Seasonal reproductive costs contribute to reduced survival of female greater sage-grouse.

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ABSTRACT

Tradeoffs among demographic traits are a central component of life history theory. I investigated tradeoffs between reproductive effort and survival in female greater sage-grouse breeding in the American Great Basin. The two primary questions I approached this research with included 1) do females that successfully hatch nests and raise broods have lower survival than their unsuccessful counterparts, and 2) what are the seasonal and annual patterns in survival in this study system. I analyzed survival and reproductive histories from 328 unique female sage-grouse captured between 2003 and 2011 using a combination of known fate survival and multistate capture-mark-recapture analyses. Using these methods, I estimated monthly and annual survival rates and examined the effect of reproductive effort on survival. I conducted all analyses in Program MARK, and used AIC hypothesis testing to evaluate support for my competing models based on a criteria that models > 2.0 ΔAIC did not receive sufficient support from the data to be considered competitive. My model selection results suggested that survival varied among biological seasons, and between successful and unsuccessful females, but did not vary among years (Table 1). Annual rainfall patterns also influenced spring and fall survival rates (Table 1). Monthly survival was greatest during the winter (November – March; $\Phi_W = 0.99 \pm 0.001$ SE), and summer (June – July; $\Phi_S = 0.98 \pm 0.01$ SE), and lower during nesting (April – May; $\Phi_N = 0.93 \pm 0.02$ SE) and fall (August – October; $\Phi_F = 0.92 \pm 0.02$ SE). Females who hatched nests and successfully raised broods to 35 days of age had lower monthly survival during the summer and fall, respectively. This effect was greatest during fall. Females that

successfully fledged chicks had lower annual survival (0.47 ± 0.05 SE) than females who were not successful (0.64 ± 0.04 SE). Annual survival did not vary across years, consistent with a slow-paced life history strategy in sage-grouse (Fig. 1). Female sage-grouse incur costs to survival associated with reproduction. In addition to having relevance for sage-grouse life history strategies, these results may be relevant for conservation because high-quality breeding females are removed from the population at a greater rate than their low-quality counterparts.

Table 1. Performance of known fate models of female greater sage-grouse monthly survival (Φ) in Eureka Co., NV, based on radio-telemetry data collected from 2003-2011.

Model[a]	ΔAIC_c	w_i	K
Season + Nest(Summer) + Brood(Fall) + Rain(Fall)	0.00	0.20	7
Season + Nest(Summer) + Brood(Fall) + Rain(Fall) + Rain(Nesting)	0.46	0.16	8
Season + Nest(Summer) + Brood(Fall)	0.76	0.14	6
Season + Nest(Summer) + Brood(Fall) + Rain(Nesting)	1.22	0.11	7
Season + Brood(Fall)	1.27	0.11	5
Season + Nest(Summer) + Brood(Fall) * Rain(Fall)	1.95	0.08	8
Season + Nest(Summer)*Rain(Nesting) + Brood(Fall) + Rain(Fall)	2.00	0.07	9
Season + Nest(Summer) + Brood(Fall) + Rain(Winter)	2.45	0.06	7
Season + Nest(Summer) + Brood(Fall) + Rain(Summer)	2.75	0.05	7
Season + Nest(Summer)	7.19	0.01	5
Season + Nest(Fall)	7.39	0.01	5
Season	7.70	0.00	4
Season + Brood(Nesting)	8.01	0.00	5
Season + Nest(Nesting)	9.65	0.00	5
Season + Brood(Winter)	9.66	0.00	5
Season + Nest(Winter)	9.71	0.00	5
Month	12.54	0.00	9
Year + Season	18.80	0.00	12
Year + Month	23.67	0.00	17
Null	38.00	0.00	1
Age	39.35	0.00	2
Age^2	41.32	0.00	3
Year	48.77	0.00	9

[a] Season = Nesting (April, May), Summer (June, July), Fall (August – October), Winter (November – March); Year = Study year, 2003-2011; Month = Calendar month. Age = Minimum known age since capture; Nest = Effect of nest success on subsequent survival; Brood = Effect of brood success on subsequent survival; Rain = annual rainfall from August 1 to July 31 during the previous year. The effects of Rain, Nest, and Brood were applied to specific seasonal intervals, as indicated within parentheses.
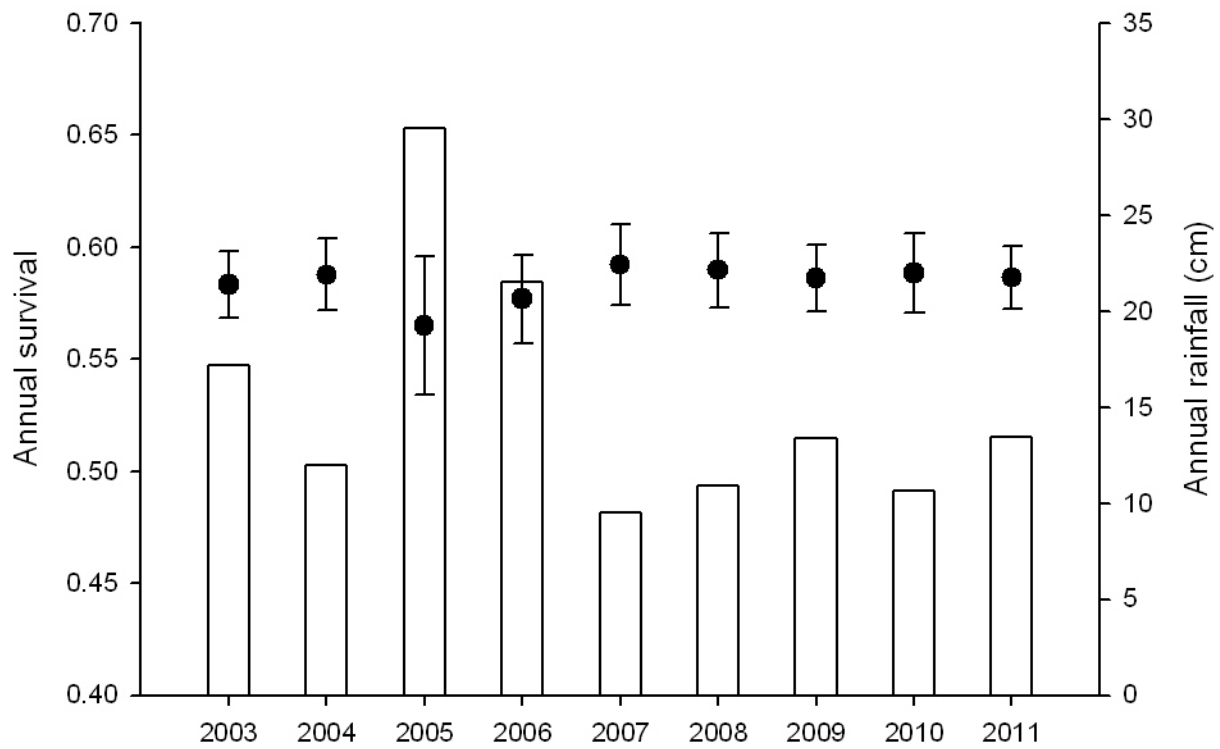
Figure 1. Annual survival of female greater sage-grouse (closed circles; error bars represent SE) compared with annual levels of precipitation (open bars) in Eureka County, NV, from 2003 to 2011.