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M. I. Tosa, M. T. Springer, E. M. Schauber, and C. K. Nielsen. Increased overwinter mortalities of white-tailed deer (*Odocoileus virginianus*) fawns during a drought year.

Abstract

Mortality rates of white-tailed deer (*Odocoileus virginianus* (Zimmerman, 1780)) fawns have been quantified throughout North America. Few studies, however, have assessed cause-specific mortality of fawns after the first 3 months of life or during a severe weather event. During 2010-2014, we captured and radiotracked 93 fawns in southern and central Illinois and recorded 18 mortality events. In order of importance, survival rates were affected by days since capture, year of drought, age at capture, week post-capture (1/0 indicator), and region. Estimated overwinter (fall through spring) survival rate ($\pm$ SE) of fawns in both regions during 2010-14 was 0.83 $\pm$ 0.04. However, estimated overwinter survival rates were depressed during 2012-13, following the severe drought of 2012 (0.63 $\pm$ 0.11 or 0.66 $\pm$ 0.11 depending on model). Main causes of mortality were capture-related and predation, though some dead deer also showed signs of hemorrhagic disease. We suspect that the extreme drought of 2012 created favorable conditions for fall-spring mortality of fawns, due to elevated disease transmission and lower forage quality and quantity for deer. In addition, drought may have contributed to predation by reducing abundance of alternative prey. Our results suggest that severe weather conditions during summer can substantially impact overwinter fawn survival.

Introduction

Accurate estimates of vital rates are important for understanding wildlife population dynamics and for species management. For white-tailed deer (*Odocoileus virginianus* (Zimmerman, 1780)), fawn production and survival rates are especially important to population dynamics (Fuller 1990; Hatter and Janz 1994; Gaillard et al. 1998; White and Lubow 2002). Much research has focused on neonatal fawn survival because young fawns are most susceptible to mortality, particularly predation by coyotes (*Canis latrans* (Say, 1823)), bobcats (*Lynx rufus* (Schreber, 1777)), black bears (*Ursus americanus* (Pallas, 1780)), and wolves (*Canis lupus* (L., 1758)) (Cook et al. 1971; Porath 1980; Nelson and Mech 1981; Epstein et al. 1983; Ballard et al. 1999; Rohm et al. 2007). More recently, research has focused on changes in young fawn survival due to the expansion of predator distributions to novel regions (Jackson and Ditchkoff 2013; Kilgo et al. 2014; Chitwood et al. 2015*a*, 2015*b*; Gulsby et al. 2015; Nelson et al. 2015). Other causes of neonatal mortality are abandonment, starvation, disease, parasites, and agricultural operations (Cook et al. 1971; Porath 1980). Typically, survival of fawns increases significantly following the first 8 weeks of life, as they become more mobile and can elude predators better (Carroll and Brown 1977; Nelson and Woolf 1987). Fawns > 6 months old often have mortality rates similar to adult females (Brinkman et al. 2004; Anderson et al. 2015). Therefore, few fawn mortality studies follow deer to the end of the first year.

Studies that have continued to monitor radiomarked fawns past the first 8 weeks of life have attributed older fawn mortalities to hunting, poaching, and vehicle collisions (Vreeland et al. 2004; Rohm et al. 2006; Burroughs et al. 2006; Hiller et al. 2007). Thus, another method for estimating deer vital rates is by analyzing deer harvest data (e.g., fawn-to-doe kill ratios, age structure of harvest). Although harvest data can provide general estimates of fawn survival rates,

these estimates can be constrained by limited hunter access and because hunters may be biased toward harvesting certain age and sex classes (Roseberry and Woolf 1991). Harvest data are also constrained to hunting seasons, which typically end in January when fawns are 6-7 months old, and fail to identify causes of mortality besides harvest.

Another knowledge gap regarding fawn survival is that few researchers have studied the effects of weather. Much of this research focuses on winter weather severity; for instance, Verme (1977) observed that winter weather severity was a negative indicator of fawn birth mass and survival the following summer, and DelGiudice et al. (2002) found that deer survival was negatively associated with winter severity, primarily snow depth. In contrast, spring and summer conditions could also affect subsequent overwinter survival of fawns. In particular, summer drought severity could decrease fawn growth rates. Toïgo et al. (2006) reported that drought intensity during the summer of birth decreased fawn body size and mass. These findings suggest that weather conditions, especially winter severity and drought severity, can significantly decrease deer recruitment. Still, none of these studies examine how drought affects deer vital rates. Moreover, since severe weather conditions are (by definition) rare, they are difficult to predict and study. Therefore, estimates of fawn survival in severe weather conditions would provide useful insight into deer population dynamics.

We examined overwinter (i.e., fall through spring) survival rates of white-tailed deer fawns in southern and east-central Illinois from 2010-2014, with a severe drought occurring in 2012. We predicted that fawn survival would be depressed following the drought. We report increased mortalities, especially due to predation and capture, following a severe drought year.

Study Area

As part of a larger project, we captured and collared juvenile white-tailed deer in 2

regions (southern and east-central Illinois, USA) from October to March during 2010 to 2014. The southern Illinois region consisted of 4 study areas (Johnson Farm, Touch of Nature Environmental Center, Crab Orchard National Wildlife Refuge, and Rend Lake). This region typically has hot humid summers and mild winters; mean monthly temperatures range from 32 C in July to -5 C in January, and annual precipitation average 120 cm (National Oceanic and Atmospheric Administration 2010). Study areas in southern Illinois are primarily oak-hickory forest with some residential and agricultural areas; bobcats, coyotes, and domestic dogs (*Canis lupus familiaris* (L., 1758)) are the primary predators of fawns in this region (Rohm et al. 2007). All study areas in southern Illinois were closed to hunting except for 4-day deer hunts for handicapped persons in November at Touch of Nature Environmental Center and Rend Lake.

The study area in east-central Illinois consisted of areas surrounding Lake Shelbyville. Mean monthly temperatures in range from 30 C in July to -8 C in January, and annual precipitation average 100 cm (National Oceanic and Atmospheric Administration 2010). This area is primarily row-crop agriculture with some developed land and forest (Anderson et al. 2013). The areas surrounding Lake Shelbyville are open to hunting, and primary causes of mortality of deer in this region are deer-vehicle collisions, coyotes, and hunter-related (harvest or wounding) (Anderson et al. 2015).

The state of Illinois experienced a severe drought during 2012 with greatest severity during May-August (Figure 1) – months corresponding to parturition and early fawn growth of white-tailed deer. Epizootic hemorrhagic disease (EHD) outbreaks occurred regionally during late summer and fall 2012 (Stallknecht et al. 2015). All other periods of the study experienced near-normal or above average precipitation (Figure 1) and low levels of EHD.

Material and methods

We used drop nets, rocket nets, and darts to capture deer during October to January of 2011-14 in southern Illinois and January to March of 2011-2014. Each captured deer was immobilized by intramuscular injection of 4mg/kg Telazol® (Fort Dodge Animal Health, Fort Dodge, Iowa, U.S.A.) and 2mg/kg xylazine HCl, ear-tagged, and aged as a fawn (ca. 0.5 yr old) by tooth replacement and wear (Severinghaus 1949). Fawns were equipped with a GPS collar (0.76 kg; TGW-4500; Telonics, Inc., Mesa, Arizona, USA or 0.83 kg; G2110E; Advanced Telemetry Systems, Inc., Minnesota, USA) or proximity logger collar (0.40 kg; E2 V1.0; SirTrack, Havelock North, New Zealand). GPS collars were programmed to record locations at least hourly, and for all collars, VHF mortality signals were emitted after 4 hours of inactivity. Effects of xylazine HCl were antagonized using 4 mg/kg tolazine HCl, and deer were observed until they were able to leave the capture area on their own. Deer unable to leave the capture area after several hours were euthanized, and necropsies were conducted at the laboratory.

We monitored collars daily during capture and weekly thereafter until collars detached. We programmed collars in southern Illinois to detach on 1 June each year; we released collars remotely via satellite communication in east-central Illinois in November each year. If we detected mortality signals, we attempted to recover the collar and carcass immediately. We conducted field necropsies and assessed site evidence to determine cause-specific mortality according to the criteria given by Garner et al. (1976) and Rohm (2005). Specifically, we looked for hemorrhaging in wounds to distinguish between scavenging and predation, and we considered caching behavior to be characteristic of bobcat predations. We also used the level of feeding on the carcass to distinguish between domestic dog and coyote predations. Mortalities that occurred within 7 days of capture were considered capture-related (Burroughs et al. 2006). Using these criteria, we classified causes of mortality into capture-related, vehicle collision,

predation, and unknown categories. We did not expect hunter-related mortality because trapping

occurred after the end of all hunting seasons. In addition, we noted any signs of hemorrhagic

disease such as sloughing of the hooves or splenomegaly. We calculated age at capture by

assuming fawns were born June 6, the peak of parturition in southern Illinois as reported by

Rohm (2005). Capture and sampling procedures were approved by the Institutional Animal Care

and Use Committee at Southern Illinois University Carbondale (Protocol 11-027).

All data analyses were conducted in Program R version 3.1.2 (R Core Team 2014).We

estimated the daily survival rate of collared fawns until 222 days after capture in the package

RMark (Laake 2013) using a known-fates survival estimator without staggered entry. All

encounter histories began the day of capture and were right-censored if alive when the collar

detached or if alive on 1 June (when fawns were considered yearlings). We formatted the data in

this way because staggered entry does not allow for coding time variables post-capture, merely

time from the beginning of the study. Since we were interested in modeling elevated mortality

risk during the first 7 days following capture in our survival estimates, entering all deer at

capture allows us to separate the first 7 days from the remainder of the study period. We

evaluated and ranked candidate models using Akaike's Information Criterion adjusted for small

sample sizes (AIC_C). We built models based on various biologically meaningful combinations of

the following predictor variables: sex, year (categorical), year of drought (1 for 2012, 0

otherwise), region, age at capture (days), quadratic effects of age at capture (i.e., [age at

capture]^2), myopathy window (1 during first 7 days after capture, 0 thereafter), and days since

capture. We also included two-way interaction effects between sex, drought, region, age at

capture, myopathy window, and days since capture. Note that we are using 3 temporal variables

to disentangle 3 different effects; 1) age effect is tested by days since capture to account for older

fawns that generally survive better, 2) individual heterogeneity ("frailty") effect is tested by age at capture to account for a biased sample of fawns in which frail fawns are underrepresented later in the study (Pollock et al. 1989), and 3) capture effect is tested by myopathy window to account for higher survival after the capture-myopathy window. Typically, the frailty effect is built into survival models using staggered entry, which we did not use. We modeled the quadratic effect of age at capture because we believed that survival may increase nonlinearly for fawns that were captured when they were older.

Models ≤ 2 ΔAIC_C were considered competitive (Burnham and Anderson 2010). Goodness-of-fit statistics are currently unavailable for known-fates models. Therefore, we performed a overdispersion sensitivity analysis of the variance inflation factor ($\hat{c}$); we iteratively adjusted $\hat{c}$ from 1 (no overdispersion) to 3 (extreme overdispersion) in increments of 0.25 and examined the resulting model selection output (Brasher et al. 2006).

Results

Over four trapping seasons, we collared 94 fawns (34 in southern Illinois, 60 in east-central Illinois; 49 F, 45 M) (Table 1). We recorded 19 mortalities (13 F, 6 M): nine capture-related, six predation events, two vehicle collisions, and two unknown. Three of the capture-related mortalities were caused by trauma (broken spine and major internal bleeding). Capture-related mortalities were most numerous in 2012-13 ($n = 6$), twice as many as all other years combined (1 in 2010-11; 2 in 2011-12, 0 in 2013-14). Based on a median parturition date of 6 June, fawns were 234 ± 4 days (mean $\pm$ SE) old at time of capture (southern Illinois: 186 ± 5 days, east-central Illinois: 260 ± 2 days). Bobcats were the most prominent predator, accounting for four predation events. Coyotes and domestic dogs each accounted for one predation mortality. Only fawns that died during 2012-13 showed signs of disease ($n = 3$): one had splenomegaly,

one had white mucosal nodules in the spleen, and one had sloughed hooves. Two of these fawns were unable to recover from chemical immobilization and were euthanized.

Assuming no overdispersion, all competitive survival models included both days since capture and year of drought, and all but one model also included age at capture and myopathy window (Table 2). As we adjusted ĉ from 1 to 3, the top survival models changed considerably, indicating that model selection was sensitive to presence and level of overdispersion (which are unknown). Three models, however, consistently performed ≤2 $\Delta QAIC_C$ under all values of ĉ (Table 3 and 4). All 3 consistently competitive models included days since capture and year of drought, two included age at capture, two included myopathy window, and one included region. Survival increased with increasing days since capture ($\beta_{DaysCapt} = 0.03 – 0.05$), survival was lower during the drought year ($\beta_{Drought} = -1.14 – -1.39$), and survival was greater for fawns that were captured when older ($\beta_{AgeCapt} = 0.01 – 0.01$) (Figure 2). Survival increased following the first 7 days after capture ($\beta_{MyopWind} = 0.93 – 0.96$) and was higher in east-central Illinois ($\beta_{Region} = 1.19$). Overall, estimated fawn survival ± SE from day of capture to 222 after capture was 0.83 ± 0.04. Parameter estimates indicate a consistent pattern across models of daily mortality risk being 3-4 times greater (relative risk ratio) during the drought year than all other years (Table 4), resulting in substantially lower estimates of overwinter survival following the drought (Table 5). In competitive models that included a difference between regions, overall estimated survival rate was lower for fawns in southern than in east-central Illinois (Table 5).

Discussion

Studies of fawn mortality have generally found low mortality rates, especially due to predation, after 8 weeks of age. Here, we report generally low mortality rates of fawns, but unusually high fall-spring mortality rates (relative risk 3-4 times greater) of fawns born in the

drought year, 2012. Most of these fawns either died shortly after capture or were confirmed or likely killed by predators, and some showed signs of disease (spleen pathology and sloughed hooves consistent with EHD). Frequent predation mortalities have only been observed in neonatal fawns in this area (Rohm et al. 2007). In studies of fawns >8 weeks old, however, predation events were rare: out of 91 radiotracked fawns during 2002 – 2004 in southern Illinois (Rohm et al. 2006) and 68 radiotracked fawns during 2006 – 2010 in east-central Illinois (Schauber and Nielsen 2010), just three predation events were reported. Overwinter survival rates of fawns during the other three study years (0.88 – 0.89) were similar to those reported by Anderson et al. (2015; 0.85), Ballard et al. (1999; 0.86), Wickham et al. (1993; 0.85), Storm et al. (2007; 0.87), and Vreeland (2002; 0.87 – 0.89). Survival estimates specific to southern Illinois during non-drought years (0.77) were similar to those in other studies in southern Illinois (0.73; Rohm et al. 2006) and Minnesota (0.76; Brinkman et al. 2004). These regional differences in survival rates could reflect differences in dominant landscape (forest vs. agriculture).

We expected age at capture to be an important variable for survival because we did not use a staggered entry approach to analyze survival data. Staggered entry accounts for differences in underlying survival probability among individuals (i.e., individual "frailty") that cause survival rate to be biased upward by data from animals captured later in a vulnerable period (i.e., underrepresentation of frail animals that die early and therefore are unavailable for inclusion in the study; (Pollock et al. 1989). As such, we found evidence for lower survival for fawns captured when they were younger. We also expected days since capture to be an important variable; younger fawns are more vulnerable to mortality because they are typically smaller and still growing (Halls 1984). The consistent positive effect of after myopathy window on fawn survival highlights the vulnerability of fawns to mortality within the first week after capture.

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We suspect that the high fawn mortality rate we observed from fall 2012 through spring 2013 can be attributed to severe drought during the summer of 2012 (Illinois Department of Natural Resources 2013). Drought conditions decrease forage quantity and quality (Singer et al. 1989) that, especially during and following parturition, can result in smaller and weaker fawns (Knowlton 1976; Toïgo et al. 2006). In addition, drought conditions are associated with enhanced transmission of EHD; drought may force animals to congregate around remaining water sources while promoting reproduction of vector midges (Dubay et al. 2004; Calzolari and Albieri 2013). Considering the rapid progression of acute EHD (Savini et al. 2011) and the time of year the deer died in our study, we conclude that fawns that showed signs of infection were likely recovering from chronic forms of the disease. Undoubtedly, recovering deer (fawns or their mothers) experience additional nutritional and physical stress, which may lead to smaller and weaker fawns (Wobeser 2006) more vulnerable to predators.

Coyotes and bobcats are the primary fawn predators in our study regions, but the large number of predations by bobcats (67% of all predations) was unexpected. Even for neonatal fawn mortalities, bobcats account for only a small proportion of predations (7.0 - 12.5%; Ballard et al. 1999, Vreeland et al. 2004, Kilgo et al. 2012, Nelson et al. 2015). Bobcat densities in southern Illinois were relatively high over 10 years ago (27 – 34 bobcats/100 km^2; Nielsen and Woolf 2001), but have increased dramatically since then (Bluett 2013), which may elevate predation pressure on older fawns. Moreover, the impact of drought on predators may compound the effects of drought on fawns. Alternative prey populations of coyotes and bobcats, such as small mammals, may become scarce months after a severe drought (Nelson 1993; Merritt et al. 2001), and predators often change their food habit responses in relation to prey abundance (Beasom and Moore 1977). Although deer typically compose only a small portion of bobcat diets

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(7-9% occurrence; (Woolf and Nielsen 2002) and a small portion of fawns are depredated by bobcats (Kilgo et al. 2012), bobcats may focus on deer when other prey are scarce (Beasom and Moore 1977). Prey switching behavior has also been observed in coyotes in years with below average precipitation (Knowlton 1976). This switch in prey species may account for increased predation, especially by bobcats, on older fawns that may already be weakened by the drought and disease.

It should be noted that capture myopathy and drought may have contributed to the mortalities observed in this study. We expect, however, that capture myopathy would occur during all years of the study. All carcasses were examined for gross signs of capture myopathy (i.e., striations in muscle tissue; Beringer et al. 1996), but none were observed. Still, we documented nine mortalities occurring shortly after capture. In east-central Illinois, we recorded three capture-related mortalities during the year of the drought, but ≤ 1 capture-related mortality during each of the other years of the study; in southern Illinois, we recorded three capture-related mortalities during the year of the drought, but only a total of two capture-related mortalities during all other years of the study. The additional stress related to the drought may have caused this increase in capture-related mortality without causing any detectable signs of capture myopathy. Moreover, predators in southern Illinois may have capitalized on fawns with diminished capacity to evade predators due to the aftereffects of capture, which may include lower daily movement rates (Dechen Quinn et al. 2012). Thus, we expected the interaction between drought and myopathy window due to capture to be an important variable in survival. This interaction was among the top competitive models that assumed no overdispersion, but did not perform consistently well in the overdispersion sensitivity analysis. Therefore, we cannot state with confidence that vulnerability to capture-related mortality was greater during the

drought year.

Overdispersion of ecological data is not uncommon. A possible reason for overdispersion in our data could be that we did not account for fawn mass, body condition, or disease status. Instead, we used age at capture as an indicator of fawn mass. Fawn masses were not recorded during capture because historical patterns indicated that fawns would have similar overwinter survival as adult females (Carroll and Brown 1977; Nelson and Woolf 1987). Another possible reason for overdispersion could be that we did not observe enough mortalities to disentangle the different factors impacting survival. By conducting the sensitivity analysis, we reduced our chances of selecting overly complex models and improved inference by selecting more parsimonious models with support across a range of overdispersion magnitudes (Richards 2007).

Management Implications

Deer population projections are often based on the assumption of relatively high survival of fawns after their first hunting season. Our results indicate that assumption can sometimes fail. With increasingly variable and extreme weather patterns in temperate regions due to climate change (Seneviratne et al. 2012), increasing predator populations (Bluett 2013), and novel predator communities due to recolonization and expansion of predator ranges into novel habitats (Gompper 2002; LaRue and Nielsen 2016; Smith et al. 2016), wildlife managers should be aware that historical patterns (e.g., similar overwinter survival in fawns and adult females) may no longer hold true. These interacting environmental trends indicate that periodic research to update estimates of age-specific survival may be needed to responsively manage deer populations.

Acknowledgements

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Table 1.— White-tailed deer (*Odocoileus virginianus* (Zimmerman, 1780)) fawns captured and collared in southern and east-central Illinois from fall through spring (Oct – Jun) of 2010-14. Number of mortalities listed in parentheses.

Year*	Sex	Southern Illinois	East-central Illinois	Total
2010	Female	0	16 (2)	16 (2)
	Male	0	10 (1)	10 (1)
2011	Female	6 (2)	1 (0)	7 (2)
	Male	0	12 (0)	12 (0)
2012	Female	7 (6)	7 (2)	14 (8)
	Male	3 (1)	6 (1)	9 (2)
2013	Female	9 (1)	3 (0)	12 (1)
	Male	9 (2)	5 (1)	14 (3)
Total		34 (12)	60 (7)	94 (19)

*Year reflects the year in which the fawns were born

Table 2.— Top models evaluated for survival (S) of white-tailed deer (*Odocoileus virginianus* (Zimmerman, 1780)) fawns in southern and east-central Illinois from fall through spring (Oct – Jun) of 2010-14. Models were ranked according to ΔAICc.

Model number	Model	K	AIC$_c$	ΔAIC$_c$	w_i	Deviance
8	S(~MyopWind + Drought + AgeCapt + DaysSinceCapt)	5	231.07	0.00	0.13	221.06
5	S(~Drought + AgeCapt + DaysSinceCapt)	4	231.67	0.60	0.09	223.67
12	S(~MyopWind:Drought + MyopWind + Drought + AgeCapt + DaysSinceCapt)	6	232.11	1.04	0.07	220.10
10	S(~MyopWind:AgeCapt + MyopWind + Drought + AgeCapt + DaysSinceCapt)	6	232.38	1.31	0.07	220.38
11	S(~MyopWind:Drought + MyopWind:AgeCapt + MyopWind + Drought + AgeCapt + DaysSinceCapt)	7	232.56	1.49	0.06	218.55
9	S(~Drought:AgeCapt + MyopWind + Drought + AgeCapt + DaysSinceCapt)	6	232.60	1.53	0.06	220.59
14	S(~Sex + MyopWind + Drought + AgeCapt + DaysSinceCapt)	6	232.87	1.80	0.05	220.86
17	S(~MyopWind + Region + Drought + DaysSinceCapt)	5	232.96	1.89	0.05	86.52
4	S(~MyopWind + Drought + AgeCapt + Age2 + DaysSinceCapt)	6	233.03	1.96	0.05	221.02
13	S(~Region + MyopWind + Drought + AgeCapt + DaysSinceCapt)	6	233.06	1.99	0.05	221.05
6	S(~Drought:AgeCapt + Drought + AgeCapt + DaysSinceCapt)	5	233.09	2.02	0.05	223.08
16	S(~Region + Drought + DaysSinceCapt)	4	233.38	2.31	0.04	88.95
15	S(~Sex + Drought + AgeCapt + DaysSinceCapt)	5	233.50	2.43	0.04	223.49
3	S(~Drought + AgeCapt + Age2 + DaysSinceCapt)	5	233.60	2.53	0.04	223.59
7	S(~Region + Drought + AgeCapt + DaysSinceCapt)	5	233.64	2.57	0.03	223.63
2	S(~AgeCapt + DaysSinceCapt)	3	234.68	3.61	0.02	228.68
18	S(~Global additive)	10	240.49	9.42	0.00	220.47
19	S(~Global with interactions)	16	246.13	15.06	0.00	214.07
1	S(~1)	1	275.12	44.05	0.00	86.02

Table 3.— Summary of overdispersion sensitivity analysis of competitive models assuming no overdispersion. Variance inflation factors were adjusted from 1 (no overdispersion) to 3 (extreme overdispersion) in increments of 0.25.

Model number	Model	K	≤ 1 ΔAIC_c	≤ 2 ΔAIC_c	≤ 3 ΔAIC_c	Total models
5	S(~Drought + AgeCapt + DaysSinceCapt)	4	9	0	0	9
8	S(~MyopWind + Drought + AgeCapt + DaysSinceCapt)	5	7	2	0	9
17	S(~MyopWind + Region + Drought + DaysSinceCapt)	5	0	8	1	9
12	S(~MyopWind:Drought + MyopWind + Drought + AgeCapt + DaysSinceCapt)	6	0	4	5	9
9	S(~Drought:AgeCapt + MyopWind + Drought + AgeCapt + DaysSinceCapt)	6	0	3	6	9
10	S(~MyopWind:AgeCapt + MyopWind + Drought + AgeCapt + DaysSinceCapt)	6	0	3	6	9
4	S(~MyopWind + Drought + AgeCapt + Age2 + DaysSinceCapt)	6	0	2	7	9
13	S(~Region + MyopWind + Drought + AgeCapt + DaysSinceCapt)	6	0	2	7	9
14	S(~Female + MyopWind + Drought + AgeCapt + DaysSinceCapt)	6	0	2	7	9
11	S(~MyopWind:Drought + MyopWind:AgeCapt + MyopWind + Drought + AgeCapt + DaysSinceCapt)	7	0	2	7	9

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Table 4.— Parameter estimates of survival models of white-tailed deer (*Odocoileus virginianus* (Zimmerman, 1780)) fawns in southern and east-central Illinois from fall through spring (Oct – Jun) of 2010 – 2014 that consistently performed well in the overdispersion sensitivity analysis.

Model number	Model	Intercept	Days since capture	Age at capture	Myopathy window	Region	Year of drought (2012)
5	S(~Drought + AgeCapt + DaysSinceCapt)	1.89	0.049	0.014			-1.14
8	S(~MyopWind + Drought + AgeCapt + DaysSinceCapt)	2.52	0.034	0.014	-0.96		-1.15
17	S(~MyopWind + Region + Drought + DaysSinceCapt)	4.98	0.035		-0.93	1.192	-1.40
	Average	3.13	0.040	0.014	-0.95	1.192	-1.23

Table 4.— Ranges for estimated survival rates (95% CI) of white-tailed deer (*Odocoileus virginianus* (Zimmerman, 1780)) fawns in southern and east-central Illinois from fall through spring (Oct – Jun) of 2010 – 2014 for survival models that consistently performed well in the overdispersion sensitivity analysis.

Model number	Normal years			Drought year		
	Both regions	Southern	East-Central	Both regions	Southern	East-Central
5	0.88 (0.78 – 0.93)			0.66 (0.43 – 0.83)		
8	0.88 (0.78 – 0.94)			0.66 (0.43 – 0.83)		
17		0.77 (0.58 – 0.89)	0.92 (0.83 – 0.97)		0.35 (0.15 – 0.63)	0.72 (0.48 – 0.88)

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Figure 1. Monthly Palmer Drought Severity Index values 2010-14 (NOAA 2016) from (A) Illinois climate division 8 (which contains Carbondale, Illinois and most of our southern study areas) and (B) Illinois climate division 7 (which contains Lake Shelbyville and our east-central Illinois study areas). Strongly negative values in May-August 2012 indicate severe drought.

Figure 2.— Daily survival estimates of white-tailed deer (*Odocoileus virginianus* (Zimmerman, 1780)) fawns in Illinois from fall through spring (Oct – Jun) of 2010 – 2014 by age at capture, myopathy window (black = after myopathy window, grey = myopathy window), and drought (dashed = drought year, solid = other years) in the best survival model (model 8).