Wyoming Governor's Sage-Grouse Conservation Initiative: Habitat Mapping Project

2009 Annual Report: Data Gathering, Integration, Dissemination, and Maintenance

To the

Wyoming Game and Fish Commission: State of Wyoming Governor's Sage-Grouse Conservation Initiative

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The Wyoming Geographic Information Science Center
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Project Name: *Wyoming Governor's Sage-Grouse Conservation Initiative: Habitat Mapping Project*

Funding Scheme: Memorandum of Understanding Titled: Geospatial Services, Original Game and Fish Memorandum of Understanding Number 11-106, Addendum Number 4 made and entered into by and between the Wyoming Game and Fish Commission and University of Wyoming, Research Office, WYGISC.

University of Wyoming Project ID: WGF49781

Period Covered: 5/1/2008 to 6/30/2010

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The results presented reflect neither a consensus of opinion nor the views and policies of the Wyoming Game and Fish Commission, the University of Wyoming, or the Wyoming Geographic Information Science Center.

Executive Summary

In 2007 the Governor's Sage-Grouse Conservation Implementation Team identified a set of priorities needed for sage-grouse conservation in Wyoming. One of these priorities was an immediate need for information on the sage-grouse habitats in Wyoming. The Implementation Team convened a group of biologists, private and public land managers, and habitat information specialists to generate a scope of information needs and feasibility assessment of the information needs. The Implementation Team's information group selected two working committees, one to generate a list and description of information needs, the Biologists, and another group, the GIS/Mappers, to provide feedback on potential information sources usually in the form of a map. A wide range of potential information needs were identified, including those requiring long term study of many years. Short and long term planning to generate data is needed, but immediate information sources are required for decisions currently being made or in the near future.

From the recommendations of the Biologist and GIS/Mapping Committees appointed by the Governor's Sage-Grouse Conservation Implementation Team a project plan was developed by WyGISC in March and April 2008. Funding, once to Game and Fish from the legislature, was awarded to WyGISC under an existing Memorandum of Understanding and is to be performed over the period 5/1/08 to 6/30/10. Identified information was available by the end of 2008 to meet immediate needs, but the project also produced a framework for acquiring new information at appropriate map scales and is supporting collaborative sage-grouse habitat analysis through 2010.

The ***"Overall Dream"*** of the Implementation Team Committees was: high resolution continuous canopy cover of all plant species, by species; high resolution data for landscape and anthropogenic features; and detailed soil and hydrologic data.

The data collection process conducted by the Wyoming Geographic Information Science Center (WyGISC) throughout this effort strove to meet these needs, as well as to identify areas that will require further data development to meet the full potential of the overall dream.

The project consists of four components: gathering and integration of sage-grouse habitat map data across Wyoming, statewide field data collection of sagebrush communities, generation of new sagebrush map information, and data dissemination, collaborative assistance, and maintenance.

Data gathering and integration involved an assessment of data availability, creating a scale dependent inventory of data and finally, publishing the gathered data online with proprietary controls as necessary. The data inventory provides a structural framework for an Internet-mapping application, and provides support for data input to the attribution of an existing sagebrush map component. The application will be used to standardize sage-grouse habitat data in Wyoming, provide a framework for

appropriately using the data in decision support and habitat assessments at disparate spatial scales, and as a communication tool among users. Metadata will be placed within the Wyoming GeoLibrary, which serves as the data distribution mechanism for spatial data.

WyGISC is handling public distribution through the Wyoming GeoLibrary (http://www.wygisc.uwyo.edu/geolibrary/index.htm). Here users can directly obtain all public information and are directed to the appropriate data steward with regards to restricted data. For distribution to WGFD, a collection of DVDs have been created containing the entire database. This project also provided funds for WyGISC to gather another round of data with regards to those layers which may change over the coming year. This will be done in spring of 2010 and distributed to the public and WGFD in the same manner as identified above.

To facilitate communication among partnering agencies with regards to creating this database, an application, the Wyoming Sage-Grouse Data Explorer, was developed allowing for users to view and comment on the database. This application is a user-restricted mapping application found on MyWyGISC (http://alkali.wygisc.uwyo.edu/MyWyGISC/login.aspx). Further, the application, by inventory and displaying habitat layers, provides a robust tool for identifying data gaps. The identification of data gaps, at disparate scales, can then be used as a planning tool for future habitat data generation and integration.

The set of sagebrush species distribution maps generated by this project and the set of rangeland variable component maps generated by the USGS were created to meet the needs of multiple analysis requirements and not one set goal. It is intended that these data describe current ecological conditions for sage-grouse across Wyoming and will therefore provided baseline quantitative information. The data layers will be applicable for a variety of uses and represent the 'building blocks' or 'ingredients' for a suite of potential habitat studies and are flexible enough to help answer a wide range of management questions.

Initial efforts, such as refinement of the Wyoming Governor's Sage-Grouse Core Areas, will focus on state-wide solutions to management analysis requirements, but we anticipate that regional differences across the state may require different recipes from the data. With the completion of this the report and our initial data development the project will provide collaborative support to analysis needs identified by the Governor's Sage-Grouse Implementation Team through June 2010.

Acknowledgements

This project is made possible by the Wyoming State Governor and the Governor's Sage-Grouse Conservation Implementation Team. WyGISC would like to thank the Governor's Office, Wyoming Game and Fish Commission, and all the members of the Governor's Implementation Team both Public and Private for their dedication and vision in bringing such an ambitious project to fruition.

Thank you to members of Wyoming's Natural Resources Consulting Firms for their support of this effort. Their contribution completed in addition to ongoing work helped make this project a success. They should be applauded for volunteering their talents to a Wyoming public need. The number of consultants donating their skills was impressive, making it difficult for project principals to track all names. We thank all participants and specifically: Renee Taylor of Taylor Environmental; Cathy Cooper, Allen Aksamit, and Tony Burrows of Western Land Services; Bill Bellah, Jason Sutton, Jacob Gay, Jenna Foss, and Zach Byram of Grouse Mountain Environmental Consultants; John Leonhart, Bill Vetter, Brian Grasman, and Timothy Ludwick of ICF Jones and Stokes; Ryan Bombeck, Brian Heath, and Matt Strauser of ARCADIS; Paul Dixon of Dixon Land Management; Lin Gilbert and Linette Sutphin of Bighorn Environmental Consultants; and Duffy Brown and Dan Doke of Wildlife Resources LLC.

A special thank you goes out to the staff and affiliates of the Wyoming Geographic Information Science Center. Teal Wyckoff lead database development efforts and Phil Polzer created the Sage-Grouse Data Explorer Application. Arne Buechling contributed to the species modeling effort. Front office staff, Kathy Olson, Fawn Sprague, and Khristian Owens provided invaluable logistical support to the overall project and 14 field crew personnel. Dr. Jeffrey Brasher lead the field crew supervision. Dr. Steven Prager served as advisor to our Master's Graduate student Arjun Dongre; Steve and Arjun are leveraging project efforts to analyze possible road mitigation techniques from minerals development in Wyoming sage-grouse habitats.

Thank you to the many Federal and State agency staff that collaborated in this effort.

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Major Accomplishments

- Spatial Map Database of all known Wyoming sage-grouse habitat map layers. Comprising 534 individual thematic map layers. Distributed to project partners on set 4 DVD data discs.
- Most extensive analytical field sample survey of Wyoming vegetation habitats within the sage-grouse range ever attempted.
- Electronic metadata library of all known Wyoming sage-grouse habitat layers accessible over basic internet connection.
- Electronic spatial map data viewer of common sage-grouse habitat layers accessible over basic internet connection.
- Generation of species distribution maps for all sagebrush species known to be used by sage-grouse in Wyoming.
- Review, description, and distribution of state-wide USGS generated sagebrush habitat layers.
- Collaborative contribution to the Governor's sage-grouse core areas concept including ongoing efforts at refinement through sage-grouse seasonal range analysis and mapping.

Deliverable Timelines

Wyoming GeoLibrary Sage-Grouse Project Data Is Complete and Accessible

Wyoming Sage-Grouse Data Explorer Application is complete:
During the fall of 2009 the Explorer will be converted to new software.

Wyoming Project Data Disk Set Distribution: Will be complete by July 31, 2009.

Users of the Project Database and Project Applications will be identified by the fall of 2009.

WyGISC principles anticipate beginning the training phase near the end of the 2009 calendar year.

Collaborative analysis of sage-grouse habitat data layers is ongoing.

Outreach

Livestock Roundup newsletter on the project was created by John Emmerich, Jim Magagna, and Eli Rodemaker.

Eli Rodemaker provided an interview to the Rocky Mountain Energy (unsure of actual newsletter title) reporter Ellen Miller at the suggestion of Bob Budd.

Jeff Hamerlinck mentioned the project in an interview on NPR-Wyoming.

Stakeholder meeting was held at the University of Wyoming April 22nd and 23rd 2008 with approximately 24 attendees including colleagues, Cam Aldridge and Collin Homer, from the USGS performing the sagebrush remotely sensed mapping intended for use in this project.

Eli Rodemaker met with BLM, members of the Governor's Implementation Team: GIS Team sub-committee and others at the BLM state office May 6th 2008 to review to the proposed project elements.

Eli Rodemaker and Dick Loper requested collaboration for data collection from members of the Wyoming Stock Grower's Association and have coordinated regarding presenting the project effort at a stock grower's function. Planning for event is ongoing.

Eli Rodemaker provided a presentation on the project goals and efforts to the Wyoming State Legislature Travel, Recreation, Wildlife, and Cultural Resources Committee.

Eli Rodemaker provided the Key Note Address to the 2009 US-Department of Interior Remote Sensing Group including an introduction of the project.

Eli Rodemaker coordinated with Dr. Jeffrey Beck (UW) and graduate students to provide protocols and data for sage-grouse persistence studies in the Bighorn Basin and Atlantic Rim area.

Project Coordination with Other Entities

The Governor's Sage-Grouse Conservation Implementation Team identified ongoing efforts valuable to sage-grouse management in Wyoming that this project should attempt to coordinate efforts. Coordination with other groups entailed ensuring that data generated by the project could be used by the other efforts. Further coordination was encouraged to avoid any duplications of effort

Eli Rodemaker coordinated with Heather Paskevic and Carl Sylvester of ESRI and the Western Gov's Association Wildlife Habitat Corridors Initiative concerning data interoperability and standardization. He also attended USGS Sagebrush Ecosystems and Energy Development Group briefings concerning their research efforts with BLM in Wyoming. Jim Oakleaf met with Kevin Doherty of Wyoming Audubon and Nyssa Whitford of Game and Fish regarding wildlife and habitat data.

Database Development Description

Data have been collected from agencies and organizations with data relevant to the sage-grouse database development effort. Data were collected to meet the purposes of the data needs outlined in by the Governor's Sage-Grouse Conservation Implementation Team: Biologist Sub-committee's Habitat Variable Recommendations for the Wyoming Sage-Grouse Habitat Mapping Priorities, as compiled on January 06, 2008 (See Appendix A).

WyGISC has organized all incorporated data according to a standard data hierarchy (figure 1). Data has been organized into a data scale, such that data can be scaled down (i.e., from large scale to small scale, fine to coarse). The data organization by hierarchy is represented as:

1. Region/State – 1:100,000 scales smaller (i.e., 1:250,000)
2. Management – scales smaller than 1:24,000 to those greater than or equal to 1:100,000
3. Project/Site – scales larger than or equal to 1:24,000

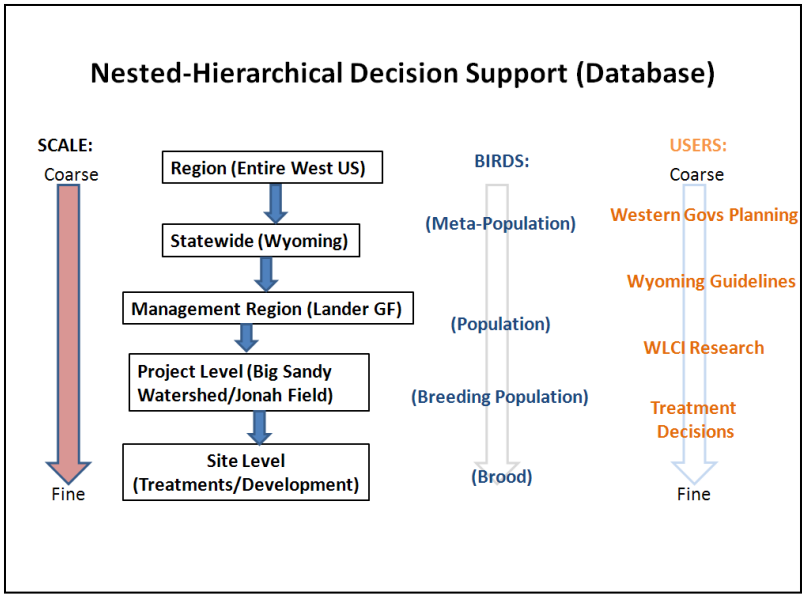


Figure 1. Conceptual overview of Decision Support Database Structure. Nested hierarchical decision support database (system) provides standard and protocol framework.

The Region/State Scale is defined by those spatial data only appropriate for use at a scale of 1:100,000 or less (e.g. 1:250,000). The Management Scale grouping those

data having a scale greater than or equal to 1:100,000 but not to equal or exceed 1:24,000. Finally, the Project/Site Scale containing only those data with the ability to use at scales at or above 1:24,000.

WyGISC principle investigators categorized each data by the scale hierarchy. During a workshop the principles reviewed each data element, discussed the data in terms of sage-grouse habitat ecology or management, and then inventoried the element to one of the three hierarchical scales.

Agencies Contacted

The following list is comprehensive of agencies and organizations that provided data, with a theme-based list of data acquisition included.

- United States Department of the Interior
  - Bureau of Land Management:
    - Field Offices: roads*, raptors, vegetation treatments, fences, grazing allotments, wild horse areas, project areas, roads, weeds, wildland and prescribed fires, mine locations, visual resource management areas, special management areas*
    - State Office: *land management and ownership, wilderness study areas, areas of critical environmental concern, oil and gas sale parcels 2005 - 2008*
    - National Office: Legacy Rehost 2000 data – *oil and gas, rangeland allotments, solid mineral leases, surface management agencies, sub-surface management agencies, renewable resources energy leases, rights of way, land use permits*
  - United States Geological Survey
    - GAP Land Cover Program: *land cover for Wyoming at 1:100,000*
    - Northwest GAP Analysis Program: *land cover for Wyoming 30m*
    - Landscape Fire Resource Management Planning Tools Project: *EDNA aspect, biophysical settings, canopy bulk density, canopy base height, canopy cover, canopy height, EDNA filled DEM, environmental site potential, existing vegetation cover, existing vegetation height, existing vegetation type, fire behavior fuel model 13, fire behavior fuel model 40, fire regime condition*

class, fire regime condition class departure index, fire regime groups, mean fire return interval, simulated historical percent of low severity fires, simulated historical percent of mixed severity fires, simulated historical percent of replacement severity fires, succession classes, EDNA slope (degrees)

- National Land Cover Program: *National Land Cover Dataset, 2001*
- SAGEMAP - A GIS Database for Sage-grouse and Shrub-steppe Management in the Intermountain West
- National Hydrography Dataset: *medium and high resolution hydrological data*
- Rocky Mountain Geographic Science Center: *land cover mapping status and trends*
- Earth Resources Observation and Science Data Center: *Shuttle Radar Topography Mission Program Data*, *Landsat 30m. satellite imagery*

– U.S. Fish & Wildlife Service

- National Wildlife Refuges in Wyoming: *national wildlife refuge boundaries in Wyoming, Seedskadee NWR vegetation*
- National Office: *National Wetlands Inventory*

- U.S. Department of Agriculture: *major land resource areas, coordinated resource areas*
  – U.S. Forest Service: *MODIS forest type inventory analysis, roadless areas*
  – Natural Resources Conservation Service – state office: *SSURGO Wyoming soils data, U.S. General Soils Data, Ecological Site Descriptions*
- National Renewable Energy Laboratory: *wind potential at 500mb height, solar potential*
- National Oceanic and Atmospheric Administration: *U.S. climate data*
- Federal Communications Commission: *communication tower site locations*\
- Wyoming Game and Fish Department: *sage-grouse lek locations and statistics, sage-grouse distribution, big game migration, barriers and seasonal habitat, wetlands, region boundaries, sage-grouse working group areas, current and historic sage-grouse range, habitat management plan and vegetation for South Wind River mule deer herd*
- Wyoming County Weed and Pest Districts: *weed distributions for five Wyoming counties*
- Wyoming Oil and Gas Conservation Commission: *wells*

- Wyoming State Geological Survey: *pipelines*
- Oregon State University: PRISM Climate Research Group: *PRISM climate data*
- University of Colorado: National Snow and Ice Data Center
- University of Wyoming: *30 m. DEM, 90 m. DEM, geology, soils, land cover, PLSS, base data themes, watersheds, landtype associations, transportation, weather station locations and data*
    - Daily Surface Weather and Climatological Summaries: *climate data*
- Upper Green River Valley Mapping Project:
- The Nature Conservancy: *NWI/NHD dataset merged*
- Audubon Wyoming: *current sage-grouse active range, Powder River Basin Land Cover (University of Montana project data)*
- Wild Utah Project: *Heart of the West wildlands network design*
- Northern Plains Conservation Network: *Northern Plains conservation network opportunities*
- American Bird Conservancy: *coordinated implementation plan for bird conservation in Wyoming*
- Western Governors Association: Wildlife Habitat and Corridors Initiative
- Environmental Systems Research Institute: Broomfield, Colorado.

Compilation and Processing of Data and Metadata

Data were obtained in a variety of formats from the above contact list. Refer to Appendix A for an explanation of data needs that have been met and those areas requiring future data development.

Data underwent a variety of processing, depending on the original data extent and format. Some of the techniques applied included clipping, re-projection, ascii to GRID transformation, raster mosaic, vector merge, coverage to shapefile, shapefile to file geodatabase feature class, and layer file creation.

Metadata are an essential part of the data collection and development process. Metadata are defined as “information about data” and includes information regarding the “who, what, when, where and how” of the data. Metadata include identification information that consists of a brief abstract, the purpose of the data, the access and use constraints; the spatial organization information; entity and attribute information that provides an explanation of the attributes; distribution information that consists of contact information for the data; and finally metadata reference information.

In order to meet the needs of this data collection effort, each metadata document associated with the data received, had to be created, completed, cleaned, or otherwise standardized. Steps in the process included but were not limited to metadata collection, compilation, development, standardization, assessment, cleaning, organization, and image creation. In addition the Wyoming GeoLibrary metadata clearinghouse preparation tool was applied to all metadata records with each record being published to the GeoLibrary. Finally, keywords were added were added for reference purposes, notes were added, and, distribution information was defined as either restricted, contact (restricted), distribute through WyGISC or from an alternate source. Refer to 'Data Distribution: Wyoming GeoLibrary Metadata Clearinghouse' section below for further explanation of the metadata distribution associated with this project.

Application Development

The Wyoming Sage-Grouse Data Explorer internet mapping application (Figure 2) has been developed in conjunction with the database development and data collection portions of this project. The application is available for project identified individuals to use. There are two main objectives for the mapping application. The first is to allow data users (Researchers) the ability to view data prior to downloading for use in their own projects. The second is to allow non-GIS users the opportunity to explore data in an easy-to-use application that does not require special software. Using just a browser (and Internet connection) the user can display and query non-restricted data that have been collected. Metadata for each dataset can be viewed which allows for the dataset to be accessed. Data for the application are stored and deployed using ESRI SDE, Microsoft SQL Server, and ESRI ArcServer technologies.

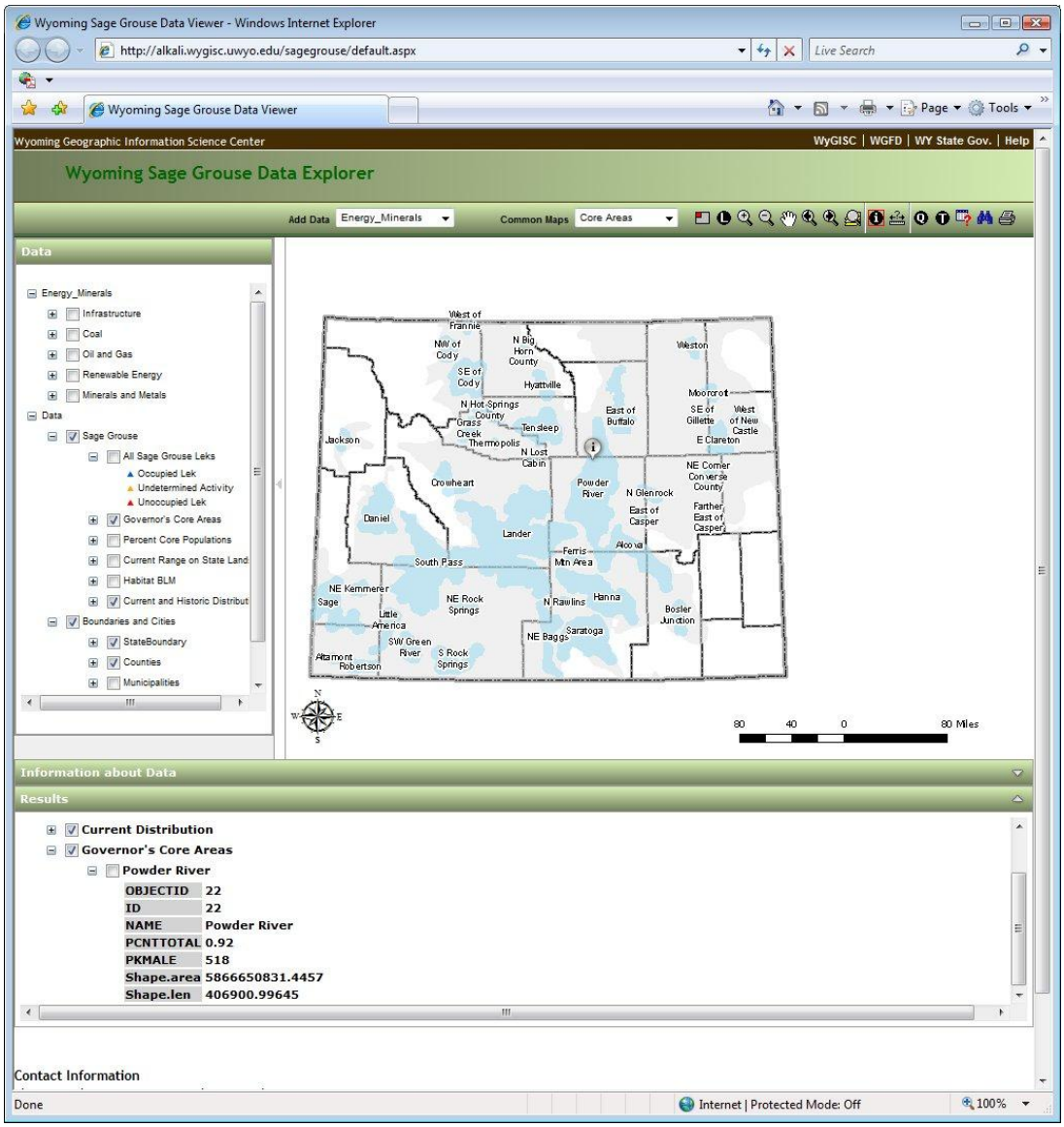


Figure 2. Wyoming Sage-Grouse Data Explorer internet application example.

Wyoming Sage-Grouse Data Explorer is complete: During the fall of 2009 the Explorer will be converted to new 'Flex' software.

Identification of Needed New Habitat Layers

Sage-grouse habitats in Wyoming are dominated by sagebrush and a kin of closely related drought tolerant shrub, grass, and forb species. As a community these plants are frequently identified as a sagebrush-grassland and much is known or is being studied about the ecology of these communities. However, the spatial information or mapping of these communities, so important to the sage-grouse, is limited. For many years now land management agencies have been using the only statewide map of sagebrush and associated dry land communities in Wyoming, the USGS Gap Analysis Program Land Cover Map Layer (Merrill et al. 1996)

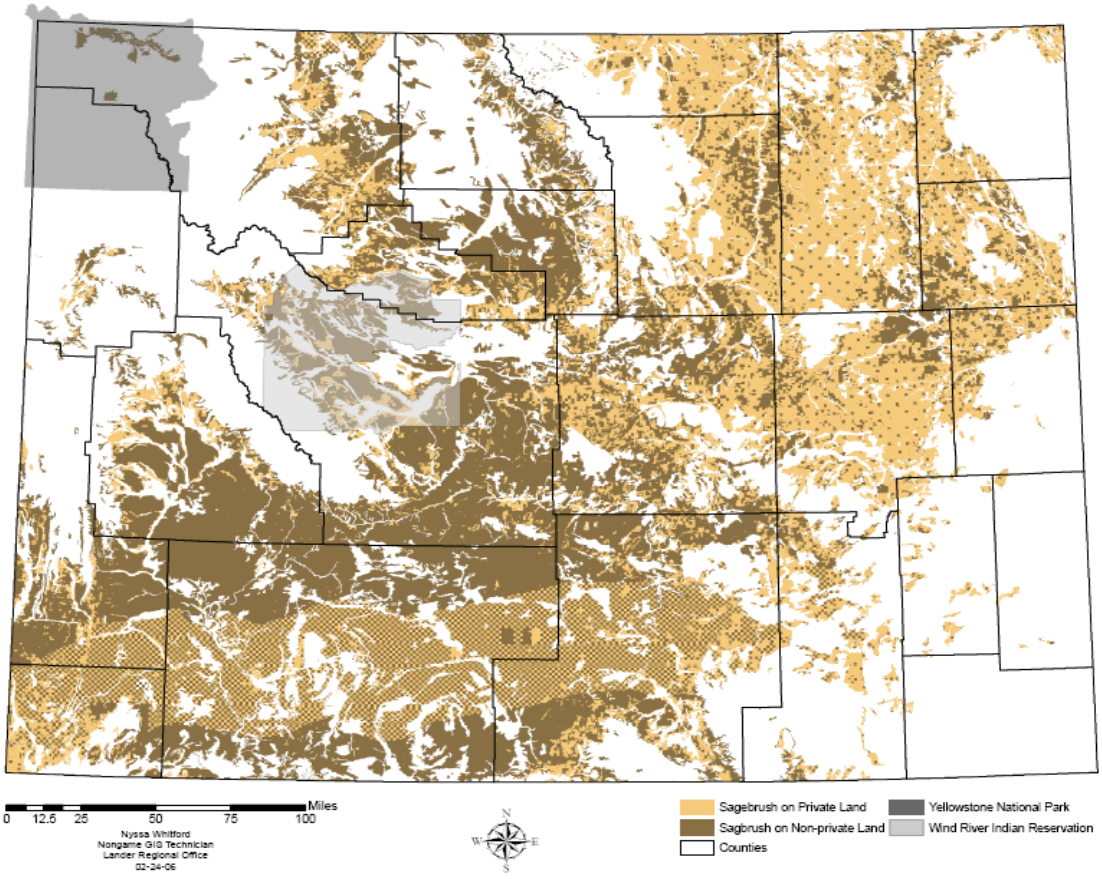


Figure 3. Distribution of sagebrush on both private and public lands in Wyoming (Wyoming Game and Fish modified from Merrill et al. 1996; BLM 2001. Link: **http://gf.state.wy.us/wildlife/nongame/LIP/Sagebrush/index.asp**).

The original Wyoming Gap Land Cover effort was a moderate to coarse scale effort and did not attempt to define the type of sagebrush species present or the amount (cover) of the plants present. When interested in species distribution of sagebrush in Wyoming sources of spatial information have until recently been very limited. For instance one could look at the distribution of plant specimen collected for an herbaria, which is only intend as a spatial reference for the location of the specimen voucher, not as a map, see Figure 4.

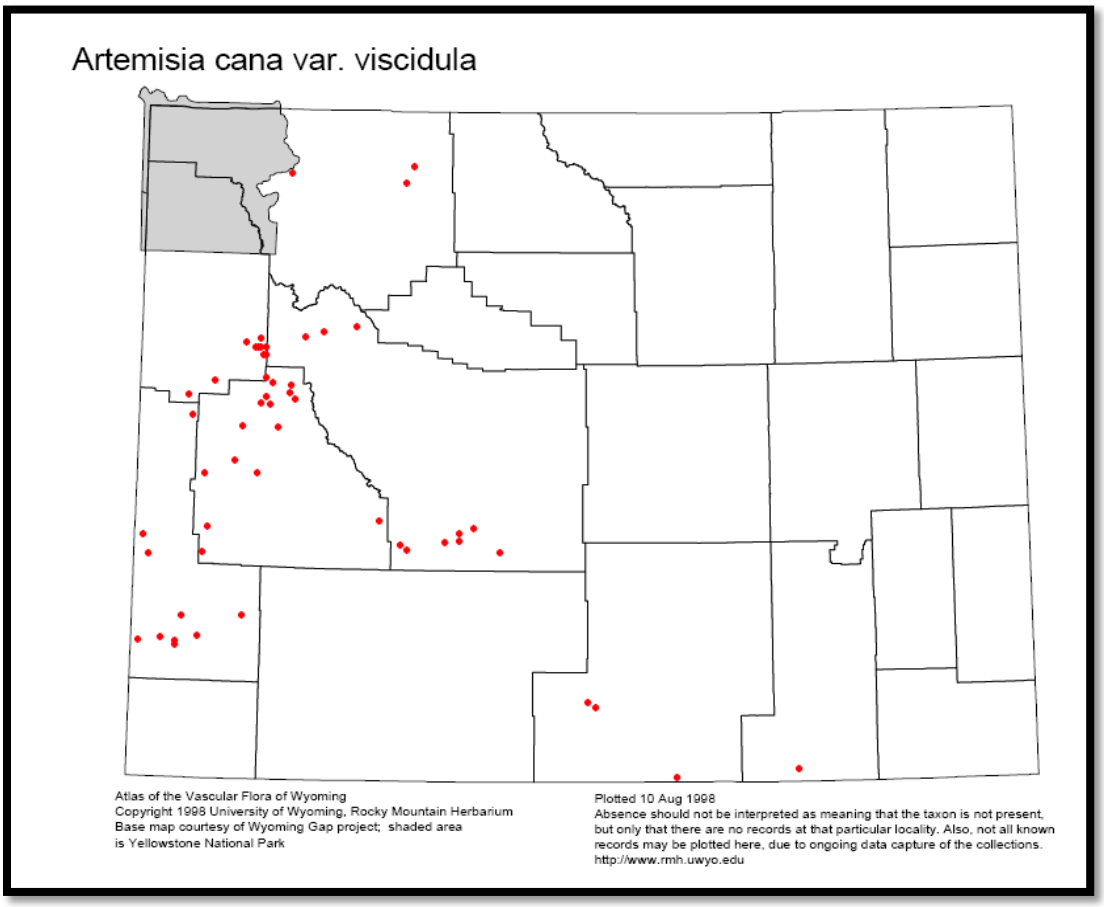


Figure 4. Distribution of all samples with locations for Mountain Silver Sagebrush at the University of Wyoming Rocky Mountain Herbarium.

Or we use the most up to date sagebrush habitat guide available for Wyoming written by Dr. Alan Beetle of the University of Wyoming and published in 1982, see Figure 5. Dr. Beetle's publication provided distribution maps created in the days before computers (see Beetle 1960) and were interested as general location guides not for spatial analysis of species distributions.

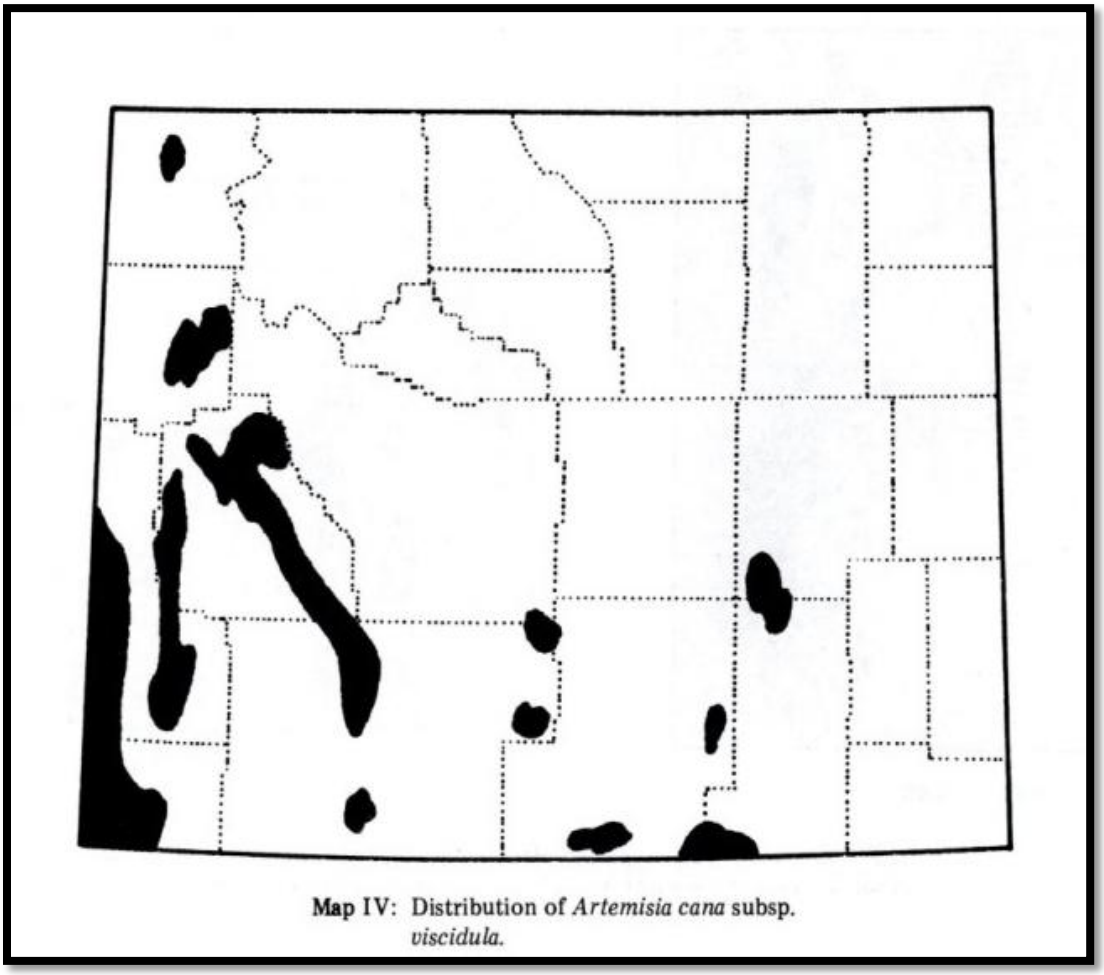


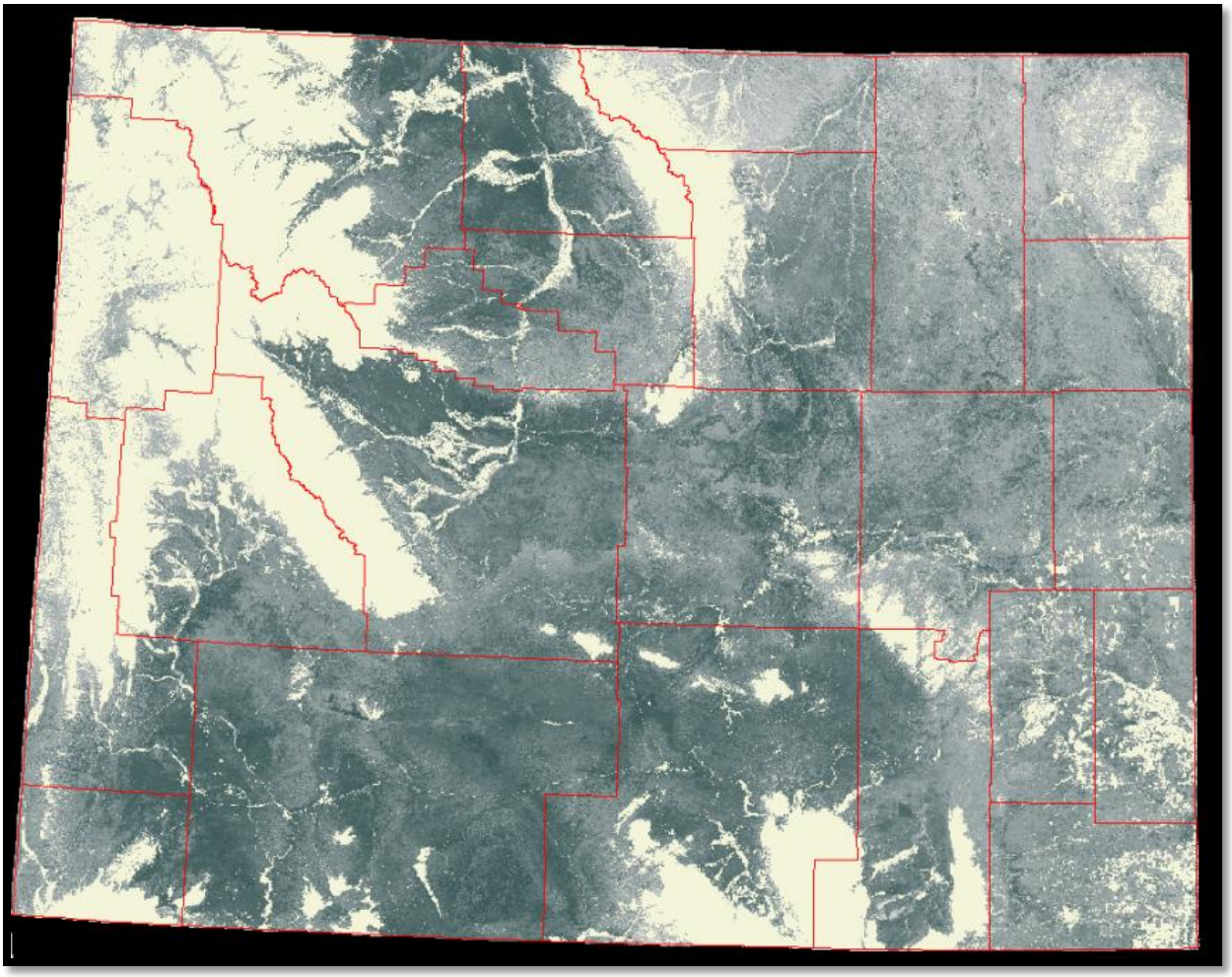
Figure 5. Distribution of Mountain Silver Sagebrush as shown in 'Sagebrush in Wyoming' by Alan Beetle and Kendall Johnson.

Thus the distribution and abundance of any sagebrush species, known to be crucial as forage and cover for sage-grouse, within Wyoming is largely unknown. As planned sagebrush mapping products are developed over the next couple of years this project will provide a means of the State of Wyoming to perform an independent assessment of these data by using a standard sage-grouse habitat database framework (hierarchically organized and scale inventoried) and detailed ground condition information about the sagebrush and associated plant communities across the state.

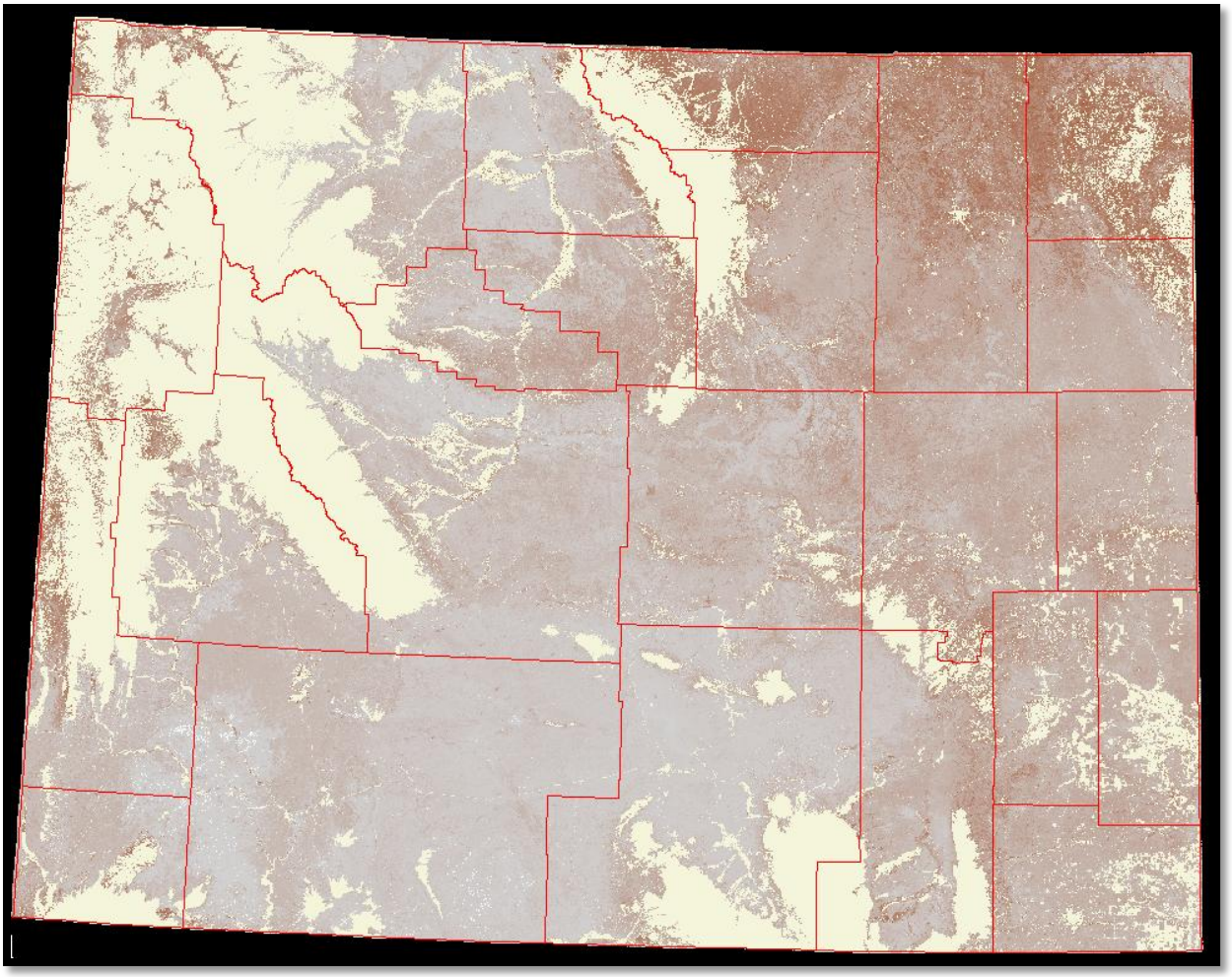
Wyoming Rangeland Component Mapping by the USGS

The USGS Eros Data Center has created a set of 30 m. resolution continuous estimates of 8 crucial habitat variables for assessing rangelands. These data are much anticipated for sage-grouse habitat analysis in Wyoming and this project leveraged these USGS efforts to support our habitat mapping and database development. Further this project has supported development of the USGS dataset and leveraged these data in numerous ways. Development support mainly has occurred as participating and facility stakeholder outreach with the USGS research teams, such as at our April 22nd and 23rd meeting. During this meeting the USGS research principals demonstrated their sampling protocols and showed examples of preliminary sagebrush habitat variable development. WyGISC also provided assistance in assessing the habitat variable mapping by taking preliminary products to the field in May and June of 2009. Results of 6 field trips, 2 by WyGISC and 4 by the Game and Fish Department's Habitat Division, were assembled and transferred to the USGS researchers. Further, WyGISC made available to the USGS our project field sampling dataset providing an independent assessment data source. Finally the USGS data and sagebrush species prediction mapping will be incorporated into the project database and GeoLibrary folder during a planned spring 2010 database update or as appropriately available.

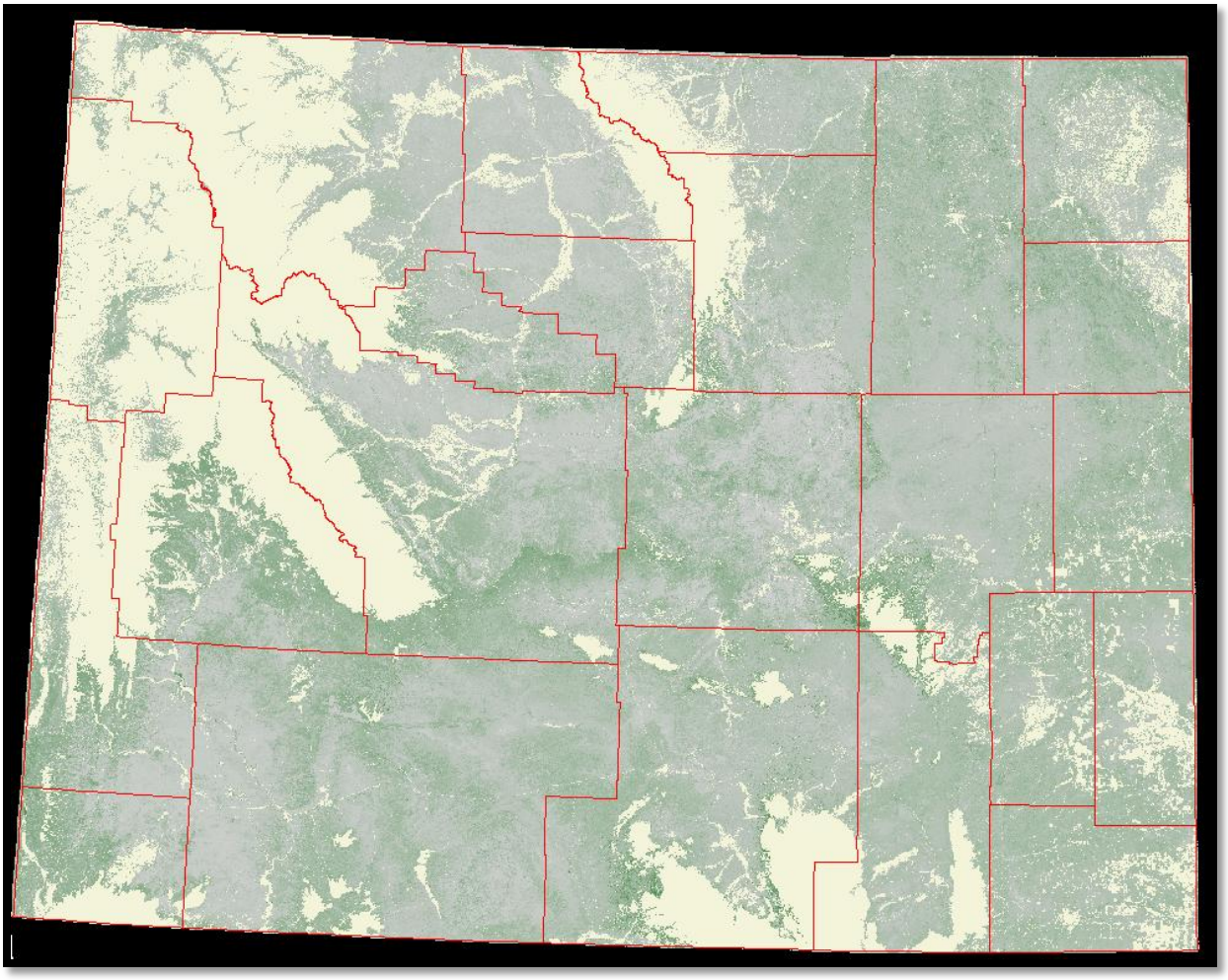
Seven of the GIS raster layers show, in increments of 1 integer percents, estimates of the variables: percent bare ground, herbaceous cover, shrub canopy cover, sagebrush (*Artemisia ssp.*) canopy cover, 'big sagebrush' canopy cover, Wyoming Big Sagebrush cover, and litter. A final layer shows the average shrub heights as centimeters. Colors within the figures show low to high values of each habitat variable as a color scale from light to heavy. Areas excluded from the mapping of the variable are shown in white, such as the higher elevation areas of the state.



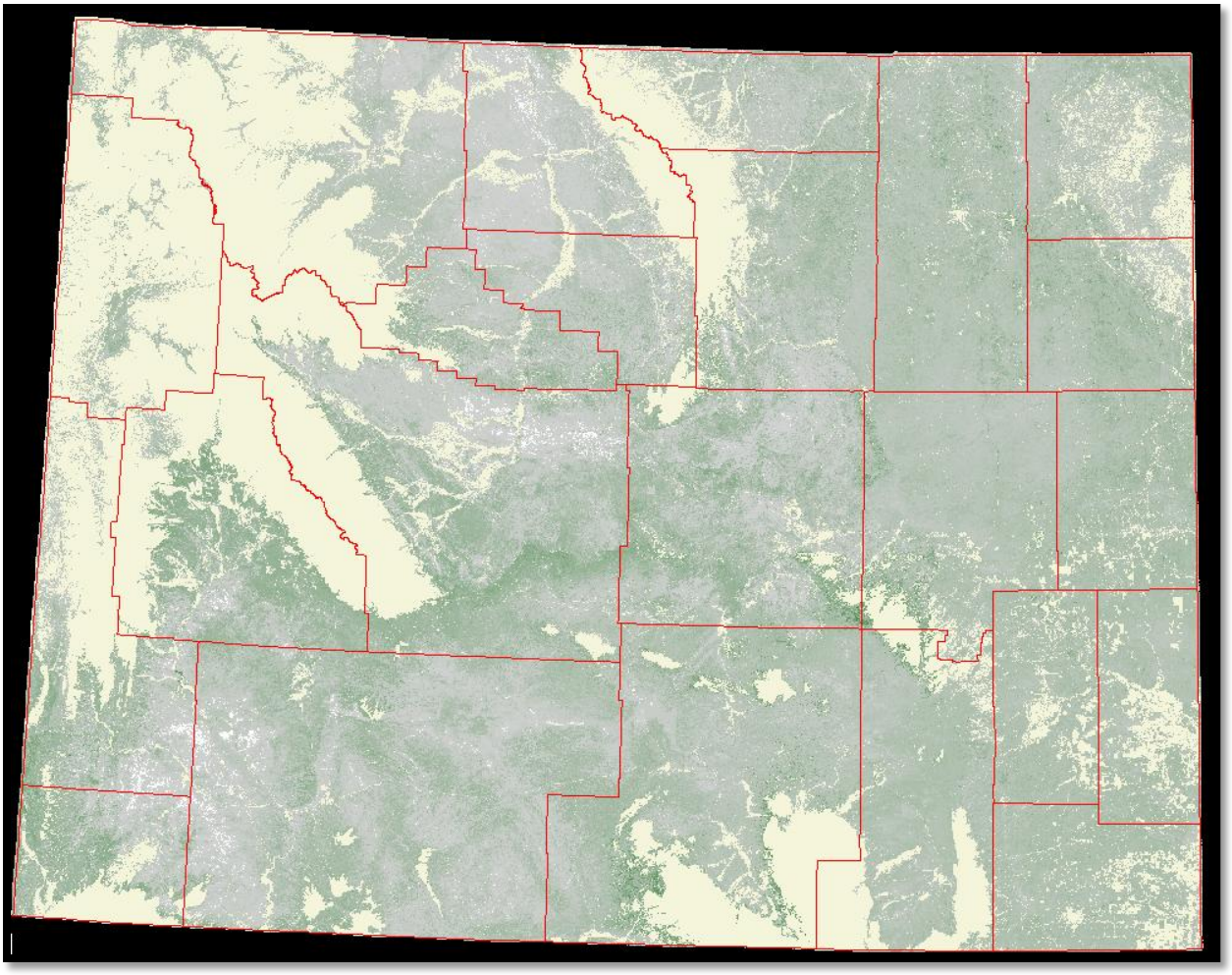
Bare Ground Cover



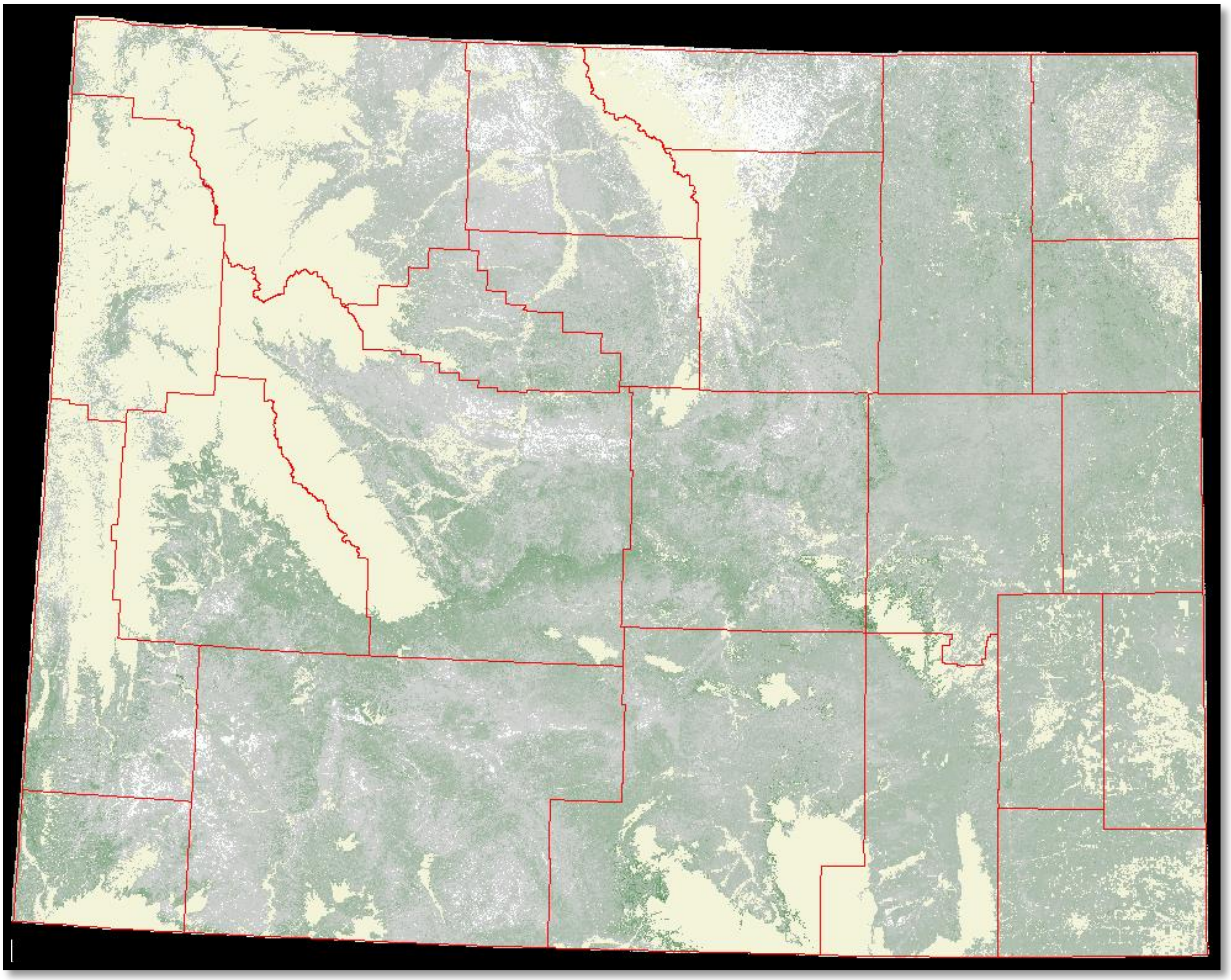
Herbaceous Cover



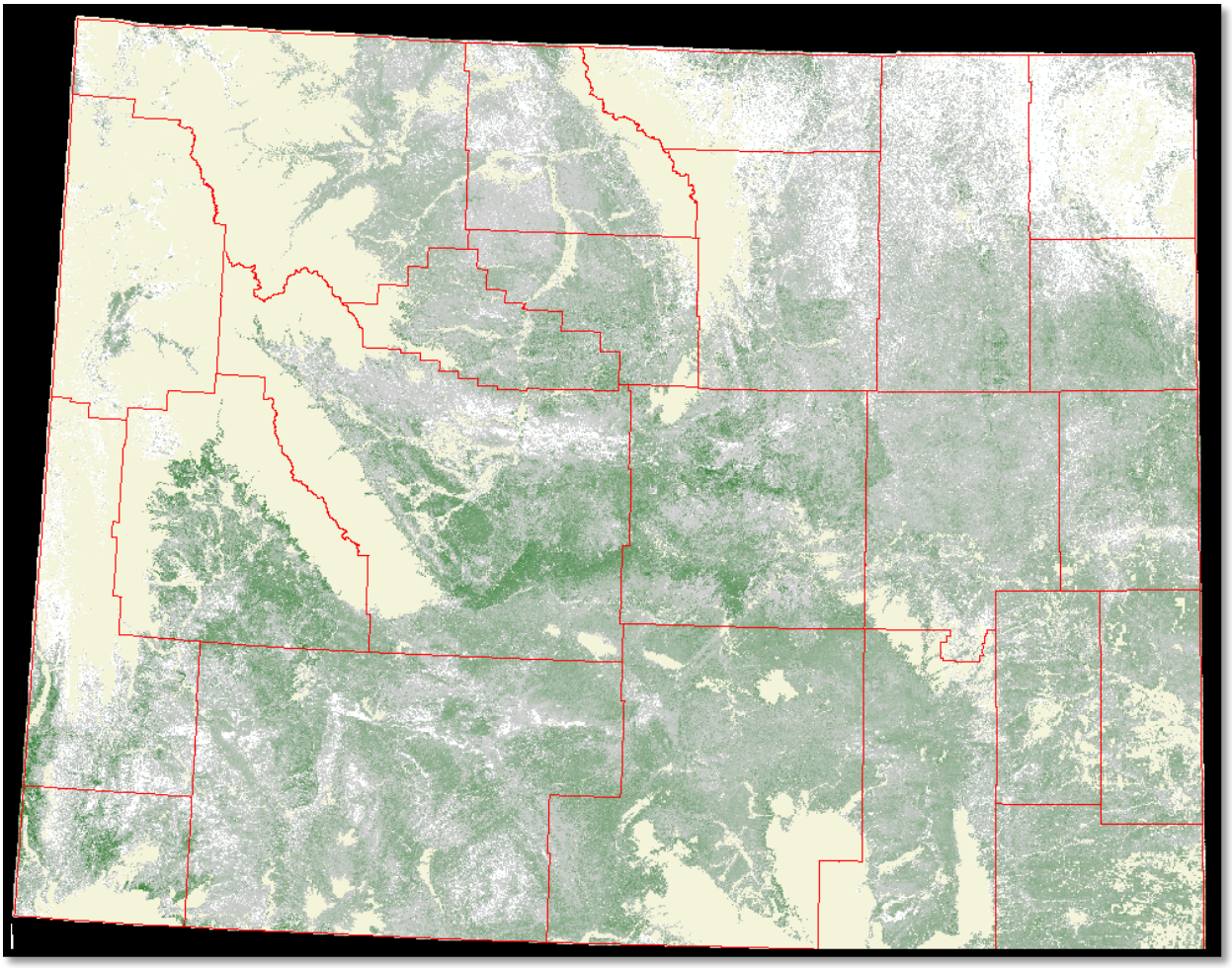
Shrub Cover



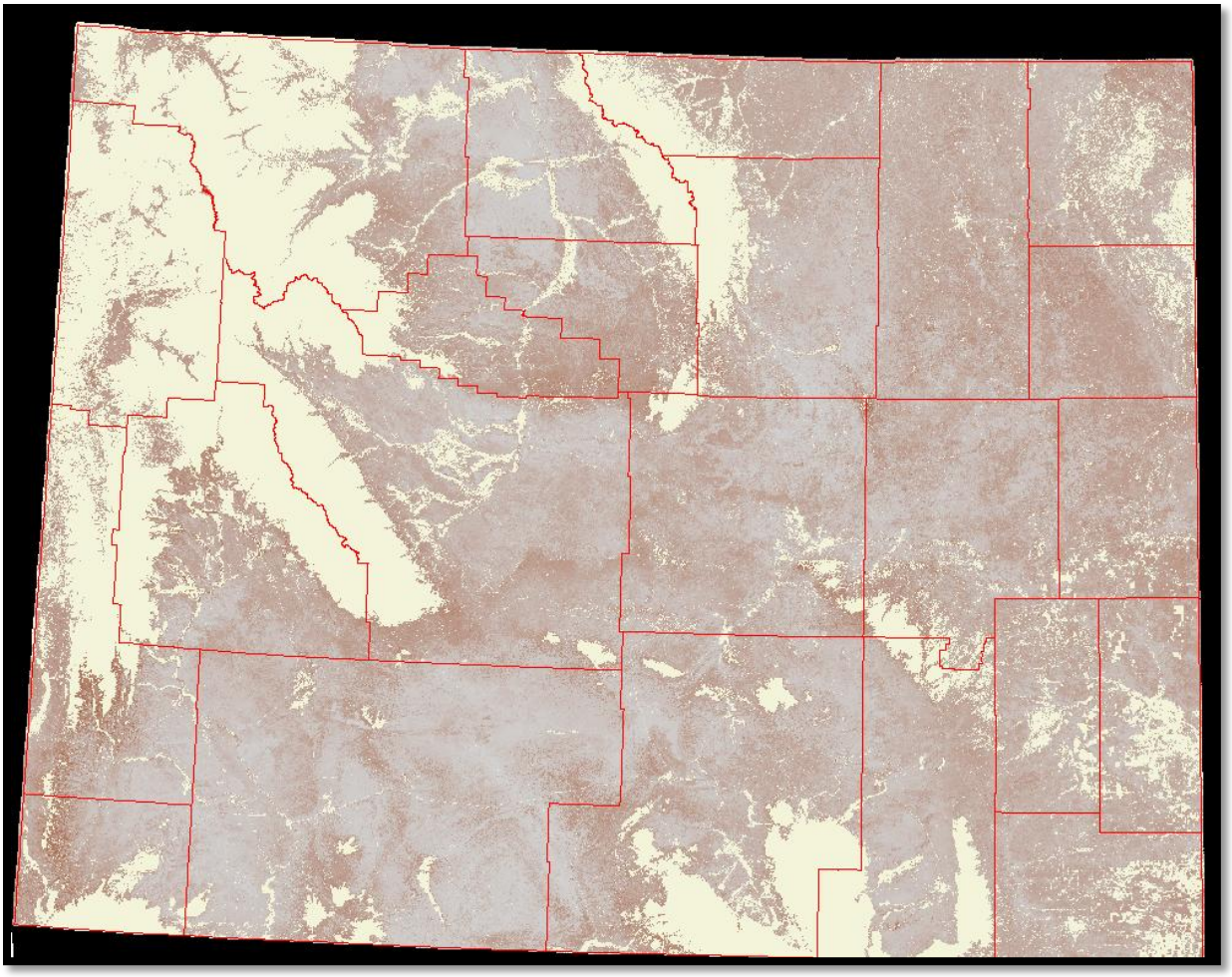
Sagebrush (*Artemisia* species) Cover



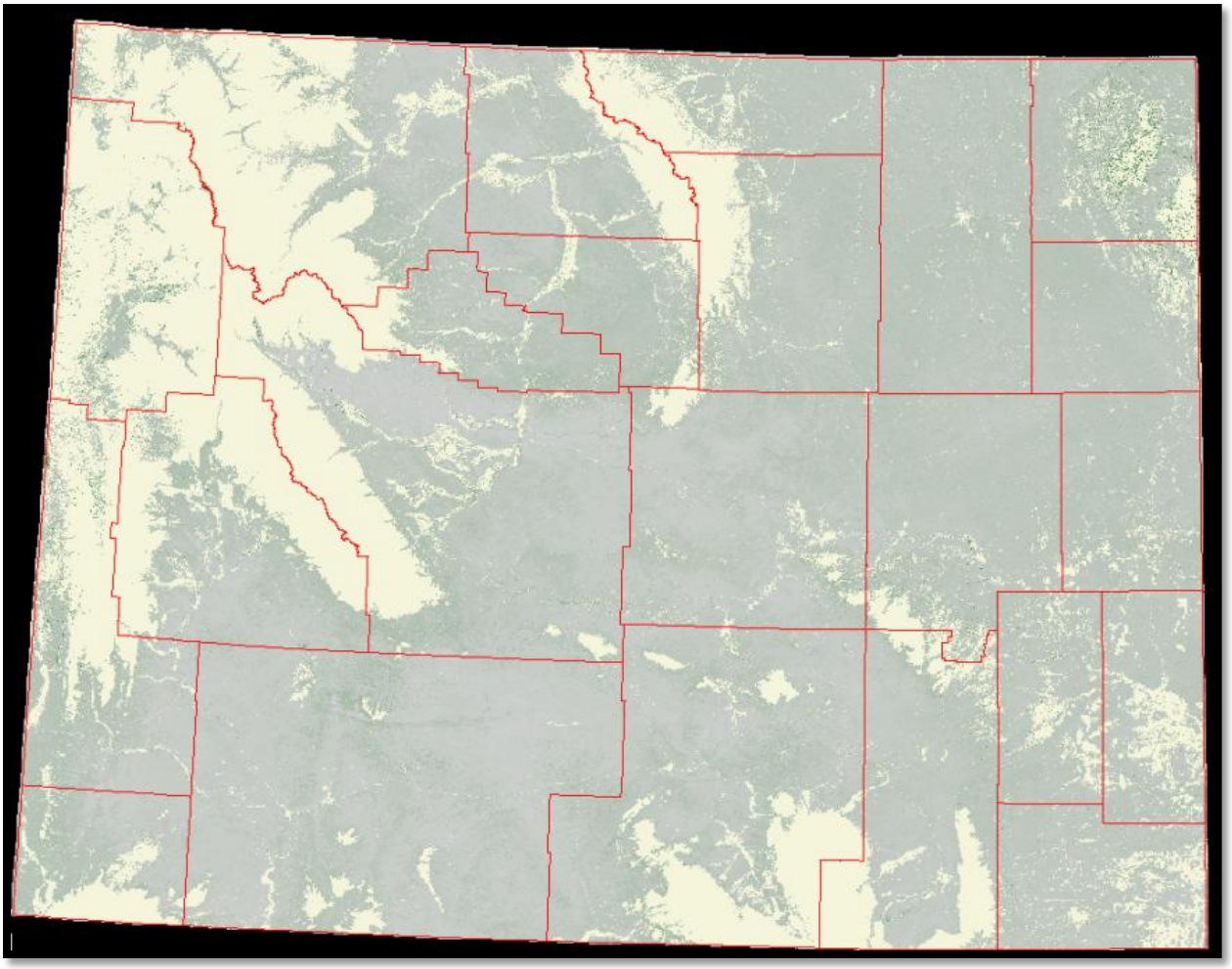
Big Sagebrush (*Artemisia tridentata* species) Cover



Wyoming Big Sagebrush (*Artemisia tridentata var. wyomingensis*) Cover



Litter Cover



Average Shrub Height (centimeters)

Investigation of Federal Agency Sagebrush Habitat Data

The USGS Eros Data Center has generated statewide 30 m. resolution continuous estimates of many key attributes of shrubland communities in Wyoming. WyGISC provided independent qualitative assessment of these data for two locations in Wyoming.

A trip to Northern Albany County in 2 May 2009 produced the following field notes:

Eli Trip 2May09 (North East of Medicine Bow on Marhall and Fetterman roads)						
	WGS84 datum lat/lon					
Site	Latitude (DMS)	Longitude (DMS)		Eli notes, occular estimates with low intensity of investigation	understory	GS estimate
1a, 1b	41 55 33.99 N	106 10 16.22 W		sub-scale (180m north/south), narrow band of PiPo w/ ArWy & maybe ArNo	weathered slate	10% shrub closure
1c, 1d, 1e	41 55 40.35 N	106 10 20.12 W		sub-scale, narrow band of Birdfoot sage and Gardner's Saltbush	carex/grama	6% shrub closure
2a, 2b, 2c	41 58 12.467 N	106 06 17.265 W		7% closure Wyoming big sage at 8 to 12 inches tall	carex/grama	7% shrub closure
3a, 3b	41 59 15.311 N	106 01 05.114 W		Wyoming big sage up to 18% closure in patches, 8 to 12 inches tall, bare ground about 60%	carex/grama	8% shrub closure
4a, 4b	42 01 11.382 N	106 02 05.763 W		4% Wyoming big sage closure at 8 inches tall, more herbaceous cover at site 4 than site 3	carex/grama	8% shrub closure
5a, 5b	42 05 21.22 N	106 02 13.31 W		2% Wyoming Big sage closure at 6 inches tall	carex/grama	7% shrub closure
6a, 6b, 6c	42 07 00.675 N	106 00 20.759 W		Birdfoot sage - Saltbush stand: 8% total shrub cover, 6% of which is Birdfoot sage, 15% wheatgrass cover	wheatgrass	5%shrub & 5% big sage closure
7a, 7b	42 16 53.765 N	105 52 55.500 W		Irrigated hay field, other areas on ranch masked	native hay?	10% shrub closure
During rest of day extensive Black sage stands seen to NE of these sites as well as Wyoming big and birdfoot/saltbush and greasewood/sagebrush stands.						
Most land use is as sage dominant range lands, little treatment evidence noted. Many 'Ranchlet' entrances seen along Fetterman road.						

Another trip on 26 May 2009 to central Carbon County including the Hanna Sage-Grouse Core area (see Figure 17) was conducted by WyGISC. Most sites visited showed good results from the USGS work. The principle issues noted were of the USGS data not being masked for land uses. Field work notes of masking issues are below:

Projection: UTM, zone13, nad83 datum								
X	Y	Issue						
378790.00	4622344.00	In this general area the data used to mask Insterstate 80 and State Highw						
384926.00	4620442.00	Small lake not masked, mapped as sagebrush						
368573.00	4637872.00	Reclaimed stip mine - coal						
360594.00	4639385.00	Clouds masked						
373490.00	4642118.00	Mining facility						
373391.00	4652718.00	Ranch with irrigated hay						
358730.00	4658749.00	Ranch with irrigated hay						
358000.00	4664938.00	irrigated hay to north of pt						

Further assessments were conducted by Game and Fish Department Habitat Division Staff including Bill Gerhart, Bert Jellison, Keith Schoup, and Jerry Altermatt. These assessments were transferred to UGSS by the project.

Field Data Survey

Sage-grouse habitats in Wyoming consist of a variety of plant communities with all sharing common floristic characteristics such as members of the Artemisia shrubs being common. A key component of this project was the need to collect extensive data about these vegetation communities across the sage-grouse habitats in Wyoming. Consistent and rigorous collections of information about all the vegetation communities in the sage-grouse habitats of Wyoming are not performed programmatically. This is partially due to the significant costs involved in addressing such a large area, see Figures 3 and 17, but also in the challenges of providing consistent information across a variety of land uses and ownerships containing the habitats. An additional constraint for this project was the need to collect sufficient data within one growing season. Further, a lack of domain wide existing sampling stratification (i.e. an existing map that can be used to predetermine sampling locations) increased the need and complexity of the field sampling protocols.

Primary protocol needs and goals needed to satisfy multiple tasks. We also provided samples for a state-wide prairie dog survey in 2008 by recording the presence or absence of the prairie dogs at sample location and an estimate of the number of their mounds.

Field Data Collection Project Goals:

1) This project collected statewide data to:

   A. Provide an independent assessment of the USGS generated state-wide sagebrush closure stratification (Homer et al. 2009).

   B. Provide field data for training of a sagebrush community model to be appended to the state-wide sagebrush stratification.

2) This project also collected data at focused areas needed to conduct regional or project level summer habitat mapping with remote sensing and ecological modeling.

3) Finally this project attempted to demonstrate standard protocols for field data collection efforts undertaken by collaborators.

Field Sampling and Assessment Protocols Collaborative Workshop

At the beginning of the project we sponsored a workshop with collaborators to review appropriate methods of field data sampling for mapping. We also compared these techniques to those used for sage-grouse habitat assessments by the WGFD, US-BLM, US-NRCS, and US-FWS. The workshop on April 22nd and 23rd included members of energy and agriculture industries (Wy Farm Bureau, Wy State Grazing Board, Encana, Williams, Powder River Coal, many environmental consultants), Audubon Wyoming, the Sublette and Medicine Bow County Conservation Districts, USGS, BLM, NRCS, FWS, WGFD, Wy DEQ, Wy Dept of Ag, and the University of Wyoming.

Figure 6. Project collaborators meet April 22 and 23 to discuss the sampling protocols employed by state and federal sage-grouse assessment protocols, the techniques employed the USGS to sample and map rangelands, and the techniques employed by this project. Collaborators recognized many consistencies among approaches. Spatial scale dependencies of sampling techniques are crucial however, where data used to provide a map source such as satellite imagery delimits the footprint or extent of observation one must use in field sampling.

The second goal of the project's first collaborative workshop was the determination of field crew areas of focus, chain of supervisory command, and level of effort. Based on ongoing efforts of collaborators to identify sage-grouse core areas and population density areas and anticipated impact from habitat modification compared to existing mapping priority areas were identified. The identification of field priority areas is also part of the decision support database framework development, in that these areas are defined with user needs requiring fine to intermediate scales of thematic and spatial content (see Figure1). Field data collected in 2008 essentially begins field mapping efforts for areas identified as lacking needed habitat information and is thus an example of the 'living nature' of the project protocol since the field data must be collected before models of habitat for each area can be developed.

Protocols to conduct seasonal sage-grouse habitat site assessments are included in Appendix D. Sampling protocols applied in this project ultimately need to provide analogous information to complementary elements of the assessments. Specifically the methods used to sample and characterize (e.g. vegetation heights) cover at field training data sites. Currently among project collaborators, field data collection of vegetation cover is performed with a number of different techniques. Often these techniques are intended to produce comparable information that will ultimately be

used to follow recommended guidelines. For example a specific range of sagebrush canopy cover may be necessary for sage-grouse fecundity. Quantification of sagebrush cover must therefore provide information comparable to the scientific techniques used to set the guidelines. Habitat mapping via remote sensing, regardless of the modeling technique employed, relies on an appropriately descriptive field dataset.

Project collaborators have provided many recent scientific contributions to the needs of field sampling for remote sensing. The sampling protocols used in this project are shown in Appendix C. Examples of the protocols listed for sage-grouse habitat assessments by the USDI_BLM and Wyoming Game and Fish Department are shown in Appendix D for reference. Other studies by collaborators with the USDA Agricultural Research Service have provided useful points of reference such as Booth and Tueller, 2004 'Rangeland Monitoring Using Remote Sensing' with specific reference to some of Neil West's conclusions and specifically to vegetation sampling in Booth et al. 2006 'Accuracy of Ground-Cover Measurements'. While some elements of sampling are constrained by scale dependencies all are linked by the fundamental estimation of vegetative cover.

This project has attempted to standardize field data collection as per current habitat assessment guidelines and to compare to partner protocols currently ongoing, such as in industry, the USGS, and partner universities and agencies. Results of the collaborative meeting demonstrated that many techniques of sampling vegetation cover result in comparable measures, but the spatial scale of determining a sampling unit is crucial.

Field Crew Training

Once field crew staff and priorities were assembled we initiated project protocols to train and ensure quality of field crew efforts in May and early June. Depending on staff (volunteer or summer techs) experience and interest the project began with attendance at a project sponsored symposium at the University of Wyoming featuring experts in the elements of Sage-grouse habitat ecology.

Training of WYGISC crews was conducted at the University of Wyoming, including field trips to study sampling protocols. Joy Handley Assistant Botanist with the Wyoming Natural Diversity Database provided a 2 day class and herbarium trip to WYGISC crews and Gretchen Meyer of BLM on identification of common non-woody

Wyoming plants. Dr. Larry Munn provided a 2.5 hour lecture on Wyoming soils and their environmental attributes. Dr. Ken Driese provided a lecture on Wyoming Landforms. Eli Rodemaker provided multiple days of class and field training on the project goals, methods, and identification of sagebrush and other woody species in concert with Joy, Larry, and Ken's classes for about a week total 'mini-course' on sampling for Wyoming Landscapes.

Next steps will include multiple training sessions at regional locations in the state in June. These will usually include a partial day lecture in project goals, techniques in vegetation identification, and demonstration of the sampling techniques in the field.

During the length of the growing season, these training sessions are repeated in an effort to "re-calibrate" crews working individually. The project manager verifies crew sampling and provides feedback about protocols to the crews. Finally, field data is quality assured by a two-stage process of a local expert or supervisor reviewing crew data and then the project manager and staff reviewing all data collected across the state, see WYGISC sampling protocol below.

Figure 7. With help from Implementation Team members a group of twenty private consultants and BLM staff were recruited to collect field samples in the 'Powder River and Great Divide Basin' areas. These twenty volunteers joined Eli Rodemaker, two of his staff, and Bert Jellison in Sheridan for a half day conference meeting and one and a half days of field training on sampling techniques for needed project data. These volunteers were able to provide a significant set of field samples while conducting planned work.

Figure 8 shows the results of all field crew efforts using the WyGISC sampling protocols.

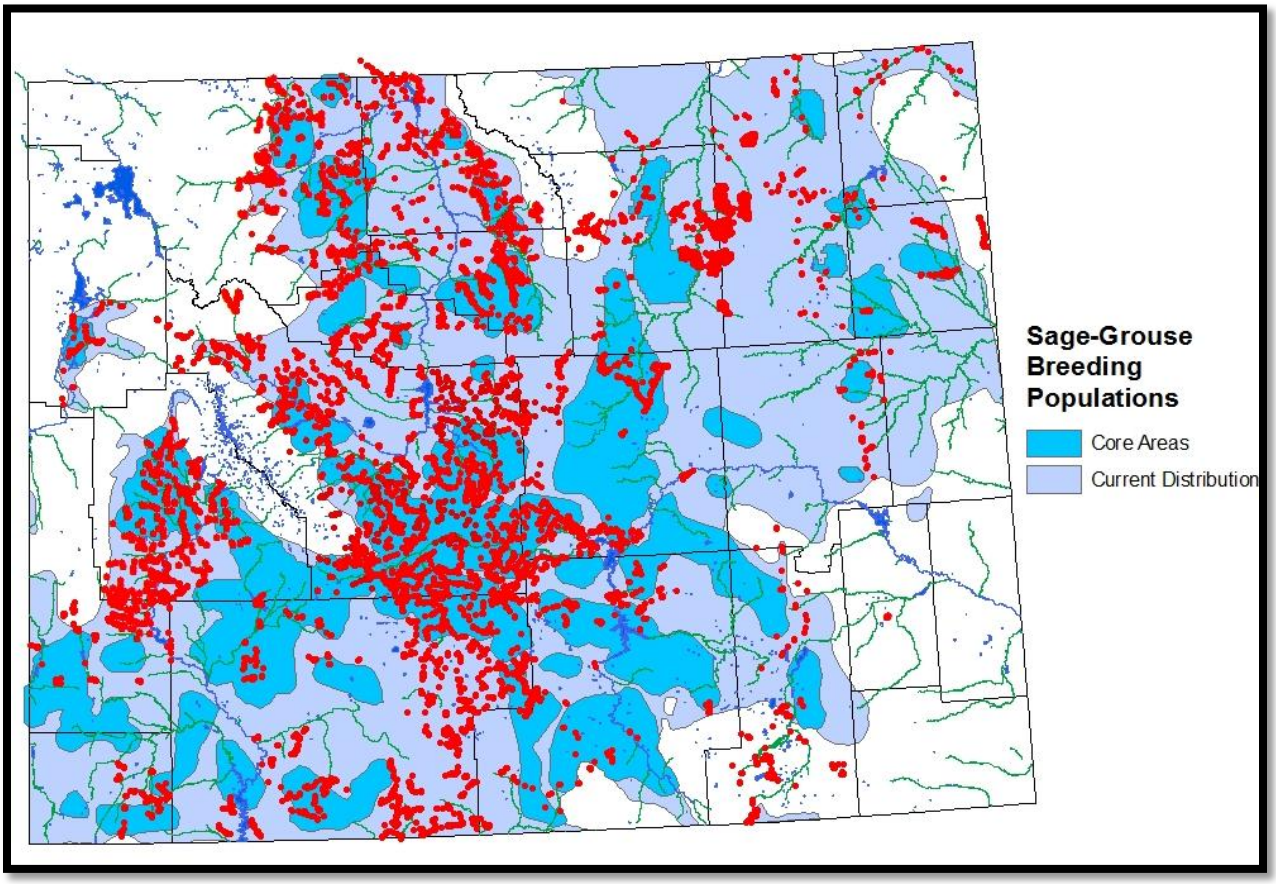


Figure 8. Locations in red of field sample sites collected with the WyGISC protocols and the distribution of the sage-grouse in Wyoming.

Field Sampling Protocol

The following is an example of the sampling protocol used in recent WyGISC remote sensing efforts: “The primary goal of the field protocol is to provide samples of homogeneous terrain units at the appropriate scale. The sampling protocol selects the ‘pure’ (30 m. X 30 m.) pixels in the center of a terrain unit and eliminates ‘edge’ pixels which are not.

Reference data are usually collected by multiple field crews. Some crews use a GPS and laptop with remotely sensed imagery and GIS layers as reference. These crews delimit a GIS polygon over the imagery as a spatial sample of a field reference

site. Other crews use a GPS unit and describe the spatial relationship of the field reference site to a GPS coordinate. All crews collect site photos and complete a 'two page' field form (or digital GPS Data Dictionary) containing spatial, terrain, and floristic data fields for each sample site. Field collection data include notes on perceivable anthropogenic impact, soil color, relationship to neighboring sites, and the sampling confidence or fitness of the unit type. See Appendix C for an example field form, the data collection instructions, foliar cover chart, and cover type list for stratification examples.

The sampling protocol, partly due to the demands of the modeling technique, relies on a large sample size in trade for some level of detail and precision in measurement. The primary tool for estimation of vegetation cover was ocular estimation. In order to provide consistency among field crews and within a crew from day to day, crews use "comparison charts for visual estimation of foliage cover" adapted from Terry and Chilingar (Anderson 1986). Often termed the "Petri Dish" charts, they provide a calibration to various foliar covers in different spatial patterns. See Appendix C.3- Ocular Cover Chart for an example. Importantly, all crews are also trained together in multiple seminar and field trip meetings early in the project and as calibration regroup during the field season on multiple occasions. At the trainings, crews use line-intercept and quadrat sampling methods as well as ocular estimation at test areas to become experienced with sampling cover. At the calibration meetings, crews again compare ocular estimates to line-intercept or quadrat sampling as well as review sampling protocols and plan target areas or types. Through the field season crews are encouraged to employ line-intercept or similar sampling as needed to retain estimation confidence.

Crews also receive training from botanical experts on vegetation species identification. As needed, crews are instructed to collect specimens of unknown species with significant abundance. These unknown species are either identified by local experts or, in the case of some sagebrush, using the 'black light' florescence technique. Sagebrush species identification and nomenclature follow Robert Dorn's (2001) treatment with cross reference to Alma Winward's (2004) or Alan Beetle's treatments (Beetle and Johnson 1982) and other previous publications or treatments from neighboring states such as Montana and Idaho (Beetle 1960, Frisina and Wambolt 2004, Tart 1996, Hironaka et al. 1983, Rosentreter, 2003). 'Black lighting' of sagebrush species follows the process and florescence categorization of Rosentreter (2003) and Rinkes (2006).

Figures 9 and 10 (below) show example GIS data generated during field sampling. Examples of samples where polygon spatial information was digitized in the

field with a laptop computer are shown in Figure 9. Figure 10 shows an example where point based data was collected with differentially corrected GPS waypoints.

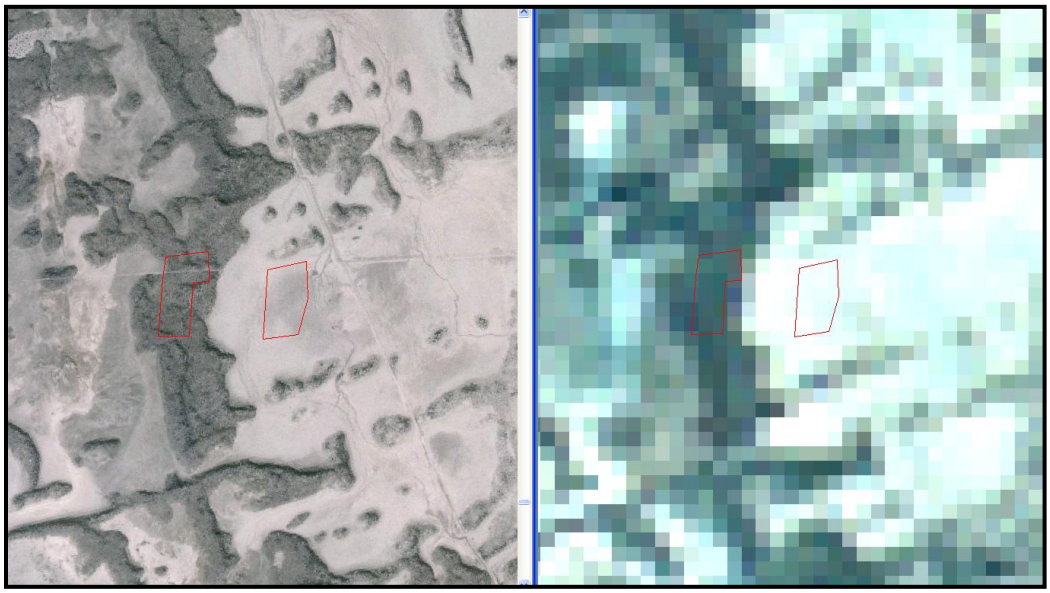


Figure 9. One-meter color infrared imagery on the left and Landsat Thematic Mapper (TM5) imagery on the right with GIS overlay of two polygons digitized in the field for spatial samples of terrain units.

Figure 10. Differentially corrected GPS waypoints used to reference sampled terrain units.

Ultimately, field reference data are used to sample specific Landsat Thematic Mapper pixels (30 m. x 30 m. or 900 sq. m.). To do this, the GPS-collected field data are translated from points to a spatial extent using information about each sample point. For instance, some of the sites inaccessible to the field crews are moved in the lab based on field notes. Further, as mapping strata are refined, the spatial position of the GPS and polygon data are reviewed and sometimes adjusted based on field notes and remotely sensed imagery, e.g. into a more representative pixel or pixels. In general the spatial extent of the samples generated from GPS only are kept small due to subjectivity of interpreting field notes and the relative inexperience of the field crew. An example of the derived spatial samples is shown in Figure 11.

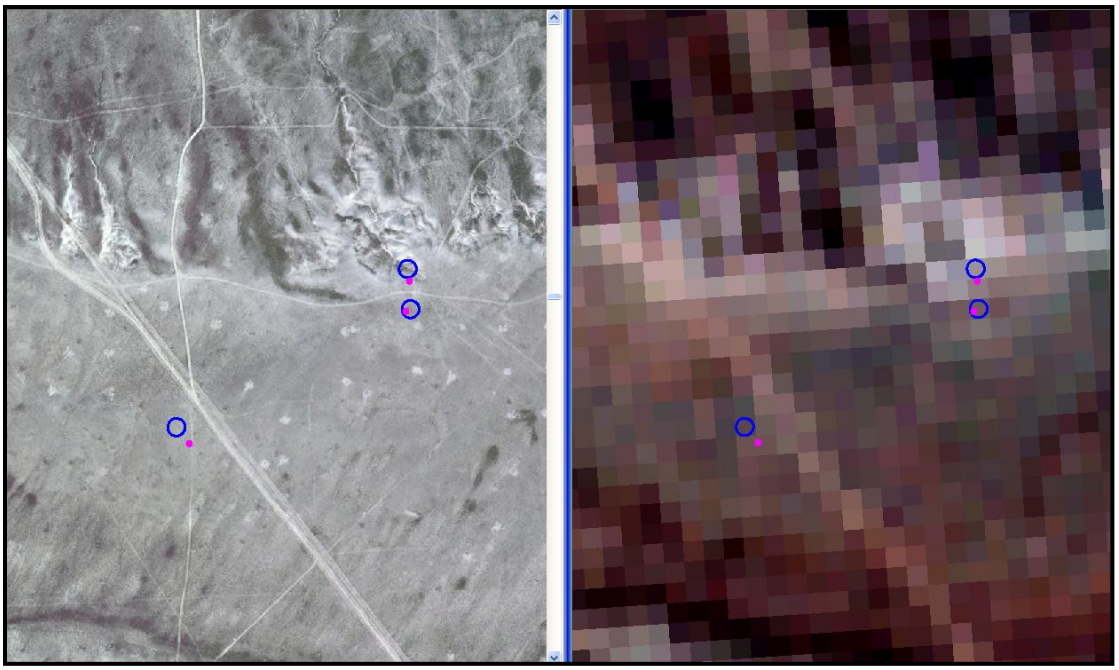


Figure 11. 1 m. Color Infrared Aerial imagery on the left with Landsat Thematic Mapper on the right. On both images GIS overlays of the GPS waypoints and a polygon overlay of the derived spatial sample are shown.

Field Data Collection Leveraged to Jump-Start New Regional Land Cover Efforts

Field data has been entered into a database and GIS to allow for the querying of multiple environmental attributes sampled at thousands of rangeland sites across the state. Besides being used to generate a current statewide sagebrush map and provide samples for inventory, the field database itself will be used to answer future research questions and needs. Such as where updated or finer scale regional level assessments and mapping efforts still need to be preformed within the state. Field data will be used to jump-start mapping efforts for areas needing more detail or newer maps than currently existing or produced as part of the Governor's state-wide effort.

Creation of Sagebrush Species Distribution Maps

Distribution Maps for 12 Wyoming Sagebrush Species Complete

A statistical modeling approach was investigated for the species and varieties of sagebrush of interest within the sage-grouse habitats of Wyoming. Statistical models were informed by samples of the species of interest distribution. These samples were developed from the extensive field survey elements of the project.

Wyoming Sagebrush Species Meta-analysis for Key Environmental Attributes

In order to inform the modeling process we performed a Meta-analysis about the crucial environmental attributes of each of the sagebrush species to be modeled. The meta-analysis was focused to research conducted in Wyoming, see below, but expanded versions were created from neighbor states when information was unknown for Wyoming. A summary table of the resulting meta-analysis is shown in Appendix E.

Field Data Used in Modeling

The total number of field sites visited by the field teams was 8,045. As explained in the sampling protocol section earlier, 1,083 of these 8,045 sites were collected with a

GPS only technique while 6,962 sites were collected with a GPS and laptop computer technique. The use of laptop computers with geospatial data loaded such as remotely sensed imagery provides much more confidence about the extent and location of a field sampled site and will frequently allow for more area of the site to be assessed.

Statistical sampling of field visited sites was conducted along a 900 sq. m. grain or 30 m. by 30 m. orthogonal area. The number of samples per site depended on the size of the area sampled at the site, for example if the site was square and 9,000 sq. m. then up to 10 samples could be created from the one site. These sites represent pseudo-replicates, but can be used in the statistical approaches chosen in this project as replicates. During database development, quality assurance and quality control of the field data we reduced the number of sites to 6,377 producing a total number of 50,232 samples (pseudo-replicates) for statistical analysis, see Figure 12.

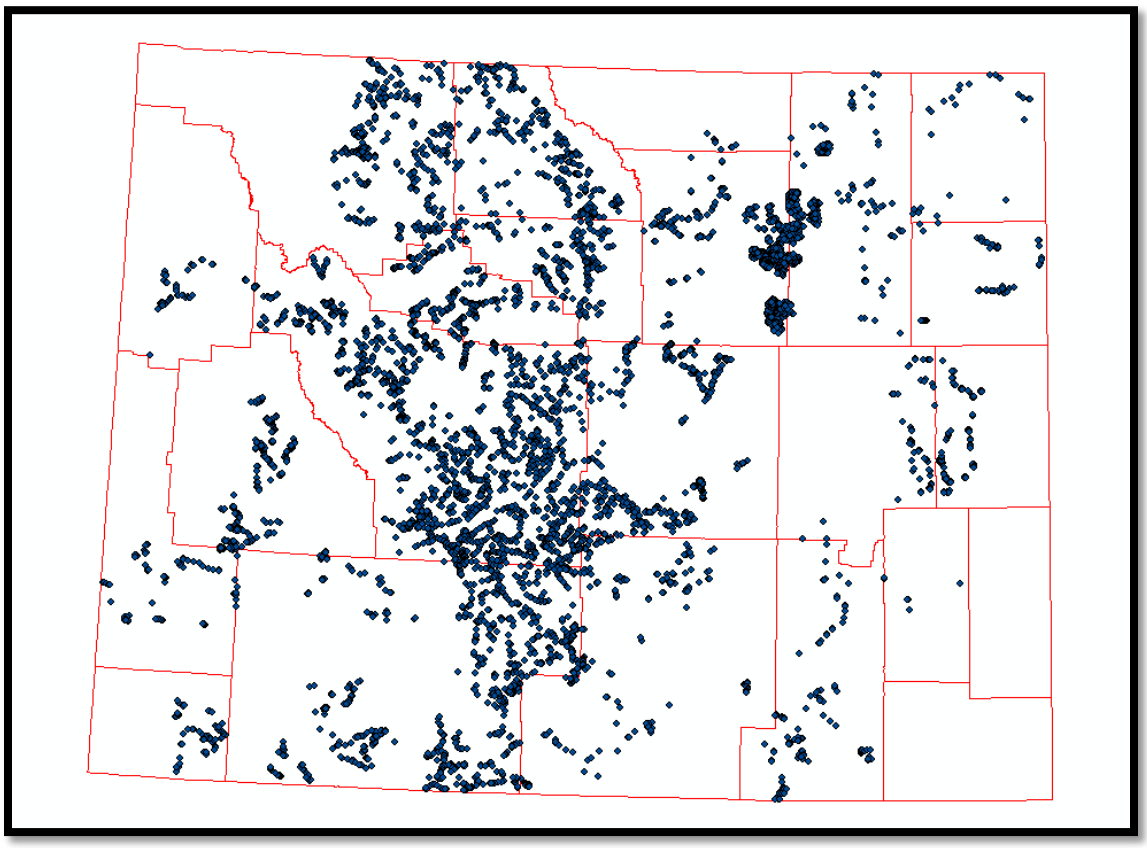


Figure 12. Distribution of 6,377 field sites resulting in 50,232 samples used in the modeling process.

Not all sites sampled were sagebrush dominated or rangelands as crews were instructed to collect representative data from all appropriate land cover types identifiable

in a survey area. See Appendix C for a detailed description of sampling protocols and the list of land cover types used to identify potential sampling strata. A summary of field data collections by sagebrush species are shown below.

Species/Variety	Number of sites discovered	Number of sites as dominant cover type	Number of samples
Basin big sagebrush	366	145	1257
Birdsfoot sagebrush	293	118	841
Black sagebrush	582	254	1423
Bud sagebrush	18	3	18
Early (Alkali) sagebrush	69	32	113
Fringed sagebrush	385	24	6860
Low sagebrush	25	3	103
Mountain big sagebrush	818	511	1830
Mountain silver sagebrush	101	8	450
Plains silver sagebrush	192	56	3013
Sand sagebrush	53	4	507
Tall three tip sagebrush	8	5	11
Wyoming big sagebrush	3469	2045	25529
Wyoming three tip sagebrush	76	31	528
Sagebrush totals:	6455	3239	42483

Table 1. The distribution of sagebrush species sampled by sites. Some species were found in more than one site.

Algorithm development

In general, we generated a statistical model of the distribution of sagebrush species or varieties and used GIS models to map the probability of presence in Wyoming. The sagebrush of interest within the sage-grouse habitats of Wyoming included:

- Basin big sagebrush *Artemisia tridentata var. tridentata* (Rydberg) Boivin,
- Birdsfoot sagebrush *Artemisia pedatifida* Nuttal,
- Black sagebrush *Artemisia nova* Nelson,
- Bud sagebrush *Picrothamnus desertorum* Nuttal,
- Early (Alkali) sagebrush *Artemisia arbuscula var. longiloba* (Osterhout) Dorn,

- Fringed sagebrush *Artemisia frigida* Willdenow,
- Low sagebrush *Artemisia arbuscula* Nuttal *var. arbuscula,*
- Mountain big sagebrush *Artemisia tridentata var. pauciflora* Goodrich, McArthur, Winward *or Artemisia tridentata var. vaseyana* (Rydberg) Boivin,
- Mountain silver sagebrush *Artemisia cana var. viscidula* Osterhout,
- Plains silver sagebrush *Artemisia cana* Pursh *var. cana*,
- Sand sagebrush *Artemisia filifolia* Torrey,
- Tall three tip sagebrush *Artemisia tripartita* Rydberg *var. tripartita*,
- Wyoming big sagebrush *Artemisia tridentata var. wyomingensis* (Beetle and Young) Welsh,
- and Wyoming three tip sagebrush *Artemisia tripartita var. rupicola* (Beetle) Dorn.

Species or varieties ultimately not mapped but known to occur in Wyoming included Rothrock sagebrush *Artemisia Rothrockii* Gray, Sand sagebrush, Tall three tip sagebrush, and Subalpine sagebrush *Artemisia spiciformis* Osterhout. Hot springs sagebrush *Artemisia arbuscula ssp. thermopola* Beetle, Subalpine sagebrush, and Rothrock sagebrush are not known to occur (Beetle, 1982) in sage-grouse habitats identified by the Wyoming Governor's Sage-Grouse Implementation Team and were not discovered during field sampling of these area. Sand sagebrush was sampled at 53 sites for 507 samples but statistical models would not converge to a dependable logistic regression. Only four sites of Sand sagebrush were describe as a Sand sagebrush dominant land cover and all these sites were located in Platte County outside of the sage-grouse core areas. Tall three tip sagebrush (8 sites/11 samples) was sampled rarely in sage-grouse habitats and a statistical model was not attempted.

About 100 layers of GIS data were used in this study, which include 8 layers of topographic datasets, and 92 layers of climatic datasets. The final grid is 30 m., but due to the spatial resolution of the major model input dataset (DAYMET climate dataset), which has a spatial resolution of 1km, the resulting resolution of the final products are approximately 1km. The general accuracy for the model outputs are approximately 80-85%.

The logistic regression models with logit link were developed using SAS 9.1. Using stepwise selection approach, the software automatically selected significant covariates from the environmental response variables. Then, we looked at the 95% Wald confidence interval to make sure those selected covariates make sense. Later, we applied Hosmer-Lemeshow test on the logistic regression model and the test showed our model fit very well. At a certain cutting point, the specificity and sensitivity can both reach above 80%. In general, all those tests showed our model fit very well.

Climatic and biophysical predictor variables were selected based on their hypothesized influence on the spatial distribution or environmental space of the modeled species. The selection process was constrained by the availability, spatial resolution, and geographic extent of particular environmental layers. Data describing important processes that potentially constrain plant distributions, such as interspecific competition, dispersal barriers, or site disturbance history, all of which may cause local extinctions or limit colonization of ecologically suitable habitats, are currently unavailable at appropriate spatial scales (Phillips 2008). Many explanatory variables acquired or developed for the models represent proxies for other, more direct, limiting environmental conditions. For example, data describing aspect, slope position, and precipitation may serve as surrogate variables that indirectly quantify soil moisture availability. All explanatory data layers were spatially assembled in a GIS to a common data projection for use in the models (Lambert Conformal Conic NAD 1983).

Climatic gradients have been shown to significantly affect plant species distributions in complex mountainous terrain (Ohmann & Gregory 2002; Engler et al. 2004). In Oregon, habitat studies have identified associations between climatic seasonality and vegetation gradients (Ohmann & Spies 1998). Climatic data were acquired from Daymet (http://www.daymet.org/), a model developed at the University of Montana that integrates daily weather measurements from ground-based meteorological stations and Digital Elevation Models (DEM) to produce continuous 1.0 km. resolution grid layers for the conterminous United States (Thornton et al. 1997). A total of 91 climatic variables were processed in a GIS and include monthly and annual mean values for air temperature, precipitation, daily short wave radiation, and water vapor pressure. DAYMET grids were resampled to a 30 m. grid cell size to correspond with the spatial resolution of the predictive models.

Environmental predictors representing physical habitat parameters were derived from a DEM developed from the USGS Shuttle Radar Topography Mission (SRTM; http://eros.usgs.gov/products/elevation/srtmdted.php#). The SRTM data was collected using Interferometric Synthetic Aperture Radar (IFSAR) in February 2000 by NASA and is available at a spatial resolution of 30 meters. We further processed the elevation data in ERDAS Imagine 9.3 (ERDAS, Norcross, GA) using a moving window mean focal filter to fill isolated pixels lacking data with the mean elevation values of adjacent pixels. A total of 9 topographical variables were developed from the elevation data and include slope, terrain curvature, surface roughness, and a landform model. All variables were generated using various Spatial Analyst tools in ArcGIS 9.3 (ESRI, Redlands, CA). An index representing terrain curvature was calculated for both the parallel and tangential

directions relative to the steepest slope. Surface roughness was derived from the standard deviation of elevation values in a moving windows analysis. Landform categories representing site moisture availability were derived from a model incorporating slope, aspect, location, elevation, flow direction, flow accumulation, and other interpolated data (Manis et al. 2001). Terrain aspect was used to estimate the radiation budget of a site based on a model proposed by Roberts and Cooper (1987).

For this project we employed a new WyGISC potential riparian zone model to help delineate the habitats of sagebrush species. The explanatory model delineating the riparian or flood zone was also developed from the SRTM elevation data and various hydrologic analysis tools available in ArcGIS 9.3. A stream network was first calculated from elevation values (Figure 13). Regions of pixels representing the spatial extent of riparian areas were subsequently delineated based on slope and elevation gradients adjacent to the computed stream network locations (Figure 14). A cost distance tool in GIS was used to delimit the riparian zones based on specified maximum slope thresholds. A total of 9 riparian classes, representing various stream orders, and one upland class were generated in an automated fashion. Additional information was added for waterbodies, such as reservoirs and lakes, using the National Hydrography Dataset (NHD: http://nhd.usgs.gov/). Finally, areas within the hydrologically closed Great Divide Basin did not perform as expected (Boggy Meadows, Red Wash northwest to Red Lake) and were manually modified on the riparian zone layer and cataloged separately.

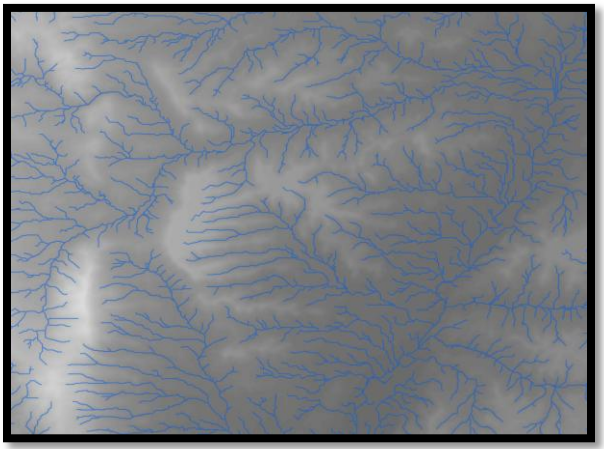


Figure 13: Stream locations computed from DEM.

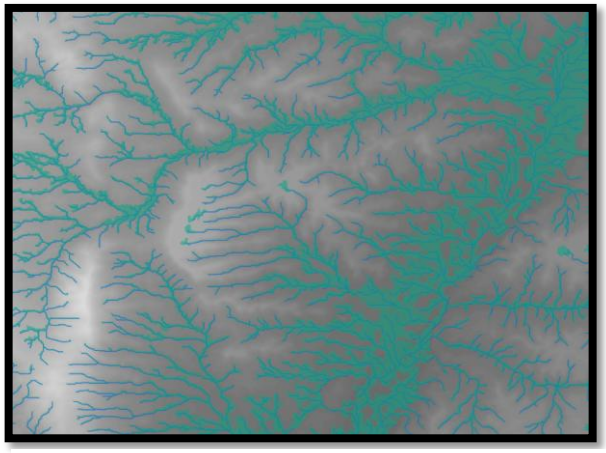


Figure 14: Floodplain extent estimated from slope and elevation thresholds.

An area of the riparian layer and a corresponding area of a Landsat image are shown in the figure below over. The colors in the riparian area layer are related to stream order or position within the watershed.

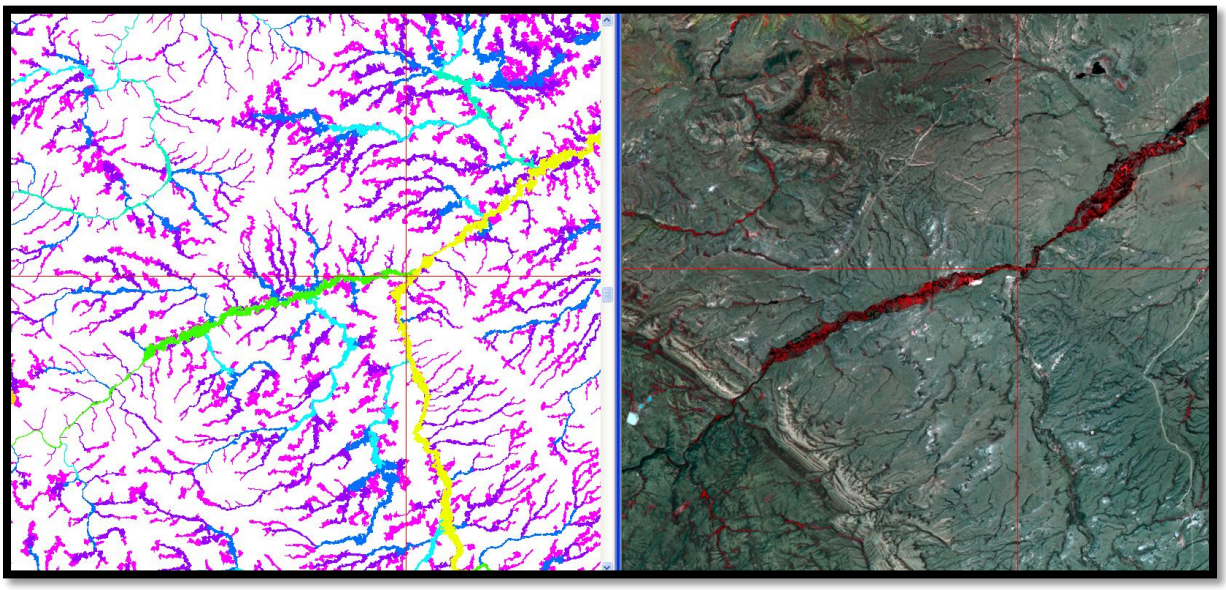


Figure 15a. Color coded riparian delineations on the left shown with a corresponding area of Landsat Thematic Mapper imagery (Path36, 29 Jun2008 shown as bands 4, 3, 2 as Red, Green, Blue channels).

Figure 15b. Corresponding color coding of riparian delineation.

The riparian area layer will help delimit certain sagebrush species, such as Basin big sagebrush, that are contained to soil types of riparian zones. The riparian area layer

is also added to the habitat database for potential modeling efforts such as seasonal ranges.

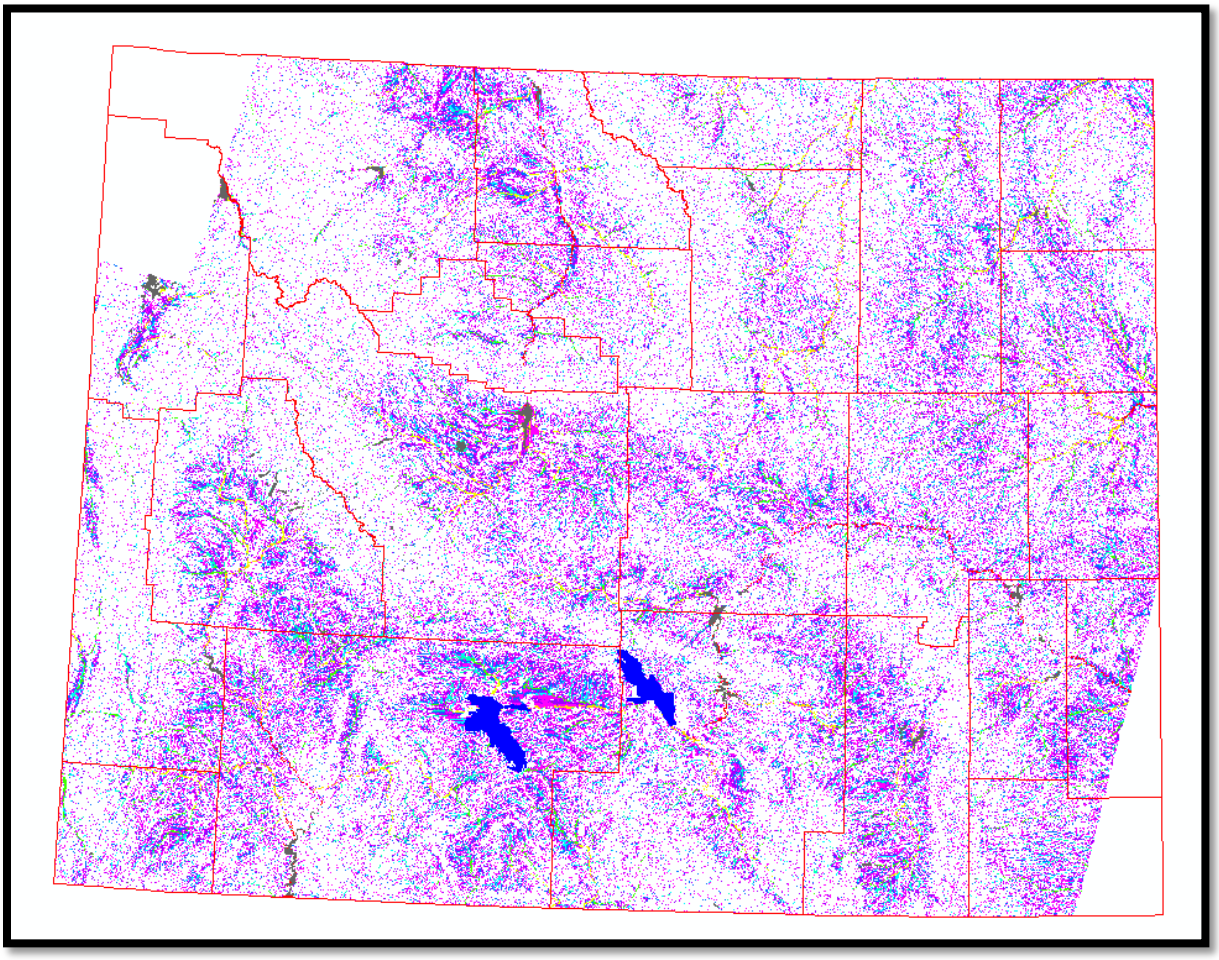


Figure 16. Riparian zones across the model domain with Wyoming county boundaries.

Predictor variables representing major soil types (Munn and Arneson 1998) and surficial geology (Case et al. 1998) were also acquired and processed for model development. A total of 45 soil types and 27 surficial and landform features are identified in these classifications. These substrate data layers were resampled from an original resolution of 1:500,000 scale.

Remotely sensed spectral data and associated vegetation indices were also used as predictors in the models. Previous studies have demonstrated the facility of Landsat Thematic Mapper data to discriminate sagebrush cover types in Wyoming (Rodemaker and Driese 2006, Sivanpillai et al. 2008). MODIS (http://modis.gsfc.nasa.gov/data/) data with 36 spectral bands and a spatial resolution of 250 meters was acquired for use in this study, but a cloud free image date was not identified and subsequently MODIS imagery was not used in the models. In order to

accentuate vegetation structure and corresponding spatial patterns, a Normalized Difference Vegetation Index (NDVI) (Tucker et al. 1979) was computed from a ratio of reflectance values in the red and near-infrared spectral regions.

Attributing Training Data with Explanatory Values

The logistic regression model was calibrated with the values of the explanatory variables corresponding with training data locations. Essentially, the predictive model was fitted with quantitative data describing the environmental conditions present at known species locations. Training point data was therefore attributed with associated predictor variable data in a GIS environment using Hawth's tool for ESRI ArcMap.

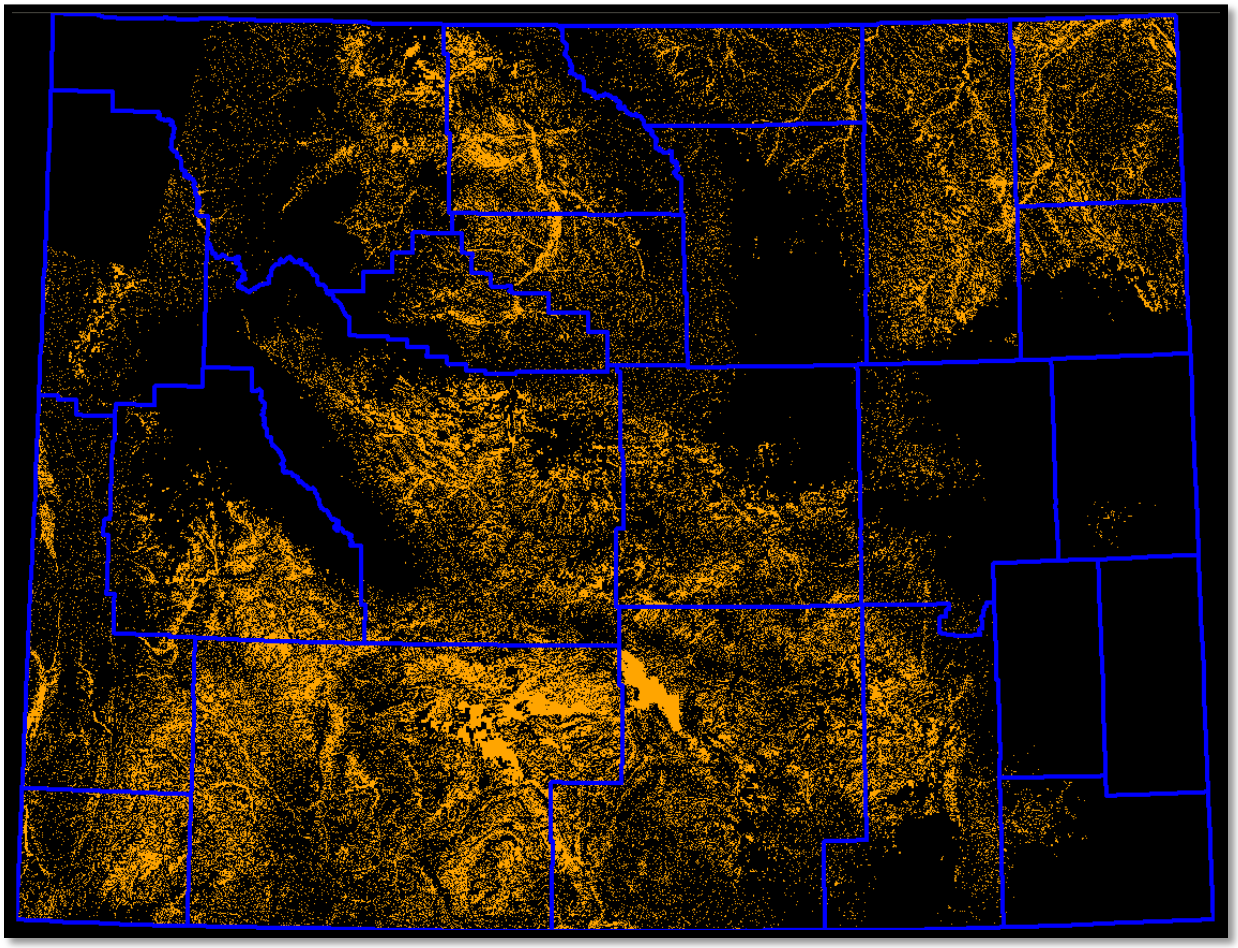
Table 2: Environmental predictor variables.

Explanatory variable	***Data type***	***Scale factor***	***Units***
Air temperature (monthly mean)	*continuous*	*10*	*°C*
Air temperature maximum (annual and monthly means)	*continuous*	*10*	*°C*
Air temperature minimum (annual and monthly means)	*continuous*	*10*	*°C*
Elevation	*continuous*	*1*	*Meter*
Evapotranspiration potential (monthly means)	*continuous*	*1000*	*None*
Floodplain extent	*categorical*	*1*	*10 classes*
Frost days (annual total and inter-annual variation)	*continuous*	*10*	*None*
Geology	*categorical*	*1*	*27 classes*
Landform position model	*categorical*	*1*	*10 classes*
Moisture stress	*continuous*	*100*	*deg C / ln(cm)*
Normalized difference vegetation index	*continuous*	*1*	*None*
Precipitation (annual and monthly means)	*continuous*	*10*	*Centimeter*
Radiation index (from aspect)	*continuous*	*1*	*None*
Reflectance (Landsat)	*continuous*	*1*	*None*
Shortwave radiation (annual and monthly means)	*continuous*	*100*	*$MJ/m^2/day$*
Slope	*continuous*	*1*	*Percent*
Soil types	*categorical*	*1*	*45 classes*
Terrain curvature	*continuous*	*1*	*None*
Topographic surface roughness index	*continuous*	*1000*	*None*
Water vapor pressure (annual and monthly means)	*continuous*	*1*	*Pascal*

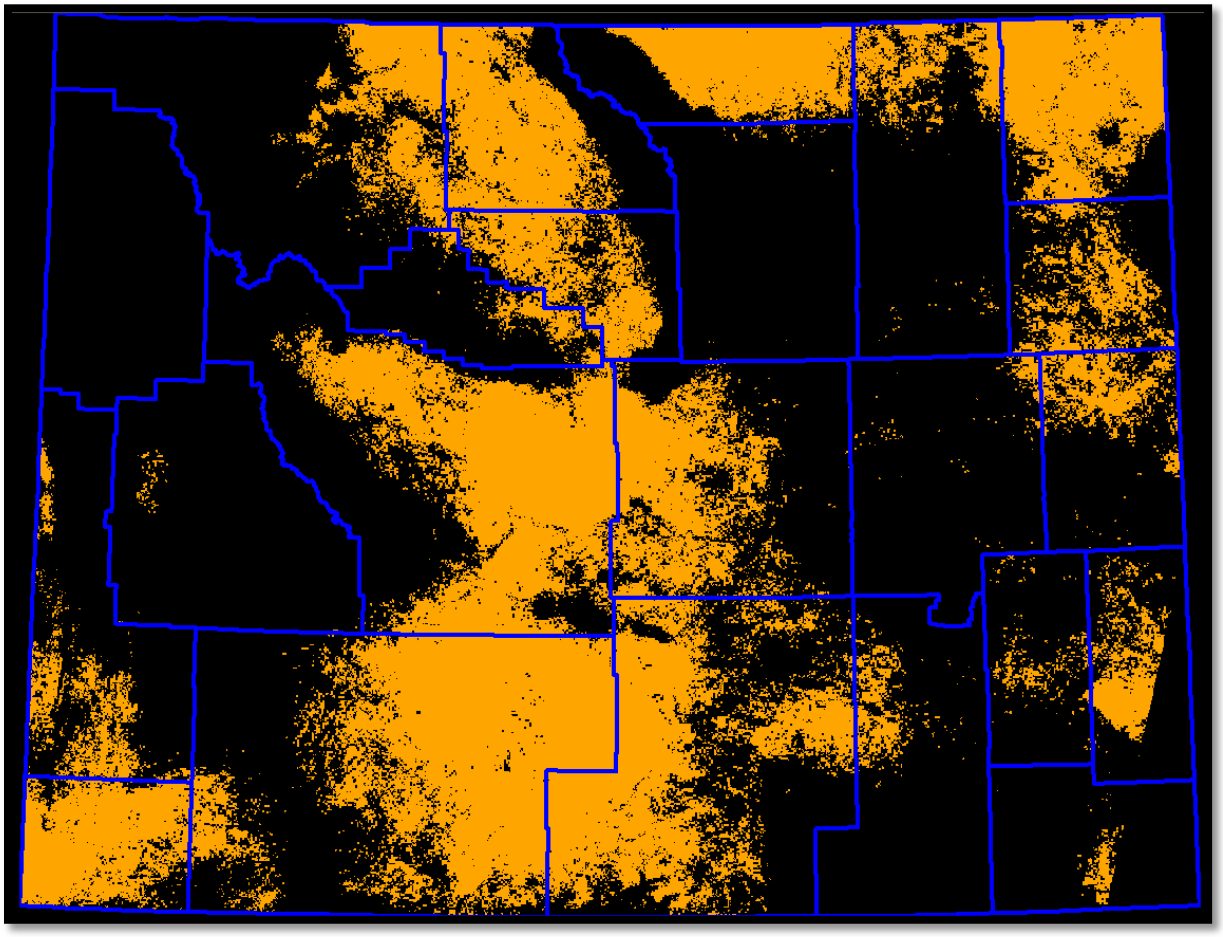
For each model the results final map grid has a 30m pixel resolution, but due to the spatial resolution of the major model input dataset (DAYMET climate dataset), which has a spatial resolution of 1 km., the resulting scale appropriateness of the final products is approximately 1 km. resolution and at least 1:250,000 scale. The general accuracy for the model outputs are approximately 80-85%.

Species Distributions, Unmasked Results as Twelve Maps

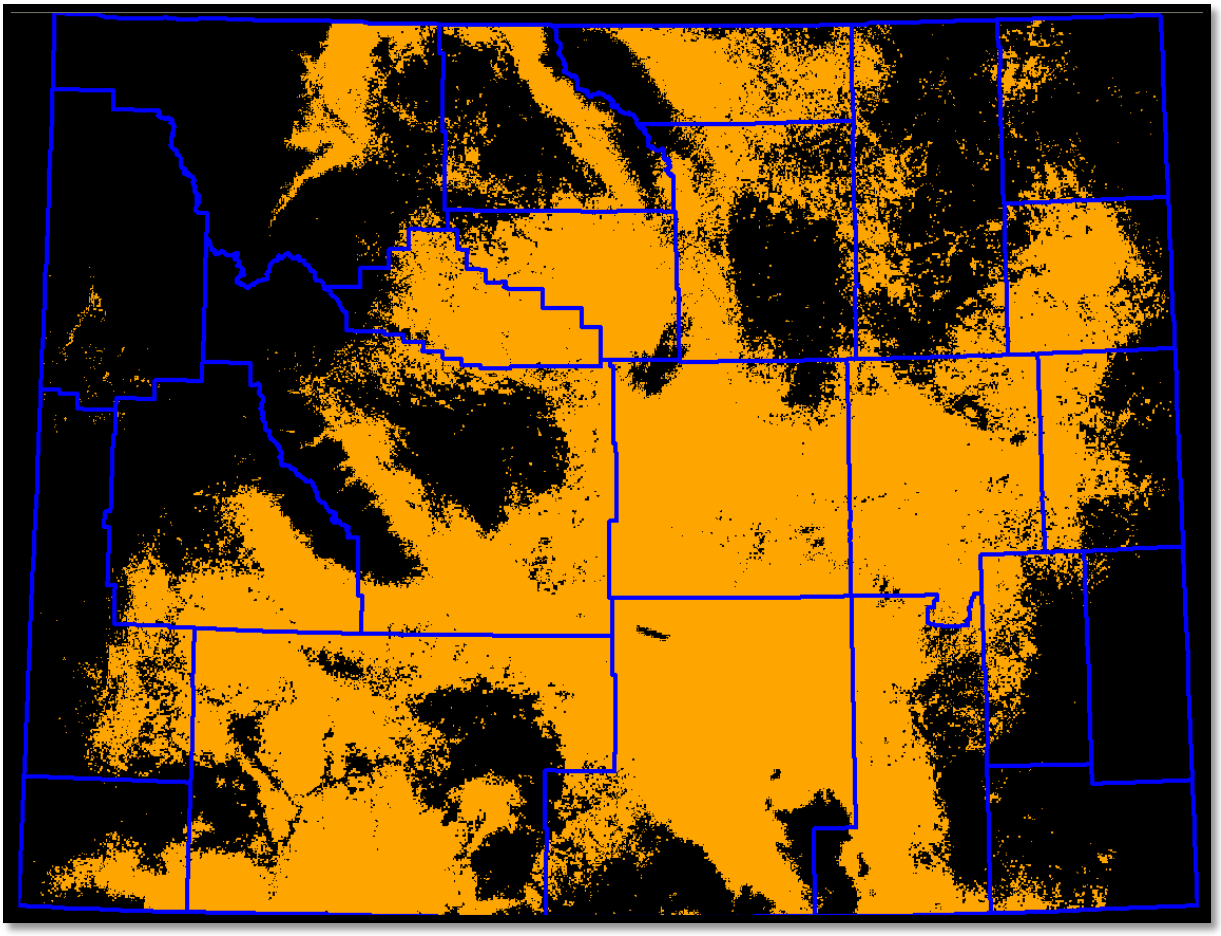
Distributions of 12 sagebrush species predictions were mapped across the study domain. Each distribution maps represents areas where the species could occur. As these are potential distribution map, they are as yet un-masked results not showing land use conversions. Each map may also be masked by additional data elements such as to a land cover layer (USGS sagebrush delineation) showing the current extent of all sagebrushes.



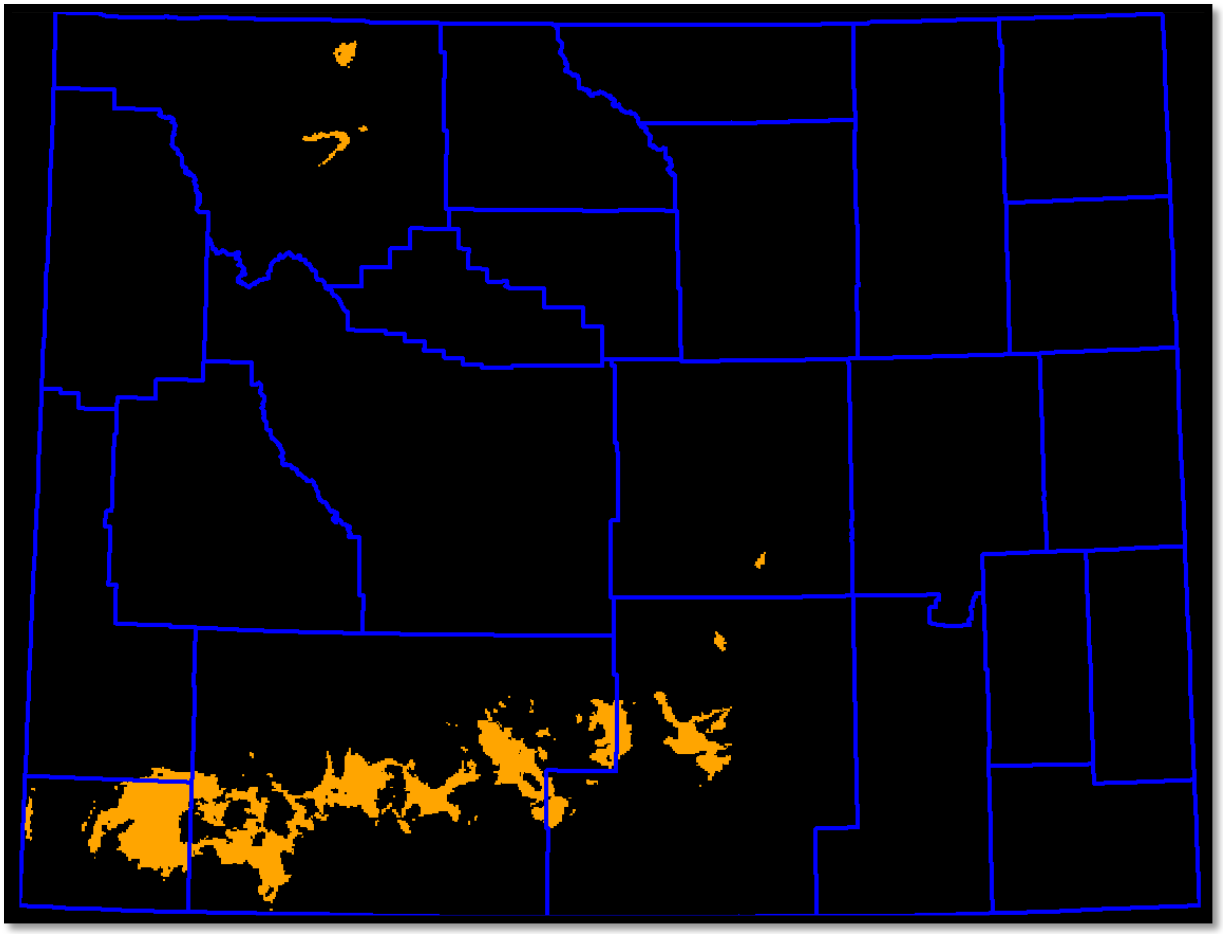
Basin Big Sagebrush



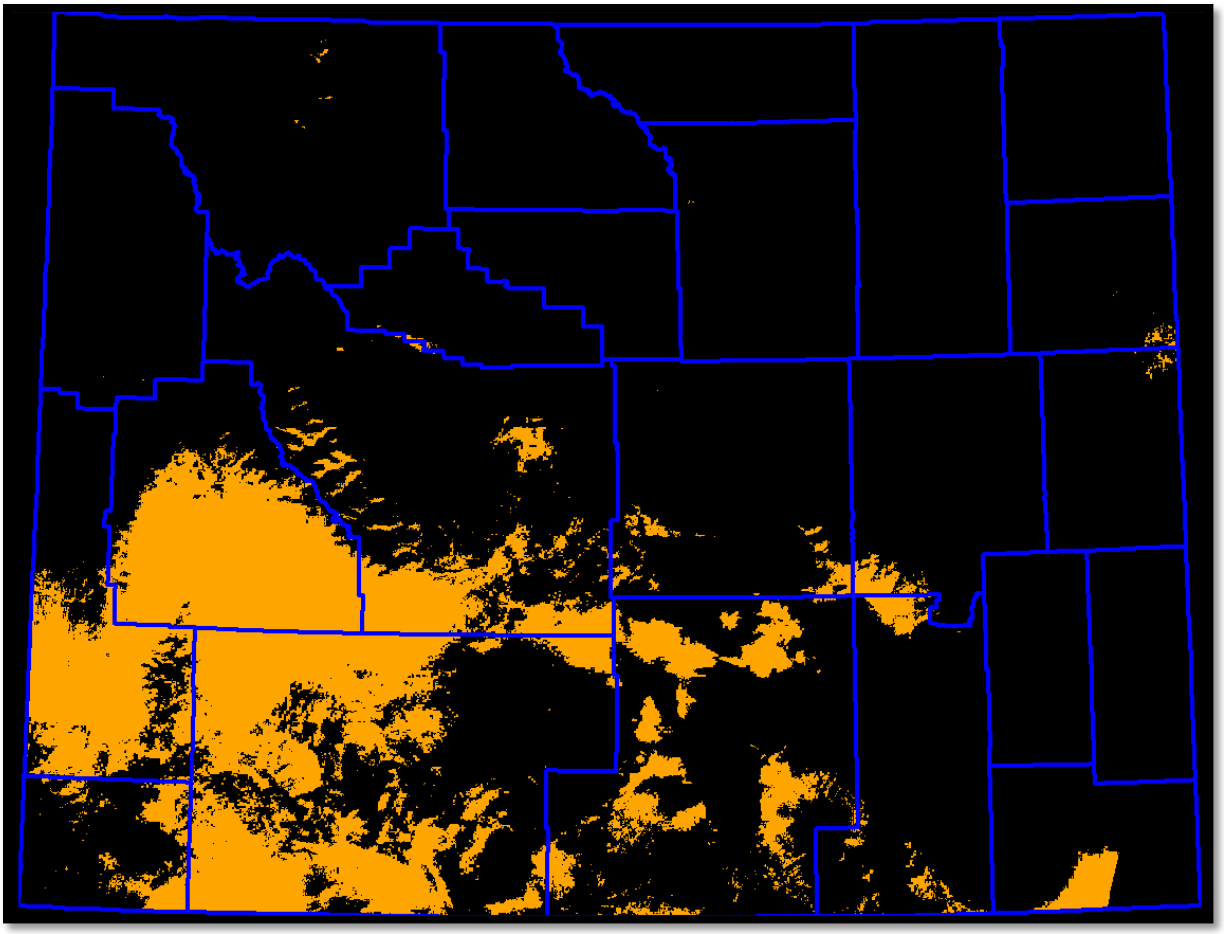
Birdsfoot Sagebrush



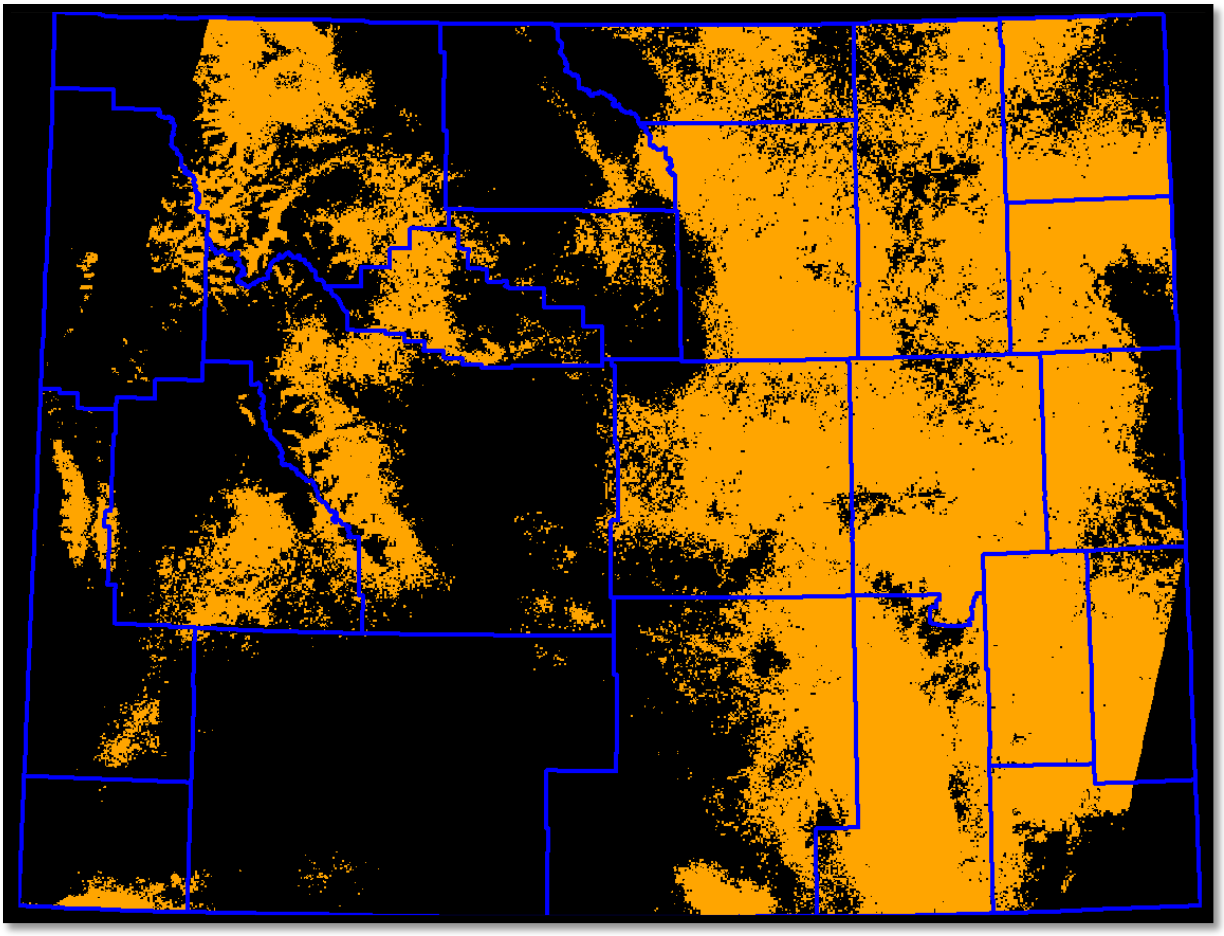
Black Sagebrush



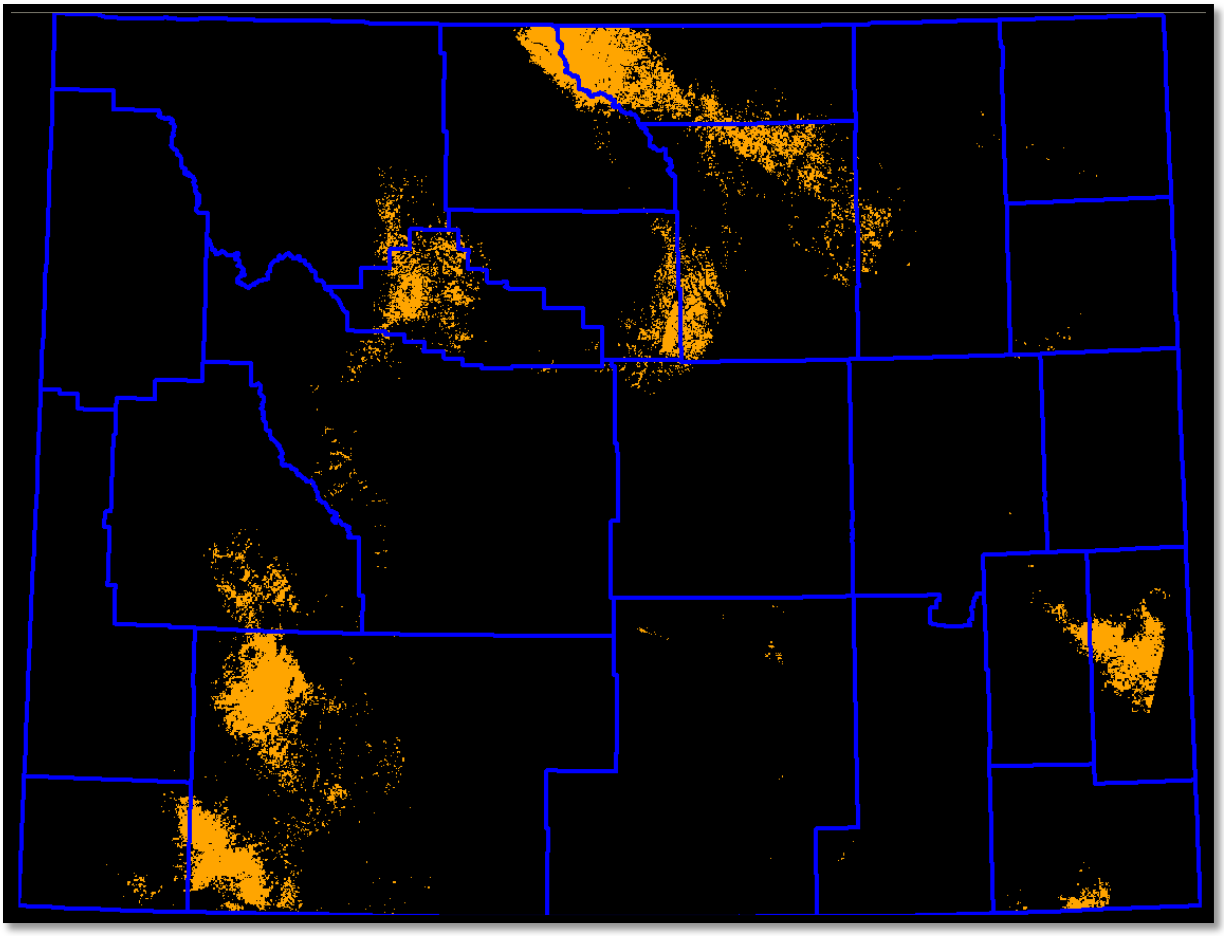
Bud Sagebrush



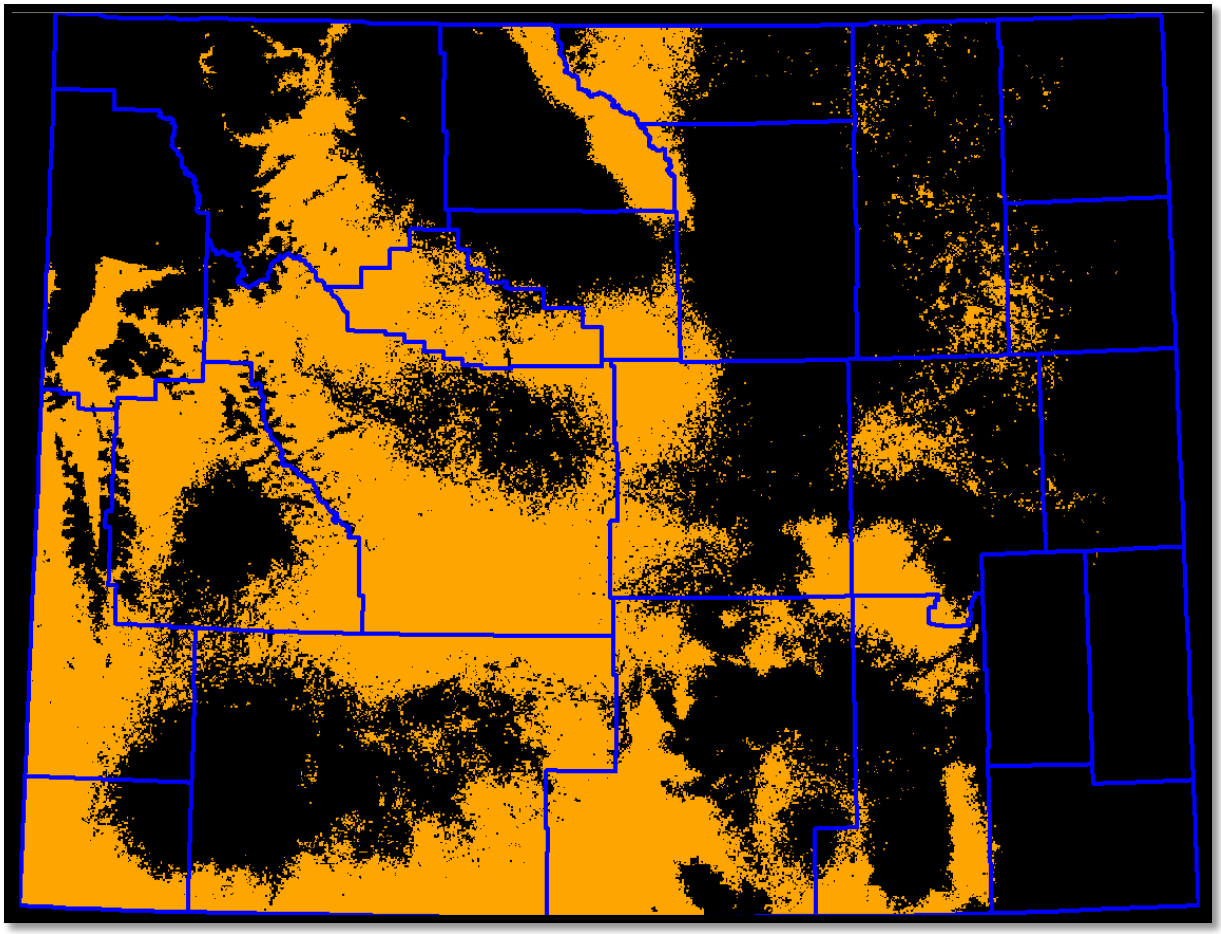
Early (Alkali) Sagebrush



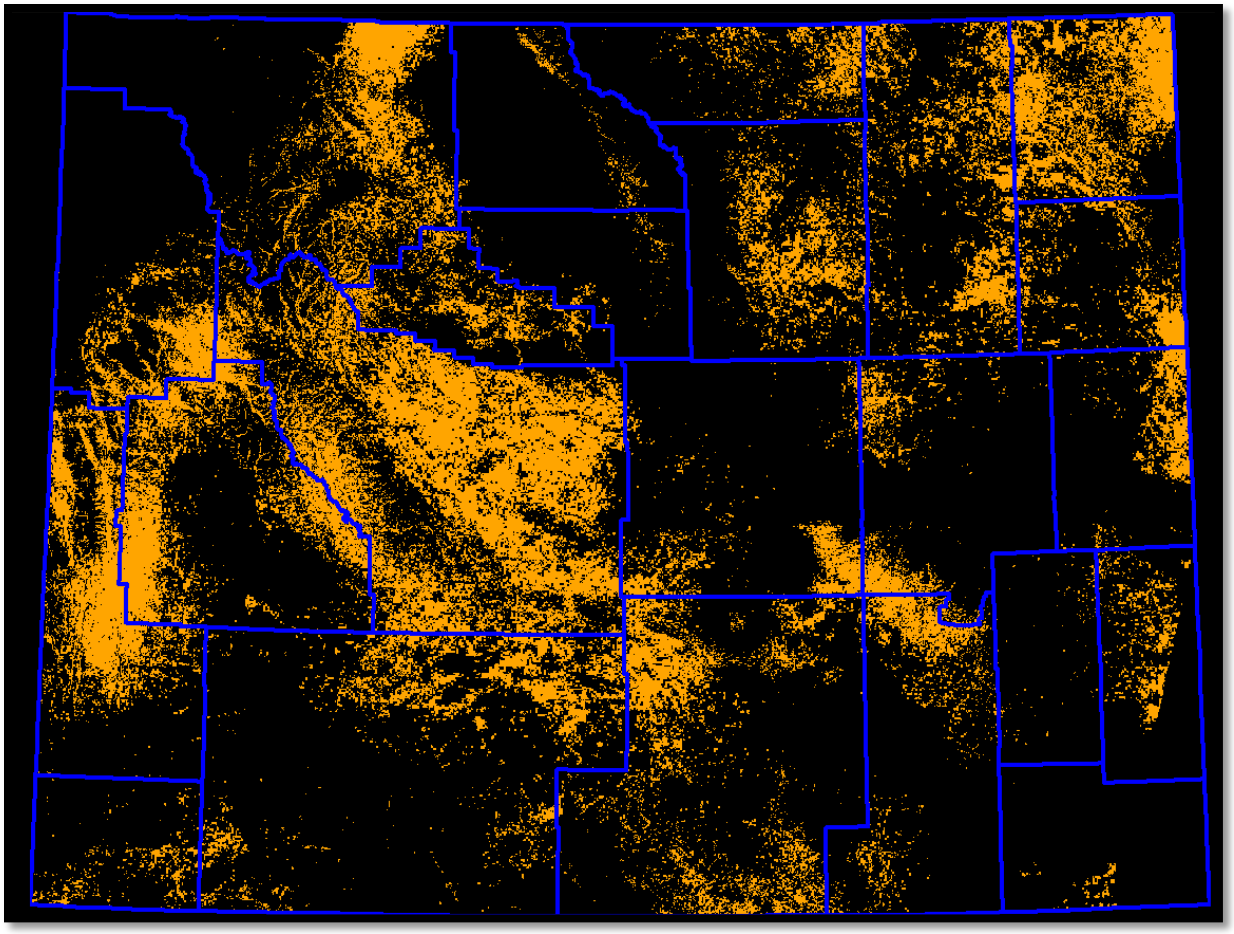
Fringed Sagebrush



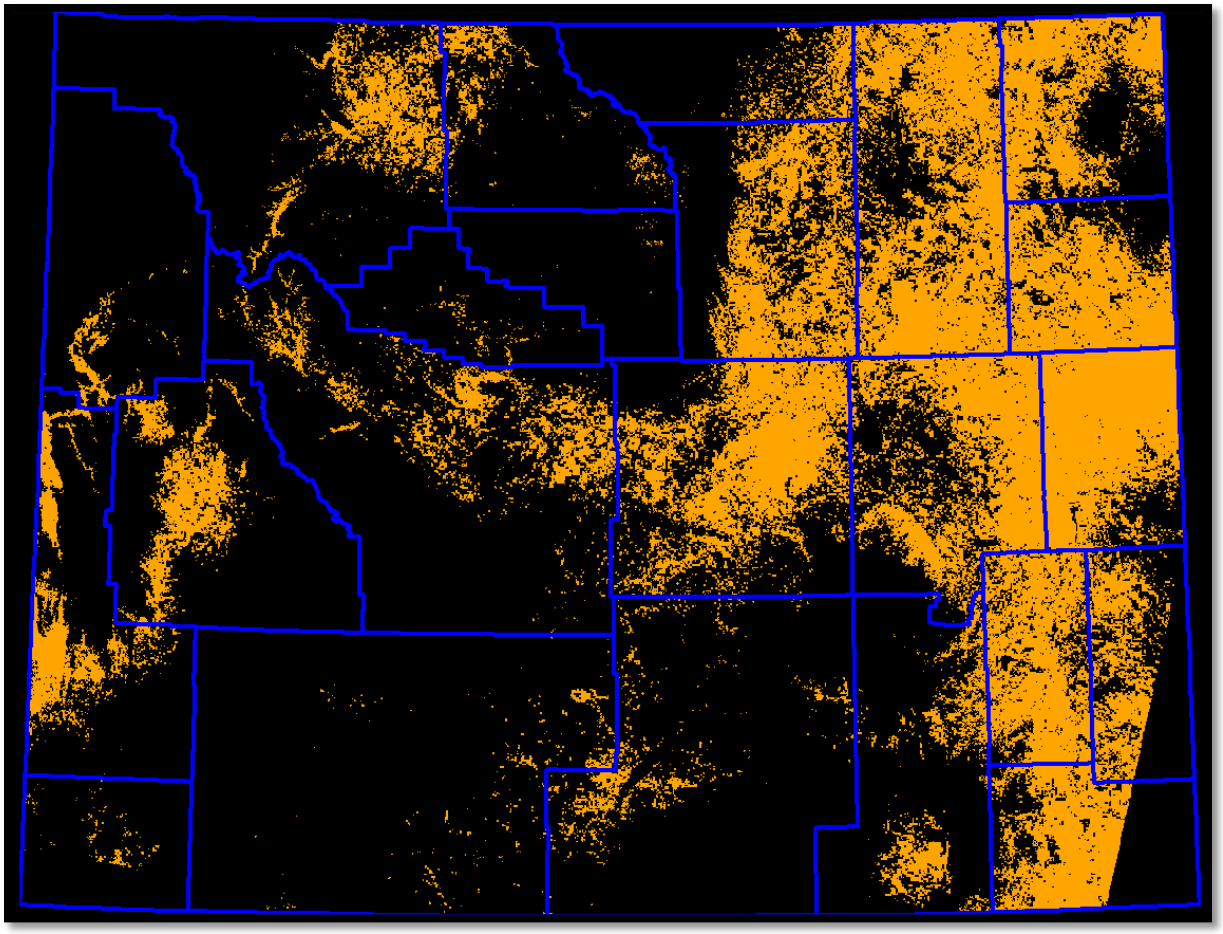
Low Sagebrush



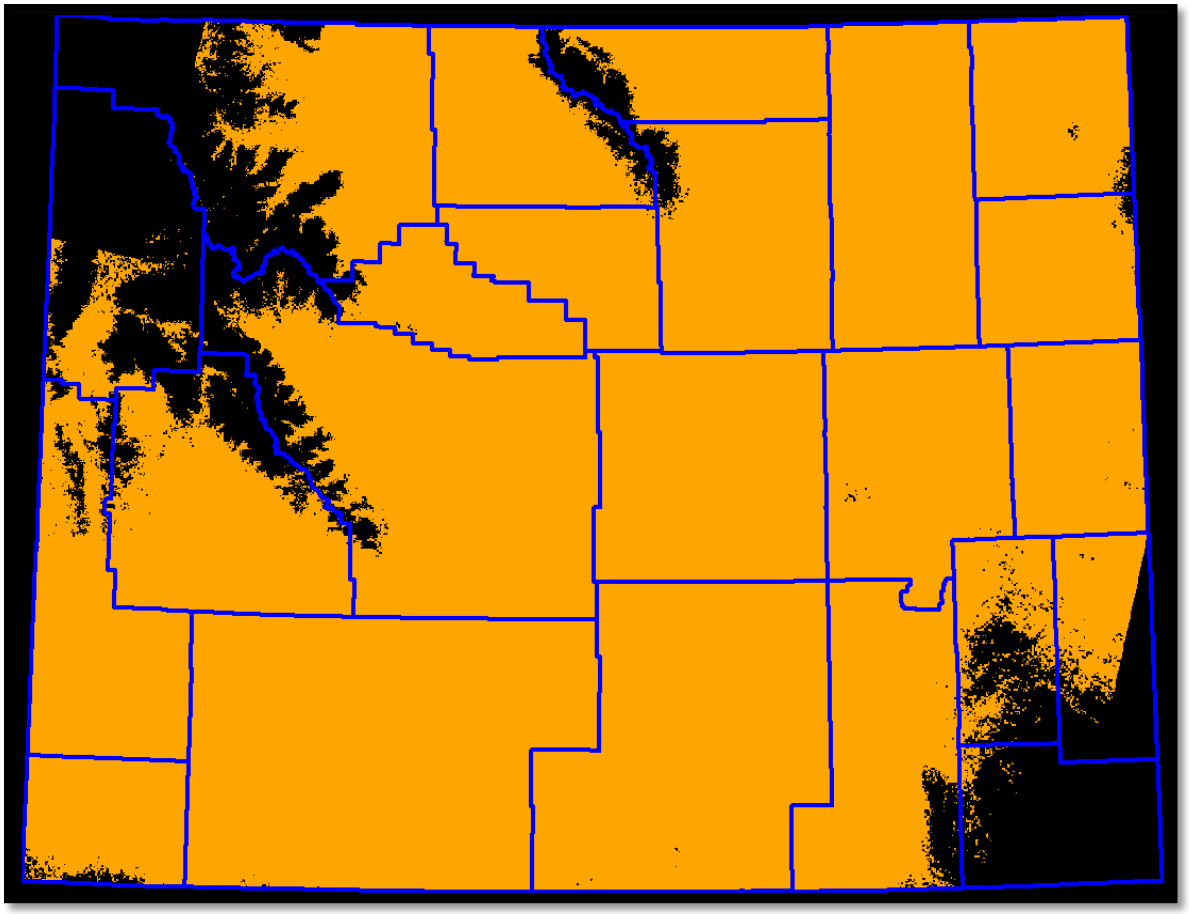
Mountain Big Sagebrush (Includes Mountain Big Sagebrush, Vasey's Sagebrush, and Subalpine Big Sagebrush)



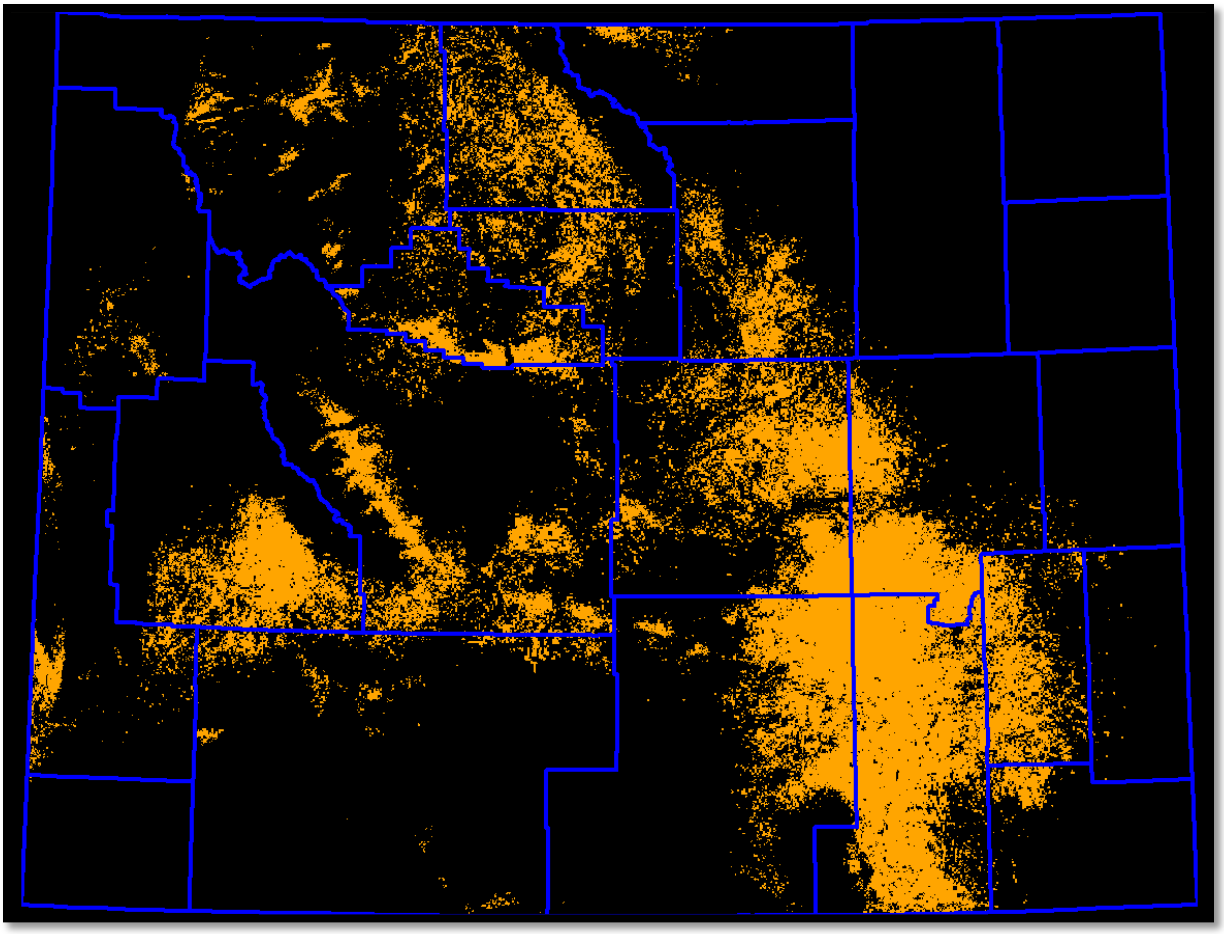
Mountain Silver Sagebrush



Plains Silver Sagebrush



Wyoming Big Sagebrush



Wyoming Three Tip Sagebrush

Tall Three Tip Sagebrush was discover at 8 locations, 5 of which it was the dominate sagebrush species, and we determined that too few samples (11) were collected to model. Sand Sagebrush was found at 53 sites, but only 5 of those sites was the species the dominate shrub and these 5 sites were located outside of the model domain area (i.e. sage-grouse distribution). A logistic model was tested for these Sand Sagebrush samples but convergence to a reliable statistical solution was not accomplished. Distribution mapping of the species was therefore not attempted.

Use of Sagebrush Habitat Maps

During the collaborative support phase of this project (planned through June 2010) we will be performing or assisting multiple management and research efforts. Planned activities include

- Assessment and assistance in revision of USGS rangeland components mapping for Wyoming (through 2009).
- Assessment and use of resulting USGS rangeland components as baseline stratification of WyGISC generated sagebrush species mapping. The project is currently assessing threshold the USGS sagebrush cover component to a minimum viable cover.
- Assessment and assistance into use of combined USGS and WyGISC sagebrush variables for sage-grouse seasonal habitat range mapping.
- Assessment of WyGISC sagebrush species mapping for use in a Sagebrush Habitat Guide for Wyoming. We will assess possibilities of using the distribution mapping results, field survey, sagebrush species meta-analysis, and project results as the basis of a guidebook for land managers in Wyoming. Upon positive findings to support guidebook development we will provide a scope of possible avenues to generate the guide.

The set of sagebrush species distribution maps generated by this project and the set of rangeland variable component maps generated by the USGS were created to meet the needs of multiple analysis requirements and not one set goal. It is intended that these data layers will therefore be applicable for a variety of uses and the data represent the 'building blocks' or 'ingredients' needed to create a focused description. Initial efforts, such as refinement of the Wyoming Governor's Sage-Grouse Core Areas (see Figure 17), will focus on state-wide solutions to management analysis requirements, but we anticipate that regional differences across the state may require different recipes from the data. For instance qualification of a potential sage-grouse habitat as 'bad or good' requires recoding the sagebrush component layers into categories from the original continuous information, as habitats in Wyoming differ by region, the actual values used to qualify these types may require distinction by climatic region. The project will provide collaborative support to analysis needs identified by the Governor's Sage-Grouse Implementation Team through June 2010.

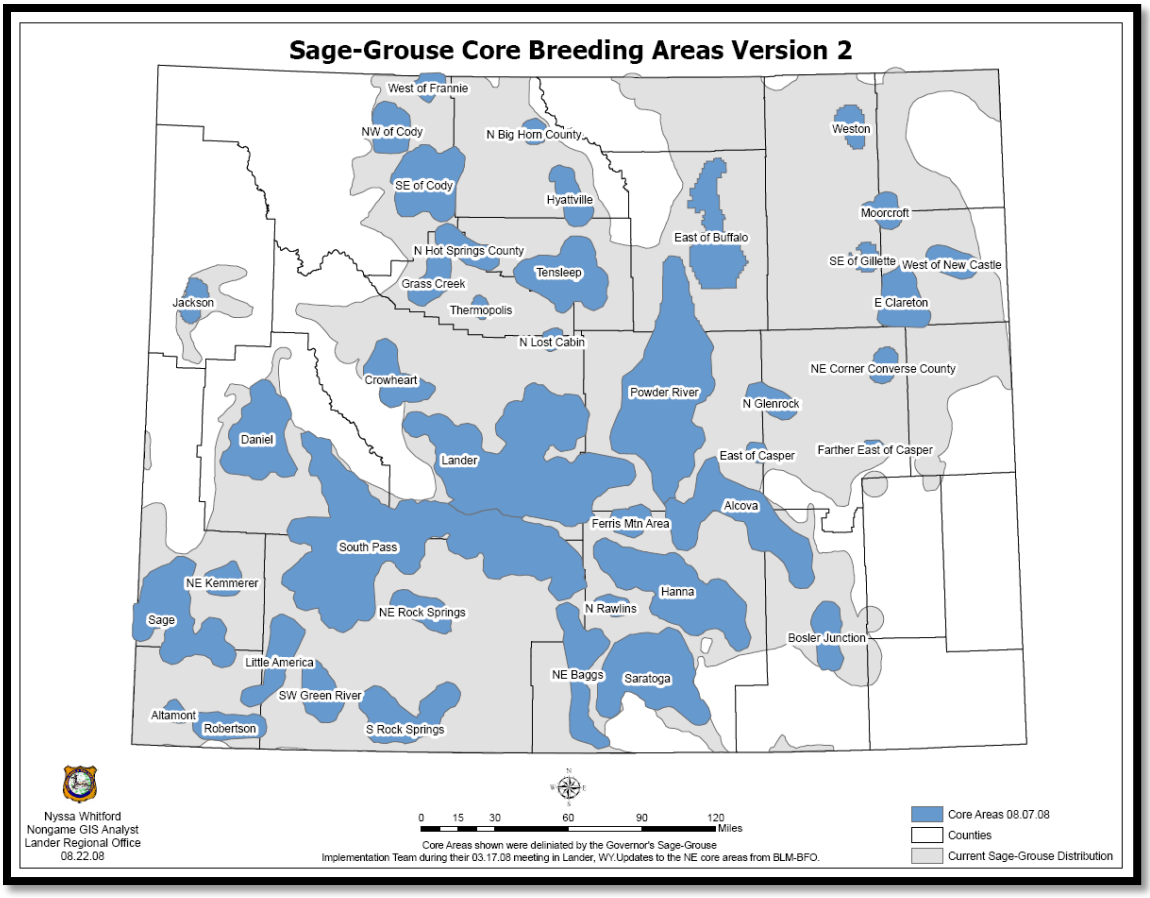


Figure 17. Wyoming Sage-Grouse Core Breeding Areas as developed by the Governor's Sage-Grouse Implementation Team on 17 March, 2008.

Final Products

Data associated with this project are being distributed via two avenues. The first of which includes metadata information that has been published to the Wyoming GeoLibrary. The second method is a one-time effort to provide data to the key constituents of this project via a data disk set that comprises the data directly associated with this project.

Data Distribution: Wyoming GeoLibrary Metadata Clearinghouse

The Wyoming GeoLibrary is a website that provides tools to assist in finding, evaluating and accessing geospatial information for Wyoming and has been capitalized upon to meet the needs of the Sage-Grouse Project data distribution.

Wyoming GeoLibrary Background

The Wyoming GeoLibrary provides the Wyoming geospatial community the ability to access and disseminate spatial data. The goal of the GeoLibrary is to create a data clearinghouse that is supported by a statewide network of geospatial data producers. All producers have the ability to publish and maintain their own metadata documents within the GeoLibrary. This offers data providers a method to disseminate data with minimal hardware, software, and human resources while giving them full control of their contents within the GeoLibrary.

Metadata are an essential part of the data collection and development process. Metadata are defined as "information about data" and includes information regarding the "who, what, when, where and how" of the data. Metadata include identification information that consists of a brief abstract, the purpose of the data, the access and use constraints; the spatial organization information; entity and attribute information that provides an explanation of the attributes; distribution information that consists of contact information for the data; and finally metadata reference information.

In order to meet the needs of this data collection effort, each metadata document associated with the data received, had to be created, completed, cleaned, or otherwise standardized. Steps in the process included but were not limited to metadata collection, compilation, development, standardization, assessment, cleaning, organization, and image creation. In addition the Wyoming GeoLibrary metadata clearinghouse preparation tool was applied to all metadata records with each record being published to the GeoLibrary. Finally, keywords were added for reference purposes, notes were added, and, distribution information was defined as either restricted, contact (restricted), distribute through WyGISC, or from an alternate source. Further explanation follows.

Wyoming GeoLibrary Data User Perspective

The foundation of the Wyoming GeoLibrary is based on giving users the ability to view metadata re-cords associated with geospatial information. The tools within the Wyoming GeoLibrary help users locate metadata documents that meet their search criteria. The users can limit results by using one or all of the following methods: defining an area of interest using an interactive map, selecting a specific data type (e.g., downloadable data) or category (e.g., Sage-Grouse Lek Locations) and by typing in a keyword (e.g., sage-grouse project). Users can also browse metadata documents based on who created the data, by subject matter, or by WyGISC project (e.g., data specific to the Sage-Grouse Project). The metadata in the Sage-Grouse Project section of the Wyoming GeoLibrary is organized by data hierarchy, provides a central location for data related to sage-grouse data in Wyoming, and serves as the central location for data related to this data collection and development effort. The results from a search are a list of available metadata. The user can view the full metadata document, see the extent of the data described by the metadata, download, or, in the case of Internet mapping services, directly link to these data with their desktop GIS software.

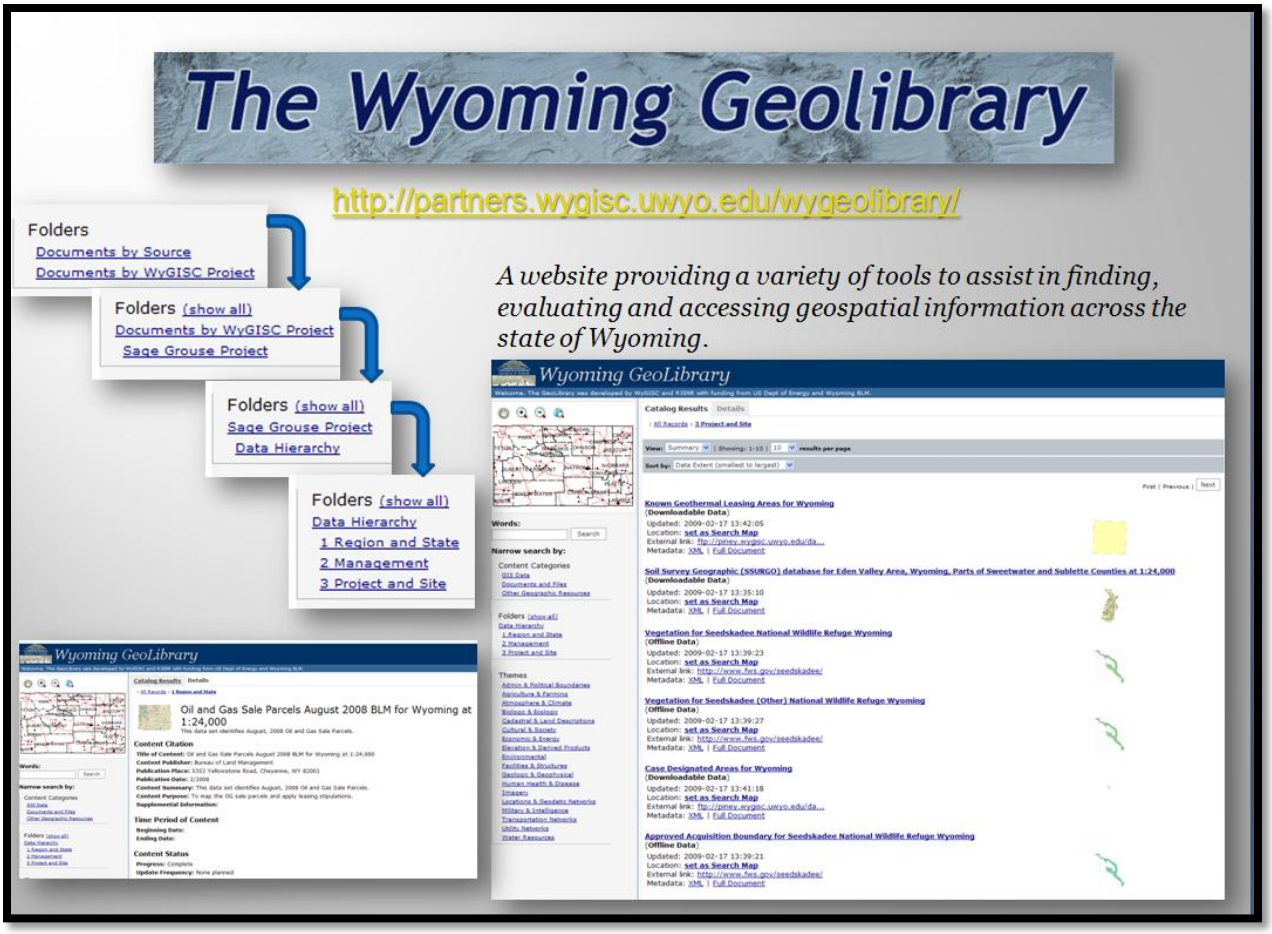


Figure 18. Examples of features and structures of the project database stored in the Wyoming GeoLibrary internet application.

Wyoming GeoLibrary Data Provide Perspective: Future Development

WyGISC strives to develop working relationships with data providers around the state of Wyoming to participate by providing metadata and data access to Wyoming Geospatial data users within the state, the United States and around the world. Partnerships developed through the Sage-Grouse Project are one of the avenues to this development of significant working relationships with agencies and other data providers with a pertinent and common goal in question: Sage-grouse science and management support. The Wyoming GeoLibrary is an ESRI ArcIMS Metadata Server providing a mechanism to disseminate Wyoming geospatial information. With the appropriate permissions and ESRI's desktop data-browser application, ArcCatalog, data providers can connect via the Internet and publish metadata documents directly to the Wyoming GeoLibrary. With a basic set of metadata requirements, the process is straightforward

and easy to use. WyGISC provides a custom desktop application: the Wyoming GeoLibrary Preparatory Tool. This application works with any selectable object within ArcCatalog producing and/or editing the local metadata content through an easy-to-use dialog box. Once the metadata is properly formatted, the data provider through a simple copy/paste command using ArcCatalog can transfer the document. Only the data provider and the site administrator have access to modify and/or delete the meta-data record. These changes are automatically reflected in the Wyoming GeoLibrary. This process allows the data provider to maintain their metadata and data products individually, thereby providing the most up to date information to the geospatial user community.

Wyoming GeoLibrary Sage-Grouse Project Data Distribution: Special Note

Within the Wyoming GeoLibrary under Folders a new heading of Data by WyGISC Project has been created with a sub-folder for all sage-grouse data (Sage-Grouse Project). Data within this folder have been organized by the data hierarchy (Refer to Project Overview and Data Structure, above). Metadata records were placed in the appropriate data hierarchical folder based on the assessed scale and accuracy of the associated data that record provides access to. All records compiled include full metadata documentation with direct data download options, or at minimum contact information for the data provider to gain access to restricted time and/or content sensitive data.

Wyoming GeoLibrary Sage-Grouse Project Data Is Complete and Accessible: WyGISC principles are anticipating conducting a training session near the end of the 2009 calendar year.

Data Distribution: Data Disk Set

All data collected, processed, and otherwise developed is being distributed to Wyoming Game and Fish Department State Office in digital format. This will consist of a DVD set of pertinent, organized data relevant to Sage-grouse science and management in the state of Wyoming.

Kirk Nordyke, GIS Coordinator, has been contacted about preferred distribution methods and at his request the disk dataset can be duplicated for regional offices or agency partners such as USDI-BLM.

Wyoming Project Data Disk Set Distribution: Will be complete by July31, 2009.

User Training

A key phase of the project will be the successful transfer of project knowledge and results. As this report has outlined, users will find the most complete sage-grouse habitat database possible for the State of Wyoming, but they will also find the volume of data intimidating. Organization of the project database in multiple frameworks, including scale dependency and thematic content, is anticipated to facilitate data discovery. Users, identified with the assistance of the Wyoming Game and Fish Department and the Wyoming Governor's Sage-Grouse Conservation Implementation Team, will benefit from an overview of the project database and elements from WyGISC principles.

A separate set of user's may be identified for the project's Wyoming Sage-Grouse Data Explorer application than the database itself. Beginning with the Implementation Team and the Wyoming Game and Fish Department again, project principles will demonstrate the internet based application, review the database elements appropriate to the application (including review of sensitive data), and train identified interested users.

Use of particular project database elements that are new to most habitat management personnel in Wyoming, such as the USGS statewide sagebrush mapping layers, the WyGISC sagebrush species distribution modeling, or the NRCS Ecological Site Descriptions, will be introduced during these trainings. These data, having no previous analogous comparison, represent new opportunities but also new challenges in understanding of how they can be incorporated into habitat management decision making.

The use of the project database as a hierarchically organized resource, project database elements, the project as stored in the Wyoming GeoLibrary, use of Ecological Site Description data, and the internet based Wyoming Sage-Grouse Data Explorer will be the focus of this training phase.

Users of the Project Database and Project Applications will be identified in the fall of 2009.

WyGISC principles anticipate beginning the training phase near the end of the 2009 calendar year.

Long Term Project Maintenance

The database and mapping application that has been developed for this initiative will be used by collaborators to conduct assessments and perform modeling efforts. WyGISC will actively maintain this project both from a data and application standpoint through June of 2010. Data updates will be distributed via the Wyoming GeoLibrary and will be reflected within the on-line mapping application. Technical assistance will be available during this time to users regarding any questions data and application users might have. The Wyoming Sage-Grouse Data Explorer application is maintained on a public domain server (computer) at WyGISC, and will be supported via this initiative. Any Internet-based user will be able to access the application via a password controlled entry system. The application does not require users to have local GIS or database software, just dependable Internet access.

WyGISC is responsible for supporting, distributing and maintaining all data assembled in this effort. Support not only focuses on supporting the public in access and use of the database but also includes a round of training to provide WGFD and partners with a full understanding of the database and application. Distribution of the database will be accomplished through two methods. One distribution method will use the Wyoming GeoLibrary to provide the public either direct access or the knowledge for accessing these data. The other way in which WyGISC will distribute these data is via a collection of DVDs distributed to the WGFD. Finally there is a data maintenance task scheduled for early spring 2010 to allow for necessary data to be updated to the most current version available.

WyGISC maintenance of data elements and collaborative involvement of project principles is planned through June 2010.

Future Data Development Needs

The project has provided a framework for identifying future sage-grouse habitat data needs. Some data elements identified by the Wyoming Governor's Sage-Grouse Conservation Implementation Team are still needed at the writing of this reports; see Appendices A and B. These data usually require new analyses to be generated, such as 'Areas of Conifer Invasion' identified as a need but currently unknown.

Part of the long term maintenance support planned by this project through the 2009 project year includes assisting groups which may take on these analysis needs. By serving as a both a starting and focal point for sources of sage-grouse habitat data in Wyoming, the project intends to be leveraged by these new research efforts to provide quicker and more robust results than they would have accomplished on their own.

Further, the project hierarchical database and database support tools for discovery, searching, and viewing will provide Wyoming a definitive source for identifying data. This will allow for the accurate timely identification of data gaps as future management analyses are performed.

Conclusion

The efforts of this project represent the state of knowledge about spatial habitat layers for sage-grouse in Wyoming. Further, this project proposes a place based decision framework for analyzing the future of sage-grouse habitats in Wyoming. By proposing a spatially organized framework the project hopes to de-confound some of the confusion in data understanding caused by conducting an analysis for a species such as the Greater Sage-Grouse that must be considered across a wide landscape. Digital data layers representing features across these landscapes have not always been created with the biological behaviors of our species of interest in mind or if they had the data may not appropriately describe all the behaviors of the bird at all appropriate spatial scales. For instance the behaviors of the young birds in a brood may have to do with the spatial scale of individuals, such as an insect or forb plant for feeding, a shrub for cover, or a tree for a perching site of a predatory raptor. While the behaviors of the entire brood will have to do with the distribution of communities affected by the availability of water to support forbs and insects, and the land cover and use in general for the distribution of raptors, shrub cover, or anthropogenic disturbances. An analysis of the individual versus the community or larger group requires differing levels of precision and accuracy. For certain analyses one may require detailed description of an event at an exact location but these can only be obtained with a high level of effort. A high level of effort required in gathering precise data frequently limits how extensively the data are collected. Gaps in data and knowledge are inevitable and need to be discovered for each management decision analysis area. This project attempts to provide decision makers with an expedited method of collecting needed data or discovery of gaps in knowledge.

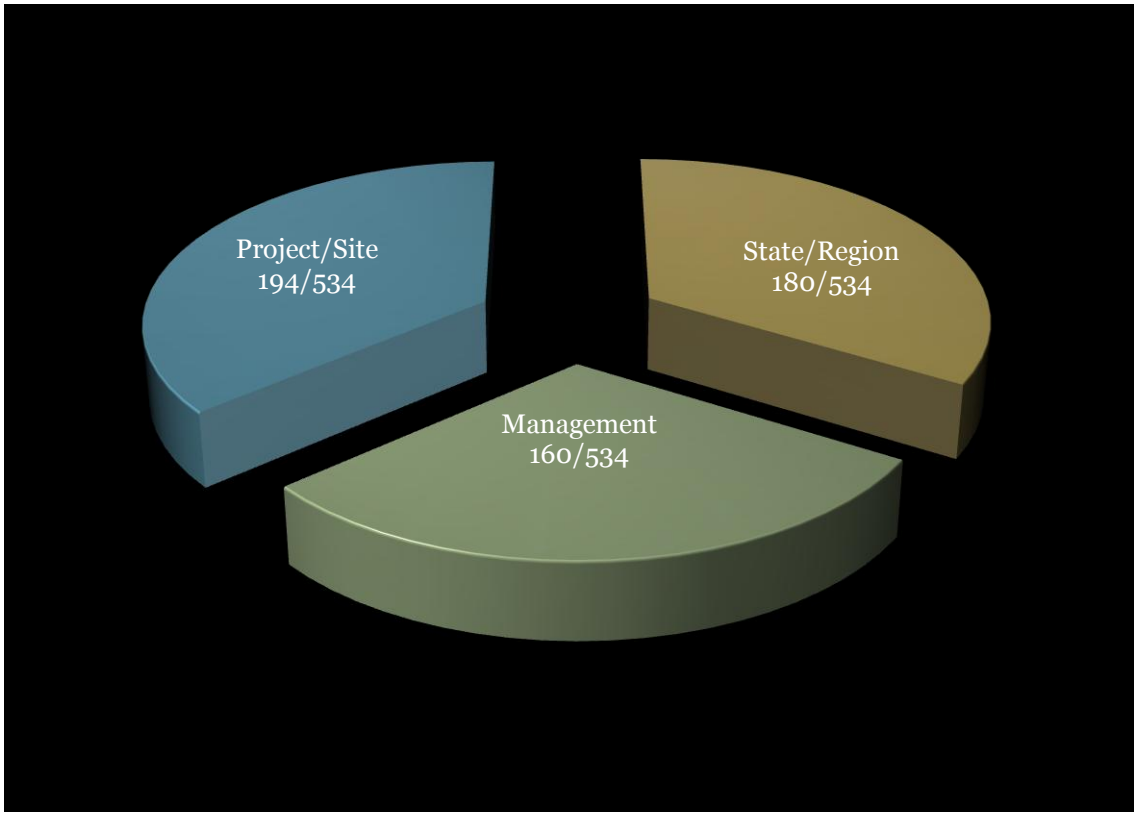


Figure 19. Breakdown of database elements by spatial scale hierarchy.

The spatial database created focused on obtaining all existing data which could be used in decision making with regards to sage-grouse or sagebrush habitat. To assist in managing and using these data, a data hierarchy approach was taken which placed data into three main categories; region/state, management and project/site. The goal of taking this approach was to help guide those using these data in understanding which layers were appropriate for the spatial scope of the decision being made.

A breakdown of expenditure proportions for this project is shown below. Extensive effort was put towards collecting field survey data or 'on the ground' knowledge.

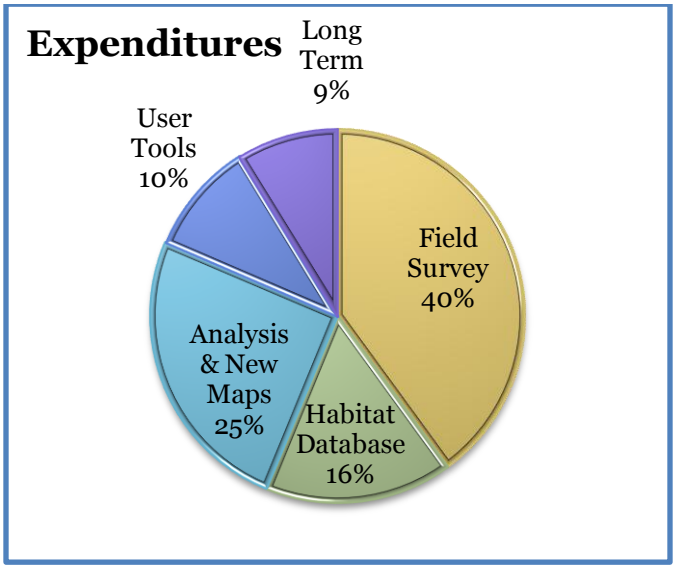


Figure 20. Breakdown of project efforts by planned task.

Such empirical information will prove invaluable as future, possibly unexpected, management needs are brought forth. Further, the dataset cannot be recreated as it provides a measure of the conditions of the time of sampling now past. Any future sampling or data generation plans can now look forward to our extensive efforts as a baseline previously unavailable.

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Appendix A: Sage-Grouse Implementation Team Habitat Mapping Priorities

Appendix A comprises the original Appendix G from the WyGISC project proposal to the Wyoming Game and Fish Commission, with the addition of noted data acquisition related to each item.

Governor's Sage-grouse Conservation Initiative: Biologist Sub-committee Habitat Variable Recommendations

Wyoming Sage-grouse Habitat Mapping Priorities, January 06, 2008

Overall "Dream": *High-resolution continuous canopy cover of all plant species, by species; all sage-grouse use information for the entire state; high-resolution data for landscape and anthropogenic features; and great soil and hydrologic data.*

Habitat Variables *Nesting and Early Brood Rearing habitat (we can't really separate these two; early brood rearing is a microenvironment within nesting habitat):*	
	Sagebrush:*
NLCD (1992, 2001)	
LANDFIRE	
Northwest ReGAP (2001)	
GAP(1994)	
Anderson 1970's (2000 updates)	
USGS Vegetation Work	*Sagebrush canopy cover*
USGS Vegetation Work	*Grass cover*
USGS Vegetation Work	*Forb cover*
USGS Vegetation Work	*Sagebrush height*
USGS Vegetation Work	*Grass height*
USGS Vegetation Work	*Forb height*
USGS Vegetation Work	*Other vegetation cover (e.g. litter, bare ground, conifers, riparian areas, etc.)*
WyGISC Vegetation Work	*Sagebrush species*
	Dominant/co-dominant plant over story and understory
	Sagebrush seral stage
	Roughness index
	***Late Brood Rearing habitat**:*
USGS Vegetation Work	*Sagebrush canopy cover*
USGS Vegetation Work	*Grass cover*
USGS Vegetation Work	*Forb cover*
WyGISC Vegetation Work	*Riparian areas – including perennial native hay meadows (can't map alfalfa fields since they move around between years)*
WyGISC Vegetation Work	*Greenness/wetness index*
	Winter Habitat:

USGS Vegetation Work	*Sagebrush canopy cover*
USGS Vegetation Work	*Sagebrush height*
	Roughness index
	Sagebrush species
USGS Vegetation Work	*Non-sagebrush habitat*
	Lek Habitat:
USGS Vegetation Work	*Sagebrush canopy cover*
LR2000 leases, etc.	*Anthropogenic activities*
	Common "threads" for all seasonal habitats:
USGS Vegetation Work	*Sagebrush canopy cover*
USGS Vegetation Work	*Grass cover*
USGS Vegetation Work	*Forb cover*
USGS Vegetation Work	*Sagebrush height*
USGS Vegetation Work	*Sagebrush non-habitat (bare ground, other vegetation classes, etc.).*
WyGISC Vegetation Work	*Landscape features (riparian areas, anthropogenic features)*
WyGISC Vegetation Work	*Sagebrush species*
	Roughness index
Anthropogenic Variables	
	Anthropogenic features *(many of these layers already exist)*
	Roads (by road class)
street map	
TIGER	
BLM FO Modified Roads	
ESDs - SSURGO Data	*Habitat conversion by type*
Pipeline Authority	*Pipelines*
WOGCC	*Oil and gas pads*
FEMA	*Power lines*
FCC	*Communication and similar towers*
LR2000	*Wind facilities*
LR2000, BLM FOs	*Mines*
	Sources of noise pollution
SW Wyoming, some BLM FOs	*Fences*
Grazing Allotments - LR2000, BLM FOs	*Grazing regimes*
Grazing Allotments - LR2000, BLM FOs	*Grazing intensities and frequencies*
BLM	*Habitat improvement projects for sage-grouse*
5 County Weed & Pest Dist., BLM FOs	*Distribution of exotic/invasive plants*
BLM, NPS, USFS	*Fire history (both human caused for any purpose and wild)*
Sage-grouse Variables	
	Sage-grouse information*:*
WGFD	*Lek locations*
	Populations and sub-populations

	Population movement corridors
	Population linkage corridors
	Location of seasonal habitats
WGFD	*Use of seasonal habitats (from this and the preceding bullet, the identification of high quality habitats).*
	Juxtaposition of seasonal habitats
University of Wyoming	*West Nile virus occurrences (as predicted by climate models).*
WGFD	*Areas of non-habitat*
Other Items *These items are important for habitat management, but did not fall neatly into other categories. T hey are not prioritized as most already exist as data layers.*	
	Other items:
NOAA, PRISM	*Precipitation zones*
NHD, NWI	*Hydrological layers*
SSURGO, STATSGO, Munn, et al.	*Soil types*
30m DEM, limited 10m DEM	*Elevation*
Derived from 30m DEM	*Slope*
	Distance to water (from sagebrush cover)
Derived from 30m DEM	*Aspect*
ROWs, Municipal Boundaries, etc.	*Distribution of anthropogenic features and natural features across a landscape*
Additional Items *These items did not rank high in priority, were identified as needed in the future, or were not consistently identified by all respondents.*	
USGS Vegetation Work	*Forb height*
BLM	*Wild horse areas*
	Areas of conifer invasion
LR2000 leases, etc.	*Proposed/future anthropogenic features*

Appendix B: Scale Organized Sage-Grouse Habitat Database Elements

Total database size: 14.6 Gigabytes

Metadata list sorted by: 1) Hierarchy by decreasing number with 1 being State, 2 being Management and 3 being Project or Site level, 2) source alphabetically, and 3) Name alphabetically. Scale is noted where defined by the metadata or otherwise noted from data source. The access information relates to data access method, whether it consists of a WyGISC FTP download, a download from the data source directly, or requires contacting the data publisher directly. All information has been extracted from the metadata of each record.

Name	Source	Access	Scale	Hierarchy
Wyoming Sagebrush/Sage-Grouse Habitats for Wyoming at 1:100,000	BLM	Other Download	1:100,000	1
AM Radio Service in the United States	FCC	Other Download		1
AM Radio Service in Wyoming	FCC	WyGISC FTP		1
Antenna Structure Registration in the United States	FCC	Other Download		1
Antenna Structure Registration in Wyoming	FCC	WyGISC FTP		1
Broadband Radio Service (BRS) & Educational Broadband Service (EBS) in the United States	FCC	Other Download		1
Broadband Radio Service (BRS) & Educational Broadband Service (EBS) in Wyoming	FCC	WyGISC FTP		1
Cellular Service Area Boundaries by Callsign in the United States	FCC	Other Download		1
Cellular Service Area Boundaries by Callsign in Wyoming	FCC	WyGISC FTP		1
Cellular Tower Locations in the United States	FCC	Other Download		1
Cellular Tower Locations in Wyoming	FCC	WyGISC FTP		1
Digital TV in the United States	FCC	Other Download		1
Digital TV in Wyoming	FCC	WyGISC FTP		1
FM Radio Service in the United States	FCC	Other Download		1
FM Radio Service in Wyoming	FCC	WyGISC FTP		1
Land Mobile - Broadcast in the United States	FCC	Other Download		1
Land Mobile - Broadcast in Wyoming	FCC	WyGISC FTP		1
Land Mobile - Commercial in the United States	FCC	Other Download		1

Land Mobile - Commercial in Wyoming	*FCC*	*WyGISC FTP*		*1*
Land Mobile - Private in the United States	*FCC*	*Other Download*		*1*
Land Mobile - Private in Wyoming	*FCC*	*WyGISC FTP*		*1*
Microwave Tower Locations in the United States	*FCC*	*Other Download*		*1*
Microwave Tower Locations in Wyoming	*FCC*	*WyGISC FTP*		*1*
Paging Tower Locations in the United States	*FCC*	*Other Download*		*1*
Paging Tower Locations in Wyoming	*FCC*	*WyGISC FTP*		*1*
TV NTSC in the United States	*FCC*	*Other Download*		*1*
TV NTSC in Wyoming	*FCC*	*WyGISC FTP*		*1*
TV Service Area Contours in the United States	*FCC*	*Other Download*		*1*
TV Service Area Contours in Wyoming	*FCC*	*WyGISC FTP*		*1*
Climate Atlas of the United States 4km for Wyoming	*NOAA*	*Other Download*	*4km*	*1*
Northern Plains Conservation Network Opportunities for Wyoming	*NPCN*	*Contact*		*1*
General Soil of Wyoming at 1:250,000	*NRCS*	*Other Download*	*1:250,000*	*1*
National Coordinated Common Resource Areas for Wyoming at 1:250,000	*NRCS*	*Other Download*	*1:250,000*	*1*
National Coordinated Common Resource Areas for Wyoming Region at 1:250,000	*NRCS*	*Other Download*	*1:250,000*	*1*
National Coordinated Major Land Resource Area for Wyoming at 1:250,000	*NRCS*	*Other Download*	*1:250,000*	*1*
National Coordinated Major Land Resource Area for Wyoming Region at 1:250,000	*NRCS*	*Other Download*	*1:250,000*	*1*
Solar Resource Potential (Clear Sky Direct Normal - DNI) for Wyoming	*NREL*	*WyGISC FTP*	*4km*	*1*
Solar Resource Potential for Wyoming	*NREL*	*WyGISC FTP*	*4km*	*1*
Average Annual Minimum Temperature, 1971 - 2000 for Wyoming at 1:250,000	*PRISM*	*Other Download*	*1:250,000*	*1*
Average Annual Temperature, 1971 - 2000 for Wyoming at 1:250,000	*PRISM*	*Other Download*	*1:250,000*	*1*
Average Maximum Annual Temperature, 1971 - 2000 for Wyoming at 1:250,000	*PRISM*	*Other Download*	*1:250,000*	*1*
Average Monthly or Annual Maximum Temperature 1971 - 2000 for Wyoming	*PRISM*	*WyGISC FTP*	*1 degree*	*1*
Average Monthly or Annual Minimum Temperature 1971 - 2000 for Wyoming	*PRISM*	*WyGISC FTP*	*1 degree*	*1*
Average Monthly or Annual Precipitation 1971 - 2000 for Wyoming	*PRISM*	*WyGISC FTP*	*1 degree*	*1*
High-Resolution 103-Year Precipitation Climate Data Set for Wyoming	*PRISM*	*WyGISC FTP*	*1 degree*	*1*
High-Resolution 103-Year Temperature Climate Data Set for Wyoming	*PRISM*	*WyGISC FTP*	*1 degree*	*1*

Near-Real-Time High-Resolution Monthly Average Maximum/Minimum Temperature for Wyoming	*PRISM*	*WyGISC FTP*	*1 degree*	*1*
Near-Real-Time Monthly High-Resolution Precipitation Climate Data Set for Wyoming	*PRISM*	*WyGISC FTP*	*1 degree*	*1*
Processed Annual Precipitation 1971 - 2000 for Wyoming at 1:250,000	*PRISM*	*Other Download*	*1:250,000*	*1*
Processed Monthly Precipitation April 1971 - 2000 for Wyoming at 1:250,000	*PRISM*	*Other Download*	*1:250,000*	*1*
Processed Monthly Precipitation August 1971 - 2000 for Wyoming at 1:250,000	*PRISM*	*Other Download*	*1:250,000*	*1*
Processed Monthly Precipitation December 1971 - 2000 for Wyoming at 1:250,000	*PRISM*	*Other Download*	*1:250,000*	*1*
Processed Monthly Precipitation February 1971 - 2000 for Wyoming at 1:250,000	*PRISM*	*Other Download*	*1:250,000*	*1*
Processed Monthly Precipitation January 1971 - 2000 for Wyoming at 1:250,000	*PRISM*	*Other Download*	*1:250,000*	*1*
Processed Monthly Precipitation July 1971 - 2000 for Wyoming at 1:250,000	*PRISM*	*Other Download*	*1:250,000*	*1*
Processed Monthly Precipitation June 1971 - 2000 for Wyoming at 1:250,000	*PRISM*	*Other Download*	*1:250,000*	*1*
Processed Monthly Precipitation March 1971 - 2000 for Wyoming at 1:250,000	*PRISM*	*Other Download*	*1:250,000*	*1*
Processed Monthly Precipitation May 1971 - 2000 for Wyoming at 1:250,000	*PRISM*	*Other Download*	*1:250,000*	*1*
Processed Monthly Precipitation November 1971 - 2000 for Wyoming at 1:250,000	*PRISM*	*Other Download*	*1:250,000*	*1*
Processed Monthly Precipitation October 1971 - 2000 for Wyoming at 1:250,000	*PRISM*	*Other Download*	*1:250,000*	*1*
Processed Monthly Precipitation September 1971 - 2000 for Wyoming at 1:250,000	*PRISM*	*Other Download*	*1:250,000*	*1*
Current Distribution of Sage-grouse in North America at 1:2,000,000	*SAGEMAP*	*Other Download*	*1:2,000,000*	*1*
Historic Distribution of Sage-grouse in North America at 1:2,000,000	*SAGEMAP*	*Other Download*	*1:2,000,000*	*1*
MODIS Forest Type Mapping Using Forest Inventory and Analysis Data Confidence Dataset, Wyoming	*USFS*	*WyGISC FTP*		*1*
MODIS Forest Type mapping Using Forest Inventory and Analysis Data, Wyoming	*USFS*	*WyGISC FTP*		*1*
1070's Land Use Data Refined with 2000 Population Data to Indicate New Residential Development 100m for Wyoming	*USGS*	*WyGISC FTP*	*100m*	*1*
Quadrangles for Wyoming at 1:250,000	*USGS*	*WyGISC FTP*	*1:250,000*	*1*
Bedrock Geology of Wyoming at 1:500,000	*UW*	*WyGISC FTP*	*1:500,000*	*1*
Geologic Faults of Wyoming at 1:500,000	*UW*	*WyGISC FTP*	*1:500,000*	*1*
Soils Map of Wyoming at 1:500,000	*UW*	*WyGISC FTP*	*1:500,000*	*1*
Surficial Geology of Wyoming at 1:500,000	*UW*	*WyGISC FTP*	*1:500,000*	*1*
Local Working Group Areas	*WGFD*	*Contact*		*1*
Major Wetland Complexes in Wyoming	*WGFD*	*WyGISC FTP*		*1*

Sage-Grouse Core Breeding Areas for Wyoming	*WGFD*	*Contact*		*1*
Sage-Grouse Management Zones for Region	*WGFD*	*Contact*		*1*
Pipelines for Wyoming	*WSGS*	*Contact*		*1*
Railroads for Wyoming	*WSGS*	*WyGISC FTP*		*1*
Heart of the West Wildlands Network Design for Wyoming	*WUP*	*Contact*		*1*
GAP Vegetation 1994 for Wyoming	*WyGISC*	*WyGISC FTP*	*1:100,000*	*1*
GAP Vegetation Check Type Table 1994 for Wyoming	*WyGISC*	*WyGISC FTP*	*1:100,000*	*1*
GAP Vegetation Checked Table 1994 for Wyoming	*WyGISC*	*WyGISC FTP*	*1:100,000*	*1*
GAP Vegetation Crown Table 1994 for Wyoming	*WyGISC*	*WyGISC FTP*	*1:100,000*	*1*
GAP Vegetation Data Source Description Table 1994 for Wyoming	*WyGISC*	*WyGISC FTP*	*1:100,000*	*1*
GAP Vegetation Display Table 1994 for Wyoming	*WyGISC*	*WyGISC FTP*	*1:100,000*	*1*
GAP Vegetation Disturbance Table 1994 for Wyoming	*WyGISC*	*WyGISC FTP*	*1:100,000*	*1*
GAP Vegetation Imagery Scene Table 1994 for Wyoming	*WyGISC*	*WyGISC FTP*	*1:100,000*	*1*
GAP Vegetation Name Table 1994 for Wyoming	*WyGISC*	*WyGISC FTP*	*1:100,000*	*1*
GAP Vegetation Relational Table 1994 for Wyoming	*WyGISC*	*WyGISC FTP*	*1:100,000*	*1*
GAP Vegetation Type Table 1994 for Wyoming	*WyGISC*	*WyGISC FTP*	*1:100,000*	*1*
GAP Vegetation Wetlands Table 1994 for Wyoming	*WyGISC*	*WyGISC FTP*	*1:100,000*	*1*
Coordinated Implementation Plan for Bird Conservation in Western Wyoming 2005	*Wy St Comm*	*Contact*		*1*
Digital Elevation Model (DEM) 90m for Wyoming	*WyGISC*	*WyGISC FTP*	*90m*	*1*
Areas of Critical Environmental Concern, BLM for Wyoming	*BLM*	*Other Download*		*2*
Atlantic Rim Boundary for Minerals Project Area BLM Rawlins Field Office Wyoming at 1:24,000	*BLM*	*Other Download*	*1:24,000*	*2*
Blue Gap Project Area Boundary for the BLM Rawlins Field Office Wyoming at 1:24,000	*BLM*	*Other Download*	*1:24,000*	*2*
Chemical Vegetation Treatments for the BLM Worland Field Office Wyoming	*BLM*	*Contact*		*2*
Continental Divide Environmental Impact Statement Area Boundary BLM Rawlins Field Office Wyoming	*BLM*	*Other Download*	*1:24,000*	*2*
DEQ Mine Plans for the BLM Worland and Cody Field Office for Wyoming	*BLM*	*Contact*		*2*
Desolation Flats Project Area Boundary BLM Rawlins Field Office Wyoming at 1:24,000	*BLM*	*Other Download*	*1:24,000*	*2*
Developed and Potential for Development Habitats for Sage-Grouse in Wyoming at 1:24,000	*BLM*	*Other Download*	*1:24,000*	*2*
Disposal Lands for the BLM Rawlins Field Office Wyoming at 1:100,000	*BLM*	*Other Download*	*1:100,000*	*2*
Energy Corridors BLM Cody Field Office for Wyoming	*BLM*	*Other Download*		*2*
Exclosures BLM Cody Field Office for Wyoming	*BLM*	*Other Download*		*2*
Fences for the BLM Cody Field Office for Wyoming	*BLM*	*Other Download*		*2*

Fences for the BLM Cody Field Office for Wyoming	*BLM*	*Contact*		*2*
Fences for the BLM Rawlins Field Office for Wyoming	*BLM*	*Contact*		*2*
Fences for the BLM Rock Springs Field Office Wyoming	*BLM*	*Contact*		*2*
Fences for the BLM Worland Field Office Wyoming	*BLM*	*Contact*		*2*
Fences in BLM Lander Field Office Wyoming at 1:24,000	*BLM*	*Contact*	*1:24,000*	*2*
Fences in the BLM Pinedale Field Office Wyoming at 1:100,000	*BLM*	*Contact*	*1:100,000*	*2*
Fire Occurrences in the BLM Rawlins Field Office 1980 to 2007 Wyoming	*BLM*	*Contact*		*2*
Fire Perimeters for the BLM Buffalo Field Office for Wyoming	*BLM*	*Contact*		*2*
Gates for the BLM Cody Field Office for Wyoming	*BLM*	*Other Download*		*2*
Hannah Draw Area for the BLM Rawlins Field Office Wyoming at 1:24,000	*BLM*	*Other Download*	*1:24,000*	*2*
Historic Wildland Fires for the BLM Rock Springs Field Office Wyoming	*BLM*	*Contact*		*2*
Homestead Park II Wildland Fire 2006 for the BLM Lander Field Office for Wyoming	*BLM*	*Contact*		*2*
Invasive Species Management Areas within the BLM Buffalo Field Office for Wyoming	*BLM*	*Contact*		*2*
Isohyetals of Polygons and Regions BLM Cody Field Office Wyoming	*BLM*	*Contact*		*2*
Management Zones for the Pinedale Anticline BLM Pinedale Field Office Wyoming at 1:100,000	*BLM*	*Other Download*	*1:100,000*	*2*
Mechanical Vegetation Treatments for the BLM Cody Field Office	*BLM*	*Contact*		*2*
Mechanical Vegetation Treatments for the BLM Worland Field Office Wyoming	*BLM*	*Contact*		*2*
Mine Sites for the BLM Lander Field Office	*BLM*	*Contact*		*2*
Mine Sites for the BLM Lander Field Office Wyoming	*BLM*	*Contact*		*2*
Mineral Material Sites for the BLM Cody Field Office for Wyoming	*BLM*	*Other Download*		*2*
Mines for the BLM Rock Springs Field Office for Wyoming	*BLM*	*Contact*		*2*
Mines in the BLM Rock Springs Field Office Wyoming	*BLM*	*Contact*		*2*
Mining Areas for the BLM Worland Field Office Wyoming	*BLM*	*Contact*		*2*
No Lease Areas BLM Cody Field Office for Wyoming	*BLM*	*Other Download*		*2*
No Surface Occupancy BLM Pinedale Field Office for Wyoming	*BLM*	*Other Download*	*1:100,000*	*2*
No Surface Occupancy for the BLM Cody Field Office for Wyoming	*BLM*	*Other Download*		*2*
Off-Highway Vehicle Planning Areas for the BLM Cody Field Office for Wyoming	*BLM*	*Other Download*		*2*
Permitted Mining Activities for the BLM Rawlins Field Office for Wyoming	*BLM*	*Contact*		*2*
Pipelines for the BLM Cody Field Office for Wyoming	*BLM*	*Other Download*		*2*

Prairie Dog Towns BLM Pinedale Field Office Wyoming at 1:24,000	*BLM*	*Other Download*	*1:24,000*	*2*
Prescribed Burns for the BLM Cody Field Office for Wyoming	*BLM*	*Other Download*		*2*
Prescribed Fire in the BLM Worland Field Office Wyoming	*BLM*	*Contact*		*2*
Rain Gauge Locations for the BLM Cody Field Office for Wyoming	*BLM*	*Other Download*		*2*
Rain Traps for the BLM Cody Field Office for Wyoming	*BLM*	*Other Download*		*2*
Range Improvement Projects BLM Cody Field Office Wyoming	*BLM*	*Other Download*		*2*
Raptor Nest Sites for the BLM Buffalo Field Office Wyoming	*BLM*	*Contact*		*2*
Raptor Nest Sites for the BLM Casper Field Office Wyoming	*BLM*	*Contact*		*2*
Raptor Nest Sites for the BLM Cody Field Office Wyoming	*BLM*	*Contact*		*2*
Raptor Nest Sites for the BLM Kemmerer Field Office Wyoming	*BLM*	*Contact*		*2*
Raptor Nest Sites for the BLM Lander Field Office Wyoming	*BLM*	*Contact*		*2*
Raptor Nest Sites for the BLM Pinedale Field Office Wyoming	*BLM*	*Contact*		*2*
Raptor Nest Sites for the BLM Rawlins Field Office Wyoming	*BLM*	*Contact*		*2*
Raptor Nest Sites for the BLM Rock Springs Field Office Wyoming	*BLM*	*Contact*		*2*
Raptor Nest Sites for the BLM Worland Field Office Wyoming	*BLM*	*Contact*		*2*
Recreation and Public Purpose Leases for the BLM Cody Field Office for Wyoming	*BLM*	*Other Download*		*2*
Recreation Site Boundaries for the BLM Cody Field Office for Wyoming	*BLM*	*Other Download*		*2*
Reservoirs for the BLM Cody Field Office for Wyoming	*BLM*	*Other Download*		*2*
Right of Way Corridors BLM Rawlins Field Office Wyoming	*BLM*	*Other Download*	*1:100,000*	*2*
Roads for the BLM Buffalo Field Office for Wyoming	*BLM*	*Contact*		*2*
Roads for the BLM Buffalo Field Office Wyoming at 1:100,000	*BLM*	*Contact*	*1:100,000*	*2*
Roads for the BLM Cody Field Office for Wyoming	*BLM*	*Contact*		*2*
Roads for the BLM Rawlins Field Office for Wyoming	*BLM*	*Contact*		*2*
Roads for the BLM Rawlins Field Office Wyoming at 1:100,000	*BLM*	*Contact*	*1:100,000*	*2*
Roads for the BLM Worland Field Office Wyoming at 1:100,000	*BLM*	*Contact*	*1:100,000*	*2*
Sage-Grouse Developed Habitat BLM for Wyoming	*BLM*	*Other Download*	*1:24,000*	*2*
Solid Leasables BLM Casper Field Office 2001 - 2008 for Wyoming	*BLM*	*Contact*		*2*

Solid Leasables for the Buffalo Field Office for Wyoming	*BLM*	*Contact*		*2*
Solid Leasables for the Casper Field Office for Wyoming	*BLM*	*Contact*		*2*
Special Management Areas - Recreation BLM Buffalo Field Office Wyoming at 1:24,000	*BLM*	*Other Download*	*1:24,000*	*2*
Special Management Areas for the BLM Pinedale Field Office at 1:100,000	*BLM*	*Other Download*	*1:100,000*	*2*
Special Management Recreation Areas in the BLM Pinedale Field Office Wyoming at 1:100,000	*BLM*	*Other Download*	*1:100,000*	*2*
Utility Lines for the BLM Cody Field Office for Wyoming	*BLM*	*Other Download*		*2*
Vegetation Monitoring Sites for the BLM Cody Field Office for Wyoming	*BLM*	*Other Download*		*2*
Visual Resource Management Classes for Wyoming	*BLM*	*Contact*		*2*
Water Monitoring Sites for the BLM Cody Field Office for Wyoming	*BLM*	*Other Download*		*2*
Weed Distribution in the BLM Buffalo Field Office Wyoming at 1:100,000	*BLM*	*Contact*	*1:100,000*	*2*
Weed Distribution in the BLM Rock Springs Field Office Wyoming	*BLM*	*Contact*		*2*
Wild Horse Management Areas BLM, for Wyoming	*BLM*	*Contact*		*2*
Wildland Fire for the BLM Worland Field Office Wyoming	*BLM*	*Contact*		*2*
Wildland Fire History 1984-2007 for the BLM Lander Field Office for Wyoming	*BLM*	*Contact*		*2*
Wildland Fire in the BLM Cody Field Office Wyoming	*BLM*	*Contact*		*2*
Wildland Fire Points 2006 for the BLM Lander Field Office for Wyoming	*BLM*	*Contact*		*2*
Wildland Fires 1980-2007 for the BLM Rawlins Field Office for Wyoming	*BLM*	*Contact*		*2*
Wildland Fires 1990-2007 for the BLM Casper, Buffalo and Newcastle Field Offices for Wyoming	*BLM*	*Contact*		*2*
Wildland Fires 2000 for the BLM Lander Field Office for Wyoming	*BLM*	*Contact*		*2*
Wildland Fires 2001 for the BLM Lander Field Office for Wyoming	*BLM*	*Contact*		*2*
Wildland Fires 2002 for the BLM Lander Field Office for Wyoming	*BLM*	*Contact*		*2*
Wildland Fires 2003 for the BLM Lander Field Office for Wyoming	*BLM*	*Contact*		*2*
Wildland Fires 2004 for the BLM Lander Field Office for Wyoming	*BLM*	*Contact*		*2*
Wildland Fires 2005 for the BLM Lander Field Office for Wyoming	*BLM*	*Contact*		*2*
Wildland Fires for the BLM Cody Field Office for Wyoming	*BLM*	*Contact*		*2*
Zoned Fire Points in the BLM Casper Field Office 1990 to 2007 Wyoming	*BLM*	*Contact*		*2*
Zoned Fires in the BLM Casper Field Office 1990 to 2007 Wyoming	*BLM*	*Contact*		*2*
Exclosures for the BLM Cody Field Office Wyoming	*BLM*	*Other*		*2*

		Download		
Project Locations in the BLM Cody Field Office Wyoming	BLM	Other Download		2
Solid Leasables BLM Casper Field Office 2008 Wyoming	BLM	Contact		2
Roads for Wyoming at 1:100,000	Census	WyGISC FTP	1:100,000	2
Transmission Lines for Wyoming at 1:100,000	FEMA	WyGISC FTP	1:100,000	2
Wyoming Wind Resource Potential at 50m Height	NREL	WyGISC FTP	400m	2
Power line Corridors in the Western United States and Canada at 1:100,000	SAGEMAP	Other Download	1:100,000	2
Major Roads of Wyoming at 1:100,000	US Census	WyGISC FTP	1:100,000	2
National Inventoried Roadless Areas (IRAs) for Wyoming at 1:100,000	USDA	WyGISC FTP	1:100,000	2
Quadrangles for Wyoming at 1:100,000	USGS	WyGISC FTP	1:100,000	2
Weed Distribution in Bighorn County, Wyoming	W&P - BC	Contact		2
Weed Distribution in Campbell County, Wyoming	W&P-CC	Contact		2
Weed Distribution in Fremont County Wyoming	W&P-FC	Contact		2
Weed Distribution in Lincoln County, Wyoming	W&P-LC	Contact		2
Weed Distribution in Natrona County, Wyoming	W&P-NC	Contact		2
Antelope Hunt Area and Herd Unit Boundaries 2008 for Wyoming	WGFD	Contact	1:100,000	2
Bighorn Sheep Hunt Area and Herd Unit Boundaries 2008 for Wyoming	WGFD	Contact	1:100,000	2
Bighorn Sheep Parturition Areas	WGFD	Contact	1:100,000	2
Bighorn Sheep Seasonal Range Boundaries 2006 for Wyoming	WGFD	Contact	1:100,000	2
Bighorn Sheep Seasonal Range Boundaries 2006 for Wyoming	WGFD	Contact	1:100,000	2
Bighorn Sheep Statewide Migration Barriers	WGFD	Contact	1:100,000	2
Bison Hunt Area Boundaries 2007 for Wyoming	WGFD	Contact	1:100,000	2
Black Bear Hunt Areas and Management Units 2008 for Wyoming	WGFD	Contact	1:100,000	2
Elk Hunt Area and Herd Unit Boundaries 2008 for Wyoming	WGFD	Contact	1:100,000	2
Elk Migration Corridors in Wyoming	WGFD	Contact	1:100,000	2
Elk Parturition Areas	WGFD	Contact	1:100,000	2
Elk Seasonal Range Boundaries 2006 for Wyoming	WGFD	Contact	1:100,000	2
Moose Hunt Area and Herd Unit Boundaries 2008 for Wyoming	WGFD	Contact	1:100,000	2
Moose Migration Corridors for Wyoming	WGFD	Contact	1:100,000	2
Moose Parturition Areas	WGFD	Contact	1:100,000	2
Moose Seasonal Range Boundaries 2006 for Wyoming	WGFD	Contact	1:100,000	2
Mountain Lion Hunt Area Boundaries 2007 for Wyoming	WGFD	Contact	1:100,000	2

Mule Deer Hunt Area and Herd Unit Boundaries 2008 for Wyoming	*WGFD*	*Contact*	*1:100,000*	*2*
Mule Deer Migration Corridors for Wyoming	*WGFD*	*Contact*	*1:100,000*	*2*
Mule Deer Parturition Areas	*WGFD*	*Contact*	*1:100,000*	*2*
Mule Deer Seasonal Range Boundaries 2006 for Wyoming	*WGFD*	*Contact*	*1:100,000*	*2*
Pronghorn Parturition Areas	*WGFD*	*Contact*	*1:100,000*	*2*
Pronghorn Seasonal Range Boundaries 2006 for Wyoming	*WGFD*	*Contact*	*1:100,000*	*2*
Rocky Mountain Goat Hunt Area and Herd Unit Boundaries 2007	*WGFD*	*Contact*	*1:100,000*	*2*
Rocky Mountain Goat Migration Corridors for Wyoming	*WGFD*	*Contact*	*1:100,000*	*2*
Rocky Mountain Goat Parturition Areas	*WGFD*	*Contact*	*1:100,000*	*2*
Rocky Mountain Goat Seasonal Range Boundaries 2006 for Wyoming	*WGFD*	*Contact*	*1:100,000*	*2*
Sage-Grouse Core Breeding Areas for Wyoming	*WGFD*	*Contact*		*2*
Sage-Grouse Distribution on State Lands in Wyoming	*WGFD*	*Contact*	*1:24,000*	*2*
South Wind River Mule Deer Herd Habitat Management Plan, Wyoming at 1:100,000	*WGFD*	*Contact*	*1:100,000*	*2*
Statewide Pronghorn Antelope Migration Barriers	*WGFD*	*Contact*	*1:100,000*	*2*
White-tailed Deer Hunt Area and Herd Unit Boundaries 2008 for Wyoming	*WGFD*	*Contact*	*1:100,000*	*2*
White-tailed Deer Migration Routes in Wyoming	*WGFD*	*Contact*	*1:100,000*	*2*
White-tailed Deer Seasonal Range Boundaries 2006 for Wyoming	*WGFD*	*Contact*	*1:100,000*	*2*
Wells January 2009 Wyoming Oil and Gas Conservation Commission for Wyoming	*WOGCC*	*Other Download*		*2*
County Boundaries for Wyoming at 1:100,000	*WyGISC*	*WyGISC FTP*	*1:100,000*	*2*
Land Cover 30m for Southeast Wyoming	*WyGISC*	*WyGISC FTP*	*30m*	*2*
Land Cover Crosswalk at 2 Acre MMU for the Kemmerer Field Office Wyoming	*WyGISC*	*WyGISC FTP*	*30m*	*2*
Land Cover Crosswalk at 2 Acre MMU for the Rawlins Field Office Wyoming	*WyGISC*	*WyGISC FTP*	*30m*	*2*
Land Cover Crosswalk at 2 Acre MMU for the Rock Springs Field Office Wyoming	*WyGISC*	*WyGISC FTP*	*30m*	*2*
Land Cover NDVI Difference 1970s to 1980s 30m Southeast Wyoming	*WyGISC*	*WyGISC FTP*	*30m*	*2*
Land Cover NDVI Difference 1970s to 2002 30m Southeast Wyoming	*WyGISC*	*WyGISC FTP*	*30m*	*2*
Land Cover NDVI Difference 1980s to 2002 30m Southeast Wyoming	*WyGISC*	*WyGISC FTP*	*30m*	*2*
State Boundary of Wyoming at 1:100,000	*WyGISC*	*WyGISC FTP*	*1:100,00*	*2*
TC1 Difference 1970s to 1980s 30m for Southeast Wyoming	*WyGISC*	*WyGISC FTP*	*30m*	*2*
TC1 Difference 1970s to 2002 30m for Southeast Wyoming	*WyGISC*	*WyGISC FTP*	*30m*	*2*
TC1 Difference 1980s to 2002 30m for Southeast	*WyGISC*	*WyGISC FTP*	*30m*	*2*

Wyoming				
Weather Station Monthly Total and Annual Precipitation, 1970 - 2000 for Wyoming	*WyGISC*	*WyGISC FTP*		*2*
Coal Development Sites - Known Boundaries for the BLM Rawlins Field Office Wyoming at 1:24,000	*BLM*	*Other Download*	*1:24,000*	*3*
Fences for the BLM Lander Field Office for Wyoming	*BLM*	*Contact*	*1:24,000*	*3*
Fences for the BLM Rock Springs Field Office Wyoming	*BLM*	*Other Download*	*1:24,000*	*3*
Fences in BLM Rawlins Field Office Wyoming at 1:24,000	*BLM*	*Contact*	*1:24,000*	*3*
Land Ownership for Wyoming at 1:24,000	*BLM*	*WyGISC FTP*	*1:24,000*	*3*
Land Withdrawals for the BLM Cody Field Office Wyoming at 1:24,000	*BLM*	*Other Download*	*1:24,000*	*3*
Land Withdrawals for the BLM Pinedale Field Office Wyoming at 1:24,000	*BLM*	*Other Download*	*1:24,000*	*3*
Mine Permit Boundary Coverage for the BLM Rawlins Field Office Wyoming at 1:24,000	*BLM*	*Contact*	*1:24,000*	*3*
Oil and Gas Sale Parcels April 2006 BLM for Wyoming	*BLM*	*Other Download*	*1:24,000*	*3*
Oil and Gas Sale Parcels April 2007 BLM for Wyoming	*BLM*	*Other Download*	*1:24,000*	*3*
Oil and Gas Sale Parcels April 2008 BLM for Wyoming	*BLM*	*Other Download*	*1:24,000*	*3*
Oil and Gas Sale Parcels August 2006 BLM for Wyoming	*BLM*	*Other Download*	*1:24,000*	*3*
Oil and Gas Sale Parcels August 2007 BLM for Wyoming	*BLM*	*Other Download*	*1:24,000*	*3*
Oil and Gas Sale Parcels August 2008 BLM for Wyoming	*BLM*	*Other Download*	*1:24,000*	*3*
Oil and Gas Sale Parcels December 2005 BLM for Wyoming	*BLM*	*Other Download*	*1:24,000*	*3*
Oil and Gas Sale Parcels December 2006 BLM for Wyoming	*BLM*	*Other Download*	*1:24,000*	*3*
Oil and Gas Sale Parcels December 2007 BLM for Wyoming	*BLM*	*Other Download*	*1:24,000*	*3*
Oil and Gas Sale Parcels December 2008 BLM for Wyoming	*BLM*	*Other Download*	*1:24,000*	*3*
Oil and Gas Sale Parcels February 2006 BLM for Wyoming	*BLM*	*Other Download*	*1:24,000*	*3*
Oil and Gas Sale Parcels February 2007 BLM for Wyoming	*BLM*	*Other Download*	*1:24,000*	*3*
Oil and Gas Sale Parcels February 2008 BLM for Wyoming	*BLM*	*Other Download*	*1:24,000*	*3*
Oil and Gas Sale Parcels June 2006 BLM for Wyoming	*BLM*	*Other Download*	*1:24,000*	*3*
Oil and Gas Sale Parcels June 2007 BLM for Wyoming	*BLM*	*Other Download*	*1:24,000*	*3*
Oil and Gas Sale Parcels June 2008 BLM for Wyoming	*BLM*	*Other Download*	*1:24,000*	*3*
Oil and Gas Sale Parcels October 2006 BLM for Wyoming	*BLM*	*Other*	*1:24,000*	*3*

		Download		
Oil and Gas Sale Parcels October 2007 BLM for Wyoming	BLM	Other Download	1:24,000	3
Oil and Gas Sale Parcels October 2008 BLM for Wyoming	BLM	Other Download	1:24,000	3
Permitted Mining Activities for the BLM Rawlins Field Office Wyoming at 1:24,000	BLM	Contact	1:24,000	3
Poison Spider Fire Perimeter 2006 for the BLM Lander Field Office for Wyoming	BLM	Contact	1:24,000	3
Prescribed Burns 1996-2006 for the BLM Casper Field Office for Wyoming	BLM	Contact	1:24,000	3
Prescribed Fires for the BLM Casper Field Office 1996 to 2006 for Wyoming at 1:24,000	BLM	Contact	1:24,000	3
Range Improvement Projects BLM Pinedale Field Office Wyoming	BLM	Other Download	1:24,000	3
Special Management Areas within the BLM Rawlins Field Office Wyoming at 1:24,000	BLM	Other Download	1:24,000	3
Special Management Areas within the BLM Cody Field Office for Wyoming	BLM	Other Download	1:24,000	3
Special Management Areas within the Rawlins Field Office for Wyoming	BLM	Other Download	1:24,000	3
Wilderness Study Areas in Wyoming at 1:24,000	BLM	Other Download	1:24,000	3
Wilderness Study Areas in Wyoming at 1:24,000	BLM	Other Download	1:24,000	3
Withdrawals for the BLM Cody Field Office for Wyoming	BLM	Other Download	1:24,000	3
Acquisitions LR2000 for Wyoming	LR2000	WyGISC FTP	1:24,000	3
Active Mining Claims LR2000 for Wyoming	LR2000	WyGISC FTP	1:24,000	3
All Land Use Permits LR2000 for Wyoming	LR2000	WyGISC FTP	1:24,000	3
All Mining and Mineral Division Leases LR2000 for Wyoming	LR2000	WyGISC FTP	1:24,000	3
All Right of Ways LR2000 for Wyoming	LR2000	WyGISC FTP	1:24,000	3
All Subsurface Management Agencies LR2000 for Wyoming	LR2000	WyGISC FTP	1:24,000	3
All Surface Management Areas LR2000 for Wyoming	LR2000	WyGISC FTP	1:24,000	3
All Wind Energy Leases LR2000 for Wyoming	LR2000	WyGISC FTP	1:24,000	3
Applied Wind Energy Leases LR2000 for Wyoming	LR2000	WyGISC FTP	1:24,000	3
Areas of No Subsurface Management LR2000 for Wyoming	LR2000	WyGISC FTP	1:24,000	3
Authorized Agreements of Oil and Gas LR2000 for Wyoming	LR2000	WyGISC FTP	1:24,000	3
Authorized Land Use Permits LR2000 for Wyoming	LR2000	WyGISC FTP	1:24,000	3
Authorized Mining and Mineral Division Leases LR2000 for Wyoming	LR2000	WyGISC FTP	1:24,000	3
Authorized Right of Ways LR2000 for Wyoming	LR2000	WyGISC FTP	1:24,000	3
Authorized Wind Energy Leases LR2000 for Wyoming	LR2000	WyGISC FTP	1:24,000	3

BLM Bankhead-Jones Farm Tenant Act Lands LR2000 for Wyoming	*LR2000*	*WyGISC FTP*	*1:24,000*	*3*
BLM Dissolved Lands LR2000 for Wyoming	*LR2000*	*WyGISC FTP*	*1:24,000*	*3*
BLM Districts LR2000 for Wyoming	*LR2000*	*WyGISC FTP*	*1:24,000*	*3*
BLM Lands LR2000 for Wyoming	*LR2000*	*WyGISC FTP*	*1:24,000*	*3*
Bureau of Indian Affairs Surface Management LR2000 for Wyoming	*LR2000*	*WyGISC FTP*	*1:24,000*	*3*
Bureau of Reclamation Lands LR2000 for Wyoming	*LR2000*	*WyGISC FTP*	*1:24,000*	*3*
Case Designated Areas LR2000 for Wyoming	*LR2000*	*WyGISC FTP*	*1:24,000*	*3*
Case Exchanges LR2000 for Wyoming	*LR2000*	*WyGISC FTP*	*1:24,000*	*3*
Case Grants LR2000 for Wyoming	*LR2000*	*WyGISC FTP*	*1:24,000*	*3*
Cases Pending Exchange LR2000 for Wyoming	*LR2000*	*WyGISC FTP*	*1:24,000*	*3*
Closed Agreements of Oil and Gas Leases LR2000 for Wyoming	*LR2000*	*WyGISC FTP*	*1:24,000*	*3*
Closed Coal Leases LR2000 for Wyoming	*LR2000*	*WyGISC FTP*	*1:24,000*	*3*
Closed Land Use Permits LR2000 for Wyoming	*LR2000*	*WyGISC FTP*	*1:24,000*	*3*
Closed Mining and Mineral Division Leases LR2000 for Wyoming	*LR2000*	*WyGISC FTP*	*1:24,000*	*3*
Closed Rights of Ways LR2000 for Wyoming	*LR2000*	*WyGISC FTP*	*1:24,000*	*3*
Closed Wind Energy Leases LR2000 for Wyoming	*LR2000*	*WyGISC FTP*	*1:24,000*	*3*
Coal Leases LR2000 for Wyoming	*LR2000*	*WyGISC FTP*	*1:24,000*	*3*
Coal Permits and Licenses LR2000 for Wyoming	*LR2000*	*WyGISC FTP*	*1:24,000*	*3*
Coal Subsurface Management LR2000 for Wyoming	*LR2000*	*WyGISC FTP*	*1:24,000*	*3*
Corrective Cases LR2000 for Wyoming	*LR2000*	*WyGISC FTP*	*1:24,000*	*3*
Department of Defense Surface Management LR2000 for Wyoming	*LR2000*	*WyGISC FTP*	*1:24,000*	*3*
Dissolved National Forests LR2000 for Wyoming	*LR2000*	*WyGISC FTP*	*1:24,000*	*3*
Gas Density LR2000 for Wyoming	*LR2000*	*WyGISC FTP*	*1:24,000*	*3*
General Right of Ways LR2000 for Wyoming	*LR2000*	*WyGISC FTP*	*1:24,000*	*3*
Geothermal Leases Closed LR2000 for Wyoming	*LR2000*	*WyGISC FTP*	*1:24,000*	*3*
Known Geothermal Leasing Areas LR2000 for Wyoming	*LR2000*	*WyGISC FTP*	*1:24,000*	*3*
Logical Mining Units Closed for Solid Minerals LR2000 for Wyoming	*LR2000*	*WyGISC FTP*	*1:24,000*	*3*
Logical Mining Units for Solid Minerals LR2000 for Wyoming	*LR2000*	*WyGISC FTP*	*1:24,000*	*3*
Mineral Patents LR2000 for Wyoming	*LR2000*	*WyGISC FTP*	*1:24,000*	*3*
Mining Claims Plans and Notices Closed LR2000 for Wyoming	*LR2000*	*WyGISC FTP*	*1:24,000*	*3*
Mining Claims Plans and Notices LR2000 for Wyoming	*LR2000*	*WyGISC FTP*	*1:24,000*	*3*
National Forests LR2000 for Wyoming	*LR2000*	*WyGISC FTP*	*1:24,000*	*3*
National Parks LR2000 for Wyoming	*LR2000*	*WyGISC FTP*	*1:24,000*	*3*
Nonproducing Geothermal Leases LR2000 for Wyoming	*LR2000*	*WyGISC FTP*	*1:24,000*	*3*
Oil and Gas Basin Study Areas LR2000 for Wyoming	*LR2000*	*WyGISC FTP*	*1:24,000*	*3*

Oil and Gas Closed Leases LR2000 for Wyoming	*LR2000*	*WyGISC FTP*	*1:24,000*	*3*
Oil and Gas Communization Agreements LR2000 for Wyoming	*LR2000*	*WyGISC FTP*	*1:24,000*	*3*
Oil and Gas Lease Sale Parcels LR2000 for Wyoming	*LR2000*	*WyGISC FTP*	*1:24,000*	*3*
Oil and Gas Leases Authorized LR2000 for Wyoming	*LR2000*	*WyGISC FTP*	*1:24,000*	*3*
Oil and Gas Leases Nonproducing LR2000 for Wyoming	*LR2000*	*WyGISC FTP*	*1:24,000*	*3*
Oil and Gas Participating Area Agreements LR2000 for Wyoming	*LR2000*	*WyGISC FTP*	*1:24,000*	*3*
Oil and Gas Producing Leases LR2000 for Wyoming	*LR2000*	*WyGISC FTP*	*1:24,000*	*3*
Oil and Gas Stipulations LR2000 for Wyoming	*LR2000*	*WyGISC FTP*	*1:24,000*	*3*
Oil and Gas Subsurface Management LR2000 for Wyoming	*LR2000*	*WyGISC FTP*	*1:24,000*	*3*
Oil and Gas Unit Agreements LR2000 for Wyoming	*LR2000*	*WyGISC FTP*	*1:24,000*	*3*
Oil Density LR2000 for Wyoming	*LR2000*	*WyGISC FTP*	*1:24,000*	*3*
Other Oil and Gas Agreements LR2000 for Wyoming	*LR2000*	*WyGISC FTP*	*1:24,000*	*3*
Other Right of Ways LR2000 for Wyoming	*LR2000*	*WyGISC FTP*	*1:24,000*	*3*
Overview of Active Mining Claims LR2000 for Wyoming	*LR2000*	*WyGISC FTP*	*1:24,000*	*3*
Overview of Authorized Agreements for Oil and Gas Leases LR2000 for Wyoming	*LR2000*	*WyGISC FTP*	*1:24,000*	*3*
Overview of Authorized Oil and Gas Leases LR2000 for Wyoming	*LR2000*	*WyGISC FTP*	*1:24,000*	*3*
Overview of Range Land Allotments LR2000 for Wyoming	*LR2000*	*WyGISC FTP*	*1:24,000*	*3*
Pending Wind Energy Leases LR2000 for Wyoming	*LR2000*	*WyGISC FTP*	*1:24,000*	*3*
Presale Offers LR2000 for Wyoming	*LR2000*	*WyGISC FTP*	*1:24,000*	*3*
Public Law 167 LR2000 for Wyoming	*LR2000*	*WyGISC FTP*	*1:24,000*	*3*
Range Allotments LR2000 for Wyoming	*LR2000*	*WyGISC FTP*	*1:24,000*	*3*
Range Pastures LR2000 for Wyoming	*LR2000*	*WyGISC FTP*	*1:24,000*	*3*
Right of Way for Communication Sites LR2000 for Wyoming	*LR2000*	*WyGISC FTP*	*1:24,000*	*3*
Right of Way for Pipelines LR2000 for Wyoming	*LR2000*	*WyGISC FTP*	*1:24,000*	*3*
Right of Way for Power LR2000 for Wyoming	*LR2000*	*WyGISC FTP*	*1:24,000*	*3*
Right of Way for Railroads LR2000 for Wyoming	*LR2000*	*WyGISC FTP*	*1:24,000*	*3*
Right of Way for Roads LR2000 for Wyoming	*LR2000*	*WyGISC FTP*	*1:24,000*	*3*
Right of Way for Telephone LR2000 for Wyoming	*LR2000*	*WyGISC FTP*	*1:24,000*	*3*
Right of Way for Water LR2000 for Wyoming	*LR2000*	*WyGISC FTP*	*1:24,000*	*3*
Solid Mineral Leases Closed LR2000 for Wyoming	*LR2000*	*WyGISC FTP*	*1:24,000*	*3*
State Surface Management LR2000 for Wyoming	*LR2000*	*WyGISC FTP*	*1:24,000*	*3*
Subsurface Management LR2000 for Wyoming	*LR2000*	*WyGISC FTP*	*1:24,000*	*3*
United States Forest Service Regions LR2000 for Wyoming	*LR2000*	*WyGISC FTP*	*1:24,000*	*3*
US Fish and Wildlife Service Surface Management LR2000 for Wyoming	*LR2000*	*WyGISC FTP*	*1:24,000*	*3*
US Forest Service Regions LR2000 for Wyoming	*LR2000*	*WyGISC FTP*	*1:24,000*	*3*

Wild Horse Herd Management Areas LR2000 for Wyoming	*LR2000*	*WyGISC FTP*	*1:24,000*	*3*
Withdrawals Classifications LR2000 for Wyoming	*LR2000*	*WyGISC FTP*	*1:24,000*	*3*
Ecological Site Descriptions for Wyoming at 1:24,000	*NRCS*	*Other Download*	*1:24,000*	*3*
Soil Survey Geographic (SSURGO) Data by County for Wyoming at 1:24,000	*NRCS*	*Other Download*	*1:24,000*	*3*
Soil Survey Geographic (SSURGO) Database for Albany County Area, Wyoming at 1:24,000	*NRCS*	*Other Download*	*1:24,000*	*3*
Soil Survey Geographic (SSURGO) Database for Bridger National Forest, Wyoming, Eastern part at 1:24,000	*NRCS*	*Other Download*	*1:24,000*	*3*
Soil Survey Geographic (SSURGO) Database for Campbell County, Wyoming, Southern part at 1:24,000	*NRCS*	*Other Download*	*1:24,000*	*3*
Soil Survey Geographic (SSURGO) Database for Converse County, Wyoming, Southern part at 1:24,000	*NRCS*	*Other Download*	*1:24,000*	*3*
Soil Survey Geographic (SSURGO) Database for Crook County, Wyoming at 1:24,000	*NRCS*	*Other Download*	*1:24,000*	*3*
Soil Survey Geographic (SSURGO) Database for Eden Valley Area, Wyoming, Parts of Sweetwater and Sublette Counties at 1:24,000	*NRCS*	*Other Download*	*1:24,000*	*3*
Soil Survey Geographic (SSURGO) Database for Fremont County, Wyoming, Lander Area at 1:24,000	*NRCS*	*Other Download*	*1:24,000*	*3*
Soil Survey Geographic (SSURGO) Database for Goshen County, Wyoming, Northern part at 1:24,000	*NRCS*	*Other Download*	*1:24,000*	*3*
Soil Survey Geographic (SSURGO) Database for Goshen County, Wyoming, Southern part at 1:24,000	*NRCS*	*Other Download*	*1:24,000*	*3*
Soil Survey Geographic (SSURGO) Database for Henrys Fork Area, Utah-Wyoming, at 1:24,000	*NRCS*	*Other Download*	*1:24,000*	*3*
Soil Survey Geographic (SSURGO) Database for Johnson County Area, Wyoming, Southern Part at 1:24,000	*NRCS*	*Other Download*	*1:24,000*	*3*
Soil Survey Geographic (SSURGO) Database for Laramie County, Wyoming, Eastern part at 1:24,000	*NRCS*	*Other Download*	*1:24,000*	*3*
Soil Survey Geographic (SSURGO) Database for Laramie County, Wyoming, Western part at 1:24,000	*NRCS*	*Other Download*	*1:24,000*	*3*
Soil Survey Geographic (SSURGO) Database for Natrona County Area, Wyoming at 1:24,000	*NRCS*	*Other Download*	*1:24,000*	*3*
Soil Survey Geographic (SSURGO) Database for Niobrara County, Wyoming at 1:24,000	*NRCS*	*Other Download*	*1:24,000*	*3*
Soil Survey Geographic (SSURGO) Database for Platte County, Wyoming at 1:24,000	*NRCS*	*Other Download*	*1:24,000*	*3*
Soil Survey Geographic (SSURGO) Database for Riverton Area, Wyoming, Western part at 1:24,000	*NRCS*	*Other Download*	*1:24,000*	*3*
Soil Survey Geographic (SSURGO) Database for Sheridan County Area, Wyoming at 1:24,000	*NRCS*	*Other Download*	*1:24,000*	*3*
Soil Survey Geographic (SSURGO) Database for Shoshone National Forest, Wyoming at 1:24,000	*NRCS*	*Other Download*	*1:24,000*	*3*
Soil Survey Geographic (SSURGO) Database for Star Valley Area, Wyoming-Idaho at 1:24,000	*NRCS*	*Other Download*	*1:24,000*	*3*
Soil Survey Geographic (SSURGO) Database for Targhee National Forest, Idaho at 1:24,000	*NRCS*	*Other Download*	*1:24,000*	*3*

Soil Survey Geographic (SSURGO) Database for Teton Area, Idaho-Wyoming at 1:24,000	*NRCS*	*Other Download*	*1:24,000*	*3*
Soil Survey Geographic (SSURGO) Database for Teton County, Wyoming, Grant Teton National Park Area at 1:24,000	*NRCS*	*Other Download*	*1:24,000*	*3*
Soil Survey Geographic (SSURGO) Database for Washakie County, Wyoming at 1:24,000	*NRCS*	*Other Download*	*1:24,000*	*3*
Soil Survey Geographic (SSURGO) Database for Weston County, Wyoming at 1:24,000	*NRCS*	*Other Download*	*1:24,000*	*3*
Public Land Survey System - Quarter-Quarter Section Level for Wyoming at 1:24,000	*PDS*	*WyGISC FTP*	*1:24,000*	*3*
Public Land Survey System - Townships for Wyoming at 1:24,000	*PDS*	*WyGISC FTP*	*1:24,000*	*3*
Approved Acquisition Boundary for Seedskadee National Wildlife Refuge	*USFWS*	*Contact*		*3*
National Wetlands Inventory (NWI) for Wyoming	*USFWS*	*Other Download*	*1:24,000*	*3*
Vegetation for Seedskadee National Wildlife Refuge Wyoming	*USFWS*	*Contact*		*3*
Vegetation for Seedskadee National Wildlife Refuge Wyoming - Other	*USFWS*	*Contact*		*3*
GAP Analysis Program: Northwest (ReGAP) 1999 - 2001	*USGS*	*Other Download*	*30m*	*3*
LANDFIRE Biophysical Settings 30m for Wyoming	*USGS*	*WyGISC FTP*	*30m*	*3*
LANDFIRE Canopy Base Height 30m for Wyoming	*USGS*	*WyGISC FTP*	*30m*	*3*
LANDFIRE Canopy Bulk Density 30m for Wyoming	*USGS*	*WyGISC FTP*	*30m*	*3*
LANDFIRE Canopy Cover 30m for Wyoming	*USGS*	*WyGISC FTP*	*30m*	*3*
LANDFIRE Elevation Derivatives for National Applications (EDNA) 30m Aspect for Wyoming	*USGS*	*WyGISC FTP*	*30m*	*3*
LANDFIRE Elevation Derivatives for National Applications (EDNA) Filled DEM 30m for Wyoming	*USGS*	*WyGISC FTP*	*30m*	*3*
LANDFIRE Elevation Derivatives for National Applications (EDNA) Slope (degrees) 30m for Wyoming	*USGS*	*WyGISC FTP*	*30m*	*3*
LANDFIRE Environmental Site Potential 30m for Wyoming	*USGS*	*WyGISC FTP*	*30m*	*3*
LANDFIRE Existing Vegetation Cover 30m for Wyoming	*USGS*	*WyGISC FTP*	*30m*	*3*
LANDFIRE Existing Vegetation Height 30m for Wyoming	*USGS*	*WyGISC FTP*	*30m*	*3*
LANDFIRE Fire Behavior Fuel Model 13 30m for Wyoming	*USGS*	*WyGISC FTP*	*30m*	*3*
LANDFIRE Fire Behavior Fuel Model 40 30m for Wyoming	*USGS*	*WyGISC FTP*	*30m*	*3*
LANDFIRE Fire Regime Condition Class 30m for Wyoming	*USGS*	*WyGISC FTP*	*30m*	*3*
LANDFIRE Fire Regime Condition Class Departure Index 30m for Wyoming	*USGS*	*WyGISC FTP*	*30m*	*3*
LANDFIRE Fire Regime Groups 30m for Wyoming	*USGS*	*WyGISC FTP*	*30m*	*3*
LANDFIRE Mean Fire Return Interval 30m for Wyoming	*USGS*	*WyGISC FTP*	*30m*	*3*
LANDFIRE Simulated Historical Percent of Mixed Severity Fires 30m for Wyoming	*USGS*	*WyGISC FTP*	*30m*	*3*
LANDFIRE Simulated Historical Percent of Replacement Severity Fires 30m for Wyoming	*USGS*	*WyGISC FTP*	*30m*	*3*

LANDFIRE Succession Classes 30m for Wyoming	*USGS*	*WyGISC FTP*	*30m*	*3*
LANDFIRE Simulated Historical Percent of Low Severity Fires 30m for Wyoming	*USGS*	*WyGISC FTP*	*30m*	*3*
LANDIFE Canopy Height 30m for Wyoming	*USGS*	*WyGISC FTP*	*30m*	*3*
LANDIFIRE Existing Vegetation Type 30m for Wyoming	*USGS*	*WyGISC FTP*	*30m*	*3*
National Hydrological Dataset (NHD)	*USGS*	*Other Download*		*3*
National Land Cover Dataset (NLCD) 1990	*USGS*	*Other Download*	*30m*	*3*
National Land Cover Dataset (NLCD) 2000	*USGS*	*Other Download*	*30m*	*3*
Quadrangles for Wyoming at 1:24,000	*USGS*	*WyGISC FTP*	*1:24,000*	*3*
Occupied Sage-Grouse Leks in Wyoming	*WGFD*	*Contact*		*3*
Sage-Grouse Leks in Wyoming	*WGFD*	*Contact*		*3*
Undetermined Activity Sage-Grouse Leks in Wyoming	*WGFD*	*Contact*		*3*
Unoccupied Sage-Grouse Leks in Wyoming	*WGFD*	*Contact*		*3*
Municipal Boundaries for Wyoming at 1:24,000	*WyDR*	*WyGISC FTP*	*1:24,000*	*3*
Watershed Boundaries Level 4 for Wyoming at 1:24,000	*WyGISC*	*WyGISC FTP*	*1:24,000*	*3*
Watershed Boundaries Level 5 for Wyoming at 1:24,000	*WyGISC*	*WyGISC FTP*	*1:24,000*	*3*
Watershed Boundaries Level 6 for Wyoming at 1:24,000	*WyGISC*	*WyGISC FTP*	*1:24,000*	*3*
Public Land Survey System - Sections for Wyoming at 1:24,000	*PDS*	*WyGISC FTP*	*1:24,000*	*3*

Appendix C: WyGISC Field Sampling Protocols

C.1: Example of Form Used for Field Data

Page1:

Date: _____ Observer: _____

Agency: _____ Observer contact (phone/e-mail): _____

Site Location Information (See detailed instructions on separate page)
This information must be sufficient to allow the site to be precisely depicted in a digital GIS database and to be associated with the land cover information on this form!!

Unique **Site ID** (initials_mmddyyhhmm): _____

(hhmm in military time, 1 ha = 0.4047acres; 1m = 3.048ft; 1ha = 10,000m^2; 1km^2 = 100ha)

Cover type area (circle one): **< 1 ha** : **> 1 ha and < 1 km^2** : **> 1 km^2** or list:_____

Training polygon boundary extent (e.g.200m E/W x 300m N/S): _____

Terrain Position: **Slope** (circle one): Flat Slight Moderate Steep Cliff

Aspect: _____ (N, NW, S, SE, SSE, NNW, etc. or degrees)

Curvature (circle one): Flat Concave Convex Variable

Projection (e.g. UTM, Zone#, NAD83): _____

Coordinates Easting:_____ Northing:_____

Units (e.g. Meters, Feet, Lat/Lon: DMS, DD, DM): _____

Coordinates taken within the site at least 60m?:(Yes / No), if No document at bottom.

How is site location documented (gps point, gps-differential correction, gps-waypoint avg, map-topo, map-ortho)? GPS model or describe?: _____

Name and type of digital data file [e.g. shapefile] if any containing site data (polygons, tables, notes):_____ Type: _____ Other info: _____

Site photo #s: _____ ID, filename or location of photo(s): _____

Orientation of photo(s): _____

Please provide other site location and confidence information below [e.g., location of site relative to Coordinates above, description of site and neighboring areas, etc.]:

Page2:

Land Cover Description (See detailed instructions) **Site ID:** _____

Dominant Land Cover Type (from list): _____

Secondary Land Cover Type(s) if any (from list): _____

Fitness of Dominant Land Cover Type call (1 low to 5 high): _____

Sampling **Confidence** (1 low to 5 high): _____

Whitetail **Prairie Dogs** present (**Yes / No**) # of mounds/area:_____

Significant Cover Table:

Significant cover composition (use table below): Provide % cover (as can be identified) for either individual species, species groups (e.g. Bunchgrasses, willows, etc.), or the totals for each lifeform. For example, you may have a significant contribution of Pseudoroegnaria spicata that can be identified, but can only estimate the remaining grasses as either annuals or perennials. The goal is to describe all the cover and non-vegetated 'background' of the site in terms of percentages of the entire signal sensed by the imagery (i.e. *all percentages in the table summate to 100%*).

H is height of the plant species or type in inches, **%L** is live foliar cover**, %D** is dead cover and stems

BV is the 'brightness' value of non-living components (1 is darkest to 10 brightest)

TREES	%L	%D	H	SHRUBS	%L	%D	H	GRASS	%	H	FORBS	%	H	OTHER	%	BV
														ROCK		
														SOIL		
														LITTER		
														OTHER/ WATER		
TOTAL			X	TOTAL			X	TOTAL		X	TOTAL		X	TOTAL		X

Dominant **soil color** (e.g. *2.5YR 5/4* or tan, etc.): **DRY**_____**WET**_____

Were detailed plot data collected at the site? (**Yes / No**) If so, how do we access them?

Are the shrubs **hedged** by browsing? (**Yes / No**)

Comments and Condition (descriptive information about the site such as, disturbances, soil degradation, vegetation patchiness and inclusions – use extra sheet if necessary):

C.2: Data Collection Instructions Used by Field Crews

Detailed Instructions for Collection of Remote Sensing Training Data

"Training Data" are ground-based examples of land cover types that may appear in the final land cover map of SW Wyoming. These data allow the remote sensing analyst to characterize the spectral and terrain characteristics of land cover types and develop statistics that describe them. We need to collect a multitude of field samples describing the range of land cover types **and** the range of associated terrain features across the landscape. For this reason, **high quality** (spatially precise and consistently described) training data are VERY IMPORTANT to the success of this mapping project. Review the two page 'Field Data Form;' the instructions below and notes on the form provide data estimation guidelines.

Site Location Information (Page 1 of Field Form):

1. Training sites should ideally **be relatively homogenous examples** of a particular cover type from the list of types to be mapped (included as **Attachment A** with these instructions).
2. When you describe the sites, try to **imagine a "birds eye view"**. Cover always looks denser when viewed from the side than from a satellite perspective.
3. Training sites MUST be **at least 100 x 100 meters** in size (1 ha or larger) and larger is better. The resolution of Landsat satellite data is too coarse to precisely associate smaller sites with places (pixels) on the imagery.
4. You **must provide information to allow us to precisely locate the sites on a map** – this means either GPS coordinates *with map projection information* and/or digital spatial files (e.g., shapefiles) *with map projection information* and clear links to the site descriptions from the data form and/or sites carefully drawn on maps that can be transcribed into a GIS. Vague location descriptions (e.g., township/range) are not useable. Coordinates are points while training data ultimately are polygons; describe the spatial relationship of the coordinate to the polygon or field site (e.g. point (coordinate) is located in NE corner of polygon, or edge of site is 500 meters southwest from point, etc.).
5. If a **digital polygon** for the field site is created, do not draw the polygon to the edge of the site. In remotely sensed imagery site edges are most frequently mixtures of the neighboring sites. **Draw the polygon at least 15 meters (preferably 45 meters) within the site from the edge**.
6. When describing the site location (**'Terrain Position'**) draw an imaginary polygon around the site boundary. Then describe the characteristics of this polygon; such as the **'Slope'** angle relative to horizontal, what **'Aspect'** it faces, and the shape of the terrain within the polygon (**'Curvature'**).
7. **Site photos are valuable**. If you take photos of the site, please provide them to us clearly marked with the site ID. If photos are digital, please be sure that there is a way to associate the photo with the data form. At least two photos representative of the site are ideal; one close-up and one at a distance showing the site in perspective to neighboring sites. Provide description of the photo **orientation**, e.g. *photo is looking to the west from the coordinate.*
8. Any **additional descriptive information** about the site that you can provide may be useful. Use another sheet of paper if necessary.

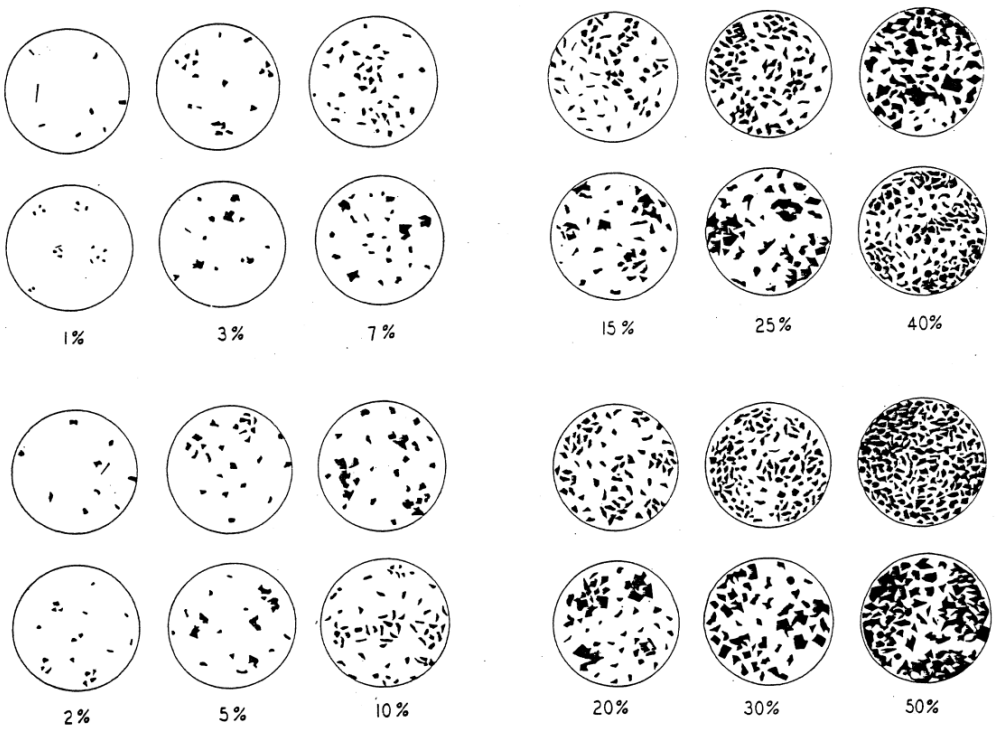
Land Cover Description (Page 2 of Field Form):

9. If site plant composition is not homogenous, please **provide as much detail as possible** about the nature of mixtures, patchiness of heterogeneities, etc. Note space is provided at bottom of page or use another sheet.
10. Some large tracks of terrain may not clearly fit into a land cover category, but are mixtures of types (e.g. ecotones). The field form allows for three methods of dealing with categorical confusion. First, the '**Significant Cover Table**' allows the specific plant composition to be detailed. Second, when naming the Land Cover Type category of mixed sites the field analyst has the option to list '**Secondary Land Cover Types**' as well as the '**Dominant Land Cover Type.**' Third, the analyst should provide a '**Confidence**' level for their Land Cover Type description of the site. This confidence describes how well the site fits into the classification scheme (see list from Attachment A). Further examples include disturbance such as burned areas or timber harvest, while the current cover type may be 'Recently Disturbed Areas' (see Attachment A category # 99.60) for our training purposes there is a difference between burned forest and burned rangelands.
11. In the '**Significant Cover Table**' the biotic and abiotic components of the site should summate to 100% of a 'bird's eye view' or the remotely sensed perspective. Determine the relative proportions of significant species or lifeforms and non-vegetated features that contribute to the 'signal' sensed by the satellite imagery. Very precise estimates of these proportions are not required, in favor of greater number of field sites collected. Record cover percentages as 5 or 10% increments, e.g. true cover of 8% can be recorded as 10%. Also, use judgment regarding species labels to minimize cost and time, refer to the Land Use/Land Cover Type List (pgs3-9), especially concerning forbs and grasses. If a species call is relatively easy, has high confidence, or determines the '**Dominant Land Cover Type**,' then list it, if not subtotals for a lifeform column are usually sufficient (e.g. the site contains 15% forb cover).
12. In the '**Significant Cover Table**' '**BV'** refers to 'brightness value' of non-vegetated components (consider the difference between dark basalts and salt playas). '**H'** refers to the 'average' above ground stature of a species or lifeform; some species may have more than one age-class of differing heights. These age-classes should be listed separately, for example a stand of conifers may contain a species with significant overstory and understory occurrences as to warrant description. '**ROCK'** refers to very large boulders, rock outcrops and escarpments. '**SOIL/BG/LR'** refers to the combination of soil, '**B**ack **G**round' elements such as twigs, chaff and leaf litter on the ground, and '**L**arge **R**ocks' on the ground not noted as '**ROCK'**. '**WATER'** refers to standing water not soil water content. If significant, Coarse Woody Debris such as logs on the ground can also be listed in the '**OTHER'** section of the table.
13. **Land Cover Type** labeling does not have to be done in the field. The '**Significant Cover Table'** and '**Comments'** concerning disturbances and vegetation patterns, etc. will be used to verify, correct, or modify the Land Cover Type calls. A Land Cover categorization is traditionally a moving target that must be adjusted to data constraints, applicable methods, and user needs such as accuracy.

Thank you! We appreciate your willingness to collect training data for us!

C.3: Foliar Cover Chart Cxample

COMPARISON CHARTS FOR VISUAL ESTIMATION OF FOLIAGE COVER 1/



1/ Developed by Richard D. Terry and George V. Chilingar. Published by the Society of Economic Paleontologist and Minerologist in its Journal of Sedimentary Petrology 25 (3): 229-234, September 1955.

Anderson, E. William 1986 A Guide for Estimating Cover RANGELANDS 8(5):236-238. October

C.4: Cover Type Classification for Field Sampling

Wyoming Mapping and Sampling

Land Use/Land Cover Types

Notes:

- Forested types are considered to have a minimum of 20% tree cover. To be designated a conifer type the stand would have >75% of tree cover as conifer species or to be designated a deciduous type the stand would have >75% of tree cover designated as deciduous species.
- Co-dominance is generally two species with each having >20% crown cover and is generally used for tree and shrub community cover type classes.
- Minimum crown cover of 20% determines the lifeform group for the Cover Type. For example 10% tree cover within a stand with >20% shrub cover would be called a shrub type.
- Sagebrush are an exception where >5% sagebrush cover and <20% juniper, tree, or other shrub species cover would be a sagebrush cover type.
- Barren lands, bare soil, rock types are generally considered to have <7.5% total vegetation cover.
- Mixed types may refer to 3 or more species within a vegetation stratum type such as mixed mountain shrub consisting of choke cherry/serviceberry/snowberry or a foothills shrub steppe dominated by a mixture of sagebrush/bitterbrush/rabbit brush or it may refer to mixed stratum dominance types such as juniper/mountain mahogany/sagebrush complex.
- Whenever approximate percentage ranges or terms such as sparse/low/open to medium/moderate or heavy/dense/closed are referred to it is assumed and/or understood there will be overlap in the categories or percentages
- Recently Disturbed Areas shall be defined as having occurred in 2001 or more recently.
- Within a year and across years the apparent abundance of many species will fluctuate, especially forbs and annual grasses. Cover type categories describe the common condition of a site and are reflected in the resulting classification as condition at the time of the remotely sensed imagery. Field data collected should reflect the current conditions of the site. Notes concerning phenologic stage of a field site can help normalize for these temporal factors.
- As a guideline the height threshold between mature shrub and tree forms is 12 feet.
- Some of these cover types may not occur in the project area**.**
- Specific notes about cover types are included below.

Cover Types — Cover Type Discussion/Description

Forest and Woodland Types

Conifer Forest

01.10 Lodgepole Pine
- 01.10.1 20-32% closure
- 01.10.2 33-67% closure
- 01.10.3 >67% closure

01.20 Douglas Fir
- 01.20.1 20-32% closure
- 01.20.2 33-67% closure
- 01.20.3 >67% closure

01.30 Spruce- Subalpine Fir
- 01.30.1 20-32% closure
- 01.30.2 33-67% closure
- 01.30.3 >67% closure .

01.40 Ponderosa Pine
- 01.40.1 20-32% closure
- 01.40.2 33-67% closure
- 01.40.3 >67% closure

01.50 Ponderosa Pine-Douglas Fir
- 01.50.1 20-32% closure
- 01.50.2 33-67% closure
- 01.50.3 >67% closure

01.51 Ponderosa Pine-Lodgepole Pine
- 01.51.1 20-32% closure
- 01.51.2 33-67% closure
- 01.51.3 >67% closure

01.52 Ponderosa Pine-Limber Pine
- 01.52.1 20-32% closure
- 01.52.2 33-67% closure
- 01.52.3 >67% closure

01.60 Limber Pine
- 01.60.1 20-32% closure
- 01.60.2 33-67% closure
- 01.60.3 >67% closure

01.61 Limber Pine-Douglas Fir
- 01.61.1 20-32% closure
- 01.61.2 33-67% closure
- 01.61.3 >67% closure

01.70 Whitebark Pine
- 01.70.1 20-32% closure
- 01.70.2 33-67% closure
- 01.70.3 >67% closure

01.80 Mixed Conifer-Juniper
- 01.80.1 20-32% closure
- 01.80.2 33-67% closure
- 01.80.3 >67% closure

01.90 Mixed Conifer-Dominant — Type includes conifer co-dominants such as Whitebark-Subalpine fir or mixtures of more than two tree species with >20% canopy cover as conifer.
- 01.90.1 20-32% closure
- 01.90.2 33-67% closure
- 01.90.3 >67% closure

01.94 Conifer-Aspen — Conifer stands with aspen canopy cover as >20% to <50%
- 01.94.1 20-32% closure to
- 01.94.2 33-67% closure
- 01.94.3 >67% closure

02.00 Deciduous Forest

02.10 Aspen
- 02.10.1 20-32% closure
- 02.10.2 33-67% closure
- 02.10.3 >67% closure

02.20 Aspen-Conifer Mix	Aspen stands with conifer canopy cover as
02.20.1 20-32% closure	>20% to <50%.
02.20.2 33-67% closure	
02.20.3 >67% closure	
02.30 Cottonwood-Riparian	
02.30.1 20-32% closure	
02.30.2 33-67% closure	
02.30.3 >67% closure	
02.80 Other or Mixed	May include Russian olive, box elder, tree
02.80.1 20-32% closure	willow species, etc.
02.80.2 33-67% closure	
02.80.3 >67% closure	
03.00 Woodlands	
03.10 Gambel Oak	
03.20 Juniper	Juniper cover >20%. Woodland, Shrub,
03.21 Juniper-Sagebrush	cover types may also contain Juniper up to this
03.22 Juniper-Mountain Mahogany	minimum.
03.40 Other	List types as appropriate or discernable. May include a Juniper mixed shrub community.

Shrub Types

04.00-0.500 Desert Shrub to Shrub-Steppe

Desert Shrubs

04.10 Bud Sage	*Picrothamnus desertorum*, Synonymy: *Artemisia spinescens*.
04.20 Greasewood	*Sarcobatus vermiculatus*.
04.21 Greasewood-Sagebrush	
04.22 Greasewood- Saltbush	
04.41 Gardner Saltbush	*Atriplex gardneri*.
04.45 Saltbush-Sagebrush	Sub-shrubs and low stature sages, such as Birdsfoot Sage, Bud Sage, Winterfat, Fringed Sage, co-dominant with Gardner Saltbush.
04.50 Winterfat	*Krascheninnikovia lanata*, Synonymy: *Ceratoides lanata, Eurotia lanata*.
04.60 Birdsfoot Sage	*Artemisia pedatifida*.
04.70 Mixed Desert Shrubs	May include low growing forms of sagebrush such as; birdsfoot, bud sage, or early along with rabbitbrush, woody aster, horsebrush, shadscale, four wing saltbush, broom snakeweed, etc.
04.90 Other Dwarf/Sub Sagebrush	May include; Fringed Sagebrush (*A. frigida*), Sand Sage (*A. filifolia*), and Chicken Sagebrush (*Tanacetum nuttallii* / syn. *Sphaeromeria argentea*).

Sagebrush-Grassland

	Sagebrush cover >5% crown closure.
05.11 Basin Big Sagebrush	*Artemisia tridentata* ssp. *tridentata*.
05.11.1 5-15% closure	
05.11.2 16-25% closure	
05.11.3 >25% closure	
05.12 Wyoming Big Sagebrush	*Artemisia tridentata* ssp. *wyomingensis*.
05.12.1 5-15% closure	

05.12.2 16-25% closure
05.12.3 >25% closure
05.13 Mountain Big Sagebrush — *Artemisia tridentata* var. *pauciflora*
05.13.1 5-15% closure — Cover Type includes; Subalpine Big Sagebrush,
05.13.2 16-25% closure — *Artemisia tridentata* var. *vaseyana*, Spiked Big
05.13.3 >25% closure — Sagebrush (*A. spiciformis*).
05.14 Black Sagebrush — *Artemisia nova*.
05.15 Mountain Silver Sagebrush — *Artemisia cana* ssp. *viscidula*.
05.16 Wyoming Three-tip Sagebrush — *Artemisia tripartita* ssp. *rupicola.*
05.17 Alkali\Early Sagebrush — *Artemisia longiloba*, Synonymy: *A. tridentata* ssp. *arbuscula* var. *longiloba*, *A. spiciformis* var. *longiloba*.
05.18 Low Sage*** — *Artemisia arbuscula* ssp. *arbuscula*, Restricted to Teton County, Wy, Synonymy: *A. arbuscula*, *A. tridentata* ssp. *arbuscula*, *A. tridentata* var. *arbuscula*.
***Includes Hotsprings Sagebrush, *Artemisia arbuscula* ssp. *thermopola*.
05.19 Plains Silver Sagebrush — *Artemisia cana* ssp. *cana.*
05.20 Rabbitbrush — Includes; *Chrysothamnus nauseosus* ssp. n*auseosus* (Gray Rubber), *C. nauseosus* ssp. *graveolens* (Green Rubber), *C. viscidiflorus* (Douglas/Green Rabbitbrush) and less common species/subspecies.
05.21 Tall Three-tip Sagebrush — *Artemisia tripartita* ssp. *tripartita.*
05.29 Other Big Sagebrush — May include; Rothrock Sagebrush (*A. rothrockii*) and hybrids such as; Bonneville Big Sagebrush (*A. tridentata*, hybrid 'B'), Gosiute Big Sagebrush (*A. wyomingensis* hybrid w/ *A. pauciflora*), Tall Black Sagebrush (*A. nova* hybrid w/ *A. wyomingensis*).

Mountain Shrubs

05.31 True Mountain Mahogany — *Cercocarpus montanus*.
05.32 Curlleaf Mountain Mahogany — *Cercocarpus ledifolius.*
05.40 Bitterbrush
05.41 Bitterbrush-Sagebrush — Sagebrush cover >20 but <50%.
05.93 Mixed mesic mountain shrubs — May include snowberry, ninebark, cinquefoil, etc.
05.94 Mixed xeric mountain shrubs — May include mtn mahogany, serviceberry, woods rose, big sage, bitterbrush, etc.
06.00 Riparian Shrub
06.10 Willow — *Salix* species.
06.12 Willow-Other Shrubs — Willow as a co-dominant.
06.70 Tamarisk — Stand may not occur in large enough patch.
06.90 Mixed Riparian Shrubs — May include willow, water birch, alder, plum, buffaloberry, chokecherry, hawthorn.

Graminoid and Forb Types

07.00-08.00 Grass-like Types — May include up to about 5% sage or 20% shrub or tree cover and unless recently disturbed should have >7.5% vegetation over. This includes both 07.00 and 08.00 categories.
07.20 Basin Grassland — Primarily native perennial grasslands
07.20.1 7.5-20% cover — restricted to lowest elevations.
07.20.2 21-40% cover
07.20.3 >40% cover
07.30 Foothills Grassland — Primarily native perennial grasslands
07.30.1 7.5-20% cover — occurring in foothills and low to

	07.30.2 21-40% cover	middle montane regions.
	07.30.3 >40% cover	
07.40	Alpine Grassland	Primarily native perennial grasslands
	07.40.1 7.5-20% cover	occurring in middle montane to
	07.40.2 21-40% cover	above tree line.
	07.40.3 >40% cover	
07.60	Riparian/Wet Meadow	May include grass/sedge/rush species.
07.80	Annual Grassland	Commonly Cheatgrass.
	07.80.1 7.5-20% cover	
	07.80.2 21-40% cover	
	07.80.3 >40% cover	
07.91	Forb	Cushion plant communities and similar low
	07.91.1 7.5-20% cover	stature forb dominated communities.
	07.91.2 21-40% cover	
	07.91.3 >40% cover	
07.92	Tall Forb	Mainly tall stature forb community types in
	07.92.1 7.5-20% cover	mountains.
	07.92.2 21-40% cover	
	07.92.3 >40% cover	
08.10	Sedge Dominated	Mainly upland community dominated by *Carex filifolia*.

Wetland Types

09.00	Marsh-Swamp Wetlands	Larger areas dominated by cattail, bulrush, and/or wetland sedges.
10.00	Aquatic Cover Types	
10.10	Water-Lentic or Standing	Ponds, lakes, reservoirs, and larger stock ponds.
10.14	Playa	
10.20	Water – Lotic or Running	Rivers, larger streams and waterways.

Agricultural Types

11.00	Cropland-Agricultural Lands	
11.10	Dry-land Agricultural Fields	Wheat, etc.
11.20	Irrigated Agricultural Fields	Alfalfa, grass hay, corn, beets, etc.
11.60	Dry-land Pastures	Seeded and other heavily managed areas, with species occurrences such as Crested Wheatgrass.
11.70	Fallow Agricultural Fields	Areas with <7.5% living vegetation cover as a result of agricultural practices such as wheat rotation, etc.

Non-Vegetated Types

12.00	Other Non-Vegetated Types	Includes barren or special feature areas.
12.40	Rock or Talus Slope	Rock outcrops, canyons cliffs, and talus fields.
12.60	Sand Dunes	Bare sand with vegetation cover <7.5%.
12.80	Snow	Glaciers and snowfields.
12.90	Bare Ground	Barren areas with bare soils and generally <7.5% vegetation cover.
99.00	Human or Disturbed Areas	Includes human built-up areas, developed areas or recently disturbed areas.
99.10	Roads and RR	Includes major roads such as highways, county, gravel surfaced and others and RR.
99.20	Mining Areas	Includes mines and infrastructure.
99.40	Range treatment	Range sites showing significant effects from mechanical, chemical, or biological alteration.

99.50	Burned areas	Burns of any vegetation type. Pre-burn cover type should noted if possible.
99.60	Clearcut	May include recent clear-cut, heavy thinning, woody debris, etc.
99.80	Oil and Gas Developments	Includes well pad areas.
99.81	Recent Pipelines	Buried or exposed pipelines.
99.90	Urban/Industrial Land	Human built-up areas. Includes impervious/semi-impervious surfaces, and human use areas such as athletic complexes and golf courses, etc. Some energy development areas will be included in this category when contiguous with residential and commercial land use areas.
99.92	Other disturbance	Floods, landslides, etc.
99.99	Cloud/Cloud Shadow/Smoke	Cover types obscured by atmospheric quality within remotely sensed imagery. This category used for classification process.

Appendix D: WGFD References to Seasonal Habitat Assessment Protocols

As stated in Gerhart, 2007 (Sage-Grouse Habitat Parameters and Guidelines for Habitat Assessment):

"General habitat indicators and assessments for various seasonal sage-grouse seasonal ranges are included in the descriptions and tables later in this document. We included both qualitative and quantitative methods for gathering the data and proposed field assessment forms. Quantitative field evaluation methods for the habitat indicators (canopy cover measurements, height measurements, etc.) are provided in the document too. These methods are consistent with guidance developed by an interagency technical team for rangeland vegetation monitoring (Herrick et al., 2005a, 2005b), draft BLM framework plans for habitat assessments on BLM lands in Wyoming (BLM 2001), recent Wyoming studies conducted by Heath et al. (1997), Heath et al. (1998), Holloran (1999), Lyon (2000) and Slater (2003) and information from Connelly et al. (2003). Overall and final site evaluations should be based on best available science, interdisciplinary involvement and tempered with qualified, acceptable professional judgment."

D.1: Quantitative Field Methods and Data Forms (Soehn et al. 2001)

Sage-grouse nesting and early brood-rearing habitat features found in Table 1 and Table 2 were developed from the BLM assessment protocols (BLM 2001) which incorporates much of the methodology used by the University of Wyoming Cooperative Wildlife Research Unit in recent sage-grouse habitat studies (Heath et al. 1997, Heath et al. 1998, Holloran 1999, Lyon 2000, Slater 2003.), Connelly et al. (2000), Connelly et al. (2003) and Management Plan Conservation Strategies for Sage Grouse in Montana. There are many different methodologies that could be used to measure the vegetative features found in these Tables. However, it is important that the methodology generally followed has been tested, follows generally accepted standard monitoring protocol and procedures as identified and closely follows or mimics procedures used in most of the Wyoming studies (Heath et al. 1997, Holloran 1999, Lyon 2000 Slater 2003) so that results are somewhat comparable. A description of the methods used in the Wyoming studies is outlined below.

Wyoming Studies Methodology

1. Nest Site Evaluations:

Vegetation variables were evaluated during the last week in May and the first two to three weeks in June using line transects centered at each nest site. The direction of the initial transect was randomly determined, and the second transect was oriented perpendicular to the original. Transect length was 15

meters for shrub variables and 2.5 meters for herbaceous variables. .

The line-intercept method (Canfield 1941) was used to determine the percent live and dead sagebrush and total shrub canopy coverage. The height of each live sagebrush plant intercepted was measured to the nearest centimeter and used to estimate live sagebrush height. Live and dead sagebrush density (plants/m^2) was estimated using a 1-meter belt along each 15-meter transect. Plants exhibiting >20% leaf cover were considered live.

Herbaceous vegetation variables were measured at the nest, 1 meter and 2.5 meters from the center along each transect. Recorded measurements were: perennial and residual grass height (cm) and percent grass, residual grass, forb, litter, bare ground, and total herbaceous cover estimated within a 20 x 50 - centimeter (7.9 x 19.7 inches) quadrate (Daubenmire 1959). Height and cover estimates were averaged over the 12 measured quadrants to get singular estimations per plot.

Grass represents a vertical screening element for nesting sage-grouse; thus, species were grouped and classified as either current year's growth or residual. Residual grass was defined as any grass standing from the previous growing season (standing dead, not litter). Grass and residual grass heights were estimated as measured average of the undisturbed vegetative height (excluding the reproductive portions of the plant) however, we recommend the undisturbed height of the plant whether vegetative or reproductive) of the tallest plants encountered within each quadrat. We also recommend including similarly derived forb height measurements as both provide a vertical screening element.

Because forbs are important food components in sage-grouse diets, they were classified to species, and were further grouped into either food or non-food categories. Common dandelion, curlycup gumweed, western salsify (*Tragopogon dubius*), western yarrow (*Achillea lanulosa*), prickly lettuce (*Lactuca serriola*), cudweed (*Gnaphalium palustre*), fleabane (*Asteraceae spp.*), sweetclover (*Melilotus officinalis*), milkvetch, alfalfa, winterfat (*Eurotia lanata*), and fringed sagewort (*Artemisia frigida*) were classified as food forbs (Patterson 1952, Peterson 1970, Wallestad et al. 1975, Barnett and Crawford 1994). All other forbs were classified as non-food.

Estimating/Measuring Residual and New Herbaceous Vegetation Heights

Studies conducted within Wyoming (Heath et al 1997, Heath et al 1998, Holloran 1999, Lyon 2000) indicated that a minimum of 4" of residual perennial grass stubble height was necessary for hiding cover in sage-grouse nesting areas. It is important to note that measurements did not measure "average" stubble height, but rather the "average height of the tallest plants" within a 20cm X 50cm Daubenmire frame (see Figures 1 and 2). This residual grass height should occur on >3 percent of the total vegetative canopy cover.

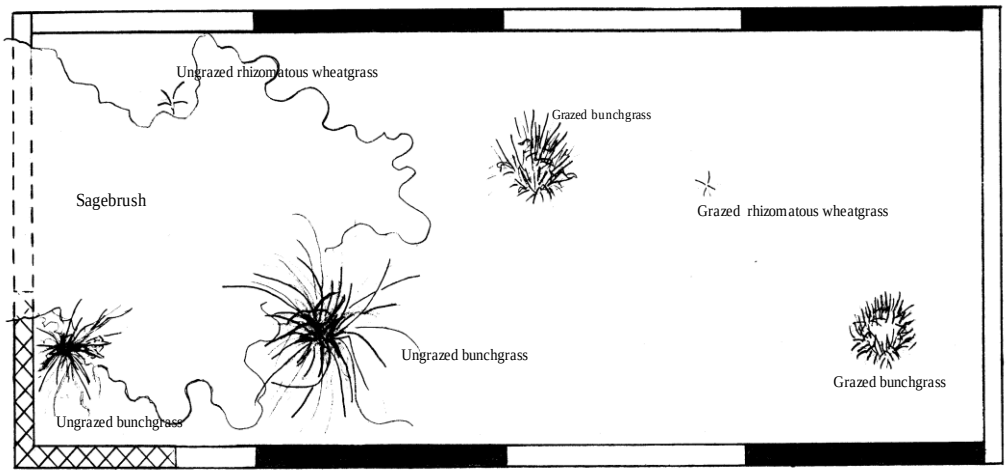


Figure 1. Daubenmire Plot Frame.

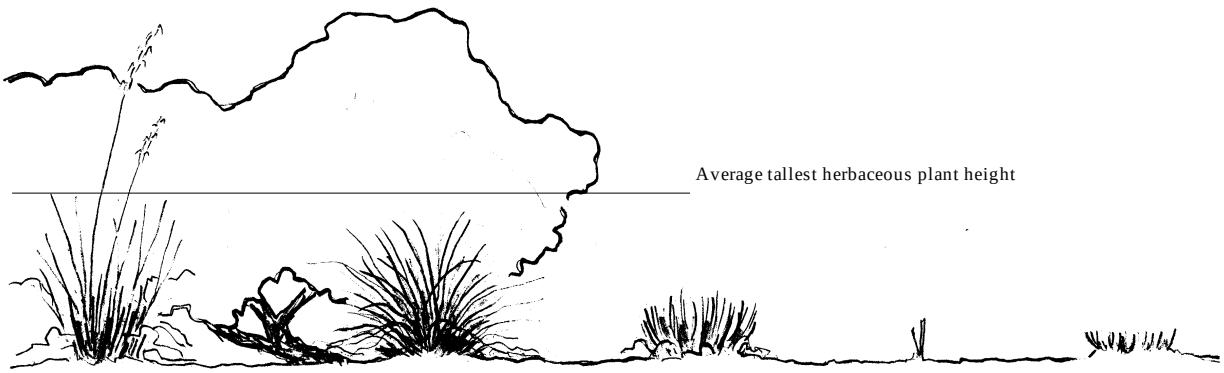


Figure 2. Herbaceous plant measurements and average tallest leaf height measurements. **NOTE:** We recommend measurement of the tallest undisturbed height (vegetative or reproductive stalk) rather than just leaf and droop heights.

Residual grass is defined as any grass left standing (standing crop) from the previous growing season and does not include grass that has been matted down and has been reduced to ground litter. These studies measured the average height of the tallest residual grasses from the base of the plant to the dropping point of the plant's leaves as illustrated in Figure 3. Again we recommend measuring the tallest height of undisturbed grass and/or forb in each plot and using the average.

Seedstalks (inflorescences) were not included in the measurement, however we recommend they be measured. The measurements were taken in the interspaces between sagebrush plants and underneath individual sagebrush plants as note example in Figure 2 above. Traditional use and stubble height studies normally classify forage underneath sagebrush plants as unavailable and exclude those grass

plants from the sample.

New (current years growth) herbaceous vegetation heights were measured in the same way. The "average height of the tallest plants" within a 20cm X 50cm Daubenmire frame was recorded. Since this measurement is used to evaluate nesting habitat, it is critical that the measurements be done as soon as nesting is completed (generally late May to mid-June).

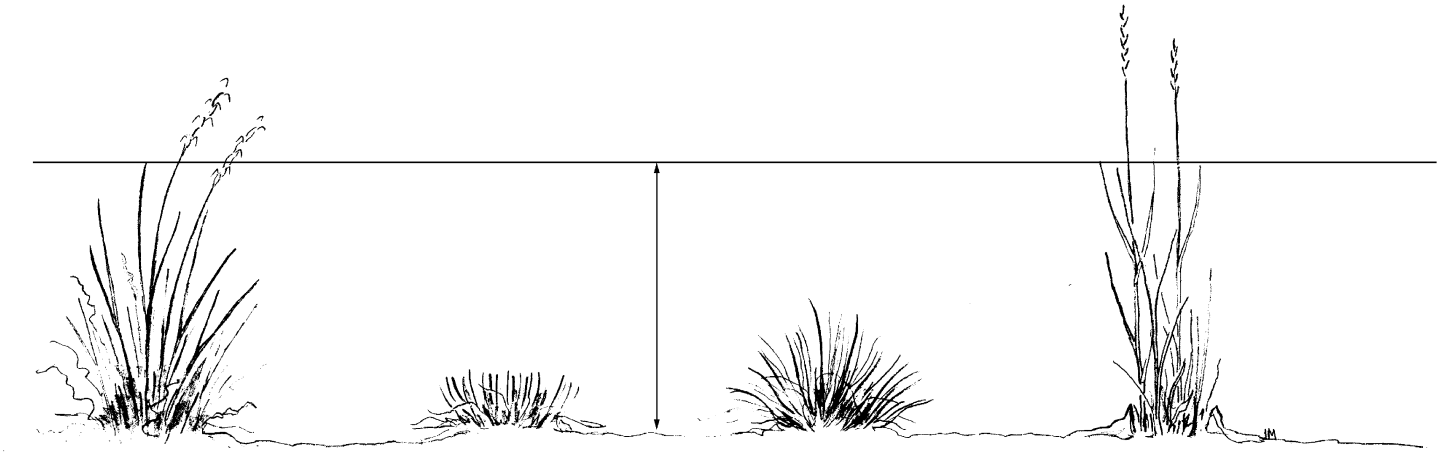


Figure 3. Average tallest leaf droop height measurements. **NOTE:** We recommend measurement of the tallest undisturbed height (vegetative or reproductive stalk) rather than just leaf and droop heights.

We recommend with modifications the following Wyoming BLM procedures which closely mimic the recent Wyoming studies by Heath et al. (1997), Heath et al. (1998), Holloran (1999), Lyon (2000) and Slater (2003). We further recommend adding the frequency information for special studies or as needed or desired and for eliminating the line/point intercept as proposed and add line-intercept as the standard protocol.

The two methods for quantifying sage-grouse habitat found in this appendix closely mimic the Wyoming studies that form the basis for Table 1. However, there are some differences. The line intercept/Daubenmire frame method most closely resembles the Wyoming studies. The line/point intercept method resembles many current ongoing BLM range studies in Wyoming. While the line/point intercept method is valid, the data produced cannot generally be directly related to the habitat features in Table 1. BLM and the University of Wyoming are conducting studies and quantification to develop additional habitat feature guidelines (Table 1) using the line/point intercept method. Until such time it will not be possible to directly relate data gathered using the line/point intercept method to Table 1.

These quantitative field evaluation methods are consistent with guidance developed by an interagency technical team for rangeland vegetation monitoring (USDI 1996), the BLM assessment protocols (BLM 2001) which incorporates much of the methodology used by the University of Wyoming Cooperative Wildlife Research Unit in recent sage-grouse habitat studies (Heath et al. 1997, Heath et al. 1998, Holloran 1999, Lyon 2000, Slater 2003.) and Connelly et al. (2003).

The methods described in this section that follows should not be viewed as exclusive.

D.2: Protocol for Line Intercept Transect and Daubenmire Frame Sampling

Equipment

Data forms and worksheets
Tape, 100-foot (in tenths of feet increments)
Stakes for tape (at least two spikes; old, medium-large screwdrivers work well)
Daubenmire frame (20 x 50 cm frame recommended)
Yardstick (for measuring shrub and grass/forb heights)
Compass
Random numbers table, wristwatch with second hand, or calculator with random function etc.
Camera and print film, extra camera battery; extra film.
Photo cards and markers; or small dry-erase board and marker
Topographic map with project area, general cover types, and pasture boundaries delineated
Aerial photographs
Soil Survey/Ecological Site Guides
GPS unit
Pencils
Colored pencils for sketching plant communities
Calculator

Protocol Note: We recommend following our protocol and the information in the Montana Plan sections 5 and 6.

Sites have been selected stratified by ecological site, NRCS range site, major cover type or other locally approved format and may include pasture or allotments or other appropriate management categories (see framework document for directions).

Randomly select a compass azimuth, using a random numbers generator, wristwatch with second hand, or other objective means. Make sure transect is at least 0.25 mile from disturbances such as roads, water sources etc. (Not sure this is always necessary and Specify why, and include information on powerlines or other raptor perch sites, etc. too).

Anchor a 100-foot tape with a stake (spike, screwdriver, etc.) and extend it snugly along the random azimuth. Secure end with a second stake.

As a minimum, accurately locate the transect's location on a 1:24000 USGS map and collect a GPS point in UTM coordinates (differentially correct if at all possible). It will be important to be able to return to the area for follow up monitoring or photos in some instances.

On the Line Intercept/Daubenmire data form (page 1), record shrub canopy cover by species and subspecies of sagebrush using the line intercept method. Record cover increments to the nearest 0.1 foot.

Record live (green) canopy for all shrub species and dead canopy for big sagebrush species only. We recommend measuring to the nearest 0.1 foot for canopy or non-canopy across the shrub plant.

Record to the nearest inch the **maximum height** of the intercepted big sagebrush plant (maximum leaf height, not including seed stalks).

At each 5-foot increment along the tape:

a. Place a Daubenmire frame (n=20 plots per transect). For each plot, estimate and record (line intercept/Daubenmire form, page 2) cover for new perennial grasses, new annual grasses, new forbs, and residual herbaceous vegetation. Note predominant species. For residual vegetation only measure standing dead, not litter material.

b. Within each plot measure and record (line intercept/Daubenmire form, page 2) the average "natural" height of the tallest new and residual herbaceous species. If no plants are within this plot record a dash and move on to next point. [Natural = the highest point of a leaf, not including seed stalk, is measured with no straightening by the observer.] Again we recommend the tallest natural plant part both reproductive and leaf.

Summarize data (bottom of page 2) for each site. For big sagebrush canopy cover, combine live and dead canopy cover.

Photographs: At least one photograph should be taken at each transect/ evaluation area. Photos will prove invaluable in locating evaluation areas in subsequent years. They will also be of substantial use in the office when preparing evaluation documents and documenting habitat condition.

Complete a Photo Card, showing, as a minimum, the date, location, allotment, and sagebrush canopy cover percentage.

With the photo card near the "zero" end of the tape, take a general photo of the area, sighting down the tape from eye level, showing landmarks in the background, if possible.

In a representative location along or near the tape, place the photo card near the base of a sagebrush plant, and take a tangential close-up photo from near ground level (2-3 feet) toward the shrub/ground interface, to document herbaceous conditions and cover.

Optional: take one or more other close-ups or panoramic photos as needed.

Depending on the complexity of the evaluation area, several line transects within a cover type may be necessary to characterize the area using this technique.

D.3: Line Intercept/Daubenmire Frame Data Form for Sage-grouse Habitat Evaluations

Part 1:

Date:	**Project/#:**	
Other Information:	**Site #:**	**Ecological Site/NRCS Range Site**
Legal Description: T. R. Section , ¼, ¼, ¼ UTM		**GPS Fire #:**
Other Location Info.:		
Examiners:	**Transect Length:**	**Permanent Transect?:**
Cover Type (circle one): **sagebrush** **perennial grassland (native, introduced)** **annual grassland with sagebrush** **annual grassland** **juniper area** **other:(name)_____** **Sagebrush species/subspecies type list:_____**		

Shrub Line Intercept Canopy Cover

(Include sagebrush species, big sagebrush subspecies and other shrub species)

Shrub Species	Intercept Inches	Total	% Cover
Live Big Sagebrush			
Dead Big Sagebrush			
	All Shrubs		

Shrub Height

(Include sagebrush species, big sagebrush subspecies and other shrub species)

Shrub Species	Shrub Height for Each Interception (record to nearest 1 inch) 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18	Total	Average Height

Big Sagebrush																			
All Shrubs																			

Comments

Line Intercept/Daubenmire Form (Part 2)

Daubenmire Cover Class & Vegetation Height Data (recorded at 5-foot intervals)

Cover Type	**Estimated Cover Class for Each Plot***																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
New Perennial Grass																				
New Annual Grass																				
New Forb																				
Residual Herbaceous																				
***Cover Classes:** **1**=0-5%, **2**=5-25%, **3**=25-50%, **4**=50-75%, **5**=75-95%, **6**=95-100%																				
Cover Type	**Vegetation Height for Each Plot (record to nearest 1 inch)**																			
New Herbaceous																				
Residual Herbaceous																				

Summary

Cover Class:	Big Sagebrush:	New P. Grasses:	New A. Grasses	
	New Forbs:	Residual Herbaceous:		
Vegetation Height:	Big Sagebrush Mean Ht.:		All Shrubs Mean Ht.:	
	New Herbaceous mean Ht.:		Residual Herbaceous Mean Ht.:	

Comments:

D.4: Line-Point Intercept Method (Transect OR Step-Point Techniques)

Alternative Method and Not Currently Preferred as Shown Here

Equipment

Data forms and worksheets
Tape, 100-foot
Stakes for tape (at least two spikes; old, medium-large screwdrivers work well)
Pin flag or Pointer: straight piece of wire or rod at least 30" long and less than 2.5mm in diameter
Yardstick (for measuring shrub and grass/forb, residual heights)
Compass
Random numbers table, wristwatch with second hand, or calculator with random function etc.
Camera and print film, extra camera battery; extra film.
Photo cards and markers; or small dry-erase board and marker
Topographic map with project area, general cover types, and pasture boundaries delineated
Aerial photographs
Soil Survey/Ecological Site Guides
GPS unit
Pencils
Colored pencils for sketching plant communities
Calculator

Protocol

Sites have been selected stratified by major cover type and pasture (see framework document for directions).

Randomly select a compass azimuth, using a random numbers generator, wristwatch with second hand, or other objective means. Make sure transect is at least 0.25 mile from disturbances such as roads, water sources etc.

Anchor a 100-foot tape with a stake (spike, screwdriver, etc.) and extend it snugly along the random azimuth. Secure end with a second stake.

As a minimum, accurately locate the transect's location on a 1:24000 USGS map. Use GPS and differentially correct if at all possible. It will be important to be able to return to the area for follow up monitoring or photos in some instances.

On the Line/Point Intercept data form, record shrub canopy cover by species using the line intercept method. Record cover increments to the nearest 0.1 foot. Record live (green) canopy for all shrub species and dead canopy for big sagebrush species only. Ignore spaces or gaps in the canopy less than 0.2 feet across. Gaps in the live canopy in excess of 0.2 feet will not be included as canopy intercepts.

Record to the nearest inch the **maximum height** of the intercepted shrub (maximum leaf height, not including seed stalks).

Begin at “0" end of tape.

Every foot drop the pin flag or pointer to the ground so that it falls precisely vertically and touches the near side of the tape at the correct mark (every foot for 100 marks).

Enter the code of the life form (codes at bottom of Line/point Intercept data form) touching the pin at its highest mark.

Record the life form of the plant with next highest live or residual leaf or stem touching the pin. Record these under the “Lower Layers” columns. Record each life form of interest only once for each mark.

Record the heights of the live herbaceous and residual herbaceous plants that touch the pin at its highest mark. If one or both life forms does not touch the pin, record the height of the nearest individual (360^0 around the pin) to the pin.

Proceed to next mark and repeat. One hundred sample points are the minimum recommended number for fairly homogeneous vegetation. Additional transects may be needed for heterogeneous vegetation.

Summarize data (bottom of page 1) for each site.

Photographs: At least one photograph should be taken at each transect/ evaluation area. Photos will prove invaluable in locating evaluation areas in subsequent years. They will also be of substantial use in the office when preparing evaluation documents and documenting habitat condition.

Complete a Photo Card, showing, as a minimum, the date, location, allotment, and sagebrush canopy cover percentage.

With the photo card near the “zero” end of the tape, take a general photo of the area, sighting down the tape from eye level, showing landmarks in the background, if possible.

In a representative location along or near the tape, place the photo card near the base of a sagebrush plant, and take a tangential close-up photo from near ground level (2-3 feet) toward the shrub/ground interface, to document herbaceous conditions and cover.

Line/Point Intercept - Transect Data Form for Sage-grouse Evaluations

Date:	**Project/#:**	
Other Information:	**Site #:**	**UTM**
Legal Description: T. R. Section , ¼, ¼, ¼ **UTM**		**GPS Fire #:**
Cover Type:	**Tape or Pace Transect? (circle one)**	
Examiner(s):	**Location Info:**	

Cover Type (circle one): **sagebrush** **perennial grassland (native, introduced)**

annual grassland with sagebrush **annual grassland**

juniper area **other:(name)_____**

Sagebrush species/subspecies type list:_____

Shrub Line Intercept Canopy Cover

Shrub Species	**Intercept (# Hits)**	**Total**	% **Cover**
Live Big Sagebrush			
Dead Big Sagebrush			
All Shrubs			

Shrub Height

Shrub Species	Shrub Height for Each Interception (record to nearest 1 inch)																	Total	Average Height
Big Sagebrush																			
All Shrubs																			

Comments

Summary Information

BSW = Wyoming big sagebrush	**BSM** = Mountain Big Sagebrush	**BSB** = Basin Big Sagebrush	**LS** = Low Sagebrush
Hits_____, %_____, Ht.*_____	Hits_____, %_____, Ht.*_____	Hits_____, %_____,Ht.*_____	Hits_____, %_____, Ht.*_____
PG = Perennial Grass	**AG** = Annual Grass	**PF** = Perennial Forb	**AF** = Annual Forb
Hits_____, %_____, Ht.*_____	Hits_____, %_____,	Hits_____, %_____, Ht.*_____	Hits_____, %_____,

* Average height recorded here.

Points	Top Layer Hit	Layer 2 Hit	Layer 3 Hit	New Herbaceous Weight	Residual Herbaceous Weight	Points	Top Layer Hit	Layer 2 Hit	Layer 3 Hit	New Herbaceous Weight	Residual Herbaceous Weight
1						51					
2						52					
3						53					
4						54					
5						55					
6						56					
7						57					
8						58					
9						59					
10						60					
11						61					
12						62					
13						63					
14						64					
15						65					
16						66					
17						67					
18						68					
19						69					
20						70					
21						71					
22						72					
23						73					
24						74					
25						75					
26						76					
27						77					
28						78					
29						79					
30						80					
31						81					
32						82					
33						83					
34						84					
35						85					
36						86					
37						87					
38						88					
39						89					
40						90					
41						91					
42						92					
43						93					
44						94					
45						95					
46						96					
47						97					
48						98					
49						99					
50						100					

Comments:

Meta-analysis for Wyoming Sagebrush Subspecies.

Black Sagebrush (Artemisia nova)

Citation numbers 2, 3, 8, 9, 18, 24, 31, and 35

Location – Wyoming

- Geology/Parent Material: dissected plateau of Tertiary Origin, Brown's Park Formation, with gravel or granitic parent material. Parent material was also not distinctly fractured
- Soil: Argic Cryoborolls, the Kimmons series, sandy loam and gravelly silt loam, no salt Accumulation, neutral to slight alkalinity, argillic horizon, duripan or bedrock, stony, affinity for calcareous soils, mesic soil temp, aridic soil moisture
  Depth: shallow, very shallow
  Drainage: drainage way floodplains, and smooth dissected alluvial fans, moderate to rapid permeability, well drained, low soil moisture and fertility
- Elevation: 2 050-9810ft
- Wind: max:8.3 m/s, min 3.5m/s, average 5 m/s
- Temperature: annual average 2.7C
- Slopes: adapted to steep slopes
- Precipitation(various readings): Annual average precip from 1969-1982: 52.6 cm, mostly as snow., 535mm mean , average annual is 10-19 inches annual, 200-400mm.
- Frost Free Days: na
- Exposure: na

Basin Big Sagebrush (Artemisia tridentata var. tridentata)

Citation numbers 1, 2, 5, 13, 24, and 35

Location – Wyoming

- Geology: n/a
- Soil
- Type: fertile plains soil, fine-silty, mixed, frigid Xeric Torrifluvent, loamy, mixed (calcareous), frigid Xerollic Torrifluvent, fine-loamy, mixed (calcareous), frigid Ustic Torrifluvent, , clay on surface, loams in subsurface; developed on heavy clays and deep sandy alluvial soils, dark brown mollisols, deep loess, Entisols developed on heavy clays and deep sandy alluvial soils, aridic to xeric moisture, frigid to mesic temps
- Depth: deep, shallow, >40cm.
- Drainage: seasonally dry, well drained
- Elevation: 457- 3230m
- Wind: N/A
- Temperature: average 7 C to -1C
- Slopes: plains, rolling, 0-8%
- Precipitation:25-31 cm
- Frost free days:55-140
- Exposure: northerly, western, southern

Low Sagebrush (Artemisia arbuscula)
Citation number: 7, 18, 24, 35

Location – Wyoming

- Geology: n/a
- Soil- heavy soils derived from alkaline shales or limey soils, hardpan, gravelly
- Type: Coarse-textured, sterile, rocky, alkaline, clay soils, aridic soil moisture, mesic temperature.
- Depth: shallow
- Drainage: dry
- Elevation: 2 296-12401 ft
- Wind: N/A
- Temperature: N/A
- Slopes: na
- Precipitation: 200-400mm
- Frost free days:
- Exposure: na

Silver Sagebrush (mountain and plains) (Artemisia cana)
Citation numbers: 2, 9, 10, 24, 34, 35

Location – Wyoming

- Species plains silver sagebrush
    - Geology/parent material: Gravely or sandstone
    - Soil
    - Type: sandy topsoils, not on heavy textured soils, can handle moderate alkalinity and slight salinity, loamy to sandy, coarse alluvial soils, along mountain streams or heavy snowpack, lots of moisture, udic moisture, cryic temps.
    - Depth: shallow to deep
    - Drainage: greater than moderate permeability, can withstand high water table
    - Elevation: 1000 - 11000feet
    - Wind: N/A
    - Temperature: -18C – 27C avg temp (in YNP)
    - Slopes: found near river beds, 0-26%
    - Precipitation: 19-26 inches, semi-dry regime
    - Frost free days: na
    - Exposure: na

Three-tip sagebrush (including Wyoming Three-tip) (Artemisia tripartita spp.)
Citation numbers 2, 9, 11, 12, 18, 24, 34, and 35

- Geology: found alluvial gravel and granitic bedrocks
- Soil
  Type: sandy and loamy textural groups; windblown loess, residuum or alluvium on slopes from 0-12%. Fine loamy, mixed frigid, Calcic Argixerolls, rocky knolls, moderate to deep well drained soils, loam, silt loam, sandy loam, loamy sand, ph 6.6-7.8, aridic-xeric moisture, and mesic temp. (Wyoming three tip has frigid to cryic temps)
  Depth: shallow to deep (>10 to >36 inches)
  Drainage: greater than slow permeability (>0.8 in/hr), not affected by high water table, well drained
- Elevation: 3000-9000ft
- Wind: na
- Temperature: 37.8C to -31.7C
- Slopes: not confined to upland position, occurred in swales, and rolling smooth slopes with very little exposure of granitic bedrock., 8-35%, aspect 2-353 degrees
- Precipitation: average annual is 11-19 inches, avg annual 300-400mm
- Frost Free Days: 120
- Exposure: does not influence distribution
  Notes: neutral to slight alkalinity

Wyoming Big Sagebrush (Artemisia tridentata var. wyomingensis)
Citation numbers 1, 2, 3, 5, 6, 8, 9, 11, 13, 14, 18, 24, 31, 33, and 35

- Geology: Brown's Park Formation
- Soil
  Type: dry, rocky, fine, silty - mixed (calcareous), frigid Typic Haplargid, fine-loamy, mixed (calcareous), frigid Typic Camborthid, frigid Ustic Torrifluvent, Argic Cryoborolls, clay on surface, loams in subsurface, Argic Cryoborolls, the Kimmons series, Kimmons series; Deep loess. Derived from volcanic origin and some sedimentary; colluviums and alluviums , loam, sandy loam, aridic to xeric moisture, mesic to frigid temperature

  Depth: shallow to deep (>10 to >36 inches), 30-35cm
  Drainage: modern drainage way floodplains, and smooth dissected alluvial fans
- Elevation: 1400-2400m
- Wind:5.3 m/s, 8.3 m/s, min 3.5m/s, average 5 m/s
- Temperature: range from 15.6 C to -4.2
- Slopes: foothills and valleys , 3-4%, 2-5%, 0-8%
- Precipitation: average annual is 11-19 inches, 18-32; 53.5 cm; 31Annual average precip from 1969-1982: 52.6 cm, mostly as snow
- Frost Free Days: 55-65, 80-110, 110-140
- Exposure: northerly, western, southern

Mountain Big Sagebrush (Artemisia tridentata var. pauciflora/vaseyana)
Citation numbers: 2, 4, 8, 13, 24, 33, 35

- Geology: fill basin sediments, parent soil material is Brown's Park Sandstone
- Soil
- Type: dry sterile, volcanic origin, Argic Cryoborlls, the Kimmons series; dark brown mollisols, sandy-loam, loam, ph + to – 7.0, soil moisture – udic, cryic temp.
  Depth: shallow, deep, 40cm.
  Drainage: well-drained
- Elevation: 3230-10,000 feet
- Wind: 3-8m/s, 8.3 m/s, min 3.5m/s, average 5 m/s, 24 km/hr
- Temperature: 2.7C
- Slopes
- Precipitation: Annual average precip from 1969-1982: 52.6 cm, mostly as snow., semi-dry moisture regime
- Frost Free Days:
- Exposure:

Rothrock Sagebrush (Artemisia rothrockii)
Citation numbers: 2, 35

- Geology: n/a
- Soil
  Type: xeric moisture, frigid to cryic temperature, fine to coarse
  Depth: deep soils on forest margins
  Drainage: well-drained
- Elevation: 8500-11000 feet
- Wind: N/A
- Temperature: N/A
- Slopes: Precipitation: na
- Frost Free Days: na
- Exposure: na

Subalpine Sagebrush (Artemisia tridentata ssp. spiciformis)
Citation numbers: 2, 35

- Geology: n/a
- Soil
  Type: highly alkaline, basic, udic moisture, cryic temps.
  Depth: deep
  Drainage: poorly drained or tight
- Elevation: 6000-10000 feet
- Wind: N/A
- Temperature: N/A
- Slopes: foothills and ranges of continental divide.
- Precipitation: semi-dry regime
- Frost Free Days: na
- Exposure: na

Hotsprings Sagebrush (Artemisia arbuscula ssp. thermopola)
Citation numbers: 2, 35

- Species Hotsprings Sagebrush
  - Geology: n/a
  - Soil
    Type: dry sterile, volcanic origin, claypan, non-calcic, possibly xeric moisture, frigid to cryic moisture
    Depth: shallow
    Drainage: N/A
  - Elevation: 5000- 9000 feet
  - Wind: N/A
  - Temperature: N/A
  - Slopes: na
  - Precipitation: semi-dry regime
  - Frost Free Days: na
  - Exposure: na

Sand Sagebrush (Artemisia filifolia)
Citation numbers: 35

- Geology: n/a
- Soil
  Type: sandy, xeric moisture, mesic temp.
  Depth: deep
  Drainage: N/A
- Elevation: 2700-7500 ft
- Wind: N/A
- Temperature: N/A
- Slopes: na
- Precipitation: na
- Frost Free Days: na
- Exposure: na

Alkali (Early) Sagebrush (Artemisia arbuscula var. longiloba)
Citation numbers: 35

- Geology: n/a
- Soil
  Type: alkali shales, light to tight clays, claypan , xeric moisture, frigid to cryic temps
  Depth: shallow
  Drainage: N/A
- Elevation: 5500-8000 feet
- Wind: N/A
- Temperature: N/A
- Slopes: na
- Precipitation: semi-dry regime
- Frost Free Days: na
- Exposure: na

ANNOTATED CITATIONS AND CITATION NUMBER

Citation 1

Barker, Jerry R and Cyrus M McKell. 1983. Habitat Differences between Basin and Wyoming Big Sagebrush in Contiguous Populations.

1. Location – Wyoming
    a. Species Basin Big Sagebrush (Artemisia tridentata var. tridentata)
        i. Geology: n/a
        ii. Soil
            - Type: fertile plains soil
            - Depth: deep
            - Drainage: seasonally dry, well drained
            - Elevation: 610-2140 meters
        iii. Wind: N/A
        iv. Temperature: N/A
        v. Slopes: plains
        vi. Precipitation: na
        vii. Frost free days:
        viii. Exposure: N/A

NOTE: From McArthur and Plummer 1978, McArthur et al. 1979, Morris et al. 1976, Winward 1980, Winward and Tisdale 1977

2. Location – Wyoming
    a. Species Wyoming Big Sagebrush (Artemisia tridentata var. wyomingensis)Sub. wyomingensis.)
        i. Geology: n/a
        ii. Soil
            - Type: dry, rocky
            - Depth: shallow
            - Drainage: N/A
            - Elevation: 1520-2150 meters

Wind: N/A
Temperature: N/A
Slopes: foothills and valleys
Precipitation: N/A
Frost free days:
Exposure: N/A

NOTE: From McArthur and Plummer 1978, McArthur et al. 1979, Morris et al. 1976, Winward and Tisdale 1977

-Notes: whenever basin and Wyoming big sagebrush are found close together, the latter subspecies always occupies the drier, poorer, shallower soils. West et al. (1978), in a biogeographical sagebrush study in Nevada, found that Wyoming big sagebrush occupied soils warmer and drier than did basin big sagebrush.

Study Sites

Location – The Sage Creek study site (N 41? 46' 36" - W 111 10 I' I11") is located about 4.8 km west of Sage Creek Junction on Highway 30 in Rich County in northeastern Utah.

- Species Wyoming Big Sagebrush (Artemisia tridentata var. wyomingensis) Sub. wyomingensis)
  - Geology: n/a
  - Soil

Type: fine, silty - mixed (calcareous), frigid Typic Haplargid
Depth: N/A
Drainage: N/A

- Elevation: 1950 meters
- Wind: N/A
- Temperature: N/A
- Slopes: 3-4%
- Precipitation: average annual - 25-30cm.
- Frost Free Days: 55-65
- Exposure: northerly

- Species Basin Big Sagebrush (Art. Tridentate tridentata)
  - Geology: n/a
  - Soil

Type: fine-silty, mixed, frigid Xeric Torrifluvent
Depth: N/A
Drainage: N/A

- Elevation: 1950 meters
- Wind: N/A
- Temperature: N/A
- Slopes: 3-4%
- Precipitation: average annual - 25-30cm.
- Frost Free Days: 55-65
- Exposure: northerly

Location – The Greasewood Wash study site (N 41?' 55' 66"- W 108? 52' 30") is located about 10.2 km north of the Jim Bridger Coal Mine along Sweetwater County Road 4-17 in southwestern Wyoming.

- Species Wyoming Big Sagebrush (Artemisia tridentata var. wyomingensis) Sub. wyomingensis)

- Geology: n/a
- Soil

Type: fine, silty - fine-loamy, mixed (calcareous), frigid Typic Camborthid
Depth: N/A
Drainage: N/A

- Elevation: 2063 meters
- Wind: N/A
- Temperature: N/A
- Slopes: 2-5%
- Precipitation: average annual – 12-22 cm.
- Frost Free Days: 80-110
- Exposure: western

➢ Species Basin Big Sagebrush (Art. Tridentate tridentata)

- Geology: n/a
- Soil

Type: fine-loamy, mixed (calcareous), frigid Xerollic Torrifluvent
Depth: N/A
Drainage: N/A

- Elevation: 2063 meters
- Wind: N/A
- Temperature: N/A
- Slopes: 2-5%
- Precipitation: average annual – 12-22cm.
- Frost Free Days: 80-110
- Exposure: western

Location – The Maeser study site (N 400 34' 1 1 " - W 40? 35') is located in the Uinta Basin, 11.2 km north of Maeser, Utah along Taylor Mountain Road.

➢ Species Wyoming Big Sagebrush (Artemisia tridentata var. wyomingensis Sub. wyomingensis)

- Geology: n/a
- Soil

Type: fine, silty - fine-silty, mixed (calcareous), frigid Ustic Torrifluvent
Depth: N/A
Drainage: N/A

- Elevation: 2296 meters
- Wind: N/A
- Temperature: N/A
- Slopes: 3-4%
- Precipitation: average annual - 25-30cm.
- Frost Free Days: 110-140
- Exposure: southern
-

- Species Basin Big Sagebrush (Art. Tridentate tridentata)
  - Geology: n/a
  - Soil

Type: fine-loamy, mixed (calcareous), frigid Ustic Torrifluvent
Depth: N/A
Drainage: N/A

- Elevation: 2296 meters
- Wind: N/A
- Temperature: N/A
- Slopes: 3-4%
- Precipitation: average annual - 25-30cm.
- Frost Free Days: 110-140
- Exposure: southern

Citation 2

Beetle, A.A. 1960. A Study of Sagebrush. University of Wyoming Agricultural Experiment Station. Bulletin 368.

Location – Wyoming

- Species Black Sagebrush (Artemisia nova)
  - Geology: n/a
  - Soil

Type: na
Depth: shallow
Drainage: N/A

- Elevation: 5000 – 8000 feet
- Wind: N/A
- Temperature: N/A
- Slopes: na
- Precipitation: na
- Frost Free Days: na
- Exposure: na

- Species Hotsprings Sagebrush (Artemisia arbuscula ssp. thermopola)Sub. thermopola)
  - Geology: n/a
  - Soil

Type: dry sterile, volcanic origin
Depth: shallow
Drainage: N/A

- Elevation: 6000-7000 feet
- Wind: N/A
- Temperature: N/A
- Slopes: na
- Precipitation: na

- Frost Free Days: na
- Exposure: na

- Species Basin Big Sagebrush (Artemisia tridentata var. tridentata)
  - Geology: n/a
  - Soil

Type: dry sterile, volcanic origin
Depth: shallow
Drainage: N/A

- Elevation: 5000-7000 feet
- Wind: N/A
- Temperature: N/A
- Slopes: na
- Precipitation: na
- Frost Free Days: na
- Exposure: na

- Species Mountain Big Sagebrush (Artemisia tridentata var. pauciflora/vaseyana)
  - Geology: n/a
  - Soil

Type: dry sterile, volcanic origin
Depth: shallow
Drainage: N/A

- Elevation: 6000-10,000 feet
- Wind: N/A
- Temperature: N/A
- Slopes: na
- Precipitation: na
- Frost Free Days: na
- Exposure: na

- Species: Subalpine Big Sagebrush (Artemisia spiciformis)
  - Geology: n/a
  - Soil

Type: highly alkaline
Depth: shallow
Drainage: poorly drained or tight

- Elevation: 6000-8,000 feet
- Wind: N/A
- Temperature: N/A
- Slopes: foothills and ranges of continental divide.
- Precipitation: na
- Frost Free Days: na
- Exposure: na

- Species: Artemisia Rothrockii
  - Geology: n/a
  - Soil

Type: na
Depth: deep soils on forest margins
Drainage:

- Elevation: 8500-11000 feet
- Wind: N/A
- Temperature: N/A
- Slopes: Precipitation: na
- Frost Free Days: na
- Exposure: na

- Species: Silver Sagebrush (Artemisia cana)
  - Geology: n/a
  - Soil

Type: loamy to sandy
Depth: deep soils
Drainage: na

- Elevation: 8500-11000 feet
- Wind: N/A
- Temperature: N/A
- Slopes: near river beds
- Precipitation: na
- Frost Free Days: na
- Exposure: na

- Species: Mountain Silver Sagebrush (Art. tri. Cana ssp. Viscidula)
  - Geology: n/a
  - Soil

Type: na
Depth: na
Drainage: along mountain streams or heavy snowpack, lots of moisture

- Elevation: na
- Wind: N/A
- Temperature: N/A
- Slopes: na
- Precipitation: na
- Frost Free Days: na
- Exposure: na

- Species: Three-tip Sagebrush (Artemisia Tripartite)
  - Geology: n/a
  - Soil

Type: na
Depth: deep
Drainage: well-drained

- Elevation: 3000-6000 feet
- Wind: N/A
- Temperature: N/A
- Slopes: na
- Precipitation: na
- Frost Free Days: na
- Exposure: na

- Species: Wyoming Three-tip Sagebrush (Artemisia tripartite ssp. Rupicola)
  - Geology: n/a
  - Soil

Type: na
Depth: na
Drainage: na

- Elevation: 8000-9000 feet
- Wind: N/A
- Temperature: N/A
- Slopes: na
- Precipitation: na
- Frost Free Days: na
- Exposure: na

Citation 3

Ingrid C. Burke. 1989. Control of Nitrogen Mineralization a Sagebrush Steppe Landscape. *Ecology*. Vol. 70(4):1115-1126

Location – 30 km west of Saratoga, Wy

- Species Black Sagebrush (Artemisia nova), Wyoming Big Sagebrush (Artemisia tridentata var. wyomingensis)
  - Geology: dissected plateau of Tertiary Origin, Brown's Park Formation
  - Soil: Argic Cryoborolls
  - Type: n/a
  - Depth: na
  - Drainage: modern drainage way floodplains, and smooth dissected alluvial fans
  - Elevation: 2400m. average
  - Wind: 5.3 m/s
  - Temperature: mean annual – 2.7C
  - Slopes: n/a
  - Precipitation: 535 mm, mean annual (mostly snow)
  - Frost Free Days: na

- Exposure: n/a

NOTES: On windward slopes ArTrWy is dominant, On windward exposures where snow accumulation and soil moisture is least ArTrNo is dominant

Citation 4

IC Burke, WA Reiners, RK Olson. 1989. Topographic control of vegetation in a mountain big sagebrush steppe. *Plant Ecology.* Vol. (84): 77-86

Location - Mountain Sagebrush Steppes of Wyoming

- Species: Mountain Big Sagebrush
  - Geology: tertiary fill basin sediments, parent soil material is Brown's Park Sandstone
  - Soil: Argic Cryoborlls
  - Type: n/a
  - Depth: na
  - Drainage: down cut in west to east direction
  - Elevation: 2400m
  - Wind: 3-8m/s
  - Temperature: na
  - Slopes: n/a
  - Precipitation: na
  - Frost Free Days: na
  - Exposure: n/a

NOTES: Windswept ridges with little snow, accumulation 0.25 max accumulation (Sturgis 1977)

Citation 5

Carl L. Wambolt and Gene F. Payne. 1986. An 18-Year Comparison of Control Methods for Wyoming Big Sagebrush in Southwestern Montana. *Journal of Range Management.* Vol. 39(4):314-319

Location - in southwestern Montana approximately 27 km west of Dillon and 3 km northeast of Bannack

- Species: Wyoming big sagebrush, basin big sagebrush
  - Geology: n/a
  - Soil: 30 to 35 cm
  - Type: clay on surface, loams in subsurface
  - Depth: deeper soils associated with Basin Big Sagebrush
  - Drainage: n/a
  - Elevation: 1890 m
  - Wind: n/a
  - Temperature: n/a
  - Slopes: rolling, 0-8%
  - Precipitation: 310 mm

- Frost Free Days: na
- Exposure: n/a

Citation 6

L. R. Rittenhouse and F. A. Sneva. 1976. Expressing the Competitive Relationship between Wyoming Big Sagebrush and Crested Wheatgrass. *Journal of Range Management,* Vol. 29(4):326-327

Location - Butte Range Station 70 km west of Burns

- Species: Wyoming Big Sagebrush
  - Geology: n/a
  - Soil: na
  - Depth: na
  - Drainage: n/a
  - Elevation: 1640 m.
  - Wind: n/a
  - Temperature: n/a
  - Slopes: na
  - Precipitation: na
  - Frost Free Days: na
  - Exposure: na

Citation 7

Darold W. Sabinske and Dennis H. Knight. 1978. Variation within the Sagebrush Vegetation of Grand Teton National Park, Wyoming. *Northwest Science,* Vol. 52(3):195-204.

Location - Grand Teton NP

- Species: Low Sagebrush
  - Geology: n/a
  - Soil: Coarse-textured
  - Depth: shallow
  - Drainage: n/a
  - Elevation: na
  - Wind: n/a
  - Temperature: n/a
  - Slopes: na
  - Precipitation: na
  - Frost Free Days: na
  - Exposure: na

Citation 8

David L. Sturges. 1986. Responses of Vegetation and Ground Cover to Spraying a High Elevation, Big Sagebrush Watershed with 2,4-D. *Journal of Range Management*, Vol. 39(2): 141-146.

- Location - Stratton Sagebrush Hydrology Study Area, in south-central Wyoming

❖ Species: Mountain Big Sagebrush
- Geology/Parent Material: Brown's Park Formation
- Soil: Argic Cryoborolls, the Kimmons series, Kimmons series
- Depth: deep
- Drainage: n/a
- Elevation: na
- Wind: max:8.3 m/s, min 3.5m/s, average 5 m/s
- Temperature: annual average 2.7C
- Slopes: na
- Precipitation: Annual average precip from 1969-1982: 52.6 cm, mostly as snow.
- Frost Free Days: na
- Exposure: na

❖ Species: Wyoming Big Sagebrush and Black Sagebrush
- Geology/Parent Material: Brown's Park Formation
- Soil: Argic Cryoborolls, the Kimmons series, Kimmons series
- Depth: shallow
- Drainage: n/a
- Elevation: na
- Wind: max:8.3 m/s, min 3.5m/s, average 5 m/s
- Temperature: annual average 2.7C
- Slopes: na
- Precipitation: Annual average precip from 1969-1982: 52.6 cm, mostly as snow.
- Frost Free Days: na
- Exposure: na

Citation 9

Albert P. Thatcher. 1959. Distribution of Sagebrush as Related to Site Differences in Albany County, Wyoming. *Journal of Range Management*, Vol. 12(2): 55-61.

- Location – Albany County, Wy

❖ Species: Big Sagebrush (no subspecies)
- Geology/Parent Material: Cretaceous bedrock, usually highly saline or alkaline / parent material: sandstones, shales, limestone, granites, terraces, and alluvial gravels
- Soil: sandy -loam, loamy or clayey top soils, no were associated with extremely heavy or sandy soils
- Depth: at least 15 inches

- Drainage: wide range of permeable soils, free from high water table exposure, well drained
- Elevation: na
- Wind: na
- Temperature: na
- Slopes: na
- Precipitation: na
- Frost Free Days: na
- Exposure: na

Notes: can handle slight alkalinity

❖ Species: Silver Sagebrush

- Geology/Parent Material: sandstone and gravel underlying or parent material.

- Soil: sandy topsoils, did not occur on soils with heavy textured topsoils, regardless of topo-
graphic position of the site
  - Depth: deep to moderately deep soils in this area, but it will grow on shallow soils in some instances
  - Drainage: needs greater than moderate permeability, can withstand a high water table
  - Elevation: na
  - Wind: na
  - Temperature: na
  - Slopes: associated with lowlands
  - Precipitation: average annual is 10-19 inches
  - Frost Free Days: na
  - Exposure: does not influence distribution

Notes: can handle moderate alkalinity and slight salinity, occurs with Basin wild rye (Elymus cinereus)

❖ Species: Black Sagebrush

- Geology/Parent Material: found only on soils with gravel or granitic parent material. Parent material was also not distinctly fractured
- Soil: sandy loam and gravelly silt loam, no salt accumulation

Depth: shallow to very shallow

- Drainage: needs moderate to rapid permeability, well drained
- Elevation: na
- Wind: na
- Temperature: na
- Slopes: adapted to steep slopes
- Precipitation: average annual is 10-19 inches
- Frost Free Days: na
- Exposure: does not influence distribution

Notes: neutral to slight alkalinity, associated with bluebunch wheatgrass

- Species: Three tip Sagebrush
  - Geology/Parent Material: found alluvial gravel and granitic bedrocks
  - Soil: sandy and loamy textural groups

  Depth: shallow to deep (>10 to >36 inches)

  Drainage: greater than slow permeability (>0.8 in/hr), not affected by high water table, well drained
  - Elevation: higher elevation than plains areas
  - Wind: na
  - Temperature: na
  - Slopes: not confined to upland position, occurred in swales, and rolling smooth slopes with very little exposure of granitic bedrock.
  - Precipitation: average annual is 15-19 inches
  - Frost Free Days: na
  - Exposure: does not influence distribution

Notes: neutral to slight alkalinity

Citation 10

Patten, D.T. 1968. Dynamics of the Shrub Continuum Along the Gallatin River in Yellowstone National Park. *Ecology,* Vol. 49(6):1107-1112.

Artemisia Cana was studied in Yellowstone Nat. Park between the elevations of 6700-7200 feet. Topography is generally level except for breaks by abandoned stream beds. Soil is coarse alluvium with sand and gravel mixed in varying amounts. Temperatures range from -18C to 27C.

Citation 11

Wright. Henry A. 1970. Response of Big Sagebrush and Three-tip Sagebrush to Season of Clipping. *Journal of Range Management,* Vol. 23(1):20-22.

Study conducted at the US Sheep Station Experimental Range near Dubois. Idaho. Elevation 5600 ft. Average precipitation is 11 inches. Species: ArTrWy and ArTrTripartita

Citation 12

Bork, Edward W, Neil E West, and John W Walker. 1998. Components of Long-Term Seasonal Sheep Grazing Treatments in Three-tip Sagebrush Steppe. *Journal of Range Management,* Vol. 51(3):293-300.

Study site near Dubois, Id. Elevation at 5600 ft. Average precipitation is 301 mm including 701 mm of snow. Average annual temp is 6.1C with max and min from 37.8C to -31.7C. 120 day frost free average day period. Soils are windblown loess, residuum or alluvium on slopes from 0-12%. Fine loamy, mixed frigid, Calcic Argixerolls. Species: ArTrTripartita

Citation 13

Bonham, CD, TR Cottrell and JE Mitchell. 1991. Inferences for Life History Strategies of Artemisia tridentate subspecies. *Journal of Vegetation Science,* Vol. 2(3): 339-344.

ArTrTr, ArTrVa, and ArTrWy are studied in this research. Study area is Northwestern Colorado. Average monthly precipitation is 30mm. Temperature ranges from 7 C to -1C. ArTrVa occurred on elevation ranges from 2365m. 2585 m. Soils were deeper than 40cm. Soil is dark brown mollisols at high elevations and deep loess and mid elevations. Entisols developed on heavy clays and deep sandy alluvial soils at low elevations. ArTrTr was in the valley bottom between 1990m and 2760m. ArTrWy occurred on a bench at 2070m.

Citation 14

Lyford, ME. 1995. Shrub establishment on drastically disturbed lands. *MS Thesis, Dept of Rangeland Ecology and Watershed Management,* University of Wyoming, Laramie.

For ArTrWy

Study site 19km south of Gillette, Wy. Mean annual temperature is 7.2C with mean daily max of 14.6C and minimum of -0.2C. Mean annual precipitation is 40cm, snowfall being 160.8cm. Elevation of 1400m.

Study Site 31km east of Wright Wyoming. Elevation at 1430km, in PRB. Mean annual air temp is 7.2C, mean daily max is 15.6, and minimum of -1.2C. Mean annual precip is 32.6cm and snowfall is 102.1 cm.

Study site is 3.2 Km north of Hanna, Wy. Elevation of 2040. Mean annual air temperature is 5.3C, mean daily max of 13.5c and minimum of -2.8C. Mean annual precip is 26.1 cm and snowfall of 114.8C

Study Site is 2160m in elevation, 8km south of Kemmerer, Wy. Mean annual air temperature is 4.1C and mean daily max is 12.2C, min of -4.2C. Precipitation is 22.7cm and snowfall at 121.7cm.

Citation 15 – NOT IN WYOMING

Meyer, S. E., S. B. Monsen, and E. D. McArthur. 1990. Germination response of Artemisia tridentata (Asteraceae) to light and chill: patterns of between-population variation. *Botanical Gazette,* 151:176-183.

ArTrTr: Samples collected in Boise Id, at 890m elev.; Dayton, NV at 1300m in elevation; Kirch Refuge, Nevada – elevation of 1620; Hailstone, Utah- 1840 elev.; Mokee Dugway, Utah – 1900 elev.

ArTrVa- samples collected in Lucky Peak , Id elevation of 985m., Gardinerville, Nevada at elevation of 1690m. Kyle canyon, Nevada at elevation of 1660m, Browse, Utah with elevation of 1430 m, and park city, Utah at elevation of 1990m.

ArTrWy- samples collected in Crowsnest, Idaho at 1410m, Three Creek Well, Id at 1720m, Caliente, Nev. At 1820m, Gardinerville, Nevada at 1600m, Mayfield, Utah at 1690m.

Citation 16 – NOT IN WYOMING

Young. JA and R Evans. 1989. Dispersal and germination of big sagebrush (Artemisia tridentate) seeds. *Weed Science,* Vol. 37:201-206.

Mountain Big Sagebrush: sites 40km north of Reno, NV. Soils derived from decomposing granite.

Basin big sagebrush: site 100km north of Reno, NV. Soils derived from alluvial meta-volcanic formations and tephra flows.

Citation 17-NOT IN WYOMING

Miller, R. G. Findley, R. R and Alderfer-Findley, J. 1980. Changes in mountain big sagebrush habitat types following spray release. *Journal of Range Management,* Vol. 33: 278-281.

Species: ArTrVa, Study site: 14.5km southwest of Ironside, Oregon. Steep topography with elevations ranging from 1830 to 2377m. Upper slopes dominated with ArTrVa. Average precipitation is 400mm, mostly as snow. ArTrVa on north-northwest exposure on 13% slopes. Soils are rocky with less than 45cm depth.

Citation 18

Miller, R. F. and L. L. Eddleman. 2000. Spatial and temporal changes of sage-grouse habitat in the sagebrush biome. *Oregon State Agricultural Experiment Station Technical Bulletin*, 151. 35p.- ELECTRONIC

Soils for the ArTrTr/Wy/Va are derived from volcanic origin and some sedimentary.

ArTrVa: 350-450mm precip, 1200-1300m elevation, moderate to deep soils
Poorly drained soils, argillic horizon, duripan or bedrock less than 33 – 50cm from surface

ArTrTr: 200-400 mm precip, <2300m elevation, deep soils
Poorly drained soils, argillic horizon, duripan or bedrock less than 33 – 50cm from surface

Artemisia tripartita: average annual precip 300-400mm, 1100-2300 m elevation, shallow, mod depth soils

ArTrWy: 180-300mm precip average, 150-1200, m elevation, moderate depth soil

Artemisia arbuscula: precip 200-400mm, elevation: 1000-3300m, shallow soils.
Poorly drained soils, argillic horizon, duripan or bedrock less than 33 – 50cm from surface

Art Nova: 200-400mm precip, 1400-2550m elevation; shallow soils
-Poorly drained soils, argillic horizon, duripan or bedrock less than 33 – 50cm from surface.
Low soil moisture and fertility.

Art rigida: 200-400mm precip, 230-1300m elevation; shallow soils.
Poorly drained soils, argillic horizon, duripan or bedrock less than 33 – 50cm from surface

Citation 19 - NOT IN WYOMING

Zamora, B. and P.T. Tueller. 1973. *Artemisia arbuscula, A. longiloba,* and *A. nova* habitat types in northern Nevada. *Great Basin Naturalist,* 33: 225-242

Study area is northern Nevada (north of 39th parallel). Soils belong to the Aridisol, Entisol, Mollisol, and Vertisol orders. Mean annual temperature is 3.9C. Mean total annual precip is 239.2mm. Monthly totals are January – 29.2mm, February -26.4mm, March 23.9mm, April – 22.9mm, May – 24.6mm, June – 18.0mm, July 9.9mm., August 7.6mm, September – 9.9mm, October-18.8mm, November- 20.6, December-27.4

Artemisia Arbuscula – found on gently rolling to hilly terrain, and slopes and ridge tops of hilly and mountainous terrain at altitudes of 1800-2700m. Soils include: Typic Haploxerolls, Typic Argixerolls, Typic Durixerolls, and Xerollic Camborthids, Mollic Paleic Durargids, Mollic Paleargids, Mollic Haplargids, and Typic Durixerolls, Lithic Argixerolls.

Artemisia Longiloba – found on slopes and on gently rolling or hilly terrain at altitudes of 1900-2100m. Soils belonged to Xerollic Camborthids and Mollic Paleargids subgroups.

Artemisia Nova – Occurs at altitudes of 1800-2300m Northern NV - foothill slopes, slopes of gently rolling to hilly terrain. Also occurs at higher altitudes where soils are derived from calcareous parent materials. Soils subgroups were Typic Torriorthents, Pachic Argixerolls, Typic Durixerolls, Pachic Halpoxerolls, and Xerollic Paleorthids, Mollic Paleargids, Mollic Haplargids, Lithic Mollic Haplargids, Typic Torriorthents.

On undulating and gently rolling pediment slopes of intermountain basins of central and east central NV with slopes less than 5% at altitude of 1800-2300m and soils are Aridisol and Entisols.

Citation 20

Despain, Don G. 1973. Vegetation of the Big Horn Mountains, Wyoming, in relation to substrate and climate. *Ecological Monograph,* 43(3):329-355.

Artemisia tridentata site characteristics:
Site 1 – elevation of 1995m, 3% slope, alluvium substrate, aspect 260 degree
Site 2- elevation of 3255m, 22% slope, shale substrate, aspect 215 degrees
Site 3 – elevation of 3010m, 7% slope, limestone, aspect 35 degrees

- All associated with deep soils

NOT specific enough

Citation 21 Not in Wyoming

Tisdale, E. W. 1986. Native Vegetation of Idaho. *Rangelands,* Vol. 8(5): 202-207.

Location – Idaho

Art(ssp.)- dominates communities over a wide range of precipitation (8-24 inches); and elevation (800-11,000 ft)

ArTrWy - Wyoming big sagebrush (subsp. wyomingensis) occurs on areas of low to moderate precipitation but shallower soils

ArTrTr - Basin big sagebrush (subsp. tridentata) occupies sites with low to moderate precipitation but deep soils;

ArTrVa- mountain big sage (ssp. vaseyana) grows in areas of higher elevation, with higher precipitation and lower temperatures

The three-tip sagebrush (Artemisia tripartita) series occurs mainly in the eastern part of the sagebrush region, apparently favored by the lower temperatures and higher percentage of summer rainfall in that area.

represents the western form of a predominantly Great Plains species. In Idaho, it dominates a type confined to stream banks and dry meadows.

Low sagebrush (Artemisia arbuscula) is one of a group of low-growing species which occupy harsh sites within the sagebrush region. The low sagebrush series occurs over a wide range climatically, but is confined to soils which are either shallow to bedrock or have a strong restrictive layer developed at shallow depth

The black sagebrush (Artemisia nova) series is confined to the driest part of the sagebrush region, usually on shallow calcareous soils derived from limestone. The

The early sagebrush (Artemisia longiloba) series is another low-growing type, occurring on shallow soils with strongly developed clay pans.

Citation 22_not in Wyoming

Paul F. Jones, Roy Penniket, Livio Fent, Joel Nicholson, and Barry Adams. 2005. Silver Sagebrush Community Associations in Southeastern Alberta, Canada. *Rangeland Ecological Management,* Vol. 58:400-405.

ArTrTr and ArTrWy
reported silver sagebrush occupying overflow sites consisting of alluvial fans, aprons, and terraces of broad poorly drained swales to glacial melt water channels. Our results supported the notion that silver sagebrush is
a quasi-riparian species, requiring mesic sites. Within the study area, the lotic and overflow sites were the driest of the riparian classes. The lotic sites have juvenile regosolic soils, whereas the overflow sites were more-developed brown chernozems. These 2 sites had the best sagebrush characteristics (i.e., greater mean percentage of occupancy, denser, more even distribution, and

taller plants). The other end of the spectrum would be the loamy site, The topography of the study area is flat to gently rolling, with occasional lava outcrops. Although the area is underlain by some 1,500 m of basalt, most INEL Site soil is derived from older silicic volcanics and paleozoic rocks from the surrounding mountains and buttes (McBride et al. 1978). Soils of the study area are primarily aeolian sandy loams and loess, but some alluvial deposits which are gravelly on the surface and underlain by a sandy loam occur along the Big Lost River (McBride et al. 1978). These soils would all be classified as Aridisols (USDA 1960)

Citation 23 not in Wyoming
Burkhardt. J. W. and E. W. Tisdale. 1976. Causes of Juniper invasion in southwestern Idaho. *Ecology,* 76: 472-484.

-Location SW Idaho

Study site is rhyolitic plateau of Miocene Columbia River Volcanics. Elevation ranges from 1400-2100m. topography is level to hilly, average annual precipitation ranges from 360-500mm and mean annual temperature ranges from 5-6C.

ArTrVa – occupies deep well drained soils in valley bottoms
Artemisia arbuscula – occupies areas of shallow soil over a restrictive layer of claypan or bedrock.

Citation 24
Mahalovich, Mary F. and E. Durant McArthur. 2004. Sagebrush Seed and Plant Transfer Guidelines. *Native plants,* Pp 141-148.

Artemisia arbuscula spp.
Arbuscula – dry, sterile, rocky, often shallow alkaline, clay soils; western Wyoming, 700-3780m elevation
Thermopolis – spring flooded, summer-dry soils; western Wyoming; 1800-2500m elevation

ArCa spp.
Cana – loamy to sandy soils of river bottoms, 1525-3350m elevation
Viscidula –mountain areas along streams and in areas of heavy snow pack; 305-3050m

Artemisia longiloba – heavy soils derived from alkaline shales or on lighter, limey soils; 1680 to 2440m elev.

Art. Nova – dry shallow stony soils, some affinity for calcareous soils; 625 to 2990m

ArTr spp.
ArTrTr – deep, dry, fertile soils of valleys and foothills, 610-2140m elev.
ArTrVa- deep well drained soils often with summer moisture available in mountains and foothills

ArTrWy – shallower, well-drained, hottest soils; 1520-2150m elevation

Art. Tripartita
Rupicola – rocky knolls; 1100-2300m elevation
Tripartita – moderate to deep, well drained soils, 1100-2300m

Citation 25_NOT IN WYOMING
Pearson, L. C. 1965, Primary production in grazed and ungrazed desert communities of eastern Idaho. *Ecology,* Vol. 46: 278-285.

No subspecies – Just ArTr

Elevation – 1500m, thick lava bedrock layer
Climate: min temp—42C, max 40C
Average annual precip: 27cm
Soil – shallow with average depth at 60cm. with lava rock underneath. PH level is 7.8.

Citation 26_NOT IN WYOMING
Blackburn, Wilbert H. and Paul T. Tueller. 1970. Pinyon and Juniper Invasion in Black Sagebrush Communities in East-Central Nevada. *Ecology,* Vol. 51(5): 841-848.

Species: ArNo
Site – East Central Nevada in a 70 mile radius around Ely, NV. Elevations from 6025 -6800, west, east, northeast facing slopes of 3-11%, undulating macrorelief, and uniform convex microrelief. Two soil types derived from limestone and two from undifferentiated volcanic rocks: loamy-skeletal, carbonate, frigid, shallow family of the Mollic Calciorthids, Lithic Mollic Calciorthids, fine-loamy, mixed, frigid family of the Mollic Durargids, frigid family of the Entic Mollic Durorthids

Citation 27_NOT IN WYOMING
Holechek, J. L. and Stephenson, T. 1983. Comparison of big sagebrush vegetation in north-central New Mexico under moderately grazed and grazing excluded conditions. *Journal of Range Management,* Vol. 36:455-456.

Species - ArTrTr
The study area was located 40 km northwest of Taos, N. Mex., in a 25-35 cm precipitation zone at 1800-2,000-m elevation. Most (65%) of precipitation occurs in the spring and summer; July and August are months of peak rainfall. Soils of the area belong to the order aridisol and the suborder argid due to their high clay content. Soil texture ranges from a clay loam on lowland sites to a silty clay loam on upland sites. Soil depth averages about 170 cm on lowland sites and 140 cm on upland sites.

Citation 28_NOT IN WYOMING
Tueller, P. T. and W. H. Blackburn. 1974. Condition and trend of the big sagebrush/needle and thread habitat type in Nevada. *Journal of Range Management,* Vol. 27:36-40

No subspecies – Just ArTr

Study areas were two rangeland water- sheds: 1) Rock Springs Watershed (T45N, R 18E) located 46 miles southeast of Wells, Nevada, and 2) Duckwater Water- shed (T14N, R55E) located 33 miles southeast of Eureka. The big sagebrush/needle and thread habitat-type was found at elevations of 5,340 to 6,580 feet on west, northwest, north, northeast, or south-facing modern drainage way floodplains and smooth and dissected alluvial fans of 1 to 12%. Soils are members of a sandy, mixed, nonacid, frigid family of Typic Torripsamments and are usually found on modern drainage way floodplains of canyons dissecting many of the north-south trending mountain ranges found in the Great Basin.

Citation 29_NOT IN WYOMING

Goodrich, Sherel and Allen Huber. 2001. Mountain Big Sagebrush Communities on the Bishop Conglomerate in the Eastern Uinta Mountains. *USDA Forest Service Proceedings RMRS-P-21*.

ArTrVa

Ashley National Forest, Uinta Mtns, Utah.

Average annual precipitation for this ecological unit likely varies between 12 and 20 inches. Frost-free period is 40 to 80 days (Ashcroft and others 1992). Summer thundershowers are common. Snow depth near the end of winter varies from about 1 ft in rare or occasional winters to 2 to 3 ft in most winters. Snow commonly covers the ground from November through April and through much of May in some years. Soils are generally Typic or Pachic Argiborolls, Cryoborolls, and Calciborolls. Calciborolls are likely more common toward the edges of the formation where the mantle of Bishop Conglomerate thins and contacts more calcareous substrates. Soils are generally fine, loamy mixed, fine mixed, or loamy skeletal mixed.

Citation 30_NOT IN WYOMING

Walton, T.P.; White, R.S.; Wambolt, C.L. 1986. Artemisia reproductive strategies: a review with emphasis on plains Silver Sagebrush. Symposium on the Biology of Artemisia and Chrysothamnus, Provo, Utah (USA), 9-13 Jul 1984. *USDA Forest Service general technical report INT - Intermountain Forest and Range Experiment Station*.

Plains Silver Sagebrush - loamy to sandy, well drained upland soils and alluvial flats and terraces of valley bottoms. Well drained alluvial, coarse textured soils in bottomlands.

Mountain Silver Sagebrush – poorly drained soils

Citation 31

Jones, G.P. 1991 Seedling survival and adult plant water relations of black sagebrush and big sagebrush in the Laramie Basin. *PhD dissertation, Dept of Botany, University of Wyoming, Laramie*.

ArTrWy – sites at 2156 and 2176 m in Laramie basin, Wyoming. Between 1-2 degrees slope and aspect of 82 and 352. Substrate colluvium

ArNo – Sites at 2289 and 2295m, aspect at 3.5 and 2 degrees from north, substrate colluviums and alluvium.

Average wind speed through the year is between 6.8 and 7.4m/s.

Citation 32

Wambolt, CL, KS Walhof, and MR Frisina. 2001. Recovery of Big Sagebrush Communities after Burning in South-Western Montana. *Journal of Environmental Management,* Vol. 61: 243-252.

Species – Wyoming Big Sagebrush
Slope: 0-16 degrees
Aspect: 0-330
Elevation: 1830-2220m

Species – Mountain Big Sagebrush
Slope- 3-22%
Aspect – 30-330 degrees
Elevation: 1950-2290m

Citation 33

Sturges, David L. 1977. Soil Water Withdrawal and Root Characteristics of Big Sagebrush. American Midland *Naturalist,* Vol. 98(2):257-273.

Study site – Stratton Sagebrush Hydrology Study Area, 29km west of Saratoga, Wy. Elevation – 2400m, 530mm annual precip. Winds average 24km/hr. Soils developed from Brown's Park Formation, loam and sandy-loam texture on A and B horizon. C horizon is fine grain sandstone in sandy-loam matrix. North facing slope. Species studied – ArTrWy and ArTrVa

Citation 34

Fisser, Herbert G. 1962. An ecological study of the Artemisia Tripartita ssp. Rupicola and Related Shrub Communities in Wyoming. *Master's Thesis, University of Wyoming*.

Species –
Artemisia tripartite rupicola elevation – 5300-9400ft, slope – 8-35 aspect 2- 353
Soil – Loam, silt loam, sandy loam, loamy sand, ph – 6.6 – 7.8
ArNo – 4600-6800ft, slope- 15-26%, aspect – 8-42, loam, silt loam, ph- 7.8
ArCa – 5300-6800ft, slope- 14-26%, 353-42, loam, ph-7.4-7.8

Citation 35

US Dept of the Interior BLM. 2002. Management Considerations for Sagebrush (Artemisia) in the Western United States: a selective summer of current information about the ecology and biology of woody North American sagebrush taxa. Attachment 1-1.

ArNo - **States of Occurrence:** Great Basin
Deciduous or Evergreen: Evergreen
Elevation: 4,500-9,500'
Flowers: August to October
Habit: Erect from spreading base, 6-18" tall
Vegetative Spreading: None
Seeds/lb: 907,000
Moisture Regime: Dry
Soil: Calcareous with rocky pavement, stony, well-drained, thin pH 6.5-7.5
Soil Moisture: Aridic
Soil Temperature: Mesic
Fire Tolerance: Intolerant

Species: *Artemisia arbuscula* ssp. *arbuscula*
Common Names: Low sagebrush, gray low sagebrush, scabland sagebrush, dark sagebrush, little sagebrush, dwarf sagebrush
States of Occurrence: Southern Colorado to western Montana, through Utah, Idaho to northern California, Oregon, and Washington
Deciduous or Evergreen: Evergreen
Elevation: 3,000-12,200'
Flowers: August to September
Habit: Dwarf, irregular shape 15-20", 15-30" wide
Vegetative spreading: Seldom layers
Seeds/lb: 980,000
Moisture Regime: dry
Soil: Harsh, infertile, alkaline, rocky, shallow, hardpan, gravelly, calcic
Soil Moisture: Aridic
Soil Temperature: Mesic
Fire Tolerance: Intolerant

Species: *Artemisia tripartita* spp. *tripartita*
Common Names: Tall three tip sagebrush, Idaho three tip sagebrush
States of Occurrence: British Columbia south through Washington to Nevada, east to northern Utah and western Montana
Deciduous or Evergreen: Evergreen to early deciduous
Elevation: 3,000-9,000'
Flowers: August to September
Habit: Erect, freely branching, 6' tall
Vegetative Spreading: Root sprouts, stem layers, stump sprouts
Seed/lb: 2,490,000 estimated
Moisture Regime: Semi-dry
Soil: Moderate to deep, well-drained, loamy, sandy
Soil Moisture: Aridic - xeric
Soil Temperature: Mesic
Fire Tolerance: Varies from tolerant to intolerant. See Response to Fire discussion. This

species is in the FEIS database, but not to the subspecies level.

Species: *Artemisia filifolia*
Common Names: Sand sagebrush, thread leaf sagebrush, old man sagebrush
States of Occurrence: South Dakota to Wyoming, Colorado, Nebraska, Kansas, Texas, Utah, Nevada, New Mexico, Oklahoma, south to Chihuahua, Mexico
Deciduous or Evergreen: Semi-deciduous
Elevation: 2,700-7,500'
Flowers: August to September
Habit: Freely branched, rounded, 2-4' tall
Vegetative Spreading: None
Seed/lb: 3,135,000
Moisture Regime: Dry
Soil: Sandy, deep
Soil Moisture: Xeric
Soil Temperature: Mesic
Fire Tolerance: See Response to Fire discussion. This species is in the FEIS database.

Species: *Artemisia tridentata* spp. *wyomingensis*
Common Names: Wyoming big sagebrush
States of Occurrence: Wyoming Basin east to Montana, Wyoming, Colorado, Idaho, North Dakota
Deciduous or Evergreen: Evergreen
Elevation: 5,000-7,000'
Flowers: Late July to September
Habit: Basally branched, rounded, uneven topped, 4-38" tall
Vegetative Spreading: None
Seed/lb: 1,215,000-3,000,000
Moisture Regime: Dry
Soil: Dry, shallow, well-drained, gravelly, fine-textured silt-loams
Soil Moisture: Aridic-Xeric
Soil Temperature: Mesic-frigid
Fire Tolerance: Intolerant
Species: *Artemisia tridentata* spp. *tridentata*
Common Names: Basin big sagebrush, big sagebrush
States of Occurrence: Montana south to New Mexico and all western states, extreme southwest North Dakota
Deciduous or Evergreen: Evergreen
Elevation: 1,500-10,600'
Flowers: August to October
Habit: Erect, spreading, heavily branched, uneven topped, 3-6 (15)' tall, 5-8' wide
Vegetative Spreading: None
Seed/lb: 2,500,000
Moisture Regime: Semi-dry
Soil: Deep, well-drained, fertile, coarse to fine
Soil Moisture: Aridic-xeric
Soil Temperature: Frigid-mesic
Fire Tolerance: Intolerant

Species: *Artemisia rothrockii*
Common Names: Rothrock sagebrush, timberline sagebrush
States of Occurrence: Southern California (Uncertain about Wyoming, Colorado, Nevada, or Utah)
Deciduous or Evergreen: Evergreen
Elevation: 8,500-11,000'
Flowers: August to September
Habit: Wide, low, 4-32" tall, 1-2' wide
Vegetative Spreading: Stem layers and root sprouts
Seed/lb: No information
Moisture Regime: Dry
Soil: Deep, fine to coarse, well-drained
Soil Moisture: Xeric
Soil Temperature: Frigid-cryic
Fire Tolerance: Tolerant

Species: *Artemisia tridentata* spp. *vaseyana*
Common Names: Mountain big sagebrush, Vasey sagebrush
States of Occurrence: Throughout the Rocky Mountains
Deciduous or Evergreen: Evergreen
Elevation: 4,600-10,000'
Flowers: July to September
Habit: Spreading, even-topped, 2-4 (6)' tall
Vegetative Spreading: Stem layers rarely
Seed/lb: 1,760,000-2,500,000
Moisture Regime: Semi-dry
Soil: Deep, well drained, pH +-7.0
Soil Moisture: Udic
Soil Temperature: Cryic
Fire Tolerance: Intolerant

Species: *Artemisia tridentata* spp. *spiciformis*, also described as *A. t. vaseyana* form *spiciformis*
Common Names: Subalpine big sagebrush
States of Occurrence: Colorado, north central Wyoming, southeastern Idaho, central Utah (see McArthur and Plummer 1978, Schultz 1986, McArthur and Goodrich 1986)
Deciduous or Evergreen: Evergreen
Elevation: 8,800-10,000'
Flowers: July to September
Habit: 2-4' tall
Vegetative Spreading: Stem layers
Seed/lb: No information
Moisture Regime: Semi-dry
Soil: Basic, deep
Soil Moisture: Udic
Soil Temperature: Cryic
Fire Tolerance: Tolerant

Species: *Artemisia tripartita* spp. *rupicola*
Common Names: Wyoming three-tip sagebrush
States of Occurrence: Central and southeast Wyoming
Deciduous or Evergreen: Evergreen to early deciduous
Elevation: 7,000-9,000'
Flowers: August to September
Habit: Decumbent, 6" tall, 12-20" wide
Vegetative Spreading: Root sprouts, stem layers, and stump sprouts
Seed/lb: 2,490,000 (Estimate)
Moisture Regime: Semi-dry
Soil: Rocky, gravelly, shallow to deep
Soil Moisture: Xeric
Soil Temperature: Frigid-cryic
Fire Tolerance: Tolerant

Species: *Artemisia longiloba*
Common Names: alkali sagebrush, early sagebrush, longleaf sagebrush
States of Occurrence: Foothills on both sides of the Continental Divide, west to southwest Montana, Utah, Idaho, Nevada, Oregon
Deciduous or Evergreen: Not persistent
Elevation: 5,500-8,000'
Flowers: June
Habit: Spreading, 6-9 (18)" tall
Vegetative Spreading: Stem layers
Seed/lb: 2,655,000
Moisture Regime: Semi-dry
Soil: Alkaline shales, light to tight clays, shallow, claypan
Soil Moisture: Xeric
Soil Temperature: Frigid-cryic
Fire Tolerance: Intolerant

Species: *Artemisia arbuscula* spp. *thermopola*
Common Names: cleft leaf sagebrush, hot springs sagebrush, thermopola sagebrush, low sagebrush
States of Occurrence: Southern Colorado to western Montana, through Utah, Idaho to northern California, Oregon, and Washington
Deciduous or Evergreen: Evergreen
Elevation: 5,000-9,000'
Flowers: August to September
Habit: Spreading, 6-9 (12)" tall, 12-16" wide
Vegetative Spreading: None
Seed/lb: 980,000
Moisture Regime: Semi-dry
Soil: Sterile, often volcanic, shallow, claypan, non-calcic
Soil Moisture: Possibly xeric
Soil Temperature: Frigid-cryic
Fire Tolerance: Intolerant

Species: *Artemisia cana* spp. *viscidula*
Common Names: Mountain silver sagebrush, silver sagebrush, coal town sagebrush

States of Occurrence: Southwest Montana to New Mexico, west to Arizona, Nevada, Utah, and Idaho
Deciduous or Evergreen: Not persistent
Elevation: 5,500-10,000'
Flowers: August to September
Habit: Erect, thickly branched, 3.3' tall
Vegetative Spreading: Stem layers and root sprouts
Seed/lb: 2,200,000
Moisture Regime: Semi-dry
Soil: Deep, rich loams
Soil Moisture: Udic
Soil Temperature: Cyric
Fire Tolerance: Tolerant

Species: *Artemisia cana* spp. *cana*
Common Names: Plains silver sagebrush, silver sagebrush, and hoary sagebrush
States of Occurrence: Southern Alberta, Saskatchewan south through Montana, western and central North Dakota, South Dakota, Wyoming, northwest Nebraska, and northern Colorado
Deciduous or Evergreen: Evergreen to deciduous
Elevation: 5,000-10,000'
Flowers: August to September
Habit: Erect, rounded, freely branched, 3-5' tall
Vegetative Spreading: Root spouts, rhizomes, and stem layers
Seed/lb: 846,000-2,200,000
Moisture Regime: Moist
Soil: Coarse, well-drained, deep, loam to sandy pH 6.5-8.5
Soil Moisture: Udic
Soil Temperature: Cyric
Fire Tolerance: Tolerant

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Wyoming Game and Fish Commission:

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By

UNIVERSITY OF WYOMING