Impacts of Predation on Greater Sage-grouse in Strawberry Valley, Utah

Rick J. Baxter
Brigham Young University
Provo, Utah

Kevin D. Bunnell
Utah Division of Wildlife Resources
Salt Lake City, Utah

Jerran T. Flinders
Brigham Young University
Provo, Utah

Dean L. Mitchell
Division of Wildlife Resources
Salt Lake City, Utah

Introduction

In March 1998, we began to study a population of greater sage-grouse in Strawberry Valley of northcentral Utah. This population decreased from between 3,000 and 4,000 birds in 1939 (Griner 1939) to an estimated 150 birds in 2000. The goal of our research was to identify factors limiting the population and to recommend measures to mitigate or eliminate those factors. Initial work with radio-collared sage-grouse showed predation by red fox (*Vulpes vulpes*), a nonnative predator, as one of the major limiting factors contributing to decreased survival and nest success.

Kamler and Ballard (2002) documented the expansion of native and nonnative red foxes across North America in the 1900s. Their estimates of the arrival of the nonnative red fox to Utah are consistent with information from on-the-ground wildlife professionals. Kendall Nelson and Alden Thomas, former Utah Division of Wildlife Resources (UDWR) employees, spent extensive time in Strawberry Valley between 1966 and 1980 and never encountered a red fox (K. D. Bunnell, personal communication 2000). During personal interviews,

Blaine Dabb, a UDWR conservation officer (early 1980s to1999), and S. Dick Worthen, a retired UDWR biologist (1971 to 1987), who both worked extensively in the area, indicated that they began seeing red fox commonly in Strawberry Valley by the mid-1980s (K. D. Bunnell, personal communication 2000).

The negative impact that introduced foxes can have on many different species of bird populations is well documented (Petersen 1982, Bailey 1993, Sargeant et al. 1998). Only two published studies (Gregg 1991, Gregg et al. 1994) have implicated predators as a limiting factor to sage-grouse populations. In both instances, unusually high predation rates on nesting females were attributed to poor habitat conditions. In addition, a recent study in Wyoming failed to demonstrate an increase in nesting success following coyote (*Canis latrans*) control (Slater 2003), reinforcing the opinion that predation is not a widespread factor limiting sage-grouse populations. Although marginal habitat may be the leading cause of poor reproductive success and mortality, scale and habitat contiguity may be more important than values of canopy cover or grass height. In Europe, where habitats are isolated, small and fragmented (Andren and Angelstam 1988), predator control has been effective in increasing nest success, juvenile survival and population size (Parker 1984, Marcstrom et al. 1988, Moss 1994) of other tetraonids. The Strawberry Valley study area is highly fragmented with large amounts of edge for predators. Cote and Sutherland (1997) showed that removing predators from bird populations increased hatching success and postbreeding population size, but it did not increase overall breeding population size. In addition, Mezquida et al. (2006) warned that predator control has the potential for both positive and negative direct and indirect effects that must be analyzed prior to initiation of control. Although the impacts of red fox predation on sage-grouse rangewide are largely unknown, the site-specific effect on sage-grouse survival in Strawberry Valley will be reported.

Our objectives were to (1) compare survival estimates of adult and juvenile sage-grouse in Strawberry Valley, Utah before (1998 to 1999) and after (2000 to 2005) predator control was initiated, (2) compare brood counts pre- and postcontrol and (3) report values of horizontal obscurity cover associated with resident locations in summer habitat.

Study Area

The study area is centered in Strawberry Valley of northcentral Utah. The area is a high mountain valley 2,460.63 to 2,679.35 yards (2,250–2,450 m),

and receives about 22.83 inches (58 cm) of precipitation annually. Strawberry Reservoir is the dominant feature of the valley covering up to 2,812.57 acres (6,950 surface ha). Within the valley, there are approximately 3,621.94 acres (8,950 ha) of sagebrush-grass habitat that primarily borders the reservoir (Utah Reclamation Mitigation and Conservation Commission and U.S. Forest Service 1997). Mountain big sagebrush (*Artemisia tridentata vaseyana*) is the dominant shrub, with silver sagebrush (*Artemisia cana)* found in wet meadows and riparian corridors.

Methods

We trapped sage-grouse during March, April and May of 1998 through 2005 using the spotlighting method (Wakkinen et al. 1992). A necklace style radio transmitter, with mortality signal, was attached to sage-grouse of both sexes (Marcstorm et al. 1989).

Radio-collared sage-grouse were located and flushed on a weekly basis throughout the spring and summer (April 1 through August 31) to monitor survival and to measure habitat parameters. Daily survival estimates were calculated using the Mayfield estimator (Mayfield 1975). The midpoint between the last date a bird was known to be alive and the date it was found dead was used to determine the number of exposure days for calculating daily survival. We limited daily survival estimates to spring and summer because, during the 7 years of the study, 75 percent of total sage-grouse mortality and 80 percent of predation mortality occurred between April 1 and August 31. Sage-grouse that could not be located or that had radio transmitters that malfunctioned were right censored and excluded from the sample.

When we found a dead sage-grouse, the condition of the remains was examined to determine the cause of death, specifically whether the death occurred from mammalian or avian predation or from other causes (e.g., power lines, human interaction, accidents, sickness, etc). If bones and feathers were broken or matted (i.e., chewed), death was attributed to mammalian predation. If it was determined that a mammalian predator was responsible for the death of a particular bird, the area was examined for hair, scat, tracks or evidence of a den in an attempt to determine the species responsible. If feathers were intact and appeared to have been plucked or if only the breast was eaten, then death was attributed to avian predation. If a substantial amount or the whole bird remained,

we submitted them to the Utah State Diagnostic Laboratory in Nephi, Utah, for necropsy. If there was an insufficient amount of evidence or information at the mortality site, the cause of death was designated unknown.

Reproductive success was measured by the ratio of chicks to hens during July and August brood counts from 1999 to 2005 (Connelly et al. 2003). Brood counts were conducted using trained German shorthair pointers to locate and flush both collared and uncollared sage-grouse hens throughout the study area. During July and August, chicks were developed enough to flush with hens but were still easily identified.

Horizontal obscurity cover, the habitat characteristic that likely has the greatest influence on predation (Gregg 1991, Gregg et al. 1994, DeLong et al. 1995), was measured at adult flush sites using a 0.84-square-yard (1-m^2) cover board stratified into thirds (0.00 to 13.11 inches [0–33.3 cm], 13.11 to 26.22 inches [33.3 –66.6 cm] and 26.22 to 39.37 inches [66.6–100 cm]) along the vertical axis with each stratification separated into 12 equal squares. Horizontal obscurity cover measurements were taken from a height of 10 to 14 inches (25.40 to 35.56 cm) at 2.73, 5.47 and 10.94 yards (2.5, 5 and 10 m) from the cover board in four directions.

Predator control efforts in Strawberry Valley began in 1999 and continued through 2005. Initial control efforts in 1999, by personnel from the U.S. Department of Agriculture, Animal and Plant Health Inspection Services, Wildlife Services (WS), were limited to aerially gunning from one fixed-wing aircraft flight and limited ground searches on, near and around the sage-grouse lek. From 2001 to 2002, WS expanded their control efforts spatially, by covering most of the sage-grouse habitat in Strawberry Valley and, temporally by increasing the frequency and timing of fixed-wing aircraft and helicopter flights followed by multiple ground searches to locate foxes, fox dens and other mammalian predators (i.e., coyote, badgers [*Taxidea taxus*] and skunks [*Mephitis mephitis*]). Active fox dens were readily identified from these aircraft by the presence of soil on top of the snow. WS subsequently treated active fox dens at the request of the UDWR with a large gas cartridge (Environmental Protection Agency registration number 56228-21). Also, beginning in 2003, WS broadened their efforts again by using leg-hold traps for terrestrial predators and poison egg baits for avian predators (corvid species). During 2003 through 2005, the overall predator control effort reached its highest point as aerial gunning, gassing dens, site-specific shooting and trapping, and weekly poison egg baits were used to protect sage-grouse of all ages. In addition to the aforementioned

control by WS personnel, ground hunting and gassing dens by volunteers was used to remove and disrupt breeding of resident red foxes throughout the study area. Control was timed to kill as many red foxes as possible prior to breeding and, thus, to reduce fox densities and predation on sage-grouse before and during the lekking, nesting and brood-rearing seasons because our data indicated that this was when the majority of sage-grouse mortality occurred.

We used a chi-square test for homogeneity of proportions in a two-by-two table for pre- and postcontrol mortality rates. We considered results significant at an alpha-level of 0.05.

Results

Over the 8-year duration of the study, 160 resident sage-grouse were monitored to determine spring-summer survival rates. Combined spring-summer survival of sage-grouse radio-collared in 1998 (no red fox control) and 1999 (limited red fox control) was 43.6 percent using a Mayfield estimator (Mayfield 1975). Comparatively, spring-summer survival of sage-grouse during and after red fox control was expanded (2000–2005) averaged 67.8 percent. A chi-square test showed a significant difference (Pearson's chi-square statistic 20.95, with d.f. 1, P is less than 0.00001) between pre- and postcontrol mortality rates. Percent of overall mortality due to predation by red fox decreased from 68 percent in precontrol years to 54 percent in postcontrol years (Table 1). Of predation-related mortality, 87 percent was attributed to canids (Table 1).

During brood counts in 1999, prior to expanded predator control, we counted 12 chicks with 44 hens for a chick to hen ratio of 0.27, compared to an average chick to hen ratio of 0.72 for 2000 to 2005, after predator control was implemented (Table 2). We also documented an increase in the overall numbers of chicks and hens flushed during the brood-rearing season.

Horizontal obscurity cover from ground level to a height of 13.11 inches (33.3 cm) at 2.73 yards (2.5 m) from the nest (n = 22, where n represents the number of nests) or the adult flush site (n = 126, where n represents the number of male or female summer locations) was 99.3 percent and 97.1 percent respectively. Horizontal cover from 5.47 and 10.94 yards (5 and 10 m) at both the nest and adult flush sites totaled 100 percent.

In 1999, 24 active fox dens were located and treated with gas cartridges, and 5 foxes were killed through air and ground hunting, primarily from the area around the sage-grouse lek. During 2000 to 2005 an average of 26 fox dens were

Table 1. Spring-summer sage-grouse survival, percent mortality due to predation and percent predation due to canids and avian predation in Strawberry Valley, Utah, 1998 to 2005.

	Sage-grouse		Percent mortality	Percent predation by species	
	Monitored	Survival	due to predation	Canid/Red fox	Avian
1998[a]	21	0.384	0.92	0.92	0.08
1999[b]	22	0.484	0.42	0.8	0.2
2000	12	0.836	0.00	0	0
2001	27	0.636	0.75	0.83	0.17
2002	18	0.751	0.50	0.5	0.5
2003	14	0.777	0.33	1	0
2004	17	0.814	0.67	1	0
2005	29	0.862	0.50	1	0
Average	20	0.679	0.61	0.87	0.13

[a] no predator control

[b] limited predator control

Table 2. Summary of sage-grouse reproductive success measured through summer brood counts in Strawberry Valley, Utah, from 1999 to 2005.

	Hens	Chicks	Chick to hen ratio
1999[a]	44	12	0.27
2000	19	29	1.53
2001	38	9	0.24
2002	48	39	0.81
2003	12	11	0.92
2004	60	78	1.30
2005	171	86	0.50
Total	392	264	0.67

[a] limited predator control

treated with gas cartridges and 20 foxes were killed through aerial gunning and ground hunting-trapping throughout Strawberry Valley (Table 3). Red foxes are still found throughout the Strawberry Valley, so control efforts that focus only on sage-grouse habitat will never be effective in eliminating them there. We do not know if the density of red fox outside of core sage-grouse habitat is the same as fox density within the sage-grouse use areas.

Discussion

In our opinion, the red fox was not a causative factor in the early decline of the sage-grouse population in Strawberry Valley. It is likely that habitat loss

Table 3. Summary of predator control efforts to protect sage-grouse in Strawberry Valley, Utah.

	Red fox dens treated[b]	Red foxes killed	Other mamalian predators removed[c]	Estimated number of ravens removed[d]
1999[a]	24	5.0	19.0	0.0
2000	34	1.0	25.0	0.0
2001	25	12.0	48.0	0.0
2002	18	6.0	19.0	13.0
2003	10	32.0	33.0	75.0
2004	52	31.0	63.0	137.0
2005	5	35.0	37.0	150.0
Average	24	17.4	34.9	53.6

[a] control limited to the area around the sage-grouse lek

[b] This represents the number of active dens treated with a gas cartridge, where tracks, scat, fresh dirt or other fresh sign demonstrated current activity.

[c] Other mammalian predators included coyotes, badgers, skunks and racoons.

[d] Values reflect limited aerial and ground shooting; a large percentage of data comes from a U.S. Department of Agriculture, Animal and Plant Health Services, Wildlife Services estimate of one raven killed per four poison egg baits administered.

was the major cause of the original population reduction. In Strawberry Valley, 10,007.77 to 14,999.30 acres (4,050–6,070 ha) of sage-grouse habitat were treated to reduce sagebrush cover and increase forage for livestock (Utah Reclamation Mitigation and Conservation Commission and U.S. Forest Service 1997). In addition, Strawberry Reservoir was expanded in 1985 from 8,673.40 acres (3,510 ha) to its current size of 17 ,173.82 acres (6,950 ha), flooding 8,500.43 acres (3,440 ha) of sage-grouse habitat. In spite of this loss, some available and apparently suitable habitat is currently unoccupied by sage-grouse (Bunnell et al. 2004). Although red foxes were likely not responsible for the initial reduction in the sage grouse population, our data suggest that red fox predation is a major factor limiting the recovery of the population and, if left uncontrolled, threatens extirpation of this sage-grouse population.

Sage-grouse survival rates in Strawberry Valley during 1998 and 1999 are below the levels reported in other studies (Connelly et al. 1994, Zablan 1993; Table 1), and reproduction-recruitment for 1999 was only a fraction of the recommended guideline for a stable or increasing population (Connelly et al. 2000) (Table 2). We know many breeding aged birds are being killed, and red foxes are the implicated predator in at least 30 of 37 cases, based on examination of bird carcasses and the abundance of red fox. In support of this conclusion, mortality rates of sage-grouse declined following red fox control during winter 1999 and the expansion of this effort in 2000 through 2005 (Figure 1).

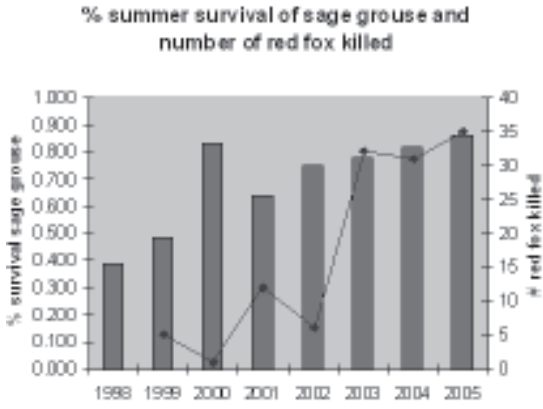

Figure 1. Percent survival of resident sage-grouse and the number of red fox taken by U.S. Department of Agriculture, Animal and Plant Health Inspection Servcies, Wildlife Services in Strawberry Valley, Utah, from 1998 to 2005.

Although we do not have conclusive evidence that predation is limiting recruitment (radio transmitters have not been placed on chicks), we feel strongly that, given the information available, predation on chicks is a major factor limiting recruitment. The fact that entire broods, rather than portions of broods, are lost is consistent with our hypothesis that predation, rather than habitat, is limiting chick survival. This hypothesis is also strengthened by the fact that brood counts prior to 2000 were only 66 percent of what they were during active control years (2000–2005) (Figure 2).

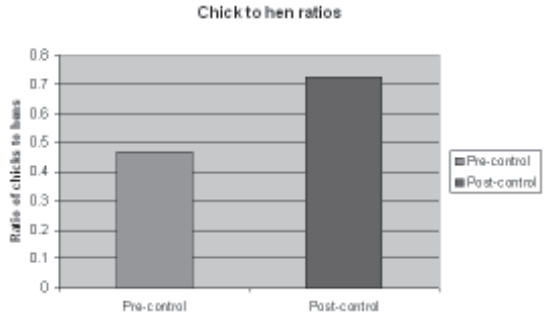

Figure 2. Chick to hen ratios of sage grouse from prepredator control years (1998–1999) and postcontrol years (2000–2005) in Strawberry Valley, Utah.

Horizontal obscurity cover, usually in the form of residual or current year growth of grass, is a major factor influencing predation on nesting sage-grouse (Gregg 1991, Gregg et al. 1994, DeLong et al. 1995). DeLong et al. (1995)

suggested that vegetative cover around nest sites, where birds are most vulnerable, provides scent, visual and physical barriers to potential predators. Based on these findings, the sage-grouse guidelines (Connelly et al. 2000) recommend maintaining herbaceous cover greater than 7.09 inches (18 cm) tall in nesting habitat. Because horizontal cover at both nest and adult sites approaches 100 percent at 13.11 inches (33.3 cm) above ground level, it does not seem to be a contributing factor to the high level of predation we found on sage-grouse.

Many factors likely contribute to the abundance of red fox in Strawberry Valley. The area is a popular recreation destination for camping and fishing, which results in large amounts of refuse and food products littered along the shoreline and at campsites. The productivity of Strawberry Reservoir as a fishery may contribute to the abundance of red fox by providing them with fish parts and entrails washed ashore or left on the banks by fishermen during the summer and found on the ice during the winter. In addition, the 11 tributaries that feed the reservoir boast large numbers of introduced Kokanee salmon (*Oncorhynchus nerka*) that spawn and die in the fall. Each of these events create a rich food supply, but Kokanee salmon consumed in September and October may bolster fat supplies going into the winter or may provide food for caches to be consumed later. Localized areas in Strawberry Valley also have large populations of Uinta ground squirrels (*Spermophilus armatus*) and sizeable breeding populations of waterfowl, both of which provide red fox with alternative prey. Strawberry Valley is also home to robust populations of mule deer (*Odocoileus hemionus*) and elk (*Cervus canadensis*). And, U.S. Highway 40 runs the entire length of the valley. This provides foxes and other scavengers with an almost year around supply of road kill.

Harding et al. (2001) documented a significant short-term (3 months) positive relationship between removal rates of red fox and population growth of a California clapper rail (*Rallus longirostris obsoletus*) population. Unfortunately, after only 3 months, red fox densities returned to pretreatment levels. The relationship between red fox and sage-grouse in Strawberry Valley is likely very similar. The major differences between our study and the Harding et al. (2001) study is that control efforts start in January and go through July and that WS and volunteers have been controlling all terrestrial predators (not just red fox) using various different techniques from 1999 to the present. In addition, control of avian predators began in 2003 and has intensified to place more than

600 poison egg baits during 2005. This sustained control has also increased in time and space since the inception of the control program. We expect that fox densities will increase after discontinuance of predator control; however, if fox densities in critical habitats can be reduced during breeding, nesting and brood-rearing seasons (early spring to early summer), it may have a significant positive influence on the sage-grouse population. Future research should focus on the feasibility of red fox control as a short-term management tool as part of a long-term conservation strategy and as the minimum viable population size or fecundity estimates necessary to withstand red fox predation.

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