Influences of Livestock Grazing on Sage Grouse Habitat

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Jeffrey L. Beck and Dean L. Mitchell

Abstract Livestock grazing has been identified as one factor associated with the widespread decline and degradation of sage grouse (*Centrocercus urophasianus*) habitat. We identified n=17 positive and negative impacts of livestock on sage grouse and habitat. Little information is currently available concerning the directs impacts of livestock grazing on sage grouse habitat. Indirect impacts are better understood than direct impacts. Chemical and mechanical treatments intended to provide increased quantities of grass forage for livestock have indirectly reduced the acceptability of sagebrush (*Artemisia* spp.) rangelands for sage grouse. Our paper examines: 1) potential mechanisms whereby livestock grazing in big sagebrush (*A. tridentata*) communities can modify sage grouse habitat and 2) the indirect influences of livestock production on sage grouse habitat. Overall, livestock grazing appears to most affect productivity of sage grouse populations. Residual grass cover following grazing is essential to conceal sage grouse nests from predators. Future research needs are identified and management implications related to livestock grazing in sage grouse habitats are included.

Key words *Artemisia tridentata, Centrocercus urophasianus,* livestock grazing, sagebrush habitat, sage grouse

Sage grouse (*Centrocercus urophasianus*) were found originally in Alberta, Arizona, British Columbia, California, Colorado, Idaho, Kansas, Montana, Nebraska, Nevada, New Mexico, North Dakota, Oklahoma, Oregon, Saskatchewan, South Dakota, Utah, Washington, and Wyoming (Aldrich 1963, Johnsgard 1983, Johnson and Braun 1999). Sage grouse have been extirpated in Arizona, British Columbia, Kansas, Nebraska, New Mexico, and Oklahoma (Johnson and Braun 1999). Breeding populations in 9 other states and Alberta declined 17–47% (33.4±2.6% [$\bar{x}$±SE]) from 1985 to 1994 from long-term averages through 1984 (Connelly and Braun 1997).

The decline of sage grouse has been so great that recently a population viability analysis, a procedure oriented toward managing rare and threatened species (Akçakaya et al. 1999), was performed to evaluate population viability on the largest population of hunted sage grouse in Colorado (Johnson and Braun 1999). Recent behavioral and morphological research indicates phenotypic divergence between sage grouse populations (Hupp and Braun 1991, Young et al. 1994, Braun and Young 1995). These findings suggest that a distinct species of sage grouse (*C. minimus*, the Gunnison sage grouse) resides in southwestern Colorado and southeastern Utah, further increasing the complexities of conservation.

Biologists have recognized that long-term conservation of sage grouse populations depends on protecting large, continuous blocks of viable sagebrush (*Artemisia* spp.) habitat (Braun et al. 1977). Prior to large-scale eradication and degradation of sagebrush habitat, sage grouse occurrence was predictably wherever big sagebrush (*A. tridentata*) occurred (Aldrich 1963, Dalke et al. 1963, Johnsgard 1983). Vegetation treatments known to decrease

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the amount and acceptability of sagebrush habitat for grouse include plowing (Swenson et al. 1987), herbicides (Autenrieth 1969, Klebenow 1970, Martin 1970), mechanical removal (Wallestad 1975), surface mining (Eng et al. 1979), and fire (Fischer et al. 1996). In particular, broad-leafed herbicide treatments (primarily aerial spraying of 2,4-D (2,4-dichlorophenoxy)acetic acid)) have caused substantial loss, fragmentation, and deterioration of sage grouse habitat (Klebenow 1970, Wallestad 1975, Braun and Beck 1996). Sturges (1993) and Braun and Beck (1996) reported that sagebrush ranges sprayed with 2,4-D initially experience loss of sagebrush, suppression of forbs, and increases in grasses.

Following World War II and through the 1970s, large expanses of sagebrush habitat in the western United States were burned or chemically or mechanically treated and often reseeded to increase production of grass forage for livestock consumption (Schneegas 1967, Shown et al. 1969, Vale 1974, Branson 1985). Vale (1974) reported about 10-12% of 40 million ha of sagebrush rangeland in North America had been treated to increase grass production for livestock forage by 1974. Schneegas (1967) estimated 2.0-2.4 million ha of western sagebrush range were altered in this manner in a 30-year period.

According to Guthery (1996), direct impacts of livestock herbivory on sage grouse habitat are contextual; effects can be positive, negative, or neutral, depending on habitat application. Empirical evidence supporting direct effects of livestock herbivory on sage grouse habitat is limited (Table 1). However, Connelly and Braun (1997) implicated livestock grazing as one of 3 range-wide factors (fire and weather patterns also were listed) associated with widespread declines of sage grouse through habitat deterioration, loss, and fragmentation. A synthesis of livestock grazing mechanisms associated with changes in sage grouse habitat is lacking. Objectives of our paper are to: 1) review current literature to evaluate impacts, 2) propose hypotheses that should be tested in future research to predict

Table 1. Review of literature implicating livestock grazing with direct and indirect impacts on sage grouse and habitat.

Location[a]	Impact	Source(s)[b] Expert opinion	Empirical Evidence
	Direct Positive		
NV	Light or moderate cattle grazing in dense, grassy meadows induced sage grouse use.		6
NV	Cattle grazing stimulated growth of grouse food forbs in upland meadows.		2
NV	Light cattle grazing made food forbs more available.		9
NV	Rest-rotation cattle grazing promoted recovery of grouse food forbs in rested units.		9
	Direct Negative		
UT	Sheep bed grounds on ridges destroyed sagebrush used by sage grouse in heavy snows.	11	
NV	Overgrazing leads to deteriorated wet meadow hydrology; reduces grouse habitat.		7, 10
UT	Sheep and cattle trampling destroyed eggs.		11
UT	Sheep and cattle caused nest desertions.		11
NV	Heavily grazed meadows in poor condition avoided by sage grouse.		6
CO	Densities of nest-depredating ground squirrels likely increased following heavy grazing.	4	
	Indirect Positive		
ID	Sage grouse created new leks on domestic sheep salting grounds.		3
RW	Reducing dense sagebrush cover should improve herbaceous plants used by sage grouse in summer.	12	
	Indirect Negative		
RW	Reduction in habitat through conversion of sagebrush to livestock grass forage.		1
GB	Livestock grazing can promote introductions of alien weeds.		13
RW	Winter sagebrush cover lost through sagebrush conversion to grassland.		12
MT	Sprayed sagebrush strips contained lower abundances of sage grouse food forbs.		8
ID	Sage grouse quit nesting in areas treated with herbicides to increase grass forage.		5

[a] Locations are: CO = Colorado, GB = Great Basin, ID = Idaho, MT = Montana, NV = Nevada, RW = range-wide, UT = Utah.

[b] (1) Braun et al. 1977, (2) Evans 1986, (3) Hulet 1983, (4) Giesen 1995, (5) Klebenow 1970, (6) Klebenow 1982, (7) Klebenow 1985, (8) Martin 1970, (9) Neel 1980, (10) Oakleaf 1971, (11) Rasmussen and Griner 1938, (12) Vale 1974, (13) Young and Longland 1996.

influences of livestock grazing on sage grouse and their habitat, and 3) provide implications for management to enhance sage grouse habitat in areas grazed by livestock.

Influences of livestock grazing on sagebrush communities

Livestock grazing effects on distribution, density, and cover of sagebrush

Miller et al. (1994) lists intensive season-long grazing as one cause (reduced fire frequency and climate change are also listed) of increases in woody vegetation during the late 1800s and early 1900s on western sagebrush ranges. High levels of livestock grazing can reduce competition between grasses and sagebrush and trigger increases in sagebrush density (Vallentine 1989). In particular, Laycock (1979) noted that high levels of spring grazing by cattle and domestic sheep reduce vigor and production of herbaceous species, leading to increases in sagebrush. Peterson (1995) reported that scientific and historical evidence does not support increases in sagebrush distribution by livestock grazing. Vale (1975) suggested sagebrush was a common shrub across most of the Intermountain West prior to settlement and grazing only increased brush densities in local areas.

Brotherson and Brotherson (1981) compared vegetative cover in grazed and ungrazed (not grazed for 35–40 yr) big sagebrush communities surrounding Utah Lake in central Utah. They found an average increase of 12.9% for big sagebrush cover in grazed communities. However, a 54% increase in big sagebrush canopy cover occurred in southeastern Idaho following cessation of grazing for 25 years (Anderson and Holte 1981). It is important to note that sagebrush-grass associations can appear to be stable over a wide range of brush-to-grass compositions (West et al. 1984), so increases in sagebrush cover following periods of grazing should be related to nearby ungrazed community compositions.

Trampling by livestock can kill sagebrush, particularly smaller plants. Owens and Norton (1990) reported cattle grazing caused great mortality of juvenile (<50-cm^2 canopy) and lesser mortality of adult (>50-cm^2 canopy) basin big sagebrush (*A. t. tridentata*) under short-duration and continuous season-long grazing. When subjected to trampling by cattle and domestic sheep, basin big sagebrush seedlings sheltered by mature plants exhibited greater survivability than those in unsheltered interspaces (Owens and Norton 1992).

Domestic sheep and goats have been used as biological agents to reduce brush (Riggs and Urness 1989, Sharrow et al. 1989) and have been suggested to control big sagebrush (Laycock 1979). Sheep browsing in fall and winter can reduce density and vigor of sagebrush (Laycock 1967, 1979), especially where sagebrush densities are low (Frischknecht and Harris 1973). In some instances, high levels of browsing by concentrations of wintering big game have severely reduced cover and density of big sagebrush (McArthur et al. 1988, Wambolt and Sherwood 1999). However, under most normal conditions, browsing by wild ungulates should not dramatically affect density and cover of big sagebrush.

Livestock grazing effects on herbaceous composition of sagebrush communities

Understory herbaceous productivity may not increase in depleted sagebrush ranges following release from grazing (Holechek and Stephenson 1983, West et al. 1984). Laycock (1991) suggested grazing can move sagebrush-grass communities into lower successional stable states dominated by sagebrush with little herbaceous understory. Changes in grazing practices may not be adequate to move new sagebrush-dominated communities across a threshold toward a grass-sagebrush state; additional management inputs are often needed to reverse these lower successional stable states.

West et al. (1984) reported no increases in total herbaceous standing crop on a native big sagebrush rangeland in west-central Utah following 13 years

Grazing probably most affects nesting success of sage grouse. Nests in sagebrush areas with greater residual cover of herbaceous plants have a greater likelihood of success. Pictured is a successful sage grouse nest under good cover components.

of no livestock grazing. A study in the more mesic sagebrush steppe of southeastern Idaho indicated basal cover of perennial grasses increased from about 0.3% to 5.8% following 25 years of grazing exclusion (Anderson and Holte 1981). Herbaceous plant basal cover is considered more adequate for range trend comparisons than canopy cover because basal cover is not as sensitive to climatic fluctuations (Bureau of Land Management 1996). This point suggests that range condition on this Idaho sagebrush range improved following elimination of grazing.

A knowledge of grazing histories in various sagebrush rangelands is vital to provide insights into current botanical compositions. Cattle selectively graze grasses, whereas domestic sheep prefer forbs (Vallentine 1990). Ellison (1954) suggested intensive long-term grazing can shift herbaceous community composition to comprise those species which are less acceptable to classes of livestock (e.g., forbs on cattle ranges and grasses on sheep ranges; Figure 1). Holechek and Stephenson (1983) attributed historic domestic sheep grazing with a near absence of forbs in grazed areas and areas protected following grazing in a big sagebrush rangeland in north-central New Mexico.

Season of use is another factor contributing to changes in sagebrush community composition. Bork et al. (1998) related that long-term fall grazing by domestic sheep at the United States Sheep Experiment Station in southeastern Idaho resulted in more perennial grass and forb cover and less shrub cover. Spring grazing resulted in less perennial forb cover and increases in cover of shrubs and grazing-tolerant perennial grasses.

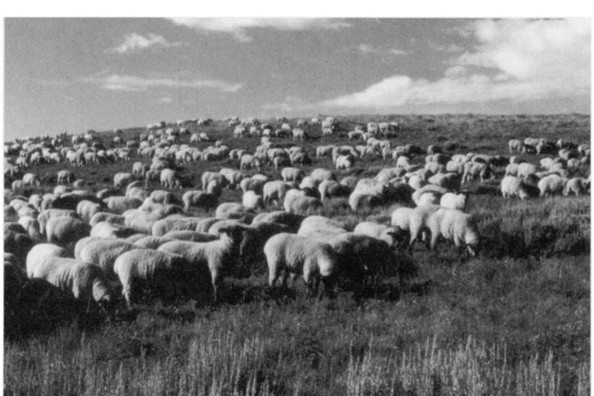

Figure 1. A knowledge of grazing histories can lend insight to current sagebrush understory compositions. Over time, sheep grazing can shift ranges toward grass dominance, whereas cattle grazing can cause rangeland to be composed of more forbs.

Van Poolen and Lacey (1979) compiled results from 18 western grazing system studies and found adjustments in livestock numbers caused herbage production to increase 35±14% ($\bar{x}$±SE) and 28±13% when grazing use levels were reduced from high (heavy, 60-80%) to moderate (40-60%) and moderate to light (20-40%), respectively. Mean herbage production increased 13±8% when grazing systems were implemented at moderate use levels. These authors concluded stocking intensity was more important than implementing grazing systems to improve herbage production. Hart et al. (1988) compared herbage production, botanical composition, and basal cover in continuous (season-long), deferred-rotation (4-pasture), and short-duration (8-pasture) grazing systems in southeastern Wyoming. They reported no differences in peak standing crop due to stocking rate or grazing system in any year. Differences in production among years were affected only by amount and timing of precipitation. Yearly fluctuations in precipitation may account for large differences in annual forage productivity (Vallentine 1990), which can mask effects of grazing observed during normal weather years.

Influence of livestock production on modifications to sagebrush communities

Vale (1974) reported that herbicide spraying projects through the early 1970s were more common in sagebrush areas with good grass understories (e.g., Wyoming) than in areas with limited grass understories (e.g., Nevada). Wambolt and Payne (1986) found 2,4-D-sprayed and burned Wyoming big sagebrush (*A. t. wyomingensis*) in southwestern Montana yielded similar production (kg/ha) of bluebunch wheatgrass (*Pseudoroegnaria spicata*), the dominant forage species, and perennial forb and grass classes 18 years post-treatment. Crested wheatgrass (*Agropyron cristatum*) has been seeded as a monoculture in many areas with poor grass understories to facilitate increases in forage production (Shown et al. 1969, Ritchie et al. 1994). Crested wheatgrass seedings provide extremely poor habitat structure and diversity, causing declines of sage grouse and other sagebrush-obligate birds (Reynolds and Trost 1980).

Johnson et al. (1996) reported thinning big sagebrush in Wyoming with tebuthiuron (*N*-[5-(1,1-dimethyl)-1,3,4-thiadiazol-2-yl]-*N*-*N*-dimethylurea) produced greatest herbaceous production (dry g/m^2 of forbs, graminoids, or both) when sagebrush cover had been reduced to about 11-17%. Furthermore, they suggested production of sage grouse food forbs may be enhanced by thinning big sagebrush to about 15% cover.

Fire has been used to suppress big sagebrush because it does not resprout following fire (Pechanec et al. 1965). Burning may suppress sagebrush cover for long time periods (Wambolt and Payne 1986). In some areas sagebrush cover returns relatively soon following burns. For example, Harniss and Murray (1973) reported mean density of sagebrush (no. plants/30.5 m^2) was 34.3 and 41.0 in burned and unburned sagebrush habitat, respectively, following a 30-year-old burning treatment in southeastern Idaho.

Sagebrush rangelands disturbed by livestock overgrazing and other factors have promoted establishment of the annual, cheatgrass (*Bromus tectorum*), in the Great Basin and the Northwest (Branson 1985). Fine, dense fuels provided by cured annual grasses increase probability of fire ignition and rate of spread. This mechanism reverses normal rangeland fire renewal processes toward native sagebrush and bunchgrass to exotic annual grass-dominated communities (Young and Longland 1996). Grazing can reduce fine fuels necessary to carry fires (Miller et al. 1994). Hobbs (1996) indicated cycling of nutrients via ungulate urine and feces conserves nutrients otherwise volatilized through burning biomass.

Discussion

Positive and negative effects have been observed and documented for direct and indirect impacts of livestock grazing on sage grouse and their habitat (Table 1). Ten of 17 (58.8%) relationships detailed in Table 1 imply direct impacts of livestock grazing on sage grouse and their habitat. However, it appears that indirect impacts of livestock grazing have adversely affected sage grouse habitat more than direct impacts have. Large-scale rangeland treatments intended to increase grass forage for livestock have reduced critical sagebrush components essential to sage grouse (Braun et al. 1977). Impacts should be considered in the context of their scale. For example, a sage grouse population in southeastern Idaho may have benefitted indirectly from presence of livestock when they established strutting grounds on sheep salting areas (Hulet 1983), whereas weed infestations induced by livestock grazing in the Great Basin (Young and Longland 1996) may reduce quality of habitat for sage grouse populations across this vast region.

Three studies (Neel 1980, Klebenow 1982, Evans 1986) have demonstrated that cattle grazing can be used to stimulate forbs important as sage grouse food. These studies were conducted in Nevada and focused on livestock use of mesic upland meadows frequented by sage grouse. These relationships may not have as wide applicability to areas where summer forb abundances are not as tied to localized wet meadow areas as they are in Nevada.

Fagerstone and Ramey (1996) indicated certain species of ground squirrels (*Spermophilus* spp.) may be favored by high levels of grazing. Secondary succession promoted by elevated grazing disturbances can encourage weedy plants preferred by ground squirrels, thereby increasing squirrel numbers (Sampson 1952). Giesen (1995) reported that depredation, primarily by Richardson's ground squirrels (*S. richardsonii*), accounted for most sage grouse nest losses in 2 years in northern Colorado following a period of high grazing levels precipitated by drought conditions. Giesen suggested ground squirrel densities coupled with reduced cover for sage grouse nests may have increased ground squirrel depredation.

Stocking intensity can profoundly affect residual vegetation following grazing (Van Poolen and Lacey 1979). Daddy et al. (1988) reported that a big sagebrush site moderately grazed (2 ha/AUM) by cattle in northwestern New Mexico had greater total herbaceous cover and biomass than either a site protected from grazing for 21 years or a site grazed at high use levels. Timing of use coupled with stocking intensity may have the greatest impact on value of sagebrush habitat to sage grouse. In particular, grazing during the late spring nesting period may reduce herbaceous cover components essential in concealing nests from avian and mammalian predators (Gregg et al. 1994, DeLong et al. 1995). Giesen (1995:32) related that "while predation may be the proximate cause of sage grouse nest loss, habitat at the nest site may be the ultimate factor determining nesting success."

Connelly and Braun (1997) acknowledged that there is little direct evidence associating sage grouse population levels with grazing practices. However, evidence can be derived from productivity of sage grouse in regions where grazing has influenced botanical composition and productivity of sagebrush rangelands. Studies suggest that sage grouse nesting and brooding success corresponds with grazing practices (Gregg et al. 1994, DeLong et al. 1995, Sveum et al. 1998).

Crawford and Lutz (1985) concluded that long-term declines in Oregon sage grouse populations were only from changes in productivity; survival indices showed no consistent trends. Likewise, Klebenow (1985) reported long-term declines in sage grouse in portions of Nevada were related to low reproduction (no. chicks/100 hens). Crawford and Lutz (1985) recommended studying factors related to sage grouse nesting and brooding success.

Gregg et al. (1994) found only 18 (14.5%) of 124 sage grouse nests located in 3 years in Oregon were not depredated. Tall grass cover was greater at successful nests than at random sites or depredated nests and, except in one case, tall grasses at non-depredated nests consisted of residual cover. DeLong et al. (1995) found odds of predation of simulated sage grouse nests in southeastern Oregon with 5% tall grass cover and 29% medium shrub cover (average cover for depredated nests [Gregg et al. 1994]) were 1.34 times greater than odds of predation of artificial nests with 18% tall grass cover and 41% medium shrub cover (average covers for nondepredated sage grouse nests). Sveum et al. (1998) concluded that sagebrush communities with abundant herbaceous cover appeared to have greatest probability of concealing sage grouse nests. They recommended increasing cover of native perennial forbs and grasses to enhance food and cover in sagebrush.

Drut et al.'s (1994) work on sage grouse chicks in southeastern Oregon suggests that chicks consume numerous plant and insect foods in concordance with long-term rangeland productivity estimates. Their results indicated sage grouse chick survival may be related to rangeland productivity of primary foods (forbs and insects). Barnett and Crawford's (1994) results indicated nutrient content of forbs increases the overall nutrition of composite hen sage grouse diets prior to egg laying. In addition, a year of decreased forb abundance in Barnett and Crawford's study area corresponded with decreased chicks/hen and average brood size the same year. These results suggested a reproductive response by sage grouse hens to forb availability.

Changes to sagebrush habitat intended to provide additional forage to grazing livestock have severely altered habitat for sage grouse across their range. Direct impacts of livestock grazing on sage grouse habitat point to reduced sage grouse fecundity. Livestock grazing is a long-standing use of western rangelands. These conditions suggest the need for further understanding effects of livestock herbivory on sagebrush habitat to evaluate responses of sage grouse populations.

Future research needs

Replicated field experiments are needed to determine widespread, relative effects (Ratti and Garton 1994) of grazing treatments and stocking intensities on sage grouse nesting success and brood survival. Replicated field experiments also are needed to evaluate effects of grazing treatments, use levels, and stocking intensities on abundances of important grouse forbs and insects in brood-rearing habitat relative to grazing treatments. Kind and class of livestock, season of use, stocking intensity, and duration of grazing should be considered in treatment designs to assess the reaction of various types of sagebrush ranges to livestock grazing (Tisdale and Hironaka 1981).

Studies need to be conducted to assess sage grouse population responses to livestock grazing adjacent to control areas where grazing does not occur. Again, replications are needed in these designs to facilitate certainty (few alternate hypotheses likely) in hypotheses testing while providing large inferential ability to many areas (Ratti and Garton 1994).

Management implications

Range and livestock management on sagebrush rangelands inhabited by sage grouse should be approached from the standpoint of adaptive management to improve specific habitat components for grouse. The following recommendations should be considered in sage grouse habitat management scenarios in areas grazed by livestock:

1) Sagebrush eradication treatments should not be practiced. However, herbicides (or mechanical treatments) could be used to thin dense sagebrush stands to about 15% cover in nesting and brooding areas to enhance herbaceous plants while maintaining sagebrush cover (Johnson et al. 1996). Small burns to enhance herbaceous mosaics in sagebrush brooding habitats may provide benefits in mountain big sagebrush (*A. t. vaseyana*) areas (Pyle and

Crawford 1996), but may be detrimental in xeric sagebrush (Wyoming big sagebrush and 3-tipped sagebrush [*A. tripartita*]) habitats (Fischer et al. 1996). Burns should be applied cautiously to improve sage grouse brood habitat as Pyle and Crawford (1996:323) reported "the proper pattern of interspersion and ideal size of burn sites for enhancement of chick foods remains unknown."

2) Rehabilitation work following disturbances such as wildfires should focus on immediate reestablishment of mixes of sagebrush and native herbs. Annual grassland establishment following fire is very detrimental to sagebrush habitat integrity (Young and Longland 1996). Grazing should not be allowed on seeded areas until plant recruitment (including sagebrush) has occurred. Seeded areas should not be grazed for at least 2 consecutive growing seasons after seeding or until seeded species are well established (Holechek et al. 1989). Work by Owens and Norton (1990, 1992) suggests longer periods of rest from grazing may be needed to ensure young sagebrush plants are not killed by livestock trampling.

3) Range seedings should focus on establishing forbs and subspecies of big sagebrush suited to various range sites. Native grasses that do not outcompete beneficial forbs and shrubs also should be included in seeding mixtures to provide additional cover. Seedings designed strictly to increase grass production are discouraged. Monoculture seedings of crested wheatgrass and other non-native grasses are especially discouraged. Soil type, elevation, and amount of precipitation should be considered when determining suitability of plant materials to various locations (Vallentine 1989).

State and federal resource agencies can often provide information on species adapted to local conditions. For example, Beck and Mitchell (1997) provided lists of herbaceous plants suitable for reseeding big sagebrush types in Utah to enhance sage grouse habitat.

4) Applying insecticides to sage grouse summer habitat is not recommended. Johnson and Boyce (1990) found that insects were essential for survival of captive sage grouse chicks up to 3 weeks of age and were required by chicks of all ages for normal development. Extra caution is suggested in spraying areas frequented by broods as Johnson and Boyce (1990) indicated densities and compositions of insects needed by sage grouse chicks to meet their requirements are not known. Furthermore, Blus et al. (1989) documented sage grouse die-offs resulting from exposure to organophosphorus insecticides applied to cultivated crops adjacent to rangeland in southeastern Idaho.

Figure 2. Grazing can be used as a tool to enhance sage grouse habitat. For example, livestock grazing could be used periodically inside meadow exclosures to reduce old vegetation, thereby exposing and rejuvenating succulent forbs used by sage grouse.

5) Livestock use around water sources and wet meadows in brood-rearing areas should be regulated through fencing, grazing, or herding management to restrict overuse, thereby protecting vulnerable forbs and grasses. However, livestock grazing could be used periodically inside meadow exclosures to reduce old vegetation, thereby exposing and rejuvenating succulent forbs (Evans 1986; Figure 2).

6) In general, livestock grazing should be managed to allow optimum growth of forbs, grasses, and sagebrush. Management for a variety of sagebrush covers should exist with important use areas reflecting the general preference of sage grouse for sagebrush cover of 5–10% in summer or 20–35% in winter (Eng 1986). Grazing system, season of use, grazing duration, kind of livestock, and stocking

Prior to large-scale conversions of sagebrush habitat, sage grouse occurrence was predictably wherever big sagebrush was found.

intensity should be adjusted to maximize desired vegetal effects for sage grouse on ranges on a case-by-case basis.

7) Managers should consider removing livestock from sage grouse nesting areas prior to peak standing-crop development to maintain residual grass growth essential for nest concealment (Gregg et al. 1994) and then delay grazing the same areas until after nesting.

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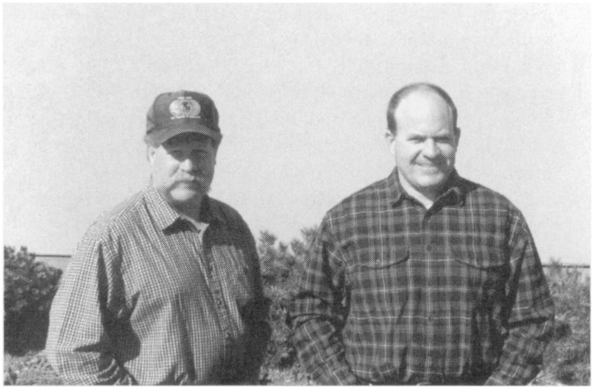

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