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December 2, 2013

Ms. Erin Jones, NEPA Coordinator
Bureau of Land Management
Northwest Colorado District
2815 H Road
Grand Junction, CO 81506

Delivered Via Email: blm_co_nw_sage_grouse@blm.gov
erjones@blm.gov

Re: Northwest Colorado Greater Sage-Grouse Draft Land Use Plan Amendment and Environmental Impact Statement

Dear Ms. Jones,

Please accept this letter and accompanying comments and documents from Grand County, in its capacity as a cooperating agency, on the *Northwest Colorado Greater Sage-Grouse Draft Land Use Plan Amendment and Environmental Impact Statement, August 2013* (Draft EIS). Grand County supports the Bureau of Land Management (BLM) in its colossal effort to identify Greater Sage-Grouse (GRSG) conservation measures and respond to the United States Fish and Wildlife Service's (USFWS) identified threats and listing factors to avoid the need for the USFWS to list the GRSG as threatened or endangered under the Endangered Species Act (ESA).

In addition to specific Draft EIS Comments (attached), this letter will service as an overview of issues Grand County has with Preliminary Priority Habitat (PPH) and Preliminary General Habitat (PGH) mapping and Appendix F, Disturbance Cap Management.

Preliminary Priority Habitat (PPH) and Preliminary General Habitat (PGH)

Grand County made previous comments (June 25, 2013) regarding the inaccurate Preliminary Priority Habitat (PPH) and Preliminary General Habitat (PGH) mapped and depicted within Grand County that BLM included in the Draft EIS. The baseline PPH/PGH data was prepared in conjunction with Colorado Parks & Wildlife (CPW) at a very coarse scale and should not be

utilized to effectively map GRSG habitat in Grand County. The CPW PPH/PGH dataset was developed from a combination of: 1) CPW occupied range dataset; 2) 4-mile buffers applied to active leks; and 3) the results of the Dr. Mindy Rice habitat model. CPW occupied range data and 4-mile buffer to active leks are recorded parameters of observed field data. The Rice model was a modeling technique that was performed at a coarse-scale (i.e. 1-km cell resolution) incorporating only variables that considered percent-proportion of specific vegetation communities. As such, many criteria cited in readily-available, peer-reviewed reports were omitted in assessing potentially suitable habitat, including: elevation, slope, topographical position, precipitation, distance to nearest water source, anthropogenic disturbances, etc. The exclusion of these additional criteria resulted in large, contiguous areas of non-habitat that are erroneously classified as GRSG PPH and PGH.

In order to address this issue, Grand County for forced to spend taxpayer dollars and hire a consultant to analyze and accurately model GRSG habitat in Grand County. Attached is a copy of the *Greater Sage-Grouse Habitat Modeling and Mapping Project, Grand County, Colorado, October 2013.* Grand County's GRSG habitat model and mapping project was an unfunded mandate and burden that was placed on local government in order to bring the inaccuracy issue to the forefront and provide the best available science to back it up.

Greater Sage-Grouse Habitat Modeling and Mapping Project, Grand County, Colorado, October 2013 employed two different modeling methods of multi-criteria overlay analysis: 1) weighted overlay analysis, and 2) Fuzzy modeling. Both methods utilized a statistical inductive approach, as well as a theoretical deductive approach to form the model parameters. The model results were validated utilizing 1,154 CPW telemetry data points that tracked observed GRSG locations in the field during the years 2000-2008. Twenty (20) models were ran, varying the weighting of vegetation, slope, distances to forest and other parameters to determine which model validated the best against CPW telemetry data and on the ground habitat conditions. Model results concluded:

- Fuzzy Deductive (Expert Literature Based) Results validated the best against CPW radio telemetry of GRSG location and mapped approximately 67% of the study area as habitat, or approximately 33% less than what the PPH / PGH Map indicated as GRSG habitat; and

- Fuzzy Inference (Inductive, Radio Telemetry Data-Driven) Results mapped 59% of PPH / PGH as being habitat, or approximately 41% less than what the PPH / PGH Map indicated as GRSG habitat.

These final models resulted in GRSG habitat in Grand County being 60%-70% of what is represented in the PPH / PGH habitat models. Figure 7: Fuzzy Deductive resulted in 174,754 acres of GRSG habitat. Figure 8: Fuzzy Inference resulted in 155,370 acres of total GRSG habitat. With this in mind and considering all PPH and PGH habitat totaled 259,294 acres (mapped by Grand County) and 266,100 acres represented in Table 1 of the Draft EIS, the current PPH and PGH acreage maps and tables, including ownership, within the Draft EIS reflect and represent inaccurate GRSG habitat within Grand County.

Without more scientifically accurate baseline data and mapping, the proposed conservation measures associated with the PPH and PGH, which will become Priority Habitat and General Habitat upon any Record of Decision (ROD), will remain flawed and jeopardize the integrity of any Disturbance Cap Management (Appendix F) contemplated as part of the proposed Alternative D.

Grand County respectfully requests that the *Greater Sage-Grouse Habitat Modeling and Mapping Project, Grand County, Colorado, October 2013* be incorporated into the Draft EIS and specifically, the maps and data be utilized to accurately reflect and depict PPH and PGH acreages within the NW CO Management Zone 13 in Grand County. Grand County's habitat modeling and mapping project has been shared with local CPW staff. Grand County will provide any and all data and GIS shape files to BLM and CPW in order to amend the PPH and PGH maps within Grand County to accurately reflect GRSG habitat.

Appendix F, Disturbance Cap Management

The overall Disturbance Cap Management is not clearly defined, difficult to interpret and creates uncertainty with regard to how the cap management will be administered.

Ecological Sites Supporting Sagebrush

Page F-1, Line 14 states the reference to ecological sites supporting sagebrush is intended to focus disturbance cap management on the most preferred sagebrush habitat. Page F-1, Line 22 states "Under Alternative D, management of the disturbance cap is restricted to this preferred sagebrush habitat." Table F-4 states that a 5% anthropogenic disturbance cap and 30% total disturbance cap would be applied in ecological sites supporting sagebrush. These notations cite that the disturbance cap is applied to sagebrush habitat.

However, Page F-1, Lines 9-10, Alternative D is stated to limit anthropogenic disturbance in PPH to less than 5% of ecological sites capable of supporting sagebrush. Page F-1, Line 11 states the reference to ecological sites is made to include areas not currently supporting sagebrush but with the potential to do so. As well, Page F-2, Lines 22-26 and Page F-3, Lines 1-9, state the goal of Alternative D is to retain in sagebrush habitat, for each management zone, a minimum of 70 % of the ecological sites capable of supporting sagebrush and that BLM will manage a total disturbance cap of less the 30% to include all loss of sagebrush from all causes. The cap is stated to apply to all designated habitat in the entire management zone and sites capable of supporting sagebrush habitat would count against the cap until they have recovered.

Ecological sites "capable" of supporting sagebrush differ from ecological sites supporting sagebrush. The above narrative language, as well as the Table F-4, is contradicting. Grand County requests clarification of what the 5% anthropogenic cap and the 30% total cap (narratives and Table F-4) will include; "ecological sites capable of supporting sagebrush", or "ecological sites supporting sagebrush". Again, this language creates confusion and is subject to interpretation, which lessens the integrity of the disturbance cap management if not properly clarified.

Figure 2-1, Appendix B Ecological Sites Supporting Sagebrush in Preliminary Priority Habitat. **Is this map tied to the Disturbance Cap Management? If so, why is there no reference to Figure 2-1 with Appendix F? Is Figure 2-1 Ecological Sites Supporting Sagebrush or Ecological Sites "capable" of Supporting Sagebrush? Grand County requests further information regarding Figure 2-1 and what, if any, relationship it has with the Disturbance Cap.**

Plowed Field Agriculture including Upland Hay

Table 3.20 and narrative on Page 275. Agriculture/Irrigated Meadows mostly found on private lands account for 10.2 % of All Designated Habitat (ADH) and 9.9 % of Preliminary Priority Habitat (PPH). Although a small percentage, this represents the second largest vegetation community of GRSG Habitat behind sagebrush steppe at 61.4% of ADH and 69.8% of PPH. *Appendix F Disturbance Cap Management, Page F-3* states that GRSGD make limited use of irrigated hay fields, which do not count against the cap. However, "plowed field agriculture including upland hay" is considered a physical disturbance and counts toward the 30% total disturbance cap. If plowed field agriculture is part of the Agriculture/Irrigated Meadows vegetation community, it should not be counted as a disturbance against the cap.

Grand County requests that "plowed field agriculture including upland hay" not be considered a disturbance and not count against the disturbance cap.

Regional GAP Analysis Project

Page F-3, Lines 29-34. *"The initial calculations and the analysis in this document are based on sagebrush maps created using the Regional GAP Analysis Project data, but implementation would be based on site-specific information wherever it is useful. Areas currently dominated by sagebrush, or specially identified by CPW as contributing to the health of GRSG populations, would be included in the analysis and calculations, independent of ecological site maps."*

- **How was the *Regional GAP Analysis Project* data generated?**
- **What is the rationale for using *Regional GAP Analysis Project data* to determine ecological sites capable of supporting sagebrush, when a different vegetation dataset (e.g. the CVCP dataset) was used in the CPW (Dr. Mindy Rice) habitat model, in part, to create and map PPH and PGH areas used throughout the Draft EIS?**
- **Was Regional GAP Analysis Project data used to generate the map in Figure 2-1 Ecological Sites Supporting Sagebrush in PPH?**
- **The cap management disturbance program may also include areas not dominated by sagebrush or capable of supporting sagebrush (as currently written), that may provide benefit to the health of GRSG populations at the discretion of CPW. What is the specific criteria and protocol for CPW to make such determination?**
- **How would the BLM handle areas that do not support sagebrush, but are mapped by *Regional GAP Analysis Project* as being an "ecological site supporting sagebrush"?**
- **What is the process for validating *Regional GAP Analysis Project* mapping?**

- **Based on the *Greater Sage-Grouse Habitat Modeling and Mapping Project, Grand County, Colorado, October 2013,* the CVCP dataset appeared to have the highest degree of vegetation dataset accuracy in Grand County, not ReGAP data.**

Grand County requests the above questions be answered regarding clarification on the Regional GAP Analysis data. Grand County requests that CVCP vegetative dataset be used as the baseline data for the all Disturbance Cap related sagebrush maps, including Figure 2-1 Ecological Sites Supporting Sagebrush, consistent with the Draft EIS PPH and PGH Maps.

Exemption from the Anthropogenic Disturbance Cap

Page F-5, Lines 20-26. "The authorized officer may authorize disturbance in excess of the 5-percent disturbance cap without requiring additional mitigation with concurrence from CPW under the following scenario: Where data-based documentation is available to warrant a conclusion that GRSG populations in the applicable Colorado GRSG MZ are healthy and stable at objective levels, or increasing, and that a specific proposal for development would not adversely affect GRSG populations due to habitat loss or disruptive activities."

What is sufficient data to secure the data-based documentation requirement? What criteria or statistical methods would a project proponent use to produce data that would be accepted?

Grand County requests that data-based documentation criteria be included within Appendix F Disturbance Cap Management.

Table F-4, Alternative D Preliminary Disturbance Data – Existing Disturbance in Ecological Sites Supporting Sagebrush in PPH.

"Total Acres PPH" within Table F-4 is stated to be 154,400 acres in Colorado Management Zone 13 (Grand County). This differs from the total PPH acres of 203,700 listed for Grand County in Table 1 (ES-1, Page XXIV).

Grand County requests that this discrepancy in PPH acreage be clarified and amended as necessary to provide consistent PPH acres within Grand County, particularly acreage utilized for the Disturbance Cap. Grand County again requests that the GRSG acreage from *Greater Sage-Grouse Habitat Modeling and Mapping Project, Grand County, Colorado, October 2013* be utilized.

Conclusion

Grand County could support an alternative to listing the GRSG under the ESA if that alternative is supported by proper science and provides accurate GRSG habitat maps that includes GRSG habitat and acreage from *Greater Sage-Grouse Habitat Modeling and Mapping Project, Grand County, Colorado, October 2013*. The alternative needs to ensure an equitable balance between conserving and enhancing GRSG habitat, while protecting and promoting multiple-use on public

and private lands and giving adequate consideration to its current and future social and economic value. Grand County does not support retiring any grazing allotments. Grazing closures should not become or made part of any proposed Alternative. Lastly, the Disturbance Cap Management program needs to better define how the cap management program will be administered and what data and habitat is being consistently utilized.

We appreciate your consideration of Grand County's Draft EIS comments; thank you for the opportunity to comment.

Sincerely,

James L. Newberry
Commissioner Chair

Gary Bumgarner
Commissioner

Merrit Linke
Commissioner

GRAND COUNTY – ADDITIONAL DRAFT EIS COMMENTS

Section 1.1.1 Pg.4- *"The current delineations of GRSG may be refined in collaboration with CPW, USFS and USFWS as additional information is gained and data are refined regarding GRSG habitats and use."*

- **The word "habitat" needs to be inserted following "GRSG".**
- **Grand County requests that its "refined" data and mapping of GRSG habitat according to the *Greater Sage-Grouse Habitat Modeling and Mapping Project, Grand County, Colorado, October 2013, be utilized.***

Table 1.2 Planning Area Land Ownership and GRSG Habitat (in Acres), Pg.8- PPH and PGH Habitat (in acres) is not accurately depicted in Grand County, nor is it correctly defined in Table 1.2. Grand County requests that GRSG habitat acreages, according to the *Greater Sage-Grouse Habitat Modeling and Mapping Project, Grand County, Colorado, October 2013,* be respectfully used in Grand County.

Table 1.2 Planning Area Land Ownership and GRSG Habitat (in Acres), Pg.8-

- The table includes 6,700 acres of Linkage Habitat. This Linkage Habitat is not mapped or depicted within the Map Figures within Appendix B. **Grand County requests documentation and the location of the 6,700 acre Linkage Habitat in Grand County.**
- In addition to the 22,600 acres of PPH/PGH, Table 1.2 also includes 5,200 acres of State, County and City of PPH. **Grand County requests documentation and further information regarding the 5,200 acre State, County and City PPH.**

Section 1.3.1, Pg.12- *"In Grand County, there is a high risk of habitat fragmentation and loss due to urban development and related infrastructure, especially in the east end of the county."* Prior development in and around Granby may be a factor of habitat fragmentation on the east end of the county. However, habitat fragmentation naturally occurs due to the east end of the county being topographically isolated from the GRSG habitat in the west end of the county. The topographical constraints fragment GRSG habitat north of US Hwy. 40, between Hot Sulphur Springs and Granby. Urban development west of Hot Sulphur Springs is virtually non-existent. This land use pattern has resulted in little or no disturbance or habitat fragmentation in the management zone from Hot Sulphur to Kremmling, which has remained unchanged for decades. Grand County Master Plan and Land Use Regulations do not allow high density development west of Hot Sulphur Springs in this PPH area. **Grand County requests that Section 1.3.1, Pg. 12 clarify that urban development is not a factor of habitat fragmentation in central and west end of Grand County and that "*topographical constraints*" be included as a factor of habitat fragmentation between the east and west end of Grand County.**

Page 246, Kremmling Field Office: *"In Grand County, there are 19 active leks, 1 inactive lek, and 41 historic leks (2010 data). Of those, 21 leks are on BLM-administered lands."* This statement contradicts Page 12, Kremmling Field Office: *"In Grand County, there are 19 active leks, 1 inactive lek, and 41 historic leks (2010 data). Seven of those 19 leks are on BLM-administered lands."* **Grand County requests that the correct number of leks in Grand County and on BLM lands be correctly and consistently stated in the Draft EIS.**

Appendix B – Figures 1-1 through 3-12, Pages B1-B37. **Grand County respectfully requests that all applicable Figures within Appendix B depicting PPH and PGH within Grand County be amended to accurately reflect and depict GRSG habitat acreage according to the *Greater Sage-Grouse Habitat Modeling and Mapping Project, Grand County, Colorado, October 2013.***

Alternatives C. Grand County does not support does not support *"retiring grazing allotments within all GRSG habitat"* or *"grazing closure of All Designated Habitat (ADH) in the planning area"*, as included within Alternative C. Grazing closures should not become or be made part of any proposed Alternative.

Greater Sage-Grouse Habitat Modeling

Habitat Modeling & Mapping Project

Grand County, Colorado *October 2013*

Prepared for:

Grand County Board of County Commissioners
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Table of Contents

1. Introduction

Greater sage-grouse (*Centrocercus urophasianus*) have experienced long-term population declines in the western United States, including Colorado. Extensive loss and degradation of sagebrush (*Artemisia tridentata*) habitats are the greatest factor contributing to overall population declines. While population trends have been stable in more recent years, some populations continue to see declines (Connelly et al. 2004, Knick and Connelly 2011). The reasons for population declines differ, but the primary cause is the loss of suitable sagebrush habitats (Connelly and Braun 1997, Aldridge et al. 2008, and summarized in Knick and Connelly 2011). As a result, the Bureau of Land Management (BLM) is in the process of producing a Greater Sage-Grouse Resource Management Plan Amendment/Draft Environmental Impact Statement (RMPA) for the Colorado BLM Northwest Colorado District.

The planning area for the Draft RMPA/EIS consists of approximately 8.6 million acres of land, which includes approximately 1.7 million acres of BLM- and Forest Service-administered lands and approximately 2.7 million acres of BLM-administered subsurface federal mineral estate that may lie beneath private or state managed lands. Surface estate and federal mineral estate is managed by five BLM field offices and one National Forest that span portions of 10 northwest Colorado counties, including Grand County. If approved, the RMPA would amend the current BLM RMPs and the Forest Service Land and Resource Management Plan and would guide the management of greater sage-grouse habitat on public lands administered by the BLM and on private lands with a nexus to the BLM planning process (e.g., projects extracting federal minerals or accessing federal lands across private lands).

In the spring of 2013, Grand County contracted URS and its associates at elev8 Inc. to map potential greater sage-grouse habitats within areas identified by Colorado Parks & Wildlife (CPW) and the BLM (as detailed in the RMPA) as supporting sage-grouse habitat and sage-grouse populations in Grand County. This report details the assumption, methods, and limitations of the habitat mapping effort.

1.1. Background

In November 2004, the BLM published the National Sage-Grouse Habitat Conservation Strategy. The BLM National Strategy emphasized partnerships in conserving greater sage-grouse habitat through consultation, cooperation, and communication with federal agencies, state fish and wildlife agencies, local sage-grouse working groups, and various other public and private partners. In addition, the Strategy set goals and objectives, assembled guidance and resource materials, and provided comprehensive management direction for the BLM's contributions to the ongoing multi-state sage-grouse conservation effort.

Following a full status review in 2005, the U.S. Fish and Wildlife Service (USFWS) determined that the greater sage-grouse was "not warranted" for protection. Decision documents in support of that determination noted the need to continue and/or expand all efforts to conserve sage-grouse and their habitats. As a result of litigation challenging the 2005 determination, the USFWS revisited the determination and concluded in March 2010 that the listing of the greater sage-grouse is warranted but precluded by higher priority listing actions, and is currently a Candidate species.

In July 2011, the BLM announced its revisions to the National Greater Sage-Grouse Planning Strategy. In August 2011, the BLM convened the Sage-Grouse National Technical Team (NTT), which brought together resource specialists and scientists from the BLM, State Fish and Wildlife Agencies, the USFWS, the Natural Resources Conservation Service (NRCS), and the U.S. Geological Survey (USGS). The NTT developed a series of science-based conservation measures to be considered and analyzed through the land use planning process. On December 2011, the BLM issued Instructional Memorandum (IM) No. 2012-044. This IM instructed the BLM to review existing regulatory mechanisms and to implement new or revised regulatory mechanisms through the land use planning process to conserve and restore the greater sage-grouse and their habitat.

Based on the identified threats to the greater sage-grouse and the USFWS timeline for making a listing decision on this species, the BLM is tasked with incorporating explicit objectives and desired habitat conditions, management actions, and area-wide use restrictions into Land Use Plans by the end of Fiscal Year 2014. The BLM's objective is to conserve sage-grouse and its habitat and potentially avoid an Endangered Species Act listing. IM 2012-044 provided directions to the BLM on how to consider these conservation measures in the land use planning process.

During this process, CPW developed habitat maps for greater sage-grouse in Grand County (and all of northwestern Colorado). CPW's mapping was adopted by the BLM for use in the RMPA for all Alternatives considered in the EIS.

The habitat mapping for greater sage-grouse in the RMPA was divided into the three following categories. These habitats have been identified (mapped) by CPW in coordination with the State BLM office (Draft RMPA EIS 2013):

1. Preliminary Priority Habitat (PPH)—Areas that have been identified as having the highest conservation value to maintaining sustainable GRSG populations; include breeding, late brood-rearing, and winter concentration areas.
2. Preliminary General Habitat (PGH)—Areas of seasonal or year-round habitat outside of priority habitat
3. Linkage Habitat—Areas that have been identified as broader regions of connectivity important to facilitate the movement of GRSG and to maintain ecological processes

These three habitat categories are also sometimes combined, and are collectively referred to as All Designated Habitat (ADH).

1.2. Sage-Grouse Habitat Mapping Objective

In November 2004, the BLM published the National Sage-Grouse Habitat Conservation Strategy. The BLM National Strategy, as stated in the RMPA, and the CPW (with coordination from BLM) identified PPH and PGH habitats in the western portions of Grand County, including limited habitat surrounding the Town of Granby and north of US 40 from Hot Sulphur Springs to Granby. The Western Association of Fish and Wildlife Agencies (WAFWA) designated Management Zones throughout the range of greater sage-grouse, based on threats identified by USFWS in the 2010 listing decision framework (Stiver et al. 2006). The management area designated in the Grand County area is Management Zone

II (see **Figure 1**). This report addresses the PPH and PGH designated areas within Zone II in Grand County. Henceforth, this report refers to Zone II in Grand County as the "Study Area".

The project objective was to locate and quantify the availability of suitable greater sage-grouse habitat in the Study Area within Grand County, independent of those already mapped by the BLM, CPW, or other interested parties. However, the methodology did significantly utilize and tier to existing sage-grouse research, information, data, and peer-reviewed and accepted habitat parameters for sage-grouse in developing the suitable habitat maps.

The habitat modeling process employed a phased approach, as outlined below:

- Phase 1: Perform literature research and determine relevant criteria for identifying suitable habitat for the greater sage-grouse within northern Colorado. Build a multi-criteria suitability spatial model incorporating all relevant criteria to model areas for general habitat suitability.
- Phase 2: Perform field verifications to validate accuracy of spatial data to on-the-ground habitat and non-habitat conditions.
- Phase 3: Build multi-criteria suitability spatial models to delineate year-round greater sage-grouse habitat types, including breeding, summer (brood rearing), fall, and winter habitats.

1.3. Project Area Conditions

The 261,483-acre Study Area occurs within Grand County as shown in **Figure 1**. The spatial extent of the Study Area represents all areas within the County currently indicated as Preliminary Priority Habitat (PPH) and Preliminary General Habitat (PGH) as mapped by CPW and adopted by the BLM. Of the 261,483-acre PPH analysis area 71,249 acres (27%) are BLM Lands, 27,543 acres (11%) are State Lands, while the remaining 160,502 acres (62%) are private lands.

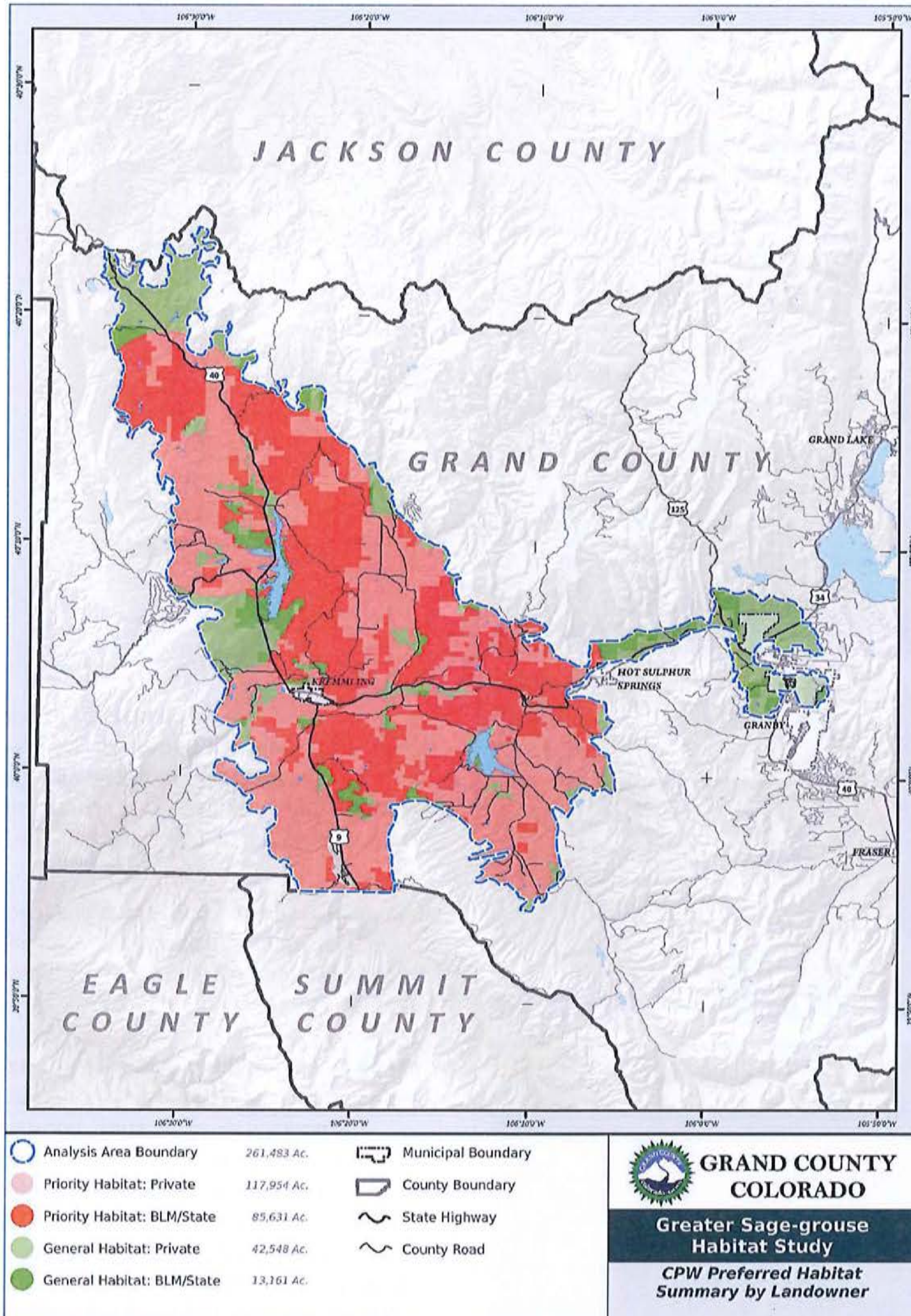
The climate of the Grand County Study Area is semiarid and exhibits extreme fluctuations in monthly precipitation. Consecutive months often receive little precipitation. Mean annual precipitation is 14 ± 7 inches for eight weather stations in the region, and snowfall comprised about 50% of the total precipitation. The mean annual temperature varies from 45° F at 5,900 feet elevation to 30° F at 8,860 feet elevation.

The topography of the study area can be described as a series of gently sloping river basins, converging in the Kremmling area, which are is dissected by drainages with gentle slopes. The sagebrush steppe consists of undulating ridges characteristically draining towards the Colorado, Blue, and Muddy Rivers. The rolling ridge tops are wide and have large transitions between aspects. The ridges are gently rolling; however, the drainages that separate them are steep. Sagebrush cover and height slightly varies given the aspect and slope. The drainages usually have very narrow sedge/willow communities; the larger drainages and Troublesome Creek have broader valley bottomlands, supporting larger riparian systems and irrigated pasturelands.

Vegetation is dependent upon slope, aspect, and elevation. Sagebrush cover and height varies with aspect and elevation, with sparser and shorter sagebrush occurring on ridge tops and on south-facing slopes. Taller, denser sagebrush occurs on north-facing slopes and at higher elevations. In lower bottomlands in shaley soils, sagebrush sometimes transitioned into greasewood (*Sarcobatus vermiculatus*) communities. At the upper elevation range, sagebrush transitions to a montane meadow, aspen, and sometimes lodgepole pine (and mixed conifer) community types. On some of the steeper slopes and topographic breaks, serviceberry (*Amelancier utahensis* and *A. alnifolia*) and chokecherry (*Prunus virginiana*) occur.

Free water can be scarce in dry years or late in the summer as most springs dry up. There are moderately scattered stock tanks and dugouts for watering cattle, and the larger rivers provide sources of surface water.

Photos showing the variability in sagebrush habitats in the study area.



Land Status	Priority Habitat		General Habitat		Total - All Habitat	
	Ac.	%	Ac.	%	Ac.	%
Private	117,954	58%	42,548	76%	160,502	62%
State of Colorado	25,247	12%	2,296	4%	27,543	11%
Bureau of Land Management	60,384	30%	10,865	20%	71,249	27%
Total - All Lands	203,585	100%	55,709	100%	259,294	100%

2. Greater Sage-Grouse Ecology

This section presents an overview of the ecological literature on the greater sage-grouse. This describes the essential information that was considered to determine habitat suitability. More specific information from CPW studies in the area are presented later in this document.

The greater sage-grouse is a large, rounded-winged, ground-dwelling bird, up to 30 inches long and two feet tall, weighing from two to seven pounds. The birds are found at elevations ranging from 4,000 feet to over 9,000 feet and are highly dependent on sagebrush for cover and food. Greater sage-grouse are found in Washington, Oregon, Idaho, Montana, North Dakota, eastern California, Nevada, Utah, western Colorado, South Dakota and Wyoming. They are also found in the Canadian provinces of Alberta and Saskatchewan.

Greater sage grouse closely associate with sagebrush ecosystems of western North America. Sage-grouse require wide expanses of sagebrush, and the mere presence of sagebrush in small patches does not indicate an area is suitable sage-grouse habitat (Knick and Connelly 2011). Effective sagebrush habitat types vary greatly in plant composition, the degree of habitat fragmentation, topographic character, types of substrate, climate, and fire regimes. Consequently, sage-grouse are adapted to a mosaic of sagebrush habitats throughout their range, including (1) relatively tall sagebrush (big sagebrush, three-tip sagebrush [*A. tripartita*], silver sagebrush [*A. cana*]); (2) relatively low sagebrush (low sagebrush [*A. arbuscula*], black sagebrush [*A. nova*]); (3) forb-rich mosaics of low and tall sagebrush; (4) riparian meadows; (5) steppe dominated by native grasses and forbs; (6) scrub-willow (*Salix* spp.); and (7) sagebrush savannas with juniper (*Juniperus* spp.), ponderosa pine (*Pinus ponderosa*), or quaking aspen (*Populus tremuloides*) (Schroeder et al. 1999). Although sage-grouse have adjusted to altered habitats, including those habitats that include alfalfa (*Medicago sativa*), wheat (*Triticum* spp.), and crested wheatgrass (*Agropyron cristatum*), the usefulness of altered habitats often depends on their spatial arrangement with native habitats (Braun et al. 1977, Sime 1991, Braun 1998, Hays et al. 1998).

Leks or breeding season display grounds are placed on sites surrounded by potential nesting habitat (Wakkinen et al. 1992) and are characterized by relatively high female traffic (Gibson 1992, 1996). Leks often are situated on broad ridgetops, grassy swales, disturbed sites (such as burns), dry lake beds, or around stock tanks; the common feature of lek sites is that these have less herbaceous and shrub cover than surrounding habitats (Schroeder et al. 1999). There is no evidence that lek habitat is limited throughout the species range, including in Grand County.

Nests are placed in sites with relatively dense plant cover, usually dominated by big sagebrush (Wakkinen 1990, Gregg et al. 1994). Nest habitat occasionally is dominated by grasses or other species of shrubs, including three-tip sagebrush, rabbitbrush (*Chrysothamnus* spp.), greasewood, and antelope bitterbrush (*Purshia tridentata)* (Connelly et al. 1991). Vegetatively diverse habitats may provide the best nesting environments by ensuring both horizontal and vertical concealment (Wakkinen 1990, Connelly et al. 1991, Gregg et al. 1994, Hanf et al. 1994, Sveum et al. 1998a). Proximity to water, or sagebrush vegetation associated with water, may be important in some areas for higher forb and insect availability.

After hatching, hens move chicks to areas which can be diverse in structure, including sagebrush, riparian meadows, greasewood bottoms, alfalfa, grain, and irrigated pastures; but the common feature of brood areas is that these are rich in forbs and insects (Dunn and Braun 1986, Sveum et al. 1998b, Schroeder et al. 1999). Broods respond to dry conditions during mid- and late summer by concentrating in areas with succulent vegetation or by moving to more mesic sites (Connelly et al. 1988, Fischer et al. 1997).

In Colorado, many wintering grouse migrate attitudinally, or at least move to areas with different cover and structure of sagebrush. Greater sage-grouse migrate singularly or in pairs at night.

Winter range can be similar to breeding range, except that sage-grouse winter in areas dominated by 6–43% cover of sagebrush, primarily big sagebrush, low sagebrush, and/or silver sagebrush (Hanf et al. 1994, Schroeder et al. 1999). Variation in topography and height of sagebrush ensures the availability of sagebrush in different snow conditions (Connelly 1982, Hupp and Braun 1989). By evidence of droppings (pellets), greater sage-grouse tend to congregate in the winter on wind-swept ridges in parts of the geographic range in Colorado (Petterson 2003, 2004, 2005, 2007, WWE 2008, Apa et al. 2010).

Predation on eggs and birds is the primary cause of mortality. Other causes of mortality include human disturbance; trampling by livestock; collisions with farm machinery, moving vehicles, electric or telephone wires, or fences; poisoning from pesticides; fire; flood; drought; sun exposure; heavy rain; and cold (Schroeder et al. 1999).

Please refer to Appendix A of the NNT Report (NTT 2011) and the USFWS listing document (USFWS 2010) for more information on greater sage-grouse biology and ecology.

3. Criteria Influencing Habitat Suitability

Appendix A summarizes all criteria currently being reviewed that may influence the suitability of selected greater sage-grouse habitats. The criteria were generated from a literature review of the historical publications describing greater sage-grouse habitats in the western United States that are pertinent to specific habitat types and the suitability thereof. **Table 3.1** summarizes the relevant textual description, habitat parameters, the author/source, as well as application to specific habitat types.

3.1. Table 1: Habitat Parameters from Reviewed Literature and General Habitat Parameters Employed in Modeling

Author	General Habitat	Lek/ Breeding	Breeding/ Nesting	Brood Rearing Summer	Summer-Fall	Winter
Apa 2010						
Sagebrush	-	-	37%	30%	-	-
Total Shrub	-	-	68%	34%	-	-
Walker 2010[1]						
Sage *dominance*	-	57-96% (100m)	-	50-92% (100m)	-	-
Sage+grass+MMS dominance	-	90-98% (350m)	-	88-91% (350m)	-	-
Forest	-	0.5-6.5% (350m)	-	4.5-11.5% (740m)	-	-
MMS[2]	-	0-1.2% (740m)	-	0-1.3% (740m)	-	-
CO Sage-Grouse Consv. Plan 2008						
Sagebrush cover	-	20-30% around leks	15-38% avg. 27%	10-15% 20-25% for escape	>15%	>25%
NTT Report[3]						
Sagebrush cover	-	-	-	10-25%	-	-
Connelly et al. 2000						
Sagebrush cover	-	15-25%	-	10-25%	-	10-30%
Grass/forb cover	-	>25%	-	>15%	-	NA
Area with	-	>80%	-	>40%	-	>80%

suitable habitat						
Knick & Connelly 2011						
Sagebrush cover	12-48%	Follow Connelly et al. 2000				
Grass/forb cover	-	Follow Connelly et al. 2000				

1 Walker paper is from a report specific to the Parachute- Piceance-Roan area, but is still a contemporary CPW effort
2 MMS= Mixed Mountain Shrubland
3 Info is actually from USFWS listing document
4 Dist. To Forest- graduated from <100m, 275m, 350m, and then >350m with areas closer to Forests receiving lower scores. Anything closer than 100m was considered "non-habitat".
5 Dist. To Shrubby Woodlands (PJ & oakbrush) >50m (areas closer than 50m were considered marginal habitat)

4. Modeling Process for Grand County Investigation Area

The objectives of our modeling investigation are to locate and quantify the availability of suitable greater sage-grouse habitat with in the Study Area, independent of analysis already performed. To meet the objectives, we have employed two different methods of multi-criteria overlay analysis in a Geographic Information System (GIS); 1. Weighted overlay analysis and 2. Fuzzy modeling. Furthermore, our models considered two approaches to forming the appropriate model parameters and the degree of membership to each model; 1) a statistical approach (i.e. inductive method) that utilizes empirical data to extract and quantify patterns and relationships between local populations and habitat conditions and 2) a theoretical approach (i.e., deductive method) that employs literature, research, or expert opinions to derive relationships between local populations and habitat conditions. The following discussion briefly describes the general overlay analysis process, the two approaches used to formulate model parameters, as well as both methods of overlay analysis employed.

In its simplest form, overlay analysis is a process by which spatial data are combined in an algorithm to measure the suitability of a particular use at a given location based on the range of conditions across a defined landscape. Relative measures of suitability are produced by combining all pertinent criteria that may influence the suitability of areas across a defined geographic area to a given use and evaluating these to yield final values on a common, relative index. While overlay analysis attempts to evaluate the suitability of habitat, and provide a means for comparing suitability across broad areas, the results are not absolute in predicting a species presence or occupation of habitat. The following lists the general steps required to perform an overlay analysis:

1. Define the study area
2. Compile all factors that may influence suitability for general habitat
3. Order the identified factors by significance in determining suitability
4. Transform the factors into spatial data and reclassify the data based on applicability of the thematic attributes in meeting the specified use
5. Weight the input spatial datasets by significance
6. Combine the input spatial datasets in the overlay model and analyze for suitability

4.1. Inductive vs. Deductive Approach

Habitat models typically employ one of two classes in determining model parameters that estimate potential habitat for a given species; 1) a statistical approach, or inductive method, or 2) a theoretical approach, or deductive method. The inductive method develops model parameters by using empirical data to sample environmental conditions for preference in habitat selection. For example, using marked telemetry points for a tracked species, the data can be used to sample the average slope that the species prefers in selecting habitat. The data are then summarized and plotted to identify any patterns of selection that are subsequently used in formulating how the model variable is constructed and fit to the habitat model. By contrast, the deductive method relies on existing literature and/or expert opinion to formulate appropriate habitat parameters and their degree of membership to the habitat model.

The differing basis of these two methods may produce habitat results that disagree and may affect the applicability and utility of the results at the regional planning level. While the inductive method provides a more objective assessment of species-habitat relationships within a defined analysis area, it also requires large amounts of empirical data with adequate spatial distribution to properly assess habitat selection by the species. For species where abundance, broad datasets, and/or behavior are not well understood or available, the derived statistics indicating habitat preference for a set of conditions may be poorly modeled resulting in erroneous results. In addition, the temporal nature of the empirical data (i.e., the timeframe in which the data were collected) may skew the derived statistics for habitat selection if the environmental conditions data being sampled were developed outside the timeframe of the empirical data collected. The deductive method may overcome these restrictions by relying less on raw data and statistics and instead employing expert-based knowledge on the relationships between a species and habitat selection. However, limitations of the deductive approach include the potential for expert bias to be introduced into the model, thereby skewing habitat model results, or the potential to omit characteristics of a local population that may not capture all utilized habitat.

In our modeling efforts, we modeled habitat within the Grand County Study Area using both inductive methods (utilizing radio-tracked bird data supplied by CPW) and deductive methods (utilizing habitat characterizations from sage-grouse literature, including CPW reports).

4.2. Weighted Overlay Model

The weighted overlay method is widely employed in modeling habitat suitability for a variety of plant and wildlife species and is commonly known as a Habitat Suitability Index (HSI). The HSI results are returned on a numerical index, with higher values indicating higher levels of habitat suitability. HSI models may employ both categorical (e.g., land cover types) and continuous data (e.g., percent slope), though ultimately the data are transformed and analyzed as discrete datasets. For example, considering the criteria of slope, a model may define areas having slopes less than 20% as a suitable habitat parameter. As such, all locations in a model area having slopes less than 20% would be scored as 1, while all remaining areas with slopes exceeding 20% would be scored as 0. Furthermore, the sensitivity of the analysis can be enhanced by ranking thematic attributes on a common numerical index. For example (continuing with the example of slope), expert opinion may suggest that while areas with slopes under 20% are suitable for habitat, there is a greater preference for those areas with slopes less than 10%. As such, the data would be reclassified into "crisp" sets so that slope ranges between 0% and 10% receive the highest score (i.e., 1), slope ranges between 10% and 20% receive a reduced score (i.e., 0.7) and slopes exceeding 20% are scored as 0.

A shortcoming of the weighted overlay analysis approach is the rigid nature of the model framework as well as the assumption that the input data supplied to the model accurately reflects environmental conditions. As demonstrated above, the thematic data in a weighted overlay analysis is employed in a simple Boolean logic test, whereby a condition is tested against the data, resulting in a true/false response and classification to a predefined bin. The rigid nature of the forced Boolean classification allows for only one of two possible responses; a variable either participates (e.g. absolute membership) or is excluded from the analysis (e.g., non-membership). Referencing the slope example above, an area with 1% slope would be just as acceptable as an area with 10% slope; Boolean logic

fails to account for the varying degree to which a variable can participate in determining suitable habitat conditions. Likewise, weighted overlay analysis is constrained in the ability to accurately reflect conditions as these occur in reality. By categorizing all input data into discreet values or bins, hard delineations are created to classify the data into similar zones, creating sharp lines across the model landscape that do not exist in the natural setting.

In the example of vegetation data, land cover types are classified into broader communities based on dominant local characteristics; polygons are subsequently created to delineate the perimeter of the vegetation community. As such, the data depict a condition whereby the vegetation in a landscape change only by crossing an absolute threshold (e.g., the vegetation community polygon perimeter). However, we know that vegetation rarely, if ever, exhibits hard boundaries in the natural landscape; rather, vegetation usually transitions from one community to the next gradually, creating ecotones that are not accurately represented in the categorical data. As a result, weighted overlay analysis may produce discrepancies between the model results and the reality of the modeled environment by forcing data into rigid storage formats that do not adequately express the natural variability present.

4.3. Fuzzy Model

Fuzzy overlay analysis is a method that handles vagueness and uncertainty in the attribute and geometry of spatial data. Fuzzy logic is based on the idea of set theory, whereby data can be classified based on degree of membership to a particular set, or class, as opposed to being forced into one single specific class (e.g., "crisp" set) with no allowance for even partial consideration in other classes.

Fuzzy logic addresses the inherent inaccuracies in spatial data whereby the boundaries between classes are not implicitly defined, but instead assigns associating degrees of membership to classes. To demonstrate, let us compare how the criteria of slope are evaluated under a fuzzy logic approach versus a weighted overlay analysis. As discussed above, in a weighted overlay analysis, continuous data such as percent slope is ultimately classified into discreet data values, indicating a probability as it pertains to habitat suitability. So, slope values are ultimately quantified numerically as either highly suitable (e.g., 0% - 10% slopes), moderately suitable (e.g., 10% - 20% slopes) or not suitable (e.g., slopes greater than 20%). Under this scenario, while the broader classes (e.g., highly suitable, moderately suitable, not suitable) provide limited distinction amongst variables, variables within the same class are indistinguishable (i.e., an area with 1% slope is scored exactly as an area with 10% slope). By contrast, the fuzzy model approach can distinguish variances and applicability of a variable to better assess fitness to the habitat model, ultimately indicating how "true" the membership of a variable is to suitable habitat conditions. Assuming that the degree of suitability for percent slope rises as slopes decrease, an area with 1% slope may be scored as 0.995 on a continuous index of 0 to 1, compared to an area with 10% slope that may be scored as 0.725.

Fuzzy membership transforms input data to a continuous scale of 0 to 1 using a variety of functions and arithmetic operators. The transformation method utilized depends on how the data are distributed and contribute to suitability. The fuzzy membership functions used in this analysis are presented in overview below.

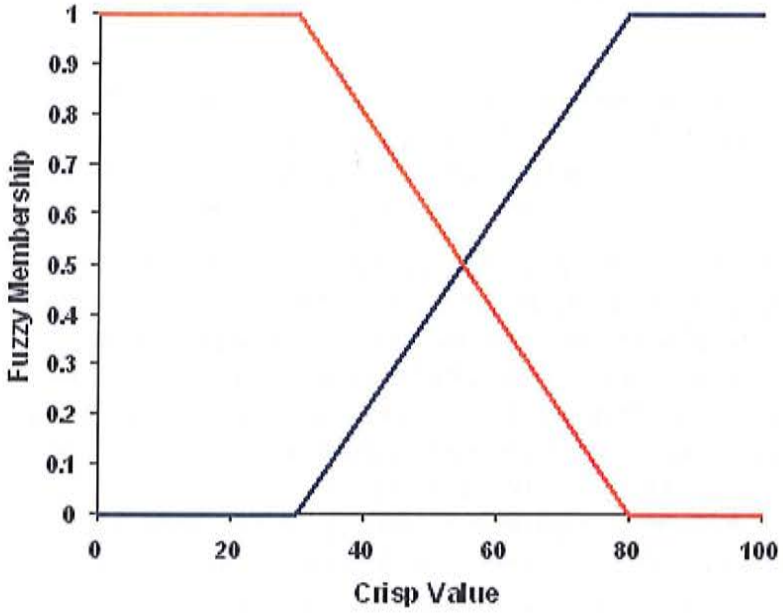
4.3.1. Fuzzy Linear Membership

The Fuzzy Linear transformation function applies a linear function between the user-specified minimum and maximum values. Anything below the minimum will be assigned a 0 (definitely not a member) and anything above the maximum a 1 (definitely a member). The blue line in **Figure 2** below represents a positive sloped linear transformation with a minimum of 30 and a maximum of 80. Any value below 30 will be assigned a zero and anything above 80 a 1.

If the minimum is greater than the maximum, a negative linear relationship (a negative slope) is established. The red line in the image below represents a negative slope linear transformation. Any value less than 30 will be assigned a 1 and anything above 80 a 0.

Where the slope of the line is increasing or decreasing defines the transition zone (between 30 to 80 in the image below).

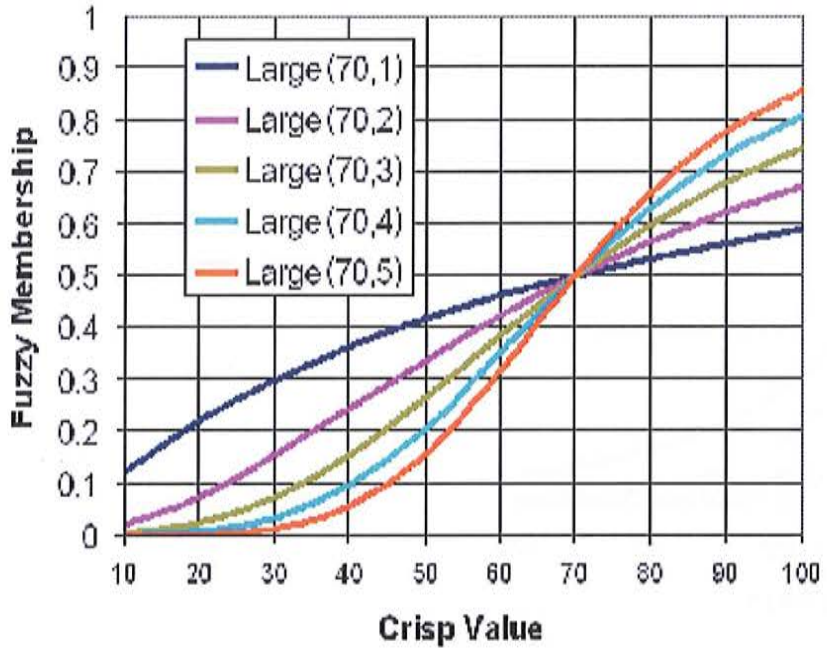
4.3.1.1. Figure 2: Example of Fuzzy Linear Membership Functions



4.3.2. Fuzzy Large Membership

The Fuzzy Large transformation function is used when the larger input values are more likely to be a member of the set. The defined midpoint identifies the crossover point (assigned a membership of 0.5) with values greater than the midpoint having a higher possibility of being a member of the set and values below the midpoint having a decreasing likelihood of membership. The spread parameter defines the shape and character of the transition zone.

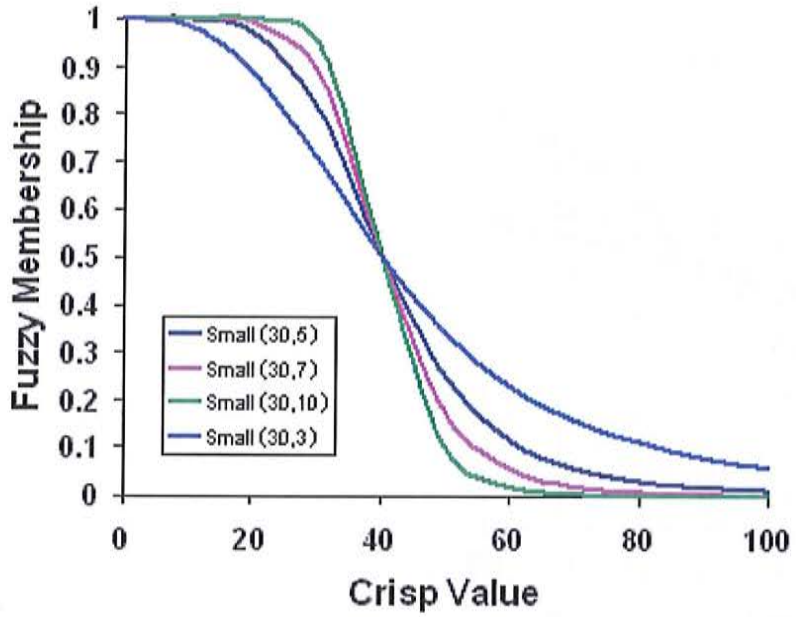
4.3.2.1. Figure 3: Example of Fuzzy Large Membership Functions



4.3.3. Fuzzy Small Membership

The Fuzzy Small transformation function is used when the smaller input values are more likely to be a member of the set. The defined midpoint identifies the crossover point (assigned a membership of 0.5) with values greater than the midpoint having a lower possibility of being a member of the set and values below the midpoint having a higher possibility of membership. The spread parameter defines the shape and character of the transition zone.

4.3.3.1. Figure 4: Example of Fuzzy Small Membership Functions



Multiple techniques are available to examine and analyze the relationships between all sets for a multi-criteria fuzzy overlay model, including *And*, *Or*, *Product*, *Sum* and *Gamma* overlays. Each technique attempts to quantify the membership of phenomenon to specific classes. For example, employing a Fuzzy '*Or*' technique, the model returns the maximum value of all sets, using the highest potential membership for each cell and returns constrained results that reflect only the highest suitable areas, or "the best of the best." By contrast, using a Fuzzy '*And*' technique, the model uses the minimum assigned value for each class the location belongs to, thereby identifying the lowest possibility of suitability and producing much broader acceptable results.

The fuzzy model results produced for this analyses utilized the '*And*' overlay technique.

4.4. Initial Data Review

The following datasets were acquired for the purpose of modeling potential greater sage-grouse habitat in the Grand County study area. Not all datasets were employed in each spatial model, and no new datasets were created. Rather, some datasets were acquired and reviewed for accuracy, or for use in different model runs utilizing alternative data sources for input criteria.

4.4.1. Table 2: Data Sources for Modeling Efforts

Criteria	Criteria Subset	Data Source(s)	Resolution
Elevation		10-meter National Elevation Dataset	*10-meter*
Slope		Derived from 10-meter NED	*10-meter*
Aspect		Derived from 10-meter NED	*10-meter*
Curvature		Derived from 10-meter NED	*10-meter*
Terrain Roughness			
	Surface Area Method	Derived from 10-meter NED	*10-meter*
	Slope Variability Method	Derived from 10-meter NED	*10-meter*
	Standard Deviation Method	Derived from Curvature	*10-meter*
	Terrain Ruggedness Index Method	Derived from 10-meter NED	*10-meter*
Landforms		Derived from 10-meter NED	*10-meter*
Vegetation Cover			
	Colorado Vegetation Classification Program (CVCP)	CDOW/BLM/USFS	*25-meter*
	REGAP (reviewed but not used)	USGS	*30-meter*
	LANDFIRE Vegetation Type (reviewed but not used)	LANDFIRE	*30-meter*
Distance to Forest		Derived from Vegetation Cover	
Canopy Cover		LANDFIRE	*30-meter*
Sage Density (100-meter neighborhood)		Derived from Vegetation Cover	
Sage Density (350-meter neighborhood)		Derived from Vegetation Cover	
Sage Density (1,000-meter neighborhood)		Derived from Vegetation Cover	

Sage Patch Size		Derived from Vegetation Cover	
Sage Patch Distance		Derived from Vegetation Cover	
Proportion Forest (350-meter neighborhood)		Derived from Vegetation Cover	
Distance to Highways		Derived from Grand County 'Roads' shapefile	*10-meter*
Distance to Roads		Derived from Grand County 'Roads' shapefile	*10-meter*
Road Density		Derived from Grand County 'Roads' shapefile	*10-meter*

Of these datasets, the vegetation datasets produced the largest amount of subjectivity, and would also have the largest amount of potential impact on sage-grouse habitat model results. This is due to the fact that sage-grouse are strongly sage-brush obligates, and therefore accurate mapping and data of sagebrush vegetation types would have significant weight in any habitat modeling results. We therefore vetted the CVCP, ReGAP and Landfire vegetation datasets against high resolution aerial photography for the Grand County study area. Based on our review, we found that **CVCP** appeared to have the highest degree of accuracy in the study area.

From the CVCP dataset, we categorized the following vegetation types as being potential habitat based on on-site visits to the study area, CPW-supplied sage-grouse radio telemetry data, and existing literature. Below in section ***4.6.1 Table 3: Habitat Suitability index Model Component Ranking and Weights***, the weighting of these vegetation types as effective habitat is presented.

- Sage
- Grass
- Sage/Grass
- Grass/Sage
- Sage/Mixed Mountain Shrub
- Riparian