In a mixed agricultural and forest landscape of southeast Minnesota, 86% of mortalities were hunter-related (Simon 1986). Vulnerability to mortality by human-related causes in intensively farmed areas was likely due to a well-established road network, high hunter density (Hansen et al. 1997), and the highly fragmented landscape with limited escape cover (Nixon et al. 1991).

The fawn and adult survival rate detected during this study was highest (1.0) during the pre-hunt period (May–Aug). Other studies have reported maximum survival during the summer months (0.90–1.0; Dusek et al. 1989, Fuller 1990, Nixon et al. 1991, Van Deelen et al. 1997, Whitlaw et al. 1998, DePerno et al. 2000). We concur with Nixon et al. (1991) that high summer survival was likely due to condensed home ranges, abundant food and cover (e.g., corn fields), and minimal human disturbance.

Neonate mortality in our study (16%) was lower than reported in similar habitat in Iowa (21%; Huegel et al. 1985), Illinois (30%; Nelson and Woolf 1987), and Missouri (33%; Bryan 1980). Furthermore, heavy neonate losses have been reported in Texas (72%, Cook et al. 1971), Colorado (66%, Whittaker and Lindzey 1999), New Brunswick (53%, Ballard et al. 1999), and South Dakota (40%, Benzon 1998). Several studies have shown predation to be the primary cause of mortality for neonates (Cook et al. 1971, Hamlin et al. 1984, Nelson and Woolf 1987, Whittaker and Lindzey 1999), and local and annual fluctuations in neonate survival have been attributed to variation in predator density (Beasom 1974, Stout 1982). Lower summer survival in 2002 (72%) compared to 2001 (95%) may be related to coyote density. However, we believe the high-pooled neonate survival (84%) observed was likely the result of relatively low predator density in the region. Brinkman (2003) reported that only 1 coyote was captured after 1,350 trap nights (1 trap set for 24 hours) in the same area in which neonates were captured. Both suspected coyote kills occurred in the same section of land in which the coyote was captured. In addition to low predator density, nutritional condition of dams (Verme and Ullrey 1984) due to readily abundant and highly nutritious food supplies in intensive agriculture areas (Gladfelter 1984, Nixon et al. 1991), and vegetation structure at neonate bedsites (Huegel et al. 1985, Benzon 1998) also may contribute to high neonate survival in farmland Minnesota. However, fawning habitat quality has not been evaluated in intensively farmed Minnesota, and effects on survival are speculative.

Management implications

Deer models in Minnesota are employed to determine the number of antlerless permits to allocate to maintain deer population goals within each permit area (Grund 2001). Minnesota Department of Natural Resources' Farmland Zone deer model has used educated guesses, rather than empirical data, to evaluate survival parameters incorporated into the model. Our study provided region-specific, empirical data that was previously absent, thus improving the simulated output of the model.

This study documented that adult and fawn female and neonate white-tailed deer populations have high survival in the intensively farmed region of Minnesota. The fact that hunting is the primary cause of mortality for adult and fawn deer validates the use of annual restricted harvest as the primary management tool to maintain deer populations within goal ranges.

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