

Investigating the Sagebrush Biome Using SMRRT



7 April, 2017

Using Resilience and Resistance Concepts to Manage Threats to Sagebrush Ecosystems, Gunnison Sage-Grouse, and Greater Sage-Grouse in Their Eastern Range: A Strategic Multi-Scale Approach

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Using the SMRRT Science Framework, investigate Sagebrush biome and threats in BLM CO Districts

Location and Data Sets

- Where are areas of sagebrush?
 - Data sets: LandFire, Homer/USGS grass shrub
- Where are Resistant and Resilient (R&R) areas?
 - What is R&R?
- How does R&R vary across the sagebrush biome?
 - May provide information on how areas respond to treatment, and likely recovery or conversion to undesirable states

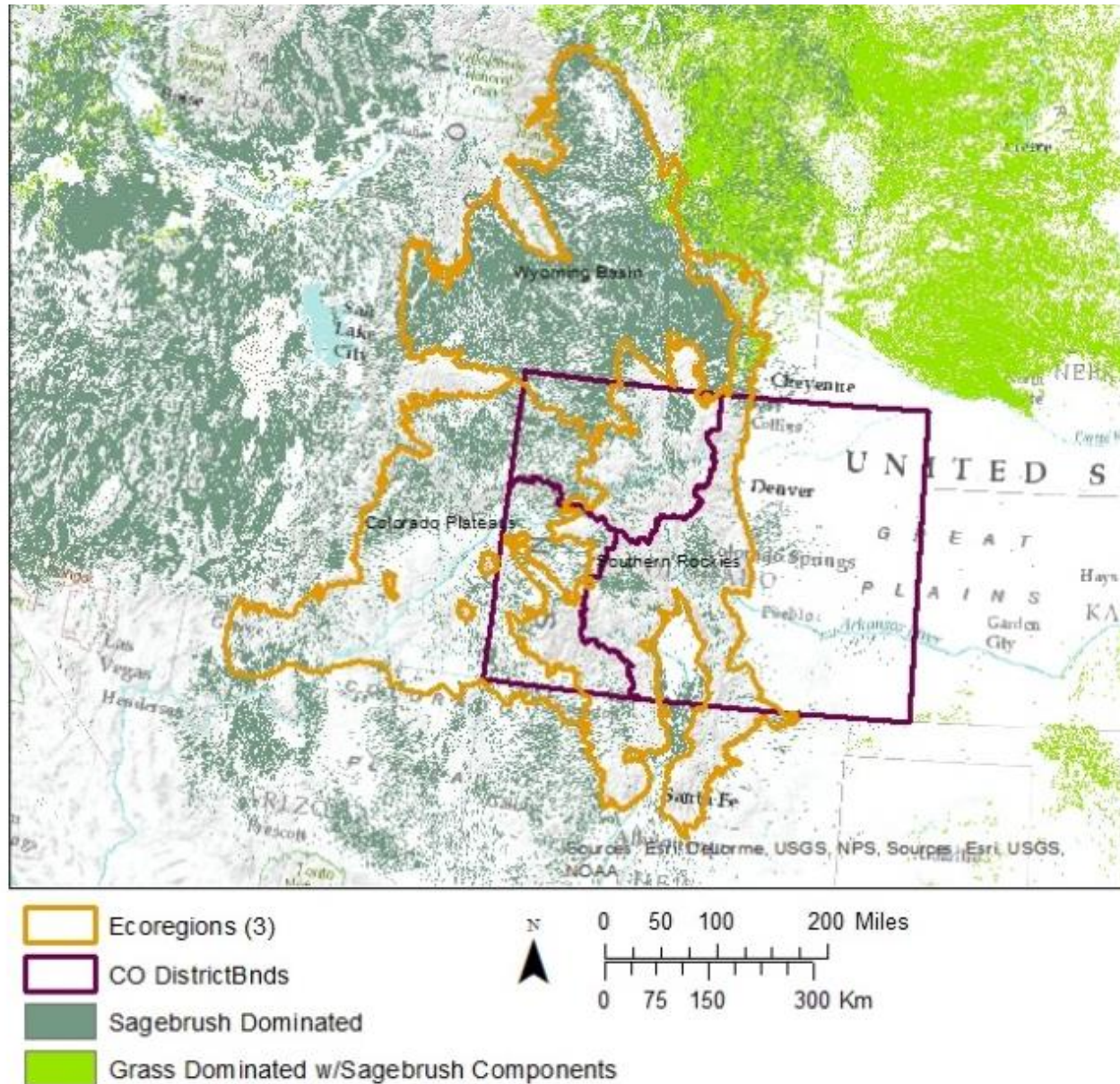
Using the SMRRT Science Framework, identify Predominant Threats to the Sagebrush Biome

- Where are areas of cheatgrass?
 - Data sets: LandFire, Pacific NW National Lab (Larson/PNNL)/FWS, Homer/USGS (not yet)
- Where are areas of pinyon juniper (PJ)?
 - Data sets: Falkowski, Chambers, Rehfeldt
- Where are developed areas?
 - Data sets: USGS Landscape Intactness, Development Footprint
- What is the spatial distribution of fire risk?
 - Data sets: Crist, Short

Using the SMRRT Science Framework, identify Sagebrush Interactions with Predominant Threats and Change Agents

- How does the R&R vary in areas where PJ is likely to expand into sagebrush?
- Are areas of sagebrush fragmented by development (DV)?
- Where might WY Big Sagebrush grow in 2050?
- How does R&R vary in areas dominated by sagebrush and invaded by cheatgrass?
- Where will Wyoming Big Sagebrush grow in 2050?
- How does fire risk vary in sagebrush and PJ expansion areas?
- How will future changes affect the sagebrush biome? E.g. development, climate change
- What about grazing – this is mentioned as an option for management and treatment, not as a CA?

Where are areas of sagebrush?



What is Resilience & Resistance?

- **Resilience** refers to the ability of ecosystems to reorganize or recover after disturbances like wildfire
- **Resistance** is the capacity of an ecosystem to remain largely unchanged despite disturbances or pressure from invasive species, like cheatgrass
- Resilience and resistance concepts help managers better understand key drivers of ecosystem change, identify relative risks of crossing thresholds to undesired states, and design appropriate management actions to promote desired ecosystem trajectories

(Maestas et al, 2016)

Where are Resistant and Resilient (R&R) Areas?

-- Optimal Soil Characteristics for Sagebrush and Cheatgrass

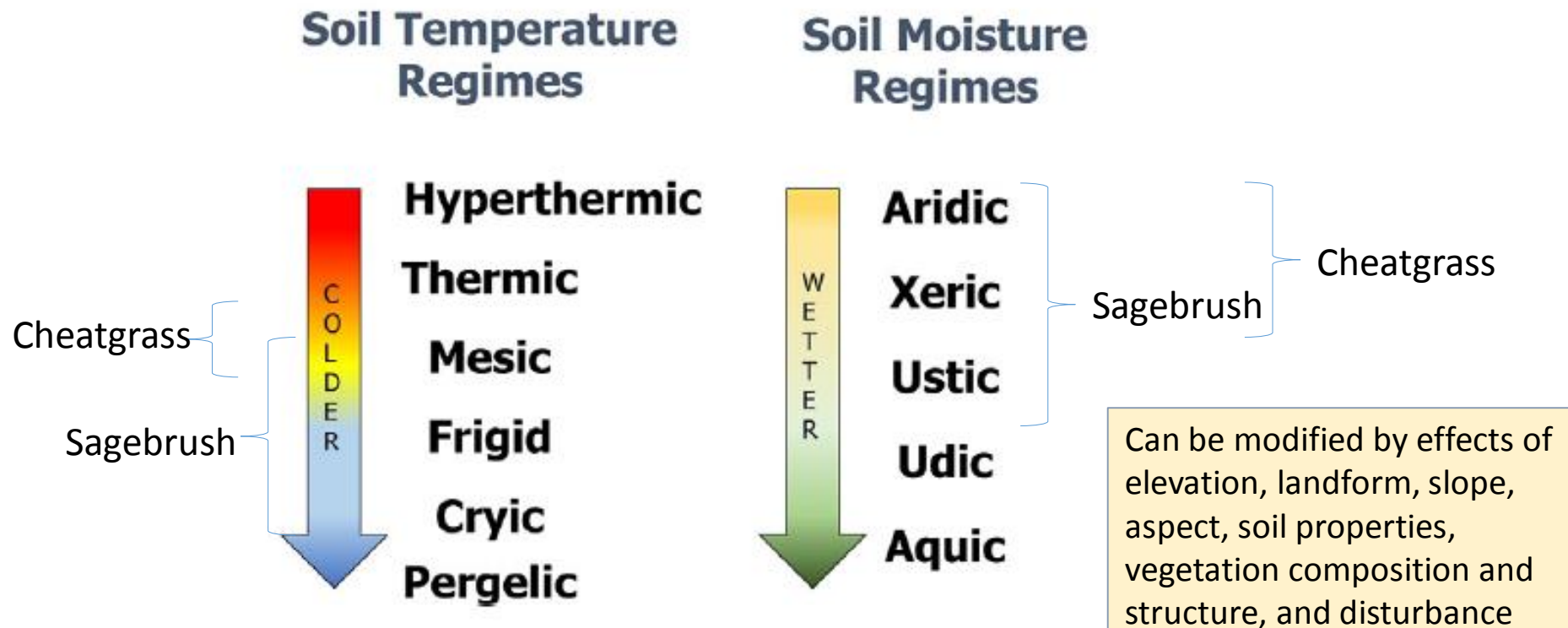


Figure 1. Soil taxonomic temperature and moisture regime terminology. Temperature regimes are defined by specific mean soil temperatures, and seasonal fluctuations from the mean, within the main root zone. Moisture regimes relate to the length of time plant-available moisture is present during the growing season. For complete definitions see the 2014 Keys to Soil Taxonomy.⁸

(Maestas et al, 2016)

R&R Soil Characteristics: Sagebrush Optimal Conditions

(Maestas et al, 2016)

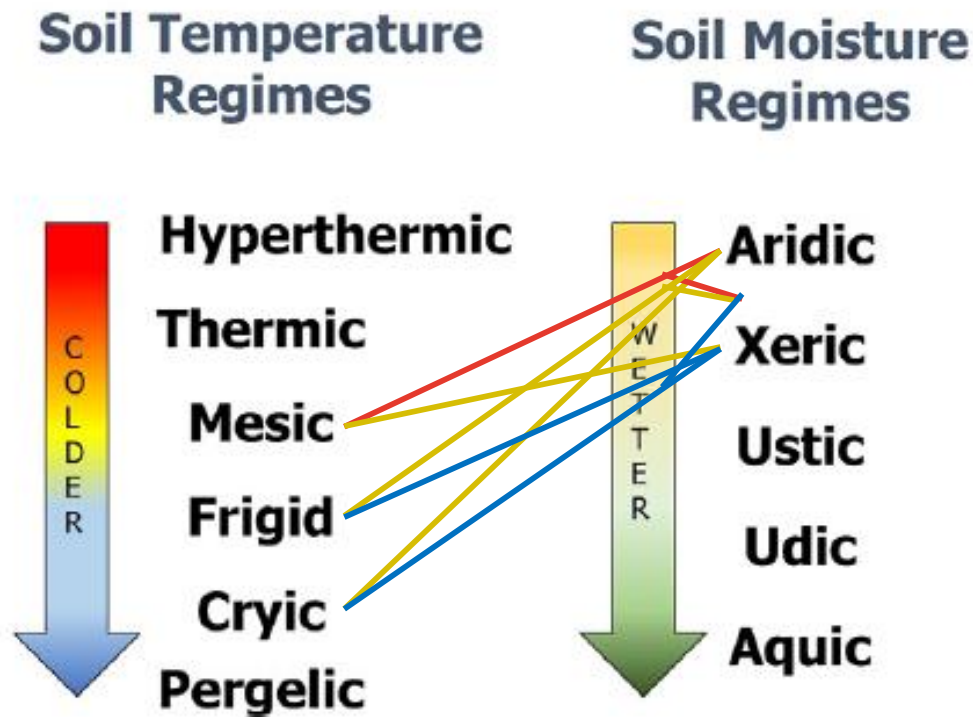
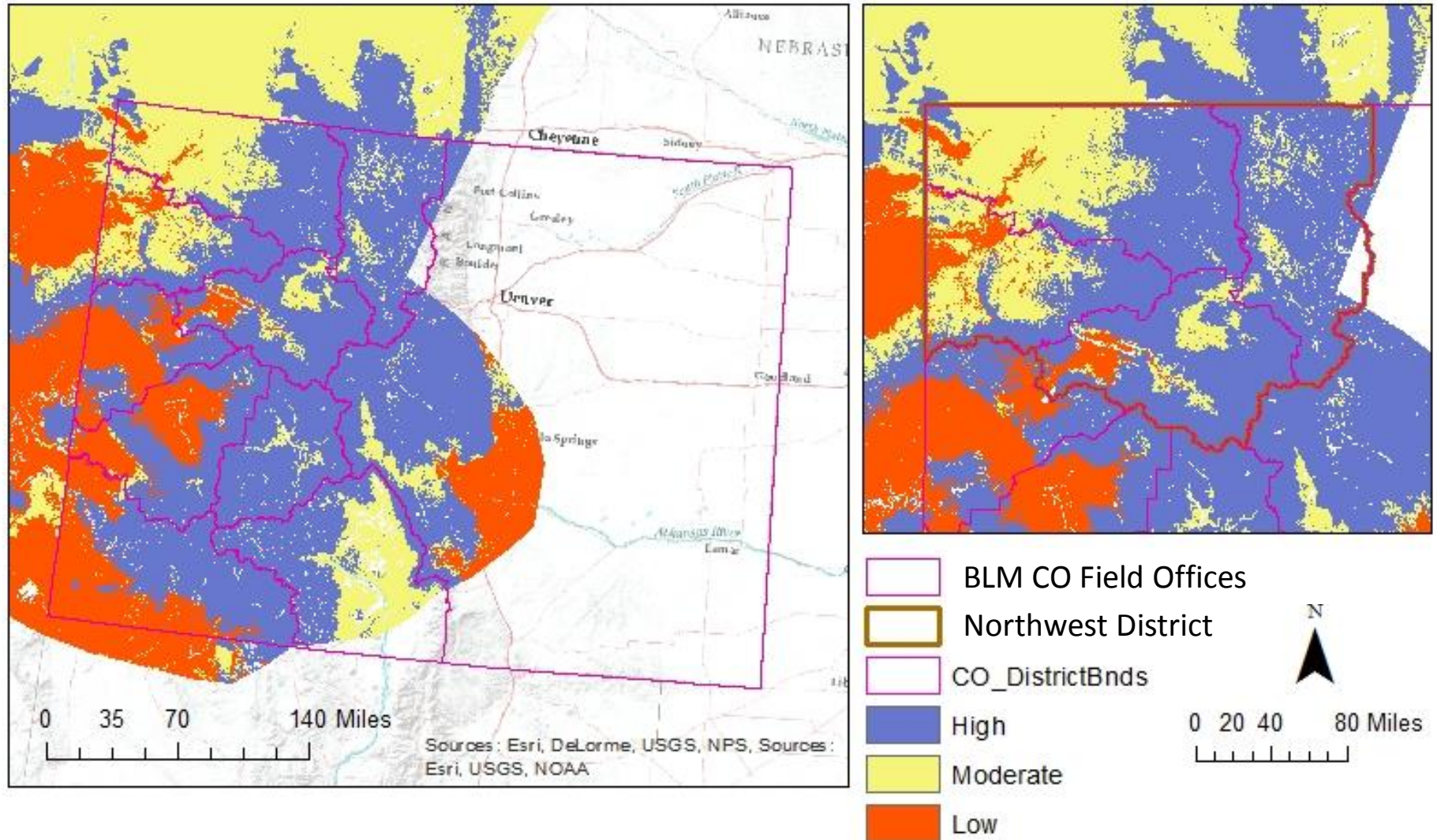


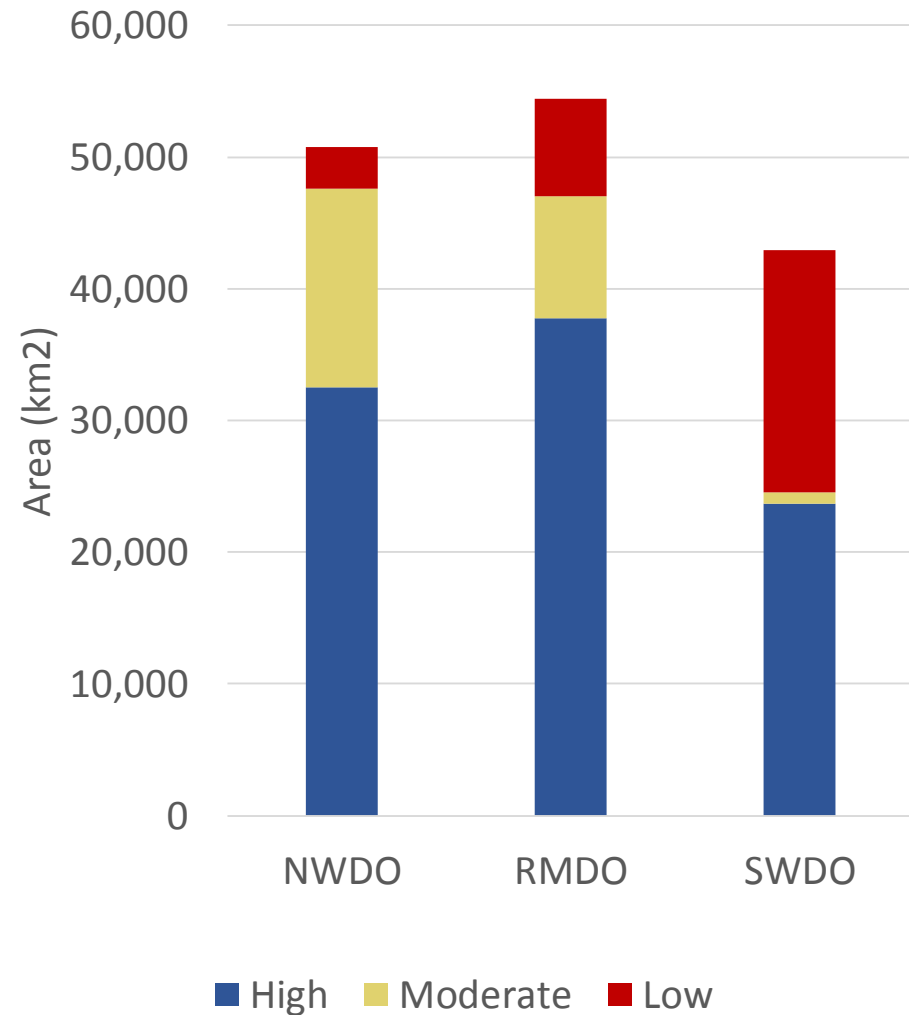
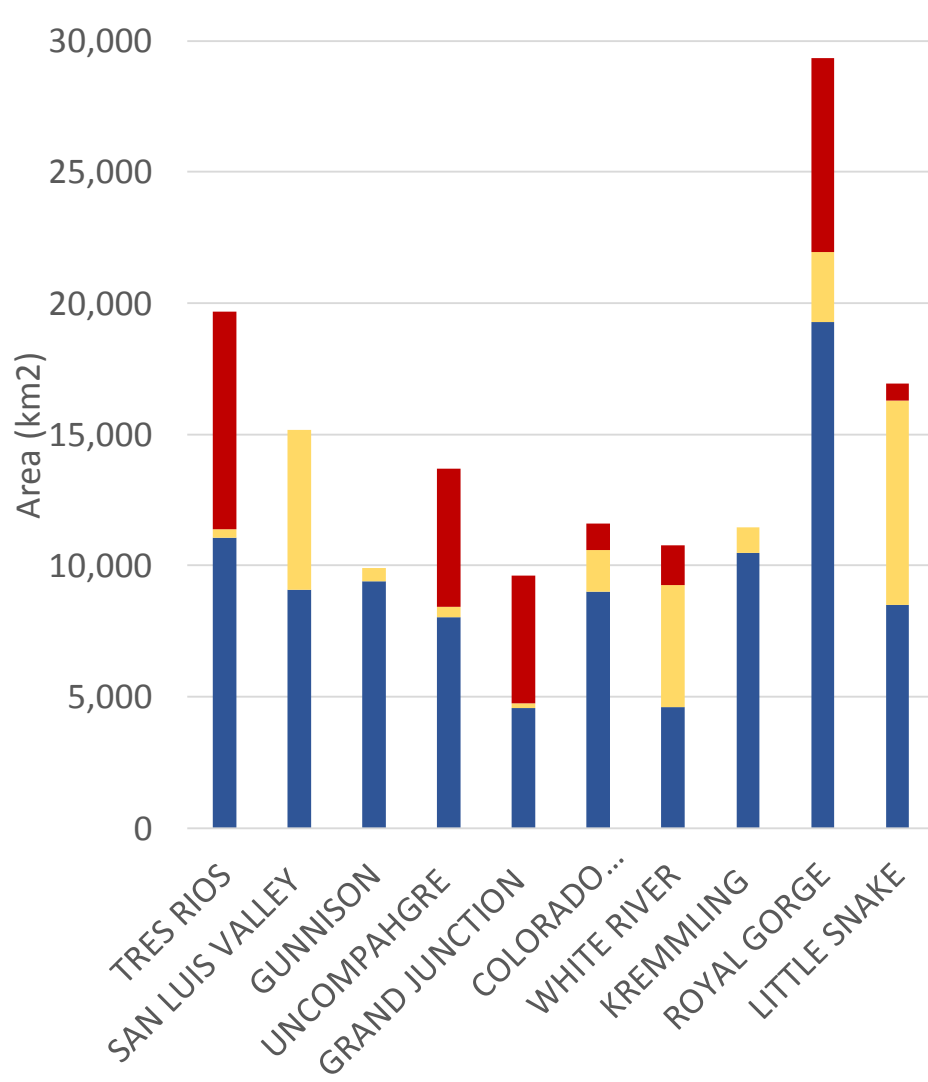
Figure 1. Soil taxonomic temperature and moisture regime terminology. Temperature regimes are defined by specific mean soil temperatures, and seasonal fluctuations from the mean, within the main root zone. Moisture regimes relate to the length of time plant-available moisture is present during the growing season. For complete definitions see the 2014 Keys to Soil Taxonomy.⁸

- High
- Moderate
- Low

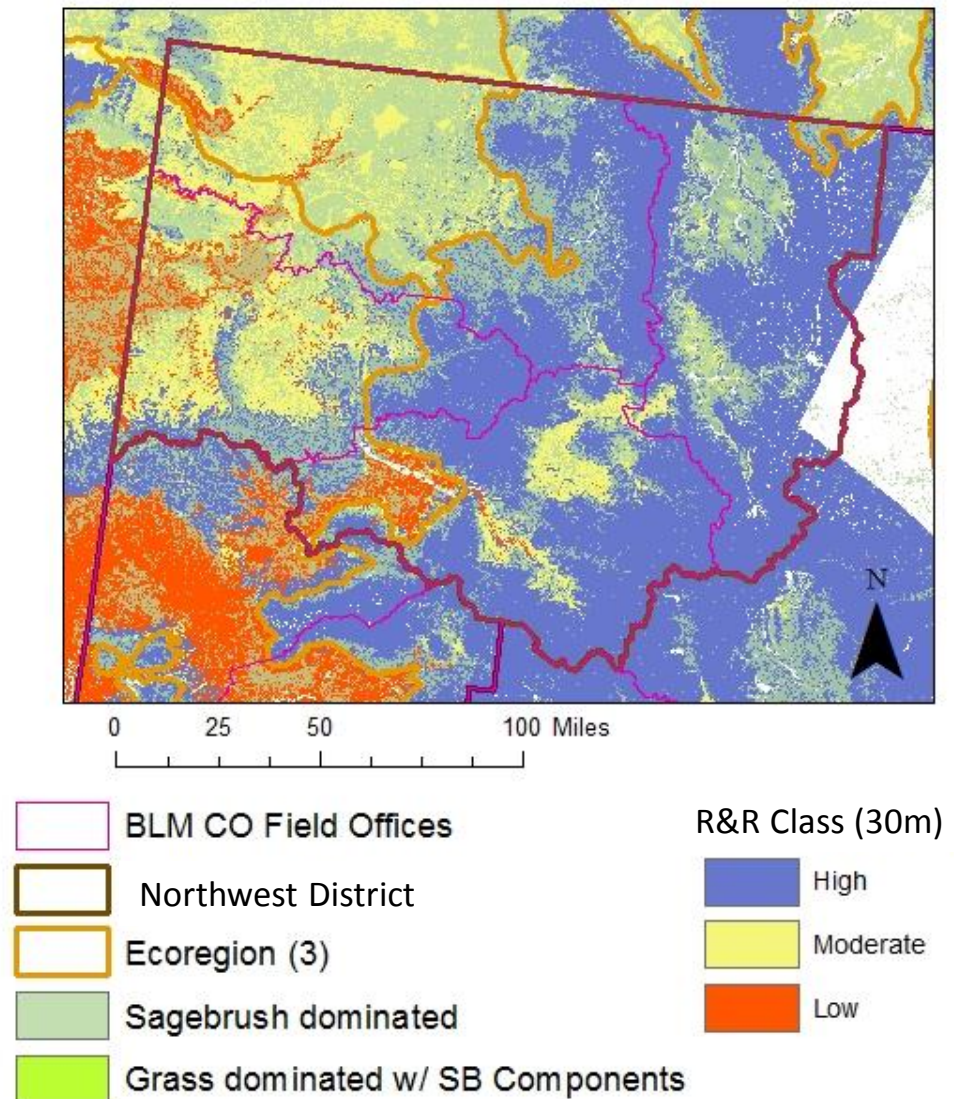
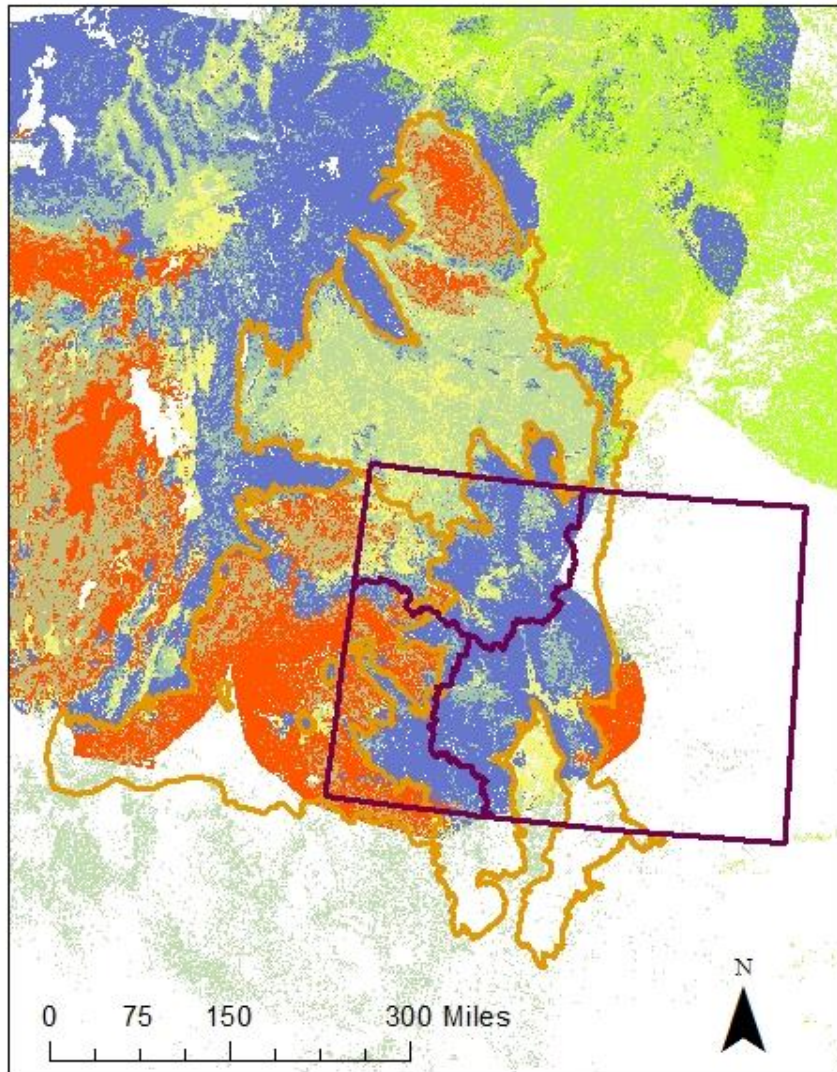
Where are Resistant and Resilient (R&R) areas?



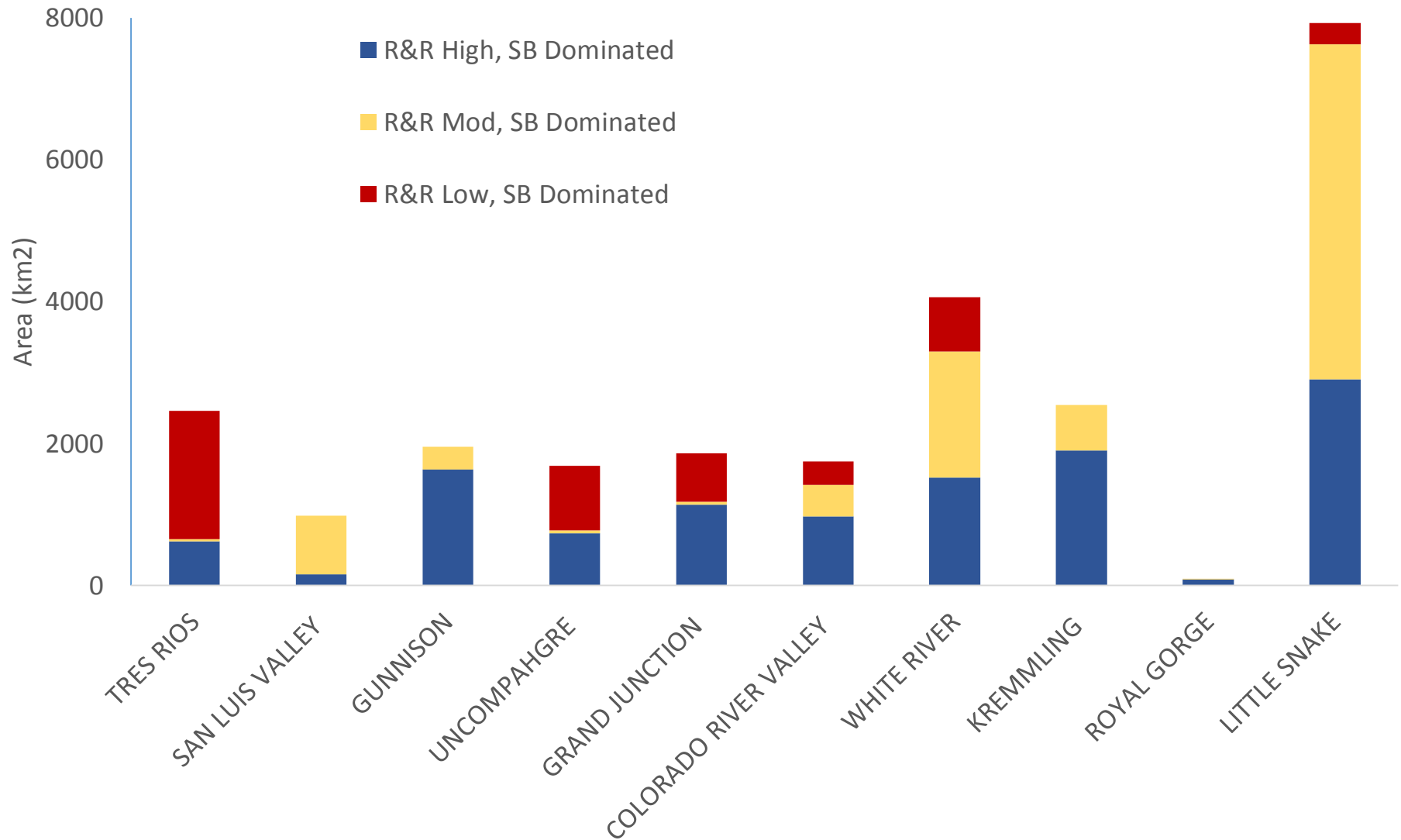
Resistance and Resilience by Colorado BLM Field Offices and District Offices



How does R&R vary across the sagebrush biome?



How does R&R vary in areas of sagebrush by FO?



Predominant Threats, Change Agents, and Sagebrush Interactions

- Cheatgrass
- Pinyon-Juniper
- Development
- Fire
- Climate Change



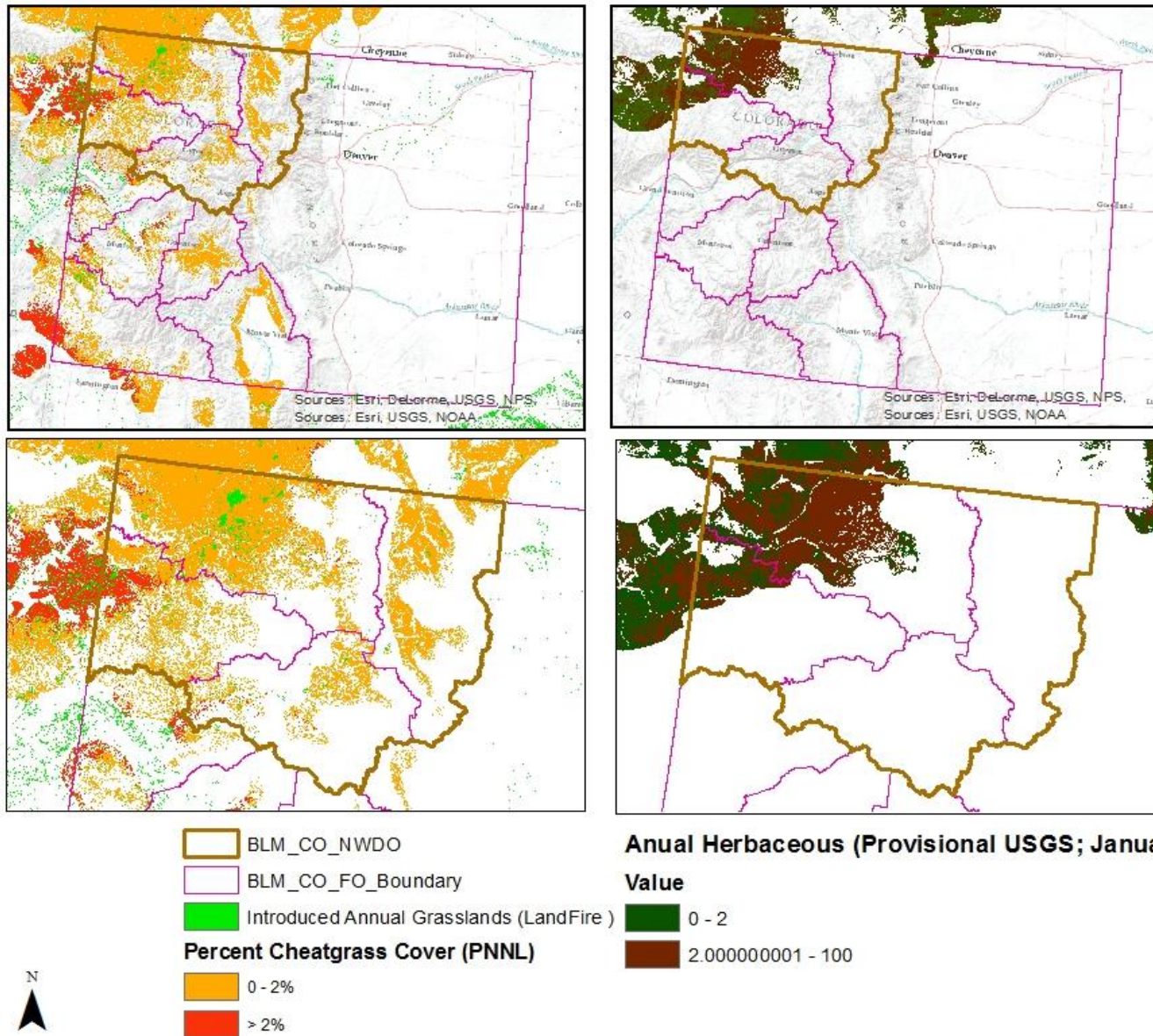
Cheatgrass

Data sets

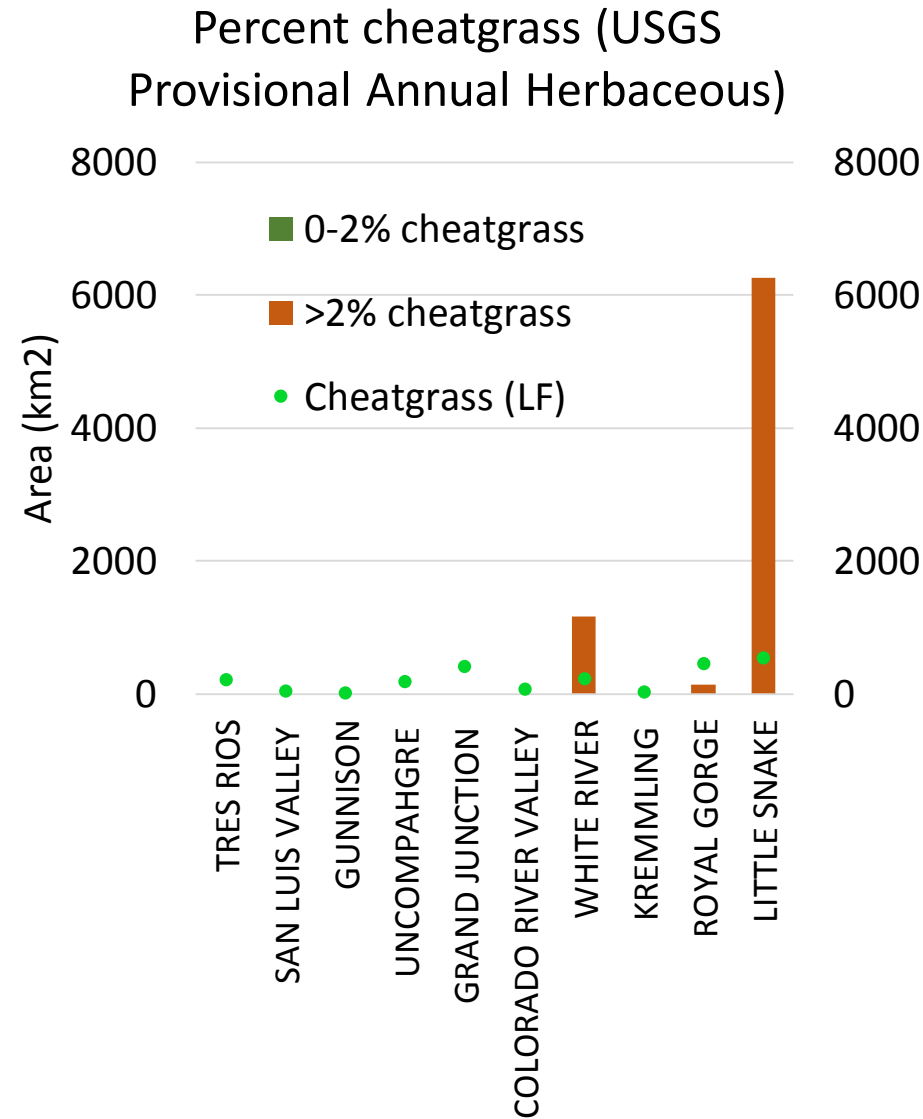
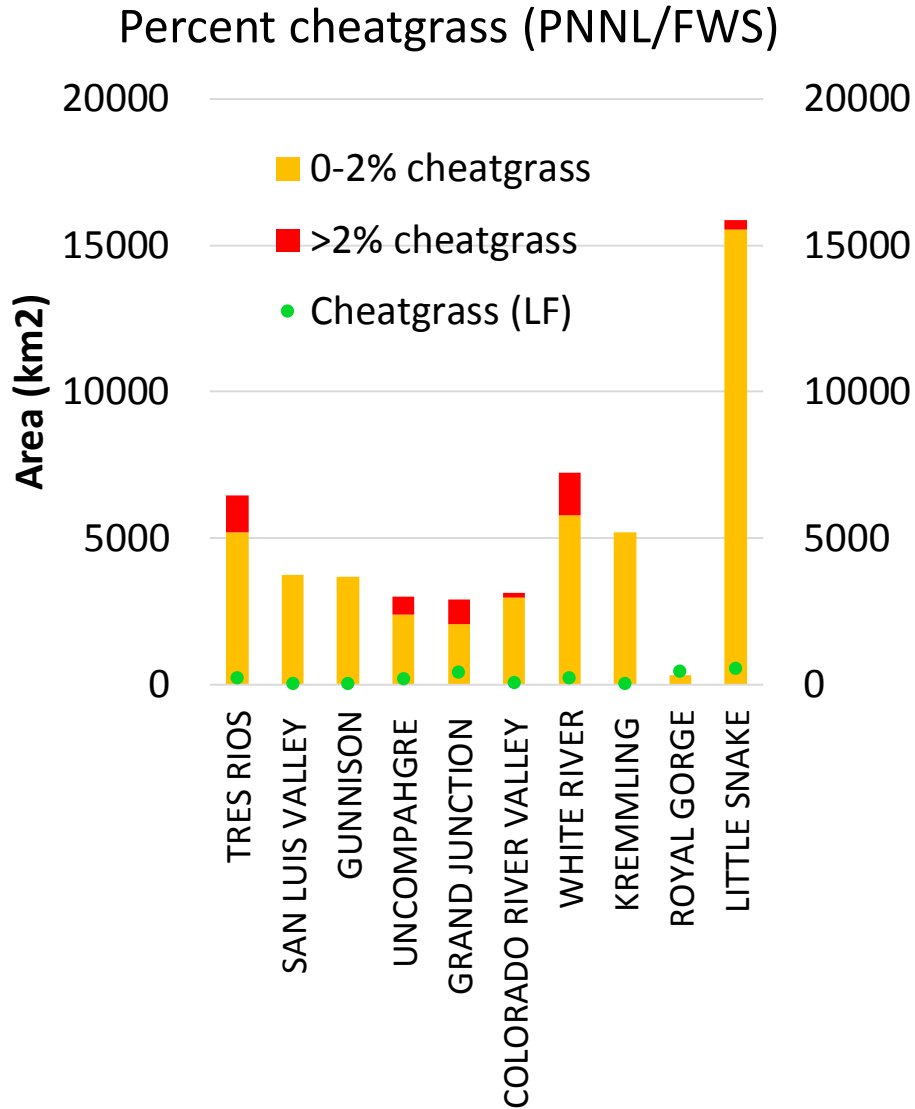
- LandFire: raster cells only where Introduced Annual Grasses (cheatgrass) is the dominant cover so appears to be underestimate extent
- PNNL (Larson)/FWS: field measurements used to derive a statistical model based on biophysical and remotely sensed variables. The 2 % cover threshold was from a natural break in the cheatgrass data. Other percent covers are not available.
- USGS (Homer) provisional Grass Shrub: Annual herbaceous data – derived using Landsat. Full range of percent cover values for cheatgrass are available.

Where is cheatgrass predicted to occur in CO and NW District?

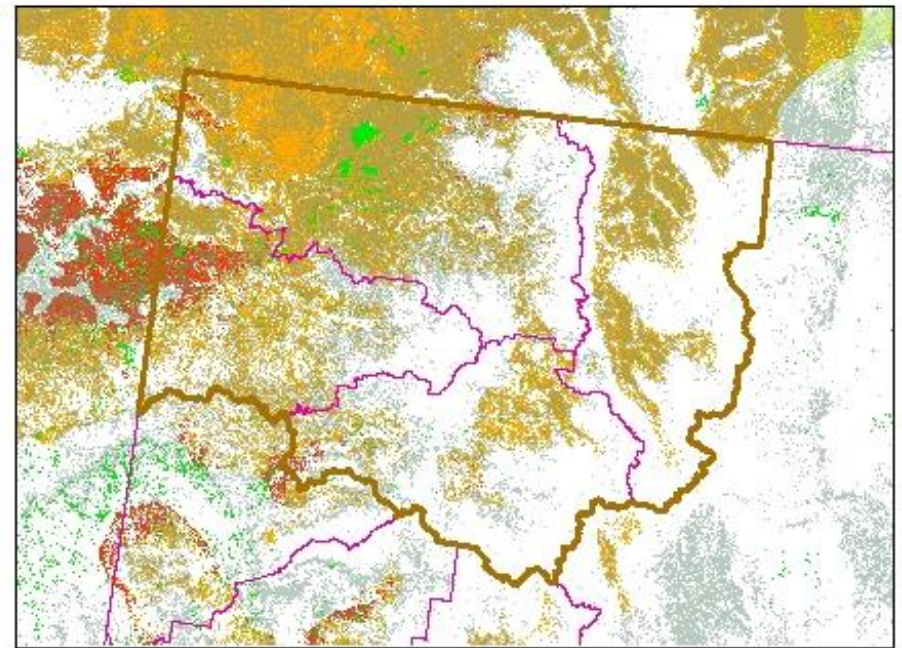
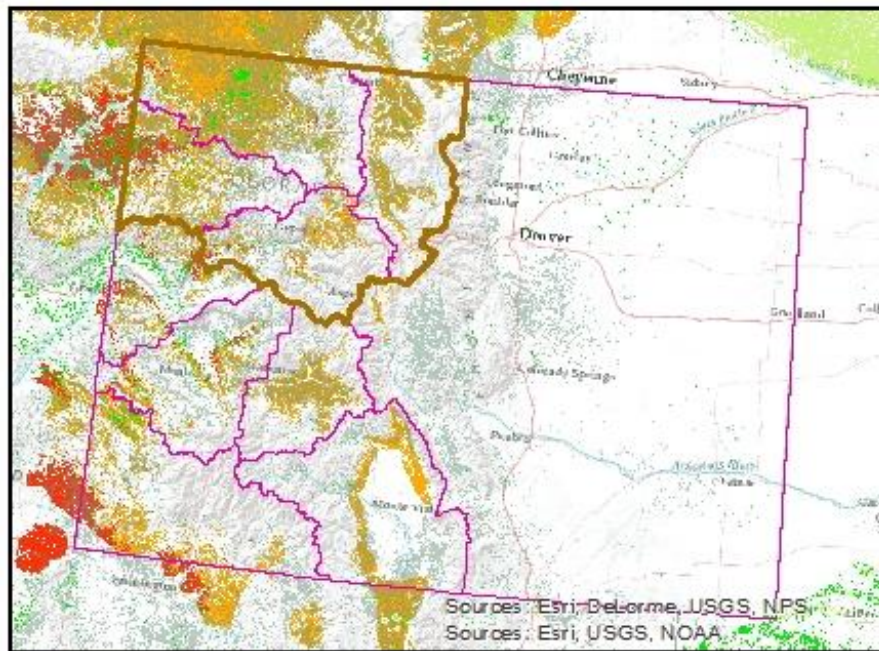
3 data sets – LandFire and PNNL (Downs/Larson)/FWS (*left*), USGS Provisional Grass Shrub (*right*)



Summarize cheatgrass by Colorado FO



Where are areas of sagebrush and cheatgrass?



BLM_CO_NWDO
BLM_CO_FO_Boundary

Other
Sagebrush Dominated
Grass Dominated w/Sagebrush Components

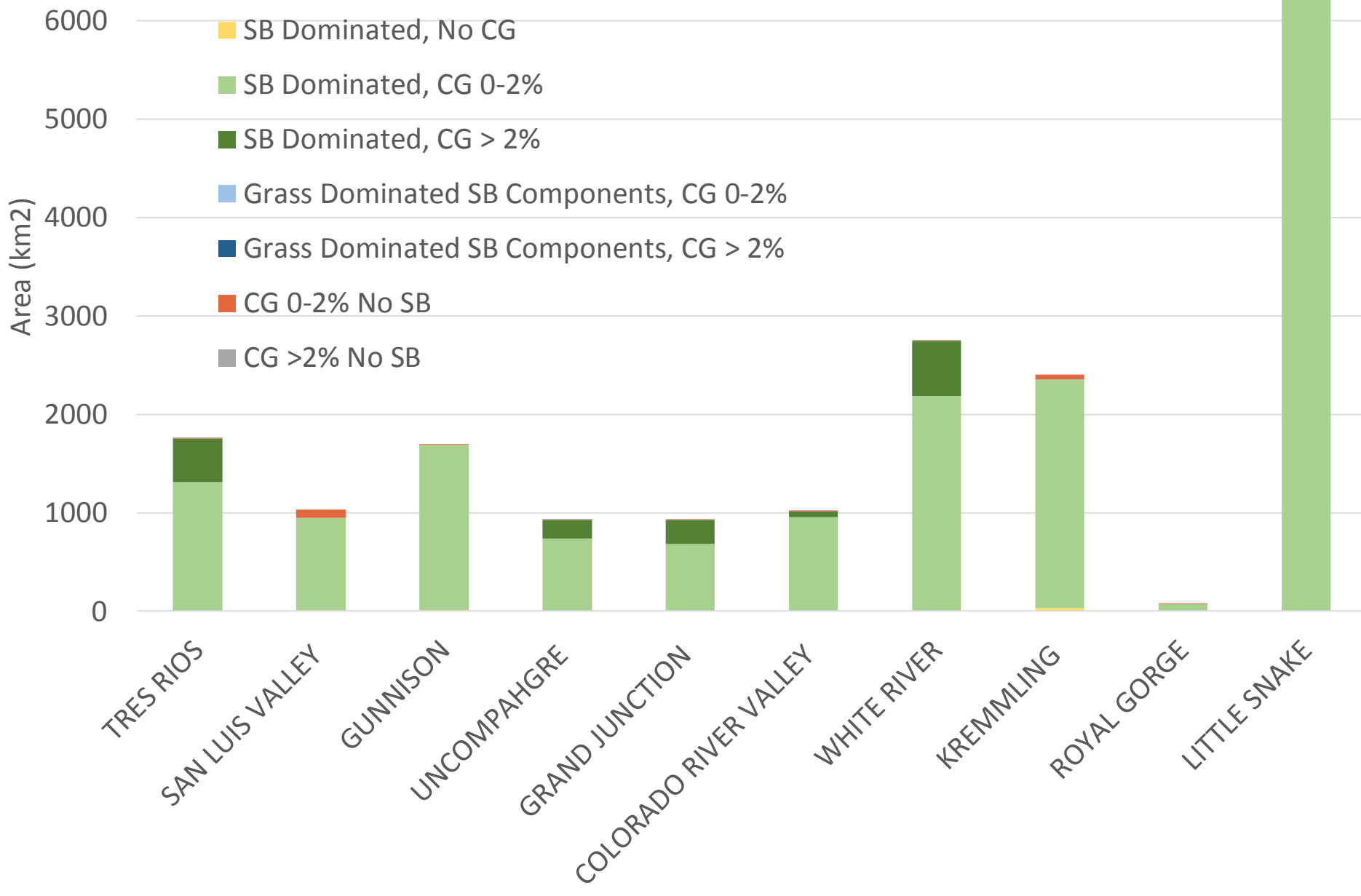
Introduced Annual Grasslands (LandFire)

Percent Cheatgrass Cover (PNNL)

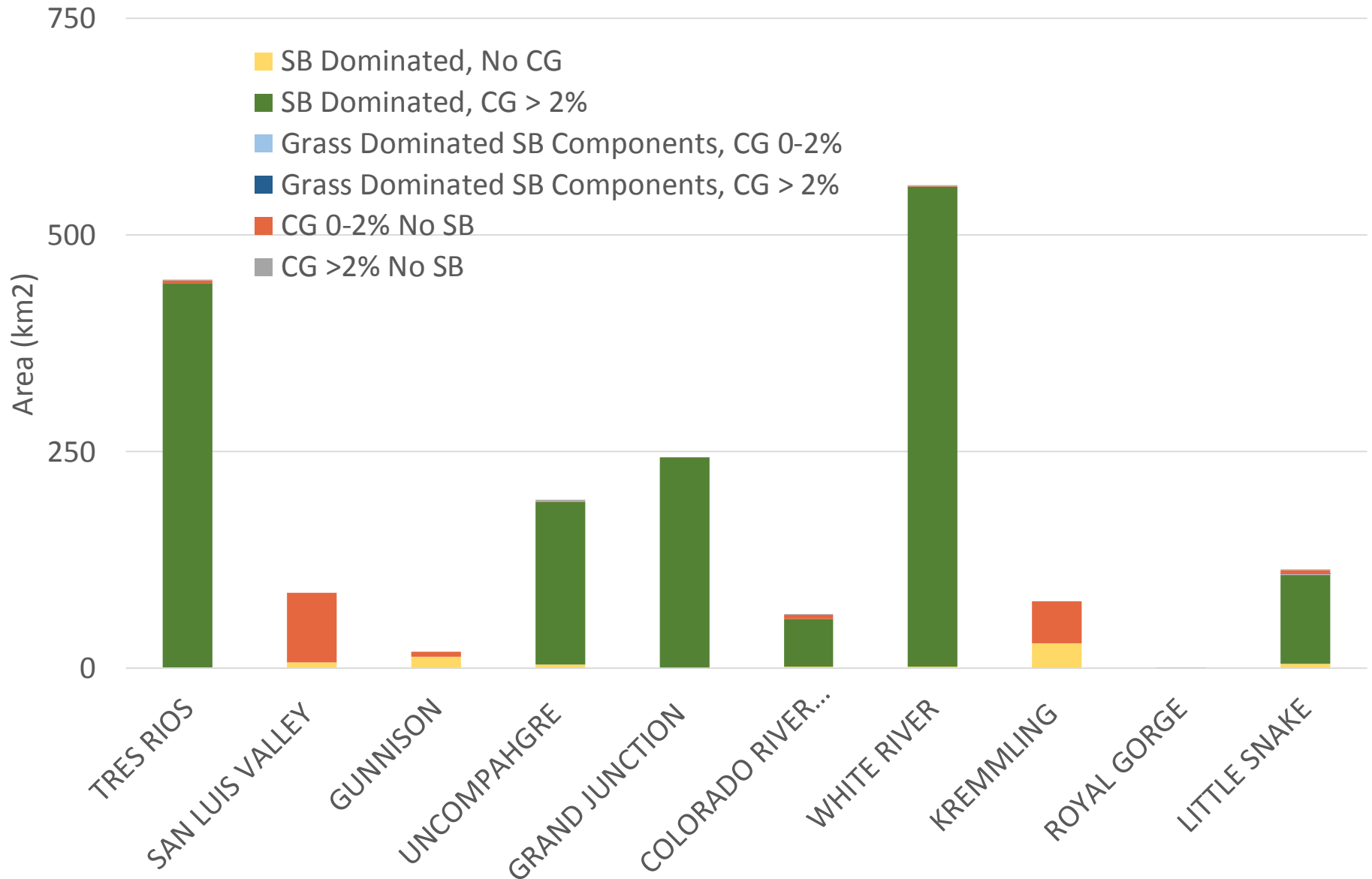
0 - 2%
> 2%



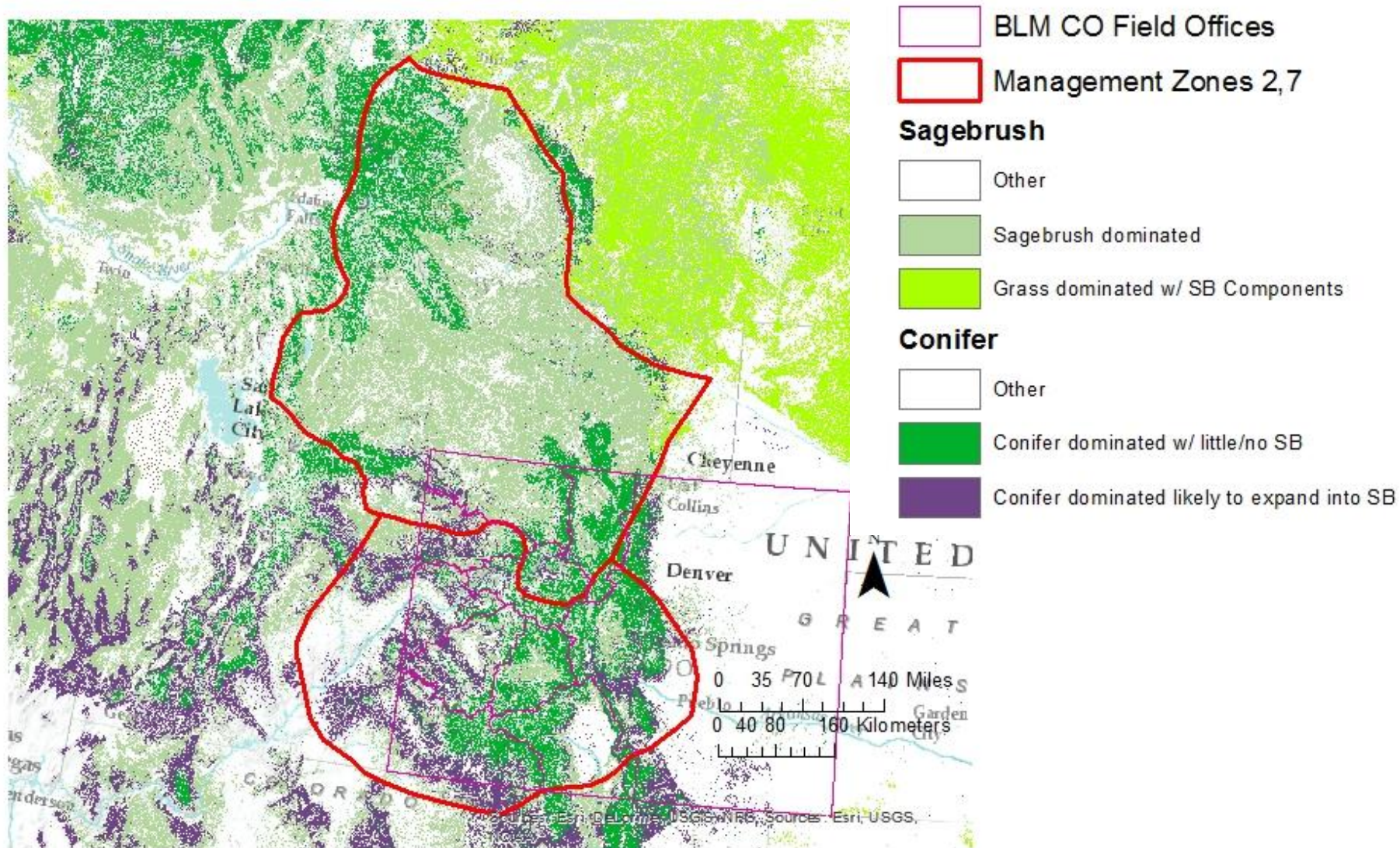
How much sagebrush (SB) dominated land is invaded by cheatgrass (CG)?



How much sagebrush (SB) has cheatgrass (CG)?



Where are areas of Sagebrush and Conifer?



Ecological systems in BpS and EVT capable of supporting sagebrush vegetation and capable of providing suitable seasonal habitat for Greater Sage-Grouse.

Colorado Plateau Mixed Low Sagebrush Shrubland	Inter-Mountain Basins Semi-Desert Shrub-Steppe
Columbia Plateau Low Sagebrush Steppe	Northwestern Great Plains Mixed Grass Prairie
Columbia Plateau Scabland Shrubland	Northwestern Great Plains Shrubland
Columbia Plateau Steppe and Grassland	Rocky Mountain Gambel Oak-Mixed Montane Shrubland
Great Basin Xeric Mixed Sagebrush Shrubland	Rocky Mountain Lower Montane-Foothill Shrubland
Inter-Mountain Basins Big Sagebrush Shrubland	Western Great Plains Floodplain Systems
Inter-Mountain Basins Big Sagebrush Steppe	Western Great Plains Sand Prairie
Inter-Mountain Basins Curl-Leaf Mountain Mahogany Woodland and Shrubland	Wyoming Basins Dwarf Sagebrush Shrubland and Steppe
Inter-Mountain Basins Mixed Salt Desert scrub	Artemisia tridentata ssp. Vaseyana Shrubland Alliance (EVT only)
Inter-Mountain Basins Montane Sagebrush Steppe	Quercus gambelii Shrubland Alliance (EVT Only)

Source: Greater Sage-grouse Monitoring Framework: Table 4. Used in Chambers et al 2016

Ecological systems with conifers most likely to encroach into sagebrush vegetation.

Colorado Plateau Pinyon-Juniper Woodland *Pinus edulis*

Columbia Plateau Western Juniper Woodland and Savanna

East Cascades Oak-Ponderosa Pine Forest and Woodland

Great Basin Pinyon-Juniper Woodland *Pinus monophylla*

Northern Rocky Mountain Ponderosa Pine Woodland and Savanna

Rocky Mountain Foothill Limber Pine-Juniper Woodland

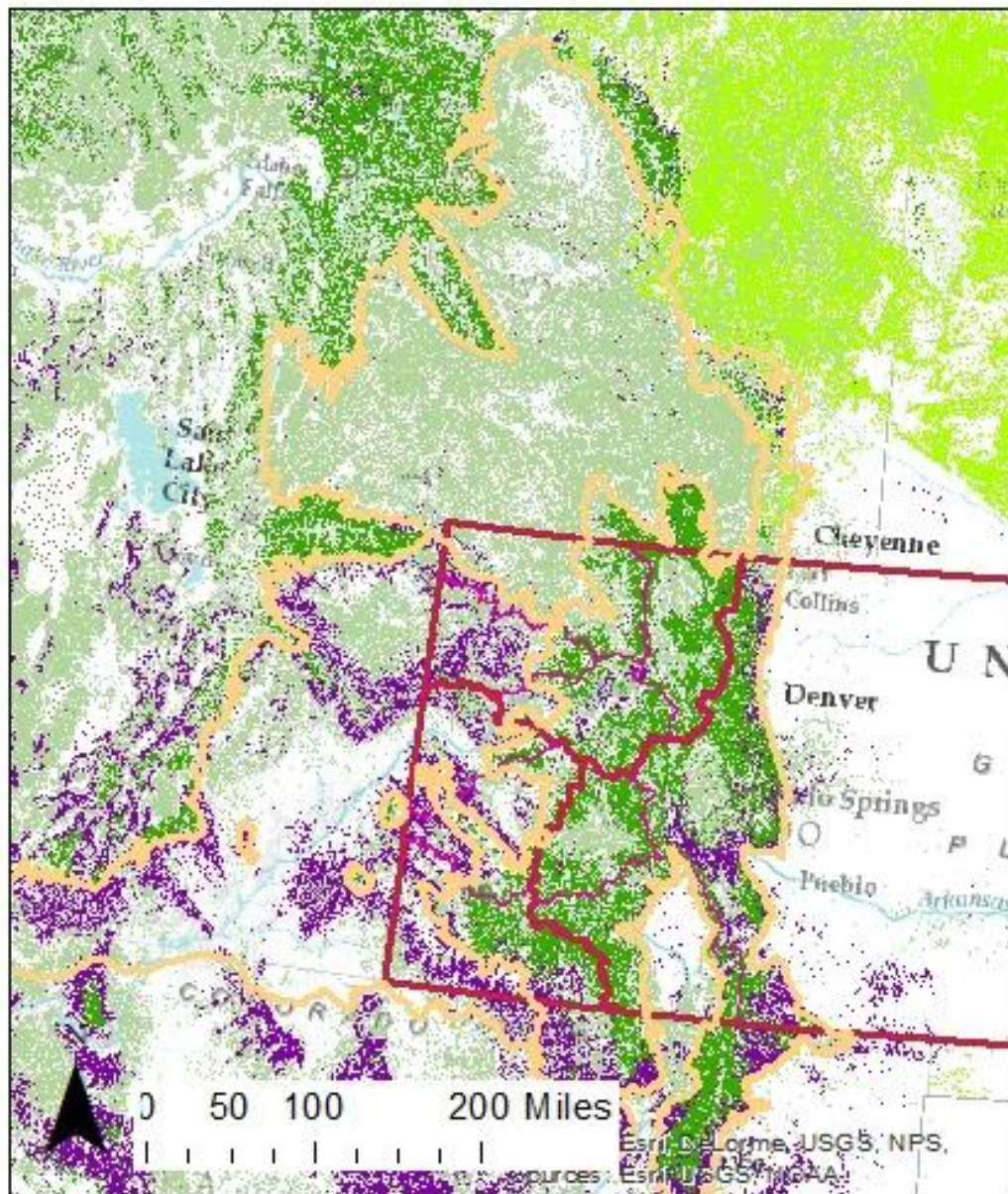
Rocky Mountain Poor-Site Lodgepole Pine Forest

Southern Rocky Mountain Pinyon-Juniper Woodland

Southern Rocky Mountain Ponderosa Pine Woodland

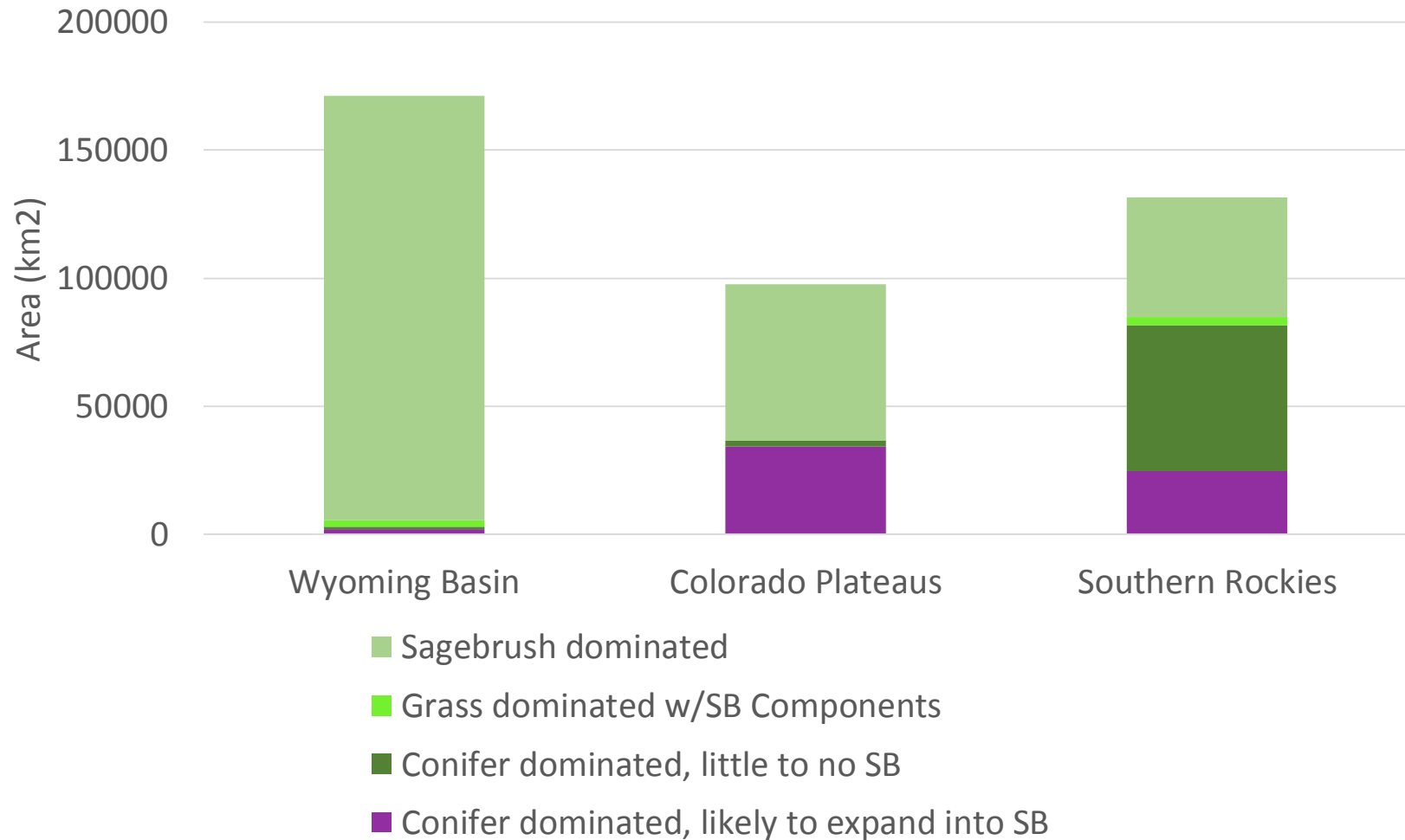
Source: Greater Sage-grouse Monitoring Framework: Table 5. Used in Chambers et al 2016

Conifer and sagebrush by Level 3 Ecoregions

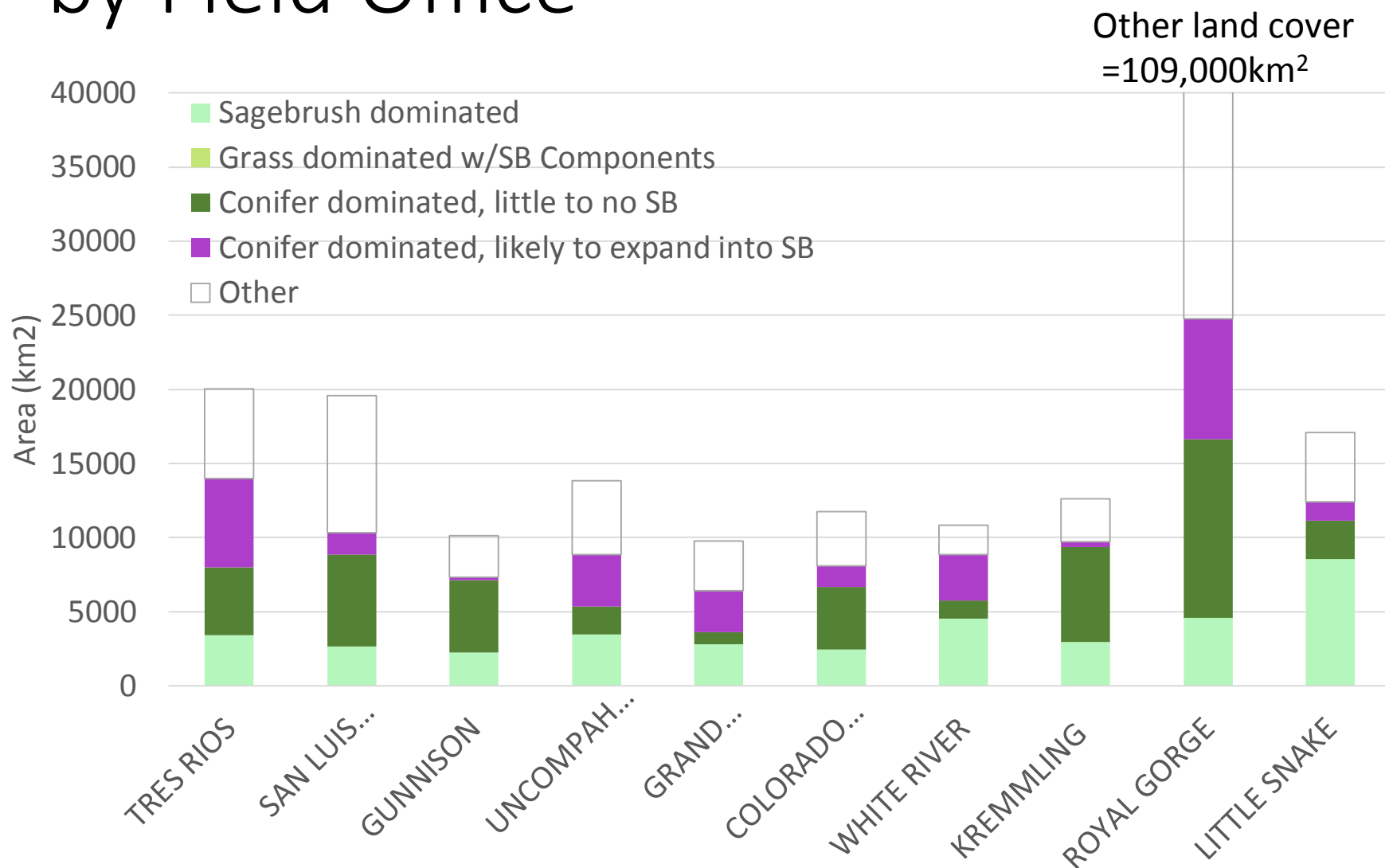


- BLM_CO_Field Offices
- CO District Bnds
- L3_WYB_COP_SR
- Sagebrush dominated
- Grass dominated w/ SB Components
- Conifer dominated w/ little or no SB
- Conifer dominated, likely to expand into SB

Conifer and sagebrush coverage by Level 3 Ecoregions



Conifer and sagebrush coverage by Field Office

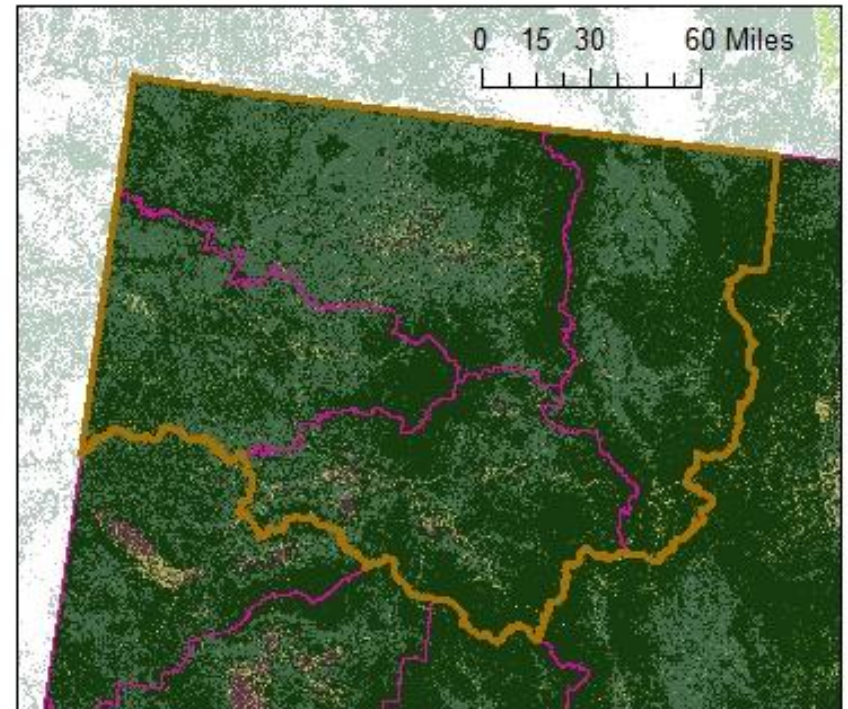
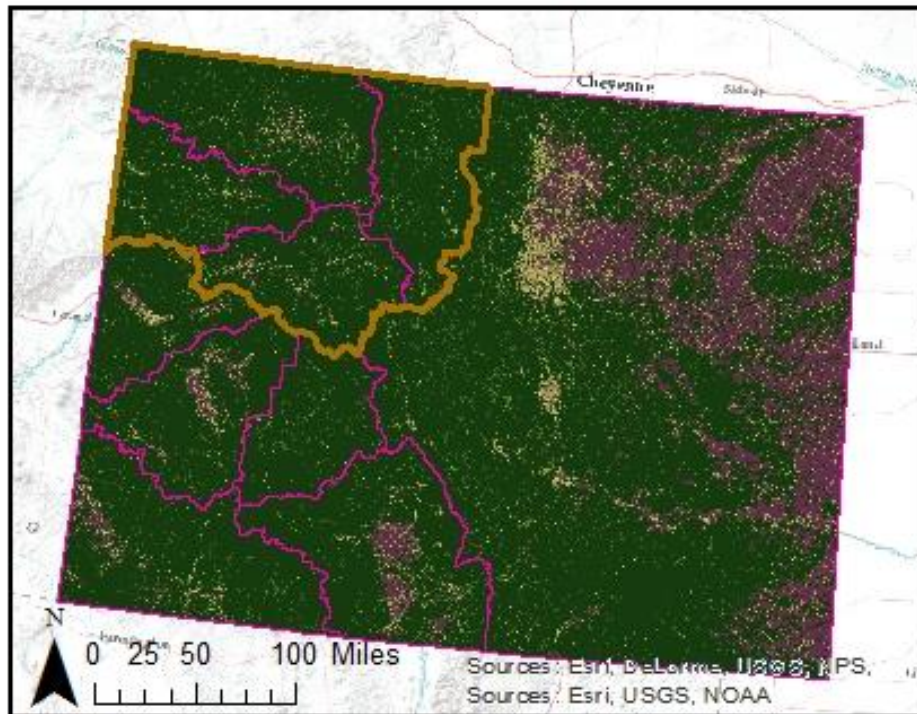


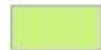
Development



- Data sources:
 - USGS West-wide Intactness and Development Footprint
 - Percent DV by 90m cell size
 - Includes urban, agricultural, energy/utilities, and transportation
 - BLM NOC Wildlife Lab Disturbance Data Set
 - Vector-based area footprint
 - Excludes agriculture
 - Based on detailed State guidelines. States calculate disturbances for broad scale and project scale. Calculation of disturbances vary by percent disturbance threshold, by definition of the extent used to calculate the disturbance (i.e., various buffers and boundaries), and vary according to the threats considered at difference percent disturbance. Threats are listed in the GrSG Monitoring Framework, Table 2. Local guidelines can be found in RMPs. Where else?

Where are developed areas (*left*) in relation to sagebrush (*right*)?



-  BLM_CO_NWDO
-  BLM_CO_FO_Boundary
-  Sagebrush Dominated
-  Grass Dominated w/Sagebrush Components

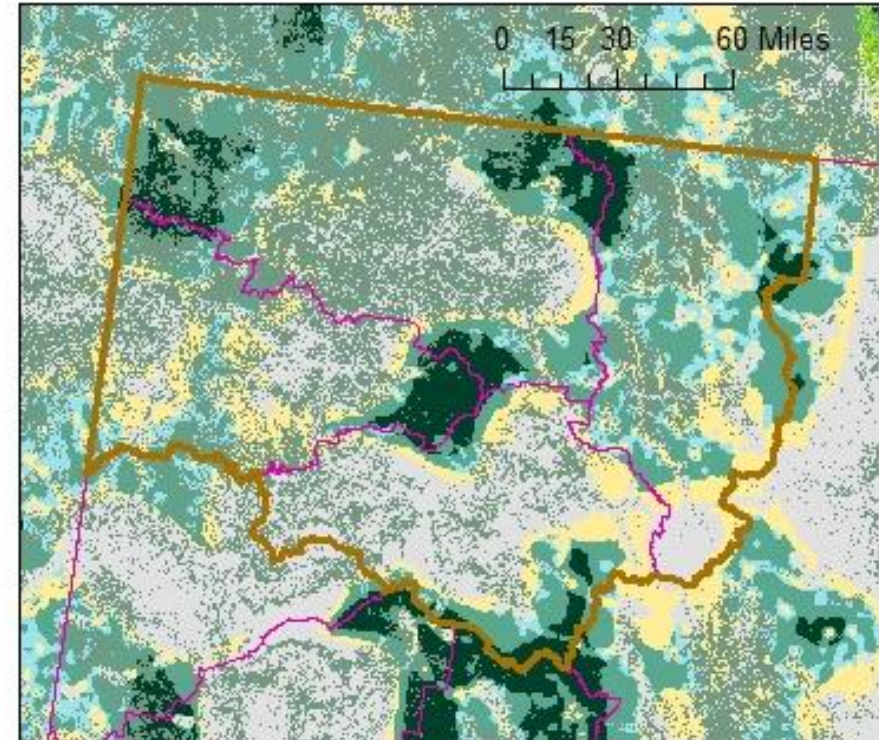
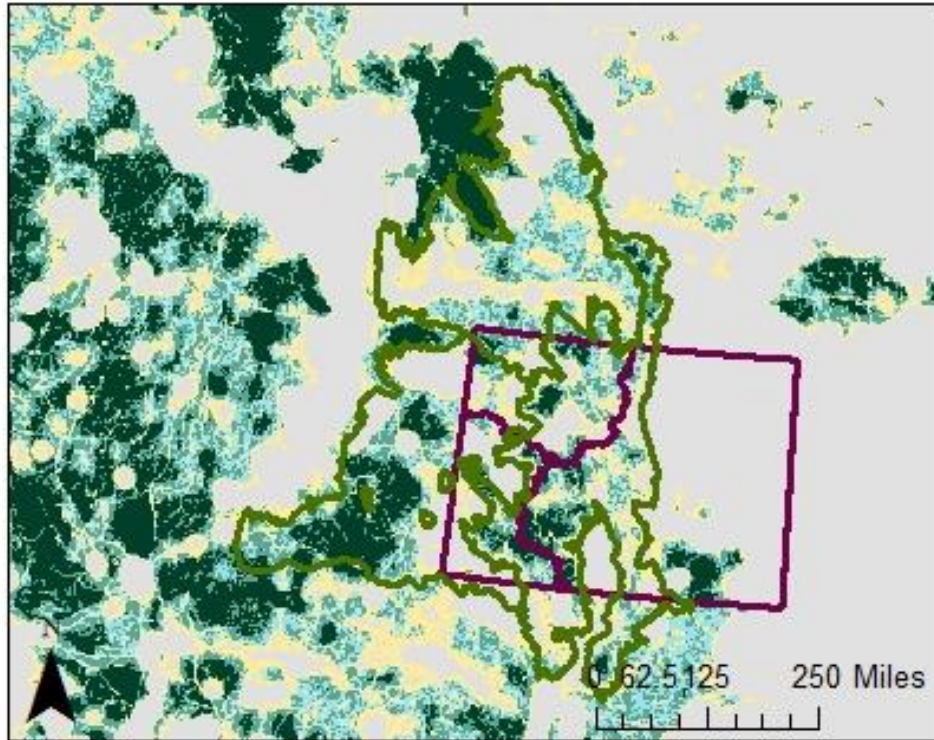
Development by percent area of 90m cell



USGS Landscape Intactness Levels Defined by 2.5km and 20km Radii Moving Windows

- Highest = 0 to 1 % at both scales
- Very-high = 0 to 1% at one scale and 1 to 2 % at the other scale
- High = 1 to 2 percent at both scales
- Moderate = 2 to 3 percent at one scale and less than 3 percent at the other scale
- Lowest = greater than 3 percent at either scale.
- What are useful thresholds of development to consider?

Landscape Intactness (*left*) and Sagebrush overlaid (*right*)



-  BLM_CO_NWDO
-  BLM_CO_FO_Boundary
-  Sagebrush Dominated
-  Grass Dominated w/Sagebrush Components

USGS Multiscale Index of Landscape Intactness

Level

-  Lowest
-  Moderate
-  Very high
-  High
-  Highest

Fire!



Photo Source: NPS

Fire Risk Assessment for the Greater Sage-Grouse Raster (Crist et al 2016)



Three GIS datasets were used in the assessment:

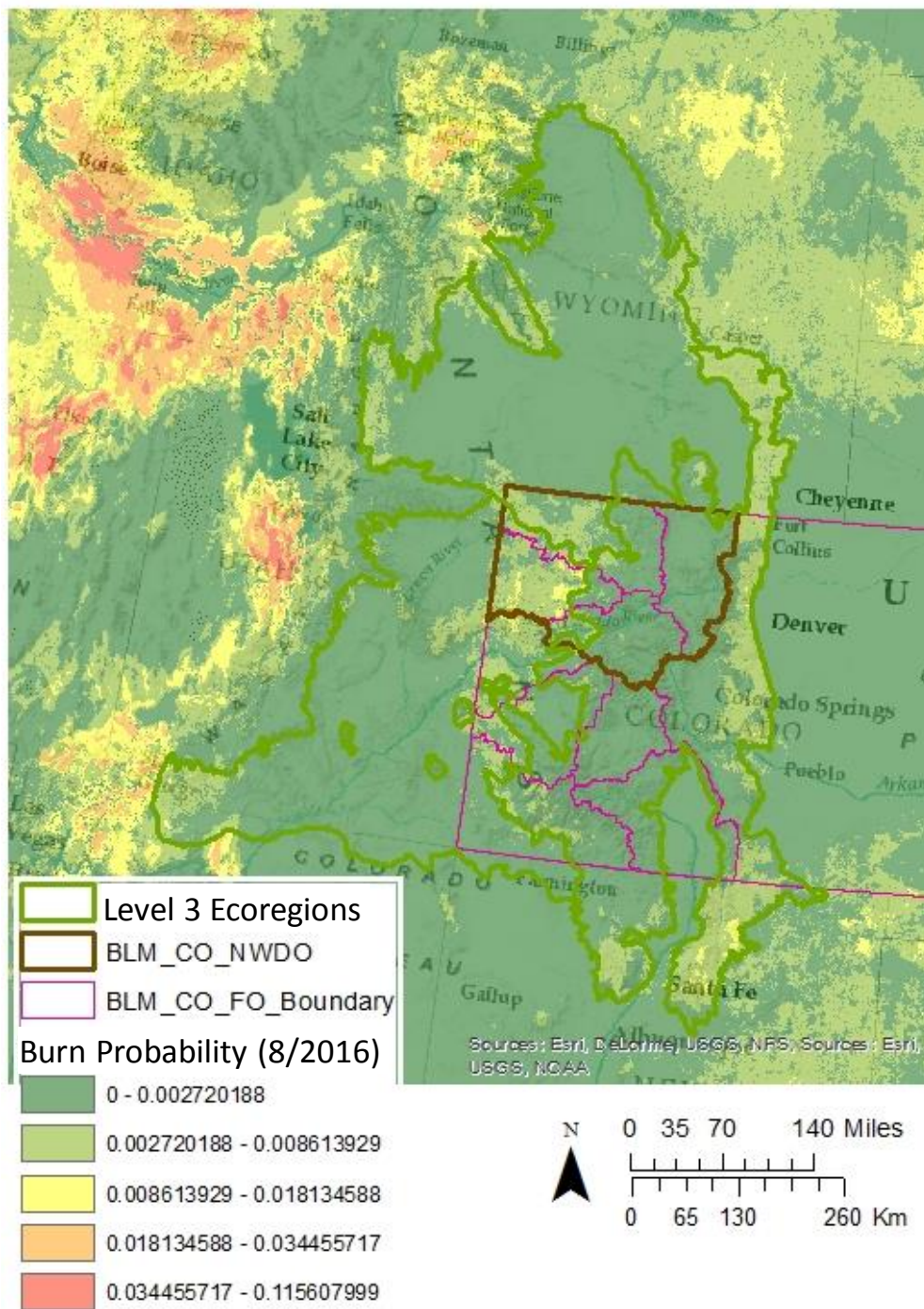
1. large fire burn probability (Short et al. 2016 – next slide);
2. greater sage-grouse breeding habitat probabilities (Doherty et al. 2016), and
3. resilience and resistance as indicated by soil temperature and moisture regimes (Maestas et al. 2016).

The three datasets were combined by summing the values in a raster grid format.

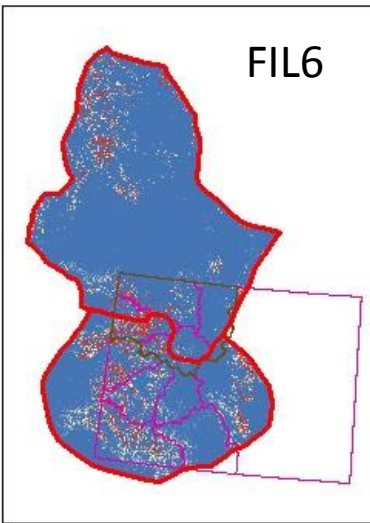
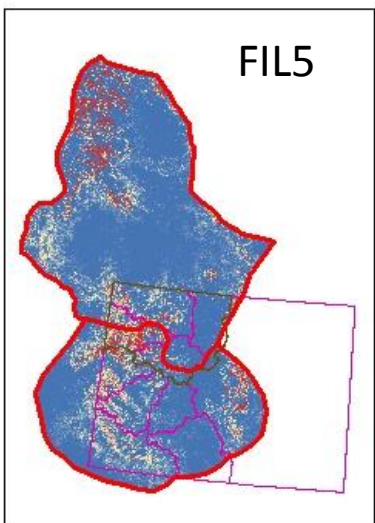
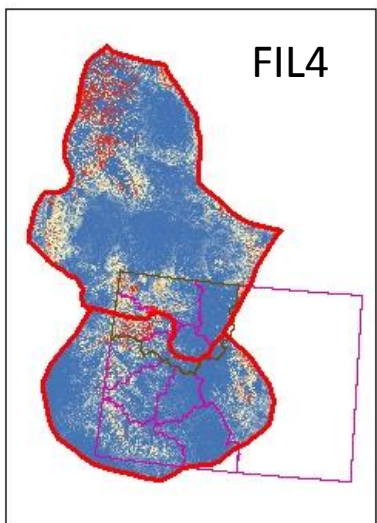
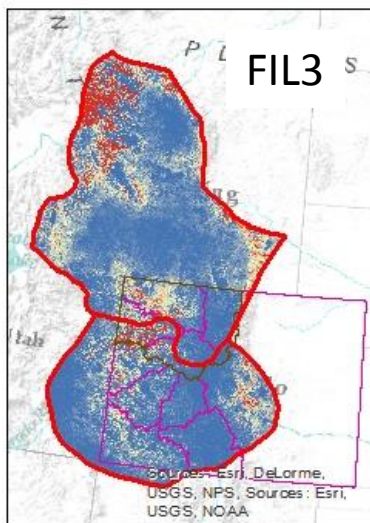
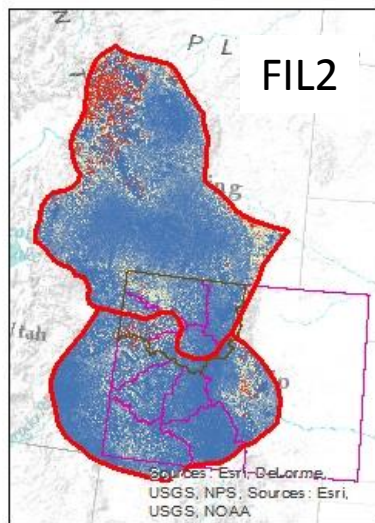
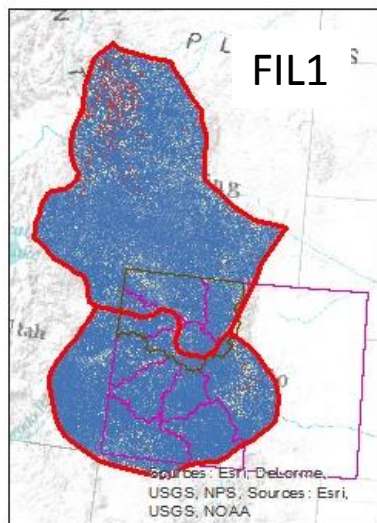
Breeding habitat probabilities raster is the mask for this data set so this is incomplete for the sagebrush biome.

Actual Burn Probabilities (Short et al, 2016 – data set only)

- BP is West-wide data
- Fire behavior variability is expressed in terms of conditional probabilities of flame length or fire intensity level. The conditional probabilities from all six categories sum to 1.0 and can be multiplied by the actual burn probability to produce absolute probabilities (next slide). (Finney et al, 2011)



Fire Risk = Burn Probabilities X Fire Intensity
Level (Flame Length) Conditional Probabilities



FIL1 = < 2 ft flame length

FIL2 = 2 - 4 ft

FIL3 = 4 - 6 ft

FIL4 = 6 - 8 ft

FIL5 = 8 - 12 ft

FIL6 = 12+ ft

MZ_2_7

BLM_CO_NWDO

BLM_CO_FO_Boundary

Burn Prob * Fire Intensity x

Value

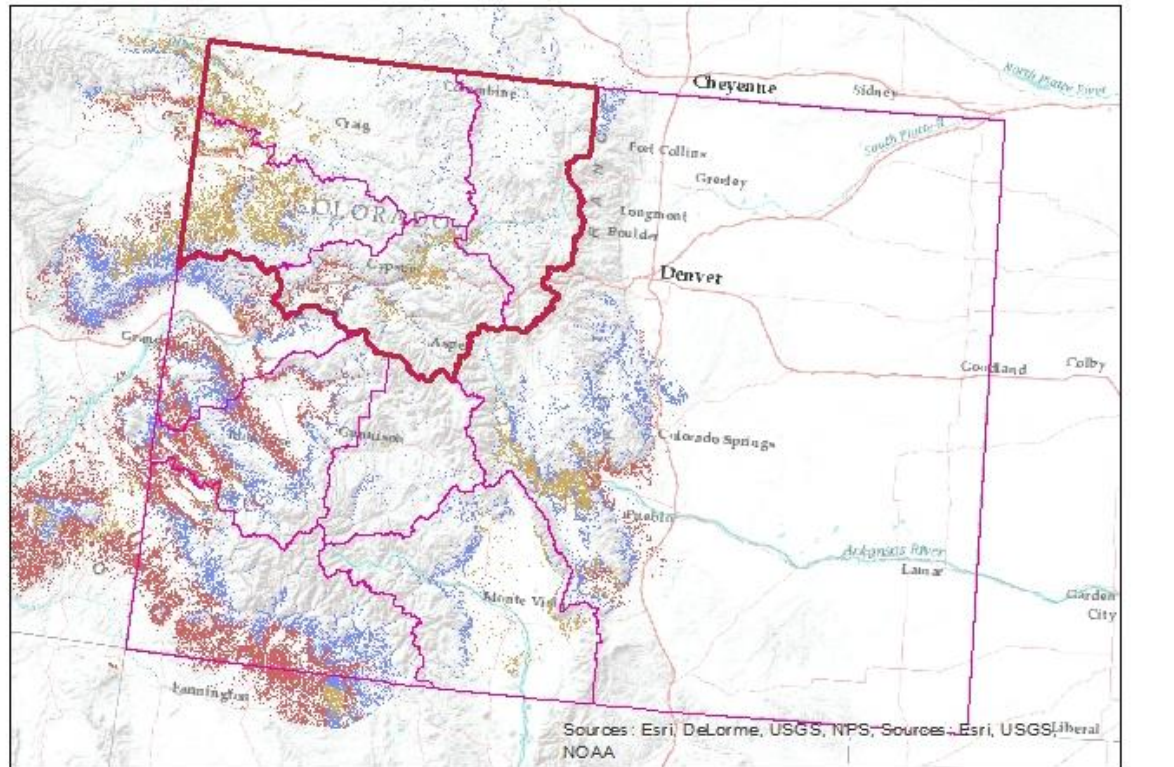
High : 0.0254795

Low : 0

Sagebrush interactions with predominant threats

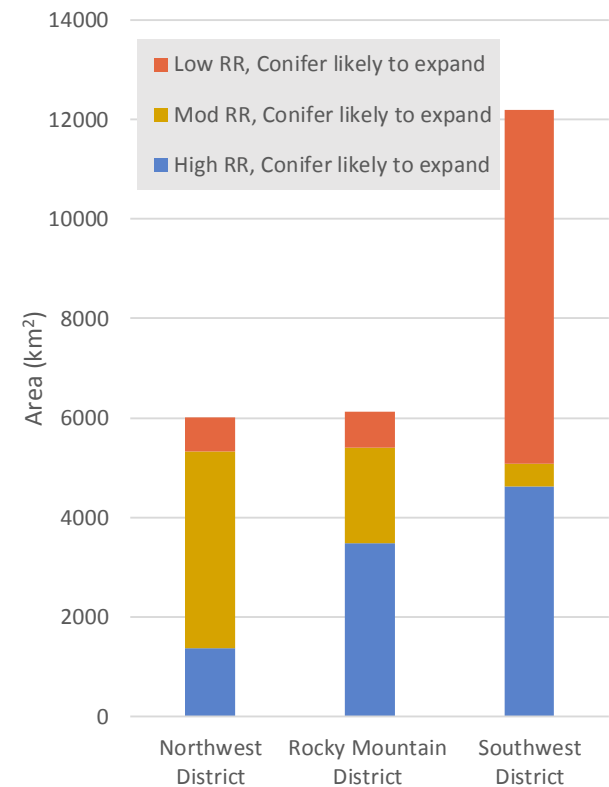
- ✓ How does the R&R vary in areas where PJ is likely to expand into sagebrush?
- ✓ How does fire risk vary in sagebrush and PJ expansion areas?
- ✓ How does R&R vary in areas dominated by sagebrush and invaded by cheatgrass?
- ✓ Where might WY Big Sagebrush grow in 2050?
 - Are areas of sagebrush fragmented by development (DV)?
 - How will future changes in development affect the sagebrush biome?
 - What about grazing – this is mentioned as an option for management and treatment, not as a CA?
 - What other interactions are relevant?

How does the R&R vary in areas where conifer is likely to expand into sagebrush? Colorado

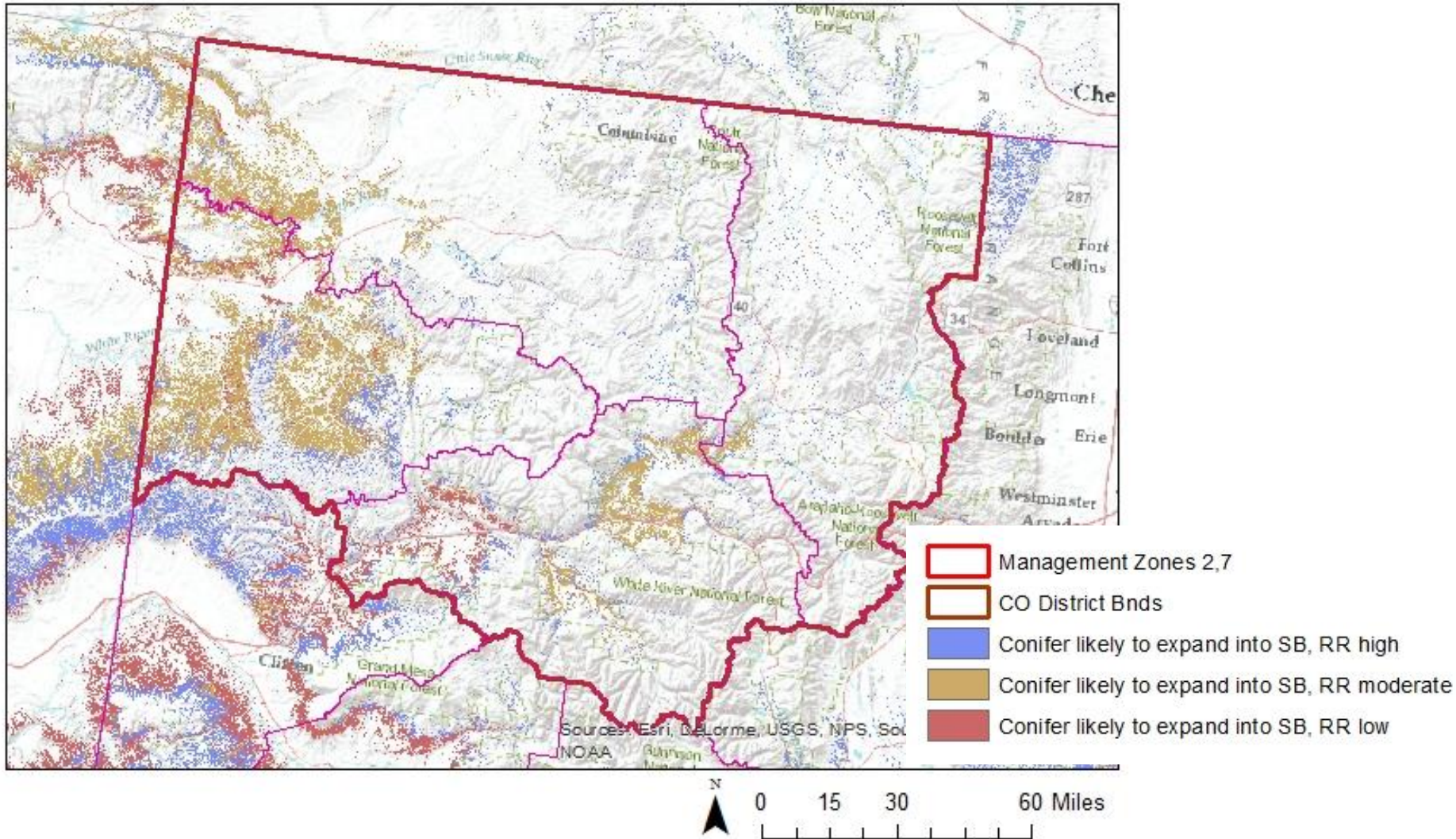


- Management Zones 2,7
- CO District Bnds
- Conifer likely to expand into SB, RR high
- Conifer likely to expand into SB, RR moderate
- Conifer likely to expand into SB, RR low

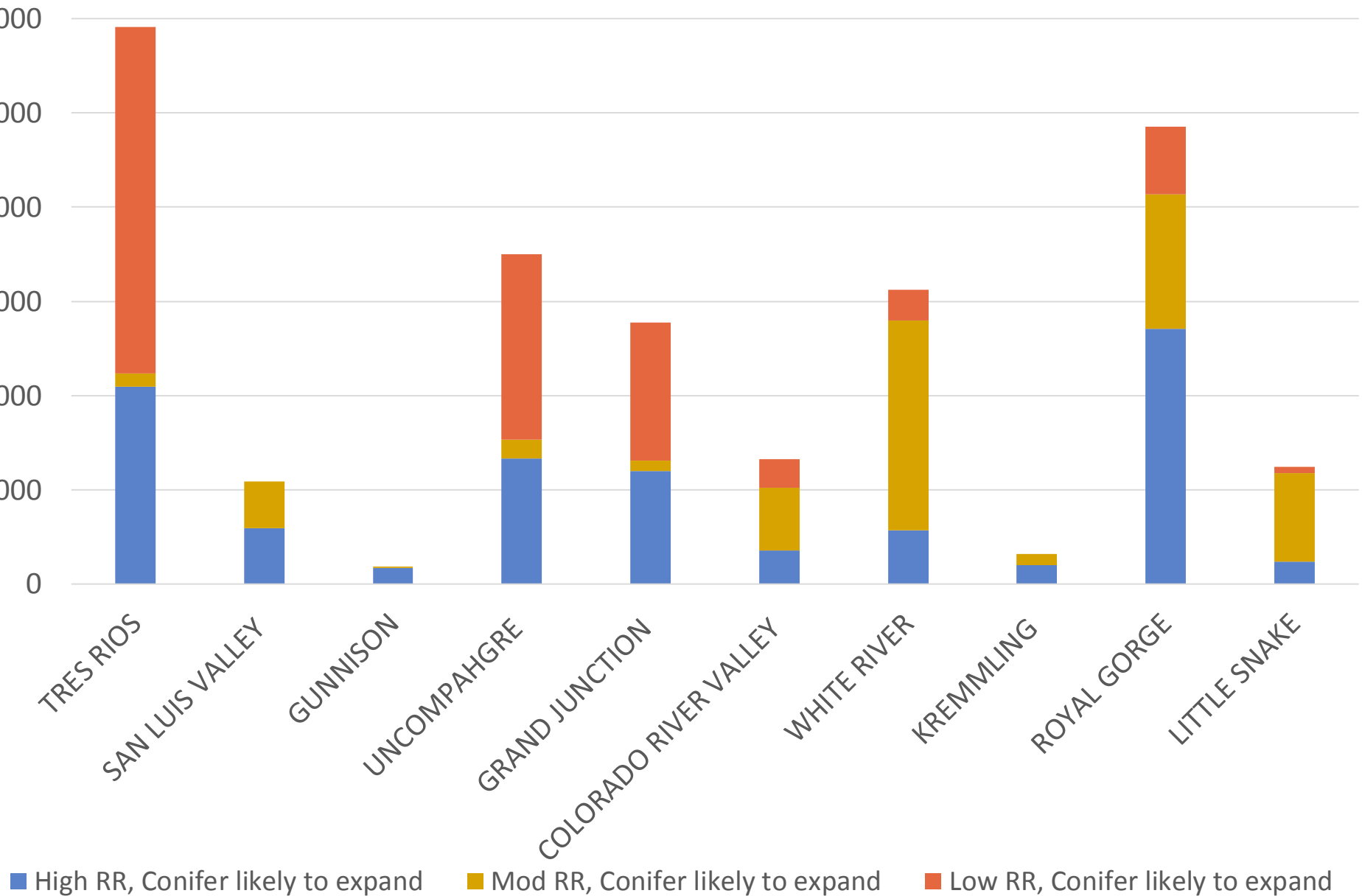
Areas that are conifer dominated and likely to expand into sagebrush by R&R



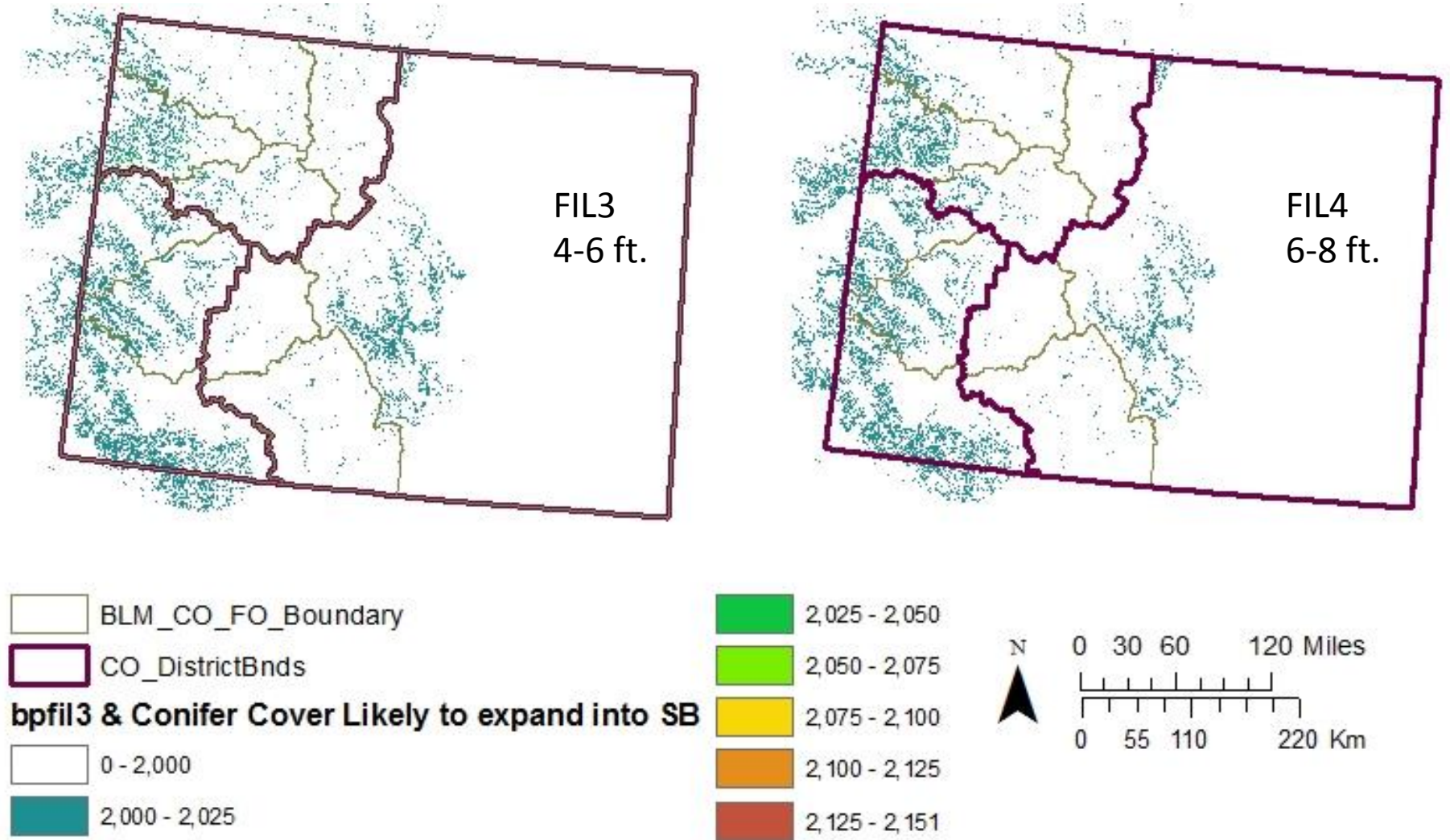
How does the R&R vary in areas where conifer is likely to expand into sagebrush? Northwest District, CO



How does the R&R vary in areas where conifer is likely to expand into sagebrush? CO Field Offices



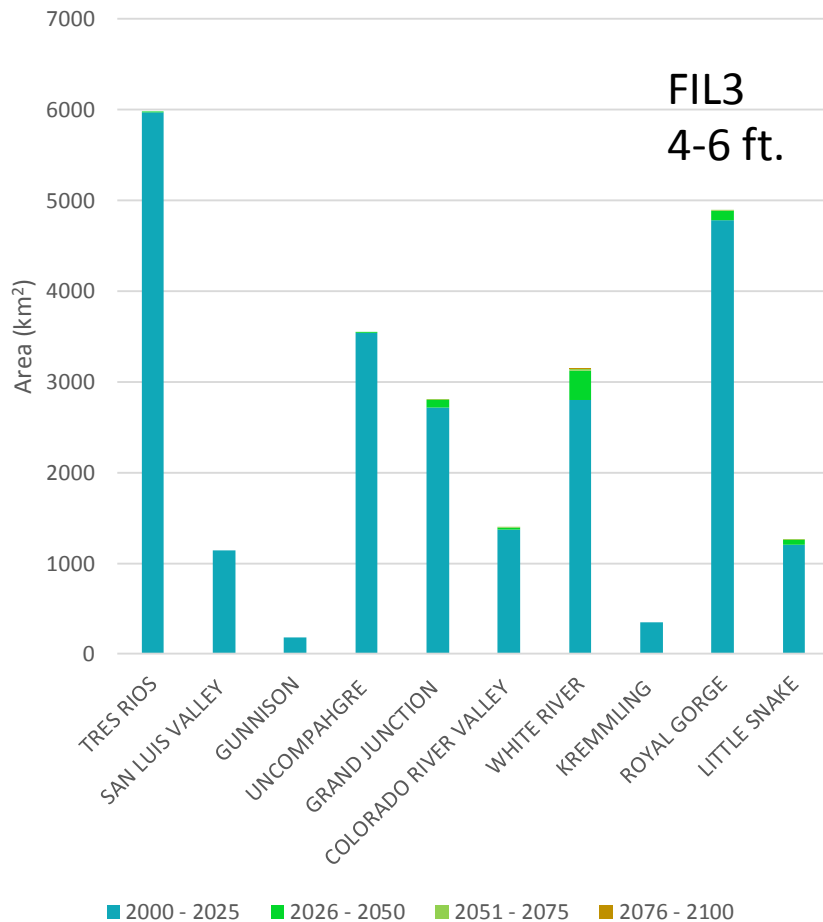
How does fire risk vary in sagebrush and conifer expansion areas?



Warmer colors indicate higher fire probabilities. See notes to explain the values

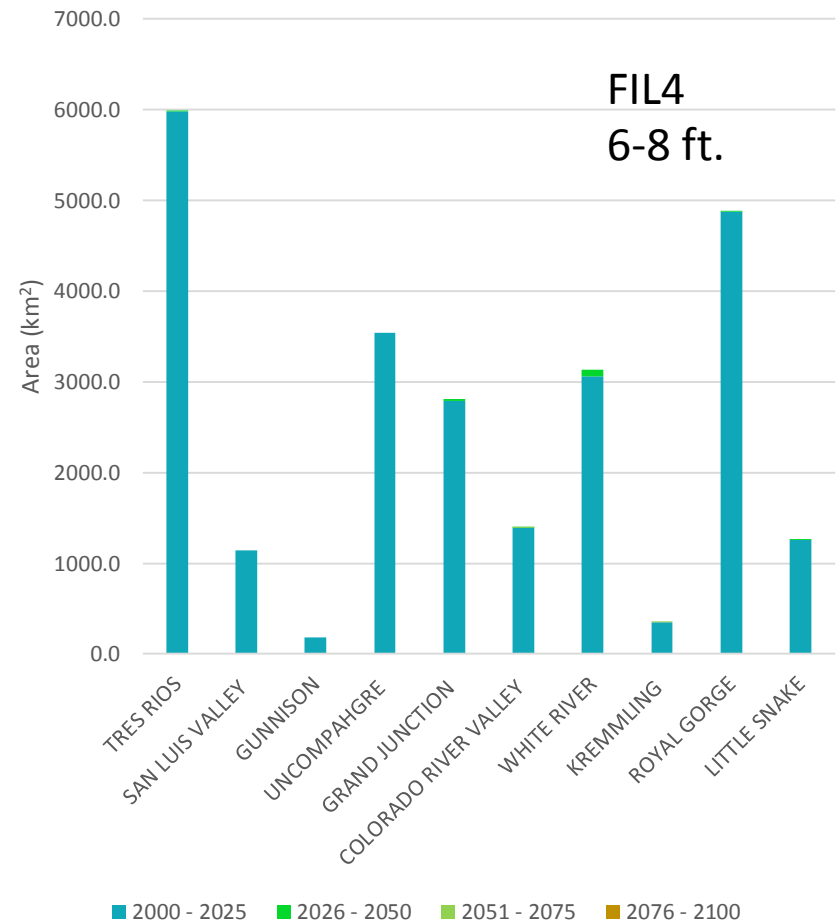
Identify areas of expanding conifer cover with higher fire risk using FIL3 and FIL4 in CO

Fire probabilities at 4-6 ft flame length and
Conifer Cover likely to expand into Sagebrush



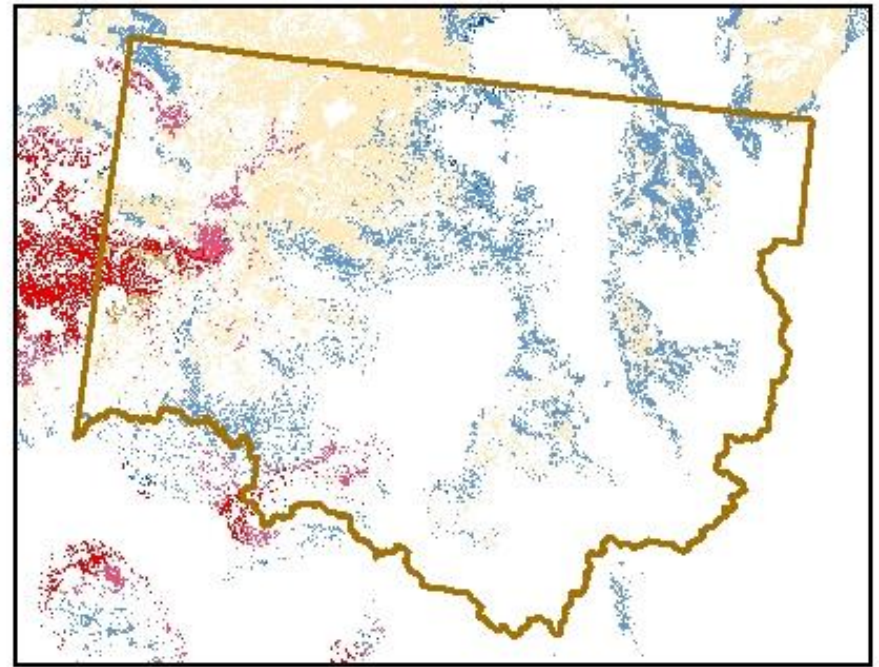
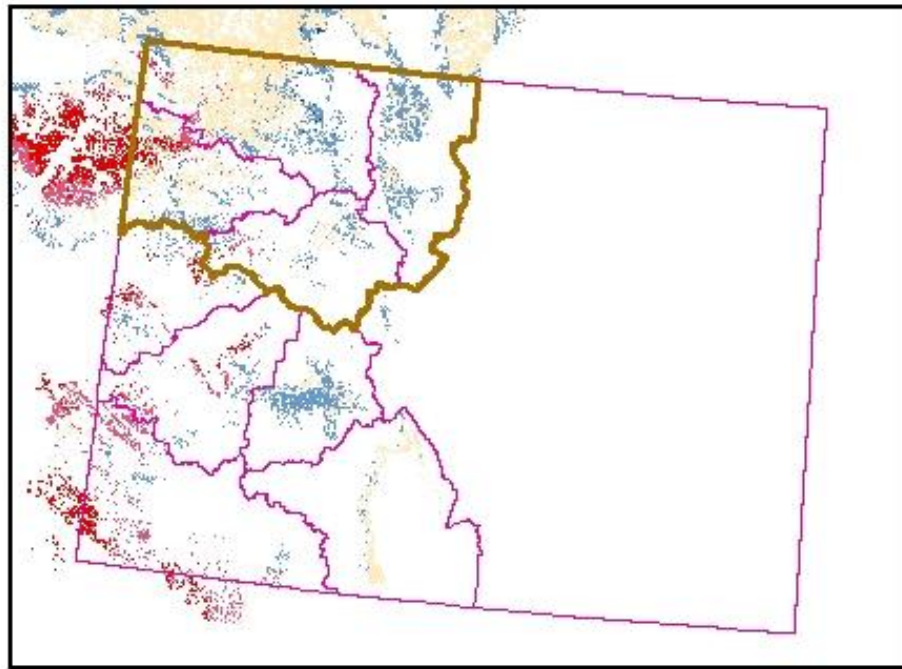
<- Lower to higher fire risk ->

Fire probabilities at 4-6 ft flame length and
Conifer Cover likely to expand into Sagebrush



<- Lower to higher fire risk ->

How does R&R vary in areas dominated by sagebrush and invaded by cheatgrass?



BLM_CO_NWDO
BLM_CO_FO_Boundary

R&R, Sagebrush, Cheatgrass

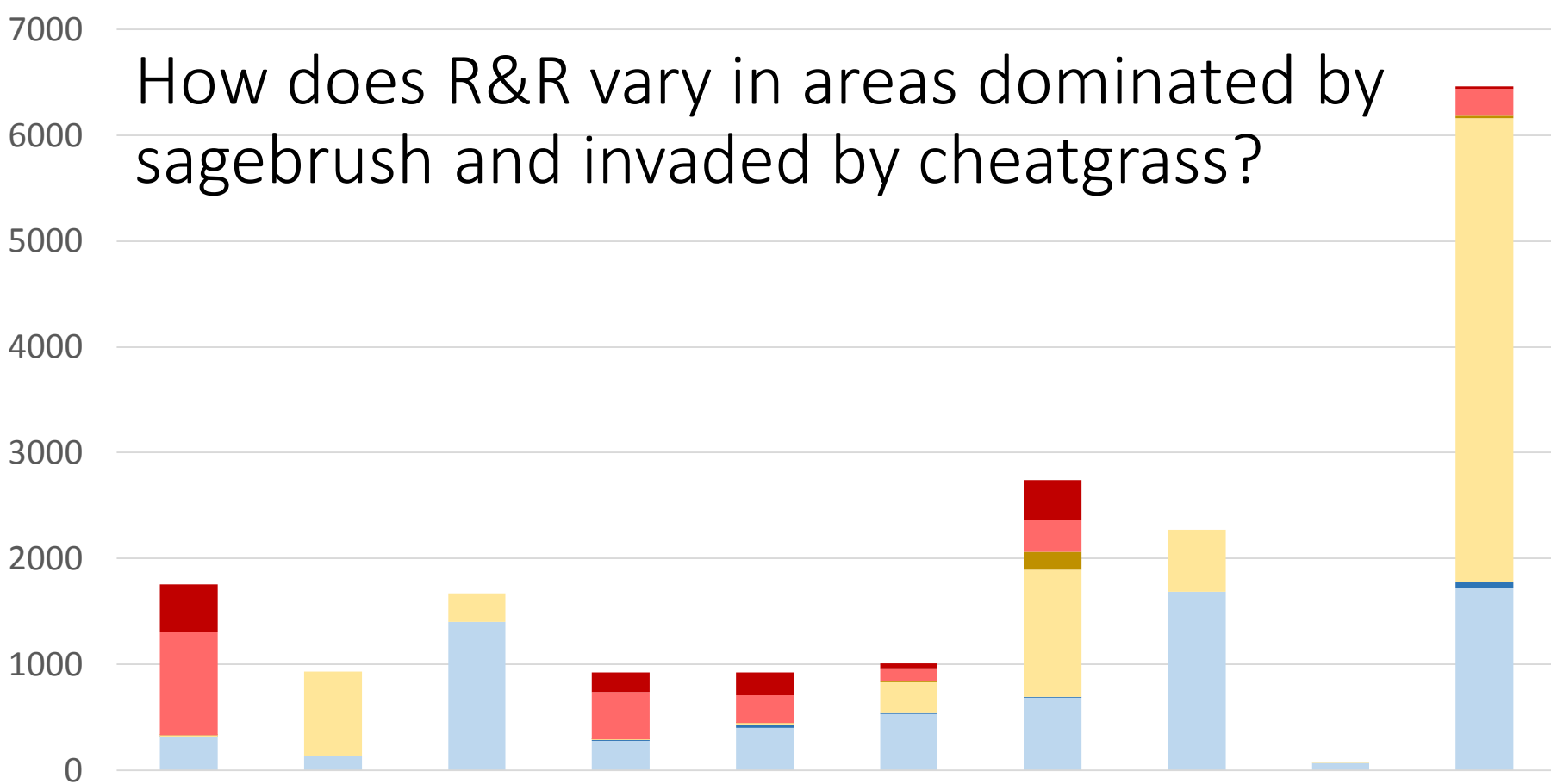
Hi RR, SB Dom, CG 0-2%
Hi RR, SB Dom, CG > 2%
Mod RR, SB Dom, CG 0-2%

Mod RR, SB Dom, CG > 2%
Low RR, SB Dom, CG 0-2%
Low RR, SB Dom, CG > 2%



How does R&R vary in areas dominated by sagebrush and invaded by cheatgrass?

Area (km²)



Hi R&R, SB Dom, CG 0-2%

Hi R&R, SB Dom, CG > 2%

Mod R&R, SB Dom, CG 0-2%

Mod R&R, SB Dom, CG > 2%

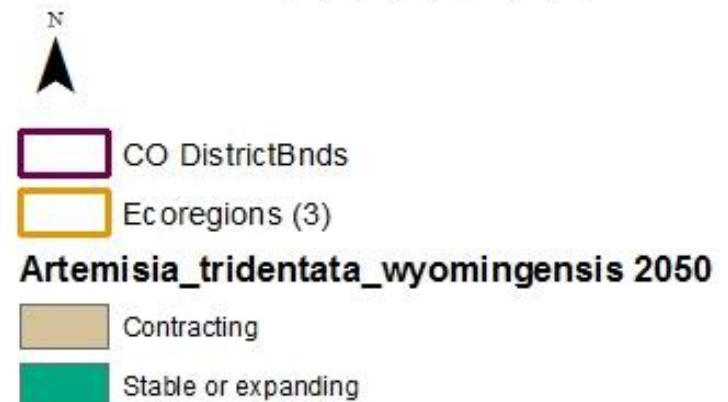
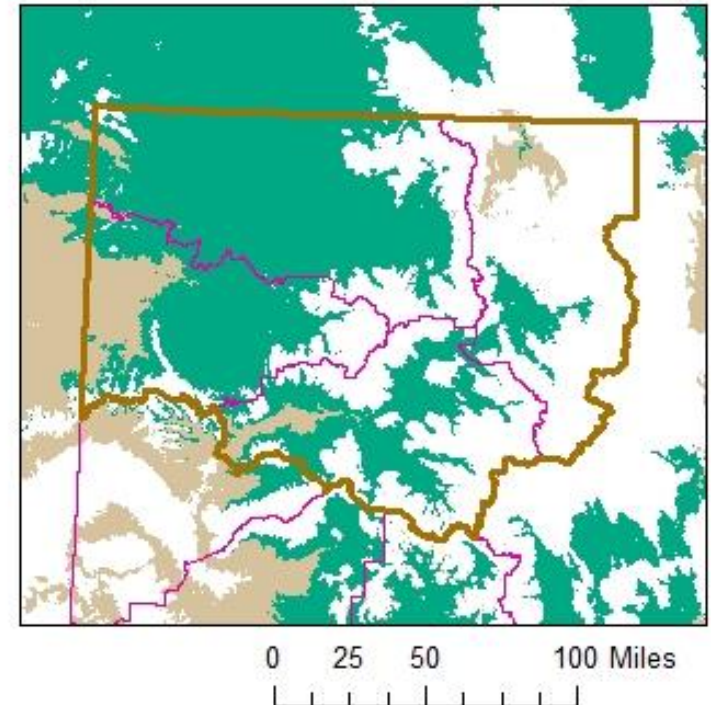
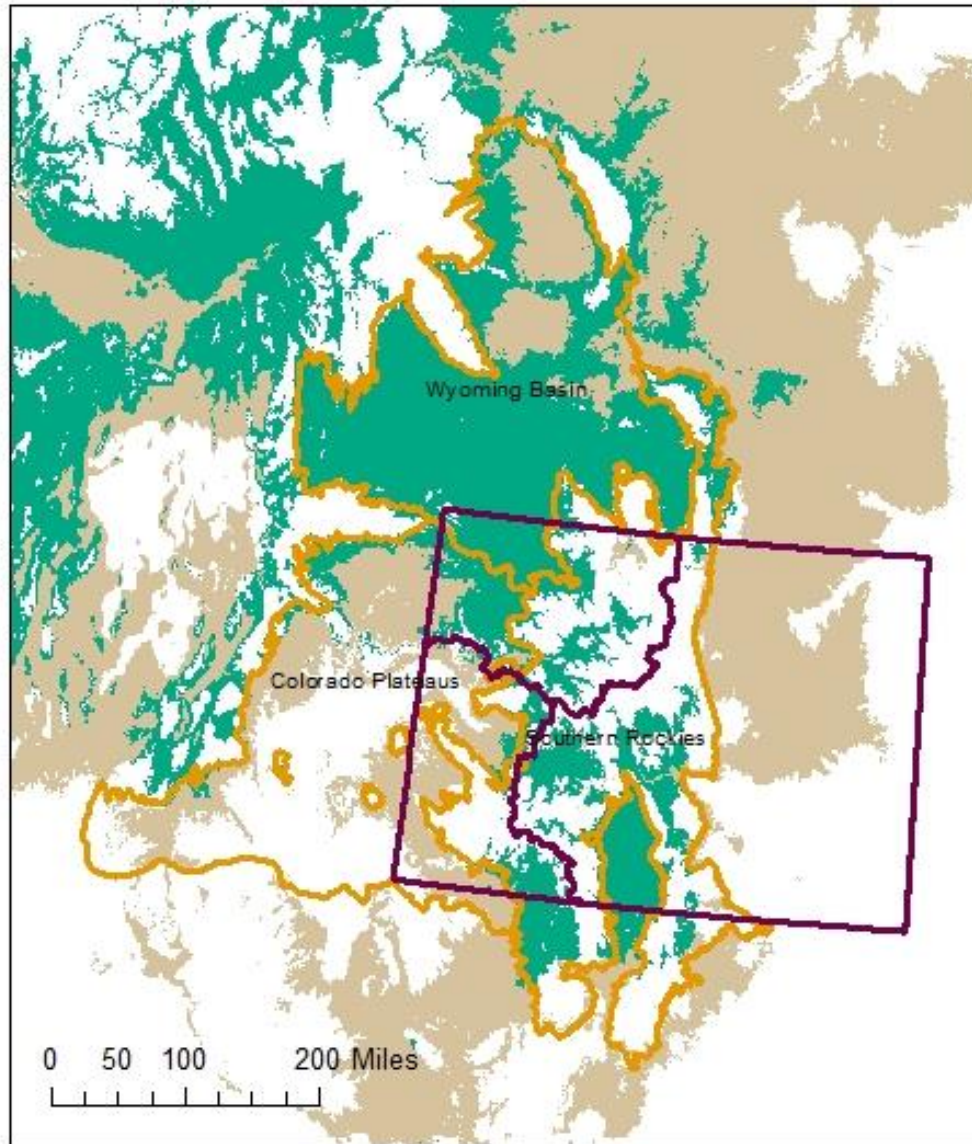
Low RR, SB Dom, CG 0-2%

Low RR, SB Dom, CG > 2%

Are areas of sagebrush fragmented by development (DV)?

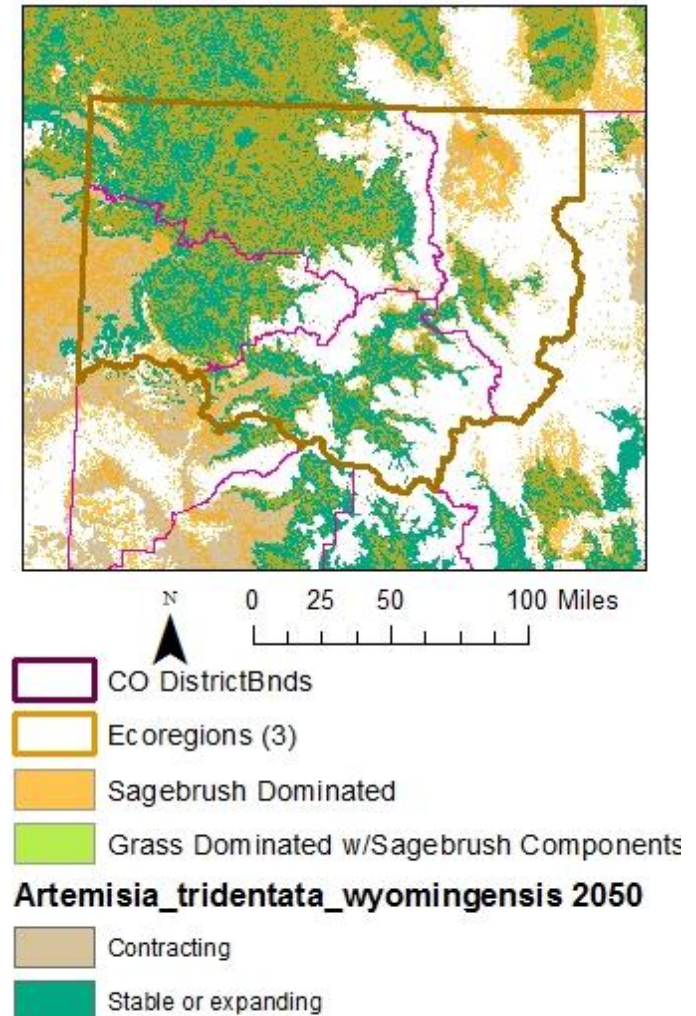
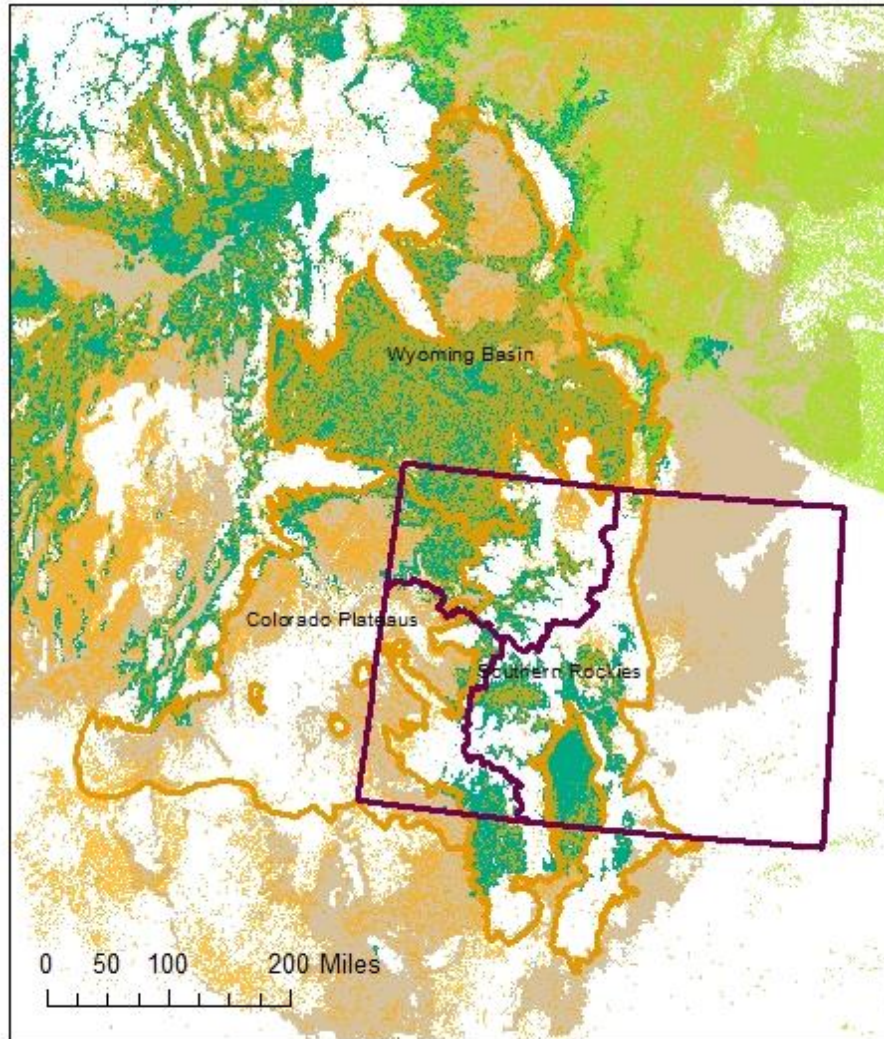
Analysis not yet complete

Where might WY Big Sagebrush grow in 2050?



Still & Richardson, 2015

Potential Sagebrush changes compared to current LandFire Sagebrush coverage



How will future development affect the sagebrush biome?

Analysis not yet complete

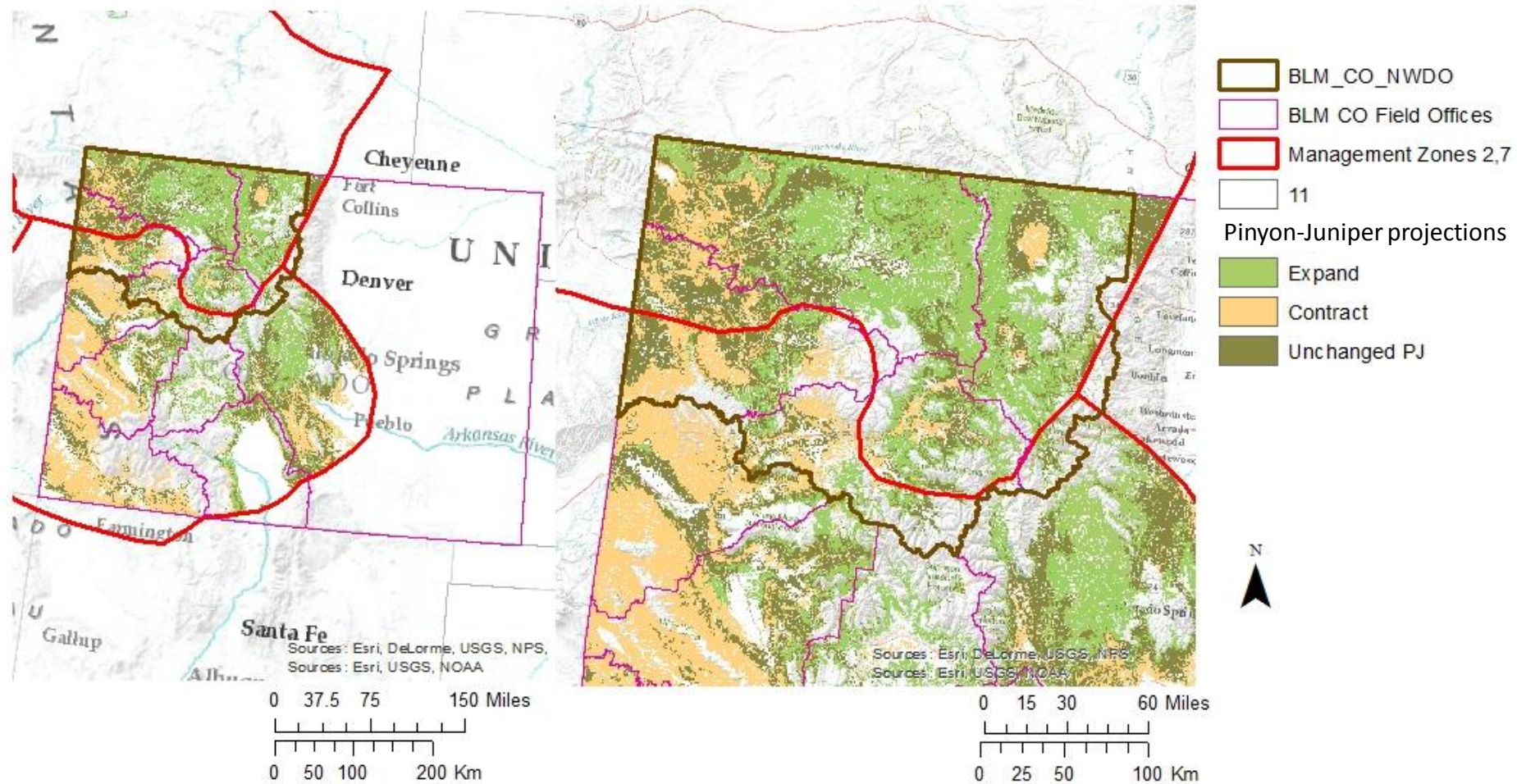
Climate Change

- Used data from **Research on Forest Climate Change: Potential Effects of Global Warming on Forests and Plant Climate Relationships in Western North America and Mexico**
- Rehfeldt et al, 2006 Empirical Analyses of Plant Climate Relationships for the Western US.
- Random Forests multiple regression tree modeling using current climate and projecting using downscaled GCM
- Initially 25 biotic communities and 9 species
- This work is expanded to more species, to US-wide coverage
- The work is updated for assessment reports
 - AR3 – Emissions scenarios: A1B, A2, B1, B2 *for greenhouse gas emissions and was superceded by*
 - AR5 - Representative Concentration Pathways (rcp45, rcp60, rcp85) *for greenhouse gases concentrations*
- Data resolution about 1km

PJ viability under climate change

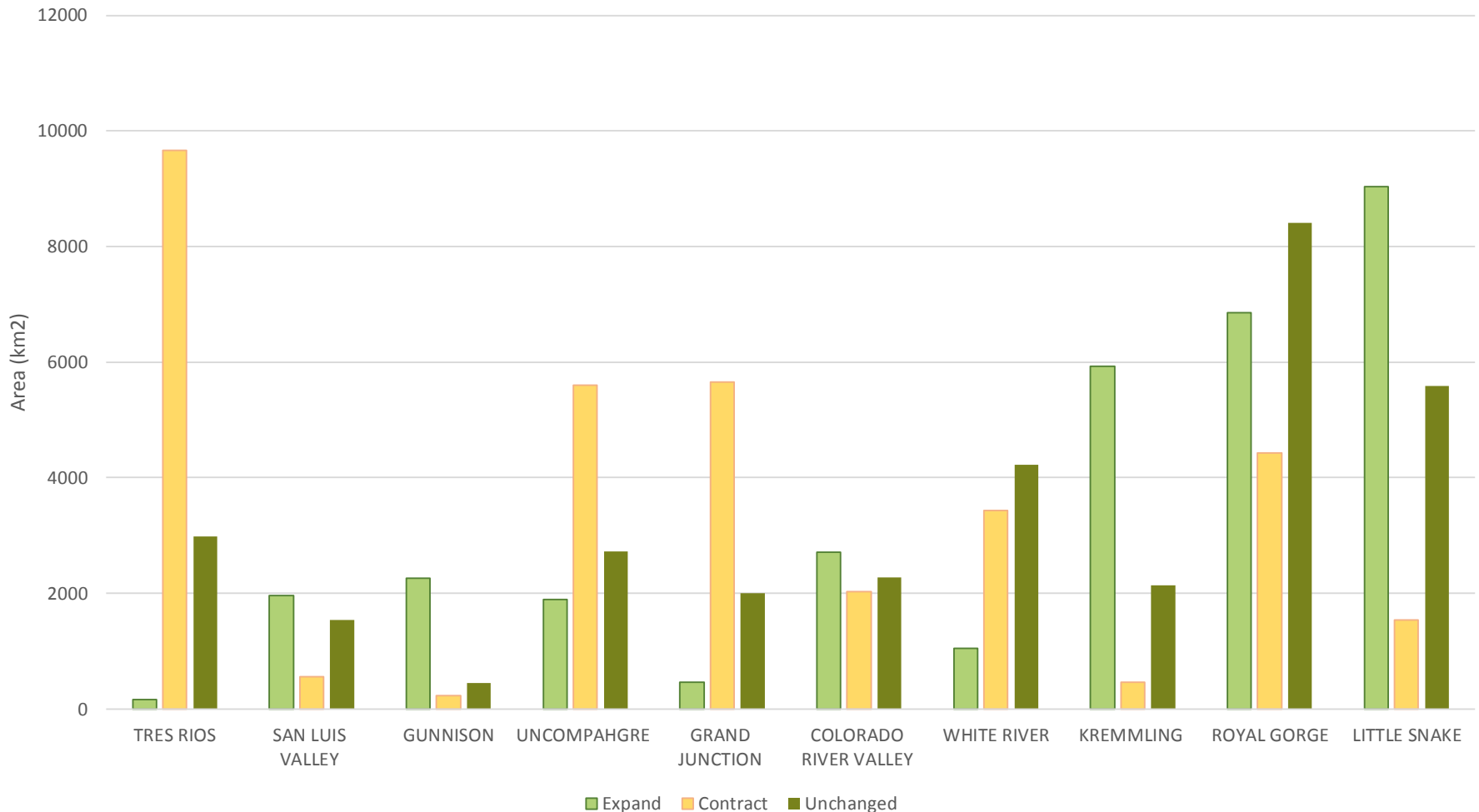
- Species used: Pinyon Pine, Rocky MT Juniper and Utah Juniper
- Current and SRES A2, 2030, CGCM – 2060 and 2090 also available
- Species viability is modeled 0 to 1 where 1 means that the species is most viable under that climate
- **For the 3 PJ species, use the max value of the 3 rasters for current and 2030**

A comparison of Current and Projected (2030) PJ species viability -> Expansion and contraction (excluding areas of more than 5% development)



Expanding, contracting, and unchanged PJ

– currently includes dv'd areas



Summary – Questions - Next Steps

- SMRRT – we used best broad-scale and consistent data sets for sagebrush, R&R, and threats
 - Did we miss any potential threats?
 - Are some threats more important than others, i.e. deserve more focus?
 - Do development threats need to be analyzed separately (e.g., oil and gas)
- What other analyses would be useful?
- Would it be useful to determine thresholds and map/summarize using those?
 - For example: is 2% cheatgrass cover a useful threshold?

Using the SMRRT Science Framework, identify Management Questions specific to Sagebrush biome in CO Districts – these MQs are species specific, how do we make this relevant to the sagebrush biome?

Prioritize areas for management

- Need to develop thresholds for threats (development, cheatgrass, fire)
- Does the area provide suitable habitat and support species populations?
- Can the area be improved by active management?
- If area is at risk due to low R&R but has high conservation value for a focal species, how can it be maintained or improved through management?

References

- Chambers, J.C et al. 2016. **Using resilience and resistance concepts to manage threats to sagebrush ecosystems, Gunnison sage-grouse, and Greater sage-grouse in their eastern range: A strategic multi-scale approach.** Gen. Tech. Rep. RMRS-GTR-356. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 143 p. https://www.fs.fed.us/rm/pubs/rmrs_gtr356.pdf
- Chambers, J.C. et al. 2017. **Science framework for conservation and restoration of the sagebrush biome: Linking the Department of the Interior's Integrated Rangeland Fire Management Strategy to long-term strategic conservation actions. Part 1. Science basis and applications.** Gen. Tech. Rep. RMRS-GTR-360. Fort Collins, CO: U.S Department of Agriculture, Forest Service, Rocky Mountain Research Station. 213 p. <https://www.treesearch.fs.fed.us/pubs/53983>
- Maestas et al, 2016. **Tapping Soil Survey Information for Rapid Assessment of Sagebrush Ecosystem Resilience and Resistance.** Rangelands, 38(3):120-128. <http://www.bioone.org/doi/full/10.1016/j.rala.2016.02.002>
- Still and Richardson, 2015. **Projections of Contemporary and Future Climate Niche for Wyoming Big Sagebrush (*Artemisia tridentata* subsp. *wyomingensis*): A Guide for Restoration.** Natural Areas Journal, 35(1):30-43. DOI: <http://dx.doi.org/10.3375/043.035.0106>
- Rehfeldt et al, 2006. **Empirical analyses of plant-climate relationships for the western United States.** Int. J. Plant sci. 167(6):1123–1150.

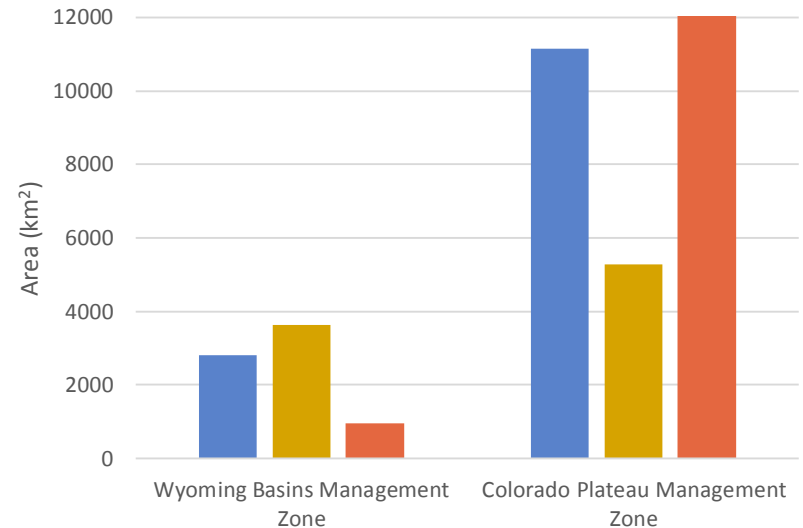
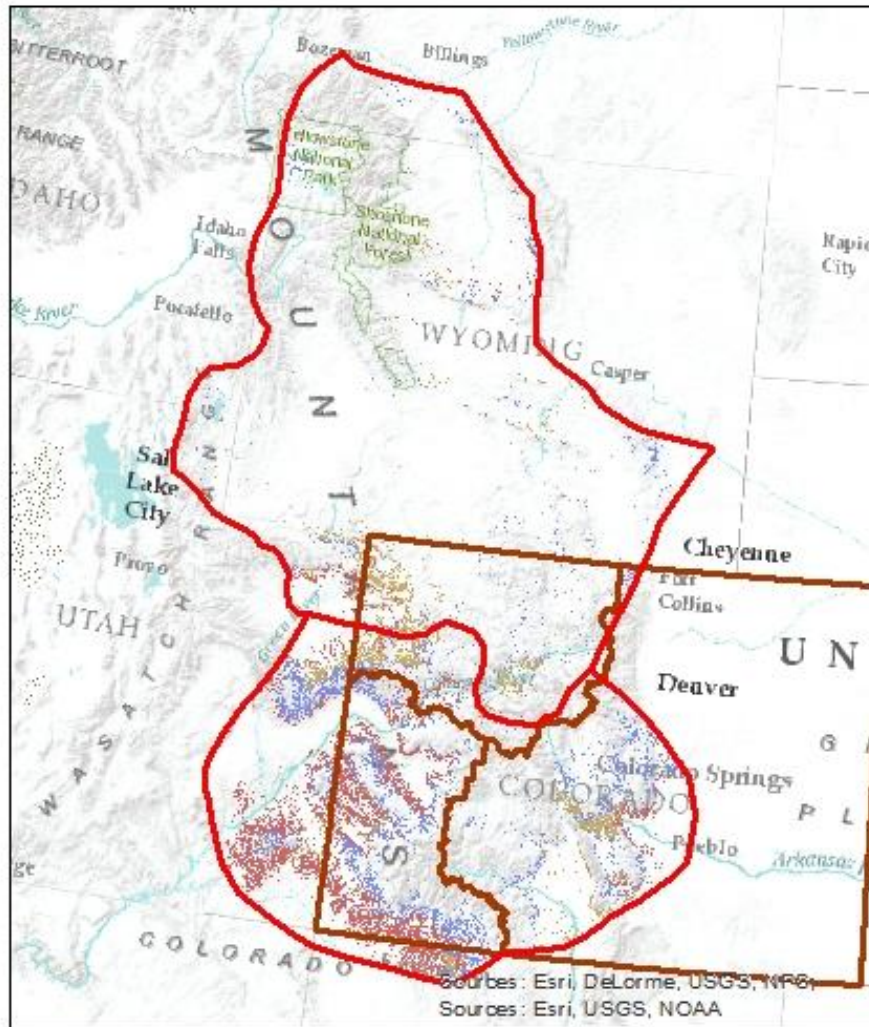
Unused slides

Data sources

- Chambers et al (2016; Sciencebase: Science Framework for the Conservation and Restoration Strategy)
 - Conifer and Sagebrush: These data sets are derived from LandFire EVT.
 - R&R: data sets are derived from Statsgo and SSURGO (Maestas et al, 2016, Chambers et al 2016)
 - Boundary data sources:
 - BLM (Field Offices, District Offices)
 - Chambers et al, (2016; Sciencebase: Science Framework for the Conservation and Restoration Strategy) – PAC, Management Zones
 - Falkowski et al (2016) Percent conifer cover
 - Cheatgrass:
 - LandFire Introduced Annual Grassland
 - PNNL (Larson) percent cheatgrass thresholded at 2%
 - Provisional USGS (Homer) Annual Herbaceous
- Do we want to look at the LF EVT list for conifers and adjust for only PJ or will using Falkowski be better option?

Where are areas that are conifer dominated and likely to expand into sagebrush by R&R

Areas that are conifer dominated and likely to expand into sagebrush by R&R



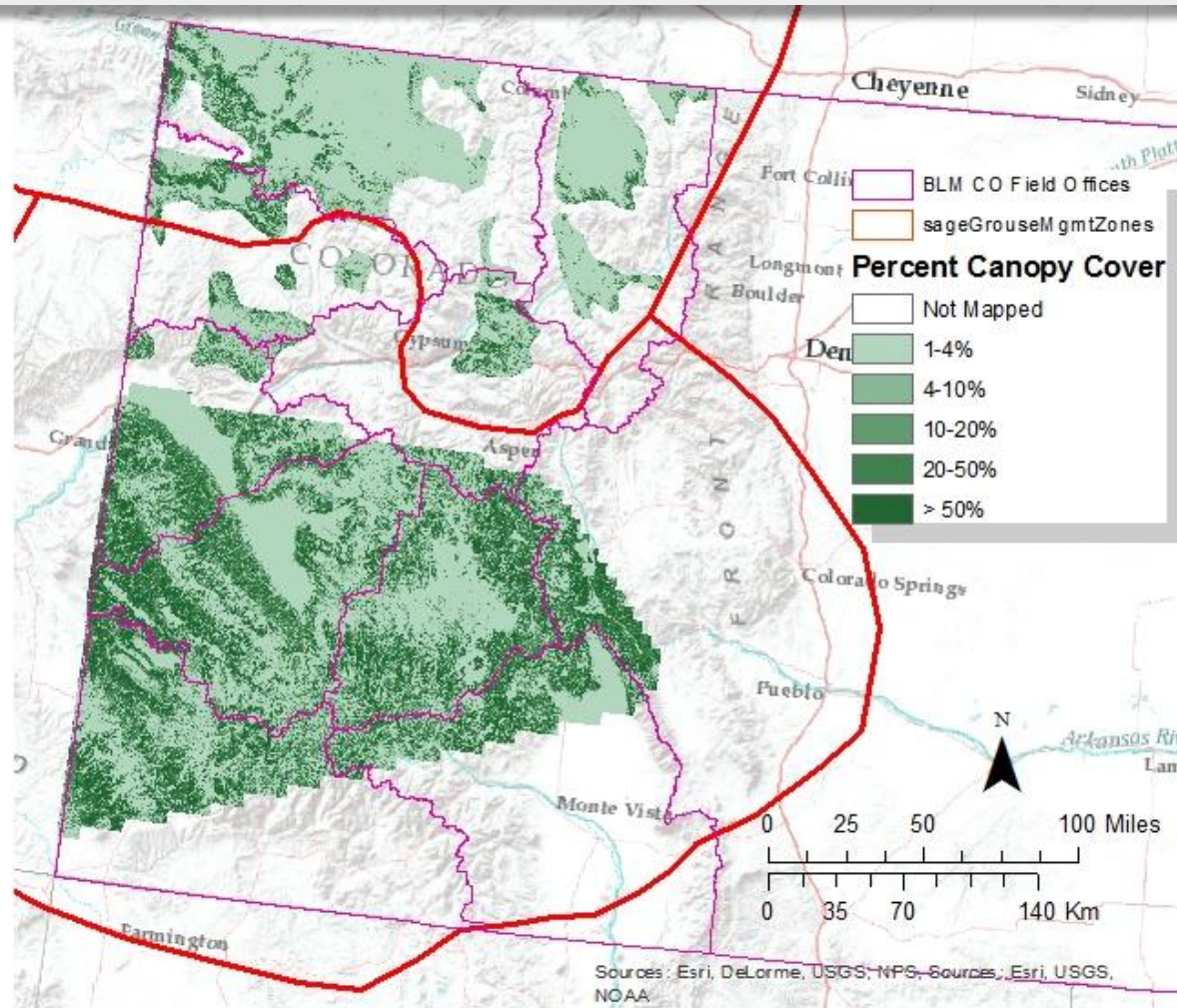
- Management Zones 2,7
- CO District Bnds
- Conifer likely to expand into SB, RR high
- Conifer likely to expand into SB, RR moderate
- Conifer likely to expand into SB, RR low



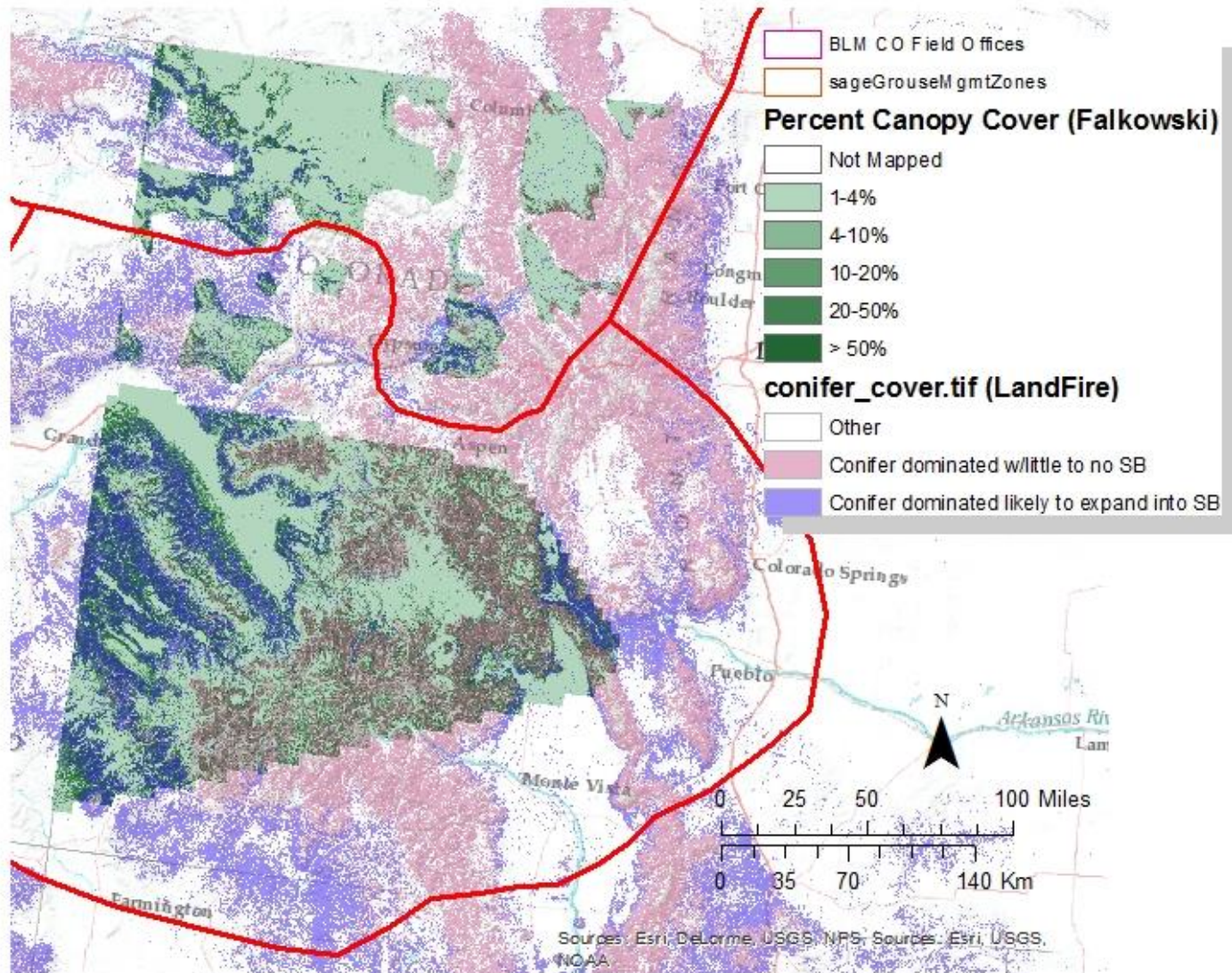
0 75 150 300 Miles

Percent Canopy Cover (Falkowski et al, 2016)

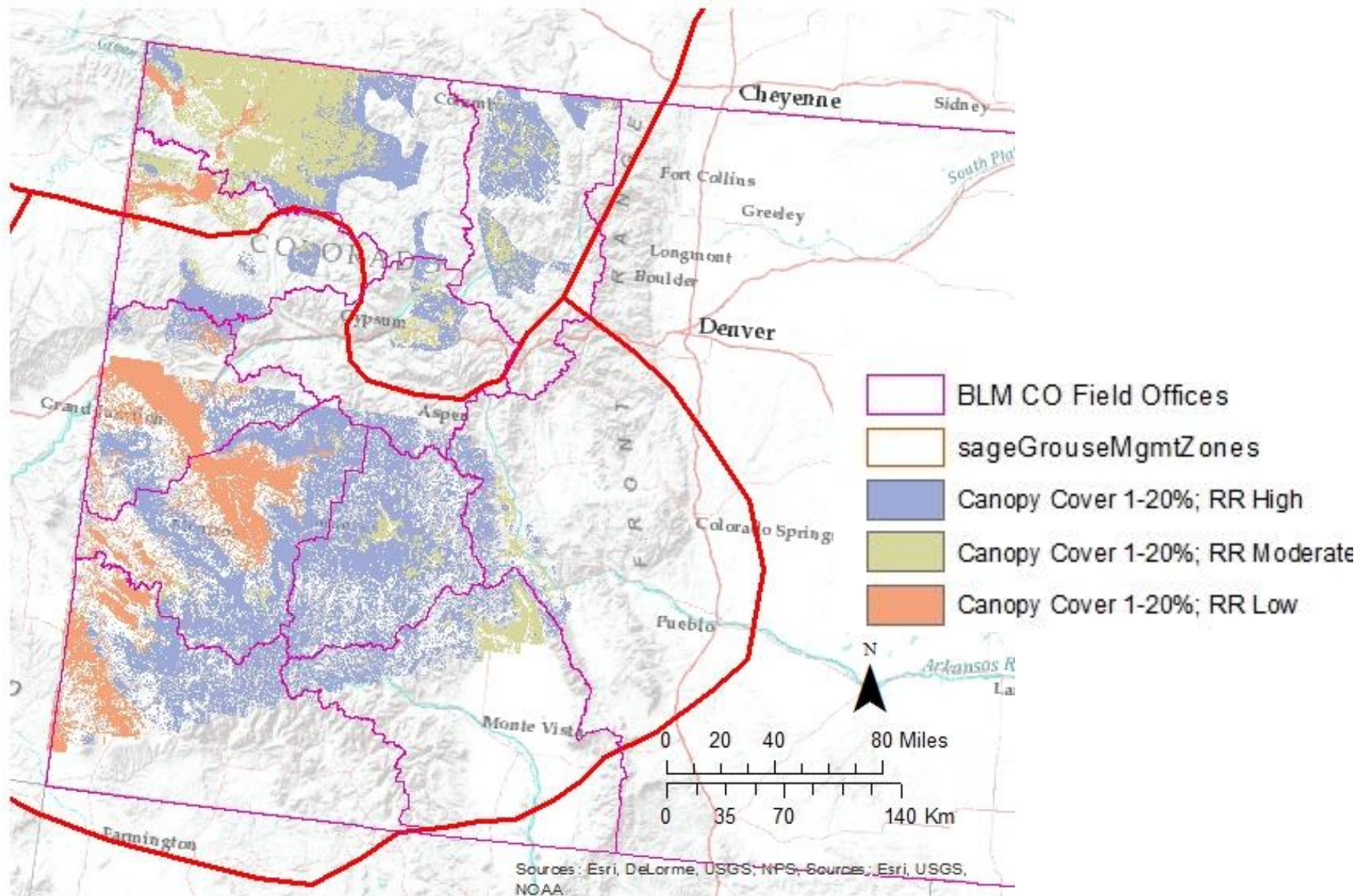
- 1 – 20% cover generally indicates early to mid succession conifer used as a surrogate here for conifer expansion
- Canopy cover is mapped in occupied sage grouse habitat only



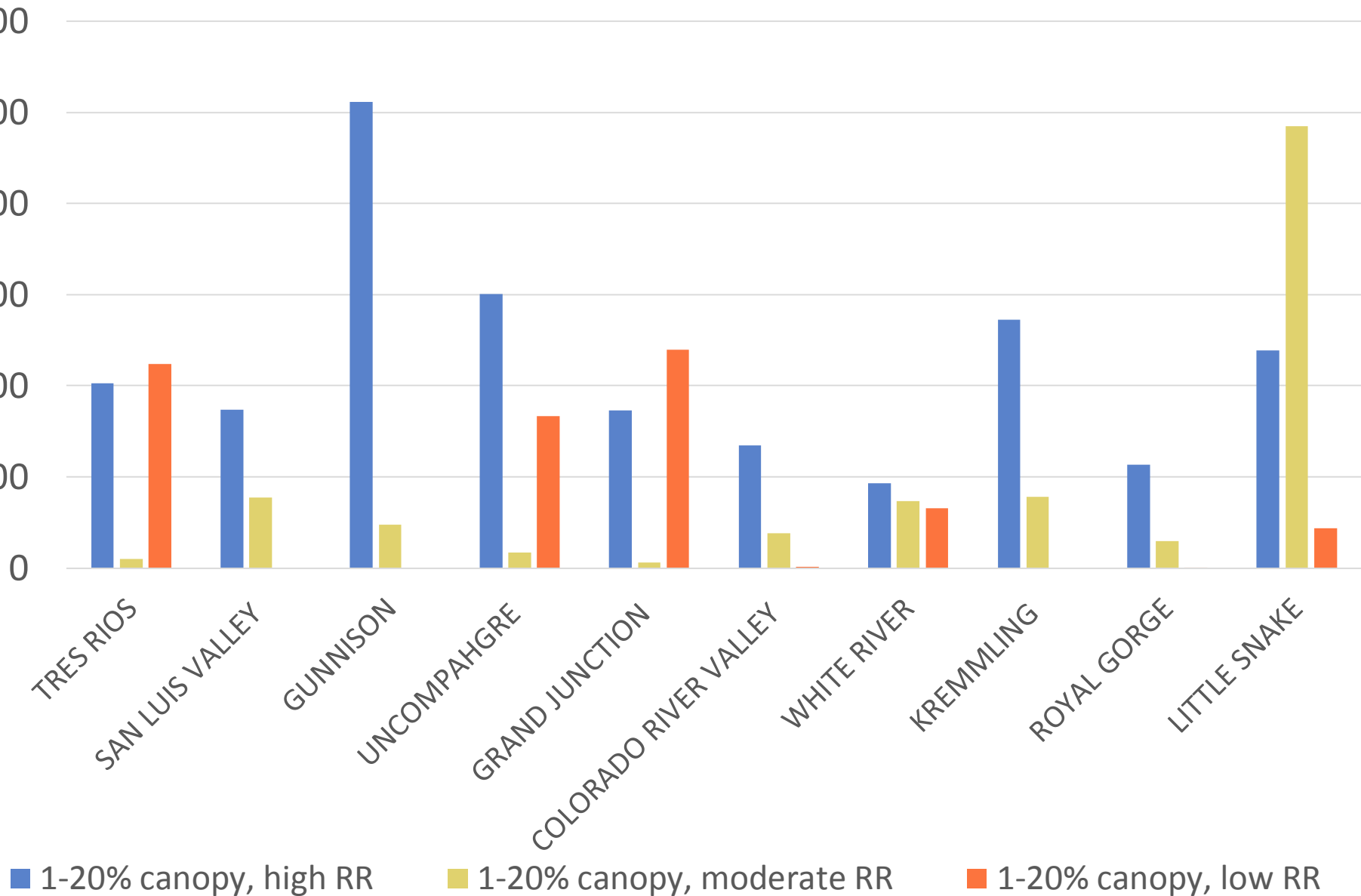
Compare Falkowski Percent Canopy Cover to LandFire Conifer Canopy Cover (Chambers)



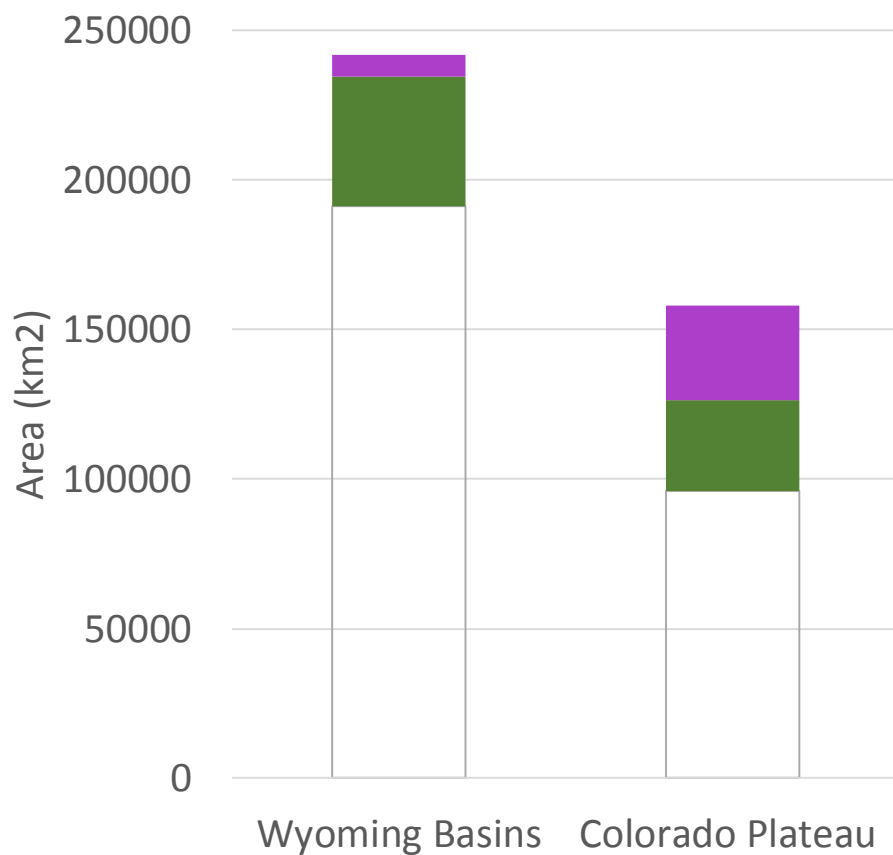
Percent Canopy Cover by Resistance & Resilience



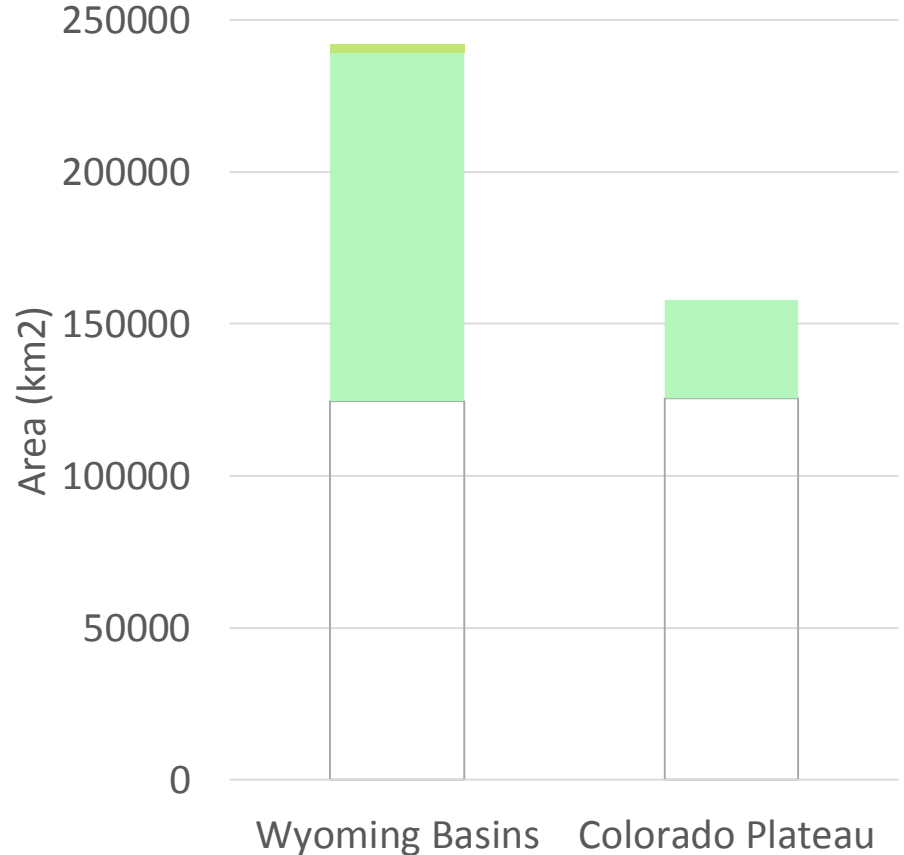
Potential Conifer Expansion (1-20% canopy cover) by R&R: CO Field Office



Conifer and sagebrush coverage by Management Zone

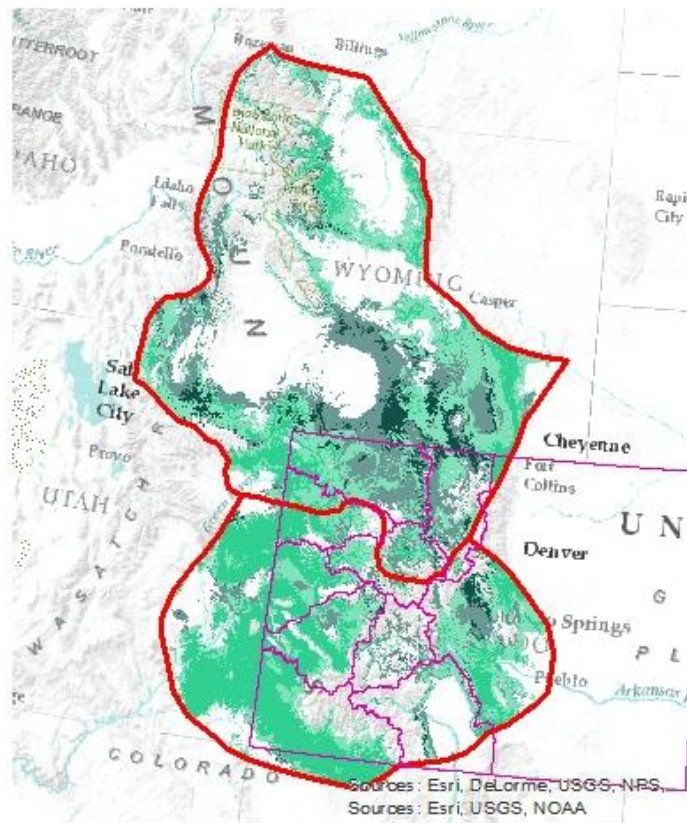


- Conifer dominated, likely to expand into SB
- Conifer dominated, little to no SB
- Other

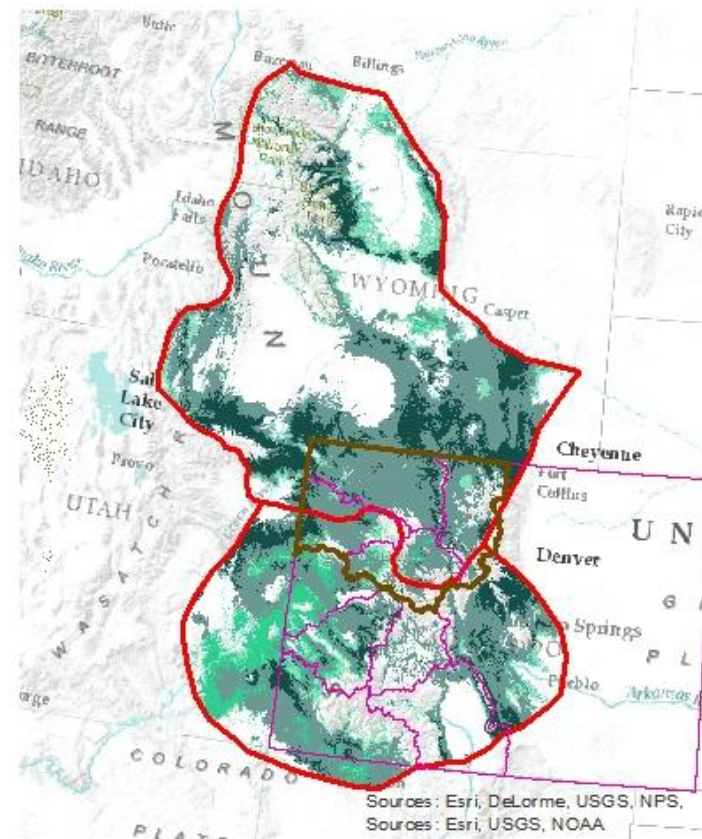


- Grass dominated w/SB Components
- Sagebrush dominated
- Other

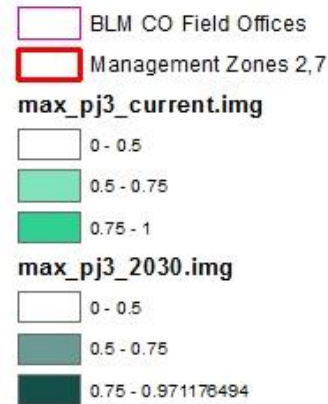
Pinyon juniper species viability: current and 2030, Management Zones 2 and 7



Current over 2030. Dark green
areas show *expansion* in 2030.



2030 over Current. Bright green
areas show *contraction* in 2030.



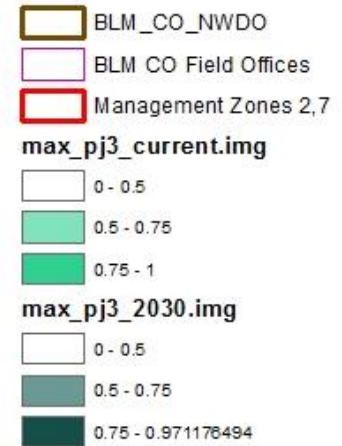
Pinyon juniper species viability: current and 2030, NW District



Current over 2030. Dark green areas show *expansion* in 2030.



2030 over Current. Bright green areas show *contraction* in 2030.



A comparison of Current and Projected (2030) PJ species viability -> Expansion and contraction

