CHAPTER TWENTY-TWO

Response of Greater Sage-Grouse to the Conservation Reserve Program in Washington State

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Abstract. We examined the relationship between the Conservation Reserve Program (CRP) lands and Greater Sage-Grouse (*Centrocercus urophasianus*) in Washington state including an assessment of population change, nest-site selection, and general habitat use. We monitored nest-site selection of 89 female sage-grouse between 1992 and 1997 with the aid of radiotelemetry. The proportion of nests in CRP lands significantly increased from 31% in 1992–1994 to 50% in 1995–1997, although more nests were detected in shrub steppe (59% vs. 41% of 202 nests). The increase appeared to be associated with maturation of CRP fields, which were characterized by increased cover of perennial grass and big sagebrush (*Artemisia tridentata*). Nest success was similar (P = 0.38) for nests placed in the two cover types (45% in CRP and 39% in shrub steppe). Counts of fecal pellets indicated that sage-grouse selected areas with greater sagebrush cover, especially in relatively new CRP in a shrub steppe landscape. Analysis of male lek attendance prior to implementation of CRP (1970–1988) illustrated similar rates of declines in two separate populations of sage-grouse in north-central and south-central Washington. Data from 1992 to 2007 following establishment of the CRP revealed a reversal of the population decline in north-central Washington while the south-central population continued a long-term decline (~17% vs. 2% of the occupied areas were in the CRP, respectively). These results indicate that lands enrolled in the CRP can have a positive impact on Greater Sage-Grouse, especially if they include big sagebrush and are focused in landscapes with substantial extant shrub steppe. The CRP for sage-grouse and other sage-dependent species should be considered a long-term investment because of the time required for sagebrush plants to develop.

Key Words: Artemisia tridentata, big sagebrush, *Centrocercus urophasianus*, Conservation Reserve Program, Greater Sage-Grouse, habitat restoration, population dynamics, shrub steppe, Washington.

Respuesta del Greater Sage-Grouse al Programa de Reservas para la Conservación en el Estado de Washington

Resumen. Examinamos la relación entre las tierras del Conservation Reserve Program (CRP, Programa de Reservas para la Conservación) y el

Schroeder, M. A., and W. M. Vander Haegen. 2011. Response of Greater Sage-Grouse to the conservation reserve program in Washington State. Pp. 517–529 *in* S. T. Knick and J. W. Connelly (editors). Greater Sage-Grouse: ecology and conservation of a landscape species and its habitats. Studies in Avian Biology (vol. 38), University of California Press, Berkeley, CA.

Greater Sage-Grouse (*Centrocercus urophasianus*) en el estado de Washington, incluyendo una evaluación de cambios de la población, de selección de sitios de anidación, y del uso general del hábitat. Monitoreamos la selección de sitios de anidación de 89 hembras de sage-grouse entre 1992 y 1997 con la ayuda de radio telemetría. La proporción de nidos en tierras del CRP aumentó perceptiblemente de un 31% en 1992-1994 a un 50% en 1995–1997, aunque más nidos (59 contra el 41% de 202 nidos) fueron detectados en el hábitat de shrub steppe (arbustos de estepa). El aumento parecería estar asociado a la maduración de los campos de CRP, que estuvieron caracterizados por la cubierta creciente de hierbas perennes y de sagebrush grande (*Artemisia tridentata*). El éxito de anidación fue similar ($P = 0.38$) para nidos ubicados en los dos tipos de cubierta vegetal (el 45% en CRP y el 39% en hábitats de shrub steppe). Los conteos de heces fecales indicaron que el sage-grouse seleccionó las áreas con mayor cubierta de artemisa, especialmente en áreas nuevas del CRP en paisajes de shrub steppe. El análisis de la asistencia de machos a los leks (sitios de cortejo) antes de la puesta en marcha del CRP (1970–1988) ilustró índices similares de descenso en los números de dos poblaciones separadas de sage-grouse en Washington central del norte y central del sur. Los datos que surgieron entre 1992–2007 a partir del establecimiento del CRP revelaron una revocación leve de la disminución de la población en Washington central del norte, mientras que la población central del sur continuó un descenso de población de largo plazo (~el 17% contra el 2% de las áreas ocupadas estaba en el CRP, respectivamente). Estos resultados indican que las tierras alistadas en el CRP pueden tener un impacto positivo en el Greater Sage-Grouse, especialmente si incluyen a la *A. tridentata* y se centran en paisajes que han permanecido con shrub steppe abundante. El CRP debe considerarse como una inversión a largo plazo tanto para el sage-grouse como para otras especies dependientes de la artemisa debido al tiempo requerido para el desarrollo de la vegetación en este tipo de hábitat.

Palabras Clave: Artemisia tridentata, big sagebrush (artemisa), *Centrocercus urophasianus*, dinámica poblacional, estepa arbustiva, Greater Sage-Grouse, Programa Reserva para la Conservación (Conservation Reserve Program), restauración del hábitat, Washington.

Shrub steppe communities historically dominated the landscape of eastern Washington (Daubenmire 1970). Today, <50% of Washington's historical shrub steppe remains, and much of it is degraded, fragmented, and/or isolated from other similar habitats (Jacobson and Snyder 2000, Vander Haegen et al. 2000). Conversion to cropland has resulted in the greatest loss of shrub steppe in Washington, particularly among deep-soil communities (Dobler et al. 1996, Vander Haegen et al. 2000). Similar large-scale conversion of shrub steppe to cropland has occurred in north-central Oregon, southern Idaho, and eastern Montana (Wisdom et al. 2000a, Knick et al. 2003). Shrub steppe communities across the Intermountain West also have been lost or degraded by extensive energy extraction, inappropriate livestock grazing, invasion by exotic plants, and changes in fire frequency (Yensen et al. 1992, Pashley et al. 2000, Knick et al. 2003).

Loss and degradation of extensive shrub steppe communities has greatly reduced habitat available for a wide range of shrub steppe–associated wildlife (Quigley and Arbelbide 1997, Saab and Rich 1997, Vander Haegen et al. 2000). Most species identified as having a high management concern in an analysis of species at risk within the interior Columbia River Basin were those associated with shrub steppe (Quigley and Arbelbide 1997). Moreover, according to the Breeding Bird Survey, half of these shrub steppe–associated species have experienced long-term population declines (Saab and Rich 1997).

The Greater Sage-Grouse (*Centrocercus urophasianus*) illustrates the problems associated with shrub steppe–dependent wildlife. Populations of Greater Sage-Grouse have declined in recent decades throughout much of their range (Connelly and Braun 1997, Braun 1998, Connelly et al. 2004, Schroeder et al. 2004). These declines have been particularly dramatic in Washington, where sage-grouse have been reduced to two separate populations, one in north-central and the other in south-central Washington (Schroeder et al. 2000). The reduction in distribution of sage-grouse has been caused by numerous factors, but foremost is the conversion of native sagebrush (*Artemisia* spp.)–dominated shrub steppe to cropland (Yocom 1956, Swenson et al. 1987, Dobler et al. 1996, Schroeder et al. 2000). Degradation of remaining habitats, particularly those used for nesting and brood-rearing, has also had negative impacts (Connelly et al. 1991, Gregg et al. 1994, Schroeder 1997, Connelly et al. 2000c, Connelly et al. 2004). Declines of sage-grouse populations throughout their range have resulted in numerous efforts to list this species as either threatened or endangered (United States Department of the Interior 2005b, 2008a). The Greater Sage-Grouse is currently considered warranted for federal listing in the state of Washington, but precluded from listing by higher priorities (United States Department of the Interior 2001a). The species is presently listed by the state of Washington as threatened (Hays et al. 1998).

Habitat restoration is a fundamental component of the recovery plan for Greater Sage-Grouse in Washington (Stinson et al. 2004). Shrub steppe is currently being restored through the Conservation Reserve Program (CRP), both by design and by happenstance. This voluntary program (administered by the United States Department of Agriculture) pays farmers to take agricultural lands out of production to achieve conservation objectives, including reduced soil erosion and improvement of wildlife habitat. The program allows farmers to periodically enroll lands for intervals of at least 10 years. In Washington as of July 2006, 599,314 ha of converted farmland had been planted to perennial grasses, forbs, and shrubs under the CRP (Schroeder and Vander Haegen 2006). The vast majority of CRP land in Washington occurs on land that was historically shrub steppe. The current acreage of CRP land in eastern Washington equals roughly 10% of the region's total agricultural lands. This program is not the ideal solution to the problem of declining native habitat, but CRP has enormous potential to provide cover and food for many species associated with shrub steppe habitat.

CRP fields have historically been planted with a variety of nonnative grasses; more recently (late 1990s), an increasing number of fields have been planted to native grasses, forbs, and arid-land shrubs. Native shrubs (particularly big sagebrush [*Artemisia tridentata*]) frequently seed-in from adjacent shrub steppe, making some fields potentially usable by shrub-nesting species. Despite the potential of CRP land as wildlife habitat, no studies have examined use of these lands by wildlife, and specifically Greater Sage-Grouse, in Washington.

The purpose of our research was to examine the behavioral and population response of Greater Sage-Grouse to the presence of CRP fields in the state of Washington. In addressing this goal, some basic questions were considered. Do Greater Sage-Grouse use CRP land for nesting, and is this use proportional to its availability? Is the use of CRP land a function of its characteristics, such as age and configuration relative to native shrub steppe? Does CRP positively impact populations of Greater Sage-Grouse?

METHODS

Telemetry

We studied Greater Sage-Grouse on a 3,000-km^2 area near Mansfield, Washington (Schroeder 1997). Female sage-grouse were trapped on seven leks with walk-in traps (Schroeder and Braun 1991) during March and April, 1992–1996. Sex and age were ascertained for all captured birds (Beck et al. 1975); all females were fitted with battery-powered radio transmitters attached by poncho-like collars (Amstrup 1980) or necklaces.

Females were located either visually or by triangulation at least once every three days with a portable receiver and four-element Yagi antenna to monitor location and success of nests. Variation in intensity of transmitter signals was also used as an indication of female behavior; radio transmitters emitted a constant signal when a female was on her nest and a variable signal when she was walking or flying. Fixed-wing aircraft were used to locate lost birds.

Observations of females on nests were made by triangulating from a distance of about 30 m from the nest site to minimize disturbance while allowing nests to be located following hatch or failure. We considered females to have nested successfully if at least one egg hatched. Analyses of nest success and habitat selection were conducted with logistic regression (PROC CATMOD, SAS Institute 2006). Most nests were located during the laying stage or early in incubation, and exposure period differed little among nests.

After a female ceased her nesting effort, two 18-m perpendicular transects were established, centered on the nest, with orientation of the initial transect chosen randomly. Ten point-intercept locations were positioned 2 m apart along each transect (total of 20 points). All plant species intercepted at each point were identified and recorded (or the site was recorded as bare ground). Data were simplified to shrub cover, grass cover, forb cover, and bare ground for purposes of our analysis. The majority of shrubs in CRP land were big sagebrush (~75% near nest sites); the other shrubs consisted primarily of threetip sagebrush (*Artemisia tripartita*), antelope bitterbrush (*Purshia tridentata*), and rabbitbrush (*Chrysothamnus* spp.). No effort was made to differentiate between the subspecies of big sagebrush (Frisina and Wambolt 2004) due to ambiguity in their characteristics in Washington. A visual obstruction reading was recorded with the aid of a Robel pole (Robel et al. 1970) at each of the 20 points. Visual obstruction readings were taken from a distance of 4 m from each point perpendicular to the transect direction and at a height of 1 m. Height of the tallest shrub (shrub height) within 9 m of the nest site (length of each transect outward from the nest site) was recorded to the nearest centimeter. Species diversity was recorded as the number of different plant species identified within 9 m of the nest site in a 10-min period.

We used logistic regression (Hosmer and Lemeshow 2000) to examine the likelihood of a nest occurring in CRP land versus other vegetation types, primarily shrub steppe or wheat fields. The outcome variable was CRP land or shrub steppe with three explanatory variables: female age (adult or yearling), order of the nest (first nest or renest), and year (1992 through 1997). Females tend to display spatial fidelity to nesting sites (Schroeder and Robb 2003), and the relative likelihood of consecutive nests being in the same cover type was also examined.

We used logistic regression to assess the influence of cover type on nest success, with nest fate (successful or failed) as the outcome variable and three explanatory variables: cover type (CRP land or shrub steppe); female age (adult or yearling); and order of nest (first nest or renest). Nests for females that were killed by predators while off the nest were excluded from this analysis. Nests for which knowledge of success was ambiguous also were excluded. Variables describing vegetation structure were not included in this analysis; measurements were not taken at all nests because some nests could not be examined in a timely fashion. We tested for model fit using the Hosmer-Lemeshow test (Hosmer and Lemeshow 2000). Percentage data were arcsin-transformed prior to analysis to improve normality and converted back to percentages for presentation. We also considered the influence of multiple comparisons when evaluating significance values.

Pellet Counts

Greater Sage-Grouse pellet counts (a pellet is an individual unit of fecal material) were conducted as part of a larger study designed to evaluate the potential role of CRP in the long-term conservation of species associated with shrub steppe habitats in the Columbia Basin (Schroeder and Vander Haegen 2006). Sage-grouse deposit pellets throughout the year, but the vast majority of those detected were deposited in autumn, winter, and early spring, when the sage-grouse diet is primarily sagebrush. Pellets deposited during late spring and summer tend to be less durable because of the relatively moist diet of sage-grouse during this time of year (Schroeder et al. 1999). Most observed pellets likely represent distinct seasons—the fresh pellets (light brown with a hint of dull yellow) from the recent autumn-spring period and the old pellets (grayish-brown) from previous autumn-spring periods.

Pellet count research was divided into two phases. Forty-eight study sites were selected in Douglas, Grant, Lincoln, and Adams Counties for phase 1 in 2004–2005 (Fig. 22.1). The 48 study sites were divided into eight spatially separated clusters, each with 6 study sites with a different treatment. The six treatments included three cover types (shrub steppe, old CRP, new CRP) and two landscapes (surrounding landscape dominated by shrub steppe or cropland). Shrub steppe cover was not grazed by livestock and was dominated by native vegetation, with an overstory of big sagebrush and an understory of bunchgrasses and forbs. Old CRP cover was former cropland planted to nonnative bunchgrasses in the late 1980s; shrubs were present if big sagebrush encroached from adjacent shrub steppe. New CRP cover was former cropland planted to a mix of nonnative and native species including big sagebrush, generally in the late 1990s. Pellet count research was conducted in the four

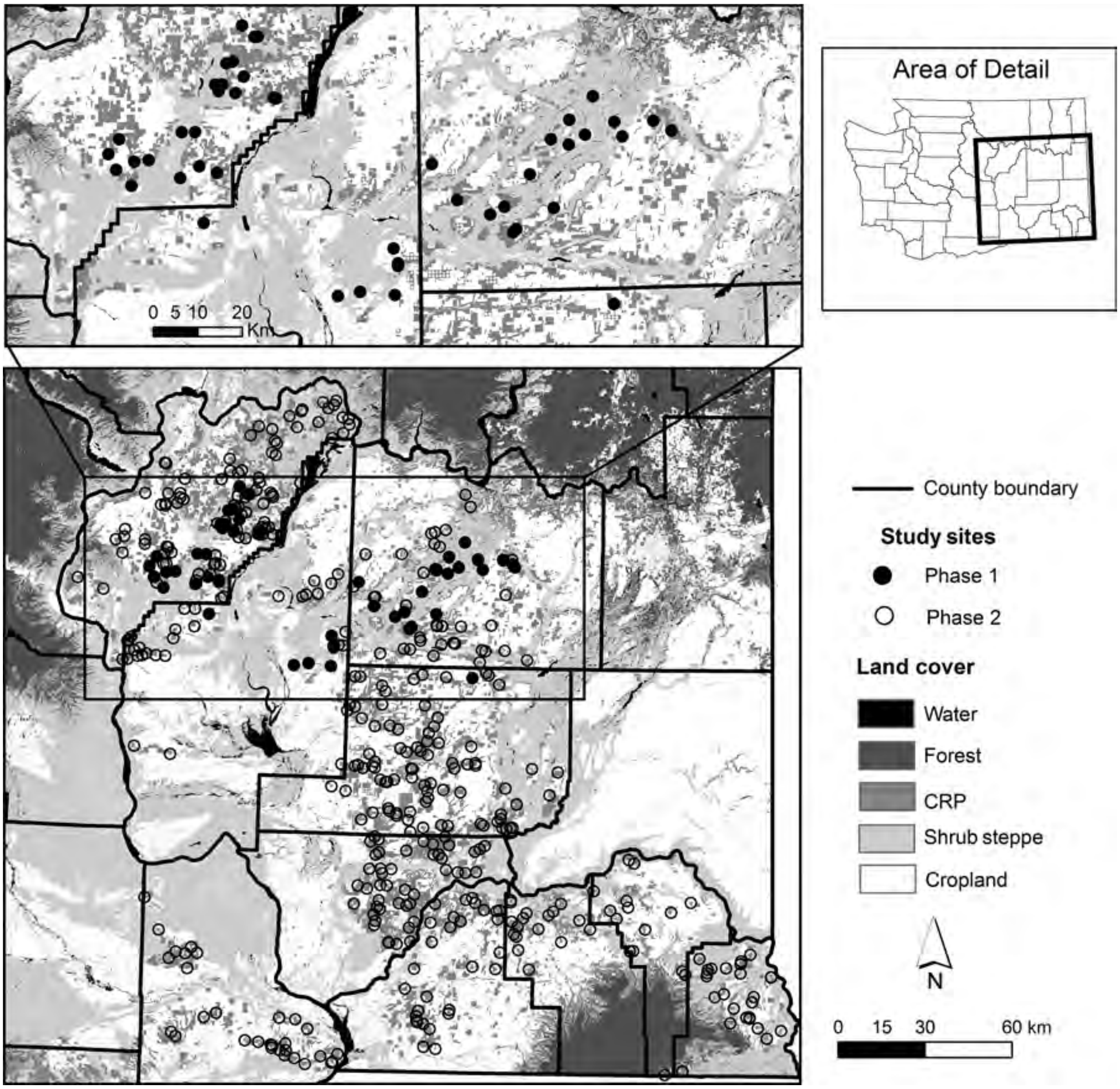

Figure 22.1. Phase 1 (enlarged map at top) and phase 2 (large map at bottom) study sites for Greater Sage-Grouse pellet surveys in eastern Washington, 2004–2006. During phase 1, pellets were only counted in the western 24 study sites in Douglas and Grant Counties. Land cover was derived from Landsat imagery (1993–1994; Jacobson and Snyder 2000) and aerial photography in Conservation Reserve Program archives (1996 photos; USDA Farm Services Agency).

westernmost clusters of study sites (six sites/cluster equally divided by habitat and landscape). These 24 westernmost sites were within the distribution of Greater Sage-Grouse, whereas the easternmost sites were outside the distribution (Schroeder et al. 2000).

Each study site in phase 1 was 25 ha, buffered by at least 100 m of similar vegetation to prevent edge effects. Each study site contained four 100-m fixed-radius circles spaced 300 m apart, providing a 100-m buffer between each circle perimeter. Pellet counts were conducted within circular 50-m^2 plots at cardinal directions 50 m from the center of each fixed-radius circle (16 plots/study site). Each circular 50-m^2 plot was delineated with the aid of a 4-m string looped over a permanent center stake. By walking the perimeter at the end of the string, an observer was able to identify pellets that were in the circle. Once the perimeter was established, pellets clearly within the circle were identified, counted, and removed. Surveys were conducted in October 2004 and April 2005.

Vegetation on each study site was assessed within 15 × 6.67 m (100 m^2) rectangular plots randomly located and oriented within each of the four 100-m fixed-radius circles (Fig. 22.2). Vegetation plots were stratified by plant community; if more than one plant community was present within the circle, an additional plot was randomly placed within the additional community. Thus, from four to eight vegetation plots were measured on each study site.

Colored flags were placed at set distances along the plot boundary to create "subplots" and assist with cover estimation (Fig. 22.2). Percent cover of shrubs, perennial grasses, and forbs was visually estimated as one of nine values: (1) ≤1%, (2) >1–5%, (3) >5–15%, (4) >15–25%, (5) >25–35%, (6) >35–50%, (7) >50–75%, (8) >75–95%, and (9) >95%. The midpoint of each cover category was used for analysis. A visual obstruction reading (Robel et al. 1970) was recorded for each of 10 fixed points along the perimeter of the sampling plot. Readings were taken at a height of 1 m and at a distance of 4 m from the inside of the plot looking toward the outside. The average visual obstruction reading was used in subsequent analyses. All sampling was completed in June and July of 2004.

Phase 2 of the pellet count research was conducted in 2006 on 410 study sites scattered throughout much of eastern Washington in CRP lands of differing ages, conditions, and landscape configurations (Fig. 22.1). Study sites were randomly placed in CRP fields similar to those in phase 1 except that only one 100-m fixed-radius circle was used within each study site, rather than four circles. Fifty-four of the 410 study sites were eliminated from analyses due to lack of established perennial vegetation. The same basic technique used to record sage-grouse pellets in phase 1 was also used in phase 2, with the following exceptions: four plots were examined for each of the 356 study sites in April–July 2006 (rather than 16 plots for each study site in phase 1); plots in phase 2 were 100 m from the center of the fixed-radius circles, rather than 50 m; pellets were not removed; and pellets detected while in transit between plots were also recorded.

Habitat data were collected the same way in phase 2 as in phase 1, except the visual obstruction reading was not recorded and rectangular plots were positioned with a corner in the center of the circle and oriented randomly. Study sites in phase 2 of the pellet research were positioned randomly relative to the general landscape, and three additional variables were quantified for the area within 1 km of the center of each circle: (1) proportion of cover in CRP land, (2) proportion of cover in shrub steppe, and (3) ratio of CRP land to nonshrub steppe cover. We also recorded distance to the nearest active sage-grouse lek and maximum attendance of males at the nearest lek in 2006.

We used a general linear model to examine pellet counts at the level of the fixed-radius circles. The outcome variable was the number of pellets, and the explanatory variables were cover type, landscape, and year. We used logistic regression to examine presence and absence of pellets in relation to cover type and specific vegetation characteristics. We tested for model fit using the Hosmer-Lemeshow test (Hosmer and Lemeshow 2000).

Populations

Greater Sage-Grouse historically were found throughout much of eastern Washington, but surveys conducted between 1955 and 2007 suggest that only three populations existed during that

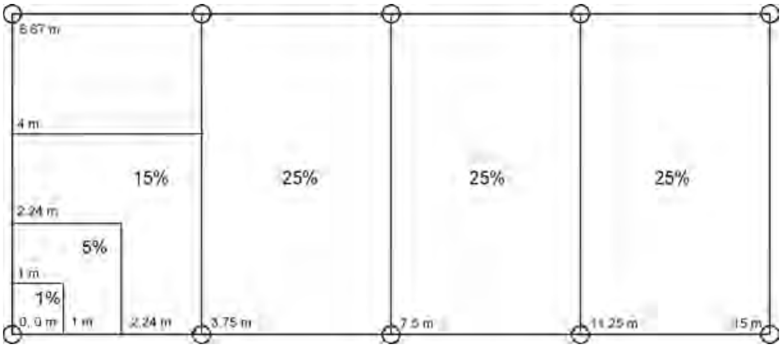

Figure 22.2. Sample vegetation plot showing corner stakes and distances along plot edges for placement of pin flags to create subplots for percent cover estimation. Circles represent locations for placement of the Robel pole.

time interval (Schroeder et al. 2000). These include a population primarily in the Moses-Coulee area of Douglas County, north-central Washington; a population in south-central Washington, primarily on the United States Army's Yakima Training Center in Yakima and Kittitas Counties; and a population primarily in Lincoln County. We did not consider the population in Lincoln County in our analysis of CRP because it has been extinct since the mid-1980s. The north-central Washington population has been monitored regularly since 1955, and the south-central Washington population has been monitored since 1970. Only data collected since 1970 were used in our analysis of CRP to make comparisons between areas consistent.

We defined a lek complex as a group of leks $<$3 km from one another. Lek complexes were spatially separated from adjacent lek complexes by $>$6 km. We surveyed lek complexes between 1970 and 2007 to obtain information on sage-grouse populations and annual rates of change (Schroeder et al. 2000). The survey protocol included searches for new and/or previously unknown complexes and multiple ($\geq$3) visits to all known complexes. Some original data from the 1970s were lost so that only single high counts remained, despite some complexes having been observed on more than one occasion.

Numbers of males attending lek complexes were analyzed using the greatest number of males observed on a single day for each complex for each year. This technique is well established for Greater Sage-Grouse (Connelly et al. 2004), but it may have biases (Jenni and Hartzler 1978, Emmons and Braun 1984, Walsh 2002, Walsh et al. 2004). Despite these potential biases, lek counts presently provide the only assessment of a population's long-term trend (Connelly et al. 2004). We estimated annual rates of population change by comparing total number of males counted at lek complexes in consecutive years. Sampling was occasionally affected by effort and/or size and accessibility of leks, and those not counted in consecutive years were excluded from the sample for the applicable intervals (Connelly et al. 2004). Annual instantaneous rates of change for each population were estimated as the natural logs of the males counted on leks in one year divided by the males counted on the same leks the previous year. We also estimated rates of change for individual leks in each population. In this analysis, lek counts were transformed by adding one male to each count; this avoided undefined calculations. Annual rates of change were only started when a lek was first discovered.

The CRP was authorized in 1986, and analysis of population data in Washington permitted a comparison of pretreatment data (before CRP) with treatment data (after CRP). However, because implementation of CRP was not instantaneous and planted fields took time to develop, we eliminated transition years to avoid confusion. CRP lands were not usable by grouse in 1987, the year most of the fields were first planted, thus we did not consider data for population changes between 1988 and 1992 in subsequent analyses because 1992 was the first year nests were documented in CRP. These five years of data represent four annual intervals of population change. We used the 1987–1988 interval as the last pretreatment interval because CRP fields resembled wheat fields during their first year. Thus, pretreatment years included 1970 through 1988. The treatment years included 1992 through 2007. We treated the population in south-central Washington as a control because of the small amount of CRP land (Table 22.1).

RESULTS

Telemetry

We documented 204 nests from 89 females monitored between 1992 and 1998. However, only one nest was found in 1998 and it was eliminated from the sample; a second nest was eliminated from the analysis because it was in a wheat field. The remaining 202 nests were either in CRP land or shrub steppe. Females nesting in shrub steppe were usually in vegetation dominated by big sagebrush, but were occasionally in areas dominated by other shrub species or perennial grass. CRP land was also variable, with some fields containing a mixture of shrubs and perennial grasses and other fields largely dominated by grasses.

Eighty-three (41.1%) of the 202 nests were in CRP fields, and 119 nests (58.9%) were in shrub steppe. Neither age ($\chi^2 = 0.19$, $P = 0.67$) nor nest order ($\chi^2 = 0.99$, $P = 0.32$) was significant in the logistic regression, but year offered a significant explanation ($\chi^2 = 6.60$, $P = 0.01$) for the observed variation in nest placement between CRP land and shrub steppe cover (Hosmer and Lemeshow test; $\chi^2 = 3.48$, $P = 0.84$). Nests were more likely to be

TABLE 22.1

Potential habitat quantity in relation to current and historical distribution of Greater Sage-Grouse in Washington (adapted from Table 1 in Schroeder et al. 2000).

	Area dominated by each cover type (%)				
Range or population	Shrub steppe[a]	Cropland[a]	CRP[b]	Other[b]	Total area (km^2)
North-central Washington	44.3	35.1	16.7	3.9	3,529
South-central Washington	95.6	0.5	1.9	1.9	1,154
Total occupied range	57.0	26.6	13.0	3.4	4,683
Unoccupied range	42.3	42.8	5.5	9.4	53,058
Total historical range	43.5	41.5	6.1	8.9	57,741

[a] Landsat Thematic Mapper, 1993.
[b] Conservation Reserve Program (CRP) was measured from aerial photos dated 1996.

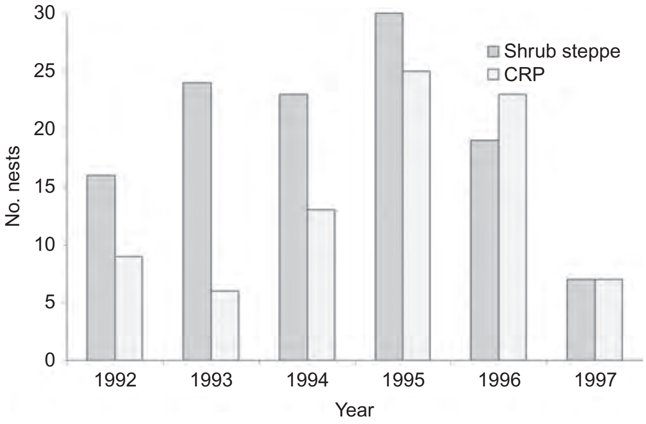

Figure 22.3. Number of nests of radio-marked Greater Sage-Grouse in Conservation Reserve Program and shrub steppe cover in north-central Washington between 1992 and 1997.

in CRP land later in the study (Fig. 22.3), perhaps in response to the maturation of CRP fields, most of which were planted in the late 1980s. Some variability in this trend was noted, particularly in 1997, as that year also had the smallest sample size of nests (14). During the first half of the study (1992–1994), 30.8% of nests were in CRP land, and during the last half of the study (1995–1997), 49.5% of nests were in CRP land.

The shift in selection of nesting cover was also noted when comparing individual females. Between 1992 and 1997, 121 of the 202 documented nests for radio-marked females were at least a female's second nest. Seventy-seven of the 121 nests (63.6%) were in the same cover as the previous nest. Of the 44 changes in cover type, 26 (59.0%) were shifts from shrub steppe to CRP land and 18 (41.0%) were shifts from CRP land to shrub steppe.

Sage-grouse nested in CRP land in proportions substantially greater (41.1% of nests were in CRP land) than availability would suggest (16.7% of the sage-grouse range in north-central Washington was CRP land; Table 22.1). Sage-grouse also nested in shrub steppe more often than its availability would suggest (58.9% use vs. 44.3% availability). These observations are due to the almost complete absence of nests in cropland, which is an abundant cover type (35.1%). If nonnest cover types are removed from consideration, 27.4% of the potential nesting habitat was CRP land and 72.6% was shrub steppe. Thus, CRP land and shrub steppe were used in similar proportions to availability during 1992–1994, but CRP land was used more during 1995–1997.

We also examined nest success in relation to habitat selection for 192 nests (excluding 10 nests in which females were killed by predators while

TABLE 22.2

Logistic regression analysis of Conservation Reserve Program versus shrub steppe vegetation characteristics at Greater Sage-Grouse nest sites in north-central Washington, 1992–1997.

Parameter	χ^2	P
Visual obstruction reading	0.05	0.82
Species diversity	15.40	<0.001
Shrub height	0.55	0.46
Shrub cover	8.01	0.005
Grass cover	4.74	0.03
Forb cover	0.11	0.74
Bare ground	1.88	0.17
Hosmer and Lemeshow goodness of fit	15.10	0.06

TABLE 22.3

General linear model analysis of study site configuration in relation to number of Greater Sage-Grouse pellets in phase 1 of pellet research in north-central Washington, 2004–2005.

Parameter	F	P
Area (four different clusters of study sites)	3.87	0.01
Cover type (shrub steppe, old CRP[a], or new CRP)	4.83	0.01
Landscape (shrub steppe or cropland)	5.70	0.02
Cover type–landscape interaction	4.16	0.02
Year (2004 or 2005)	1.61	0.21

[a] CRP refers to the Conservation Reserve Program.

off the nest or when the nest's outcome was ambiguous). Seventy-nine nests were in CRP land and 113 nests in shrub steppe. Nest success did not significantly differ by age of female (χ^2 = 0.15, P = 0.70), nest order (first nests vs. renests; χ^2 = 0.24, P = 0.62), year (χ^2 = 0.24, P = 0.62), or cover type (χ^2 = 0.77, P = 0.38; Hosmer and Lemeshow test; χ^2 = 9.33, P = 0.32). Overall nest success for this sample was 37.0%. Apparent nest success was estimated to be 40.5% in CRP land and 34.5% in shrub steppe; these values were not significantly different (χ^2 = 0.72, P = 0.40).

We used 161 nests for analysis of specific vegetation characteristics. The difference in sample sizes from the previous analysis represented nests that could not be examined in a timely fashion or for which the actual nest bowl was not located. Vegetation characteristics differed between nests in CRP land and nests in shrub steppe (Table 22.2). Nests in CRP land had lower average (± SE) plant diversity (10.47 ± 0.57, CRP; 17.95 ± 0.60, shrub steppe), lower shrub cover (1.85 ± 0.20%, CRP; 3.74 ± 0.06%, shrub steppe), and higher grass cover (4.74 ± 0.03%, CRP; 4.43 ± 0.03%, shrub steppe).

Large differences in specific vegetation characteristics occurred between general cover types (CRP and shrub steppe), and specific characteristics were examined in relation to nest success for each cover type separately. None of the characteristics was apparently related to nest success in a logistic regression with vegetation characteristics as independent variables in either shrub steppe (overall χ^2 = 7.12, df = 7, P = 0.42; Hosmer and Lemeshow test, χ^2 = 11.48, P = 0.18) or CRP land (overall χ^2 = 3.64, df = 7, P = 0.82; Hosmer and Lemeshow test, χ^2 = 2.67, P = 0.95).

Pellet Counts

We counted 1,839 individual Greater Sage-Grouse pellets on 24 study sites in phase 1 of the pellet research. Pellets were found on 12 of the 24 study sites, 32 of 96 fixed-radius circles, and 60 of 384 plots. The number of pellets detected on each study site was strongly correlated with sampling period (r^2 = 0.90, P < 0.01). A general linear model detected significant effects of area, cover type, landscape, and interaction of cover and landscape on number of pellets (Table 22.3). The largest number of pellets was observed in new CRP land in the shrub steppe landscape (Fig. 22.4). The only significant variables detected in a logistic regression were cover type and percent shrub cover (Table 22.4). New CRP land was 53.1% likely to have pellets, while the likelihood was only 21.9% in old CRP land and 25.0% in shrub steppe. Average (± SE) shrub cover was 12.0 ± 2.4% at points with sage-grouse pellets and 8.6 ± 1.2% at points without pellets. In addition, 48.4% of the points without pellets had <5% shrub cover, while 71.9% of the points with pellets had >5% shrub cover (Fig. 22.5).

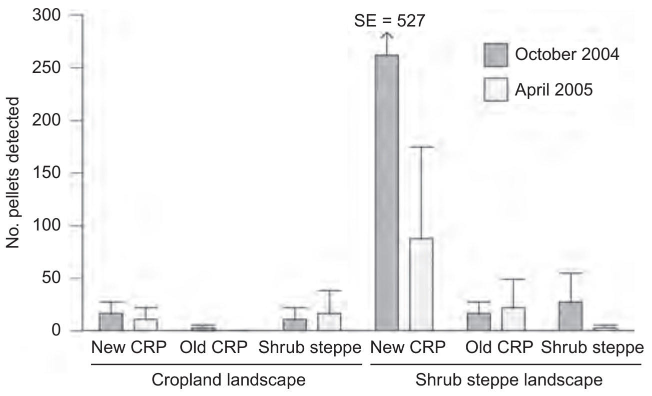

Figure 22.4. Number of Greater Sage-Grouse pellets counted in study sites in native shrub steppe, old Conservation Reserve Program (CRP), and new CRP in landscapes dominated by shrub steppe or cropland. Bars show mean and standard error.

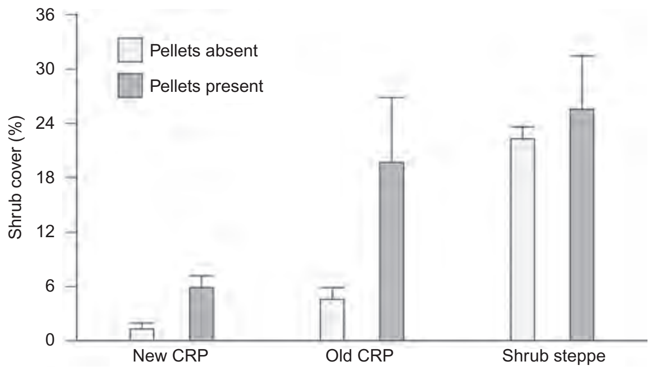

Figure 22.5. Percent shrub cover in relation to cover type and presence or absence of Greater Sage-Grouse pellets in north-central Washington, 2004–2005. Bars show mean and standard error.

During phase 2 of this study, 65 Greater Sage-Grouse pellets were counted on 356 study sites (single fixed-radius circles similar to phase 1). Presence and absence of pellets was considered in a logistic regression analysis, and pellets found in transit between the four standard pellet count plots were also considered. This increased the sample size of study sites with sage-grouse pellets from four to nine. No pellets of Greater Sage-Grouse were found in the 267 study sites outside their known distribution in Washington, and the logistic regression was only used for the remaining 89 study sites.

Pellets were found in the same areas in phase 2 as in phase 1, despite the substantially greater distribution of study sites in phase 2. Landscape and vegetation parameters were analyzed in a logistic regression to identify which characteristics of study areas were correlated with presence of sage-grouse pellets (Table 22.5). The only significant variables were percent shrub cover and maximum attendance of males at the nearest active lek. Percent shrub cover ($\pm$ SE) was higher on study sites with pellets (14.67 $\pm$ 5.33%) than on areas without pellets (1.66 $\pm$ 0.55%). The maximum ($\pm$ SE) number of males attending the nearest lek was greater for study sites with pellets (24.11 $\pm$ 4.89 males) than for sites without pellets (13.66 $\pm$ 1.23 males).

Populations

Sixty-five active leks were documented in Washington between 1955 and 2007; 32 in north-central Washington, 23 in south-central Washington, and 10 in the Lincoln County population that is now extinct. Leks in north-central Washington and south-central Washington, except one, were active at least as recently as 1970. As of 2007, 15 active leks occurred in north-central Washington and seven active leks were in south-central Washington.

The average ($\pm$ SE) annual instantaneous rate of change for populations during the pretreatment period was -0.016 ± 0.073 in north-central Washington and -0.012 ± 0.063 in south-central Washington. The variances in annual rates of change were large, but the declines were comparable. Overall, the population in north-central Washington declined 25% and the population in south-central Washington declined 19% between 1970 and 1988. The average ($\pm$ SE) annual

TABLE 22.4

Logistic regression analysis of study site characteristics in relation to presence or absence of Greater Sage-Grouse pellets in phase 1 of pellet research in north-central Washington, 2004–2005.

Parameter	χ^2	P
Cover type (shrub steppe, old CRP[a], or new CRP)	12.43	<0.001
Landscape (shrub steppe or cropland)	0.01	0.90
Cover type–landscape interaction	0.18	0.67
Visual obstruction reading	0.09	0.77
Shrub cover	9.54	0.002
Perennial grass cover	1.95	0.16
Forb cover	0.59	0.44
Bare ground	0.01	0.94
Hosmer and Lemeshow goodness of fit	12.80	0.12

[a] CRP refers to the Conservation Reserve Program.

TABLE 22.5

Logistic regression analysis of study area characteristics in relation to presence or absence of Greater Sage-Grouse pellets in phase 2 of pellet research in north-central Washington, 2006.

Parameter	χ^2	P
CRP[a] within 1 km (%)	1.72	0.19
Shrub steppe within 1 km (%)	1.01	0.31
Ratio of CRP to non-shrub steppe within 1 km	1.36	0.24
Shrub cover	10.04	0.002
Perennial grass cover	0.16	0.69
Forb cover	0.002	0.96
Bare ground	0.10	0.75
Maximum attendance of males at the nearest active lek in 2006	3.72	0.05
Distance to nearest active lek	2.07	0.15
Hosmer and Lemeshow goodness of fit	4.45	0.81

[a] CRP refers to the Conservation Reserve Program.

instantaneous rate of change for the treatment period (addition of CRP in north-central Washington) was 0.011 ± 0.065 in north-central Washington and −0.055 ± 0.060 in south-central Washington. Overall, the population in north-central Washington increased 19%, while the population in south-central Washington decreased 56% between 1992 and 2007.

Observations for the populations were similar when each lek complex was considered individually. The average (± SE) annual instantaneous rate of change for the pretreatment period was −0.038 ± 0.019 in north-central Washington and −0.145 ± 0.065 in south-central Washington. When leks were considered individually, variances were smaller, but results were still not significant. The average (± SE) annual instantaneous rate of change for the treatment period was 0.001 ± 0.025 in north-central Washington and −0.074 ± 0.038 in south-central Washington.

DISCUSSION

CRP lands were extremely variable in north-central Washington with regard to landscape and vegetative characteristics, primarily related to shrub steppe and sagebrush. This variation clearly influenced habitat use, as illustrated by pellet data. Pellet research indicated substantial use of CRP land by sage-grouse, particularly CRP land in shrub steppe landscapes and CRP land with relatively abundant shrub cover, especially sagebrush. Results from telemetry research were consistent with the pellet data, despite the different seasons involved in the research. The likelihood of sage-grouse nesting in CRP land increased with age of the CRP field—at the same time shrubs were becoming established. Nest success was at least as high in CRP land as in native shrub steppe during this study.

We considered the potential for biases in this research. The telemetry data included 89 females and 204 nests; many of the females nested more than once in a year and in more than one year. However, little variation was observed in the likelihood of nesting (100%) or renesting (87%). Nothing indicated that observations were influenced by an unusual effect of age, year, weather, or capture location. We also considered the possibility that pellets may be more observable in new

CRP fields, where use appeared to be highest, when compared to other habitat types. Examination of old pellets that were detected during the 2005 portion of the phase 1, and missed during the 2004 portion of the survey, indicated the potential bias in detection was negligible. For example, the proportion of old pellets detected in 2005 was 11% in new CRP land (41 pellets), 2% in old CRP land (2 pellets), and 9% in shrub steppe (6 pellets).

Habitat use data would have little value if habitat selection were not related, at least in part, to long-term changes in populations. Greater Sage-Grouse populations have declined substantially in Washington (Schroeder et al. 2000) across years and regions, with one exception. The population in north-central Washington that was 17% CRP land appeared to be at least stable since 1992, while the population in south-central Washington (2% CRP) substantially declined. This is particularly noteworthy given the widespread declines of most populations of sage-grouse in North America during the same time interval (Connelly et al. 2004). Population data from Washington are consistent with the habitat use information gathered with telemetry and pellet data; thus, we believe that CRP is benefiting sage-grouse in north-central Washington.

No evidence suggested that other factors such as potential regional variation in weather affected differences in rates of population change. However, the sage-grouse population in south-central Washington is primarily on the Yakima Training Center, which is a focal point for anthropogenic disturbance associated with military training activities (Stinson et al. 2004). The north-central Washington population, in contrast, is a focal point for anthropogenic disturbance associated with many other activities, such as farming, residential activity, and recreation, by a population of about 400 people within the sage-grouse population perimeter. Additional research is needed to evaluate the impacts of these disturbances.

Concurrent efforts have been made to restore shrub steppe within both populations (Stinson et al. 2004). The primary management tool has been removal of livestock from public lands (public lands are more common in the south-central Washington population), but direct enhancement of native vegetation has also been implemented. Reduced livestock grazing has resulted in an apparent increase in herbaceous cover, at least in localized areas (Schroeder et al. 2009), but it is not clear whether these efforts have impacted sage-grouse. Our research did not focus on the tremendous variation in characteristics of shrub steppe. We considered shrub steppe one cover type for comparison with CRP land. However, little doubt exists that shrub steppe represents substantial diversity in soil type, moisture regime, dominant plants, habitat condition, and historical management (Dobler et al. 1996, Vander Haegen et al. 2000). More research is needed to illustrate why some areas of shrub steppe support sage-grouse and others do not.

CRP land and shrub steppe are not independent cover types in north-central Washington. The region has a historic mix of cropland and shrub steppe, with close spatial association between the different cover types. For example, 10 of 15 leks in north-central Washington in 2007 were in cropland, while the other five were in shrub steppe. It was not unusual for sage-grouse to nest on the edge of habitats and have access to multiple vegetation types. It seemed clear that presence of CRP land adjacent to shrub steppe improved the value of each cover type for sage-grouse, but it was difficult to quantify this interaction. The majority of sites used by sage-grouse in north-central Washington, regardless of cover type, are in a shrub steppe–dominated landscape. Many areas in eastern Washington had extensive areas of CRP land, but little or no shrub steppe in the surrounding landscape; none of these areas support sage-grouse.

We were limited in our assessment of new CRP land in that sagebrush had been planted in these cover types only since 1997. They will likely be used more by sage-grouse as vegetation in these areas matures and shrub height increases. CRP is clearly benefiting sage-grouse in north-central Washington, but it is possible these observations are peculiar to habitat types and landscape configurations in this area and may not be applicable to other areas. For instance, north-central Washington had a relatively large component of cropland prior to implementation of the CRP (>50% of the area); consequently, the quantity of potential nesting habitat may have been limiting. Replacement of cropland with CRP land may make little difference in regions with a smaller proportion of cropland. Sage-grouse in north-central Washington have larger clutch sizes and higher rates of nest initiation and renesting when compared with sage-grouse elsewhere (Schroeder

1997). These life-history characteristics may be related to the unique configuration of cropland (and CRP land) with shrub steppe in north-central Washington (Schroeder et al. 2000).

The best way to examine the significance of sage-grouse use of CRP land in north-central Washington would be to compare these observations to different locations throughout the range of sage-grouse (data used in Connelly et al. 2004). These data could be compared for multiple areas using controls with both pretreatment and treatment data, as was done for Washington. Areas of particular interest include portions of the current distribution of Greater Sage-Grouse with abundant CRP land such as northern Utah, southeastern Idaho, western Colorado, and eastern Montana.

CONSERVATION IMPLICATIONS

CRP land was of greatest benefit to sage-grouse when it contained sagebrush and when it was in a shrub steppe landscape. CRP land with a sagebrush component is increasingly providing suitable nesting cover for sage-grouse. Use of CRP land by sage-grouse in north-central Washington appears to be correlated with slight increases in population size. Nesting and early brood-rearing are often identified as the most important time periods in the annual life cycle of sage-grouse (Connelly et al. 2004). CRP is supporting a substantial portion of the sage-grouse breeding population in north-central Washington, and it is likely the population would be severely impacted if CRP cover were removed.

The use of CRP as a conservation tool has potential benefits beyond sage-grouse. CRP may help connect fragmented patches of shrub steppe, thereby creating a relatively continuous vegetative community. CRP land in these shrub steppe landscapes supports many species that normally depend on sagebrush-dominated habitats such as the Brewer's Sparrow (*Spizella breweri*) and Sage Thrasher (*Oreoscoptes montanus*; Schroeder and Vander Haegen 2006). CRP in north-central Washington is concurrent with restoration efforts in intact shrub steppe, leading to the following question: would it be more beneficial and/or efficient to restore existing shrub steppe or to convert cropland to CRP? This question is fundamentally difficult to answer. The historical conversion of shrub steppe to cropland in Washington was heavily focused on areas with relatively deep soil (Vander Haegen et al. 2000). It is likely that soils supporting croplands are more productive than soils supporting shrub steppe, which may explain, at least in part, why CRP fields have been so successful in supporting wildlife.

Improvement of native shrub steppe habitat can increase its usefulness for sage-grouse (Bunting et al. 2003). However, cropland in a shrub steppe landscape offers at least two encouraging opportunities. First, CRP converts areas that are unlikely to support sage-grouse to habitat that has the potential to support this species, particularly in a shrub steppe landscape. CRP fields planted to benefit sage-grouse should include big sagebrush and be focused in landscapes with substantial extant shrub steppe. Second, croplands typically have deeper soil than unconverted native habitats (Vander Haegen et al. 2000) and provide substantial opportunities for establishing suitable plant communities to benefit wildlife. CRP for sage-grouse and other sage-dependent species should be considered a long-term investment because of the time required for sagebrush plants to mature.

ACKNOWLEDGMENTS

The fieldwork represented in this chapter, in particular the lek surveys, was accomplished with the aid of many more biologists than can possibly be mentioned. The primary fieldwork was provided by Devon Anderson, Ron Bassar, Scott Downes, Catherine Engleman, Gabrielle Gareau, Melissa Hill, Wendy Jessop, Marie-France Julien, Sherri Kies, James Lawrence, Luke R. Lillquist, Susan Lundsten, Ann Manning, James Mason, Joanne McDonald, Ann Peterka, Leslie A. Robb, Dina Roberts, Darina Roediger, Audrey Sanfacon, Jeff Scales, Anna Schmidt, John Slotterback, and Ashley Spenceley. We thank Wan-Ying Chang for help with statistical analyses. We also received a great deal of cooperation from many landowners in the region who graciously permitted access to their lands. Substantial financial support was provided by the United States Department of Agriculture Farm Service Agency, the United States Fish and Wildlife Service, the National Fish and Wildlife Foundation, and the Washington Department of Fish and Wildlife through the Federal Aid in Wildlife Restoration Project W-96-R. We thank C. A. Hagen, J. W. Connelly, L. A. Robb, S. T. Knick, and R. D. Northrup for their thoughtful reviews.