Synthesis of Livestock Grazing Management Literature Addressing Grazing Management for Greater Sage-Grouse Habitat in the Wyoming Basin - Southern Rocky Mountains Ecoregions

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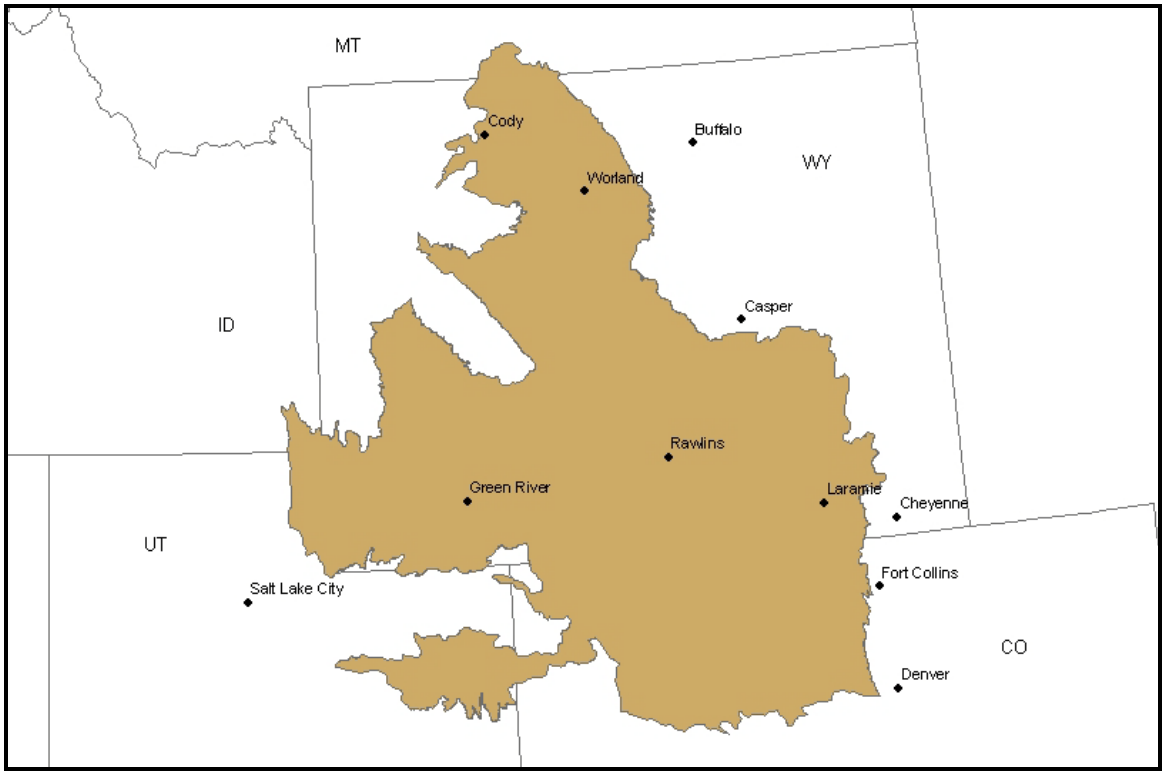
Introduction

The following tables contain literature addressing grazing management in Greater Sage-Grouse habitat within the Wyoming Basin - Southern Rocky Mountains Ecoregions (Figure 1). Information within the tables are direct citations from the identified sources. There may be two tables for each subject; the first table includes sources located within the Wyoming Basin-Southern Rocky Mountains Ecoregions, and the second table contains references that may be relevant to the Wyoming Basin - Southern Rocky Mountains ecoregions, but were not conducted within the ecoregional boundaries. This document is not intended to be an all-inclusive guide to grazing management in sage-grouse habitat, but rather an information reference that sage-grouse local working groups and land managers may utilize as they develop recommended grazing practices for promoting the conservation of sage-grouse and sagebrush habitats.

Figure 1: Wyoming Basin – Southern Rocky Mountains Ecoregions



Grazing Management and Greater Sage-Grouse

Source	Citation
Deseret Land and Livestock Ranch. No date. Deseret Land and Livestock Ranch Livestock Grazing and Rangeland Management Benefit Greater Sage Grouse. Western Governor's Association, U.S. Department of Agriculture Natural Resources Conservation Service.	The principle management technique used on the DLL is time controlled grazing. This involves the use of a few large herds of cattle and sheep that intermittently graze the pastures. Grazing occurs on the pastures for short periods of time when forage is rapidly growing (May-July), and longer periods of time when forage is dormant or slow growing. The season of grazing varies between years, and pastures receive periodic rest for a full growing season. This system recognizes that plant health is the key to having well functioning watersheds. The time-controlled grazing practices used at [Deseret Land and Livestock Ranch] since 1979 have increased herbaceous cover on rangelands and slowed the rate of sagebrush increase. Rick Danvir of [Deseret Land and Livestock Ranch] said, "The grazing and other management techniques being used are focused on providing both forage for an economically viable ranching operation and improving habitat for a variety of wildlife species. The key items in our management system is the rest-rotation grazing system and the emphasis we place on increasing forbs, including inter-seeding forbs into crested-wheatgrass dominated rangeland."
Greer, R. 1990. Sage Grouse Habitat Requirements and Development. Wyoming Game and Fish Dept.	At livestock water troughs, bird ramps or hardware cloth should be installed.
Holloran, M.J. 2005. Greater Sage-Grouse (*Centrocercus urophasianus*) Population Response to Natural Gas Field Development in Western Wyoming. Ph.D. Dissertation. University of Wyoming, Laramie.	…we recommend management activities that allow for maintenance or restoration of dense, taller residual grasses within suitable sagebrush stands to enhance greater sage grouse populations

The following sources may contain information relevant to the Wyoming Basin - Southern Rocky Mountains ecoregions, but were not conducted within the ecoregional boundaries.

Source	Citation	Location of Study
Crawford, J. A., M. A. Gregg, M. S. Drut, and A. K. DeLong. 1992. Habitat use by female Sage Grouse during the breeding season in Oregon. BLM Coop. Res. Unit, Oregon State Univ. Corvallis, OR	Develop programs for grazing by domestic livestock on Oregon rangelands to achieve a more favorable ecological balance in the shrub canopy and herbaceous understory.	Oregon
Miller, R.F., and L.L. Eddleman. 2000. Spatial and temporal changes of sage grouse habitat in the sagebrush biome. Oregon State Univ. Agric Exp Stn. Technical Bulletin 151. Corvallis, OR.	… poor livestock grazing practices can have long-term negative impacts on sage-grouse habitat by degrading sagebrush, meadow and riparian communities. In developing grazing plans for specific areas used by sage grouse, it is extremely important to identify potential conflicts between sage grouse and livestock, and spatial and temporal heterogeneity of the management unit.	Oregon
Willis, M. J., G. P. Keister, Jr., D. A. Immell, D. M. Jones, R. M. Powell, and K. R. Durbin. 1993. Sage Grouse in Oregon. Oregon Dept. of Fish and Wildlife. Wildlife Research Report No. 15. Portland, OR.	…manage grazing at the proper level to achieve the benefits without adverse impacts …projects that actively pursue improvements in degraded habitats such as monotypic stands of grass or Wyoming big sagebrush would be beneficial.	Oregon
Rowland, M.M. 2004. Effects of management practices on grassland birds: Greater Sage-Grouse. Jamestown, ND Northern Prairie Wildlife Research Center.	Avoid development of livestock-watering structures in sage-grouse habitat (Connelly et al. 2000). If water developments are constructed for sage-grouse or other wildlife, they should be placed to ensure that water is available during movement of sage-grouse from spring to summer ranges (Wakkinen 1990). Connelly et al. (2000) recommended that pipelines from springs be built so that free water is available to maintain the spring and	Northern Great Plains (North Dakota)

	associated wet meadows.	
Woodward, J.K. 2006. Greater sage-grouse (*Centrocercus urophasianus*) habitat in central Montana. Animal and Range Sciences, Montana State University. Bozeman, Montana.	Improved livestock grazing management is the least expensive practice to restore degraded sagebrush steppe (Braun 2006) and the most important because it often treats the cause of degradation. Increases in chick production were realized in 2005 because of increased precipitation resulting in an increase in herbaceous cover. If herbaceous cover could be increased through time regardless of precipitation, production could potentially be increased markedly. Practices that increase the amount of rest a pasture receives may be useful to restore fair and poor condition range, hence, increasing herbaceous cover for grouse (Adams et al. 2004). Reductions in stocking rates (or grazing intensity) in over-grazed areas have the greatest potential to increase herbaceous cover. Braun (2006) recommends 25-30% utilization for livestock on public land that needs improvement. Decreasing intensity of grazing (stocking rate) will likely have the greatest benefit followed by changing timing of grazing, and changing frequency of grazing (Braun 2006).	Montana
Authenrieth, R., W. Molina, and C. Braun, eds. 1982. Sage Grouse Management Practices. Western States Sage Grouse Committee. Western States Sage Grouse Committee Technical Bulletin #1. Twin Falls, ID.	Guzzlers can be installed on sage grouse summer range where water is a limiting factor. An open trough guzzler at ground level is the most desirable	N/A

	All livestock water troughs should have bird ramps installed. It is more desirable for sage grouse and other birds and small mammals to develop a tank overflow system, which provides water at ground level. The BLM policy manual states water systems used by livestock will be left on for wildlife use even when livestock have been moved.	
Beck, J.L, and D.L. Mitchell. 2000. Influences of livestock grazing on sage grouse habitat. Wildl Soc Bull. 4: 993-1002.	…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 intensity should be adjusted to maximize desired vegetal effects for sage grouse on ranges on a case-by-case basis	Location unknown
Connelly, J.W. and C.E. Braun. 1997. Long-term changes in sage grouse (*Centrocercus urophasianus)* populations in western North America. Wildlife Biology 3:229-234.	There is little scientific data linking grazing practices to sage-grouse population levels.	N/A
Connelly, J. W., S. T. Knick, M. A. Schroeder, and S. J. Stiver. 2004. Conservation Assessment of Greater Sage-grouse and Sagebrush Habitats. Western Association of Fish and Wildlife Agencies. Unpublished Report. Cheyenne, Wyoming.	In a synergistic feedback mechanism, the interaction of livestock grazing, loss of understory and altered soil characteristics, and reduced fire frequency result in increased shrub cover and dominance. Even though management plans attempt to use rest-rotation or other forms of variable grazing	N/A

	intensities to mimic the previous natural grazing regimes and vegetation response, the plant communities still are not given the rest from grazing and recycling of resources is dissimilar (Bock et al. 1993, Freilich et al. 2003). Livestock grazing can affect soils, vegetation, and animal communities (Jones 2000). Livestock consume or alter vegetation, redistribute nutrients and plant seeds, trample soils and sagebrush plants, and can disrupt microbiotic crusts (Miller et al. 1994, West 1996, Belnap and Lange 2001). The extent to which these mechanisms influence habitats depends on the relationship between level of grazing disturbance and the resiliency of the habitat. At unsustainable levels of grazing, these changes can lead to loss of vegetative cover, reduced water infiltration rates, and increased soil erosion (Society for Range Management 1995). Indirect effects of livestock grazing can amplify or facilitate other disturbance. Stocking rates for livestock are based on assumptions of an average set of conditions, estimates about the size of the area necessary to produce enough food to sustain livestock, and the relationship between the current vegetation community and an ideal condition, seral stage, or climax community (Box 1990, Society for Range Management 1995, Holechek et al. 1998). Actual number of livestock that may be grazed is determined by season of use, the distribution, utilization, and	

	actual use of available forage, and the class of livestock. Average conditions rarely exist and western landscapes have experienced extensive drought periods. Stocking rates are based on livestock production and financial livelihood of grazing permittees in addition to environmental considerations (Holechek et al. 1999). In the natural world, the number of herbivores is constrained by food supply. Because the relationship between food supply and numbers of livestock is buffered either by administrative, management, or economic factors, the time lag in changing the numbers of livestock in response to changes in habitat conditions can increase the effects of grazing (Thurow and Taylor 1999). The definition of “range condition” is widely debated (Friedel 1991, Joyce 1993, Schacht 1993, Scarnecchia 1995, Society for Range Management 1995). The set of environmental qualities that form the conceptual foundation of “range condition” influence not only our understanding of the effects of grazing but also our management actions to manipulate sagebrush habitats (West 2003). Grazing and management objectives are based on an assumed predictable or linear response to disturbance (Allen-Diaz and Bartolome 1998). Grazing often has been assumed to represent a disturbance that sets a sagebrush community back from a climax stage; release from grazing then will allow the community to return to a climax stage. Under this Clementsian	

	viewpoint of successional stages in vegetation communities, potential natural communities were considered to be in excellent condition, late seral to be good condition, mid-seral to be fair, and early seral in poor range condition. Yet, the dynamics of sagebrush communities are complex and plant species response to grazing may not be correlated closely (Milchunas and Lauenroth 1993, West and Young 2000). A wide range of shrub-grass compositions can be stable, length of time within seral stages may be nonlinear, and transitions among different states may be unpredictable (West et al. 1984, Westoby et al. 1989, Laycock 1991). More important, transitions among vegetation communities may be irreversible and return to a previous state is not possible once it is crossed. Consequently, livestock herbivory can alter vegetation communities, water and nutrient availability, and soils past thresholds to which the system can return. Stocking rates and estimates of the amount of vegetation that can be removed based on differences between a current vegetation community and an ideal or climax seral stage may not be sustainable (Holecheck et al. 1998). Conversely, release from grazing may have no or unpredictable results (Anderson and Holte 1981, West et al. 1984, Stohlgren et al. 1999, West and Yorks 2002), may not return a site to a previous state (Holechek and Stephenson 1983) or, exacerbate the influence	

	of exotic plants such as cheatgrass (Young and Allen 1997). Therefore, the current evolution in assessments of habitats and the effect of grazing is based on indicators of soil characteristics and erosion, plant communities, and underlying processes to evaluate the "health" of the ecosystem (National Research Council 1994). Productivity of western shrublands has declined due to previous grazing history or drought (West 1983, Holechek and Stephenson 1983). The distribution of livestock also has changed because water developments have increased the area that could be grazed. We cannot conclude that the effect of grazing has been reduced because even reduced numbers of livestock may still exert a larger influence on those habitats. Therefore, the absence of information on management coupled with vegetation changes (e.g., Yorks et al. 1992) limits our understanding of the effect of livestock grazing on long-term dynamics of sagebrush systems. The primary habitat treatments on lands managed by the U.S. Bureau of Land Management include construction of fences, development or control of water, and habitat modifications... More than 1,000 km of fences were constructed each year from 1996 through 2002; most fences were constructed in Montana, Nevada, Oregon, and Wyoming. Linear density of fences exceeds 2 km/km^2 in some regions of the Conservation Assessment	

	study area…In addition to influencing livestock and predator movements, facilitating spread of exotic plants, and providing additional travel and access for human activities, fences potentially increase mortality of sage-grouse due to direct collisions or indirectly by increasing predation rates by increasing the number of perches for raptors. Fences used to control grazing management among allotments further modify the landscape by creating an artificial mosaic among separate pastures (Freilich et al. 2003). Water developments were widespread throughout public lands... Water developments and distribution of water sources substantially influence movements and distribution of livestock in arid western habitats (Valentine 1947, Freilich et al. 2003). Consequently, grazing pressure can be unevenly distributed and influence the composition and relative abundance of the plant relative to water sources.	
Crawford, J.A., R.A. Olson, N.E. West, J.C. Mosley, M.A. Shroeder, T.D. Whitson, R.F. Miller, M.A. Gregg, and C.S. Boyd. 2004. Synthesis Paper: Ecology and management of sage-grouse and sage-grouse habitat. J. Range Manage. 57: 2-19.	Livestock grazing has been extant in sagebrush plant communities for more than a century. However, only a few studies have directly addressed the effects of livestock grazing on habitat use by sage-grouse. Consequently, rangeland and wildlife managers must rely, with caution, on indirect evidence for guidance. Livestock grazing may affect sage-grouse habitat directly by altering structural habitat factors or plant community composition, or indirectly by altering abiotic	Location unknown

	processes (e.g., MFRI) and invasibility of sagebrush plant communities. While the impact of grazing on sagebrush plant communities varies with site potential, ecological condition, and climate variables, the aspects of livestock grazing that are controlled by management are, principally, the timing and intensity of defoliation. Research suggests that moderate livestock grazing or less in mid to late summer, fall, or winter is generally compatible with the maintenance of perennial grasses and forbs in sagebrush habitat (Pechanec and Stewart 1949, Mueggler 1950, Laycock and Conrad 1967, 1981, Gibbens and Fisser 1975, Miller et al. 1994, Bork et al. 1998). Herbaceous species in sagebrush plant communities are predominantly cool-season (C-3) plants that are vulnerable to defoliation during late spring and early summer. Heavy grazing (approximately 60% or greater utilization by weight) during this time has predictable results: 1) the vigor, yield, and cover of late-seral grasses and forbs decrease; 2) early-seral species (including annual grasses) may increase; 3) sagebrush density and canopy cover may increase (Craddock and Forsling 1938, Pechanec and Stewart 1949, Mueggler 1950, Laycock 1967, Bork et al. 1998); and 4) transition of sagebrush uplands to higher ecological status is inhibited (Mueggler 1950, Eckert and Spencer 1986, Laycock 1987…). Moderate use has traditionally been defined as	

	occurring within the range of 40–60% utilization by weight, however, generalizing a specific level of utilization that represents “proper use” can be difficult (Caldwell 1984). These difficulties arise in part due to lack of consistency in measurement technique (Frost et al. 1994), and the variable impact of a given level of utilization on plant communities in accordance with plant species present, site conditions, and climate variables. Some perennial grasses, such as Indian ricegrass (Oryzopsis hymenoides (R. & S.) Ricker), needle-and-thread (Stipa comata Trin. & Rupr.), Nevada bluegrass (Poa nevadensis Vasey ex Scribn.), and Sandberg bluegrass, can withstand severe grazing (approximately 80% or greater utilization) as long as defoliation does not occur during the plants’ reproductive period (Pearson 1964). Other grasses such as Idaho fescue, Thurber needlegrass (Stipa thurberiana Piper), and bottlebrush squirreltail (Sitanion hystrix (Nutt.) J.G. Smith) decrease with heavy grazing (Rickard et al. 1975, Eckert and Spencer 1987). Restoration of sites in poor ecological condition may benefit from reduced utilization (Holechek et al. 1999) or rest... Additionally, grazing tolerance of sagebrush- dominated plant communities can decrease with drought conditions and increase in periods of above average precipitation (Westoby et al. 1989). When used in conjunction with other information sources (e.g., weather data, non-livestock sources of herbivory) utilization data	

	can be a valuable tool for helping to interpret the influence of livestock herbivory on vegetation trend (Sanders 1998). However, utilization data are not a substitute for long-term vegetation monitoring, and management objectives should be based on desirable vegetation composition over time, not utilization guidelines (Sharp et al. 1994, Burkhardt 1997, Sanders 1998). Cattle, sheep, and horses (Equus caballus) in sagebrush habitat eat grass-dominated diets in all seasons of the year (Severson et al. 1968, Harrison and Thatcher 1970, Mackie 1970, Uresk and Rickard 1976, Olsen and Hansen 1977, Reiner and Urness 1982, Krysl et al. 1984, Ngugi et al. 1992, Crane et al. 1997, Glidewell et al. 2001) although sheep may consume a higher percentage of their diet as forbs. Livestock usually consume little to no sagebrush (< 10%) unless snow depth exceeds 20 cm (Harrison and Thatcher 1970), but winter sheep use of low elevation basin big sagebrush may be much greater (Cook et al. 1954). Sheep grazing in fall favors production of perennial forbs, whereas spring grazing can decrease forb production (Bork et al. 1998). Reduced sagebrush canopy cover in fall-grazed pastures (Mueggler 1950, Laycock 1967, Bork et al. 1998) is caused largely by competition from healthy grasses and forbs, rather than fall livestock browsing of sagebrush (Wright 1970).	

	Sagebrush cover generally increases as utilization of the herbaceous understory increases (Wright and Wright 1948, Pechanec and Stewart 1949, Mueggler 1950, Laycock 1967, Bork et al. 1998). But, once sagebrush cover reaches an upper threshold, livestock exclusion may have little effect on reversing the immediate trend (Johnson and Payne 1968, Rice and Westoby 1978, Sanders and Voth 1983, Wambolt and Payne 1986). Over long time intervals (40 years or more), sagebrush abundance may decline with a concomitant increase in understory herbaceous species (Anderson and Inouye 2001). On Wyoming big sagebrush sites with dense sagebrush and an understory of annual grasses, reductions in livestock grazing can hasten further habitat degradation if ungrazed fuel loads promulgate wildfires that burn uniformly and kill sagebrush on vast areas (Peters and Bunting 1994, West 1999). Timing of grazing greatly influences the effects of livestock grazing in meadows and riparian areas. These sites are particularly vulnerable in late summer when excessive grazing and browsing may damage riparian shrubs, reduce the yield and availability of succulent herbs (Kovalchik and Elmore 1992), and cause deterioration of riparian function over time (Klebenow 1985). However, moderate utilization by livestock in spring, early summer, or winter is sustainable in non-	

	degraded meadow and riparian areas within sagebrush habitat (Shaw 1992, Clary et al. 1996, Mosley et al. 1997). Moderate use equates to a 10- cm residual stubble height for most grasses and sedges and 5-cm for Kentucky bluegrass (Mosley et al. 1997, Clary and Leininger 2000). Shrub utilization should not exceed 50–60% during the growing season, and at least 50% protective ground cover (i.e., plant basal area + mulch + rocks + gravel) should remain after grazing (Mosley et al. 1997). While hydrophytic shrubs may not directly serve as sage-grouse habitat, they do impact the stability of riparian and meadow habitats important to sage-grouse (Winward 2000). The length of time livestock have access to meadows may be more important than the level of utilization; it has been suggested that livestock access be limited to < 3 weeks (Myers 1989, Mosley et al. 1997). In riparian and meadow habitat degraded by heavy livestock utilization, rest from grazing may be necessary for recovery (Clary and Webster 1989).	
Hockett, G.A. 2002. Livestock Impacts on the Herbaceous Components of Sage Grouse Habitat: A Review. Int. Jour. Sci.	Protect sage grouse spring, summer and fall ranges during periods of drought. Drought alone has been identified as a major factor contributing to the range-wide decline of sage grouse (Connelly and Braun 1997). Design adaptive management strategies to protect against the cumulative effects of grazing use on sage grouse forage and cover during drought.	Location unknown

	Manage 25-33 percent of the sagebrush-riparian landscape for climax species and processes using concepts outlined by Bock et al. (1993). This can be done while still providing for deferred or rest-rotation grazing over the remaining 66-75 percent of the sagebrush landscape. Target key nesting and brood rearing habitat for climax vegetation to increase sage grouse productivity. Sage grouse nest densities increase along sagebrush riparian corridors (Patterson 1952). Therefore, manage for climax vegetative cover and forage along primary sagebrush-riparian interfaces including ≥0.8 km of sagebrush habitat type on either side of riparian corridors. Unless local data indicates additional protections are necessary, this partial climax conservation strategy on grazed sage grouse habitat offers some perpetual mitigation against the inevitable effects of drought while still allowing grazing over the majority of sagebrush landscape. Avoid livestock water developments and salt grounds in traditional sage grouse spring, summer, and fall habitats. These developments significantly concentrate livestock and increase forage use, trailing, and soil compaction that fragment sagebrush habitat (Stoddart et al. 1975). These heavy-use areas may extend up to 0.8 km away from the site (Valentine 1947) providing a niche for noxious weeds and other undesirable or unpalatable vegetation to take hold. Such	

	developments should only be considered if accompanied with climax management areas as outlined…above.	

Grazing Effects on Sagebrush

Source	Citation
Deseret Land and Livestock Ranch. No date. Deseret Land and Livestock Ranch Livestock Grazing and Rangeland Management Benefit Greater Sage Grouse. Western Governor's Association, U.S. Department of Agriculture Natural Resources Conservation Service.	Grazing exclosure data [from Deseret Land and Livestock Ranch] suggest: a. grass production depends on prior-year precipitation, and b. excluding livestock increases shrub production, reduces forbs and fails to increase plant species diversity.
Greer, R. 1990. Sage Grouse Habitat Requirements and Development. Wyoming Game and Fish Dept.	Rangeland improvement programs which reduce sagebrush habitat generally impair the welfare of sage grouse. No treatment should be considered where sagebrush cover is less than 20 percent or within 2 miles of breeding, nesting, or brood areas. Improving sage grouse habitat is best approached by minimally reducing sagebrush cover while increasing the availability of favored forbs, thus creating a mosaic of sagebrush and openings. In areas with old, decadent sagebrush or continuous expanses of dense sagebrush, limited treatment may be beneficial. Sagebrush should be managed using an irregular treatment pattern of localized patches or narrow strips. Total kill or removal of sagebrush should be avoided. Treatment of localized patches or narrow strips over a period of several years promotes uneven aged stands of sagebrush, thus increasing habitat diversity. These irregular mosaic treatment patterns provide more edge-effect (and thus more benefits to sage grouse) and are much more natural looking and aesthetically pleasing than stripped or rectangular treatment blocks. The widths of treated areas should be no wider than 30 yards, and untreated areas should remain at least as wide as treated

	areas. Treated patches may be used as feeding areas following forb recovery while untreated patches may be used for shelter. Herbicides such as 2, 4-D should be sprayed as early in spring as possible or prior to the emergence of forbs. Spray rates of 1 to 1.5 pounds of active ingredient per 3 gallons of water per acre are suggested. Chaining is preferred over spraying for sagebrush control since forbs are not killed and all sagebrush is not uprooted. Chaining patterns should be in random strips, while block chaining of large areas should be avoided. When sagebrush cover is too low for chaining or burning, plowing with a crawler tractor may be used to reduce sagebrush. After plowing, forb reseeding is necessary due to high vegetative mortality. Burning in wintering or nesting habitat is undesirable. Burning small patches during late fall or early spring in brood rearing areas will create a mosaic of sagebrush and openings. Along streams, meadows, or secondary drainages, tall dense stands of sagebrush may be partially controlled and reseeded with grasses and forbs to promote feeding habitat. However, a 200 yard buffer strip of sagebrush should generally be reserved along these wetland areas.
Gibbens, R.P., and H.G. Fisser. 1975. Influence of Grazing Management Systems on Vegetation in the Red Desert Region of Wyoming. Univ. of Wyoming Agriculture Experiment Station. Science Monograph 29. Laramie, Wyoming	…even under complete protection from grazing change is slow and the existing grazing pressure did not have a marked effect on grass cover.
Heath, B. J., R. Straw, S.H. Anderson, J. Lawson, and M. Holloran. 1998. Sage-Grouse Productivity, Survival, and Seasonal Habitat Use Among Three Ranches with Different Livestock Grazing, Predator	Try to eliminate shrub control in areas that contain between 25-33% total shrub cover within 5 km of occupied leks to maintain sage grouse habitat. When it is necessary to set back plant succession and increase

Control, and Harvest Management Practices. Wyoming Game and Fish Dept.	herbaceous vegetation production, treatments should occur in patterns within the landscape that maintain a diverse mosaic of shrub seral stages.
Holloran, M.J., B.J. Heath, A.G. Lyon, S.J. Slater, J.L. Kuipers, and S.H. Anderson. 2005. Greater sage-grouse nesting habitat selection and success in Wyoming. J Wildl Manage. 69(2): 638-649.	To maintain greater sage grouse populations, we recommend that managers limit strategies that negatively affect this type of habitat (i.e. prescribed fire and herbicide application) and protect adequate amounts of suitable nesting habitat during treatment.

The following sources may contain information relevant to the Wyoming Basin - Southern Rocky Mountains ecoregions, but were not conducted within the ecoregional boundaries.

Source	Citation	Location of Study
Poley, B. E. 1969. Seasonal Movements of Sage Grouse in Colorado. Journal of Colorado Field Ornithologists. 5:1-4.	Since sagebrush competes with grass for moisture, it is often killed to allow ranges to produce more grass for livestock. When large sagebrush eradication programs are carried out on prime sage grouse range, the birds are reduced in numbers and often "eradicated".	Colorado
Coggins, K. A. 1998. Relationship between habitat changes and productivity of sage grouse at Hart Mountain National Antelope Refuge, Oregon. Oregon State Univ. Corvallis, Oregon.	Continued use of ranges in a degraded condition may inhibit recovery of herbaceous vegetation and promote sagebrush dominance.	Oregon
Rowland, M.M., and M.J. Wisdom. 2002. Research Problem Analysis for Greater Sage Grouse in Oregon. Oregon Dept. of Fish and Wildlife.	Grazing by livestock has occurred on virtually the entire range of sage grouse (Braun 1998), thus its influence is potentially the most pervasive of any land management practice.	Oregon
Marshall, D.B., Chilcote, M., and H. Weeks. 1996. Species at Risk: Sensitive, Threatened, and Endangered Vertebrates of Oregon. Oregon Dept. of Fish and Wildlife.	As summer progresses and forage drys, [sage grouse] are moved to high elevation meadows, irrigated meadows in lowlands, or onto playas from which water is receding and succulent	Oregon

Portland, OR.	forage is emerging. Winter habitat is comprised of dense sagebrush stands that are sufficiently free of snow to provide food, which at that season consists of sagebrush. Sagebrush protection is needed within at least a 1.5 mile radius of leks. Playas, including their water supply, need to be preserved. Improved coordination is needed between livestock interests and species needs in relation to land management practices such as sagebrush control programs, fire management, meadow and water improvements, and fencing programs.	
Call, M.W., and C. Maser. 1985. Wildlife Habitats in Managed Rangelands--The Great Basin of Southeastern Oregon. U.S. Department of Agriculture Forest Service Pacific Northwest Forest and Range Experiment Station. General Technical Report PNW-187. Portland, Oregon.	Fortunately, some changes resulting from livestock grazing, agricultural practices, and other land uses may have benefited sage grouse. The creation of openings in large sagebrush stands, from whatever causes, produced feeding and brooding areas and may have benefited sage grouse especially where water is close by. The creation of meadows (or meadowlike areas) within sagebrush stands improved the summer food supply of sage grouse. Where land use practices removed large, decadent sagebrush stands and permitted development of new, young plants, sage grouse habitat may have been improved. But the overall habitat is generally better where	Great Basin (Oregon)

	patches or strips of tall, dense sagebrush are retained for use as an escape cover or for roosting. In general, good habitat for sage grouse should contain openings less than 274 m (300 yd) in circumference, some dense sagebrush stands, and about equal amounts of tall and short sagebrush plants (Rogers 1964). …association with dense stands of sagebrush usually begins in September and continues through the breeding and nesting seasons. In fact, 15 percent canopy cover of sagebrush appears to be the minimum acceptable for sage grouse winter and nesting habitat (Wallestad 1971, 1975; Wallestad and Schladweiler 1974). Although openings in sagebrush habitat may be created by killing the shrubs, increased grass density may prevent the openings from being used (Carr 1968). Spring and early summer grazing by livestock removes a high percentage of grass and forbs at the time when sage grouse are turning to forbs as their primary forage. …manage the sagebrush for an average height of 30 to 80 cm (12 to 31 in) and an average composition of 20 to 30 percent. Good grouse habitat should have from 5,000 to	

	10,000 sagebrush plants per 0.4 ha (1 acre).	
Craddock, G.W., and C.L. Forsling. 1938. The Influence of Climate and Grazing on Spring-Fall Sheep Range in Southern Idaho. United States Dept. of Agriculture. Technical Bulletin No. 600	Over and above the influence of climate, the intensity and periods of grazing had a profound effect upon the grazing value of the spring-fall range.	Southern Idaho
Stinson, D.W., D.W. Hays, and M. Schroeder. 2004. Washington State Recovery Plan for the Greater Sage-Grouse. Washington Dept. of Fish and Wildlife. Olympia, Washington.	Despite the pervasive influence of livestock grazing in sage grouse range, there have been no experimental studies of the impact on sage-grouse populations. [Welch and Criddle 2003] concluded that grazing may or may not increase big sagebrush cover. Beck and Mitchell (2000) reviewed the effects of grazing on sage-grouse habitat. They found that little was known about the direct impacts on sage grouse, but more was known about indirect effects. Direct negative effects included deterioration of wet meadow hydrology and destruction of sagebrush in wintering habitat by sheep. Positive effects included an increase in growth or availability of forbs in dense grassy meadows. Several studies indicate that sage-grouse select meadows grazed by cattle over ungrazed meadows in early spring (Miller and Eddleman 2000). Livestock grazing is compatible with sage-grouse where the habitat characteristics needed for breeding and wintering can be consistently	Washington

	maintained (Connelly et al. 2000, Wambolt et al. 2002, Rowland and Wisdom 2002, and Crawford et al. 2004). Whether this is possible on any particular site probably depends on many factors including the grazing history of the site, site condition, precipitation zone, livestock involved, the season, intensity, frequency and duration of grazing.	
Sveum, C.M., W.D. Edge, and J.A. Crawford. 1998. Nesting habitat selection by sage grouse in south-central Washington. J Range Manage. 51: 265-269.	Management that protects the big sagebrush/bunchgrass community is essential for maintaining nesting habitat for sage grouse.	Washington
Hays, D., M. Tirhi, and D. Stinson. 1998. Washington State Status Report for the Sage Grouse. Washington Dept. of Fish and Wildlife. Olympia, WA.	Since most of the herbaceous species are more palatable than sagebrush, the former were reduced while the shrubs flourished (Tisdale and Hironaka 1981).	Washington
U. S. Dept. of Interior, Bureau of Land Management. 2000. Management guidelines for sage grouse and sagebrush ecosystems in Nevada.	Heavy, excessive grazing too soon after disturbances such as fire, may lead to permanent reductions in food plants and nesting cover. Current BLM policy provides for a minimum of two growing seasons for rest following fire. Drought can lead to increased competition between livestock and sage grouse for food and cover. Drought will exacerbate the adverse effects of heavy, excessive livestock grazing on vegetation and soils (Valentine 1990). In some instances, the failure to make timely adjustments in livestock use during drought has resulted in limited plant regrowth, overuse in wet meadows and riparian areas, and has negated gains in rangeland conditions	Nevada

	made during higher-precipitation years (Thurow and Taylor 1999).	
van Kooten, G.C., R. Thomsen, T.G. Hobby, and A.J. Eagle. 2004. Social Dilemmas and Public Range Management in Nevada.	During times of drought, cattle are attracted to moist areas. Failure to reduce stocking rates during these periods may result in greater impact in the form of reduced vegetative cover (Aldridge, 1998).	Nevada
Courtois, D.R., B.L. Perryman, and H.S. Hussein. 2004. Vegetation Change After 65 Years of Grazing and Grazing Exclusion. J Range Manage. 57:574-582.	The Nevada Plots exclosure system was constructed in 1937 following passage of the Taylor Grazing Act to assess long-term effects of livestock grazing on Nevada rangelands. A comparison of vegetation characteristics inside and outside exclosures was conducted during 2001 and 2002 at 16 sites. Data analysis was performed with a paired t test. Out of 238 cover and density comparisons between inside and outside exclosures at each site, 34 (14% of total) were different ($P < 0.05$). Generally, where differences occurred, basal and canopy cover were greater inside exclosures and density was greater outside. Shrubs were taller inside exclosures at 3 sites grazed by sheep (*Ovis aries*). Perennial grasses showed no vertical height difference. Aboveground plant biomass production was different at only 1 site. Plant community diversity inside and outside exclosures were equal at 11 of 16 sites. Species richness was similar at all sites and never varied > 4 species at any site. Few changes in species composition, cover, density, and production inside and outside exclosures have occurred in 65 years, indicating that recovery rates since pre-Taylor Grazing Act	Nevada

	conditions were similar under moderate grazing and grazing exclusion on these exclosure sites.	
Swanson, S., D. Franzen, and M. Manning. 1987. Rodero Creek: Rising water on the high desert. Journal of Soil and Water Conservation. 405-407.	According to Donald Klebenow, a wildlife professor at the University of Nevada, sage grouse seem to do best with moderate mid-summer cattle grazing that leaves unused vegetation in an irregular pattern with clumps of partially grazed plants just big enough to somewhat conceal adult birds.	Nevada
Neel, L.A. 1980. Sage Grouse Response to Grazing Management in Nevada. M.S. Thesis. Univ. of Nevada, Reno. Reno, Nevada.	There seems to be evidence to conclude that rest-rotation grazing has benefited sage grouse habitat in the Lone Willow area. Food forb production is higher on the …sites under rest-rotation…than on similar sites not under rest-rotation… Use [of meadows] seemed to be linked to availability of food forbs rather than structural parameters. Sage grouse seemed to show preference for grazed meadows where meadow conditions were otherwise equal.	Nevada
Rasmussen, D. I., and L. A. Griner. 1938. Life history and management studies of the Sage Grouse in Utah, with special reference to nesting and feeding habits. *In*: Transactions of the North American Wildlife Conference. 3: 852-864.	From this study at present it is difficult to see any direct competition with livestock and this bird on areas of highly productive summer ranges as concerns their feeding habitats. It is, however, logical to suppose that in areas where the entire understory of weeds and grasses have been destroyed that conditions would not be favorable for the young birds to obtain the varied plant diet they use during their first summer.	Utah

	Some competition is believed to exist [on sagebrush winter ranges] that is of extreme importance to the welfare of the grouse. The use of the open ridge tops as bed grounds for sheep and the resultant destruction of sagebrush vegetation from these ridges, which provides the regular winter feeding areas during periods of deep snows, are certainly of importance in the lives of the sage grouse.	
Ellis, K.L., J.R. Murphy, J.R., and G.H. Richins. 1987. Distribution of Breeding Male Sage Grouse in Northeastern Utah. Western Birds. 18:117-121.	Positive influences of controlled grazing by domestic animals on rangelands include the following: -Loosening of the soil surface during dry periods. -Removal of excessive vegetation that may negatively affect net carbohydrate fixation and increase water transpiration losses. -Incorporating mulch into the soil profile, which speeds development of humus. -Recycling nutrients and making some nutrients more available. -Maintaining an optimal leaf area index of plant tissue. -Trampling seeds into the ground. -Reducing excessive accumulations of standing dead vegetation and mulch that may chemically and physically inhibit new growth. -Inoculating plant parts with saliva that may stimulate plant regrowth (Reardon et al. 1974). -Reducing fire, insect, and rodent problems resulting from accumulations of vegetation.	Northeastern Utah
Myers, L.H. 1989. Grazing and Riparian Management in Southwestern Montana. *In:*	Successful [riparian grazing] systems had lower average stocking rates (4.9	Southwestern Montana

Practical Approaches to Riparian Resource Management: An Educational Workshop May 8-11, 1989. Montana Chapter American Fisheries Society; U.S. Bureau of Land Management; Western Division American Fisheries Society; U.S. Forest Service, Northern Region; Society for Range Management; Montana Riparian Association; U.S. Fish and Wildlife Service.	hectares/AUM) than unsuccessful systems (3.8 hectares/AUM) though the difference was not statistically significant. This 22% difference in stocking rate would not be expected to appreciably influence riparian vegetation response to a grazing system. The success or failure of livestock grazing systems in providing for stream riparian site recovery is related to riparian plant phenology, floodplain function, and livestock use behavior in riparian areas. Providing for herbaceous [riparian] regrowth may also extend the growing season rest needed to sustain plant vigor. Grazing systems must accommodate [restoration of major stream banks] by providing residual cover for sediment filtering and good vegetative vigor for stability. Residual cover is a function of both utilization level and for herbaceous species, post-grazing regrowth. Removing livestock by early August to accommodate at least 30 d of regrowth probably meets floodplain function needs on the study area, though more data are needed. On the study area, successful grazing systems were found to provide for more (p=0.05) post-grazing herbaceous regrowth (34.9 d), compared to only 20.8 d in unsuccessful systems. Also, through a combination of both	

	regrowth and rest treatments, successful systems provided post-growing season residual riparian cover 75% of the years, as compared to only 38% of the years in unsuccessful systems. On the study area, successful grazing systems were found to have significantly (p=0.01) less grazing during the "hot season" [July through early September] (12.5 d) than unsuccessful systems with 33.4 d. Likewise, the duration of all livestock treatments was significantly (p=0.001) shorter in successful systems (28.2 d) compared to 59.3 d in unsuccessful systems. Given the reluctance of cattle to disperse from riparian areas, the duration of grazing treatments becomes a key factor in determining the severity of impacts such as trampling and mechanical damage, soil compaction, and utilization. In a rest-rotation system Platts (1981) noted significant riparian habitat alterations at 65% utilization levels, but no detectable impacts at 25% utilization. A combination of longer duration and more frequent fall grazing deteriorated woody species vigor and regeneration, contributing to diminished floodplain function and reduced riparian dependent values.	
Wambolt, C.A., and G.F. Payne. 1986. An 18-year comparison of control methods for Wyoming Big Sagebrush in southwestern Montana. J Range Manage. 39(4): 314-319.	Rest alone resulted in a 29% reduction in sagebrush canopy during the study period [1963-1981].	Southwestern Montana

Adams, B.W., J. Carlson, D. Milner, T. Hood, B. Cairns and P. Herzog. 2004. Beneficial grazing management practices for Sage-Grouse (*Centrocercus urophasianus*) and ecology of silver sagebrush (*Artemisia cana*) in southeastern Alberta. Public Lands and Forests Division, Alberta Sustainable Resource Development. Pub. No. T /049.	Heavy grazing can lead to an expansion in big sagebrush shrub canopy cover as the shrub acts as an increaser due grazing pressure. Managed grazing can be used in a prescriptive way create more patchiness within otherwise continuous sage canopies (Beck and Mitchell 2000). The grazing response of silver sagebrush seems much different from that of big sagebrush. Silver sagebrush does not establish the same height or cover characteristics as big sagebrush and occupies a lesser prominence on Alberta Sage-Grouse ranges. It also appears that silver sagebrush behaves more like a decreaser species in response to grazing, trampling and drought, although it has a strong potential to resprout and regenerate in favorable periods of moisture and rest. Being lower in stature, silver sagebrush is likely more vulnerable to trampling by livestock, especially vegetative sprouts and juvenile plants. Trampling may be the principal cause of silver sagebrush decline on livestock wintering sites. A number of sources (Neel 1980, Klebenow 1982, Evans 1986) suggest that appropriate grazing management can be used to stimulate the productivity of forbs important as Sage-Grouse food. This will be particularly important on rangelands with a history of light grazing where forb cover has become reduced by graminoid competition, a common feature	Alberta, Canada

	of dry mixed grass prairie plant communities.	
Aldridge, C.L. 1998. Status of the Sage Grouse (*Centrocercus urophasianus urophasianus*) in Alberta. Alberta Environmental Protection, Wildlife Management Division, and Alberta Conservation Association. Wildlife Status Report No. 13. Edmonton, Alberta, Canada.	The removal of cover by cattle can impact sage grouse populations either by reducing habitat suitability, or by increasing the exposure of birds to predators and extreme weather.	Alberta, Canada
Anderson, J.E., and R.S. Inouye. 2001. Landscape-scale changes in plant species abundance and biodiversity of a sagebrush steppe over 45 years. Ecological Monographs. 71(4): 531-556.	Plots having higher species richness tended to maintain higher levels of cover and to vary less in cover relative to their mean level, indicating links between species richness and function. Abundance of nonnative species was negatively correlated with cover, but not with richness of native species. Thus, adequate cover of native species can render these semiarid communities more resistant to invasion.	Location unknown
Beck, J.L, and D.L. Mitchell. 2000. Influences of livestock grazing on sage grouse habitat. Wildl Soc Bull. 4: 993-1002.	Over time, sheep grazing can shift ranges toward grass dominance, whereas cattle grazing can cause rangeland to be composed of more forbs.	Location unknown
Blaisdell, J.P., R.B. Murray, and E.D. McArthur. 1982. Managing Intermountain Rangelands-Sagebrush-Grass Ranges. U.S. Department of Agriculture Forest Service Intermountain Forest and Range Experiment Station Gen. Tech. Report INT-134. Ogden, UT.	Bluebunch wheatgrass (*Agropyron spicatum*), an important forage plant on many western ranges, has received considerable attention. Hanson and Stoddart (1940) observed that heavily grazed plants of bluebunch wheatgrass were smaller, produced fewer seeds, and had a markedly reduced root system. Ellison (1960) concluded that the usual effect of grazing certain species in a community is to handicap them while encouraging others.	Location unknown

	Some studies suggest that forage plants respond as well under light grazing as no grazing. However, other studies show injurious effects even at light intensities (Johnson 1956). Cattle tend to graze the grasses most heavily, whereas sheep exhibit a preference for forbs. Rotation of use between cattle and sheep can prove beneficial, especially to fair and good condition sagebrush-grass ranges. …controlling [tall, dense sagebrush with little understory] and allowing native forbs and grasses to recover their former productivity would greatly improve the habitat of sage grouse (Klebenow 1969).	
Connelly, J.W., M.A. Schroeder, A.R. Sands and C.E. Braun. 2000. Guidelines to manage sage grouse populations and their habitats. Wildl Soc Bull. 28(4):967-985.	In Wyoming big sagebrush habitats, resting areas from livestock grazing may improve understory production as well as decrease sagebrush cover (Wambolt and Payne 1986). Manage breeding habitats to support 15-25% canopy cover of sagebrush, perennial herbaceous cover averaging ≥ 18 cm in height with ≥ 15% canopy cover for grasses and ≥ 10% for forbs and a diversity of forbs (Barnett and Crawford 1994, Drut et al. 1994, Apa 1998) during spring. For nonmigratory grouse occupying habitats that are distributed uniformly…protect (i.e. do	N/A

	not manipulate) sagebrush and herbaceous understory within 3.2 km of all occupied leks. For nonmigratory grouse occupying habitats that are not distributed uniformly…protect suitable habitats for ≤ 5 km from all occupied leks. For migratory populations, identify and protect breeding habitats within 18 km of leks… In areas of large-scale habitat loss (≥ 40% of original breeding habitat), protect all remaining habitats from additional loss or degradation.	
Connelly, J.W., S.T. Knick, M.A. Schroeder, and S.J. Stiver. 2004. Conservation Assessment of Greater Sage-Grouse and Sagebrush Habitats. Unpublished Report. Western Association of Fish and Wildlife Agencies. Cheyenne, Wyoming.	Dominant trends emerged along a complex gradient of shrubland disturbance regimes following intensive grazing pressure and drought (West and Young 2000). In northern, eastern, and more mesic regions of the sagebrush biome, fire was not an important disturbance necessary to maintain perennial grasses and forbs. Rather, grazing by buffalo was the primary agent of grazing disturbance. In those regions, introduction of domestic livestock increased the site-specific frequency of grazing (Mack and Thompson 1982). Improper grazing that depleted the grass and forb understory facilitated invasions by exotic plants species because of loss of understory, altered soils, or loss of microbiotic crusts in these systems (Mack and Thompson 1982). In more xeric and southern sagebrush regions, possible increases in shrub cover that resulted	N/A

	from grazing further reduced the low cover of native perennials and created a system largely resistant to recolonization by the native flora but increasingly vulnerable to invasion by exotic plants (Young and Sparks 2002). Livestock grazing can affect soils, vegetation, and animal communities (Jones 2000). Livestock consume or alter vegetation, redistribute nutrients and plant seeds, trample soils and sagebrush plants, and can disrupt microbiotic crusts (Miller et al. 1994, West 1996, Belnap and Lange 2001). The extent to which these mechanisms influence habitats depends on the relationship between level of grazing disturbance and the resiliency of the habitat. At unsustainable levels of grazing, these changes can lead to loss of vegetative cover, reduced water infiltration rates, and increased soil erosion (Society for Range Management 1995). Indirect effects of livestock grazing can amplify or facilitate other disturbance. For example, landscapes in southwestern Idaho in which grazing combined with other disturbances experienced the greatest rate of shrub loss and increase in cheatgrass compared to landscapes having a single source of disturbance (Knick and Rotenberry 1997). In shrublands dominated by cheatgrass, grazing can reduce further the remaining perennial grasses or permit excessive growth of cheatgrass if left ungrazed (Young and Allen 1997).	

	In sagebrush grasslands, herbivory of herbaceous plants during the growing season tends to favor sagebrush growth until sagebrush becomes so dense that the competition of sagebrush restricts recovery of herbaceous plants (Reichenberger and Pyke 1990). Adjustments to grazing seasons or reductions in numbers of livestock will only show improvements in sage-grouse habitat quality if the vegetation community is a sagebrush grassland mix before grazing changes are implemented. This community retains both the sagebrush and the tall bunchgrass necessary for quality habitat. The release from livestock grazing should allow the full expression of vegetation height for hiding cover and nest protection. Improvements could be expressed in the next growing season, but might take 3 to 5 years for pre-existing plants to fully express themselves and 10 to 15 years for seed production and new plant recruitment to occur assuming the site is not fully occupied by other species. Any other community whether in this vegetation state or in another state will require either additional manipulations to the community to adjust the vegetation composition, or may require additions of life forms through revegetation to improve the habitat.	
Crawford, J.A., R.A. Olson, N.E. West, J.C. Mosley, M.A. Shroeder, T.D. Whitson, R.F. Miller, M.A. Gregg, and C.S. Boyd. 2004.	Livestock grazing may affect sage-grouse habitat directly by altering structural habitat factors or plant community composition, or	N/A

Synthesis Paper: Ecology and management of sage-grouse and sage-grouse habitat. J. Range Manage. 57: 2-19.	indirectly by altering abiotic processes (e.g., MFRI) and invasibility of sagebrush plant communities. While the impact of grazing on sagebrush plant communities varies with site potential, ecological condition, and climate variables, the aspects of livestock grazing that are controlled by management are, principally, the timing and intensity of defoliation. Research suggests that moderate livestock grazing or less in mid to late summer, fall, or winter is generally compatible with the maintenance of perennial grasses and forbs in sagebrush habitat (Pechanec and Stewart 1949, Mueggler 1950, Laycock and Conrad 1967, 1981, Gibbens and Fisser 1975, Miller et al. 1994, Bork et al. 1998) Herbaceous species in sagebrush plant communities are predominantly cool-season (C-3) plants that are vulnerable to defoliation during late spring and early summer. Heavy grazing (approximately 60% or greater utilization by weight) during this time has predictable results: 1) the vigor, yield, and cover of late-seral grasses and forbs decrease; 2) early-seral species (including annual grasses) may increase; 3) sagebrush density and canopy cover may increase (Craddock and Forsling 1938, Pechanec and Stewart 1949, Mueggler 1950, Laycock 1967, Bork et al.	

	1998); and 4) transition of sagebrush uplands to higher ecological status is inhibited (Mueggler 1950, Eckert and Spencer 1986, Laycock 1987). Cattle, sheep, and horses (*Equus caballus*) in sagebrush habitat eat grass-dominated diets in all seasons of the year (Severson et al. 1968, Harrison and Thatcher 1970, Mackie 1970, Uresk and Rickard 1976, Olsen and Hansen 1977, Reiner and Urness 1982, Krysl et al. 1984, Ngugi et al. 1992, Crane et al. 1997, Glidewell et al. 2001) although sheep may consume a higher percentage of their diet as forbs. Livestock usually consume little to no sagebrush (< 10%) unless snow depth exceeds 20 cm (Harrison and Thatcher 1970), but winter sheep use of low elevation basin big sagebrush may be much greater (Cook et al. 1954). Shrub utilization should not exceed 50–60% during the growing season, and at least 50% protective ground cover (i.e., plant basal area + mulch + rocks + gravel) should remain after grazing (Mosley et al. 1997). While hydrophytic shrubs may not directly serve as sage-grouse habitat, they do impact the stability of riparian and meadow habitats important to sage-grouse (Winward 2000). A recent modeling exercise (Wisdom et al. 2002) incorporated 50 and 100% reductions in	

	the detrimental effects of livestock grazing into a population level model for sage grouse in the Interior Columbia Basin. The model predicted improved performance of sage grouse populations with a combination of active habitat restoration and reduced livestock stocking rate, and equated reductions in livestock stocking rate to decreased detrimental effects of livestock on sage grouse habitat at a 1 to 1 ratio. While this approach may appear empirically appealing in that it allows "what if" scenario modeling, caution is merited when assuming that reductions in livestock stocking rate are in a constant 1 to 1 ratio with changes in sage grouse habitat quality, given that the exact slope of this relationship is unknown (it may be substantially greater or less than 1) and is variable in accordance with timing and intensity of livestock grazing, environmental factors, and specific type of sage grouse habitat (e.g., nesting, brood-rearing, etc.). Given the complexity of the successional dynamics of sagebrush plant communities, combined with the multivariate nature of the effects of livestock grazing on these plant communities, it remains difficult to draw large-scale (time and space) conclusions regarding the impact of current livestock grazing practices on sage grouse populations. But, once sagebrush cover reaches an upper threshold, livestock exclusion may have little effect on reversing the immediate trend	

	(Johnson and Payne 1968, Rice and Westoby 1978, Sanders and Voth 1983, Wambolt and Payne 1986). Over long time intervals (40 years or more), sagebrush abundance may decline with a concomitant increase in understory herbaceous species (Anderson and Inouye 2001). On Wyoming big sagebrush sites with dense sagebrush and an understory of annual grasses, reductions in livestock grazing can hasten further habitat degradation if ungrazed fuel loads promulgate wildfires that burn uniformly and kill sagebrush on vast areas (Peters and Bunting 1994, West 1999). Timing of grazing greatly influences the effects of livestock grazing in meadows and riparian areas. These sites are particularly vulnerable in late summer when excessive grazing and browsing may damage riparian shrubs, reduce the yield and availability of succulent herbs (Kovalchik and Elmore 1992), and cause deterioration of riparian function over time (Klebenow 1985). However, moderate utilization by livestock in spring, early summer, or winter is sustainable in non-degraded meadow and riparian areas within sagebrush habitat (Shaw 1992, Clary et al. 1996, Mosley et al. 1997). Moderate use equates to a 10-cm residual stubble height for most grasses and sedges and 5-cm for Kentucky bluegrass (Mosley et al. 1997, Clary and Leininger 2000).	

	The length of time livestock have access to meadows may be more important than the level of utilization; it has been suggested that livestock access be limited to < 3 weeks (Myers 1989, Mosley et al. 1997). In riparian and meadow habitat degraded by heavy livestock utilization, rest from grazing may be necessary for recovery (Clary and Webster 1989). Some perennial grasses, such as Indian ricegrass (*Oryzopsis hymenoides* (R. & S.) Ricker), needle-and-thread (*Stipa comata* Trin. & Rupr.), Nevada bluegrass (*Poa nevadensis* Vasey ex Scribn.), and Sandberg bluegrass, can withstand severe grazing (approximately 80% or greater utilization) as long as defoliation does not occur during the plants' reproductive period (Pearson 1964). Other grasses such as Idaho fescue, Thurber needlegrass (*Stipa thurberiana* Piper), and bottlebrush squirreltail (*Sitanion hystrix* (Nutt.) J.G. Smith) decrease with heavy grazing (Rickard et al. 1975, Eckert and Spencer 1987).	
DeLong, A.K., J.A. Crawford, and D.C. DeLong, Jr. 1995. Relationships between vegetational structure and predation of artificial sage grouse nests. J Wildl Manage. 59(1):88-92.	In Wyoming big sagebrush (*A.t. wyomingensis*) stands with shrub cover >20% and mountain big sagebrush stands with shrub cover >30%, herbaceous understories are often depleted and would require sagebrush thinning to reestablish the herbaceous component (Winward 1991). Prescribed fires, herbicides,	Location unknown

	and mechanical treatments would reduce shrub cover and may increase herbaceous cover. Sagebrush reduction, however, may negatively affect sage grouse nesting habitat in the short term (Connelly et al. 1991), and therefore should be implemented only in areas where other suitable nesting habitat exists nearby. In the long term, once sagebrush reestablishes in treatment areas, sage grouse nesting habitat may be enhanced by an improved balance of shrub and grass components available to sage grouse. We recommend land management practices that increase cover and height of native grasses in sagebrush communities with medium-height shrubs as a means to enhance sage grouse nesting success and productivity.	
Glidewell, B.C., J.C. Mosley, and J.W. Walker. 2001. Sheep and cattle response when grazed together on sagebrush-grass rangeland. Western Section, American Society of Animal Science. American Society of Animal Science 52.	Grazing sheep and cattle together (i.e. common use or multispecies grazing) may increase livestock production on sagebrush-grass rangeland.	N/A
Holechek, J.L., H. Gomez, F. Molinar, and D. Galt. 1999. Grazing studies: What we've learned. Rangelands. 21(2):12-16.	The best explanation [of heavy, moderate, and light grazing] we've found was provided by Klipple and Bement (1961). They define heavy grazing as a degree of herbage utilization that does not permit desirable forage species to maintain themselves. Moderate grazing means a degree of herbage utilization that allows the palatable species to maintain themselves but usually does not permit them to improve in herbage producing ability. Light grazing means a degree of herbage production	N/A

	that allows palatable species to maximize their herbage producing ability. In the semi-arid and desert range types, rotation grazing systems generally showed no advantage over continuous or season-long grazing. In mountainous areas rotation grazing systems give convenient areas (riparian zones) opportunity for recovery, and can be advantageous over season-long grazing. In most studies, continuous or season-long grazing has given higher calf crops and animal weight gains than rotation grazing when stocking rates were the same.	
Jones, A. 2000. Effects of cattle grazing on North American arid ecosystems: a quantitative review. Western North American Naturalist. 60(2):155-164.	Eleven of 16 analyses [of the effects of cattle grazing in arid systems of 16 response variables ranging from soil bulk density to total vegetative cover to rodent species diversity] (69%) revealed significant detrimental effects of cattle grazing, suggesting that cattle can have a negative impact on North American xeric ecosystems. Livestock grazing had significant effects on vascular plants for 4 of 8 vegetation response variables analyzed. Cover of grasses and shrubs, as well as total vegetation biomass, was reduced significantly by grazing.	Location unknown
Knick, S.T., D.S. Dobkin, J.T. Rotenberry, M.A. Schroeder, W.M. VanderHagen, and	Alternatively, changes in water and nutrient cycling caused by grazing can promote the	Location unknown

C. VanRiper. 2003. Teetering on the Edge or Too Late? Conservation and Research Issues for Avifauna of Sagebrush Habitats. The Condor. 105: 611-634.	spread of invasive species, which then degrade native bird habitats by altering fire and disturbance regimes (Rotenberry 1998).	
Laycock, W.A. 1994. Implications of Grazing vs. No Grazing on Today's Rangelands. *in*: Vavra, M.; Laycock, W.A.; and R.D. Pieper, eds. 1994. Ecological Implications of Livestock Herbivory in the West. Society for Range Management. Denver, CO.	West et al. (1984) found no significant vegetative changes in a big sagebrush type in Utah after 14 years of livestock exclusion. Tisdale et al. (1969) stated that vigorous stands of sagebrush in Idaho may indefinitely delay the recovery of the herbaceous understory even after 20-25 years of protection from grazing. Sanders and Voth (1983) found no improvement over a 45-year period in three exclosures dominated by big sagebrush in southwestern Idaho. In southeastern Idaho, Anderson and Holte (1981) found that both big sagebrush and grasses increased substantially when protected from grazing for 25 years. In northern New Mexico, exclusion of cattle grazing for 22 years had little effect on sagebrush or understory species in either an upland or a lowland site (Holechek and Stephenson 1983). Potter and Krenetsky (1967) found that ground cover of grass, forbs, and browse decreased in both protected and grazed sagebrush plots in New Mexico, and stated that grazing management alone had “poor possibilities” for	Location unknown

	improvement of dense sagebrush stands. Turner (1971) found that exclusion of livestock for 10 years had little effect on shrub communities dominated by big sagebrush, shadscale and Nuttall saltbush in western Colorado. Whisenant and Wagstaff (1991) concluded that season of grazing had more effect on vegetation composition than intensity of grazing and that spring grazing was particularly damaging.	
Miller, R. F., T.J. Svejcar, and N.E. West. 1994. Implications of Livestock Grazing in the Intermountain Sagebrush Region: Plant Composition. Society for Range Management. Denver, CO.	Under lower levels of use, Holechek et al. (1989) concluded rest-rotation was a good system to consider in rugged terrain. [In eastern Idaho (Mueggler 1950, Laycock 1967)] both fall grazing and total protection maintained plant communities in good ecological condition while heavy spring use allowed sagebrush to increase and perennial grasses and forbs to decline. In general, where proper grazing management was applied, desirable perennial herbaceous vegetation increased both with and without grazing (Gibbens and Fisser 1975, Sneva et al. 1984, Kindschy 1987). However, on sites where competition from woody plants or exotic annuals limited the reestablishment of desirable plant species, little change or a decline in desirable species occurred both inside and outside the exclosure (Hughes 1980,	Location unknown

	Anderson and Holte 1981, Sanders and Voth 1983, West et al. 1984).	
Miller, R.F., and L.L. Eddleman. 2000. Spatial and temporal changes of sage grouse habitat in the sagebrush biome. Oregon State Univ. Agric Exp Stn. Technical Bulletin 151. Corvallis, OR	In the absence of fire, changes that usually occur with excessive grazing in the different sagebrush types are an increase in density and cover of shrubs, annuals forbs, and annual grasses (especially introduced species), and a decrease in perennial forbs and grasses (Branson 1985, Tisdale 1994).	Location unknown
Severson, K.E., and P.J. Urness. 1994. Livestock Grazing: A Tool to Improve Wildlife Habitat *in*: Vavra, M.; Laycock, W.A.; and R.D. Pieper, eds. 1994. Ecological Implications of Livestock Herbivory in the West. Society for Range Management. Denver, CO.	…sage grouse (*Centrocercus urophasianus*) are affected by broad-scale attempts to reduce sagebrush to favor grass production via herbicides, prescribed fire, mechanical treatments, etc. The implication here is that if past sagebrush control operations have negatively affected sage grouse or pronghorn populations, sagebrush could be reestablished by judicious use of spring grazing by livestock. Hanley and Page (1982) reported a situation where livestock grazing decreased plant structural diversity on xeric sites and increased it on more mesic sites.	Location unknown
Shaw, N.L. 1991. Recruitment and growth of Pacific will and sandbar willow seedlings in response to season and intensity of cattle grazing. *In*: Symposium on Ecology and Management of Riparian Shrub Communities May 29-31, 1991. Sun Valley, ID.	Density of Pacific willow seedlings did not vary among treatments or years. Increase in sandbar willow seedling density over time was similar for the spring grazing, fall grazing, and protected treatments, but declined over time in control pastures. Within species, seedling growth was similar in spring, fall, and protected pastures, exceeding that of controls.	N/A

U. S. Dept. of Interior, Bureau of Land Management. 2002. Management Considerations for Sagebrush (*Artemisia*) in the Western United States: a selective summary of current information about the ecology and biology of woody North American sagebrush taxa. Washington, D.C.	Excessive, or poorly managed livestock grazing, such as too high a stocking rate over the grazing period, or uncontrolled or poorly timed grazing, causes degradation of sagebrush ecosystems. Improper livestock grazing practices change the proportion of shrubs, grasses, and forbs, increase the opportunity for invasion and dominance by exotic annual grasses and forbs, shorten the growing season, and can cause an overall decline in site potential through loss of topsoil. This decline in site potential often decreases the ability of soils to capture, store, and release water, causing sagebrush ecosystems to become more arid, which in turn provides less green plant material for shorter periods of time (Miller and Eddleman 2000). It is well established that excessive livestock grazing increases the cover of Artemisia in many systems by reducing the competition from other plants (Whisenant 1990, Daddy 1988). Very often it is these other plants, especially native bunchgrasses and forbs, that are far below healthy levels in the ecosystem and that are the first to be eliminated under excessive livestock grazing (Watts and Wambolt 1996, West and Young 2000). While sagebrush densities could be increased in this way, it would likely be incompatible with attainment of BLM's Standards for Healthy Rangelands. Archer and Smeins (1991, in Hann et al. 1997)	N/A

	proposed that some traditional livestock grazing management practices are not compatible with native plant communities. They identified several examples of poor compatibility that are applicable to the sagebrush biome: (1) Traditionally, livestock are concentrated at artificially high levels. In contrast, densities of native herbivores varied seasonally and annually; (2) Fences prevent livestock from moving to new areas when the abundance of desired forages decreases. Consequently, traditional grazing practices result in higher frequencies and intensities of defoliation than would have occurred with pre-Euro-American settlement grazing regimes; (3) Mortality of native herbivores was a feedback loop that reduced grazing pressure, permitting recovery of native vegetation after periods of forage overuse. Supplemental feeding precludes mortality of livestock and thus maintains grazing over a greater portion of the year and over a higher frequency of years, compared with grazing that was exerted by native herbivores; and (4) Prolonged grazing in the sagebrush biome has decreased the capacity of grasses to competitively exclude woody plants, such as sagebrush. Therefore, sagebrush density and canopy cover increases at a faster rate compared with no grazing. Under specific circumstances, rest-rotation, deferred, deferred rotational, and seasonal grazing methods have all been demonstrated to sustain rangeland plant communities within the	

	sagebrush biome (Vallentine 1990, in Hann et al. 1997). However, none of these grazing methods have been conclusively more effective than light to moderate stocking rates under continuous seasonal grazing (Hart and Norton 1988, Heady 1975, Stoddart et al. 1975, Vallentine 1990, in Hann et al. 1997). Despite the array of grazing methods conceived and promoted since 1950 in the United States, there has been, and continues to be, considerable debate over compatibility with native plant communities. In addition, all of the livestock grazing recommendations for the sagebrush biome summarized in this section are based upon either short-term studies or short to long-term observations, rather than long-term studies. Grazing methods, and no grazing, are unlikely to elevate many plant communities that are in a low successional steady state to a higher successional state (Archer and Smeins 1991, in Hann et al. 1997). Sustainable grazing management relies on knowledge of critical thresholds and manipulation of livestock so these critical thresholds are not exceeded. Continued stocking at near-normal levels during periods of moderate to severe drought is probably the greatest cause of rangeland deterioration (Vallentine 1990, in Hann et al. 1997). Reduced stocking rates during drought, and for some time after drought, are necessary to minimize damage and hasten recovery of perennial vegetation (Vallentine 1990, in Hann	

	et al. 1997; Holechek et al. 1999). Holechek et al. (1999) report that improvement in rangeland vegetation can be achieved through changes in livestock grazing methods, and through changes in livestock stocking rates. They present two science findings that are very important to the sagebrush biome: (1) rotation livestock grazing methods in semi-arid and desert areas, which includes the sagebrush biome, show no advantage compared with continuous or season-long grazing methods; and (2) research shows that stocking rate reductions, from heavy down to conservative (35% or less forage use) have much greater probability of improvement in rangeland vegetation, compared with rotation livestock grazing methods. The greatest benefit accruing to light or conservative stocking (35% or less forage use on palatable forage species) in terms of forage production occurred in dry years. Where invasive exotic annual plants, such as cheatgrass and mustards, have produced an unnaturally high density of fine fuels that make sites much more susceptible to fire, grazing can reduce these fuels and lessen the likelihood of wildfire (Vallentine and Stevens 1994). However the timing of the livestock grazing is critical. It has to be judiciously applied within a very short window of time in early spring, before remnant native perennial species are growing, or else the livestock will consume the	

	remnant native species along with the exotics. Late autumn browsing by sheep can reduce sagebrush cover. When suitable alternative forage is lacking, animals are essentially forced to browse sagebrush because herbaceous growth is dried, reduced and less palatable (Laycock 1967). Very heavy browsing by cattle also can reduce cover of *A. t. wyomingensis* purely through mechanical damage (Watts and Wambolt 1996). If these extreme stocking levels are repeated through time, rather than during a one-time event, the understory grasses and forbs can be extirpated from the site. In Oregon, domestic sheep showed highest preference for low sagebrush (*A. arbuscula* spp. *arbuscula*) and medium preference for black sagebrush (*A. nova*). Sheep utilized, but did not prefer, Bolander silver sagebrush (*A. cana* spp. *bolanderi*) and mountain and foothill big sagebrush. They showed least preference for Wyoming and basin big sagebrush (Sheehy and Winward 1981).	
Vallentine, J.F. 1990. Grazing Management. Academic Press, Inc. San Diego, California.	Heavy grazing in the short term, implying overgrazing if continued over time, may have the following apparent advantages: -Result in more uniform grazing pressure on all species, especially the less palatable species. -Increase efficiency of forage consumption (but decrease forage availability and intake at very high stocking levels).	N/A

	-May effectively delay seedstalk formation and induce vegetative regrowth during active plant growth period (but only under ideal conditions of temperature, soil moisture, and soil fertility).	
Wambolt, C.L., A.J. Harp, B.L. Welch, N. Shaw, J.W. Connelly, K.P. Reese, C.E. Braun, D.A. Klebenow, E.D. McArthur, J.G. Thompson, L.A. Torell, and J.A. Tanaka. 2002. Conservation of Greater Sage-Grouse on Public Lands in the Western U.S.: Implications of Recovery and Management Policies. Policy Analysis Center for Western Public Lands. PACWPL Policy Paper SG-02-02. Caldwell, ID.	…grazing considerations will always be important to maintain habitat quality, but, do not appear as important in the next three to five years for the recovery of sage-grouse as are fire, habitat loss, invasive species and the other alternatives... …public land grazing lessees and others contend that current grazing regimes should not be seriously altered until several other things happen. First, other activities that clearly have a negative effect on the grouse should be addressed. These include fire in the sagebrush ecosystem; landscape fragmentation from energy development, subdivisions and utility corridors; and outright removal of sagebrush for farming and other uses. Many grazing lessees are adamant that the negative impacts from these other activities are better understood and should be considered before grazing plans are seriously altered. Second, research on the specific relationships between grazing and grouse needs should be conducted to explicitly understand how to best change grazing patterns to benefit grouse. Changes to grazing would then be based on locally specific research.	Location unknown

Grazing Effects on Greater Sage-Grouse Cover and Food Availability

Lek Sites

Source	Citation
Patterson, R. L. 1952. The Sage Grouse in Wyoming. Wyoming Game and Fish Comm. and Sage Books, Inc. Denver, Colorado.	Displaying male sage-grouse require relatively open areas during the breeding season. Lek sites are typically adjacent to sagebrush with adequate cover for nesting hens as well as protection from avian predators, and support low, sparse vegetation, if any at all. Flat or gently sloping terrain is a common characteristic of leks as is their location in valley bottoms or draws. Leks have been found on airstrips, firing ranges, gravel pits, sheep bedding grounds, cultivated fields, recently burned sagebrush, plowed fields, cleared roadsides or roadbeds, and actively occupied ant mounds. For two leks, interlek distance was 0.8 km, and for eight others, 2.4 km. In Wyoming, lek density of 29 leks within a water-reclamation project area averaged 6.8 leks per 100 km^2, compared with 8.4 leks per 100 km^2 for 18 leks in nearby, undeveloped sagebrush habitats.
Greer, R. 1990. Sage Grouse Habitat Requirements and Development. Wyoming Game and Fish Dept.	No treatment should be considered where sagebrush cover is less than 20 percent or within 2 miles of breeding, nesting, or brood areas.
Heath, B. J., R. Straw, S.H. Anderson, J. Lawson, and M. Holloran. 1998. Sage-Grouse Productivity, Survival, and Seasonal Habitat Use Among Three Ranches with Different Livestock Grazing, Predator Control, and Harvest Management Practices. Wyoming Game and Fish Dept.	Try to eliminate shrub control in areas that contain between 25-33% total shrub cover within 5 km of occupied leks to maintain sage grouse habitat. When it is necessary to set back plant succession and increase herbaceous vegetation production, treatments should occur in patterns within the landscape that maintain a diverse mosaic of shrub seral stages.
Rothenmaier, D. 1979. Sage grouse reproductive ecology: breeding	Mean height of sagebrush at 10 leks was 28 cm, mean cover was 22%;

season movements, strutting ground attendance and site characteristics and nesting. M.S. thesis. University of Wyoming, Laramie, Wyoming.	90% of sample points had sagebrush <43 cm; percentage of sagebrush cover at 6 nest sites ranged from 12 to 29% (mean = 21.6%).
Petersen, B. E. 1980. Breeding and nesting ecology of female Sage Grouse in North Park, Colorado. M.S. thesis. Colorado State University, Fort Collins, Colorado. 86 pages.	In North Park, Colorado, mating areas (arenas) within leks had an average canopy cover of only 7.3% and a mean vegetation height of 5.3 cm; sagebrush species present included big sagebrush, alkali sagebrush (*A. arbuscula longiloba*), and black sagebrush Lek sites are typically adjacent to sagebrush with adequate cover for nesting hens as well as protection from avian predators, and support low, sparse vegetation, if any at all. Flat or gently sloping terrain is a common characteristic of leks as is their location in valley bottoms or draws.

The following sources may contain information relevant to the Wyoming Basin - Southern Rocky Mountains ecoregions, but were not conducted within the ecoregional boundaries.

Source	Citation	Location of Study
Eng. R. L., and R. J. Mackie. 1982. Integrating grazing-range management practices with management of major wildlife species on rangeland in northcentral Montana. Proc. West. Assoc. Fish and Wildl. Agencies. Montana Agric Exp Stn. 62:112-119.	Sharptails did not alter their distribution or habitat use when a major segment of their home range was subjected to intensive grazing following a rest period	Montana
Gibson, R. M. 1996. A re-evaluation of hotspot settlement in lekking Sage Grouse. Animal Behaviour 52:993-1005.	Of 10 leks surveyed in Mono County, California, six were in meadows, although meadows composed only 9% of the available sagebrush/meadow habitat. In addition to open areas for display by males and traffic by hens, protection from raptors is a factor in lek location.	Mono County, California
Bradbury, J. W., R. M. Gibson, C. E.	Habitat type did not appear to be the primary	California

McCarthy, and S. L. Vehrencamp. 1989. Dispersion of displaying male Sage Grouse. II. The role of female dispersion. Behavioral Ecology and Sociobiology 24:15-24.	factor in lek location, however; instead, female dispersal traffic (patterns of travel between wintering and nesting areas) appeared to most strongly influence lek location.	
Klebenow, D. A. 1985. Habitat management for Sage Grouse in Nevada. World Pheasant Association Journal 10:34-46.	Displaying male sage-grouse require relatively open areas during the breeding season. Lek sites are typically adjacent to sagebrush with adequate cover for nesting hens as well as protection from avian predators, and support low, sparse vegetation, if any at all. Flat or gently sloping terrain is a common characteristic of leks as is their location in valley bottoms or draws.	Nevada
U. S. Dept. of Interior, Bureau of Land Management. 2000. Management guidelines for sage grouse and sagebrush ecosystems in Nevada.	Coordinate with livestock permittees to locate the placement of salt or mineral supplements appropriate distances from leks to avoid livestock concentrations and reduce the potential for harassment and displacement of birds during the breeding season.	Nevada
van Kooten, G.C., R. Thomsen, T.G. Hobby, and A.J. Eagle. 2004. Social Dilemmas and Public Range Management in Nevada.	Define, identify, conserve and enhance critical lek, nesting, brood rearing and winter habitat used by sage grouse. Characteristics of habitat types preferred by sage grouse at various times of the year, and the interrelationships between these habitat types, are not clearly defined. Public (landowners, land managers and other land users) involvement and participation in reporting sightings of sage grouse leks, nests, broods and winter locations should be encouraged. Intensive searches of sage grouse range are required to assess critical habitat	Nevada

	parameters throughout the year and the relationships between these habitat types. Abandoned habitat should be assessed for seasonal deficiencies which may limit use by sage grouse. Critical habitat must be protected and secured. Land-use practices and other factors detrimental to maintenance of quality sage grouse habitat need to be identified. Working co-operatively with land managers and other land users, initiatives need to be developed to enhance and maintain an abundance of high quality habitat on private and public lands throughout the range of sage grouse. Establish public reporting system for sage grouse leks, nesting, brood and winter locations. -Conduct searches/surveys for active leks, nests, brood rearing and winter use areas throughout sage grouse range. -Document habitat characteristics of lek, nesting, brood-rearing and winter-use areas and the interrelationships between habitat types. -Investigate habitat parameters (lek, nesting, brood rearing and winter use) in areas of abandoned leks. -Investigate the use of remote-sensing data systems to identify potential lek, nesting, brood-rearing and winter habitat. -Map critical lek, nesting, brood rearing and winter habitat areas. -Identify critical lek, nesting, brood rearing	

	and winter habitat which must be protected, secured or enhanced. -Identify land-use practices which are detrimental to provision of quality lek, nesting, brood rearing and winter habitat. -Develop cooperative initiatives to protect lek sites and lek, nesting, brood rearing and winter habitat on public lands. -Develop cooperative initiatives to protect lek sites and lek, nesting, brood rearing and winter habitat on private lands. -Develop cooperative initiatives to enhance and improve the quantity and quality of lek, nesting, brood rearing and winter habitat.	
Nisbet, R. A., S. H. Berwick, and K. L. Reed. 1983. A spatial model of Sage Grouse habitat quality. Developments in Environmental Modeling 5:267-276.	Forty-one leks in Nevada and Utah were preferentially located in black sagebrush habitats (based on use versus availability)	Nevada and Utah
Ellis, K.L., J.R. Murphy, J.R., and G.H. Richins. 1987. Distribution of Breeding Male Sage Grouse in Northeastern Utah. Western Birds. 18:117-121.	On the basis of similar dispersal distances and distribution patterns, we believe that breeding male sage grouse in other areas most likely continue to select the same day-use areas year after year. Such areas, once identified, should be protected to the greatest extent possible. Alteration of these areas may cause abandonment of a lek.	Duchesne County, northeast Utah
Ellis, K. L., J. R. Parrish, J. R. Murphy, and G. H. Richins. 1989. Habitat use by breeding male Sage Grouse: a management approach. Great Basin Naturalist 49:404-407.	During daytime, male sage-grouse in northeastern Utah used areas near leks that had comparatively greater canopy cover (mean = 31%) and taller shrubs (mean = 53 cm) than did nearby non-use areas. Minimum core day-use areas of males were 0.25 km^2 in size, and the birds often walked to such sites for feeding	northeast Utah

	and loafing.	
Rogers, G.E. 1964. Sage grouse investigations in Colorado. Tech. Publ. 16, 132 p. Colo. Game, Fish and Parks Dep., Denver.	…characteristics of 120 leks throughout Colorado during 1953-1961 and found that, on average, half were in sagebrush; 54% were on gentle slopes; 55% were in bottoms; only 5% were within 200 m of a building; and that although 42% were >1.6 km from an improved road, 26% were within 100 m of a county or state highway. Lek sites are typically adjacent to sagebrush with adequate cover for nesting hens as well as protection from avian predators, and support low, sparse vegetation, if any at all. Flat or gently sloping terrain is a common characteristic of leks as is their location in valley bottoms or draws.	Colorado
Connelly, J.W., H.W. Browers, and R.J. Gates. 1988. Seasonal movements of sage grouse in southeastern Idaho. J Wildl Manage. 52(1): 116-122. Beck, T.D.I. 1977. Sage grouse flock characteristics and habitat selection in winter. J. Wildl. Manage. 41:18-26.	Male sage grouse from the mountain valley abandoned their leks in late April or early May. Their movements to summer range were more direct and rapid than those of females. Females from the mountain valley did not move directly to summer range after nesting. Instead, these birds remained in the general area of the lek on which they had been captured before moving to summer range in early to mid-June. Limited data on male sage grouse from the lowland area suggest that males moved directly to summer ranges after leaving their leks in late April or early May. Males	southeast Idaho

	normally arrived on summer range first but were closely followed by females without broods. …protection of sagebrush within a 3.2 km radius of leks is not sufficient (Beck 1977) because protecting sagebrush habitats associated with leks will not ensure that year long habitat requirements are met for migratory populations of sage grouse.	
Hulet, B.V., 1983. Selected responses of sage-grouse to prescribed fire, predation and grazing by domestic sheep in southeastern Idaho. Thesis. Brigham Young Univ. Provo, UT.	Sage grouse created new leks on domestic sheep salting grounds. Sage grouse abandoned leks in areas where sagebrush was burned to improve the range for livestock.	southeast Idaho
Autenrieth, R. E. 1981. Sage Grouse management in Idaho. Idaho Dept. of Fish and Game. Dalke, P. D., D. B. Pyrah, D. C. Stanton, J. E. Crawford, and E. F. Schlatterer. 1963. Ecology, productivity, and management of Sage Grouse in Idaho. J. Wildl. Manage. 27:811-841.	Displaying male sage-grouse require relatively open areas during the breeding season.	Idaho
Wakkinen, W.L. 1990. Nest Site Characteristics and Spring-Summer Movements of Migratory Sage Grouse in Southeastern Idaho. Ph.D. Dissertation. Univ. of Idaho.	In a study of 31 leks in Idaho, mean interlek distance (i.e., distance between nearest neighbor leks) was about 1.6 km.	Idaho
Klebenow, D.A. 1969. Sage grouse nesting and brood habitat in Idaho. J. Wildl. Manage. 33(3):649-661.	Of 13 leks examined in the Upper Snake River Plains in Idaho, 10 were in threetip sagebrush.	Idaho
Autenrieth, R. E. 1981. Sage Grouse	Lek sites are typically adjacent to sagebrush	Idaho

management in Idaho. Idaho Dept. of Fish and Game	with adequate cover for nesting hens as well as protection from avian predators, and support low, sparse vegetation, if any at all. Flat or gently sloping terrain is a common characteristic of leks as is their location in valley bottoms or draws. Leks have been found on airstrips, firing ranges, gravel pits, sheep bedding grounds, cultivated fields, recently burned sagebrush, plowed fields, cleared roadsides or roadbeds, and actively occupied ant mounds.	
Autenrieth, R. E. 1981. Sage Grouse management in Idaho. Idaho Dept. of Fish and Game Authenrieth, R., W. Molina, and C. Braun, eds. 1982. Sage Grouse Management Practices. Western States Sage Grouse Committee. Western States Sage Grouse Committee Technical Bulletin #1. Twin Falls, ID.	Known nesting areas (3.2 km radius of leks) should be avoided from mid-April to early June to reduce abandonment.	Idaho
Dalke, P. D., D. B. Pyrah, D. C. Stanton, J. E. Crawford, and E. F. Schlatterer. 1963. Ecology, productivity, and management of Sage Grouse in Idaho. J. Wildl. Manage. 27:811-841.	Leks have been found on airstrips, firing ranges, gravel pits, sheep bedding grounds, cultivated fields, recently burned sagebrush, plowed fields, cleared roadsides or roadbeds, and actively occupied ant mounds.	Idaho
Dalke, P. D., D. B. Pyrah, D. C. Stanton, J. E. Crawford, and E. F. Schlatterer. 1963. Ecology, productivity, and management of Sage Grouse in Idaho. J. Wildl. Manage. 27:811-841. Rogers, G. E. 1964. Sage Grouse investigations in Colorado. Technical Publication 16. Colorado Game, Fish and	Leks often occur in complexes, with satellite leks on the periphery that may not be used in all years, depending on population size or weather.	Idaho, Colorado

Parks Department, Denver, Colorado. 132 pages. Wiley, R. H., Jr. 1978. The lek mating system of the Sage Grouse. Scientific American 238:114- 125.		
Dalke, P. D., D. B. Pyrah, D. C. Stanton, J. E. Crawford, and E. F. Schlatterer. 1963. Ecology, productivity, and management of Sage Grouse in Idaho. J. Wildl. Manage. 27:811-841. Aldridge, C.L. 1998. Status of the Sage Grouse (*Centrocercus urophasianus urophasianus*) in Alberta. Alberta Environmental Protection, Wildlife Management Division, and Alberta Conservation Association. Wildlife Status Report No. 13. Edmonton, Alberta, Canada.	During years of low population size, smaller dancing grounds tend to be abandoned.	Idaho, Alberta
Hanf, J. M., P.A. Schmidt, and E.B. Groshens. 1994. Sage grouse in the high desert of central Oregon: results of a study, 1988-1993. U. S. Dept. of Interior, Bureau of Land Management Series. Prineville, OR. P-SG-01.	Minimize livestock and human activity adjacent to leks during the breeding season, and continue to monitor these activities Minimize livestock and human activity adjacent to leks during the breeding season, and continue to monitor these activities.	central Oregon
Batterson, W. M., and W. B. Morse. 1948. Oregon Sage Grouse. Oregon Fauna Series No. 1. Oregon State Game Commission, Portland, Oregon. 29 pages.	Leks have been found on airstrips, firing ranges, gravel pits, sheep bedding grounds, cultivated fields, recently burned sagebrush, plowed fields, cleared roadsides or roadbeds, and actively occupied ant mounds.	Oregon
Willis, M. J., G. P. Keister, Jr., D. A. Immell, D. M. Jones, R. M. Powell, and K. R. Durbin. 1993. Sage Grouse in Oregon. Wildlife Research Report 15. Oregon	Similar lek densities were reported in Oregon; there were 4.3 leks per 100 km^2 at Hart Mountain National Antelope Refuge and 4.7 leks per 100 km^2 at Jackass Creek.	Oregon

Department of Fish and Wildlife, Portland, Oregon. 70 pages. Rowland, M.M. 2004. Effects of management practices on grassland birds: Greater Sage-Grouse. Northern Prairie Wildlife Research Center. Jamestown, ND.		
Marshall, D.B., Chilcote, M., and H. Weeks. 1996. Species at Risk: Sensitive, Threatened, and Endangered Vertebrates of Oregon. Oregon Dept. of Fish and Wildlife. Portland, OR.	Sagebrush protection is needed within at least a 1.5 mile radius of leks.	Oregon
Barrett H., E.G. Campbell, S. Ellis, J. Hanf, R. Masinton, J. Pollet, T. Rich, J. Rose, J. Sadowski, F. Taylor, and P. Teensma, 2000. Greater sage grouse and sagebrush-steppe ecosystems management guidelines. U. S. Dept. of Interior, Bureau of Land Management Connelly, J.W., H.W. Browers, and R.J. Gates. 1988. Seasonal movements of sage grouse in southeastern Idaho. J Wildl Manage. 52(1): 116-122. Vallentine, J. F. 1990. Grazing management. Academic Press, Incorporated. San Diego, CA. 553pp. Thurow, T. L., and C. A. Taylor. 1999. The role of drought in range management. Journal of Range Management 52:413-419.	Livestock allocations should only be increased if it can be demonstrated that there are no detrimental effects on sage-grouse habitat quality. Where livestock grazing results in a level of forage use (utilization levels) determined to have detrimental effects to habitat quality, changes in grazing management that will improve or restore habitat quality will be made as soon as practical but no later than the start of the next grazing year pursuant to 43 CFR 4180.2(c). Examples of changes in management that should be considered include: temporary livestock exclusion (rest); permanent livestock exclusion; change in the season, duration, or intensity of use; fencing; and changes in salting and/or watering locations. Provide secure sage grouse breeding ground habitat to reduce physical disturbance to sage	Oregon and Washington

	grouse by managing locations of salt or mineral supplements within 0.4 km (1/4 mi) of lek locations. Timing and location of livestock turnout and trailing should not contribute to livestock concentrations on leks during the sage grouse breeding season. Grazing use levels within known/occupied habitat will be determined specifically for those habitats, not averaged with use levels for the remainder of the pasture or grazing units. Coordinate with livestock permittees to locate the placement of salt or mineral supplements appropriate distances from leks to avoid livestock concentrations and reduce the potential for harassment and displacement of birds during the breeding season. Construct new spring developments to maintain their free-flowing nature and wet meadow characteristics. Where priority and funding permits, retrofit existing springs to restore free-flowing nature. Install wildlife escape ramps in all new water troughs. Where priority and funding permits, retrofit existing water troughs. Construct new livestock facilities (livestock troughs, fences, corrals, handling facilities, “dusting bags,” etc.) at least1 km (0.6 mi.)	

	from leks to avoid concentration of livestock, collision hazards to flying birds, or avian predator hunting perches. The BLM grazing regulations (43 CFR 4180.2 [c]) state: "The authorized officer shall take appropriate action as soon as practicable but not later than the start of the next grazing year upon determining that existing grazing management practices or levels of grazing use on public lands are significant factors in failing to achieve the standards and conform with the guidelines that are made effective under this section." Grazing too soon after disturbances such as fire may lead to long-term reductions in food plants and nesting cover. Current BLM policy provides for a minimum rest of two growing seasons following fire. Drought can lead to an increase in overlapping use among livestock, wild horses, and sage-grouse. Drought can exacerbate adverse effects of livestock and wild horse grazing on vegetation and soils (Vallentine 1990). In some instances, failure to timely adjust livestock use during drought has resulted in limited plant regrowth and overuse in wet meadows and riparian areas, negating gains in rangeland conditions during higher-precipitation years (Thurow and Taylor 1999).	
Stinson, D.W., D.W. Hays, and M. Schroeder. 2004. Washington State Recovery Plan for	Sage-grouse recovery will require protecting remaining shrub-steppe habitat from fires,	Washington

the Greater Sage-Grouse. Washington Dept. of Fish and Wildlife. Olympia, Washington.	harmful grazing, conversion, and development. Minimize proliferation of additional corridors for power lines, towers, and fences, except where needed to exclude livestock. Remove unneeded fences in sage-grouse use areas. Discourage removal of sagebrush from known sage-grouse wintering areas and areas that provide escape cover in breeding habitat, especially within 3 km of leks Salt grounds should not be located on sites used annually by grouse. New livestock water developments should not located at sites used by grouse unless designed to improve habitat and reduce existing damage by livestock. Use periodic deferral of grazing and rotational grazing in all rangeland pastures.	
Hofmann, L. A. 1991. The western Sage Grouse (*Centrocercus urophasianus phaios*) on the Yakima Training Center in central Washington: a case study of a declining species and the military. M.S. thesis. Central Washington University, Ellensburg, Washington.	Hofmann (1991) reported a mean size of 36 ha for the four largest leks in a study in central Washington. Leks have been found on airstrips, firing ranges, gravel pits, sheep bedding grounds, cultivated fields, recently burned sagebrush, plowed fields, cleared roadsides or roadbeds, and actively occupied ant mounds.	Washington
Wallestad, R. and P. Schadweiler. 1974. Breeding season movements and habitat use of male sage grouse in central Montana. J. Wildl. Manage. 38(4):634-637.	Eighty percent of the locations [of feeding and loafing sites of strutting cocks] occurred in sagebrush with a canopy coverage of 20-50 percent.	Montana

	Males also remain near leks during the nesting season, with one study reporting that 76% of all movements during this season were within one kilometer of the dancing grounds.	
Rowland, M.M. 2004. Effects of management practices on grassland birds: Greater Sage-Grouse. Northern Prairie Wildlife Research Center. Jamestown, ND .	Sage-grouse establish leks not only in native habitats but also in altered or recently disturbed environments. There is no evidence that suitable habitat for leks is limiting for sage-grouse. This flexibility suggests that man-made leks are a potential management tool when traditional leks are destroyed, such as by wildfire or human activities Keys to management are maintaining expansive stands of sagebrush (*Artemisia* spp.), especially varieties of big sagebrush (*A. tridentata*), with abundant forbs in the understory, particularly during spring; undisturbed and relatively open sites for leks; and healthy perennial grass and forb stands intermixed with sagebrush for brood rearing. Within suitable habitats, areas should have 15 to 25% canopy cover of sagebrush 30 to 80 cm tall for nesting, and 10 to 25% canopy cover from 40 to 80 cm tall for brood rearing (Connelly et al. 2000). In winter habitats, shrubs should be exposed 25 to 35 cm above snow level and have 10 to 30% canopy cover exposed above snow. In nesting and brood-rearing habitats, understory habitats with	North Dakota

	adequate cover of grasses (>15%) and forbs (>10%) at least 18 cm tall are needed (Connelly et al. 2000).	
Aldridge, C.L. 1998. Status of the Sage Grouse (*Centrocercus urophasianus urophasianus*) in Alberta. Alberta Environmental Protection, Wildlife Management Division, and Alberta Conservation Association. Wildlife Status Report No. 13. Edmonton, Alberta, Canada.	Males begin returning to strutting grounds in late winter, and begin displaying and establishing territories on leks as soon as snow begins to disappear.	Alberta
Schroeder, M. A., J. R. Young, and C. E. Braun. 1999. Sage Grouse (*Centrocercus urophasianus*). No. 425 in A. Poole and F. Gill, editors. The birds of North America, The Academy of Natural Sciences, Philadelphia, Pennsylvania; The American Ornithologists' Union, Washington, D.C. 28 pages.	…livestock (J. W. Connelly pers. comm.) … may adversely influence display activity when disturbances are near breeding areas. Sage-grouse establish leks not only in native habitats but also in altered or recently disturbed environments. There is no evidence that suitable habitat for leks is limiting for sage-grouse.	N/A
Mack, R. N. and J. N. Thompson. 1982. Evolution in steppe with few large, hooved mammals. American Naturalist 119:757-773.	Heavy spring grazing can prevent the plants from reproducing and can eventually eliminate the native bunchgrasses.	Location unknown
Braun, C.E. 1987. Current issues in sage grouse management. Proc. Of the Western Assoc. Fish and Wildl. Agencies 67:134-144. Dobkin, D.S. 1995. Management and conservation of sage grouse, denominative species for the ecological health of shrubsteppe ecosystems. USDI Bureau of Land Management. Portland, OR.	Indirect evidence suggests grazing by livestock or wild herbivores that significantly reduces the herbaceous understory in breeding habitat may have negative impacts on sage grouse populations.	Location unknown

Connelly, J.W., M.A. Schroeder, A.R. Sands and C.E. Braun. 2000. Guidelines to manage sage grouse populations and their habitats. Wildl Soc. Bull. 28(4):967-985.		
Scott, J. W. 1942. Mating behavior of the Sage Grouse. Auk 59:477-498. Klebenow, D. A. 1973. The habitat requirements of Sage Grouse and the role of fire in management. Tall Timbers Fire Ecology Conference 12:305-315.	Leks vary in size; Scott (1942) reported a range of 0.4 to 16 ha, based on his work on the Laramie Plains in Wyoming; one lek, however, was about 20 ha in size and supported 400 strutting males. Klebenow (1973) reported a typical range from 0.04 to 4.0 ha.	Location unknown
Connelly, J.W., M.A. Schroeder, A.R. Sands and C.E. Braun. 2000. Guidelines to manage sage grouse populations and their habitats. Wildl Soc. Bull. 28(4):967-985.	For nonmigratory grouse occupying habitats that are distributed uniformly…protect (i.e. do not manipulate) sagebrush and herbaceous understory within 3.2 km of all occupied leks For nonmigratory grouse occupying habitats that are not distributed uniformly…protect suitable habitats for ≤ 5 km from all occupied leks For migratory populations, identify and protect breeding habitats within 18 km of leks During drought periods (≥2 consecutive years), reduce stocking rates or change management practices for livestock, wild horses, and wild ungulates if cover requirements during the nesting and brood-rearing periods are not met. Grazing pressure from domestic livestock and wild ungulates should be managed in a manner that at all times addresses the possibility of drought.	Location unknown

	Human activities within view of or <0.5 km from leks should be minimized during the early morning and late evening when birds are near or on leks. Generally, fire should not be used in breeding habitats dominated by Wyoming big sagebrush if these areas support sage grouse. Increase the visibility of fences and other structures occurring within 1 km of seasonal ranges by flagging or similar means if these structures appear hazardous to flying grouse. Keys to management are maintaining… undisturbed and relatively open sites for leks	
Scott, J. W. 1942. Mating behavior of the Sage Grouse. Auk 59:477-498. Klebenow, D. A. 1973. The habitat requirements of Sage Grouse and the role of fire in management. Tall Timbers Fire Ecology Conference 12:305-315. Schroeder, M. A., J. R. Young, and C. E. Braun. 1999. Sage Grouse (*Centrocercus* urophasianus). No. 425 in A. Poole and F. Gill, editors. The birds of North America, The Academy of Natural Sciences, Philadelphia, Pennsylvania; The American Ornithologists' Union, Washington, D.C. 28 pages.	Displaying male sage-grouse require relatively open areas during the breeding season.	Location unknown
Scott, J. W. 1942. Mating behavior of the Sage Grouse. Auk 59:477-498.	Lek sites are typically adjacent to sagebrush with adequate cover for nesting hens as well as protection from avian predators, and support	Location unknown

	low, sparse vegetation, if any at all. Flat or gently sloping terrain is a common characteristic of leks as is their location in valley bottoms or draws.	
Klebenow, D. A. 1973. The habitat requirements of Sage Grouse and the role of fire in management. Tall Timbers Fire Ecology Conference 12:305-315. Giezantanner, K. I., and W. H. Clark. 1974. The use of western harvester ant mounds as strutting locations by Sage Grouse. Condor 76:218-219. Connelly, J. W., W. J. Arthur, and O. D. Markham. 1981. Sage Grouse leks on recently disturbed sites. Journal of Range Management 34:153-154. Gates, R. J. 1985. Observations of the formation of a Sage Grouse lek. Wilson Bulletin 97:219-221.	Leks have been found on airstrips, firing ranges, gravel pits, sheep bedding grounds, cultivated fields, recently burned sagebrush, plowed fields, cleared roadsides or roadbeds, and actively occupied ant mounds.	Location unknown
Connelly, J. W., W. J. Arthur, and O. D. Markham. 1981. Sage Grouse leks on recently disturbed sites. Journal of Range Management 34:153-154.	This flexibility suggests that man-made leks are a potential management tool when traditional leks are destroyed, such as by wildfire or human activities	Location unknown

Nesting Habitat

Source	Citation
Greer, R. 1990. Sage Grouse Habitat Requirements and Development. Wyoming Game and Fish Dept.	Relatively dense (20-40 percent coverage) sagebrush stands are used for nesting No treatment should be considered where sagebrush cover is less than 20 percent or within 2 miles of breeding, nesting, or brood areas.

	During livestock drives, nesting areas within 2 miles of breeding grounds should be avoided from mid-April through mid-June. High intensity grazing or trampling should be avoided in nesting and brood rearing areas.
Heath, B. J., R. Straw, S.H. Anderson, J. Lawson, and M. Holloran. 1998. Sage-Grouse Productivity, Survival, and Seasonal Habitat Use Among Three Ranches with Different Livestock Grazing, Predator Control, and Harvest Management Practices. Wyoming Game and Fish Dept.	Removing less than 50% of the herbaceous vegetation production appear to have similar affects on sage grouse nesting and early chick survival We recommend maintaining residual grass heights > 10 cm to provide nesting sage grouse with suitable concealment and screening cover.
Petersen B.E. 1980. Breeding and nesting ecology of female sage grouse in North Park, Colorado. M.S. Thesis, Colo. St. Univ. Fort Collins, Colo.	…sage grouse nest in stands with the maximum big sagebrush height and canopy cover available for nesting.
Patterson, R. L. 1952. The Sage Grouse in Wyoming. Wyoming Game and Fish Comm. and Sage Books, Inc. Denver, Colorado.	Nest destruction by livestock trampling is rare, however, the presence of livestock can cause sage grouse to abandon their nests. Patterson (1952) recorded >200 sage-grouse nests during 1949-50 in the Eden Valley- Pacific Creek area in Wyoming. Height of cover at nest sites ranged from 0 to 102 cm, with a mean of 36 cm; nests were most commonly placed beneath "short sagebrush of medium density, such as is found on drier sites, in preference to the dense, tall sagebrush found along watercourses…." (Patterson 1952:114). In Wyoming, nesting densities of sage-grouse were considerably lower (10 nests/100 ha) in areas heavily grazed by domestic sheep compared to adjacent sites with moderate grazing (28 nests/100 ha). Nest desertion caused by migrant bands of sheep also was documented.
Lyon, A. G. 2000. The potential effects of natural gas development on Sage Grouse near Pinedale, Wyoming. M.S. thesis. University of Wyoming, Laramie, Wyoming. 120 pages.	In the Green River Valley in Wyoming, Lyon (2000) compared a suite of variables at 50 nests with random vegetation plots. Compared with independent, random sites, nest-use plots had taller average live sagebrush (32.7 vs. 27.6 cm), more grass cover (10.6 vs. 5.4%), more

	forb cover (8.2 vs. 4.3%), and taller nest bushes (44.4 vs. 21.4 cm). Compared to random sites, nest sites had greater tall (>18 cm) residual grass cover and greater cover of medium-height shrubs.
Petersen, B. E. 1980. Breeding and nesting ecology of female Sage Grouse in North Park, Colorado. M.S. thesis. Colorado State University, Fort Collins, Colorado. 86 pages. Gill, R. B. 1965. Distribution and abundance of a population of Sage Grouse in North Park, Colorado. M.S. thesis. Colorado State University, Fort Collins, Colorado. 142 pages.	In North Park, Colorado, Petersen (1980) studied breeding biology of sage-grouse hens; mean sagebrush canopy cover at 35 nest sites was 24% (range from 9.4 to 52.6%), and mean sagebrush height was 32 cm (range 11.1 to 59.8 cm), with no differences between nest sites used by adult versus yearling hens. Slope at nest sites was gentle, with 85% of nests on slopes of <12% (Petersen 1980). Gill (1965), also working in North Park, located 92% of 117 nests under sagebrush; mean height of cover at the nest was 43 cm. Nests were typically on flat ground, with mean slope of 2% (Gill 1965).
Schroeder M.A., J.R. Young, C.E. Braun. 1999. Sage grouse (*Centrocercus urophasianus*). p 1–28 *In*: A. Poole and F. Gill (eds.) The birds of North America. The Birds of North America, Inc., Philadelphia, Penn. Patterson R.L. 1952. The sage grouse in Wyoming. Sage Books, Inc., Denver, Colo. Gill, R. B. 1965. Distribution and abundance of a population of Sage Grouse in North Park, Colorado. M.S. thesis. Colorado State University, Fort Collins, Colorado. 142 pages.	Density of sage-grouse nests varies across the range of the species, with densities of 3.8 to 55.6 per km^2 reported by Schroeder et al. (1999). Nest densities averaged 16.2 per km^2 over two breeding seasons within big sagebrush habitats in Wyoming (Patterson 1952). Across North Park, Colorado, nest density was estimated at 12.4 per km^2 (Gill 1965).
Giesen, K.M. 1995. Evaluation of livestock grazing and residual herbaceous cover on sage grouse nest success. Unpublished report. Colorado Division of Wildlife. Wildlife Research Report.	Combined data from both years [1993-1994] indicated nearly one-third (32.2%) of the marked hens moved farther than 3.0 km from the lek to nest. Shrub height, primarily sagebrush (*Artemisia* spp.) at nests averaged 54.6 ±14.0 cm and 57.7 ± 14.5 cm in 1993 and 1994, respectively. Mean sagebrush canopy cover and density at nests were 35.3 ± 14.9% and 14,700 ± 6,000 plants/ha in 1993 and 42.8 ± 15.0% and 15,300 ± 6,200 plants/ha in 1994. No differences in habitat selected for nesting were observed by hens marked at different strutting grounds. Ritchie et al. (1994) suggested that herbaceous cover may be more

	important in determining sage grouse nest success than sagebrush height or cover. Results from this study, particularly the comparisons between nest transects and dependent random transects agree with this finding.
Holloran, M.J., B.J. Heath, A.G. Lyon, S.J. Slater, J.L. Kuipers, and S.H. Anderson. 2005. Greater sage-grouse nesting habitat selection and success in Wyoming. J Wildl Manage. 69(2): 638-649.	Greater sage grouse in Wyoming selected nesting sites with more shrub and residual grass cover than was present at randomly selected sites, supporting our hypothesis that nest sites were characterized by appropriate sagebrush and herbaceous cover (Connelly et al. 1991). …the probability plot indicated increasing sagebrush height did not substantially influence the probability of a nest, suggesting that greater sage grouse selected for increased total shrub canopy cover given adequate sagebrush height. This contention was also supported by the relative variable importance analysis. … the confidence interval around the odds ratio for sagebrush height was centered about 1, suggesting that sagebrush height was not a good predictor of nesting habitat. Greater sage grouse generally select sagebrush patches in mid-range canopy cover conditions (i.e. 15 to 25%; Connelly et al. 2000) for nesting, and avoid sparse and excessively dense patches. However, the relationship between shrub canopy cover and the probability of a nest was linear (not quadratic), and suggested that selection was for sagebrush patches with the highest canopy cover in the range of canopies measured (i.e., range 15-40% for grouped means). The relative importance analysis suggested that taller and thicker residual grass cover characterized successful greater sage grouse nesting habitat. Our results support findings that cover of taller grasses was important to nesting grouse, while further suggesting both increased residual grass cover and height could be important individually.

	The relative importance analysis additionally indicated that herbaceous cover and height were more important than shrub cover or height in distinguishing successful from unsuccessful nests. However, the nest selection analysis established that nests were in areas with increased shrub canopy cover relative to available areas. Thus, taller, thicker residual grass cover in dense sagebrush stands appeared to increase the probability of a successful nest. Our results suggest the timing and amount of moisture received were important to nest success…cool season grass growth during the preceding year (i.e., available as residual grass to nesting females) appeared to be important for overall greater sage grouse nesting success. … selection was for areas with the densest residual grass available and, within those selected areas, nests with the densest residual grass were most successful. … residual grass heights should be a minimum of 10 cm within Wyoming big sagebrush dominated habitats. Our results suggest that sagebrush patches with a combination of dense shrub (overhead) and residual grass (lateral) cover are preferred greater sage grouse nesting areas and that tall, dense residual grasses within these dense shrub stands may be important for nesting success. The results additionally suggest that factors other than the vegetative characteristics immediately surrounding the nest influence nesting success. …our results suggest annual grazing in nesting habitat, regardless of the timing, could negatively impact the following year's nesting success.

The following sources may contain information relevant to the Wyoming Basin - Southern Rocky Mountains ecoregions, but were not conducted within the ecoregional boundaries.

Source	Citation	Location of Study
Batterson, W. M., and W. B. Morse. 1948. Oregon Sage Grouse. Oregon Fauna Series No. 1. Oregon State Game Commission, Portland, Oregon. 29 pages.	Nesting areas are found on gradually sloping sagebrush-covered hills from one to five miles from the strutting grounds and from 100 to 400 feet higher in elevation. Most nests are built at the foot of a sagebrush and under an over-hanging limb…	Columbia River Basin (Oregon and Washington)
Call, M. W., and Maser, C. 1985. Wildlife habitats in managed rangelands, the Great Basin of southeastern Oregon: Sage-Grouse. U.S. Dept. Agric. Pacific Northwest For. And Range Exp. Stn., Gen. Tech. Rep. PNW-187.	Grass cover and/or height may contribute to suitable nesting habitat and, possibly, success …so long as key vegetation components do not deteriorate, cattle are not a serious factor in destruction of nests In important sage grouse nesting and summering areas, livestock grazing should be monitored to protect at least 50 percent of the annual herbaceous vegetation (by weight) prior to mid-September. After mid-September, grouse commence feeding on sagebrush and increased livestock grazing on herbaceous vegetation will not be detrimental.	Columbia River Basin (Oregon and Washington)
Coggins, K. A. 1998. Relationship between habitat changes and productivity of sage grouse at Hart Mountain National Antelope Refuge, Oregon. Oregon State Univ., Corvallis, Oregon.	…mean nest initiation and renesting rates increased concordantly with spring forbs, which increased 2- to 3-fold in several key cover types between periods … mean nesting success increased concomitantly with increases in tall grass cover during spring	Columbia River Basin (Oregon and Washington)

Crawford, J. A., M. A. Gregg, M. S. Drut, and A. K. DeLong. 1992. Habitat use by female Sage Grouse during the breeding season in Oregon. BLM Coop. Res. Unit, Oregon State Univ. Corvallis, OR	Greater amounts of residual tall grass cover and medium height shrub cover at nests likely provided increased nest concealment from predators and resulted in greater nest success than at sites with less tall grasses and medium shrubs. Sage grouse apparently require stands of medium height (40-80 cm) sagebrush with an understory of tall (>18 cm) residual bunchgrasses for successful nesting. Management of nesting habitat should concentrate on big sagebrush stands with an understory of native perennial grasses, whereas management of brood and broodless hen habitat should concentrate on maintenance of cover type diversity and availability of forbs. Livestock grazing is the principal land management practice and proximate factor that affects grass cover and height (Rickard et al 1975). Maintain or develop stands consisting of 8-12% cover of Wyoming big sagebrush and 15-20% cover of mountain and basin big sagebrush (Winward 1991) to provide nesting habitat with medium height (40-80 cm) sagebrush and tall (>18 cm) residual grass cover.	Columbia River Basin (Oregon and Washington)
DeLong, A.K., J.A. Crawford, and D.C. DeLong, Jr. 1995. Relationships between vegetational structure and predation of	Artificial nest fate was positively associated with tall grass cover and medium-height shrub cover collectively (p=0.01).	Columbia River Basin (Oregon and Washington)

artificial sage grouse nests. J Wildl Manage. 59(1):88-92.	This study supports the hypothesis that greater amounts of tall grass and medium-height shrub cover at nest sites lower risk of nest predation for sage grouse. …land management practices that reduce herbaceous cover in sagebrush communities can negatively affect sage grouse nesting habitat…When sage grouse nesting habitat is an objective, managers should monitor livestock distribution and depletion of grasses to remove livestock before the minimum herbaceous cover and height needed for nesting is reached. Some rangelands may need rest from grazing to increase herbaceous cover and height to desired levels. In many situations, however, the absence of livestock grazing along would not increase herbaceous cover because high shrub cover effectively inhibits the herbaceous understory (Sneva et al. 1984, Laycock 1991, Winward 1991).	
Drut, M. S., J. A. Crawford, and M. A. Gregg. 1994. Brood habitat use by Sage Grouse in Oregon. Great Basin Naturalist 54:170-176.	In southeastern Oregon, 13 of 18 nests were in big sagebrush	Columbia River Basin (Oregon and Washington)
Hanf, J. M., P. A. Schmidt, and E. B. Groshens. 1994. Sage Grouse in the high desert of central Oregon: results of a study, 1988-1993. U. S. Department of the Interior, Bureau of Land Management, Prineville, Oregon. 57 pages.	Grass at nest sites was taller than at random sites and successful nesting sites had taller grass than unsuccessful sites. Medium and tall shrubs were also recurrent components of successful nest sites (Hanf et al. 1994). Grazing that occurs just prior to nesting (winter and early spring) has the most	Columbia River Basin (Oregon and Washington)

	immediate effect on residual cover; adequate herbaceous cover should be left for concealment of nests. In central Oregon, nests were most common in mountain big sagebrush (*A. t. vaseyana*); however, the percentage of nests in this type was similar to the availability of the type. Although mountain shrub types (mountain big sagebrush/antelope bitterbrush) and native grasslands were less commonly used, sage-grouse appeared to select these types for nesting; that is, use exceeded availability. Improve the quality of nesting habitat. This includes managing for appropriate habitat types and structural composition within nesting habitat, especially with respect to grass height.	
Stinson, D.W., D.W. Hays, and M. Schroeder. 2004. Washington State Recovery Plan for the Greater Sage-Grouse. Washington Dept. of Fish and Wildlife. Olympia, Washington.	Wherever possible, prevent disturbance in sage-grouse nesting and brood rearing habitat between 1 March and 15 June, including…livestock trail use… Where protection and restoration of sage-grouse is a major objective for public lands, manage grazing so that the habitat characteristics needed for breeding and wintering can be consistently maintained (Connelly et al. 2000). Discourage removal of sagebrush from known sage-grouse wintering areas and areas that provide escape cover in breeding habitat,	Washington

	especially within 3 km of leks.	
Sveum, C. M., W. D. Edge, and J. A. Crawford. 1998. Nesting habitat selection by Sage Grouse in south-central Washington. Journal of Range Management 51:265-269.	…evaluated nesting habitat selection at the Yakima Training Center in Washington, which contains some of the most intact sage-grouse habitat remaining in the state. Most first nest attempts (64% of 72) were in the big sagebrush/bunchgrass cover type. This type was preferred (use exceeded availability) in 1 of 2 yr of study. Sage-grouse nested in stiff sagebrush (*A. rigida*)/bluegrass (*Poa* spp.) and grassland cover types less than expected in both years. They showed no preference (i.e., use was proportional to availability) for nesting in big sagebrush/bunchgrass that had reduced shrub cover and increased bare ground resulting from military training activities, or in riparian cover types (ephemeral streams and wet areas). Shrub cover at nest sites averaged 51% (1992) and 59% (1993), compared with 6 to 7% at random sites. Shrub height was greater (59 and 63 cm) at nest sites than at random sites (15 and 13 cm) (1992 and 1993, respectively). Nest sites also had less cover of short (<18 cm) grasses, greater vertical cover height, less bare ground, and more litter than random sites Most nests [within the Yakima Training Center study site] (71%) were in big sagebrush (*Artemesia tridentata* Nutt.)/bunchgrass communities. Nest habitat was characterized by greater shrub cover, shrub height, vertical cover height,	Columbia River Basin (Oregon and Washington)

	residual cover, and litter than at random locations. Successful 1 m^2 nest sites within big sagebrush/bunchgrass in 1992 had less shrub cover (51%) and shrub height (64 cm) than depredated nest sites (70% and 90 cm, respectively). Successful 77 m^2 nest areas in big sagebrush/bunchgrass in 1993 had more tall grass (≥ 18 cm) than depredated nest areas. Nest sites had greater vertical cover height each year and greater standing dead cover than random sites in 1992.	
Willis, M. J., G. P. Keister, Jr., D. A. Immell, D. M. Jones, R. M. Powell, and K. R. Durbin. 1993. Sage Grouse in Oregon. Wildlife Research Report 15. Oregon Department of Fish and Wildlife, Portland, Oregon. 70 pages.	On better ranges, litter and grass-forb understory was thought to contribute to successful nesting by helping to camouflage nests. …successful nests were located in stands of sagebrush with a higher canopy coverage than those of unsuccessful nests.	Columbia River Basin (Oregon and Washington)
Gregg, M. A. 1994. Brood habitat use by Sage Grouse in Oregon. Great Basin Naturalist 54:170-176. Gregg, M. A., J. A. Crawford, M. S. Drut, and A. K. Delong. 1994. Vegetational cover and predation of Sage Grouse nests in Oregon. Journal of Wildlife Management 58:162-166.	94% of all nests of radio-marked hens were under sagebrush in an area where sagebrush composed 87% of the shrubs.	southeastern Oregon
Rasmussen, D. I., and L. A. Griner. 1938. Life history and management studies of the Sage Grouse in Utah, with special reference to	Nest destruction by livestock trampling is rare, however, the presence of livestock can cause sage grouse to abandon their nests.	Utah

nesting and feeding habits. Transactions of the North American Wildlife Conference 3:852-864.	Of 161 nests examined in Utah, two were trampled by livestock (one sheep, one cattle) and five were deserted due to disturbance by livestock. Nesting is, as a rule, definitely under way by the middle of May in the Strawberry Valley. This is subject to some seasonal variation…Observations in the Strawberry Valley (elevation 7,550 to 8,000 feet) show that in 1936 the nesting activity began early in May and nests were found between the 12th and 16th of May with clutches from 4 to 8 eggs. Observations on some nests near Portage, Utah, at an elevation of near 5,500 feet showed that nesting activity began between April 15 and April 30 in 1936. The nesting period extended until the first week of July, the last hatch with definite record was on July 5, 1936. Concealment is the first and perhaps most important requisite of a good sage grouse nesting site. Of the 161 nests studied during the two years all were found on the ground, usually protected by sagebrush and never a great distance from these shrubs. In the case of the two nests destroyed by	

	livestock one is attributed to sheep and the other to cattle, they were the only class of stock using the area where the desertion occurred. The livestock which accounted for the 5 desertions were both sheep and cattle. In all cases the stock either knocked eggs from the nest or bedded down too near the nest. In the most productive nesting habitat in the Strawberry Valley in Utah, Rasmussen and Griner (1938) found 36 nests per km^2. This habitat was composed of recently disturbed (e.g., from burning or flooding) sites in which big sagebrush or black sagebrush had recovered so that >50% of total cover was in sagebrush, and shrubs were >45 cm tall.	
Rowland, M.M. 2004. Effects of management practices on grassland birds: Greater Sage-Grouse. Jamestown, ND. Northern Prairie Wildlife Research Center.	Greater Sage-Grouse nest in a variety of cover types, but most nests are under big sagebrush (Patterson 1952, Gill 1965, Petersen 1980, Wakkinen 1990, Connelly et al. 1991, Schroeder et al. 1999). Other shrubs used for nesting cover include bitterbrush, greasewood (*Sarcobatus vermiculatus*), horsebrush (*Tetradymia* spp.), low sagebrush, mountain mahogany (*Cercocarpus* spp.), rabbitbrush, shadscale saltbush (*Atriplex confertifolia*), snowberry (*Symphoricarpos* spp.), and western juniper (*Juniperus occidentalis*) (Patterson 1952, Klebenow 1969, Wakkinen 1990, Connelly et al. 1991, Crawford and Davis 2002). Nests also have been found on bare ground devoid of cover (Patterson 1952) and	North Dakota

	under basin wildrye (*Leymus cinereus*) (Wakkinen 1990, Crawford and Davis 2002). Young (1994) reported a Gunnison Sage-Grouse nest beneath a Douglas-fir (*Pseudotsuga menziesii*) tree. The most suitable nesting habitat includes a mosaic of sagebrush with horizontal and vertical structural diversity. A healthy understory of native grasses and forbs provides 1) cover for concealment of the nest and hen from predators, 2) herbaceous forage for pre-laying and nesting hens, and 3) insects as prey for chicks and hens. Mean sagebrush canopy cover at nest sites ranges from 15 to 38%, and mean sagebrush height ranges from 36 to 79 cm (Schroeder et al. 1999). Mean distance between nests and nearest leks varies from 1.1 to 6.2 km; however, nests have been found >20 km from the nearest lek (Connelly et al. 2000). In an Idaho study, 216 nest bushes were taller and larger than big sagebrush shrubs in 40- m^2 plots surrounding the nests (Autenrieth 1981). Mean height of nest bushes ranged from 58.2 cm to 79.3 cm, compared with 30.2 to 54.9 cm in the plots. Mean diameter of nest bushes ranged from 93.9 to 109.7 cm, compared with 42.7 to 61.0 cm for other sagebrush shrubs in the plots (Autenrieth 1981). Canopy cover in the surrounding plots ranged from 23.4 to 38.1%. Distance from nests to water varied from 530 to 2,257 m.	
Poley, B. E. 1969. Seasonal Movements of	From data collected in 1968 in Colorado, it	Colorado

Sage Grouse in Colorado. Journal of Colorado Field Ornithologists. 5:1-4.	was found that females began nesting in late May. Observations indicated that sage grouse hens acted as individuals as opposed to following general patterns.	
Crawford, J. A., and D. M. Davis. 2002. Habitat use by Greater Sage-Grouse on Sheldon National Wildlife Refuge. Final Report. Game Bird Research Program, Oregon State University, Corvallis, Oregon. 119 pages.	Of 61 sage-grouse nests at the Sheldon National Wildlife Refuge (NWR) in Nevada, 41% were in mountain big sagebrush, 31% were in mountain shrub (including mountain big sagebrush, antelope bitterbrush, bluegrass, and needlegrass [*Achnatherum* spp.]), and 13% were in low sagebrush cover types. Neither cover type, medium-height (40 to 80 cm) shrub cover, nor total forb cover were related to nest success, and no relationship was found between age of hen and type of cover used for nesting.	Great Basin (Nevada and California)
Neel, L.A. 1980. Sage grouse response to grazing management in Nevada. M.S. Thesis, Univ. Nevada. Reno, Nev.	Heavy use of riparian meadows by livestock reduces the availability of succulent plant species and may induce avoidance of these habitats by sage grouse. One advantage of rest rotation grazing is that rested pastures can provide emergency forage (Ratliff and Reppert 1974), which may prevent excessive grazing in the used pastures during drought. Compared with no grazing, rest rotation grazing increased forb abundance on sage grouse meadow habitat in Nevada.	Great Basin (Nevada and California)

U. S. Dept. of Interior, Bureau of Land Management. 2000. Management guidelines for sage grouse and sagebrush ecosystems in Nevada.	During drought periods (i.e., a specified period of time in which the precipitation received is less than 75 percent of average) of two or more years, reduce stocking rates or change management practices for livestock if nesting cover and brood-rearing habitat requirements are not being met. Determine grazing use levels on that portion of the pasture which is known habitat. Grazing use levels should not be determined by "average use" throughout the entire pasture or grazing unit.	Nevada
van Kooten, G.C., R. Thomsen, T.G. Hobby, and A.J. Eagle. 2004. Social Dilemmas and Public Range Management in Nevada.	Define, identify, conserve and enhance critical lek, nesting, brood rearing and winter habitat used by sage grouse. Characteristics of habitat types preferred by sage grouse at various times of the year, and the interrelationships between these habitat types, are not clearly defined. Public (landowners, land managers and other land users) involvement and participation in reporting sightings of sage grouse leks, nests, broods and winter locations should be encouraged. Intensive searches of sage grouse range are required to assess critical habitat parameters throughout the year and the relationships between these habitat types. Abandoned habitat should be assessed for seasonal deficiencies which may limit use by sage grouse. Critical habitat must be protected and secured. Land-use practices and other factors detrimental to maintenance of quality sage grouse habitat need to be identified. Working co-operatively with land managers	Nevada

	and other land users, initiatives need to be developed to enhance and maintain an abundance of high quality habitat on private and public lands throughout the range of sage grouse. Establish public reporting system for sage grouse leks, nesting, brood and winter locations. -Conduct searches/surveys for active leks, nests, brood rearing and winter use areas throughout sage grouse range. -Document habitat characteristics of lek, nesting, brood-rearing and winter-use areas and the interrelationships between habitat types. -Investigate habitat parameters (lek, nesting, brood rearing and winter use) in areas of abandoned leks. -Investigate the use of remote-sensing data systems to identify potential lek, nesting, brood-rearing and winter habitat. -Map critical lek, nesting, brood rearing and winter habitat areas. -Identify critical lek, nesting, brood rearing and winter habitat which must be protected, secured or enhanced. -Identify land-use practices which are detrimental to provision of quality lek, nesting, brood rearing and winter habitat. -Develop cooperative initiatives to protect lek sites and lek, nesting, brood rearing and winter habitat on public lands. -Develop cooperative initiatives to protect lek	

	sites and lek, nesting, brood rearing and winter habitat on private lands. -Develop cooperative initiatives to enhance and improve the quantity and quality of lek, nesting, brood rearing and winter habitat.	
Fischer, R.A., A.D. Apa, W.L. Wakkinen, K.P. Reese, and J.W. Connelly. 1993. Nesting-area fidelity of sage grouse in southeastern Idaho. The Condor. 95:1038-1041.	Sage grouse on the Big Desert showed strong fidelity for specific nesting areas, since movements between consecutive-year nests represented only 3.5% of their median annual straight-line movement (20.9 km). Gates (1983) reported fidelity to nesting areas by three female sage grouse that all nested <200m from the previous year's nests.	Idaho
Autenrieth, R. E. 1981. Sage Grouse management in Idaho. Idaho Dept. of Fish and Game.	When heavy use occurs within the traditional sage grouse nesting and/or brood rearing habitats the result appears to be negative both in terms of harassment and competition for forbs. It is not valid to assume sage grouse can move elsewhere during heavy livestock use. The greatest potential for nest impacts on Sage-Grouse may be associated with forced livestock movements across nesting areas. Known nesting areas (3.2 km radius of leks) should be avoided from mid-April to early June to reduce abandonment.	Idaho
Wakkinen, W.L. 1990. Nest Site Characteristics and Spring-Summer Movements of Migratory Sage Grouse in Southeastern Idaho. Ph.D. Dissertation. Univ. of Idaho.	…sage grouse use different portions of the available habitat for nesting in different geographic areas. …data suggests that grass height may be a	Idaho

	factor in both nest site selection and nest fate. …hens in Idaho select less than maximum available canopy cover.	
Autenrieth, R. E. 1981. Sage Grouse management in Idaho. Idaho Dept. of Fish and Game. Klebenow, D.A. 1969. Sage grouse nesting and brood habitat in Idaho. J. Wildl. Manage. 33:649-662 Wakkinen, W.L. 1990. Nest Site Characteristics and Spring-Summer Movements of Migratory Sage Grouse in Southeastern Idaho. Ph.D. Dissertation. Univ. of Idaho.	Grass cover and/or height may contribute to suitable nesting habitat and, possibly, success…	Idaho
Klott, J. H., R. B. Smith, and C. Vullo. 1993. Sage Grouse habitat use in the Brown's Bench area of south-central Idaho. U.S. Department of the Interior, Bureau of Land Management, Denver Service Center, Denver, Colorado, and Idaho Department of Fish and Game, Jerome, Idaho. 14 pages.	In southcentral Idaho, Klott et al. (1993) found four sage-grouse nests in Wyoming big sagebrush, two in low sagebrush, and one each in mountain big sagebrush and crested wheatgrass. No nests were found in quaking aspen (*Populus tremuloides*), mountain mahogany, mountain shrub, or meadow habitat types.	Idaho
Klebenow, D.A. 1969. Sage grouse nesting and brood habitat in Idaho. J. Wildl. Manage. 33:649-662	…sage grouse nest in stands with the maximum big sagebrush height and canopy cover available for nesting. In the Upper Snake River Plains of southeastern Idaho, sage-grouse nested primarily in threetip sagebrush (Klebenow 1969). Mean height of shrubs under which sage-grouse nested was 43 cm, whereas mean height of threetip sagebrush in the study area	Idaho

	was only 20 cm. Mean total shrub cover in the vicinity of nest sites was 18.4%, compared with 14.4% in the threetip sagebrush community overall. Although big sagebrush density and crown cover were greater near nests than in the general area, sage-grouse nests were not found in big sagebrush stands with cover exceeding 25%. Bitterbrush provided all or part of the nesting shrub cover for 29% of the nests. The author used stepwise discriminant function analysis in an attempt to distinguish between nest sites and the surrounding habitat in the threetip sagebrush community; however, a satisfactory model could not be developed with the data collected. In southeastern Idaho, there were 3.8 nests per km^2 in a big sagebrush/threetip sagebrush site; however, nests were not evenly distributed across the study area, and in some areas nest density reached 24.7 nests per km^2 (Klebenow 1969).	
Rowland, M.M. 2004. Effects of management practices on grassland birds: Greater Sage-Grouse. Jamestown, ND Northern Prairie Wildlife Research Center.	Keys to management are maintaining expansive stands of sagebrush (*Artemisia* spp.), especially varieties of big sagebrush (*A. tridentata*), with abundant forbs in the understory, particularly during spring; undisturbed and relatively open sites for leks; and healthy perennial grass and forb stands intermixed with sagebrush for brood rearing. Within suitable habitats, areas should have 15 to 25% canopy cover of sagebrush 30 to 80 cm tall for nesting, and 10 to 25% canopy cover from 40 to 80 cm tall for brood rearing	North Dakota

	(Connelly et al. 2000). In winter habitats, shrubs should be exposed 25 to 35 cm above snow level and have 10 to 30% canopy cover exposed above snow. In nesting and brood-rearing habitats, understory habitats with adequate cover of grasses (>15%) and forbs (>10%) at least 18 cm tall are needed (Connelly et al. 2000). Manage livestock grazing through stocking rates and season of use on all seasonal ranges of sage-grouse to avoid habitat degradation (Paige and Ritter 1999, Beck and Mitchell 2000, Wisdom et al. 2000), especially on recently disturbed sites, such as those sprayed or burned (Braun et al. 1977). In nesting and brood-rearing habitats, ensure that grazing does not reduce herbaceous understory cover below levels that serve as a deterrent to potential predators of eggs and chicks (Connelly et al. 2000, Hockett 2002). Healthy native understories also support insects and forbs that are important in diets of pre-laying hens and chicks (Johnson and Boyce 1990, Barnett and Crawford 1994, Drut et al. 1994). Riparian areas and wet meadows used for brood rearing are especially sensitive to grazing by livestock; in these habitats, removal of livestock before the nesting season may be prudent (Beck and Mitchell 2000, Hockett 2002).	
Moynahan, B.J.; Lindberg, M.S.; J.J. Rotella; and J.W. Thomas. *In Press* (b). Factors affecting nest survival of Greater Sage-	…most nests were located under big sagebrush Management of habitats for nesting sage-	Northern Great Plains (Montana)

grouse in northcentral Montana. Journal of Wildlife Management.	grouse should focus on increasing grass cover to increase survival of first nests and contribute to favorable conditions for renesting, which should be less likely if survival of first nests increases. Precipitation affected nest survival on a daily basis. The relative effect of daily precipitation was greater than that of the lag effect and the net effect of precipitation over the course of a season was positive. Several previous studies also documented higher nesting probability for adults than for yearlings (Gregg 1991, Connelly et al. 1993); others have recorded nearly all hens nesting regardless of age-class (Schroeder 1997). We observed the lowest nesting probability in 2001 when the study area was affected by severe drought and there was little growth of non-sagebrush food items (i.e., forbs). Nesting probabilities increased markedly in 2002 and 2003 when range conditions improved. This pattern, coupled with the lower mean clutch sizes observed in 2001, supports the hypothesis that better range condition may result in improved condition of pre-laying hens (Barnett and Crawford 1994) and thus higher nesting probabilities. Reported renesting rates for sage-grouse vary widely and likely are greatly affected by weather conditions in at least 3 different ways: little or no renesting in a dry year with little	

	current year's vegetative growth; relatively high renesting effort when habitat conditions were more favorable, but first nest survival rates were moderate; and lower when conditions were favorable and relatively high survival of first nests precluded many hens from renesting. Wildlife and land managers should strive to maintain or enhance herbaceous understory conditions favorable for survival of first nests and for later-season renesting attempts. Land uses (including grazing) that reduce contributions of herbaceous vegetation to visual obstruction of sage-grouse nests may reduce nest survival at the landscape scale by resulting in increased depredation.	
Wallestad, R. O. 1975. Life history and habitat requirements of sage grouse in central Montana. Montana Fish and Game Dept. Technical Bulletin.	…average sagebrush height over nests was 15.9 inches.	Northern Great Plains (Montana)
Wallestad, R.O. and D. Pyrah. 1974. Movement and nesting of sage grouse hens in central Montana. Journal of Wildlife Management 38:630-633.	…sagebrush cover was the most important factor to nesting sage grouse in Montana, most nests were located under big sagebrush. …sage grouse nest in stands with the maximum big sagebrush height and canopy cover available for nesting. …most nests located under the tallest bushes available at a particular site. Successful nests had greater sagebrush cover	Northern Great Plains (Montana)

	within 24 inches of the nest and were located in stands of sagebrush with a higher average canopy coverage (27%) than those of unsuccessful nests (20%).	
Wallestad, R.O. and R. Schladweiler. 1974. Breeding season movements and habitat selection of male sage grouse. Journal of Wildlife Management 38:634-637.	Males also remain near leks during the nesting season, with one study reporting that 76% of all movements during this season were within one kilometer of the dancing grounds.	Northern Great Plains (Montana)
Adams, B.W., J. Carlson, D. Milner, T. Hood, B. Cairns and P. Herzog. 2004. Beneficial grazing management practices for Sage-Grouse (*Centrocercus urophasianus*) and ecology of silver sagebrush (*Artemisia cana*) in southeastern Alberta. Public Lands and Forests Division, Alberta Sustainable Resource Development. Pub. No. T /049.	…suggests that so long as key vegetation components do not deteriorate, cattle are not a serious factor in destruction of nests. Heavy grazing reduces cover and increases the chance of predation, especially by ground squirrels (*Spermophilus* spp.). Encourage practices that increase height and cover of sagebrush and of native grasses at nesting sites. Maintain light grazing intensities to produce mosaics in vegetation and an increase in herbage production that are favorable for Sage-Grouse nesting and brood-rearing habitat. Practice grazing deferral to allow for undisturbed nesting. Practices that increase the amount of rest in a pasture may be a useful to restore fair and poor condition range which will provide more cover for Sage-Grouse.	Northern Great Plains (Alberta)
Aldridge, C.L, and R.M. Brigham. 2002.Sage	If management goals are to provide suitable	Canada

grouse nesting and brood habitat use in southern Canada. J Wildl Manage. 66(2):433-444.	nesting and brood-rearing habitat, efforts should be directed toward protecting and enhancing sagebrush stands ≥ 30 m^2 and increasing overall sagebrush cover. These stands also should have a suitable understory of tall grasses and forbs to enhance nest concealment. Management strategies also should focus on increasing the availability of mesic sites and increasing the abundance of sites with > 10% forb cover, to enhance brood rearing habitat. Land managers implementing water developments for livestock need to consider the potential negative effects those developments might have on key wetlands and mesic sites.	
Connelly, J. W., M. A. Schroeder, A. R. Sands, and C. E. Braun. 2000. Guidelines to manage Sage Grouse populations and their habitats. Wildlife Society Bulletin 28:967-985.	Manage breeding habitats to support 15-25% canopy cover of sagebrush, perennial herbaceous cover averaging ≥ 18 cm in height with ≥ 15% canopy cover for grasses and ≥ 10% for forbs and a diversity of forbs (Barnett and Crawford 1994, Drut et al. 1994, Apa 1998) during spring. For nonmigratory grouse occupying habitats that are distributed uniformly…protect (i.e. do not manipulate) sagebrush and herbaceous understory within 3.2 km of all occupied leks. For nonmigratory grouse occupying habitats that are not distributed uniformly…protect suitable habitats for ≤ 5 km from all occupied	N/A

	leks. For migratory populations, identify and protect breeding habitats within 18 km of leks… During drought periods (≥ 2 consecutive years), reduce stocking rates or change management practices for livestock…if cover requirements during the nesting and brooding periods are not met. Grazing pressure from domestic livestock and wild ungulates should be managed in a manner that at all times addresses the possibility of drought.	
Authenrieth, R., W. Molina, and C. Braun, eds. 1982. Sage Grouse Management Practices. Western States Sage Grouse Committee. Western States Sage Grouse Committee Technical Bulletin #1. Twin Falls, ID.	When [heavy use of pasture in rest rotation grazing systems] encompasses nesting and/or brood rearing habitats the results are negative. It is known that hens abandon nests with little provocation while laying (mid-April through early May). It is also known that yearling hens are prone to nest abandonment when disturbed, even during incubation. Since yearling hens comprise about 35% of the reproductive segment, the impact of livestock drives could be severe. Known nesting areas (3.2 km (2 mi) radius from leks) should be undisturbed from mid-April to mid-June.	N/A
Hockett, G.A. 2002. Livestock Impacts on the Herbaceous Components of Sage Grouse Habitat: A Review. Int. Jour. Sci.	Protect sage grouse nesting and brood-rearing habitat from livestock use to encourage climax vegetative conditions. If this is not feasible, limit grazing to the month of July with the	N/A

	exact timing of grazing varying with local conditions. Defer grazing until after the peak of the growing season with the intent of providing herbaceous cover and forage for the majority of the nesting, hatching, and early brood-rearing. Cessation of grazing by 1 August is designed to minimize livestock concentrations in wet meadows and riparian areas with open water by avoiding "hot season" use and to allow a 30-day regrowth period before the first killing frost as recommended by Myers (1989). Additionally, late summer-early fall regrowth is important for carbohydrate storage in roots and stem bases of cool season grasses (Stoddart et al. 1975) that enhances plant vigor while allowing residual vegetation to accumulate cover for nesting and early brood-rearing the following spring.	
U. S. Dept. of Interior, Bureau of Land Management. 1979. Habitat Requirements and Management Recommendations for Sage Grouse. Bureau of Land Management TN 330. Denver, CO.	Height of sagebrush commonly used for nesting varies between 7 and 31 inches (17 to 79 cm) with most nests located under the tallest bushes available at a particular site (Keller et al. 1941, Patterson 1952, Trueblood 1954, Gray 1967, Klebenow 1969). Hens nest in short sagebrush of medium density, such as is found on drier sites, in preference to the dense, tall brush found along watercourses and on moist areas. Stands of 20-40% canopy coverage were most frequently selected for nesting.	Location unknown

	Patterson (1952) measured height of nesting cover in Wyoming and reported that 216 of 262 nests measured had nesting cover between 10 and 20 inches tall. … Patterson (1952) reported that on 2 occasions bands of sheep caused birds to flush and simultaneously to flip eggs out of their nests. Every effort should be made to delay sheep bands from utilizing known sage grouse nesting areas until about the first week in June, or until young sage grouse have hatched in the particular locality. Domestic sheep are known to have caused considerable nest abandonment around bedgrounds, in trailing areas, and during normal feeding (Patterson 1952). Desertion was most prevalent in the vicinity of sheep bedgrounds. Bands of from 2,000 to 3,000 sheep were serious disturbances to nesting activities (Patterson 1952). Patterson (1952) noted that it was significant that several thousand sheep began moving into his study area en route to their summer ranges coincident with the period of nest desertion. There was no indication that livestock is a serious factor in nest destruction, although nest desertion from livestock activities was of frequent occurrence under certain conditions (Patterson 1952).	

Braun, C. E. 1987. Current issues in Sage-Grouse management. Proc. Western Association Fish and wildlife agencies. Colo. Div. Wildl., Fort Collins.	Heavy grazing reduces cover and increases the chance of predation, especially by ground squirrels (*Spermophilus* spp.)	N/A
Crawford, J.A., R.A. Olson, N.E. West, J.C. Mosley, M.A. Shroeder, T.D. Whitson, R.F. Miller, M.A. Gregg, and C.S. Boyd. 2004. Synthesis Paper: Ecology and management of sage-grouse and sage-grouse habitat. J. Range Manage. 57: 2-19.	…the specific relationship between grazing pressure and sage grouse nest success has not been empirically evaluated. Heavy use of riparian meadows by livestock reduces the availability of succulent plant species and may induce avoidance of these habitats by sage grouse. Rotational grazing systems are one way to provide areas (i.e., pastures) free from livestock disturbance during nesting. This benefit may be offset if heavy use occurs in the grazed pastures (Holechek et al. 1982), especially since sage grouse can display high site fidelity (Fischer et al.1993). Grazing systems in riparian areas have met with mixed results and their influence on system recovery and vegetation response will vary based on site potential, ecological condition, stream morphology, and climate (Elmore and Kauffman 1994). One advantage of rest rotation grazing is that rested pastures can provide emergency forage (Ratliff and Reppert 1974), which may prevent excessive grazing in the used pastures during drought. This added residual cover may be important to sage grouse, but light to moderate	Location unknown

	utilization of grasses in well-managed continuously grazed systems may also provide sufficient residual cover.	
Klebenow, D.A. 1972. The habitat requirements of sage grouse and the role of fire in management. Proc. Tall Timbers Fire Ecol. Conf. 12:305-315.	Grass cover and/or height may contribute to suitable nesting habitat and, possibly, success…	Location unknown
Beck, J.L, and D.L. Mitchell. 2000. Influence of livestock grazing on sage grouse habitat. Wildlife Society Bulletin 4:993-1002.	Excessive livestock grazing has negatively impacted sage grouse habitat by creating seral conditions that favor annual grass dominance and by reducing perennial grasses used as nesting and escape cover. Grazing during the late spring nesting period can reduce herbaceous cover necessary for concealing nests from predators. 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.	Location unknown
Call M.W. 1979. Habitat requirements and management recommendations for sage grouse. USDI-BLM Denver Serv. Center Tech. Note 330 Crawford, J.A., R.A. Olson, N.E. West, J.C. Mosley, M.A. Shroeder, T.D. Whitson, R.F. Miller, M.A. Gregg, and C.S. Boyd. 2004. Synthesis Paper: Ecology and management of sage-grouse and sage-grouse habitat. J.	Nest destruction by livestock trampling is rare, however, the presence of livestock can cause sage grouse to abandon their nests.	Location unknown

Range Manage. 57: 2-19.		
Beck, J.L. and D.L. Mitchell. 2000. Influences of livestock grazing on sage grouse habitat. Wildl. Soc. Bull. 28:993–1002. Crawford, J.A., R.A. Olson, N.E. West, J.C. Mosley, M.A. Shroeder, T.D. Whitson, R.F. Miller, M.A. Gregg, and C.S. Boyd. 2004. Synthesis Paper: Ecology and management of sage-grouse and sage-grouse habitat. J. Range Manage. 57: 2-19.	Managers should consider delaying grazing of known nesting areas until after nesting.	Location unknown

Brood Rearing

Source	Citation
Greer, R. 1990. Sage Grouse Habitat Requirements and Development. Wyoming Game and Fish Dept.	Although the adult diet switches to forbs and insects in addition to sagebrush, developing young depend heavily upon insects for food. Forbs become important in the diets of juveniles as summer progresses. At this time, broods move to higher elevations in search of succulent vegetation or remain in sagebrush habitat if succulent forbs are readily available. Hens and broods are strongly attracted to lush hay meadows and alfalfa fields during late summer. Meadow grazing should be delayed until mid-August to promote sage grouse chick survival and growth. High intensity grazing or trampling should be avoided in nesting and brood rearing areas. Springs and reservoirs can be fenced in brood rearing areas with water

	piped to stock tanks or troughs. Stream meadows and the adjacent sagebrush buffer zone can be fenced, with 50 yard wide fenced corridors inserted to provide water access for cattle.
Danvir, R. E. 2002. Sage Grouse ecology and management in northern Utah sagebrush-steppe. A Deseret Land and Livestock Wildlife Research Report. Deseret Land and Livestock Ranch and the Utah Foundation for Quality Resource Management, Woodruff, Utah. 39 + appendices.	Increased use of meadows during dry summers.
Heath, B. J., R. Straw, S.H. Anderson, J. Lawson, and M. Holloran. 1998. Sage-Grouse Productivity, Survival, and Seasonal Habitat Use Among Three Ranches with Different Livestock Grazing, Predator Control, and Harvest Management Practices. Wyoming Game and Fish Dept..	Our results suggest that grazing management practices that promote increased height and coverage of grass will increase chick survival.

The following sources may contain information relevant to the Wyoming Basin - Southern Rocky Mountains ecoregions, but were not conducted within the ecoregional boundaries.

Source	Citation	Location of Study
Evans, C. 1986. The relationship of cattle grazing to sage grouse use of meadow habitat on the Sheldon National Wildlife Refuge. Ph.D. Dissertation. Univ. of Nevada, Reno. Reno, NV.	Selection for meadows which had been grazed was consistently higher for hens and juveniles. In general, sage grouse seemed to use meadows where cattle were present or in the vicinity, but appeared to avoid close contact. In riparian brood-rearing habitat, sage-grouse prefer the lower vegetation (5–15 cm vs. 30–50 cm. In riparian brood-rearing habitat, sage-grouse prefer the succulent forb growth stimulated by	Sheldon National Wildlife Refuge, Nevada

	moderate livestock grazing.	
Klebenow, D.A. 1982. Livestock grazing interactions with sage grouse. In: J.M. Peek and P.D. Dalke (eds.). Proc. Wildl. Livestock Relationships Symposium, Univ. Idaho, For., Wildl., and Range Exp. Stn., Moscow. p. 113-123.	… heavily grazed meadows in poor condition were avoided by sage grouse broods. …loss of cover due to heavy grazing was causing the avoidance of these areas. …dense grassy meadows that had been grazed lightly or moderately were attractive to sage grouse. In riparian brood-rearing habitat, sage-grouse prefer the lower vegetation (5–15 cm vs. 30–50 cm).	Nevada
Klebenow, D. A. 1985. Habitat management for sage-grouse in Nevada. World Pheasant Assoc. 10:34–46.	Sage-grouse broods at the Sheldon NWR used primarily sagebrush uplands (low sagebrush and mountain and Wyoming big sagebrush) during 1978 and 1980; however, during the drought year of 1979, use was greater in wet meadows, and upland sites were abandoned by broods by late summer. Brood habitat in uplands differed from that in wet meadows. Upland brood sites had greater canopy cover of sagebrush (mean = 25 vs. 0%), less grass cover (15 vs. 57%), and less forb cover (10 vs. 38%). Meadows into which tall sagebrush has encroached were seldom used by sage-grouse during brood rearing, with no grouse found in areas with a mean shrub height of 140 cm and >40% canopy cover. In these meadows, most broods occurred in	Nevada

	sites with relatively shorter shrubs (60 cm) and greater dominance of grass and forb cover.	
Neel, L.A. 1980. Sage Grouse Response to Grazing Management in Nevada. M.S. Thesis Univ. of Nevada, Reno. Reno, Nevada.	In riparian brood-rearing habitat, sage-grouse prefer the lower vegetation (5–15 cm vs. 30–50 cm. In riparian brood-rearing habitat, sage-grouse prefer the succulent forb growth stimulated by moderate livestock grazing. When a meadow was bisected by a pasture fence with one side grazed and the other rested, grouse selected the grazed side. As long as rest is afforded a given meadow every three years, no negative impact on sage grouse habitat seems to occur.	Nevada
Oakleaf, R.J. 1971. Relationship of sage grouse to upland meadows in Nevada. M.S. Thesis, Univ. Nevada. Reno, Nev.	In riparian brood-rearing habitat, sage-grouse prefer the lower vegetation (5–15 cm vs. 30–50 cm. The upland meadow represents the primary summer habitat available to sage grouse throughout much of its range in Nevada. Past and present management of public lands in Nevada has regarded upland meadows as sacrifice areas. A serious deterioration of this habitat has been the inevitable result and will continue unless meadows are specifically managed. Oakleaf (1971) showed that a reduction in meadow use by sage grouse occurred as an	Nevada

	increasing percentage of the juvenile population reached 11-12 weeks of age. He further found that the diminished food supply of a deteriorated meadow limited the use by sage grouse.	
Savage, D.E. 1968. The relationship of sage grouse to upland meadows in Nevada. M.S. Thesis. Univ. Nevada, Reno. 172 pp.	Favored foods are common dandelion (*Taraxacum officinale*), common salsify (*Tragopogon dubius*), western yarrow (*Archillea millifolium*) and others.	Nevada
Savage, D.E. 1969. The relationship of sage grouse to upland meadows in Nevada. Nevada Cooperative Wildlife Research, Nevada Fish and Game Commission, and Nevada Agricultural Experiment Station. 101 pp.	Meadows provided a source of food (forbs), water and cover that were unavailable on more xeric, but adjacent rangelands.	Nevada
U.S. Department of the Interior. 1975. Effects of livestock grazing on wildlife, watershed, recreation, and other resource values in Nevada. U.S. Dep. Int., Bur. Land Manage. Unpubl. Manuscript. 96 pp.	…the Bureau of Land Management (USDI 1975) identified livestock grazing as having an adverse impact on 1,413 km (883 mi) of streambank riparian habitat in Nevada. This report also described the combined effects of water development practices and livestock grazing as being the primary areas where wildlife habitat conflicts exist, and further states that "The areas around most livestock waters and water courses visited (in the 3 districts) were denuded of vegetation and trampled by livestock."	Nevada
U. S. Dept. of Interior, Bureau of Land Management. 2000. Management guidelines for sage grouse and sagebrush ecosystems in Nevada.	During drought periods (i.e., a specified period of time in which the precipitation received is less than 75 percent of average) of two or more years, reduce stocking rates or change management practices for livestock if nesting cover and brood-rearing habitat requirements	Nevada

	are not being met. Coordinate livestock use on wetland-riparian and streambank-riparian habitat to ensure known late season brood-rearing habitats are in optimal condition.	
van Kooten, G.C., R. Thomsen, T.G. Hobby, and A.J. Eagle. 2004. Social Dilemmas and Public Range Management in Nevada.	Define, identify, conserve and enhance critical lek, nesting, brood rearing and winter habitat used by sage grouse. Characteristics of habitat types preferred by sage grouse at various times of the year, and the interrelationships between these habitat types, are not clearly defined. Public (landowners, land managers and other land users) involvement and participation in reporting sightings of sage grouse leks, nests, broods and winter locations should be encouraged. Intensive searches of sage grouse range are required to assess critical habitat parameters throughout the year and the relationships between these habitat types. Abandoned habitat should be assessed for seasonal deficiencies which may limit use by sage grouse. Critical habitat must be protected and secured. Land-use practices and other factors detrimental to maintenance of quality sage grouse habitat need to be identified. Working co-operatively with land managers and other land users, initiatives need to be developed to enhance and maintain an abundance of high quality habitat on private and public lands throughout the range of sage grouse. Establish public reporting system for sage	Nevada

	grouse leks, nesting, brood and winter locations. -Conduct searches/surveys for active leks, nests, brood rearing and winter use areas throughout sage grouse range. -Document habitat characteristics of lek, nesting, brood-rearing and winter-use areas and the interrelationships between habitat types. -Investigate habitat parameters (lek, nesting, brood rearing and winter use) in areas of abandoned leks. -Investigate the use of remote-sensing data systems to identify potential lek, nesting, brood-rearing and winter habitat. -Map critical lek, nesting, brood rearing and winter habitat areas. -Identify critical lek, nesting, brood rearing and winter habitat which must be protected, secured or enhanced. -Identify land-use practices which are detrimental to provision of quality lek, nesting, brood rearing and winter habitat. -Develop cooperative initiatives to protect lek sites and lek, nesting, brood rearing and winter habitat on public lands. -Develop cooperative initiatives to protect lek sites and lek, nesting, brood rearing and winter habitat on private lands. -Develop cooperative initiatives to enhance and improve the quantity and quality of lek, nesting, brood rearing and winter habitat.	
Young, J.A. 1994. Changes in plant communities in the Great Basin induced by	Potential for competition with Sage-Grouse young may be in proportion to the extent to	Great Basin Ecoregion (Nevada and California)

domestic livestock grazing. Pages 113-123 in K.T. Harper, L.L. St. Clair, K.H. Thorne, and W.M. Hess, editors, Natural history of the Colorado plateau and Great Basin. University Press of Colorado, Niwot.	which cattle select mesic/moist sites that are preferred foraging areas. Young birds seek out insects and succulent forbs in these habitats.	
Autenrieth, R.E. 1973. Sage grouse research in Idaho. Proc. West. States Sage Grouse Workshop 8:51-52.	… livestock competition with broods on wet meadows negatively affected some sage grouse populations in Idaho.	Idaho
Autenrieth, R. E. 1981. Sage Grouse management in Idaho. Idaho Dept. of Fish and Game.	The key to sage grouse habitat enhancement is to increase favored forbs for brood use while minimally reducing protective sagebrush cover. …even in wet springs hens must move their broods to mesic areas in search of insects and forbs if domestic livestock has depleted the range. When broods do not migrate, they rely on springs and wet meadows for forbs. Livestock graze these sites making adequate forbs for sage-grouse difficult. The key to improving dryland range for sage grouse benefit is to seed forbs on depleted areas and/or control livestock use on mesic areas in June and July to prevent forb loss and trampling prior to and during brood use. One technique for protecting meadow forbs from livestock trampling and grazing is to fence the stream meadow and leave access gaps for water.	Idaho

Connelly, J.W., M.A. Schroeder, A.R. Sands and C.E. Braun. 2000. Guidelines to manage sage grouse populations and their habitats. Wildl Soc Bull. 28(4):967-985.	Brood-rearing habitats for sage-grouse are typically mosaics of upland sagebrush and other habitats (e.g., wet meadows, riparian areas) that together provide abundant insects and forbs for hens and chicks. Increased use of meadows and riparian areas in mid- to late summer is common as herbaceous vegetation in upland habitat becomes desiccated. During drought periods (≥ 2 consecutive years), reduce stocking rates or change management practices for livestock…if cover requirements during the nesting and brooding periods are not met. Grazing pressure from domestic livestock and wild ungulates should be managed in a manner that at all times addresses the possibility of drought. Restore degraded rangelands to a condition that again provides suitable breeding habitat for sage grouse by including sagebrush, native forbs (especially legumes), and native grasses in reseeding efforts (Apa 1998). If native forbs and grasses are unavailable, use species that are functional equivalents and provide habitat characteristics similar to those of native species.	Idaho
Dalke, P.D.; Pyrah, D.B.; Stanton, D.C.; Crawford, J.E.; and F. Schlatterer. 1963. Ecology, productivity, and management of sage grouse in Idaho. J. Wildl. Manage. 27: 810-841.	Sage grouse in Idaho formed large flocks near water and green meadows as plants senesced during summer.	Idaho

Fielding, D.J., and M.A. Brusven. 1995. Grasshopper densities on grazed and ungrazed rangeland under drought conditions in southern Idaho. Great Basin Naturalist 55:352-358.	Livestock grazing during drought generally reduced grasshopper production.	Idaho
Klebenow, D.A. and G.M. Gray. 1969. Food habits of juvenile sage grouse. J. Range Manage. 21(2):80-83.	Favored foods are common dandelion (*Taraxacum officinale*), common salsify (*Tragopogon dubius*), western yarrow (*Archillea millifolium*) and others. In southeastern Idaho, sage-grouse broods were most often found in big sagebrush (83% of broods), whereas sage-grouse in this area nested primarily in threetip sagebrush. Mean big sagebrush crown cover at brood locations was 8.5%, significantly less than in the surrounding area (14.3%). Broods appeared to avoid sites with dense (e.g., 40%) big sagebrush cover and few forbs. In the development of a predictive model for brood habitat with discriminant function analysis, several variables were useful in distinguishing brood habitat. Compared to the available big sagebrush habitat, broods used areas with lower density of big sagebrush plants and greater frequency of three forbs: western yarrow (*Achillea millefolium*; 23.5%), tailcup lupine (*Lupinus caudatus*; 18.3%), and common dandelion (*Taraxacum officinale*; 12.0%). Broods moved to higher elevations in summers presumably in response to food availability.	Idaho

Poley, B. E. 1969. Seasonal Movements of Sage Grouse in Colorado. Journal of Colorado Field Ornithologists. 5:1-4.	Most researchers believe that broods stay in the vicinity of the nest for about two weeks before moving toward hay meadows. The hen on the other nest under observation remained in the vicinity of the nest for 30 days before starting a very leisurely trek to a meadow about one mile away.	Colorado
Rogers, G.E. 1964. Sage grouse investigations in Colorado. Colorado Dept. Game, Fish and Parks. Tech. Publ. 16. 132 pp.	As food plants mature and dry, the grouse move to areas still supporting succulent vegetation. These may be lower elevation native meadows or irrigated meadows when no uplands with green vegetation are in the area.	Colorado
Eng, R.L. 1952. Population trends and breeding potential studies (sage grouse brood studies). Montana Fish and Game Comm., Wildlife Restoration Div. Quart. Prog. Rep. 3(4):56-62.	As food plants mature and dry, the grouse move to areas still supporting succulent vegetation. These may be lower elevation native meadows or irrigated meadows when no uplands with green vegetation are in the area.	Montana
Peterson, J.G. 1970. The food habits and summer distribution of juvenile sage grouse in central Montana. J. Wildl. Manage. 34:147-155.	Favored foods are common dandelion (*Taraxacum officinale*), common salsify (*Tragopogon dubius*), western yarrow (*Archillea millifolium*) and others.	Montana
Wallestad, R.O. 1971. Summer movements and habitat use by sage grouse broods in central Montana. J. Wildl. Manage. 35:129-136.	Sage grouse broods shifted from sagebrush grasslands to alfalfa fields and greasewood bottoms as forbs at higher elevations became desiccated.	Montana
Wallestad, R.O. 1975. Life history and habitat requirements of sage grouse in central Montana. J. Wildl. Manage. 35:129-136.	In Montana, approximately 65% of all grouse observations during August and September were recorded in bottomland types such as alfalfa fields and greasewood bottoms. Brood habitat was largely determined by the availability of succulent vegetation.	Montana

Batterson, W. M., and W.B. Morse. 1948. Oregon Sage Grouse. Oregon Fauna Series No. 1. Oregon State Game Comm. Portland, OR	During July, several broods unite and adult males join them; the grouse flocks then migrate to the alfalfa fields or other areas with more succulent feed in the valleys	Oregon
Call, M.W., and C. Maser. 1985. Wildlife Habitats in Managed Rangelands--The Great Basin of Southeastern Oregon. U.S. Department of Agriculture Forest Service Pacific Northwest Forest and Range Experiment Station. General Technical Report PNW-187. Portland, Oregon.	Livestock grazing of sagebrush ranges during years of unusually low precipitation and poor plant growth will cause an earlier than normal removal of grasses and forbs. This can have a serious impact on grouse dependent on forbs in that locality. In important sage grouse nesting and summering areas, livestock grazing should be monitored to protect at least 50 percent of the annual herbaceous vegetation (by weight) prior to mid-September. After mid-September, grouse commence feeding on sagebrush and increased livestock grazing on herbaceous vegetation will not be detrimental.	Oregon
Coggins, K. A. 1998. Relationship between habitat changes and productivity of sage grouse at Hart Mountain National Antelope Refuge, Oregon. Oregon State Univ.. Corvallis, Oregon.	Between periods brood success increased, but not significantly, with increased total forb cover and key food forb cover during summer.	Oregon
Crawford, J. A., M. A. Gregg, M. S. Drut, and A. K. DeLong. 1992. Habitat use by female Sage Grouse during the breeding season in Oregon. BLM Coop. Res. Unit, Oregon State Univ. Corvallis, OR	Maintain or develop a mosaic of low and big sagebrush habitats or big sagebrush habitats in an array of seral stages to provide 12-14% forb cover for hens with broods and broodless hens throughout the breeding season. Protect riparian habitats (lakebeds and meadows) from excessive grazing and rehabilitate riparian habitats in poor condition.	Oregon

	These habitats are critical brood-rearing and summer use areas in regions with low annual rainfall and during drought years.	
Crawford, J. A., and D. M. Davis. 2002. Habitat use by Greater Sage-Grouse on Sheldon National Wildlife Refuge. Final Report. Game Bird Research Program, Oregon State University, Corvallis, Oregon. 119 pages	In a subsequent study during 1998-2000 at Sheldon NWR, broods (n = 392 locations) used primarily low sagebrush for the first few weeks after hatching, moving to big sagebrush (mountain or Wyoming) or mountain shrub communities by 3 weeks post-hatch.	Oregon
Drut, M. S., J. A. Crawford, and M. A. Gregg. 1994. Brood habitat use by Sage Grouse in Oregon. Great Basin Naturalist 54:170-176.	In two study sites in southeastern Oregon, Hart Mountain National Antelope Refuge and Jackass Creek, sage-grouse broods were most common in low sagebrush during early brood rearing (first 6 weeks post-hatch), but then moved to sites dominated by big sagebrush (7-12 weeks after hatching). Following brood breakup in August, sage-grouse used meadows and lake beds more frequently than earlier during the brood-rearing period. During early brood rearing at Jackass Creek, forb cover at sites used by broods was 10 to 14% and exceeded forb cover at random sites (Drut et al. 1994a); however, no pattern was evident during late brood rearing. Broods at Hart Mountain used forb cover in relation to its availability during early brood rearing, but selected sites with greater forb cover (19 to 27%) during the late brood-rearing period.	Oregon

Hanf, J. M., P.A. Schmidt, and E.B. Groshens. 1994. Sage grouse in the high desert of central Oregon: results of a study, 1988-1993. U. S. Dept. of Interior, Bureau of Land Management Series. Prineville, OR. P-SG-01.	Manage mountain big sagebrush areas and low sagebrush areas for increased forb production and good brood habitat. Manage sage grouse habitats for increased forb production.	Oregon
Stinson, D.W., D.W. Hays, and M. Schroeder. 2004. Washington State Recovery Plan for the Greater Sage-Grouse. Washington Dept. of Fish and Wildlife. Olympia, Washington.	Grasshoppers are important food of growing chicks. Wherever possible, prevent disturbance in sage-grouse nesting and brood rearing habitat between 1 March and 15 June, including…livestock trail use… Where protection and restoration of sage-grouse is a major objective for public lands, manage grazing so that the habitat characteristics needed for breeding and wintering can be consistently maintained (Connelly et al. 2000). Discourage removal of sagebrush from known sage-grouse wintering areas and areas that provide escape cover in breeding habitat, especially within 3 km of leks.	Washington
Riggs, R.A. and P.J. Urness. 1989. Effects of goat browsing on Gambel oak communities in northern Utah. J. Range Manage 42:354–360.	Prescribed livestock grazing may help control woody plant encroachment in sage-grouse habitat and may reduce wildfire risks to low elevation plant communities.	Utah
Rowland, M.M. 2004. Effects of management practices on grassland birds: Greater Sage-Grouse. Jamestown, ND Northern Prairie Wildlife Research Center.	Broods at Hart Mountain used forb cover in relation to its availability during early brood rearing, but selected sites with greater forb cover (19 to 27%) during the late brood-	North Dakota

	rearing period. In these meadows, most broods occurred in sites with relatively shorter shrubs (60 cm) and greater dominance of grass and forb cover. Important brood habitats were low sagebrush (40% of all brood locations), a 10-yr old burn in a mountain big sagebrush site (19%), mountain shrub (16%), and mountain big sagebrush (13%). Differences in vegetation characteristics (e.g., tall grass cover and forbs consumed by hens) were found between brood locations and random sites; these differences, however, varied among cover types. For example, in the low sagebrush cover type, cover of forbs eaten by hens and chicks was less at brood locations (about 5.5%) than at random sites (10.2 and 8.2% for hens and chicks, respectively), but tall grass cover was greater (4.4% at brood locations vs. 1.4% at random sites). By contrast, cover of forbs used by hens and chicks in the burn was greater at brood locations (6.7 and 5.2%) versus random sites (2.3 and 3.4%, respectively), but tall grass cover was less (18.3% at brood locations vs. 26.2% at random sites). Of the five cover types in which there were significant differences, cover of forbs used by hens and chicks was greater at brood locations than at random sites in four types (all but low sagebrush). No differences were found in vegetation characteristics between early and late brood-rearing habitats.	

	Mean big sagebrush crown cover at brood locations was 8.5%, significantly less than in the surrounding area (14.3%). Broods appeared to avoid sites with dense (e.g., 40%) big sagebrush cover and few forbs. In the development of a predictive model for brood habitat with discriminant function analysis, several variables were useful in distinguishing brood habitat. Compared to the available big sagebrush habitat, broods used areas with lower density of big sagebrush plants and greater frequency of three forbs: western yarrow (*Achillea millefolium*; 23.5%), tailcup lupine (*Lupinus caudatus*; 18.3%), and common dandelion (*Taraxacum officinale*; 12.0%). Seasonal shifts in brood-rearing habitat may not occur. Broodless hens may exhibit different habitat use patterns. Broodless hens used more low sagebrush/bunchgrass, grasslands, and meadow types and less low sagebrush/fescue. Keys to management are maintaining expansive stands of sagebrush (*Artemisia* spp.), especially varieties of big sagebrush (*A. tridentata*), with abundant forbs in the understory, particularly during spring; undisturbed and relatively open sites for leks;	

	and healthy perennial grass and forb stands intermixed with sagebrush for brood rearing. Within suitable habitats, areas should have 15 to 25% canopy cover of sagebrush 30 to 80 cm tall for nesting, and 10 to 25% canopy cover from 40 to 80 cm tall for brood rearing (Connelly et al. 2000). In winter habitats, shrubs should be exposed 25 to 35 cm above snow level and have 10 to 30% canopy cover exposed above snow. In nesting and brood-rearing habitats, understory habitats with adequate cover of grasses (>15%) and forbs (>10%) at least 18 cm tall are needed (Connelly et al. 2000). Manage livestock grazing through stocking rates and season of use on all seasonal ranges of sage-grouse to avoid habitat degradation (Paige and Ritter 1999, Beck and Mitchell 2000, Wisdom et al. 2000), especially on recently disturbed sites, such as those sprayed or burned (Braun et al. 1977). In nesting and brood-rearing habitats, ensure that grazing does not reduce herbaceous understory cover below levels that serve as a deterrent to potential predators of eggs and chicks (Connelly et al. 2000, Hockett 2002). Healthy native understories also support insects and forbs that are important in diets of pre-laying hens and chicks (Johnson and Boyce 1990, Barnett and Crawford 1994, Drut et al. 1994). Riparian areas and wet meadows used for brood rearing are especially sensitive to grazing by livestock; in these habitats, removal	

	of livestock before the nesting season may be prudent (Beck and Mitchell 2000, Hockett 2002).	
Adams, B.W., J. Carlson, D. Milner, T. Hood, B. Cairns and P. Herzog. 2004. Beneficial grazing management practices for Sage-Grouse (*Centrocercus urophasianus*) and ecology of silver sagebrush (*Artemisia cana*) in southeastern Alberta. Public Lands and Forests Division, Alberta Sustainable Resource Development. Pub. No. T /049.	Potential for competition with Sage-Grouse young may be in proportion to the extent to which cattle select mesic/moist sites that are preferred foraging areas. Young birds seek out insects and succulent forbs in these habitats. During drought conditions, important forage plants may be grazed earlier than normal, thus reducing the potential forage supply for young birds. Conversely, dormant season grazing of brood rearing areas will reduce potential for overlap with Sage-Grouse diets. Maintain light grazing intensities to produce mosaics in vegetation and an increase in herbage production that are favorable for Sage-Grouse nesting and brood-rearing habitat. Patchy grazing will increase the availability of forbs and stimulate their growth in upland meadows. Grazing deferral may also prevent competition for forage, especially lush forbs required by young Sage-Grouse. Riparian area management practices are required to maintain only light to moderate grazing pressure on mesic meadows and riparian areas.	Canada

Aldridge, C. L., and R. M. Brigham. 2002. Sage-Grouse nesting and brood habitat use in southern Canada. Journal of Wildlife Management 66(2): 433-444.	Potential for competition with Sage-Grouse young may be in proportion to the extent to which cattle select mesic/moist sites that are preferred foraging areas. Young birds seek out insects and succulent forbs in these habitats. If management goals are to provide suitable nesting and brood-rearing habitat, efforts should be directed toward protecting and enhancing sagebrush stands ≥ 30 m2 and increasing overall sagebrush cover. These stands also should have a suitable understory of tall grasses and forbs to enhance nest concealment. Management strategies also should focus on increasing the availability of mesic sites and increasing the abundance of sites with > 10% forb cover, to enhance brood rearing habitat. Land managers implementing water developments for livestock need to consider the potential negative effects those developments might have on key wetlands and mesic sites.	Canada
Banasch, D. 1985. Sage grouse in Alberta, habitat requirements, life history, census techniques, summer brood survey and hunter check station analysis. Unpubl. rept., Alberta Fish and Wildlife, Edmonton, AB. 52 pp.	In Alberta, Banasch (1985) found that 85% of broods located were in wet meadows. Broods still remained relatively close to leks, with an average brood-lek distance of 2.6 km.	Canada
Authenrieth, R., W. Molina, and C. Braun, eds. 1982. Sage Grouse Management Practices.	The upland meadow represents the primary summer habitat available to sage grouse	Location unknown

Western States Sage Grouse Committee. Western States Sage Grouse Committee Technical Bulletin #1. Twin Falls, ID.	throughout much of its range in Nevada. Past and present management of public lands in Nevada has regarded upland meadows as sacrifice areas. A serious deterioration of this habitat has been the inevitable result and will continue unless meadows are specifically managed. Meadows provided a source of food (forbs), water and cover that were unavailable on more xeric, but adjacent rangelands. Oakleaf (1971) showed that a reduction in meadow use by sage grouse occurred as an increasing percentage of the juvenile population reached 11-12 weeks of age. He further found that the diminished food supply of a deteriorated meadow limited the use by sage grouse. Stoddart and Smith (1955) found that valley bottoms and areas around water sources are used first by cattle. They indicated overgrazing of mesic sites was necessary to force cattle to use less accessible, rougher terrain. The result is that mesic sites become sacrifice areas. …the Bureau of Land Management (USDI 1975) identified livestock grazing as having an adverse impact on 1,413 km (883 mi) of streambank riparian habitat in Nevada. This report also described the combined effects of water development practices and livestock	

	grazing as being the primary areas where wildlife habitat conflicts exist, and further states that "The areas around most livestock waters and water courses visited (in the 3 districts) were denuded of vegetation and trampled by livestock." When [heavy use of pasture in rest rotation grazing systems] encompasses nesting and/or brood rearing habitats the results are negative. It is not legitimate to assume sage grouse can move elsewhere during heavy livestock use. One technique for protecting meadow forbs from livestock trampling and grazing is to fence the stream meadow and leave fence gaps to provide livestock access to water. It may be that grazing should be allowed only once every 3 or more years on meadows in poor condition or in the 15-25 cm (6-10 in) precipitation zone. In 30 cm (12 in) zones, annual August grazing could probably be allowed, once adequate vegetative cover has become reestablished and the water table is adequate. A cooperative agreement should be written between the state wildlife agency and the land management agency to coordinate the responsibility of opening and closing meadow gates. Enforcement should also be coordinated.	

	In brood rearing areas springs and attendant meadow vegetation should be fenced and water piped to an outside stock tank with an atmospheric valve system. When the tank is full, water should be allowed to overflow into the fenced meadow. Reservoirs should be fenced and the water piped to a trough. Dead storage must be provided to ensure availability of late summer water for sage grouse. Catch ponds may be built in association with a snow drift fence to provide a seep meadow for brood use during early summer. Snow drift fences in nesting areas may create a temporary meadow type beneficial to young broods. Managers should evaluate [situations where winter and spring sheep range and sage grouse winter and brood use areas overlap] and recommend alternate grazing sites where competition with and overuse by domestic livestock exists. Although fencing may not be the best management practice, especially in areas of limited water availability where mesic sites are also important to antelope and/or deer; until innovative range management strategies provide for riparian areas, it may be the only solution to prevent the loss of these key habitats.	

Beck, J.L, and D.L. Mitchell. 2000. Influences of livestock grazing on sage grouse habitat. Wildl Soc Bull. 4: 993-1002.	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)	Location unknown
Call, M.W. 1979. Habitat requirements and management recommendations for sage grouse. USDI-BLM Denver Serv. Center Tech. Note 330.	However, consumption of forbs by livestock may limit their availability to sage grouse.	N/A
Crawford, J.A., R.A. Olson, N.E. West, J.C. Mosley, M.A. Shroeder, T.D. Whitson, R.F. Miller, M.A. Gregg, and C.S. Boyd. 2004. Synthesis Paper: Ecology and management of sage-grouse and sage-grouse habitat. J. Range Manage. 57: 2-19.	In riparian brood-rearing habitat, sage-grouse prefer the succulent forb growth stimulated by moderate livestock grazing. Logistics of applying prescribed grazing treatments at large spatial scales remain difficult.	N/A
Fulgham, K.O., M.A. Smith, and J.C. Malechek. 1982. A compatible grazing relationship can exist between domestic sheep and mule deer, p. 458–478. *In*: J.M. Peek and P.D. Dalke (eds.) Proc. of the Wildlife-Livestock Relationships Symp. Idaho For., Wildl. and Range Exp. Sta., Univ. Idaho, Moscow, Ida.	Brood-rearing habitat may be enhanced by grazing practices that favor upland forb production (e.g., fall grazing) and prescribed light (< 40%) to moderate spring grazing can remove standing herbage and make forbs more accessible (see above).	Location unknown
Hockett, G.A. 2002. Livestock Impacts on the Herbaceous Components of Sage Grouse Habitat: A Review. Int. Jour. Sci.	Protect sage grouse nesting and brood-rearing habitat from livestock use to encourage climax vegetative conditions. If this is not feasible, limit grazing to the month of July with the exact timing of grazing varying with local	N/A

	conditions. Defer grazing until after the peak of the growing season with the intent of providing herbaceous cover and forage for the majority of the nesting, hatching, and early brood-rearing. Cessation of grazing by 1 August is designed to minimize livestock concentrations in wet meadows and riparian areas with open water by avoiding "hot season" use and to allow a 30-day regrowth period before the first killing frost as recommended by Myers (1989). Additionally, late summer-early fall regrowth is important for carbohydrate storage in roots and stem bases of cool season grasses (Stoddart et al. 1975) that enhances plant vigor while allowing residual vegetation to accumulate cover for nesting and early brood-rearing the following spring.	
Klebenow, D.A. 1972. The habitat requirements of sage grouse and the role of fire in management. Proceedings Annual Tall Timbers Fire Ecology Conf. pp. 305-315.	As food plants mature and dry, they migrate upward, seeking out habitats where succulent fobs are still available such as more mesic swales. …birds appear to prefer relatively open sagebrush vegetation types as compared to dense stands of sagebrush. In southern Idaho the percent canopy cover of big sagebrush at brood sites was 8.5, significantly less than the average for the entire area, 14.3. 3 out of 98 broods were found where total shrub cover was 40 to 49%; the rest where cover was less than 31%. Where there was an interspersion of openings mixed	N/A

	with dense sagebrush, they used the more open portions. The incidence of sagebrush consumption increases [in late August at high elevations, or in September or October in some lower areas].	
Klebenow, D.A. 1981. Livestock Grazing Interactions with Sage Grouse Proceedings of the Wildlife-Livestock Relationships Symposium. April 20-22, 1981. Moscow, Idaho Forest, Wildlife & Range Experiment Station, Univ. of Idaho, Moscow. Coeur d'Alene, Idaho.	Brood sites contained more grass cover in all habitat types, but the difference was statistically significant in only the low sagebrush type. Meadow habitats were important for cattle as well as sage grouse. During summer 1979 grouse did not avoid the grazed areas. When the choice was possible, they sought areas in the meadow where effective cover height was less than normal for the meadow. When cattle first began grazing a meadow containing residual grass remaining from the previous year, parts of the meadow were initially grazed more intensively than others, creating a mosaic of vegetation heights. Within this mosaic, grouse sought the grazed openings. Lightly grazed meadow, the grouse selected for the grazed patches with significantly lower height of cover than average for the meadow.	Location unknown
Merritt, S., C. Prosser, K. Sedivec, and D. Bangsund. 2001. Multi-species grazing and leafy spurge. U.S.D.A.-ARS Team Leafy Spurge, Sidney, Mont.	Prescribed livestock grazing in spring and early summer, especially by sheep and goats (*Capra hircus*), can help control invasive weeds in sage-grouse habitat and may reduce	Location unknown

Mosley, J. C. 1996. Prescribed sheep grazing to suppress cheatgrass: A review. Sheep and Goat Res. J. 12:74-81. Olson, B.E. and R.T. Wallander. 2001. Sheep grazing spotted knapweed and Idaho fescue. J. Range Manage. 54:25–30.	wildfire risks to low elevation plant communities.	
Paige, C, S. Ritter. 1999. Birds in a sagebrush sea: Managing sagebrush habitats for bird communities. Partners in Flight, Western Working Group.	Potential for competition with Sage-Grouse young may be in proportion to the extent to which cattle select mesic/moist sites that are preferred foraging areas. Young birds seek out insects and succulent forbs in these habitats.	Location unknown
Schroeder, M.A.; Young, J.R.; and C.E. Braun. 1999. Sage Grouse. The Birds of North America, No. 425.	Brood-rearing habitats for sage-grouse are typically mosaics of upland sagebrush and other habitats (e.g., wet meadows, riparian areas) that together provide abundant insects and forbs for hens and chicks. Increased use of meadows and riparian areas in mid- to late summer is common as herbaceous vegetation in upland habitat becomes desiccated.	Location unknown
Smith, M.A., J.C. Malechek and K.O. Fulgham. 1979. Forage selection by mule deer on winter range grazed by sheep in spring. J. Range Manage. 32:40–45.	Brood-rearing habitat may be enhanced by grazing practices that favor upland forb production (e.g., fall grazing) and prescribed light (< 40%) to moderate spring grazing can remove standing herbage and make forbs more accessible.	Location unknown
U. S. Dept. of Interior, Bureau of Land Management. 1979. Habitat Requirements and Management Recommendations for Sage Grouse. Bureau of Land Management TN 330. Denver, CO.	Favored foods are common dandelion (*Taraxacum officinale*), common salsify (*Tragopogon dubius*), western yarrow (*Archillea millifolium*) and others. Roadsides and borrow pits are frequently used	N/A

	during June and July because of moisture and succulent vegetation present. …birds appear to prefer relatively open sagebrush vegetation types as compared to dense stands of sagebrush. In southern Idaho the percent canopy cover of big sagebrush at brood sites was 8.5, significantly less than the average for the entire area, 14.3. 3 out of 98 broods were found where total shrub cover was 40 to 49%; the rest where cover was less than 31%. Where there was an interspersion of openings mixed with dense sagebrush, they used the more open portions. The incidence of sagebrush consumption increases [in late August at high elevations, or in September or October in some lower areas]. …a rapid removal of forbs by livestock on spring and summer ranges may have a substantial adverse impact on young sage and grouse, especially where forbs are already scarce in the composition.	

Winter Range

Source	Citation
Deseret Land and Livestock Ranch. No date. Deseret Land and Livestock Ranch Livestock Grazing and Rangeland Management	Management strategies that maintain or increase available sagebrush above snow in deep snow winters, or increase forb availability in

Benefit Greater Sage Grouse. Western Governor's Association, U.S. Department of Agriculture Natural Resources Conservation Service.	droughts should reduce sage grouse mortality in poor winter years, thus maintaining larger populations to rebound in favorable weather years.
Greer, R. 1990. Sage Grouse Habitat Requirements and Development. Wyoming Game and Fish Dept.	During winter, sage grouse often use tall, dense stands of sagebrush which remain relatively exposed through deep snow.
Beck, T.D.I. 1977. Sage grouse flock characteristics and habitat selection in winter. J Wildl Manage. 41(1):18-26.	Although snow cover was a major factor in determining areas used, slope and aspect further restricted amount of suitable habitat for sage grouse. In North Park [Colorado], grouse selected sagebrush on southwest exposures and flat to gentle slopes. Sagebrush on slopes greater than 15 percent was rarely used although such areas were present…

The following sources may contain information relevant to the Wyoming Basin - Southern Rocky Mountains ecoregions, but were not conducted within the ecoregional boundaries.

Source	Citation	Location of Study
Hanf, J. M., P.A. Schmidt, and E.B. Groshens. 1994. Sage grouse in the high desert of central Oregon: results of a study, 1988-1993. U. S. Dept. of Interior, Bureau of Land Management Series. Prineville, OR. P-SG-01.	During the winter, sage grouse feed almost entirely on the leaves of sagebrush. Typical winter ranges are large expanses of dense sagebrush (>20% canopy cover) with and average height of 25 cm, on land having little, if any, slope (Eng and Schladweiler 1972). Elimination of winter range habitat would reduce sage grouse populations over large areas (Eng and Schladweiler 1972).	Oregon
Batterson, W. M., and W. B. Morse. 1948. Oregon Sage Grouse. Oregon Fauna Series No. 1. Oregon State Game Commission, Portland, Oregon. 29 pages.	Cold weather and frosts destroy the green feed in early November causing sage grouse flocks to return to the sagebrush hills to spend the winter.	Oregon
Call, M.W., and C. Maser. 1985. Wildlife Habitats in Managed Rangelands--The Great Basin of Southeastern Oregon. U.S.	Where sage grouse nest and raise broods on sagebrush-covered mountain slopes or in high mountain valleys, they usually migrate to lower	Oregon

Department of Agriculture Forest Service Pacific Northwest Forest and Range Experiment Station. General Technical Report PNW-187. Portland, Oregon.	valleys in winter to find exposed sagebrush for food. This is common in Wyoming, Colorado and Idaho but less true in southeastern Oregon where winters are milder and snow seldom covers sagebrush plants deep enough to make locating food a serious problem. …it is paramount that only light grazing be permitted on important sage grouse wintering areas. Light grazing (less than 30 percent of current year's growth) may benefit grouse in deep snow conditions by uncovering sagebrush plants, making them more available for use by grouse. Grazing by all ungulates will need to be monitored to ensure that sagebrush on the important wintering areas is not permitted to deteriorate.	
Stinson, D.W., D.W. Hays, and M. Schroeder. 2004. Washington State Recovery Plan for the Greater Sage-Grouse. Washington Dept. of Fish and Wildlife. Olympia, Washington.	Where protection and restoration of sage-grouse is a major objective for public lands, manage grazing so that the habitat characteristics needed for breeding and wintering can be consistently maintained (Connelly et al. 2000). Discourage removal of sagebrush from known sage-grouse wintering areas and areas that provide escape cover in breeding habitat, especially within 3 km of leks.	Washington
U. S. Dept. of Interior, Bureau of Land Management. 2000. Management guidelines for sage grouse and sagebrush ecosystems in Nevada.	Avoid supplemental winter feeding of livestock in known winter sage grouse habitat.	Nevada

van Kooten, G.C., R. Thomsen, T.G. Hobby, and A.J. Eagle. 2004. Social Dilemmas and Public Range Management in Nevada.	Define, identify, conserve and enhance critical lek, nesting, brood rearing and winter habitat used by sage grouse. Characteristics of habitat types preferred by sage grouse at various times of the year, and the interrelationships between these habitat types, are not clearly defined. Public (landowners, land managers and other land users) involvement and participation in reporting sightings of sage grouse leks, nests, broods and winter locations should be encouraged. Intensive searches of sage grouse range are required to assess critical habitat parameters throughout the year and the relationships between these habitat types. Abandoned habitat should be assessed for seasonal deficiencies which may limit use by sage grouse. Critical habitat must be protected and secured. Land-use practices and other factors detrimental to maintenance of quality sage grouse habitat need to be identified. Working co-operatively with land managers and other land users, initiatives need to be developed to enhance and maintain an abundance of high quality habitat on private and public lands throughout the range of sage grouse. Establish public reporting system for sage grouse leks, nesting, brood and winter locations. -Conduct searches/surveys for active leks, nests, brood rearing and winter use areas throughout sage grouse range. -Document habitat characteristics of lek, nesting, brood-rearing and winter-use areas and	Nevada

	the interrelationships between habitat types. -Investigate habitat parameters (lek, nesting, brood rearing and winter use) in areas of abandoned leks. -Investigate the use of remote-sensing data systems to identify potential lek, nesting, brood-rearing and winter habitat. -Map critical lek, nesting, brood rearing and winter habitat areas. -Identify critical lek, nesting, brood rearing and winter habitat which must be protected, secured or enhanced. -Identify land-use practices which are detrimental to provision of quality lek, nesting, brood rearing and winter habitat. -Develop cooperative initiatives to protect lek sites and lek, nesting, brood rearing and winter habitat on public lands. -Develop cooperative initiatives to protect lek sites and lek, nesting, brood rearing and winter habitat on private lands. -Develop cooperative initiatives to enhance and improve the quantity and quality of lek, nesting, brood rearing and winter habitat.	
Rowland, M.M. 2004. Effects of management practices on grassland birds: Greater Sage-Grouse. Jamestown, ND. Northern Prairie Wildlife Research Center.	During winter, sage-grouse rely almost exclusively on sagebrush for forage (Connelly et al. 2000). The spatial distribution of sage-grouse in winter often is related to snow depth (Patterson 1952; Dalke et al. 1963; Gill 1965; Klebenow 1973, 1985; Beck 1975, 1977; Danvir 2002). At the onset of winter, sage-grouse gradually move to lower elevations with greater exposure of sagebrush above the snow; in migratory populations, this movement may	North Dakota

	extend up to 160 km (Patterson 1952). During more severe winters, a large proportion of the sagebrush may be beneath snow and thus unavailable for roosting or foraging. Keys to management are maintaining expansive stands of sagebrush (*Artemisia* spp.), especially varieties of big sagebrush (*A. tridentata*), with abundant forbs in the understory, particularly during spring; undisturbed and relatively open sites for leks; and healthy perennial grass and forb stands intermixed with sagebrush for brood rearing. Within suitable habitats, areas should have 15 to 25% canopy cover of sagebrush 30 to 80 cm tall for nesting, and 10 to 25% canopy cover from 40 to 80 cm tall for brood rearing (Connelly et al. 2000). In winter habitats, shrubs should be exposed 25 to 35 cm above snow level and have 10 to 30% canopy cover exposed above snow. In nesting and brood-rearing habitats, understory habitats with adequate cover of grasses (>15%) and forbs (>10%) at least 18 cm tall are needed (Connelly et al. 2000).	
Beck, T.D.I. 1977. Sage grouse flock characteristics and habitat selection in winter. J Wildl Manage. 41(1):18-26.	Eng and Schladweiler (1972) also reported avoidance of steep slopes in winter by sage grouse in central Montana. Disturbances of sage grouse habitat in identified winter use areas should be avoided or kept to a minimum.	Montana
Adams, B. W., J. Carlson, D. Milner, T. Hood, B. Cairns, and P. Herzog. 2004. Beneficial	Call and Maser (1985) suggest that managers need to protect at least 50% of annual	Canada

grazing management practices for sage grouse (*Centrocercus urophasianus*) and ecology of silver sagebrush (*Artemisia cana*) in southeastern Alberta. Lethbridge, Alberta, Canada: Public Lands and Forests Division, Alberta Sustainable Resource Development. Publication T /049. 52 p.	production to provide adequate litter cover and that Sage-Grouse winter ranges should be even more lightly grazed.	
Authenrieth, R., W. Molina, and C. Braun, eds. 1982. Sage Grouse Management Practices. Western States Sage Grouse Committee. Western States Sage Grouse Committee Technical Bulletin #1. Twin Falls, ID.	Managers should evaluate [situations where winter and spring sheep range and sage grouse winter and brood use areas overlap] and recommend alternate grazing sites where competition with and overuse by domestic livestock exists.	Location unknown
Hockett, G.A. 2002. Livestock Impacts on the Herbaceous Components of Sage Grouse Habitat: A Review. Int. Jour. Sci.	For migratory populations focus livestock grazing activities during the growing season on sage grouse winter range. Sage grouse are 100 percent dependent on sagebrush for forage during winter (Connelly 2000). The removal of herbaceous understory plants preferred by domestic livestock during the growing season can lead to an increase in the density of sagebrush stands over time (Mueggler 1950, Laycock 1967, Beck and Mitchell 2000). Livestock and sage grouse would be separated temporally under this scenario although impacts to other wildlife species may be significant.	N/A
U. S. Dept. of Interior, Bureau of Land Management. 1979. Habitat Requirements and Management Recommendations for Sage Grouse. Bureau of Land Management TN 330. Denver, CO.	Sage grouse live almost exclusively on the leaves of sagebrush during the winter. In Montana when snow depth exceeded 12 inches, sage grouse were restricted to taller sagebrush stands, a relatively small percentage of the total range available to them in a normal	Location unknown

	(lesser snow) winter. Bean (1941) reported that when snow depth reached 13 to 15 inches in Idaho, sage grouse moved to taller sagebrush types. Eng and Schladweiler (1972) described winter ranges in eastern Montana as being large expanses of dense (20% or greater canopy coverage) sagebrush with an average height of 10 inches on land having little if any slope. This association with dense stands of sagebrush usually began in September (Wallestad 1971) and continued through the breeding and nesting seasons (Wallestad and Schladweiler 1974). Wallestad (1975) reported that 78% of 151 winter locations of radioed sage grouse occurred in the greater than 20% canopy coverage class. As weather moderated in February, activities shifted to more open stands of sagebrush. Snow depth forces the birds to lower elevations and appears to be a factor determining the actual wintering site for a flock (Klebenow 1972). Black sage (*Artemisia nova*) was preferred as forage in southeastern Idaho. Sage grouse remain on the areas supporting this species until the snow covers the plants and return again when the black sage is available (Pyrah 1954,	

	Crawford 1960). Biologists and field personnel report a similar preference for low sagebrush on Nevada and Utah ranges where it is available. Many sagebrush ranges on public lands are grazed by domestic sheep in winter. Livestock should not be permitted to heavily use known important sage grouse wintering areas. Heavy utilization may leave inadequate forage for sage grouse, but will depend on size of the wintering area and amount of sagebrush, depth of snow, and severity of the winter.	

Grazing Management and Migratory Populations

The following sources may contain information relevant to the Wyoming Basin - Southern Rocky Mountains ecoregions, but were not conducted within the ecoregional boundaries.

Source	Citation	Location of Study
Wakkinen, W.L. 1990. Nest Site Characteristics and Spring-Summer Movements of Migratory Sage Grouse in Southeastern Idaho. Ph.D. Dissertation. Univ. of Idaho.	…data supports the contention of Berry and Eng (1985) that the management of migratory sage grouse populations must be done on large ecologically defined units. Habitat management for these birds must also be done on a year-round scale. …data supports the contention of Berry and Eng (1985) that the management of migratory sage grouse populations must be done on large	Idaho

	ecologically defined units. Habitat management for these birds must also be done on a year-round scale.	
Connelly, J.W., H.W. Browers, and R.J. Gates. 1988. Seasonal movements of sage grouse in southeastern Idaho. J Wildl Manage. 52(1): 116-122.	We further urge managers to consider all seasonal ranges when evaluating factors affecting sage grouse populations. …we suggest that migratory sage grouse populations be defined on a temporal and geographic basis and that seasonal ranges and migration routes between ranges be identified. …protection of sagebrush within a 3.2 km radius of leks is not sufficient (Beck 1977) because protecting sagebrush habitats associated with leks will not ensure that year long habitat requirements are met for migratory populations of sage grouse.	Idaho
Browers, H.W., J.W. Connelly, and R.J. Gates. 1984. Movements and habitat use of sage grouse in southeastern Idaho. *In*: The 37th Annual Meeting of the Society for Range Management. February 12-17, 1984. Society for Range Management. Denver, Colorado.	The relatively large areas and diversity of habitats used by migratory sage grouse should be considered in management plans for [sage grouse].	Idaho
Hockett, G.A. 2002. Livestock impacts on the herbaceous components of sage grouse habitat: a review. Intermountain Journal of Sciences. 8(2):105-114.	For migratory populations focus livestock grazing activities during the growing season on sage grouse winter range. Sage grouse are 100 percent dependent on sagebrush for forage during winter (Connelly 2000). The removal of herbaceous understory plants preferred by domestic livestock during the growing season can lead to an increase in the density of	Location unknown

	sagebrush stands over time (Mueggler 1950, Laycock 1967, Beck and Mitchell 2000). Livestock and sage grouse would be separated temporally under this scenario although impacts to other wildlife species may be significant.	

Social Science Aspects

The following sources may contain information relevant to the Wyoming Basin - Southern Rocky Mountains ecoregions, but were not conducted within the ecoregional boundaries.

Source	Citation	Location of Study
Torell, L.A., J.A. Tanaka, N. Rimbey, T. Darden, L. Van Tassell, and A. Harp. 2002. Ranch-Level Impacts of Changing Grazing Policies on BLM Land to Protect the Greater Sage-Grouse: Evidence from Idaho, Nevada and Oregon. Policy Analysis Center for Western Public Lands. PACWPL Policy Paper SG-01-02. Caldwell, ID.	Cook et al. (1980) found that changes in spring use had a greater impact on livestock sales per AUM for Colorado ranchers than did AUM changes in any other season. Van Tassell and Richardson (1998) also found that spring and summer forage obtained from public lands was critical to the operation of federally based ranches in Wyoming. Similarly, Torell et al. (1981) found the same situation for public land ranches in northern Nevada. Optimal production strategies and ranch income were not exceptionally sensitive to increases in the grazing fee, but production and net returns changed substantially when federal AUMs were removed from any season, particularly the spring season.	Idaho, Nevada, Oregon

	If an altered land-use policy means that grazing will not be allowed during the spring period, but the number of public land AUMs allowed for grazing is not correspondingly reduced, it is possible that eliminating spring grazing and shortening the allowed grazing period on public lands would increase optimal herd sizes. Torell et al. (1981) estimated this would be the situation for northeastern Nevada ranchers when spring grazing was eliminated. Given the cost/price definition of the analysis, the profit-maximizing strategy was to make up lost public land AUMs during the spring period by feeding more hay and to substitute other forages where possible. Net returns were reduced, but it was most profitable to use BLM AUMs previously grazed during the spring in other seasons and to expand herd size. For other ranches with few low-cost alternative sources of forage, optimal herd size could decrease with the elimination of spring grazing. [Linear programming] studies found reductions in income and net ranch returns were not proportional to reductions in federal forage. The rigidity of seasonal forage availability meant the optimal use of other forages and resources were impacted when federal AUMs were removed. Other forages were reallocated to offset part of lost federal forage (Gee 1981, Van Tassell and Richardson 1998). For the Wyoming [federally based ranches]	

	studies, complete elimination of the BLM permit was estimated to decrease annual net cash income by an average of $55/BLM AUM removed [1998 dollars]. At the other extreme, because some western ranchers are not necessarily in the business to make a profit and spend more than they justifiably should to produce livestock, Rowe and Bartlett (2001) found that eliminating federal grazing permits in Colorado would actually benefit some ranchers by forcing them to reduce the size of their money-losing livestock enterprise. Economic changes from allotment adjustments varied widely, ranging from a loss of $40/AUM to a gain of $27/AUM [2001 dollars] when herd reductions were the assumed adjustment strategy. …eliminating BLM grazing to improve habitat for sage-grouse would have a significant impact on the economic viability of affected ranches. This is especially true during the spring period. Early spring grazing is valuable because few alternative forage sources are available at that time. In most cases, the only feasible forage alternative would be to feed hay. Rowe and Bartlett (2001) concluded that once hay was needed to compensate for public forage losses, reducing herd size would be the most cost-effective adjustment (Torrell et al. 2002). Making alterative grazing resources available during the spring always minimized losses	

	relative to feeding hay or reducing herd size. If complete flexibility of other deeded forages were assumed, the economic loss of restricting the early use of BLM lands was minimal; seasonal use of alternative forages would be rearranged with little if any economic consequence. The economic value of the BLM forage during the spring period was found to be 5 to 10 times the value in other seasons later in the year for both the Idaho and Nevada models. The economic impacts from reducing BLM grazing in any season were found to vary widely depending on several key factors. First, individual ranches will be able to substitute alternative forages to varying degrees as federal AUMs are eliminated. Substituting forages minimizes economic losses relative to the option of feeding hay and reducing cow herd size. Those ranches with restricted seasons of forage availability will have less ability to substitute alternative forages if BLM grazing is removed. The contributory value of the federal grazing permits for livestock production varies widely depending on the seasonal complement of forage and pasture resources ranches have, and the level of dependency on federal lands. It is widely believed that the complement between public and private lands contributes	

	greatly to the economics of western ranching and our analysis clearly shows that to be the case. For those ranches with limited off-ranch wealth and income, reducing public land grazing capacity by even marginal amounts was found to greatly impact the ability of ranchers to meet annual financial obligations and to repay debt.	
van Kooten, G.C., R. Thomsen, T.G. Hobby, and A.J. Eagle. 2004. Social Dilemmas and Public Range Management in Nevada.	Increasing tension in the Nevada ranch community may have had a negative impact on social capital. Social capital facilitates cooperation in resolving social dilemmas related to public range management. [Survey of public grazing permit holders in Nevada] results indicate that low levels of trust between ranchers and public land managers were most significantly related to previous disagreements and belief that the future of ranching is bleak. Disagreements with public agencies were mainly the caused by disputes concerning responses to wildfire, and such disagreements led to a deterioration of relations over time. Relations between ranchers and the USFS deteriorated to a greater extent than relations with the BLM, partly because the former have cut back on allowable grazing to a greater extent. While there remain opportunities to build on existing social capital in the community (horizontal relations), ranchers and the public agencies need to work on building vertical relations, thereby increasing trust. We argue that, even if the latter fails, new	Nevada

	institutions might evolve to utilize existing social capital and thereby help resolve social dilemmas. If public land agencies become too rigid, or fail to evolve sufficiently to address 'modern' needs, then ranchers will rely on their informal contacts with agency personnel – their personal network – to implement management activities that would otherwise be held up by bureaucracy and the hierarchy that inevitably accompanies it. However, if ranchers cannot work with the public agencies, range quality may deteriorate as may the habitat of threatened or endangered species. In such cases, other institutional arrangements may need to be considered, ones that yield better outcomes from a social viewpoint, and are also politically more acceptable. …trust is related to institutions and affects the costs of transacting. If confidence in an enforcement agency falters, one may not trust others to fulfill their agreements and thus enter into fewer agreements. There is an element of trust in any transaction where one has to decide (make a choice) before being able to observe the action of the other party to the transaction. One has to assume that the other person is not acting with guile, keeping information hidden that could be used to their advantage at the expense of the other party to the transaction. Like other components of social capital, trust makes an economy function more efficiently	

	(Fukuyama 1999). In the ranch community, trust, social norms (shared beliefs) and social networks – social capital – are vitally important to community health and that of the range ecosystem. The level of trust in public land agencies is inversely related to two factors – the extent to which ranchers had disagreements with public land managers about how the range is utilized and the extent to which respondents were negative about the future of ranching. Economic theory indicates that an increase in social capital can benefit the ranch community by reducing transaction costs and increasing opportunities to resolve range management conflicts. This can be accomplished primarily by restoring trust between ranchers and public land managers (vertical relations) and building upon extant relations that exist because of high levels of participation in community service and professional organizations (horizontal relations).	
Batterson, W. M., and W.B. Morse. 1948. Oregon Sage Grouse. Oregon Fauna Series No. 1. Oregon State Game Comm. Portland, OR	The only contact with farming activities is in localities where grouse spend the summer and fall on alfalfa and meadow lands.	Oregon
Dwyer, D.D., J.C. Buckhouse, and W.S. Huey. 1984. Impacts of Grazing Intensity and Specialized Grazing Systems on the Use and Value of Rangeland: Summary and	A reduction of permitted AUMs of grazing does not necessarily mean the permittee will suffer a comparable loss in net return. Improved application of animal husbandry practices can	N/A

Recommendations. *in* NRC/NAS. Developing Strategies for Rangeland Management: A Report Prepared for the Committee on Developing Strategies for Rangeland Management.	increase calf crop and weaning weight so that per-head yield is substantially increased. The manager should help the permittee apply these practices.	
Malechek, J.C. 1984. Impacts of Grazing Intensity and Specialized Grazing Systems on Livestock Response. *in* NRC/NAS. Developing Strategies for Rangeland Management: A Report Prepared for the Committee on Developing Strategies for Rangeland Management.	…reductions in permitted numbers, always a troublesome action, should be partially set-off by increased performance of individual animals. This effect is generally small and it would undoubtedly be a difficult concept to sell to a permittee as a quantitative advantage.	N/A
Workman, J.P., S.K. Fairfax, and W. Burch. 1984. Applying Socioeconomic Techniques to Range Management Decision Making: Summary and Recommendations *in* NRC/NAS. Developing Strategies for Rangeland Management: A Report Prepared for the Committee on Developing Strategies for Rangeland Management.	Multiple-use management should be based on solid empirical analyses that attempt to quantify costs and benefits of the products produced on public lands. Whenever possible, environmental concerns should be directly incorporated into benefit-cost analysis rather than used as a separate ranking device for project selections. Elimination of grazing permit eligibility requirements (prior use, commensurability, ownership of land and water) should be considered. Such elimination would allow for free transfer of grazing permits among ranchers at market-dictated prices. If grazing permits are permanently reduced, permittees should be compensated proportionately for their interest in range improvements just as they are for permit cancellations.	N/A

	Incentives for private investment in public range improvement should be created by devising a system for evaluating changes in grazing capacity that is credible to ranchers, including a guarantee that increased forage will be made available to participating permittees. Benefit-cost analysis of range improvements should be based on all costs and benefits, both private and government.	
Godfrey, E.B. 1984. Measuring the Economic Impact of Agency Programs on Users and Local Communities *in* NRC/NAS. Developing Strategies for Rangeland Management: A Report Prepared for the Committee on Developing Strategies for Rangeland Management.	If evaluated from a national perspective, the impact of use at other sites must be considered but need not be if very local considerations are paramount. This suggests that there exists a potential to overestimate the benefits of uses such as recreation, wildlife, etc. when shifts in use from one area to another are ignored.	N/A
Wambolt, C.L., A.J. Harp, B.L. Welch, N. Shaw, J.W. Connelly, K.P. Reese, C.E. Braun, D.A. Klebenow, E.D. McArthur, J.G. Thompson, L.A. Torell, and J.A. Tanaka. 2002. Conservation of Greater Sage-Grouse on Public Lands in the Western U.S.: Implications of Recovery and Management Policies. Policy Analysis Center for Western Public Lands. PACWPL Policy Paper SG-02-02. Caldwell, ID.	…significant reductions in grazing AUMs on public lands can have identifiable negative economic effects on individual producers and rural communities. …this study confirms that negative economic effects can result from large reductions in public land grazing. Public land grazers also point out that alternative management actions, such as reducing fire in the sage ecosystem or requiring habitat mitigation for sagebrush fragmentation, do not have the same negative economic consequences for individuals and local communities. The economic impacts of such actions are usually exported from the	Location unknown

	region and spread over many consumers nationwide. Eliminating BLM grazing to improve habitat for sage-grouse would have a significant impact on the economic viability of affected western ranches. Early spring grazing is valuable because few alternative forage sources are available at that time. In most cases, the only feasible forage alternative would be to feed hay. If complete flexibility of other deeded forages were possible, the economic loss of restricting the early use of BLM lands was minimal.	
Holechek, J.L., H. Gomez, F. Molinar, and D. Galt. 1999. Grazing studies: What we've learned. Rangelands. 21(2):12-16.	Financial returns per acre average about 4% higher under continuous or season-long grazing than rotation grazing systems. Torell et al. (1991) using a Colorado prairie study (Sims et al. 1976), found profit-maximizing stocking rates were well below those that would deteriorate the rangeland resource. Workman (1986)…drew the same conclusion. Rotation grazing systems have been widely recommended by various government agencies concerned with range management. However research shows stocking rate reductions from heavy to conservative, have much higher probability of increasing grazing capacity, reducing risk, increasing financial returns, and reducing erosion. The United States Department of Agriculture, Natural Resources	Location unknown

	Conservation Service continues to recommend 50% use of forage resources. However the research convincingly shows 40-45% use is moderate on most rangelands and 30-35% use is needed for improvement in rangeland vegetation. Moderate continuous grazing typically gave better vegetation, livestock, and financial performance than rotation grazing at heavy stocking rates. However under moderate stocking rates there is evidence that some rotation grazing systems give equal or superior vegetation, livestock, and financial performance to continuous grazing (Holechek et al. 1987, Heitschmidt et al. 1990, Taylor et al. 1993).	
Dietz, T. 1984 Social Impact Assessment as a Tool for Rangeland Management *in* NRC/NAS. Developing Strategies for Rangeland Management: A Report Prepared for the Committee on Developing Strategies for Rangeland Management.	A shift in the allowed amount of grazing by commercial operators will change the economic position of those operators. Cut-backs in access will increase the cost of operations and could force some ranchers out of business, though in most cases this is not likely. West (1980) argues that the elimination of provisions that exempted small users from allotment cuts had significant adverse effects on small users, and on Spanish-Americans in particular. The increase in costs might reduce local incomes and employment, produce shifts in the occupational structure of the communities surrounding the resource area, and affect the	N/A

	fiscal balance of those communities.	

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