

**US Forest Service Region 2 Greater Sage-grouse Vegetation Sampling Protocols
Medicine Bow National Forest and Thunder Basin National Grassland in
Wyoming
Routt National Forest in Colorado**

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Objective

The objective of this document is to provide consistent strategies and protocols for collecting vegetation data necessary to implement the Greater Sage-grouse Record of Decision for Northwest Colorado and Wyoming (ROD) and accompanying Land Management Plan Amendments. There are two types of vegetation sampling that will be addressed:

1. Perennial Grass Height Assessment to review compliance with ROD Table 2, Grazing Guidelines. This assessment includes measurements of perennial grass height in areas with 10% or greater sagebrush cover (potential nesting habitat)¹. Measurements are taken every ½ meter along a 50-meter transect as well as under the drip-line of

¹ Page 104 and page 76 of the ROD (footnote two), clarifies that grass heights applicable to grazing guidelines only apply in breeding and nesting habitat with greater than or equal to 10% sagebrush cover.

sagebrush. Shrub and grass plant associations will also be considered to address site capability.

2. Habitat Assessment Framework (HAF) to assess Greater Sage-grouse habitat conditions. The information in the HAF survey is used to quantify a variety of vegetative characteristics and results in labeling the inventory of existing habitat condition at specified sites as suitable, marginal, or unsuitable. The HAF survey takes into account numerous vegetative factors including the percent of shrub canopy cover, the presence of preferred forbs, and anthropogenic disturbances nearby.

Introduction and Background

This document informs Forest Service employees and other interested parties regarding the procedures used to conduct an inventory of vegetation characteristics on specified National Forest System (NFS) lands as they relate to Greater Sage-grouse (GRSG) habitat conditions and implementation of grazing guidelines in the Greater Sage-grouse Record of Decision for Northwest Colorado and Wyoming (ROD).

The protocols in this document specifically apply to GRSG data collection efforts in Region 2 (R2) of the USFS, which includes the Medicine Bow and Routt National Forests and the Thunder Basin National Grasslands. These protocols were developed in conjunction with and are consistent with USFS Region 4 protocols, which would be applied on the following R4 Wyoming forests: Bridger-Teton National Forest, Ashley National Forest and Cache National Forest. However, the R2 protocols have an added feature of collecting additional grazing guideline data (perennial grass heights) located within the drip-line of sagebrush in potential sage-grouse nesting habitat. This feature was added in order to accommodate the projected need to assess grass cover at potential sage-grouse nest sites as discussed with our cooperating state and federal agencies.

Vegetation management direction in the GRSG Land Management Plan (LMP) Amendments is designed to address threats to GRSG habitat in the following ways:

- Establish Vegetation Desired Conditions (Table 1).
- Establish grazing guidelines (Table 2).

Vegetation Desired Conditions in Sage-grouse Habitats

The GRSG ROD contains the following landscape-scale desired condition: In GRSG habitats, including all seasonal habitats, 70% or more of lands capable of producing sagebrush have from 10% to 30% sagebrush canopy cover and less than 10% conifer canopy cover. In addition, within breeding and nesting habitat, sufficient herbaceous vegetation structure and height provides overhead and lateral concealment for nesting and early brood rearing life stages. Within brood rearing habitat, wet meadows and riparian areas sustain a rich diversity of perennial grass and forb species relative to site potential. Within winter habitat, sufficient sagebrush height and density provides food and cover for the GRSG during this seasonal period.

The Land Management Plan Amendments also contain a table that identifies specific desired conditions based on seasonal habitat for GRSG at the landscape scale (Table 1). These desired

conditions summarize the suite of characteristics that represent seasonal habitat needs for GRSG as identified by research and monitoring. The [Habitat Assessment Framework \(HAF\)](#) will be used to evaluate maintenance of or progress toward desired conditions in defined areas such as restoration project areas, range allotments, and GRSG population extents. Guidance for 4th order HAF plot selection and implementation is described in the HAF section later in this document.

Grazing Guidelines

Direction for grazing management in GRSG habitat is found in the LMP amendments in the Livestock Grazing section. The Perennial Grass Height Assessment, as stated previously in the Objectives section above, is for evaluation of the grazing guidelines in Table 2 of the ROD. Those specific protocols are found later in this document in the Perennial Grass Height Assessment section.

Sample Design and Plot Selection

The [USFS Vegetation Monitoring and Assessment Tool](#), which was developed in Region 4 of the USFS, and was used to provide initial sample plot selection. Details of the procedures used can be found in the Forest Service internal document: *Using the GRSG Web Application Tool Power Point* at the following location:

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In essence, the Web tool queried existing Geographic Information System (GIS) data to identify locations that most closely meet the criteria for sage-grouse nesting and brood rearing habitat. We recognize that there are limitations to our data and that further validation will occur where necessary.

Plot Selection:

A summary of the procedure to select plot locations involves a number of steps outlined as follows:

1. The Regional Sampling Grid is used to generate a subset of random sampling locations across suitable GRSG habitat.
 - a. 1000-m grid will be used for polygons >12,350 acres (247 acres/plot)
 - b. 500-m grid will be used for polygons <12,350 and >3,089 (62 acres/plot)
 - c. 250-m grid will be used for polygons <3,089 and >772 (15 acres/plot)
2. The GRSG Web Application Tool is used to identify the polygon of interest (often a project area or pasture intersected with seasonal habitat) and to select the desired number of sample locations from the subset of sample points within the polygon. Select a minimum of 5 plots per polygon. The following steps were followed to refine the sample point selection to a level that could be accomplished by our available work crews and field season limitations:

- a) The data was first refined using two sets of data. All habitat is 10% or greater sagebrush cover, generated from Thunder Basin Grassland Prairie Ecosystem (TBGPEA) remote sensing data, or the Forest Service Vegetation Spatial Layer (FSVeg) on mountain units. All habitat parcels regardless of size were included and the points were distributed among all parcels. On Thunder Basin National Grassland (TBNG), parcels within Management Area 3.63 outside of priority sage-grouse habitat were excluded from any point locations.
 - b) All of the sample points for the Medicine Bow and Routt National Forests and Thunder Basin National Grassland were reviewed in ArcMap.
 - c) The sample points were reduced to only those associated with National Forest System (NFS) lands.
 - d) Within that data set, the sample point labeled #1 was selected. This places one sample point in each pasture.
 - e) The data set was reduced to only those points within 5.3 miles of an active Sage-grouse lek on Medicine Bow NF and Thunder Basin NG and within 4 miles of an active Sage-grouse lek on the Routt NF.
 - f) Within this remaining data set, all points on Thunder Basin NG within the Management 8.4 Minerals Development and Production area were removed outside of Priority Sage-grouse Habitats.
 - g) The final set of points were the result of removing any remaining points that occurred within 50 meters (the length of the survey transects) of private land.
 - h) A second (alternate) sample point was developed using the above GIS protocol, to provide for circumstances where a survey site is rejected in the field. The sample points labeled #5 (of the original 10 provided by the web tool) were selected as the alternate points for field review.
 - i) A third (alternate) sample point was developed using the above GIS protocol, to provide for circumstances where the first two sites are rejected in the field. The sample points labeled #6 were selected as the third alternate points for field review.
3. Apply the pre-field and field plot rejection criteria below
 4. Apply the plot adjustment criteria described below, if necessary
 5. Select a new plot, from the second and third survey points as identified in steps h and i above, if necessary.
 6. Collect HAF and Perennial Grass Assessment Data where applicable

Pre-field Rejection Criteria

The criteria below were incorporated into the GRSG Web Application Tool as described above using available GIS data. Additional pre-field validation is needed to verify the information.

Based on information in the 3rd order HAF, we would apply pre-field rejection criteria to a plot if:

- There is likely less than 5% sagebrush cover

- Conifer cover is $\geq 10\%$
- Non-NFS Ownership
- Water (NHD)-Lakes and Reservoir
- Slope $>30\%$ in breeding/nesting. 50% in all habitat
- Anthropogenic Footprints (Table B-1 below and ROD Appendix A, Table 6)
- Prior to going to a planned field plot, a crew leader or similar personnel should use aerial imagery such as is available in ArcMap or Google Earth to verify if the plotted point is likely to be in sagebrush habitat and if the modeled pre-field rejection criteria was applied accurately.

Field Rejection Criteria

Use plot adjustment criteria (preferred) or select a replacement plot if plots fall on or within the following:

- Less than 5% sagebrush cover. Make a note in the comments section if this is due to a wildfire and if the plot may have the potential to return to sage-grouse habitat.
- Rocks (lava flow, bed rock, rubble area where top soil has been removed by flood/erosion event, deposition area from flood event, etc.).
- Hazardous Plot list from Forest Inventory and Analysis (FIA): plot cannot be accessed because of a hazard or danger, for example: cliffs, quarries, strip mines, illegal substance plantations, high water, etc.) Note: some have suggested that dangerous wildlife be added as an example. The Bureau of Land Management AIM protocol uses an example of a rattlesnake on the site. However, this might be an example of a temporary rejection where the plot could be sampled at some future time.
- Denied access area - Access to the entire plot is denied by the legal owner or by the owner of the only reasonable route to the plot (from FIA).
- Dispersed and developed campsites. Use standard definition.
- Corrals, line cabins/camps, parking areas, or other similar facilities.
- Water bodies (lakes, ponds, rivers, streams)
- Transect aligns closely with area disturbed by fence, trail, road, jeep trail, etc.
- Transect crosses administrative boundary such as allotment or pasture boundary.
- Ownership Change – Non-NFS
- Anthropogenic Footprints within influence zones (Table B-1 below and the ROD, Appendix A, Table 6)

- In areas likely to have 5% or greater sagebrush canopy cover, HAF data would be collected unless rejection criteria is applicable.
- In areas likely to have 10% or greater sagebrush canopy cover, grazing guideline data (in addition to the HAF Data) would be collected unless rejection criteria is applicable.

Table B-1. Anthropogenic disturbances documented in the ROD.

Degradation Type	Subcategory	Data Source	Direct Area of Influence	Area Source
Energy (oil & gas)	Wells	IHS; BLM (AFMSS)	5.0ac (2.0ha)	BLM WO-
	Power Plants	Platts (power plants)	5.0ac (2.0ha)	BLM WO-300
Energy (coal)	Mines	BLM; Forest Service; Office of Surface Mining Reclamation and Enforcement; USGS Mineral Resources Data System	Polygon area (digitized)	Esri/Google Imagery
	Power Plants	Platts (power plants)	Polygon area (digitized)	Esri Imagery
Energy (wind)	Wind Turbines	Federal Aviation Administration	3.0ac (1.2ha)	BLM WO-300
	Power Plants	Platts (power plants)	3.0ac (1.2ha)	BLM WO-300
Energy (solar)	Fields/Power Plants	Platts (power plants)	7.3ac (3.0ha)/MW	NREL
Energy (geothermal)	Wells	IHS	3.0ac (1.2ha)	BLM WO-300
	Power Plants	Platts (power plants)	Polygon area (digitized)	Esri Imagery
Mining	Locatable Developments	InfoMine	Polygon area (digitized)	Esri Imagery
Infrastructure (roads)	Surface Streets (Minor Roads)	Esri StreetMap Premium	40.7ft (12.4m)	USGS
	Major Roads	Esri StreetMap Premium	84.0ft (25.6m)	USGS
	Interstate Highways	Esri StreetMap Premium	240.2ft (73.2m)	USGS
Infrastructure (railroads)	Active Lines	Federal Railroad Administration	30.8ft (9.4m)	USGS
Infrastructure (power lines)	1-199kV Lines	Platts (transmission lines)	100ft (30.5m)	BLM WO-300
	200-399 kV Lines	Platts (transmission lines)	150ft (45.7m)	BLM WO-300

	400-699kV Lines	Platts (transmission lines)	200ft (61.0m)	BLM WO-300
	700+kV Lines	Platts (transmission lines)	250ft (76.2m)	BLM WO-300
Infrastructure (communication)	Towers	Federal Communications Commission	2.5ac (1.0ha)	BLM WO-300

Plot Adjustment Methodology

It is important to consider that the initial generation of sample points was intended to be located in a representative sample of suitable sage-grouse habitat. Plot adjustment is used to modify the on-the-ground location of a sample point if, during field verification, surveyors find that the rejection criteria is met indicating that habitat along the transect does not meet the requirements for sampling.

If the initial sample point is rejected, follow this procedure to move the plot and sample the site:

From the original plot center point, move 50 m North (0 degrees). With this location as the center of a new potential plot, evaluate the rejection criteria. If the new plot is not rejected, sample that plot. If it is rejected, move 50 m East (90 degrees) of the original plot center point and evaluate the rejection criteria again. Each time the new plot is rejected, repeat for the remaining cardinal directions--South (180 degrees) then West (270 degrees). If 50 m in all 4 cardinal directions of the original plot center point are rejected, then reject the plot. If one of the new locations is accepted as the new plot center, then the crew must verify that the new plot location does not fall into any of the other rejection criteria. Record the reason for the original rejection and results of this adjustment procedure in the plot notes. Photo(s) should be taken of all plots that are rejected for documentation purposes.

Plot locations should only be adjusted using the rejection criteria. Additional adjustments to plot location could result in biases in the data based on varying levels of crew experience; could result in an appearance of bias that affects the credibility of the data; and would be inconsistent with ROD grazing guideline direction stating that grass height measurements apply in 10% or greater sagebrush cover.

A review of the data collected in the 2016 field season will be evaluated periodically throughout the data collection period, and at the end of the season, to determine if the data is adequate to provide an assessment of current conditions. Based on these evaluations, modifications to the protocols may be made to better describe conditions on the ground. Also, additional types of data may be collected to provide more detailed information regarding specific habitat values, vegetation characteristics, or location conditions.

Perennial Grass Height Assessment

An assessment of perennial grass height conditions must be collected to determine compliance with the grazing guidelines for Sage-Grouse Nesting and Brood Rearing Habitat as described in Table 2 of the ROD to determine (1) the average perennial grass droop height at the end of nesting season and (2) the residual height of herbaceous vegetation after grazing and growing seasons in brood rearing and summer habitat. Shrub and grass plant associations and data collected will also be considered to determine the capability of the sites to meet the grazing guidelines.

Following is the protocol for completing the Perennial Grass Height Assessment:

1. Intersect the Priority Habitat Management Area (PHMA), General Habitat Management Area (GHMA), ownership, and vegetation cover maps with the lek buffers and other seasonal habitat layers that are available. On the Thunder Basin National Grassland (TBNG) use draft sagebrush cover data to sample in areas with greater than or equal to 10% sagebrush cover (as identified in the ROD Table 2). On the Medicine Bow-Routt National Forests, use the R2 FS Vegetation Spatial data to identify areas that may be greater than or equal to 10% sagebrush cover.
2. Apply the GRSG Web Application Tool sample grid and sample size calculator to determine the appropriate sample size. Apply the Pre-field plot rejection criteria and document reasons for rejecting the plot.
3. Field crews visit plots, apply the plot rejection criteria and document any plot rejection.
 - a. Note: these sites should all be in upland locations. Apply plot adjustment criteria if located in a mesic bottom.
4. Field Protocol is as follows:
 - a. Install a single 50m tape oriented from east to west with the sample point used as the start point.
 - b. Label a white board with the plot ID and date, take a picture of whiteboard, and then a picture down the transect and in the other cardinal directions, starting with west (down transect), north, east and south. There should be a total of 5 pictures per transect (6 pictures if the transect is being completed in conjunction with the HAF). Note the file name and/or number in your general notes for the site.
 - c. Note other site descriptors such as plant vigor, sagebrush decadence, wildlife use and precipitation, if inferences can be made. Note if livestock are present.
 - d. Sampling will begin at the 1/2m mark and continue along the transect every half meter for a total of 100 points. Grass height will be measured at the closest perennial grass (new growth or residual) to the point on the right (north) side of the tape, walking on the left (south). Grass height will be measured at the droop height (including inflorescence) in quarter inches, rounding to the nearest quarter of an inch.

- e. If using a hard copy data sheet, record if the plant is grazed or ungrazed. If recording data using the VGS software, use the GRAZED qualifier for plant species if grazed, and no qualifier if ungrazed.
- f. Perennial grass height (new growth or residual) will also be measured in the drip line around sagebrush plants.
- g. Shrub height will be measured at the first 10 sagebrush that intersect the tape that meet the minimum sagebrush height standards. Black sagebrush must be 4-32 inches tall with all other sagebrush species being 12-32 inches tall (ROD Table 1). Grass heights will be measured at the droop height (including inflorescence) in quarter inches, rounding to the nearest quarter of an inch.
 - i. If ten sagebrush plants do not intersect the tape, then use a belt transect of 1 yard, located on the right side of the tape, starting at the beginning of the tape. Measure grass height at each sagebrush plant that meets the height requirements until 10 sagebrush are encountered.
 - ii. Height will be measured at 5 predetermined points on a hoop that will be placed around each of the 10 sagebrush plants for a total of 50 points.
 - iii. If using a hard copy data sheet, then record if the plant is grazed or ungrazed. If recording data using the VGS software, use the GRAZED qualifier for plant species if grazed, and no qualifier if ungrazed.

Site Capability/Ecological Site Potential Determination

When assessing grass height, certain shrub (primarily sagebrush) plant associations may not have the ecological potential to support perennial grasses with a 7-inch inflorescence droop height in breeding and nesting seasonal habitat. In general, shrub plant associations that have one of the following as a *second species name* may not be able to support the 7-inch grass height: *Poa secunda*, *Bouteloua gracilis*, and *Distichlis spicata*.

In order to determine if sites are not capable of producing 7-inch grass heights:

1. Data will be collected using the perennial grass height assessment protocol to determine ungrazed plant grass height.
2. Previous trend data and other site-specific data such as ecological site descriptions and vegetation community type descriptions will be reviewed.
3. If, after reviewing the data, uncertainty remains regarding the capability of the site, install a utilization cage to protect an area from grazing and measure grass height at the end of the nesting season.
Remeasure vegetation in the utilization cage over multiple years to account for variation in seasonal precipitation.
4. If it is determined that the site does not have the capability to meet the ROD Table 2 guidelines, then review available data to determine appropriate grazing management to move toward GRSB Habitat Desired Conditions within the limitations of the site.

Habitat Assessment Framework (HAF)

1. Intersect the PHMA, GHMA, ownership, and vegetation cover maps with the Sage-grouse lek buffers and other seasonal habitat layers that are available. On the Thunder Basin National Grassland (TBNG) use draft sagebrush cover data to sample in areas with greater than 5% sagebrush cover (The ROD does not specify canopy cover requirements, but the HAF and the Wyoming Sage-Grouse Executive Order (WY SGEO) determine that anything less than 5% is not suitable). On the Medicine Bow-Routt National Forests, use the R2 FS Vegetation Spatial data to identify areas that may be greater than 5% sagebrush cover.
2. Apply the GRSG Web Application Tool sample grid and sample size calculator to determine appropriate size.
3. Utilize pre-field plot rejection criteria and document reasons for rejecting the plot.
4. Field crews visit plots, apply the plot rejection criteria and document any plot rejection.
 - a. Note: These sites should be upland sites. Mesic meadow sampling protocol will be coming out fall/winter of 2016/17. Apply plot adjustment criteria if need be to move out of a mesic bottom.
5. Field crews collect the data on the plot according to Fourth Order HAF sampling protocol. The Habitat Assessment Framework (June 2015 version) can be found online at this link: http://www.blm.gov/wo/st/en/info/blm-library/publications/blm_publications/tech_refs/SG_HAF.html
Line-point intercept, (pg. 90 HAF), vegetation height and sagebrush shape (pg. 93 HAF), line-intercept (pg. 101 HAF, we are NOT completing Daubenmire frames) and forb diversity data (pg. 105 HAF) will be collected as described in the HAF. These forms and directions are located at the above link, so you can just download the forms and directions for all of them, or navigate to the whole document. Data will be recorded electronically using the VGS platform. On page 109-114 of the HAF is a species list that may be of assistance if needed.
6. The plot metadata form is found on page 88 with instructions on page 89. Use these guidelines to fill out the metadata info for both hard copy forms and the VGS software.
 - a. Do NOT note what habitat type the site is. This determination will be made later in a multi-disciplinary setting.
7. Photo protocol.
 - a. Label a white board with the plot ID and date, take a picture of the whiteboard, and then a picture down the transect and in the other cardinal directions, starting with west (down transect), north, east and south.
 - b. In a representative location along or near the tape, place the labeled white board near the base of a sagebrush plant, and take a tangential close-up photo near ground level toward the shrub/ground interface, to document herbaceous conditions and cover.

- c. There should be a total of 6 photos for each site (whiteboard, 4 cardinal direction photos, and a sagebrush plant with the whiteboard). Record the photo file names and/or numbers in your general notes for the site.
 - d. When using the VGS software, line-point intercept and vegetation height/shape will be recorded using the same tab in the software. Forb diversity and line intercept will be recorded on separate tabs.
 - e. Make note of other site descriptors such as plant vigor, sagebrush decadence, wildlife use and precipitation if inferences can be made. Note if livestock are present.
8. Transect layout will be as follows:
- a. Install a single, 50m tape, oriented from east to west with the sample point used as the start point. GPS point will be collected at the end points of the transect for use in another application. Note the end point in the field notes.
 - b. Pull tape until taut, and anchor the far end of the transect with a range pin.
 - c. Sampling will begin at the 1/2m mark and continue along the transect every half meter for a total of 100 points for the line-point intercept and plant height methods. Read on the right side of the tape, walk on the left.
 - d. For point-intercept method, record the intercept of both living and dead plant material by species. Note whether the plant is living or dead.
 - e. Line intercept of all shrub species will be read along the entire length of the transect. List cover increments to the nearest centimeter, ignoring gaps or spaces in the canopy that are less than 5cm. Record both live and dead canopy cover. If you have dead sagebrush canopy, add that species to the list with the qualifier of DEAD. It is important to note areas of decedent sagebrush.
 - f. Forb diversity will be read using a belt transect with a width of 1 meter, beginning at 0 meters and being read every meter. So the belt will be read in 1 meter square blocks for a total of 50 blocks. Record all species of forbs encountered, both annual and perennial. If a species is unknown, record it as such with the qualifier information recorded, and bring a sample back to the office for identification. This can be changed in the VGS software at a later point.

Helpful Resources

A number of publications that focus on the identification and assessment of sagebrush habitats for GRSG across the species' range are available. The following publications are a partial list that will help provide information on the habitat characteristics that are important to the conservation of sage grouse.

Publications

- Branton, M. and J. S. Richardson. 2011. Assessing the value of the umbrella-species concept for conservation planning with meta-analysis. *Conserv. Biol.* 25(1):9-20.
- Connelly, J. W., E. T. Rinkes, and C. E. Braun. 2011. Characteristics of greater Sage-grouse habitats: a landscape species at micro and macro scales. Pages 69-83 in S. T. Knick and J. W. Connelly, editors. *Greater Sage-Grouse: Ecology and Conservation of a Landscape Species and Its Habitats*. Cooper Ornithological Society, Studies in Avian Biology No. 38, University of California Press, Berkeley and Los Angeles, CA.
- Connelly, J. W., M. A. Schroeder, A. H. Sands, and C. E. Braun. 2000. Guidelines to manage sage grouse populations and their habitats. *Wildl. Soc. Bull.* 28(4):967-985.
- Crist, M. R., S. T. Knick, and S. E. Hanser. 2015. Range-Wide Network of Priority Areas for Greater Sage-Grouse—A Design for Conserving Connected Distributions or Isolating Individual Zoos? Open-File Report 2015-1158, U.S. Geological Survey, Reston, VA. 34 pp.
- Davies, K. W., C. S. Boyd, J. L. Beck, J. D. Bates, T. J. Svejcar, and M. A. Gregg. 2011. Saving the sagebrush sea: an ecosystem conservation plan for big sagebrush plant communities. *Biol. Conserv.* 144:2573-2584.
- Doherty, K. E., J. S. Evans, P. S. Coate, L. Juliusson, and B. C. Fedy. 2015. Importance of regional variation in conservation planning and defining thresholds for a declining species: a range-wide example of the greater Sage-grouse. U.S. Fish and Wildlife Service, U.S. Geological Survey, Lakewood, Co. 51 pp.
- Dumroese, R. K., T. Luna, B. A. Richardson, F. F. Kilkenn, and J. B. Runyon. 2015. Conserving and restoring habitat for Greater Sage-Grouse and other sagebrush-obligate wildlife: the crucial link of forbs and sagebrush diversity. *Native Plants* 16(3):276-299.
- Garton, E. O., J. W. Connelly, J. S. Horne, C. A. Hagen, A. Moser, and M. A. Schroeder. 2011. Greater Sage-grouse population dynamics and probability of persistence. Pages 293-382 in S. T. Knick and J. W. Connelly, editors. *Greater Sage-Grouse: Ecology and Conservation of a Landscape Species and Its Habitats* Cooper Ornithological Society, Studies in Avian Biology No. 38, University of California Press, Berkeley and Los Angeles, CA.
- Knick, S. T. and J. W. Connelly. 2011. Greater Sage-grouse: ecology and conservation of a landscape species and its habitats. Cooper Ornithological Society, Studies in Avian Biology No. 38, Univ. of Calif. Press, Berkeley and Los Angeles, CA.
- Knopf, F. L. 1996. Prairie legacies – birds. Pages 135-148 in F. B. Samson and F. L. Knopf, editors. *Prairie Conservation – Preserving North America's Most*

- Manier, D. J., D. J. A. Wood, Z. H. Bowen, R. M. Donovan, M. J. Holloran, L. M. Juliusson, K. S. Mayne, S. J. Oyler-McCance, F. R. Quamen, and D. J. Saher. 2013. Summary of science, activities, programs, and policies that influence the rangewide conservation of Greater Sage-Grouse (*Centrocercus urophasianus*). Open-File Report 2013–1098, U.S. Geological Survey Reston, VA. 170 pp.
- Miller, R. F., S. T. Knick, D. A. Pyke, C. W. Meinke, S. E. Hanser, M. J. Wisdom, and A. L. Hild. 2011. Characteristics of sagebrush habitats and limitations to long-term conservation. Pages 145-184 in S. T. Knick and J. W. Connelly, editors. Greater Sage-Grouse: Ecology and Conservation of a Landscape Species and its Habitats. . Cooper Ornithological Society, Studies in Avian Biology, No. 38, U.C. California Press, Berkeley and Los Angeles, CA.
- U.S. Fish and Wildlife Service. 2013. Greater Sage-Grouse (*Centrocercus urophasianus*) Conservation Objectives: Final Report. U.S. Fish and Wildlife Service, Denver, CO. 92 pp.

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