Piceance Basin Greater Sage-Grouse Habitat Inventory

Annual Progress Report
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Piceance Basin Greater Sage-Grouse Habitat Inventory Cooperators

Acknowledgements

Conservation of sage-grouse in the Piceance Basin will not be successful without the cooperation of government agencies and private landowners. We are grateful to Jerry Oldland, Pat Johnson, Dan Johnson, ExxonMobil, and EnCana for allowing us permission to use their land to access public land and/or to conduct the habitat inventory on their land. We would also like to thank EnCana for providing $17,000 to help fund this project. We hope to continue these partnerships in the future and to develop new partnerships with other landowners in the Piceance Basin.

Summary

The Bureau of Land Management (White River Field Office) initiated a 3 year, landscape-level greater sage-grouse habitat inventory for the Piceance Basin in the summer of 2006. The primary objective of the inventory was to create a landscape-scale map of the different vegetation types found within potential sage-grouse habitat that could be used to aid in: 1) determining the suitability of specific areas as potential sage-grouse habitat, 2) prioritizing areas in need of habitat restoration, and 3) evaluating land uses that may impact either suitable habitat or restoration efforts.

We began by developing a computer model of potential sage-grouse habitat within the overall range established by the Colorado Division of Wildlife for the Parachute Creek – Piceance Basin – Roan Plateau area (PPR). The next step was to ground-truth the vegetation types within the computer model. We went to areas identified by the computer model as potential habitat and classified them into general habitat categories based on the vegetation type present at the site: oak/serviceberry (OS), aspen (AS), pinyon/juniper (PJ), grass (GR), rabbitbrush (RB), mountain shrub (MT), and sagebrush (SG). We designated mountain shrub sites as those sites where ≥25% of the shrub cover (excluding rabbitbrush) at the site was composed of bitterbrush, serviceberry, and/or snowberry. At representative sites, we used 30m line transects to measure vegetation. Shrub cover was estimated using the line intercept method, forb and grass cover was estimated using the Daubenmire method, and visual obstruction was estimated using a Robel pole.

Approximately 9,885 acres were mapped during the 2006 field season. Forb, grass and shrub composition information was collected at representative rabbitbrush sites (n=3), mountain shrub sites (n=44), and sagebrush sites (n=45). The mean rabbitbrush canopy cover at rabbitbrush sites was 6.9% with a mean height of 26 cm (10 in). The herbaceous cover at the rabbitbrush sites was high with a mean total herbaceous cover of 28.0%. Mean perennial grass cover was 18.6% and mean perennial forb cover was 4.7%. Mountain shrub sites had significantly more shrub cover than sagebrush sites (t = -4.460, $P < 0.001$). However, there was no difference in either perennial grass cover (t = - 0.311, P = 0.752), perennial forb cover (t = 0.066, P = 0.948), or total herbaceous cover (t = -0.075, P = 0.940) at mountain shrub and sagebrush sites. Moreover, there was no difference in shrub height (t = 0.995, P = 0.323) or height of the herbaceous understory (t = 0.509, P = 0.611) at either site type. Results from this project indicated that total shrub canopy cover was not correlated to either total herbaceous cover (R = -0.028, P = 0.791) or the height of the herbaceous understory (R = 0.010, P = 0.927. Likewise, shrub height was not correlated to total herbaceous cover (R = -0.036, P = 0.741).

While this data is preliminary and incomplete, it is already proving valuable. We are using this information to improve our estimate of the acreage of sage-grouse habitat. We have also used this information to identify several potential areas for habitat restoration work based on dense shrub cover, low understory cover, tall serviceberry shrubs, or the encroachment of pinyon/juniper. Our goal over the next two summer field seasons is to complete the habitat inventory for all sage-grouse habitat in Piceance. To do so, it is critical that we continue our existing partnerships with private landowners and establish new partnerships.

Introduction

Purpose and Need

The Colorado Division of Wildlife (DOW) identifies the Parachute Creek – Piceance Basin – Roan Plateau area (PPR) as one of the six greater sage-grouse (*Centrocercus urophasianus,* hereafter "sage-grouse") populations in the state. DOW has been concerned for over a decade that this population is declining and ceased hunting in the mid-1990s (Beck 2006). While it is not the only threat to sage-grouse in the Piceance, an increase in the development of mineral resources within the PPR has underscored the urgent need for landscape-level conservation actions. In the next 20 years, the BLM anticipates the drilling of over 13,000 oil and gas wells in the Piceance Basin (Federal Register 2006). There have been several studies that document negative impacts to sage-grouse populations as the result of oil and gas development and the expert panel formed during the review process for listing under the Endangered Species Act found energy development to be the most significant extinction risk to sage-grouse in Colorado (Federal Register 2005). As part of its multiple-use mandate, the Bureau of Land Management is responsible for finding a way to allow for both the development of oil and natural gas resources and the conservation of sage-grouse.

The conservation of sage-grouse within the Piceance Basin depends on a collaborative effort between government agencies and private landowners. Most of the available sage-grouse habitat within the Piceance Basin is private property (Figure 1). In order to develop landscape-scale conservation strategies, we began an inventory of potential sage-grouse habitat on both public and private land. The habitat inventory will provide critical local information. First, there is currently no biologically-based and generally agreed-upon estimate for the number of acres of sage-grouse habitat in the Piceance Basin. Second, we do not know the spatial arrangement of suitable habitat and unsuitable habitat. Finally, we do not know the quality of available habitat (i.e. herbaceous understory, encroachment from pinyon/juniper, etc).

The primary objective of the Piceance Basin sage-grouse habitat inventory is to create a relatively simple landscape-scale map of the different vegetation types found within potential sage-grouse habitat. Since the map is GIS-based, it can easily be shared, updated, and overlaid with other landscape features such as leks, roads, well pads, etc. We plan to use the habitat inventory map as a means to:

1) Determine the suitability of specific areas as potential sage-grouse habitat.
2) Prioritize areas in need of habitat restoration.
3) Evaluate land uses that may impact either suitable habitat or restoration efforts.

Habitat Requirements

Sage-grouse are associated with sagebrush throughout the year and rely on it for both food and cover. They are completely dependent of sagebrush (*Artemisia* spp.) for survival since sagebrush leaves dominate the diet and constitute almost 100% of their diet for as much as eight months of the year (October to May) (Wallestad et al. 1975). When forbs and insects become available in the spring and summer, they become a critical component of both the hen's pre-laying diet as well as the diet of chicks. Forbs have been shown to increase the dietary protein intake of pre-laying hens which can have considerable impacts on clutch size, nest success, and overall chick survival (Barnett and Crawford 1994).

Productive nesting and brood-rearing areas are sagebrush stands with a vigorous herbaceous understory. While sage-grouse have been known to nest under other species of shrubs, nest success is higher when they nest under sagebrush that is 40-80 cm (16-32 in) tall. Sagebrush canopy cover at productive nesting habitats ranges from 15% to 25%. Where precipitation and soil conditions allow, grass should be managed for an average height of at least 18cm (7 in) with a canopy cover of at least 15%. Increased grass height, and thus increased visual obstruction, results in lower nest predation rates. Forbs should be managed so that there is a diversity of forbs at a minimum canopy cover of 10%. Winter habitat requires sagebrush stands with a canopy cover of 10-30% and average height of 25-35 cm (10-14 in) available above the snow (Connelly et al. 2000).

Methods

We identified potential sage-grouse habitat within the overall range of the Piceance/Parachute/Roan population using a GIS (geographic information system) model based on slope and vegetation type. Slope was generated from a DEM (digital elevation model) and limited to 15% or less since the average slope at hen use sites in Piceance was 11.4% (Hagen 1999). We used the Colorado Vegetation Classification Project (CVCP) data and included 19 vegetation classes that included grasses, forbs, sagebrush (*Artemisia tridentata)*, rabbitbrush (*Chrysothamnus* spp.), and mountain shrubs. We did not include drainages and used a 75m buffer around drainages to remove them from the model.

The next step was to ground-truth the vegetation types within the computer model. We went to areas identified by the computer model as potential habitat and classified them into general habitat categories based on the vegetation type present at the site: oak/serviceberry (OS), aspen (AS), pinyon/juniper (PJ), grass (GR), rabbitbrush (RB), mountain shrub (MT), and sagebrush (SG). We did not consider sites with <5% sagebrush cover to be sagebrush sites, but rather grass sites or rabbitbrush sites (Sather-Blair et al. 2000). We designated mountain shrub sites as those sites where ≥ 25% of the shrub cover (excluding rabbitbrush) at the site was composed of antelope bitterbrush (*Purshia tridentata)*, serviceberry (*Amelanchier utahensis*), and/or mountain snowberry (*Symphoricarpos oreophilus*). We brought aerial photos with us into the field to aid in delineating the vegetation type areas and these areas were then drawn as polygons in ArcMap.

In mountain shrub or sagebrush habitat types, we selected a representative site and then established a permanent randomly-oriented 30.5m (100ft) transect to measure the vegetation and assess habitat quality. We used the line intercept method (Canfield 1941, Connelly et al. 2003) to measure shrub canopy cover. In addition to measuring the canopy cover of sagebrush, we also measured the canopy cover of bitterbrush, rabbitbrush, serviceberry, and snowberry. To estimate herbaceous cover, we placed Daubenmire plots (n=20) at 1.5m (5ft) intervals along the transect line (Daubenmire 1959). Cover was estimated for perennial grasses, annual grasses, perennial forbs, and annual forbs. At the same points used for the Daubenmire plots, we estimated the heights of shrubs, perennial grasses, and perennial forbs using a 76cm (2.5ft) semi-circle off of the transect (Sather-Blair et al. 2000). Height was recorded for the tallest plant in the semi-circle. We did not include shrub inflorescences in the height measurements and herbaceous plant height was measured as droop height (Connelly et al. 2003). We used a robel pole (Robel et al. 1970, Connelly et al. 2003) to measure visual obstruction (or vertical cover) from both sides of the transect line at the same stations used for the Daubenmire plots. At each transect we also

recorded the shrub, grass, and forb species present as well as whether or not there was evidence (droppings, feathers, etc) that the site had been used by sage-grouse. Pictures were taken of the transect line and of the site.

We also selected representative sites to characterize the other habitat types (e.g. oak/serviceberry) but we only took pictures at those sites. We did not do vegetation transects at habitat types other than mountain shrub and sagebrush because our methods for measuring vegetation are based on rangelands and not forested areas.

We used t-tests to compare vegetation characteristics between mountain shrub and sagebrush sites. Pearson's correlation coefficients were calculated to determine correlation between shrub cover and height and herbaceous cover. All tests were considered significant at $P < 0.05$.

Results & Discussion

Sage-Grouse Habitat Inventory – Map

We mapped approximately 9,885 acres during the 2006 habitat inventory. Most of our effort focused on the eastern edge of the PPR overall range from Bitter Creek to the West Fork of Stewart Gulch (Figure 2). There are still several areas within these boundaries that we did not complete this summer due to access limitations (i.e. no permission from landowner or access impeded due to pipeline construction or hunting activities), but we hope to include those areas in the inventory work next summer. We also began work in the Ryan Gulch area and the area between West Hunter Creek and East Fawn Creek (Figure 3) when we had to change work areas due to access limitations. Most of the area inventoried was classified as either sagebrush (30.9%) or mountain shrub (33.9%) (Table 1).

One of the primary products of the sage-grouse habitat inventory is the habitat type map. The map is GIS-based and can be overlaid with other shapefiles to see the spatial arrangement of habitat types in relation to other landscape features such as leks, roads, etc. Since it covers such a large area, it is difficult to show habitat types for the entire inventoried area on a small map. Figure 4 shows a portion of the habitat inventory map for an area west of the Sprague Gulch Road and Divide Road junction. While the map shows mountain shrub sites and sagebrush sites as discrete units, it is important to remember that in reality there is a gradient between them. In some areas, the habitat inventory closely follows the modeled habitat but in other areas we have mapped acreage outside of the model. The map shows the spatial arrangement of the habitat types but it does not show areas in need of habitat restoration. We found it difficult to map encroachment and habitat quality and instead use the site photos and transect data to convey that information.

Sage-Grouse Habitat Inventory – Transect Data and Photos

We took photos (no transects) at 55 sites that included grass sites (n=19), oak/serviceberry sites (n=25), pinyon/juniper sites (n=4), mountain shrub sites (n=2), and sagebrush sites (n=5). The two mountain shrub sites did not have transects completed at those sites because the deciduous shrubs had begun to lose their leaves and would have confounded the shrub canopy cover measurements. Photos were taken of the five sagebrush sites to document encroachment on Barnes Ridge. Grass sites included pipelines and natural balds. Oak/serviceberry sites were dominated by either gambel oak (*Quercus gambelii*) or tall, dense serviceberry and pinyon/juniper sites were stands of mature pinyon pine (*Pinus edulis)* and

juniper (*Juniperus* spp.) with little herbaceous understory (Figure 5). Additionally, all of the transect sites (n=92) have site photos.

As mentioned above, we were not able to map specific areas needing habitat restoration due to encroachment of pinyon/juniper or the presence of tall serviceberry. We found that these site characteristics were best captured by the site photos. In order to prioritize areas for habitat restoration, we plan to work closely with DOW to learn from their location data if the birds are using areas with pinyon/juniper or tall serviceberry. For example, some mountain shrub sites have a fairly uniform canopy height where other sites have serviceberry shrubs that are significantly taller than the surrounding shrubs (Figure 6). We need to learn if sage-grouse are discriminating between mountain shrub sites based on shrub canopy height. Additionally, we need to learn at what threshold does the presence of tall serviceberry shrubs or pinyon/juniper at sagebrush sites preclude those sites from use (Figure 7).

To assess habitat quality, we collected transect data at representative rabbitbrush sites (n=3), mountain shrub sites (n=44), and sagebrush sites (n=45). The rabbitbrush sites were located in an old burn and averaged <1% sagebrush cover. The mean rabbitbrush canopy cover was 6.9% with a mean height of 26cm (10 in). The herbaceous cover at the rabbitbrush sites was high with a mean total herbaceous cover (cover of perennial and annual grasses and forbs) of 28.0%. Mean perennial grass cover was 18.6% and mean perennial forb cover was 4.7%. We found evidence of sage-grouse use at all three rabbitbrush transects and found a nest near one of the transects.

We designated mountain shrub sites as those sites where ≥25% of the shrub cover (excluding rabbitbrush) at the site was composed of bitterbrush, serviceberry, and/or snowberry. Technicians correctly classified 85% of the sites in the field based on ocular estimation of shrub canopy composition. Interestingly, sagebrush cover and total shrub cover were the only vegetation characteristics that were different between mountain shrub sites and sagebrush sites. Sagebrush sites had significantly more sagebrush cover than mountain shrub sites ($t = 3.333$, $P = .001$). There was quite a range in sagebrush cover with some sites exceeding the recommended canopy cover even for winter habitats (>30%) (Table 2). We calculated total shrub cover as the sum of the canopy cover for sagebrush, rabbitbrush, bitterbrush, serviceberry, and snowberry. Mountain shrub sites had significantly more shrub cover than sagebrush sites ($t = -4.460$, $P < .001$). There was no difference in either the cover of perennial grasses ($t = -.311$, $P = .752$), perennial forbs ($t = .066$, $P = .948$), or total herbaceous cover ($t = -.075$, $P = .940$) at mountain shrub and sagebrush sites. However, similar to the canopy cover of shrubs, there was also quite a range in the cover of the herbaceous understory at both site types (Table 3). Both shrub height and herbaceous understory height (perennial grasses and forbs) were weighted by canopy cover. There was no difference in shrub height ($t = .995$, $P = .323$) or height of the herbaceous understory ($t = .509$, $P = .6112$) at either site type (Figure 8). Robel pole measurements were taken to assess vertical cover (and thus visual obstruction) and were similar at both mountain shrub and sagebrush sites ($t = -1.476$, $P = .144$). Overall, there seem to be more similarities than differences between mountain shrub sites and sagebrush sites and that may be why both site types are used by sage-grouse (Hagen 1999). We found evidence of sage-grouse use at 5 mountain shrub sites and 8 sagebrush sites.

Treatments such as brushbeating are often used in dense, tall shrub sites to increase the herbaceous understory. Results from this project indicated that total shrub canopy cover was not correlated to either total herbaceous cover ($R = -0.028$, $P = 0.791$) or the height of the herbaceous understory ($R = 0.010$, $P = 0.927$, Figure 9). Likewise, shrub height was not

correlated to the total herbaceous cover (R = -0.036, P = 0.741, Figure 10). Other factors such as grazing pressure and the dry spring may have had a greater influence on the herbaceous understory than did the height or canopy cover of the shrubs. It is critical that we develop standard monitoring protocols for vegetation treatments to ensure that our treatment is producing the intended effect.

Model of Potential Sage-Grouse Habitat

Not including the Magnolia area, the computer model estimated 38,613 acres of potential sage-grouse habitat (including both public lands and private property) for the PPR population (Figure 11). While the computer model is soundly based on habitat requirements, we consider it a starting point and we plan to continue to update our estimate of potential habitat as we gain more local information. In some areas, the model overestimates habitat by including habitat types that are not suitable sage-grouse habitat such as aspen, oak/serviceberry, and pinyon/juniper. In the Piceance Basin, sage-grouse have been shown to use oak brush and pinyon/juniper only 1% and 2% of the time in the summer, with winter use being even less (Hagen 1999). Approximately 22% of the areas included in the inventory this summer were non-suitable habitat types. In other areas, the model underestimates habitat by not including the basins at the tops of drainages. We observed two sage-grouse using such a basin this summer that was outside of the modeled habitat.

We immediately began to improve our estimate of potential habitat by using the data collected from the first field season of the inventory work. In response to the observation of sage-grouse using areas outside of the modeled habitat, we ran the model again using a 20% slope cut-off instead of the original 15% slope cut-off. Using the 20% slope model, we estimated 55,170 acres of potential sage-grouse habitat.

To determine how well the model matched the on-the-ground habitat inventory, we used ArcGIS to determine the difference between the two methods. We began by querying the inventory polygons and selected rabbitbrush, mountain shrub, sagebrush, and grass areas as suitable habitat (Figure 12a). All other vegetation classes (e.g. oak/serviceberry, aspen, and pinyon/juniper) were removed from further analysis, resulting in 7,749 acres of suitable habitat identified by the inventory (Figure 12b). We then clipped the modeled habitat (using 20% slope) to the polygons identified as suitable habitat by the inventory (Figure 12c). The model only estimated 4,748 acres of the 7,749 acres of suitable habitat identified by the inventory. (Figure 12d). Thus, we found that the 20% slope model was underestimating suitable habitat by 38%. If we compensate for the 38% underestimation by adding an additional 20,965 acres, we end up with a revised estimate of 76,135 acres of potential sage-grouse habitat in the Piceance Basin. It is worth noting that we did not correct the original 20% slope model estimate for overestimation caused by including non-suitable habitat types. It would be difficult to do the same exercise in reverse (for unsuitable habitat types) because there are areas identified by the model that we did not ground-truth this summer (Figure 12c). Thus, we couldn't know if those areas outside the inventory were unsuitable or not. It should also be noted that it is unlikely that the model consistently over- or under- estimates to the same degree at all locations across the landscape.

It can not be overemphasized that our estimate of potential habitat is only an initial estimate and that it is subject to revision as we gain more local knowledge. We are trying to use our habitat inventory together with the computer models to estimate potential habitat. It is critical that we also consider how well those methods match the areas that the birds are actually using. As part of their research on the impacts of oil and gas development on sage-grouse, DOW has

been radio-collaring sage-grouse and has location data starting in the spring of this year. We plan to work closely with DOW to determine how well our model of potential habitat matches their location data and to make adjustments as necessary.

Future Work

Summer 2006 was the first of three planned field seasons for the Piceance Basin sage-grouse habitat inventory. While this data is preliminary and incomplete, it is already proving valuable. We are using this information to improve our estimate of the acreage of sage-grouse habitat. We have also used this information to identify several potential areas for habitat restoration work based on dense shrub cover, low understory cover, tall serviceberry shrubs, or the encroachment of pinyon/juniper. EnCana has provided $10,000 towards sage-grouse habitat restoration and we plan to begin work next summer. Our goal over the next two summer field seasons is to complete the habitat inventory for all sage-grouse habitat in Piceance. To do so, it is critical that we continue our existing partnerships with private landowners and establish new partnerships.

Literature Cited

Beck, J.L. 2006. Evaluating potential impacts of oil and gas development on small, isolated greater sage-grouse populations in Colorado: a proposed pilot study. Colorado Division of Wildlife, Grand Junction, Colorado, USA.

Barnett, J.K. and Crawford, J.A. 1994. Pre-laying nutrition of sage grouse hens in Oregon. Journal of Range Management 47:114-118.

Canfield, R.H. 1941. Application of the line interception method in sampling range vegetation. Journal of Forestry 39:388-394.

Connelly, J.W., Schroeder, M.A., Sands, A.R., and Braun, C.E. 2000. Guidelines to manage sage grouse populations and their habitats. Wildlife Society Bulletin 28(4):967-985.

Connelly, J.W., Reese, K.P., and Schroeder, M.A. 2003. Monitoring of greater sage-grouse habitats and populations. Station Bulletin 80. College of Natural Resources Experiment Station, Moscow, Idaho, USA.

Daubenmire, R.F. 1959. A canopy-coverage method of vegetation analysis. Northwest Science 33:43-64.

Federal Register. 2005. Endangered and Threatened Wildlife and Plants; 12-Month Finding for Petitions to List the Greater Sage-Grouse as Threatened or Endangered. Federal Register 70(8): 2244-2282.

Federal Register. 2006. Notice of Intent to Prepare an Amendment to the White River Field Office Resource Management Plan and Associated Environmental Impact Statement for Oil and Gas Development, Meeker, CO. Federal Register 71(114): 34388-34389.

Hagen, C.A. 1999. Sage grouse habitat use and seasonal movements in a naturally fragmented landscape, northwestern Colorado. Thesis, University of Manitoba, Winnipeg, Canada.

Robel, R.J., Briggs, J.N, Dayton, A.D., and Hulbert, L.C. 1970. Relationships between visual obstruction measurements and the weight of grassland vegetation. Journal of Range Management 23:295-297.

Saither-Blair, S., Makela, P., Carrigan, T., and Anderson, L. 2000. A framework to assist in making sensitive species habitat assessments for BLM-administered public lands in Idaho: Sage grouse. Bureau of Land Management, Idaho, USA.

Wallestad, R. Peterson, J.G., and Eng, R.L. 1975. Foods of adult sage-grouse in central Montana. Journal of Wildlife Management 39(3):628-630.

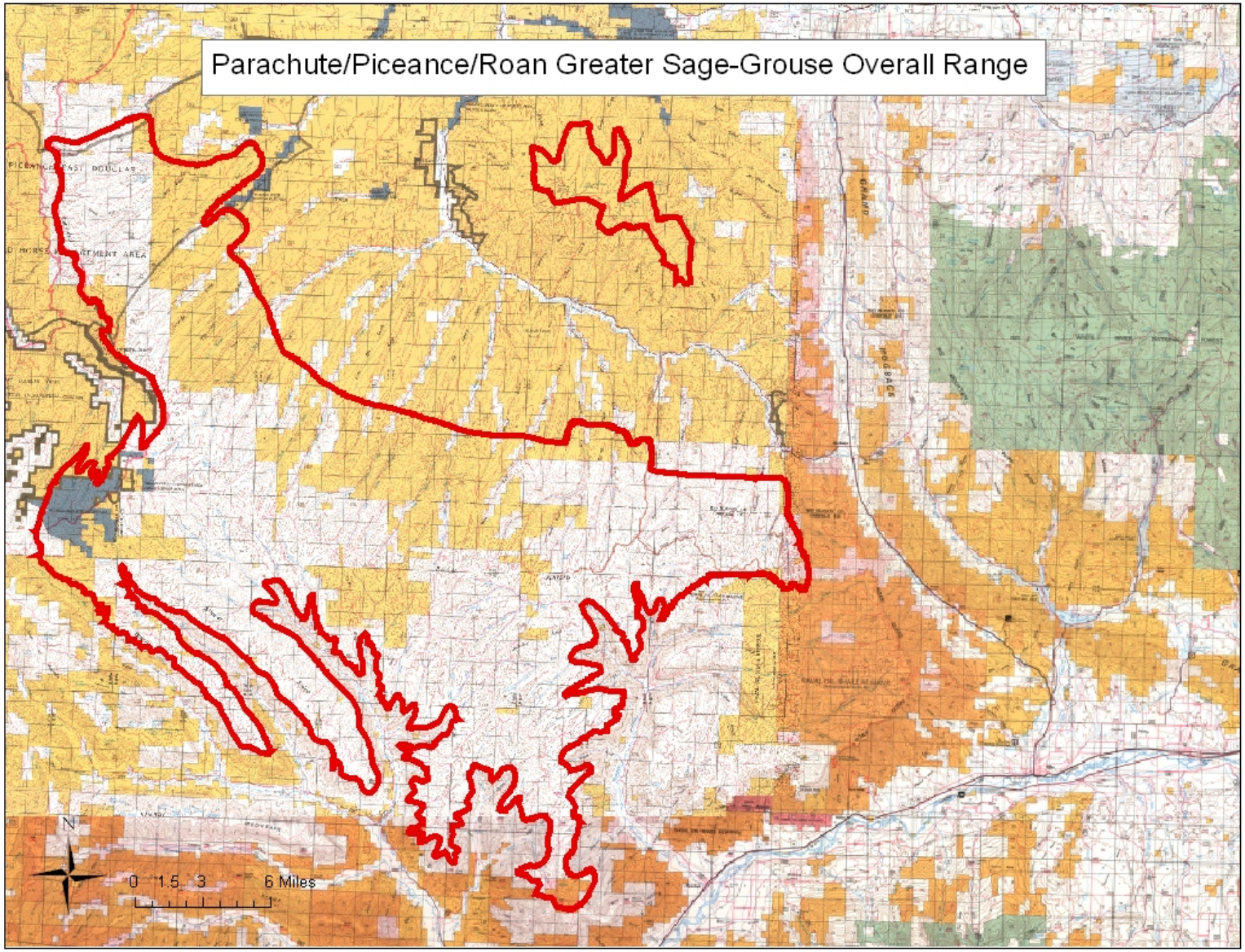


Figure 1. Colorado DOW Overall Range Map for the Parachute/Piceance/Roan Greater Sage-Grouse Population.

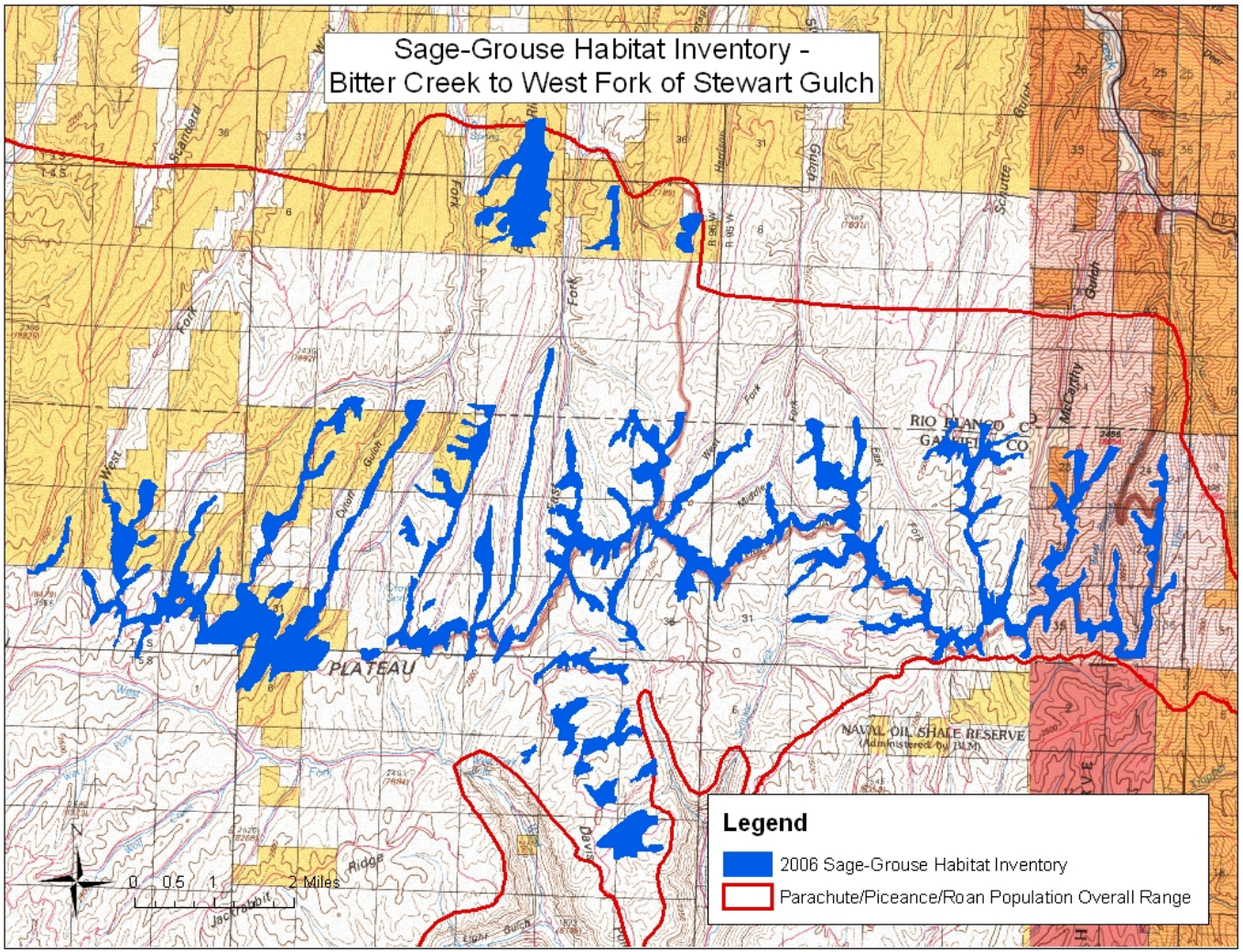


Figure 2. Area included in the 2006 sage-grouse habitat inventory. Most of the effort focused on the eastern edge of the Parachute/Piceance/Roan range from Bitter Creek to the West Fork of Stewart Gulch.

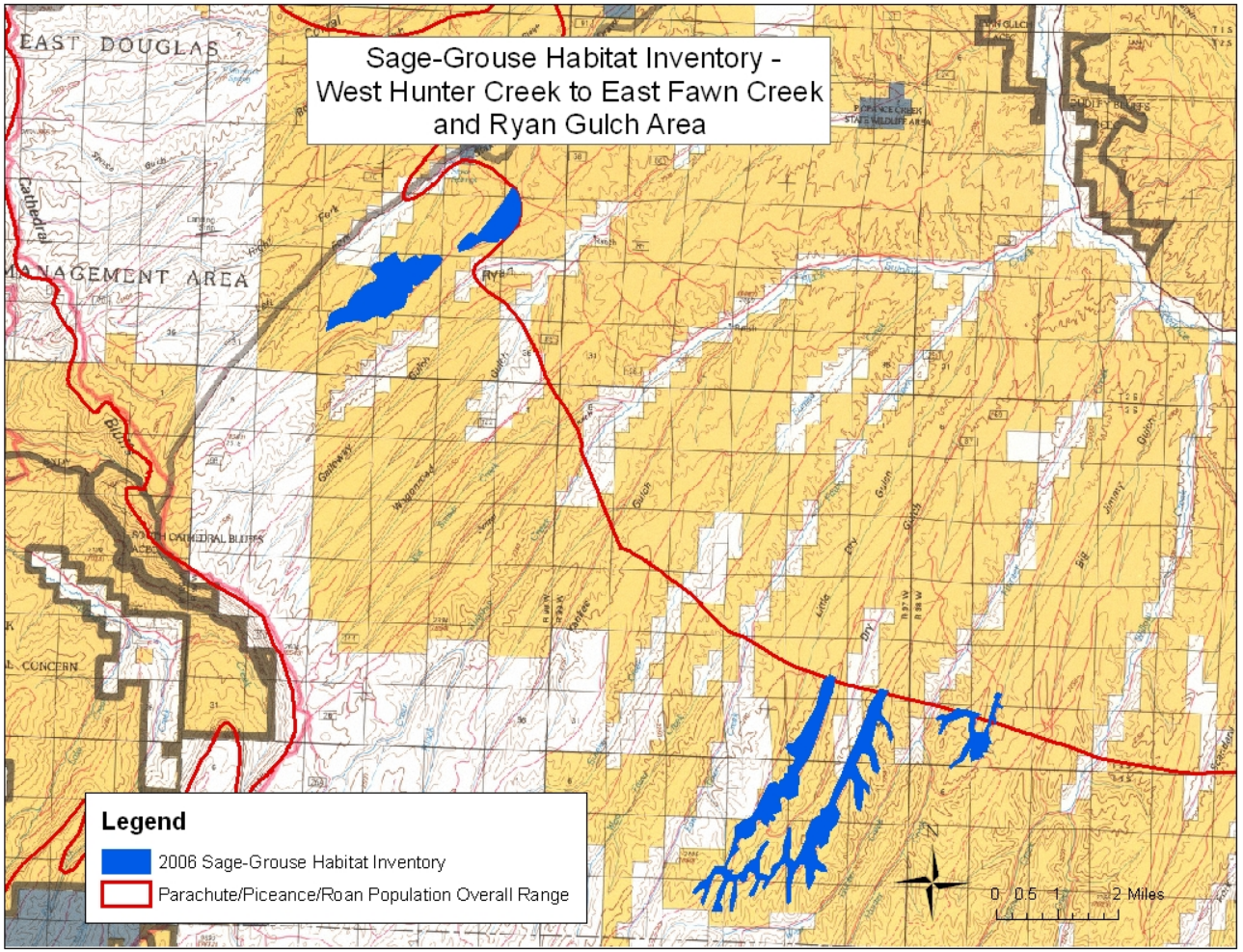


Figure 3. Additional areas included in the 2006 sage-grouse habitat inventory. Inventory work was conducted in the Ryan Gulch area and from West Hunter Creek to East Fawn Creek.

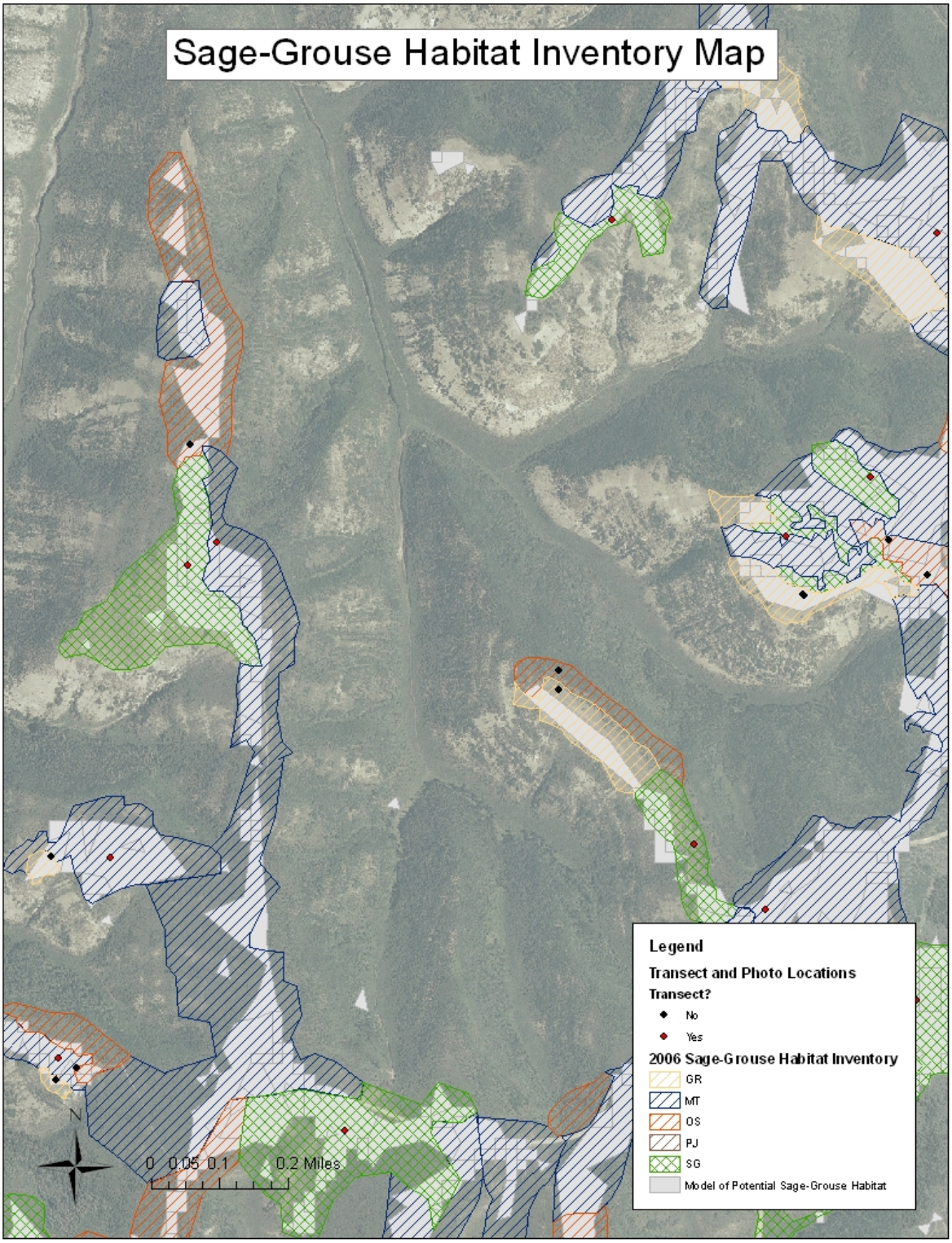


Figure 4. An example of the sage-grouse habitat inventory map for an area west of the Sprague Gulch Road and Divide Road junction. (GR=grass, MT=mountain shrub, OS=oak/serviceberry, PJ =pinyon/juniper, SG=sagebrush)

Figure 5. The top photo is an oak/serviceberry site located west of the Sprague Gulch Road and Divide Road junction. The bottom photo is a pinyon/juniper site off of Barnes Ridge.

Figure 6. The top photo is a mountain shrub site with a fairly uniform canopy height located near Cutoff Gulch. The bottom photo is a mountain shrub site near the West Fork of Stewart Gulch where the serviceberry canopy is much taller than the other shrubs.

Figure 7. The top photo is a sagebrush site near Cutoff Gulch. Note the tall serviceberry shrubs in the background. The bottom photo is a sagebrush site on Barnes Ridge that is being encroached by pinyon/juniper.

Table 1. Approximate acreage of habitat types surveyed as part of the 2006 Piceance sage-grouse habitat inventory.

Habitat Type	Acres	% of Area Surveyed
Aspen	2.0	>0.1
Grass	912.6	9.2
Oak/Serviceberry	864.3	8.7
Pinyon/Juniper	1269.2	12.8
Rabbitbrush	421.6	4.3
Mountain Shrub	3354.8	33.9
Sagebrush	3060.1	30.9
Total	9884.6	

Table 2. Shrub canopy cover (%) at sagebrush sites (n=45) and mountain shrub sites (n=44). Total shrub cover is the combined canopy cover of sagebrush, bitterbrush, rabbitbrush, serviceberry, and snowberry.

	Sagebrush Sites			Mountain Shrub Sites		
Shrub Cover	Mean	SE	Range	Mean	SE	Range
Sagebrush	25.0	1.4	8.9 - 51.1	19.9	1.1	3.2 - 37.4
Bitterbrush	1.8	0.5	0 - 10.8	10.2	1.3	0 - 31.7
Rabbitbrush	3.7	0.6	0 - 12.6	2.4	0.6	0 - 17.0
Serviceberry	0.7	0.2	0 - 5.0	6.2	1.2	0 - 33.8
Snowberry	1.2	0.3	0 - 6.1	6.9	1.1	0 - 28.9
Total Shrub Cover	33.3	1.7	9.1 - 53.6	45.5	2.1	18.0 - 80.2

Table 3. Herbaceous canopy cover (%) at sagebrush sites (n=45) and mountain shrub sites (n=44). Total herbaceous cover is the combined canopy cover of perennial and annual grasses and forbs.

	Sagebrush Sites			Mountain Shrub Sites		
Herbaceous Cover	Mean	SE	Range	Mean	SE	Range
Perennial Grasses	12.5	1.2	2.9 - 33.2	12.9	0.9	5.1 - 28.7
Perennial Forbs	7.0	0.7	1.0 - 19.0	7.0	0.5	1.6 - 15.5
Total Herbaceous Cover	19.8	1.6	3.9 - 45.6	20.0	1.0	9.0 - 36.4

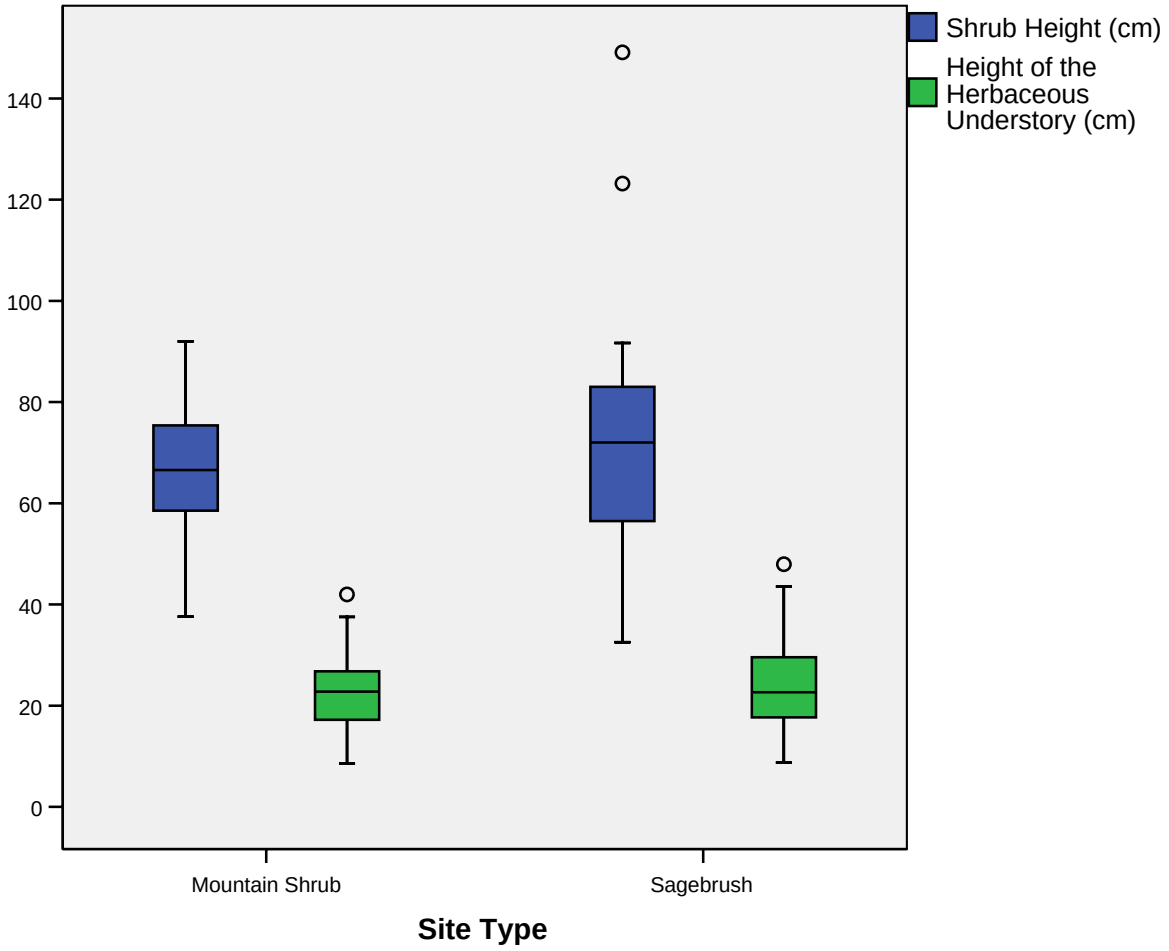


Figure 8. Box plots of shrub height and the height of the herbaceous understory (perennial grasses and forbs). Heights were weighted by canopy cover. Center lines represent the median, boxes represent the interquartile range (IQR), whiskers represent samples within ±1.5x the IQR, and circles are outliers.

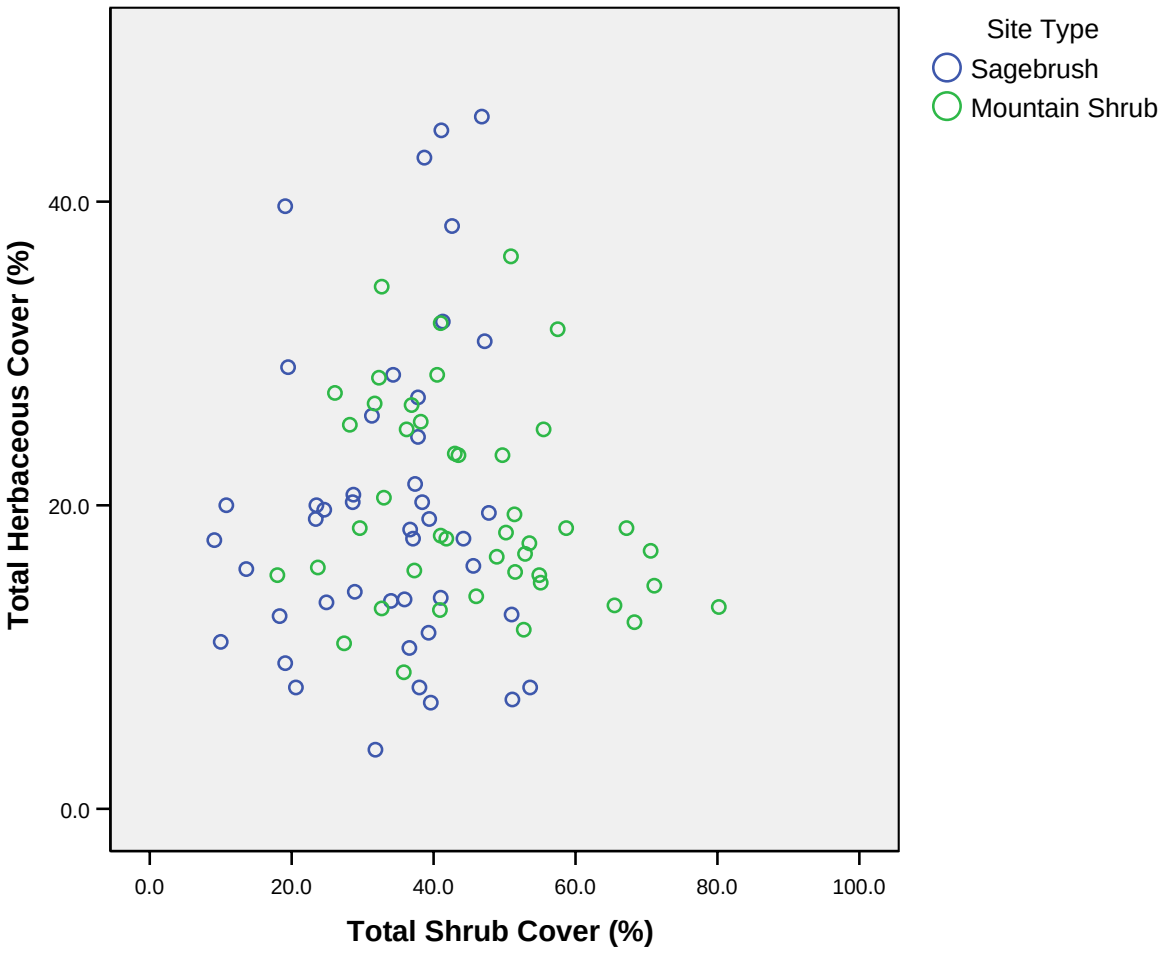


Figure 9. Scatterplot of total herbaceous cover (perennial and annual grasses and forbs) and total shrub cover (sagebrush, rabbitbrush, bitterbrush, serviceberry, and snowberry) at sagebrush and mountain shrub sites. If there was a correlation between shrub cover and herbaceous cover, the scatterplot would show the points clustering along a line rather than forming a "shotgun blast" pattern.

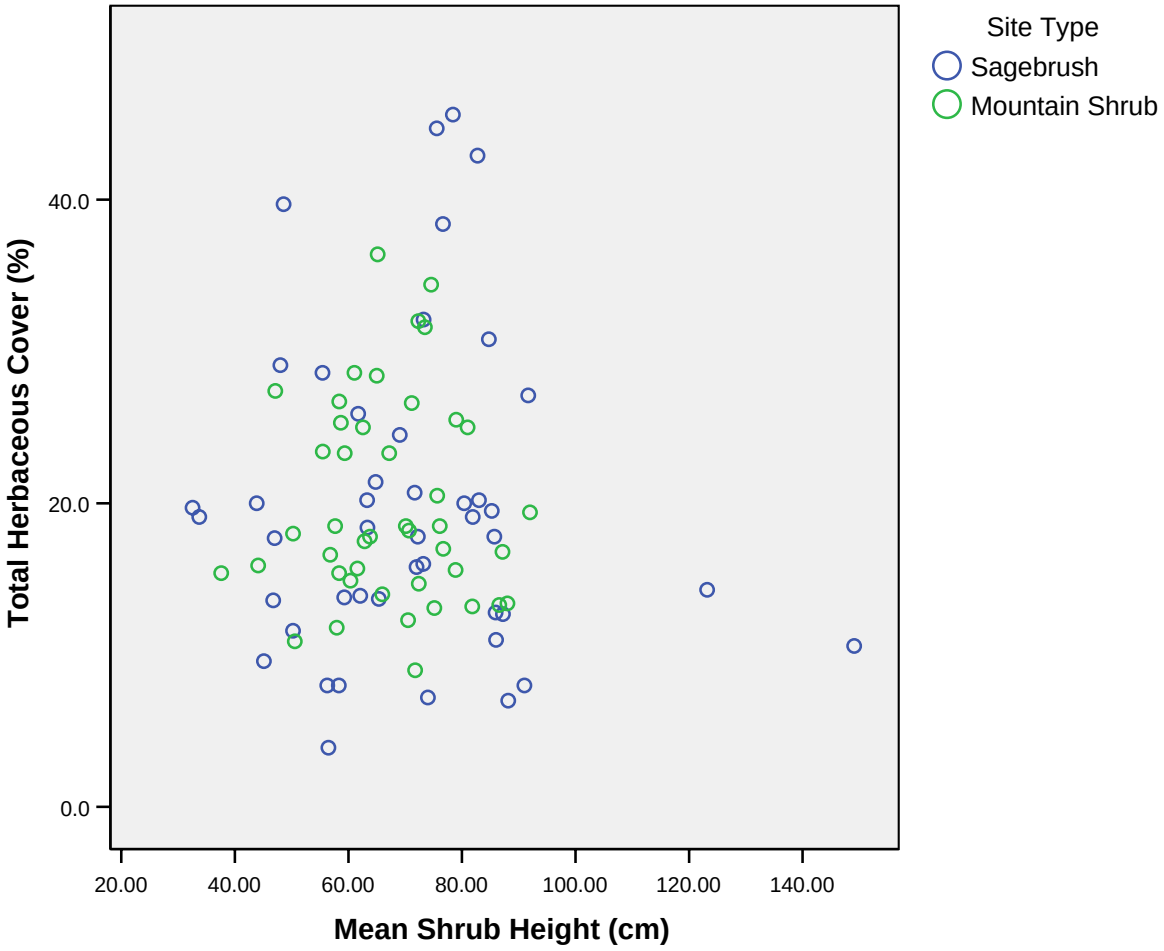


Figure 10. Scatterplot of total herbaceous cover (perennial and annual grasses and forbs) and mean shrub height (weighted by cover) at sagebrush and mountain shrub sites. If there was a correlation between shrub height and herbaceous cover, the scatterplot would show the points clustering along a line rather than forming a "shotgun blast" pattern.

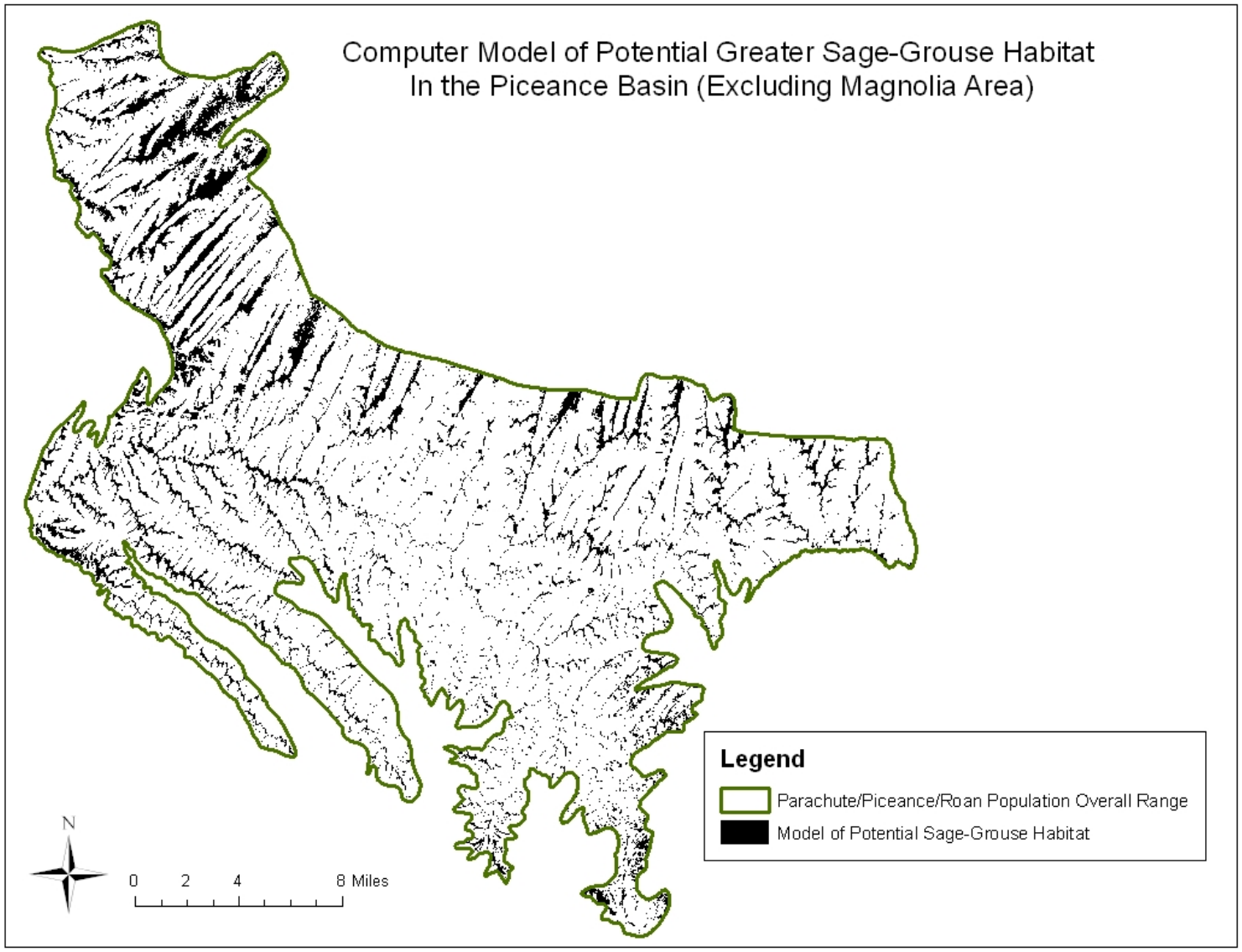


Figure 11. Computer Model of Potential Greater Sage-Grouse Habitat in the Piceance Basin (Excluding the Magnolia Area)

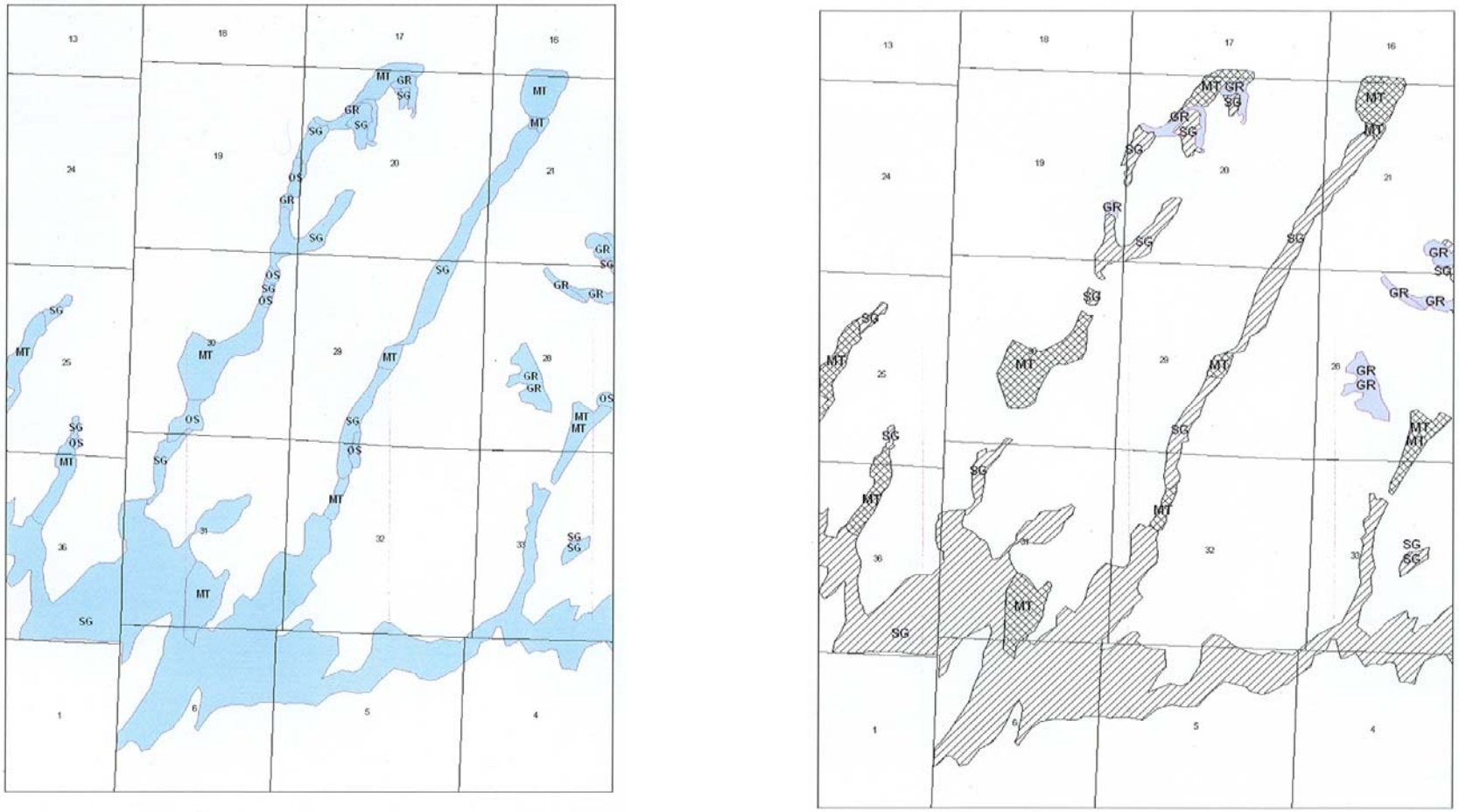
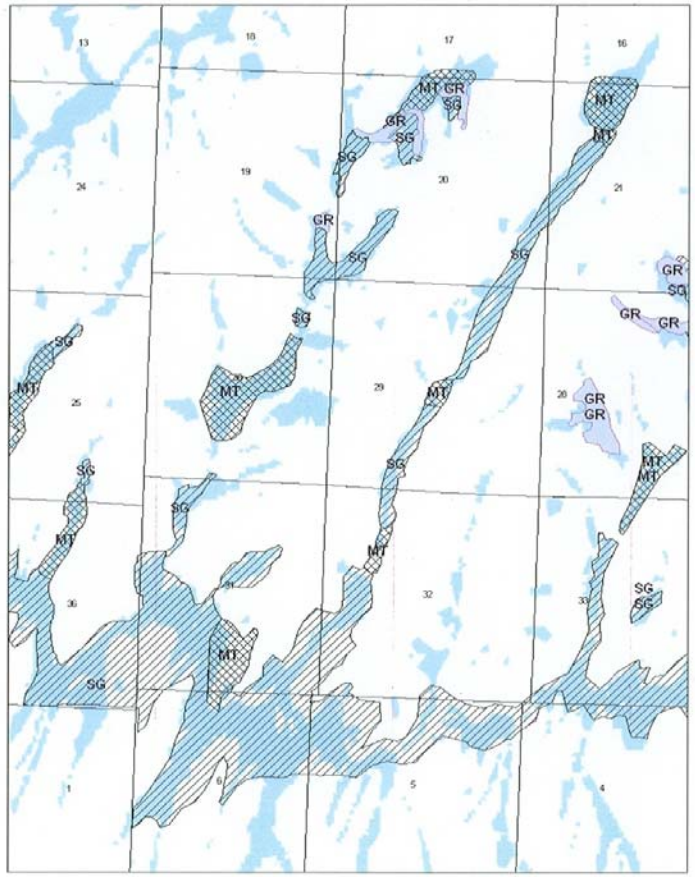


Figure 12 – Comparison of the Piceance Sage-Grouse Habitat Inventory Map and the 20% Slope Computer Model.

A. We queried the polygons on the inventory map and selected rabbitbrush (RB), mountain shrub (MT), sagebrush (SG), and grass (GR) as suitable habitat.

B. We then removed all other vegetation classes from further analysis.



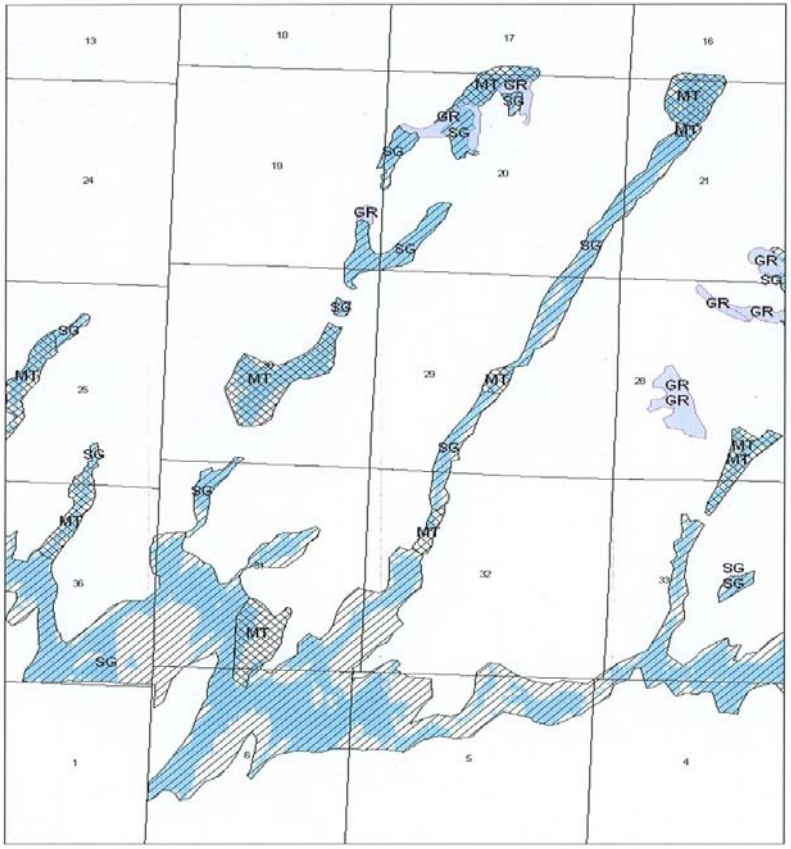


Figure 12 – Comparison of the Piceance Sage-Grouse Habitat Inventory Map and the 20% Slope Computer Model

C. Next, we added the 20% slope computer model (shown in blue) and clipped it to the polygons identified as suitable habitat by the inventory.

D. Compared to the habitat inventory polygons, the 20% slope computer model (shown in blue) under-estimates suitable habitat by approximately 38%.