Projected Impacts of Climate Change on Forests of the Dolores Watershed

A Practical Management Strategy

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Outline

1. Impacts of turn-of-the-century drought
2. Bioclimate models and projections
3. Strategy for applying projections to forest management

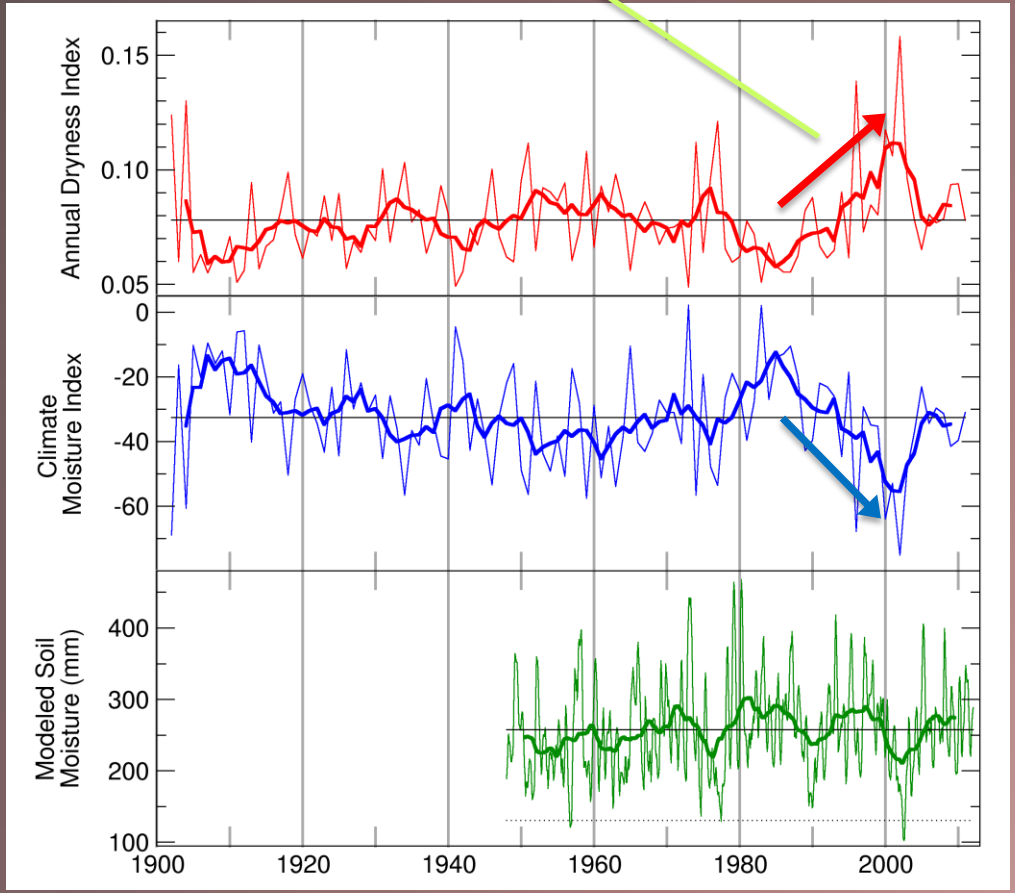
Impacts to Forests

TURN-OF-THE-CENTURY DROUGHT

Southern Rockies

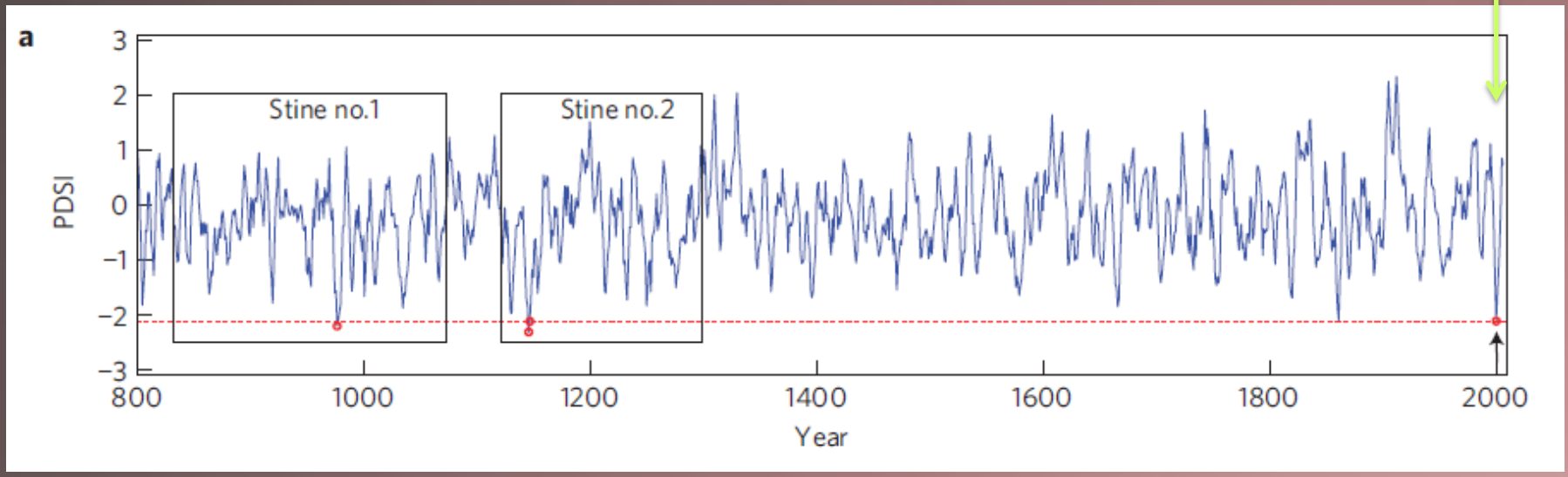
Drying trend since mid '80s

Record drought 2001-2003



Schwalm et al. 2012
Nature Geosciences

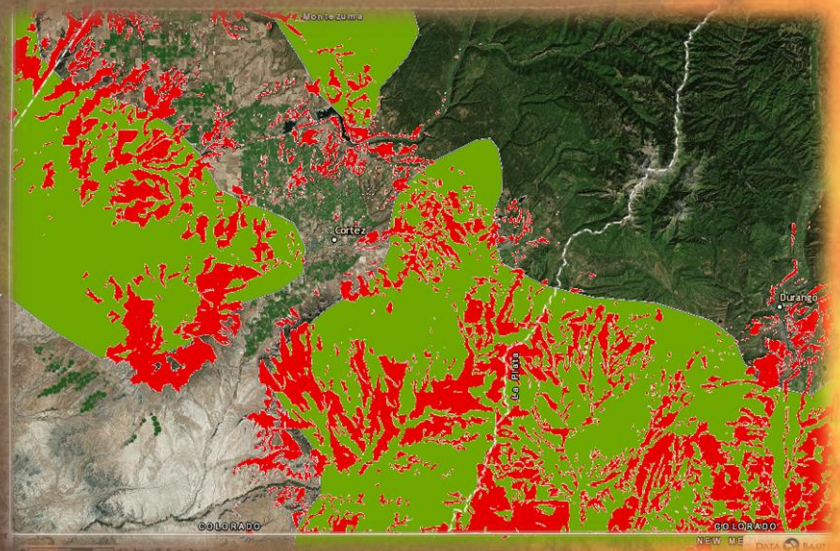
The turn-of-the-century drought in the context of the past



Conclusion:

Most recent drought that severe West-wide occurred >800 yr ago.

Piñon mortality SW CO



Dominique Bachelet, Data Basin

2.5 million acres in 4-corner states

Mountain pine beetle

3.4 million acres in Colorado

2002
927,000 acres burned
in Colorado

SAD

1.2 million acres in Colorado

Spruce beetle

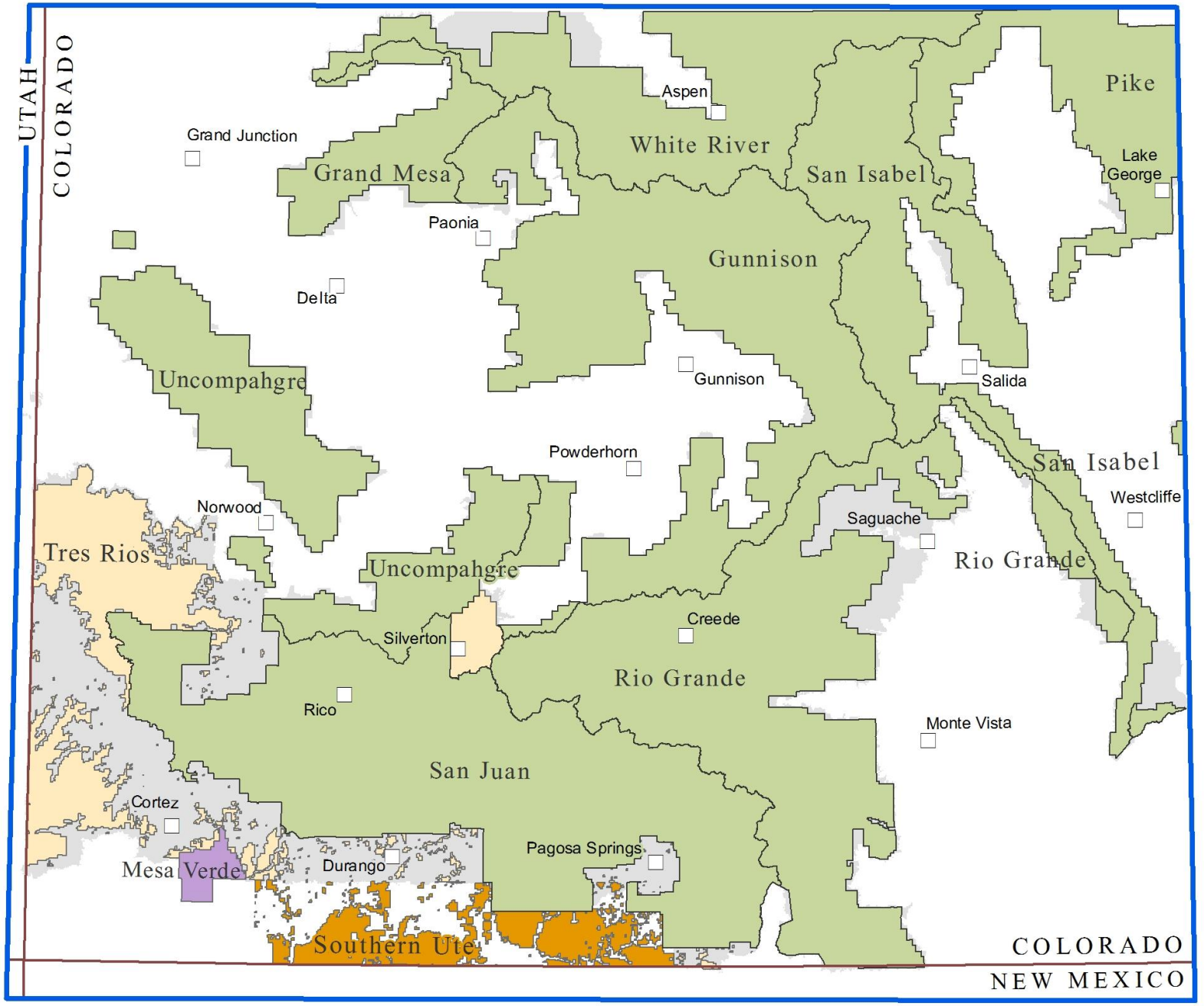
1.7 million acres in Colorado

Future Droughts

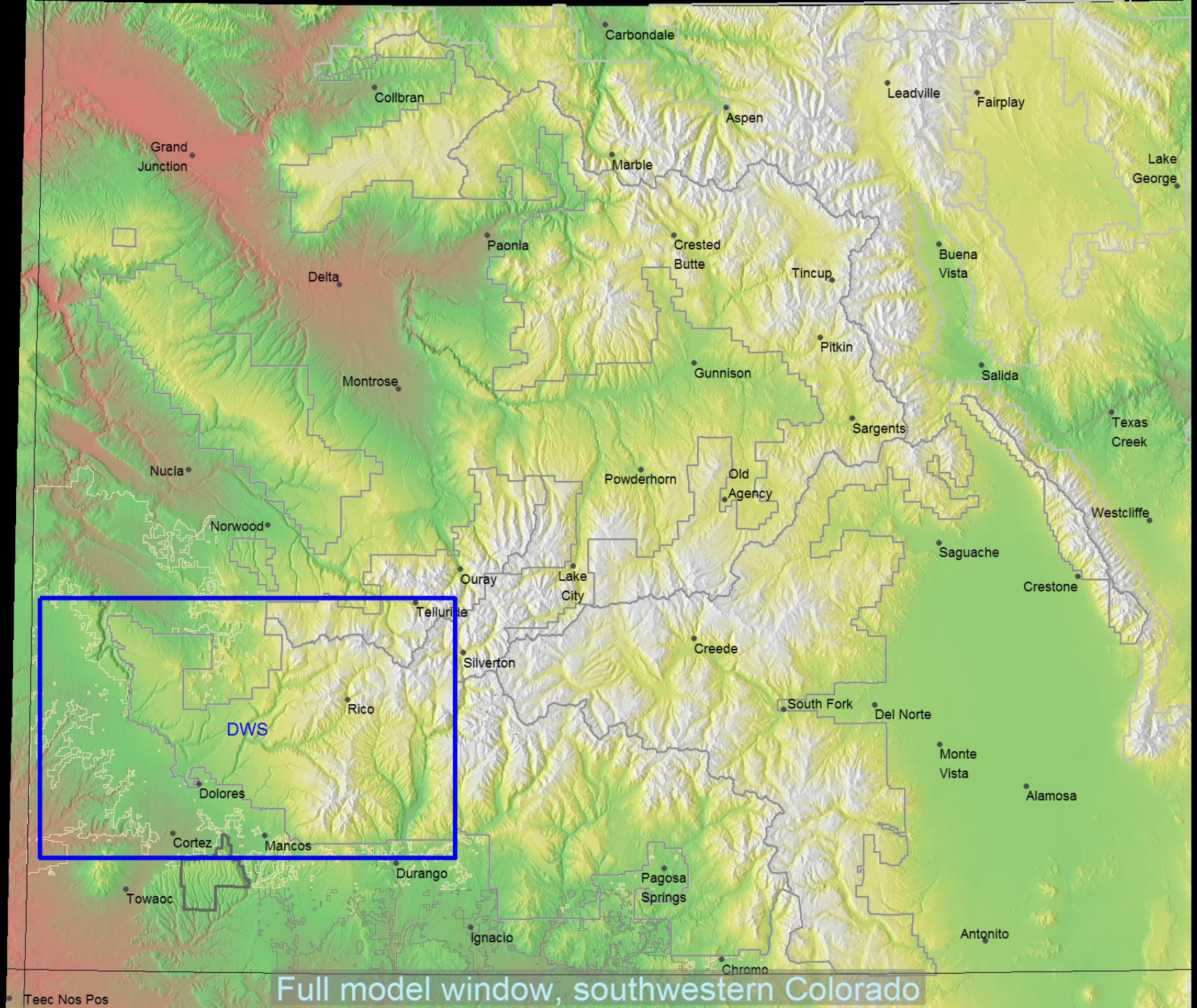
- By the 2030's, moisture conditions during the turn-of-the-century drought ". . . will become the new norm in western North America." (Schwalm et al. 2012, Nature Geosciences)
- Later in the century, conditions may be worse than during TOC.
- How can we anticipate forest impacts so that we can manage appropriately?

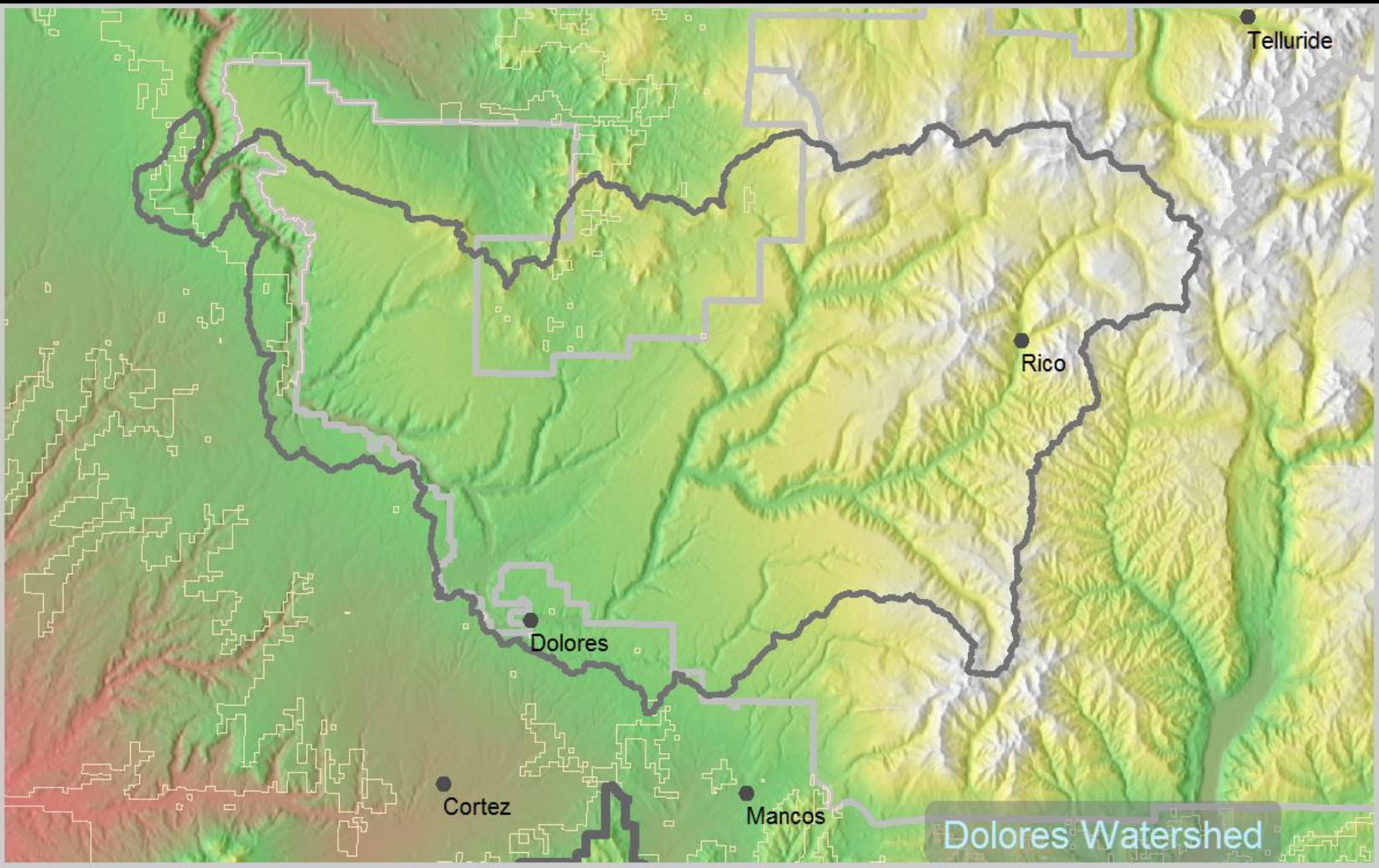
Characterize climate suitable for a species

BIOCLIMATE MODELS



Southwest Colorado Bioclimate Project


Carbondale
Collbran
Leadville
Fairplay
Aspen
Grand Junction
Marble
Lake George
Paonia
Crested Butte
Buena Vista
Delta
Tincup
Pitkin
Gunnison
Salida
Montrose
Sargents
Texas Creek
Nucla
Powderhorn
Old Agency
Norwood
Westcliffe
Saguache
Ouray
Lake City
Crestone
Telluride
Creede
Silverton
DWS
Rico
South Fork
Del Norte
Monte Vista
Dolores
Alamosa
Cortez
Mancos
Durango
Pagosa Springs
Towaoc
Ignacio
Antonito
Chromo
Full model window, southwestern Colorado
Teec Nos Pos


Telluride
Rico
Dolores
Cortez
Mancos
Dolores Watershed

Bioclimate Models

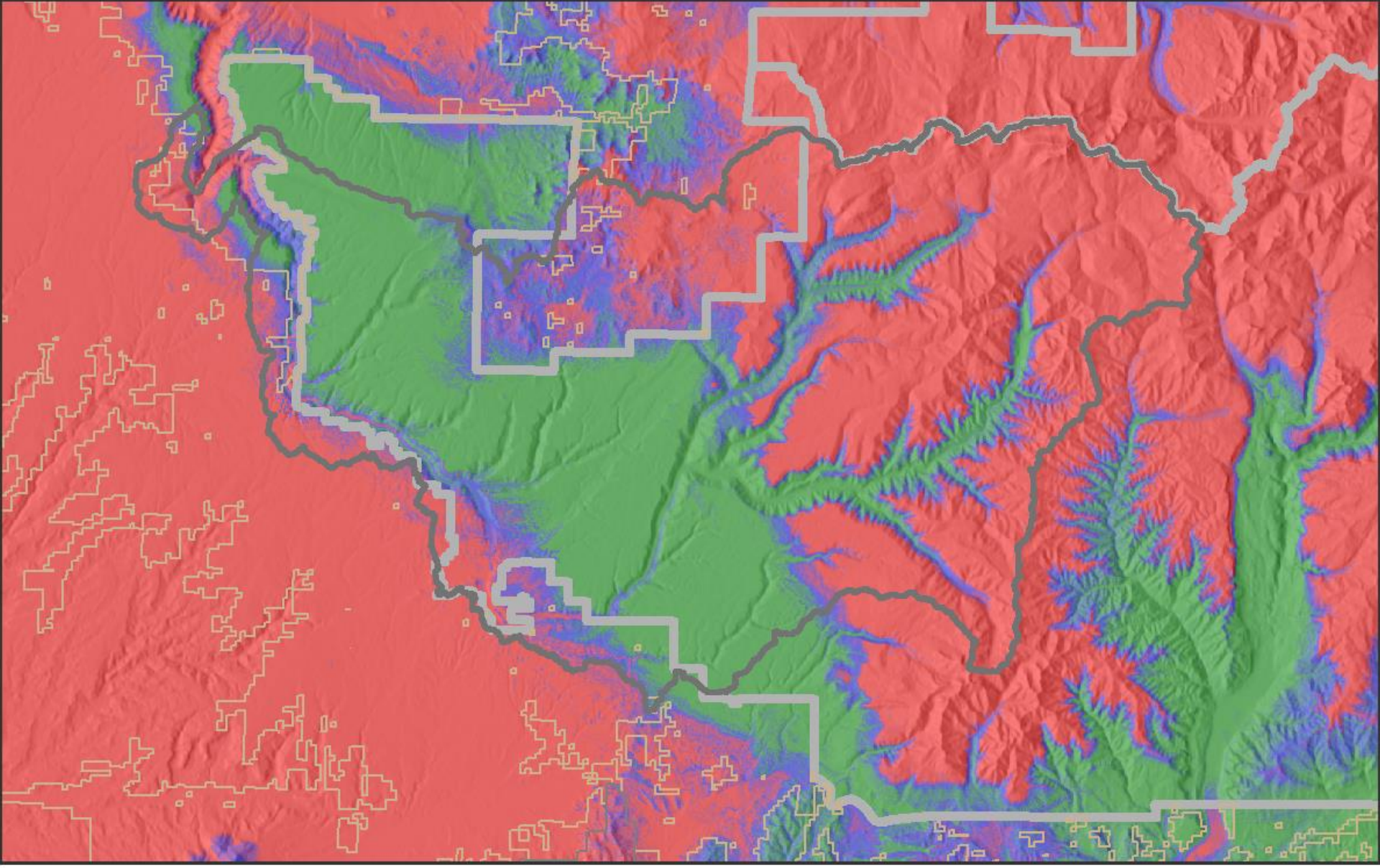
- Train on real point locations
  - Known presence/absence of species
  - Known historic/reference climate
  - Known slope and aspect
- Learn the combinations and interactions of variables associated with presence
- Given a topoclimate, can then predict the likelihood of presence

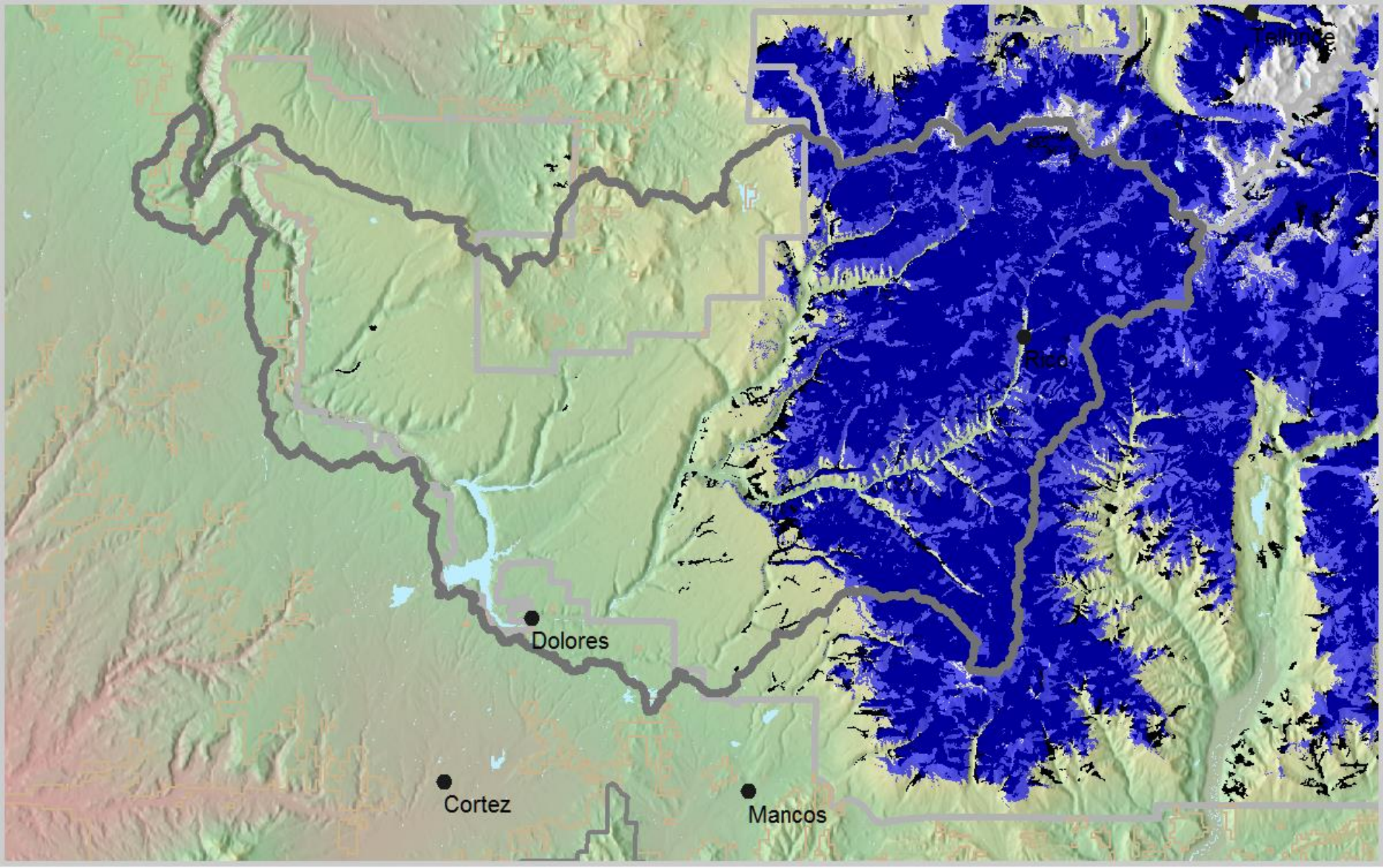
How they were built

- Training data
  - 854,000 points of known presence/absence
    - Mostly spatial veg data like FSVeg and FIA plots
  - Long-term historical climate at each point
    - Use reference climate 1961-1990
    - Also slope and aspect
- "Random forests" algorithm in R
  - "forests" of many decision "trees", using random subsets of training data

Output

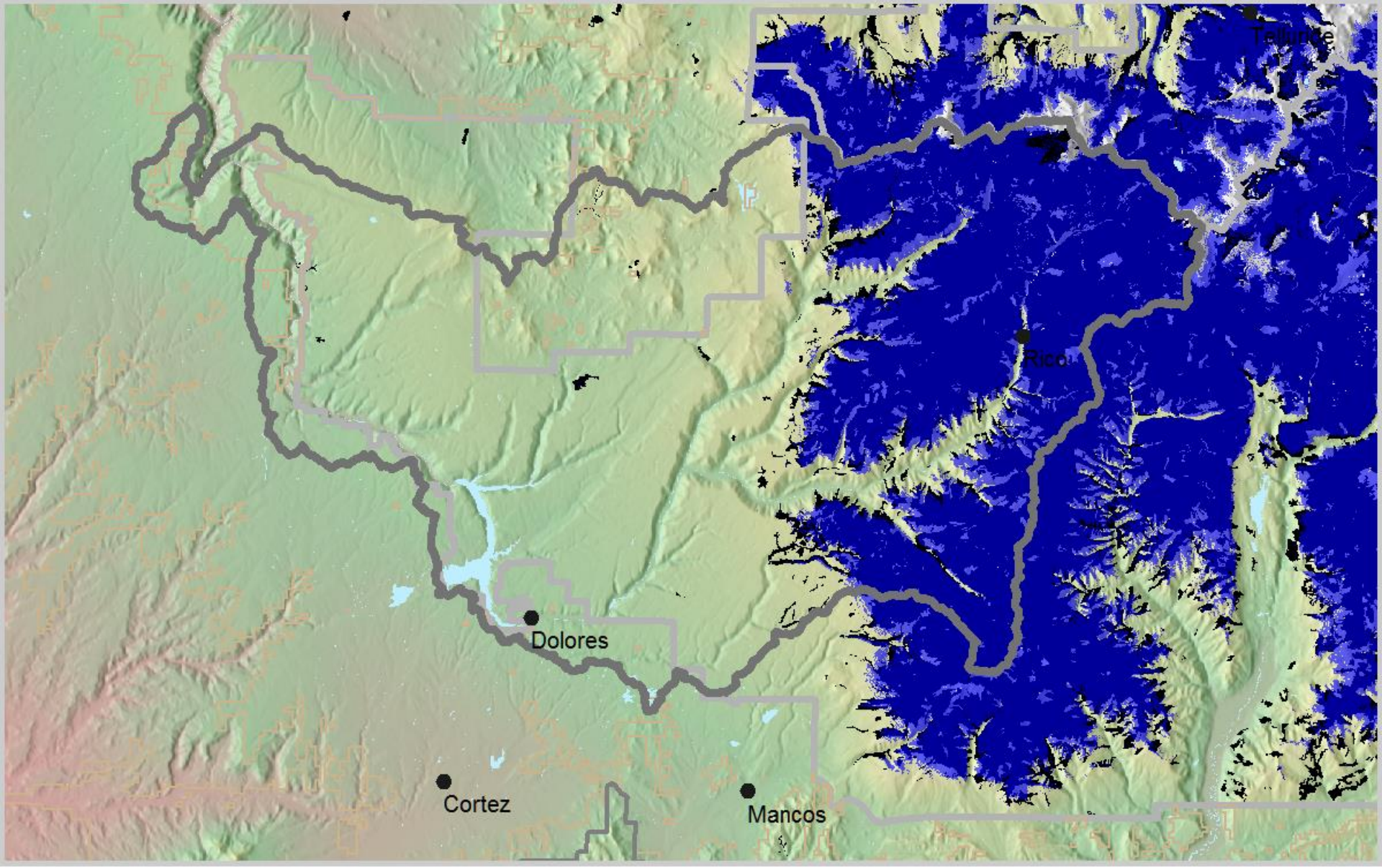
- Proportion of decision trees that ‘vote’ for the topoclimate being suitable.
- If we run each pixel on a map through the model, using each pixel’s climate, slope and aspect . . .


PIPO
Proportion
of votes
0-10
10-20
20-30
30-40
40-50
50-60
60-70
70-80
80-90
90-100



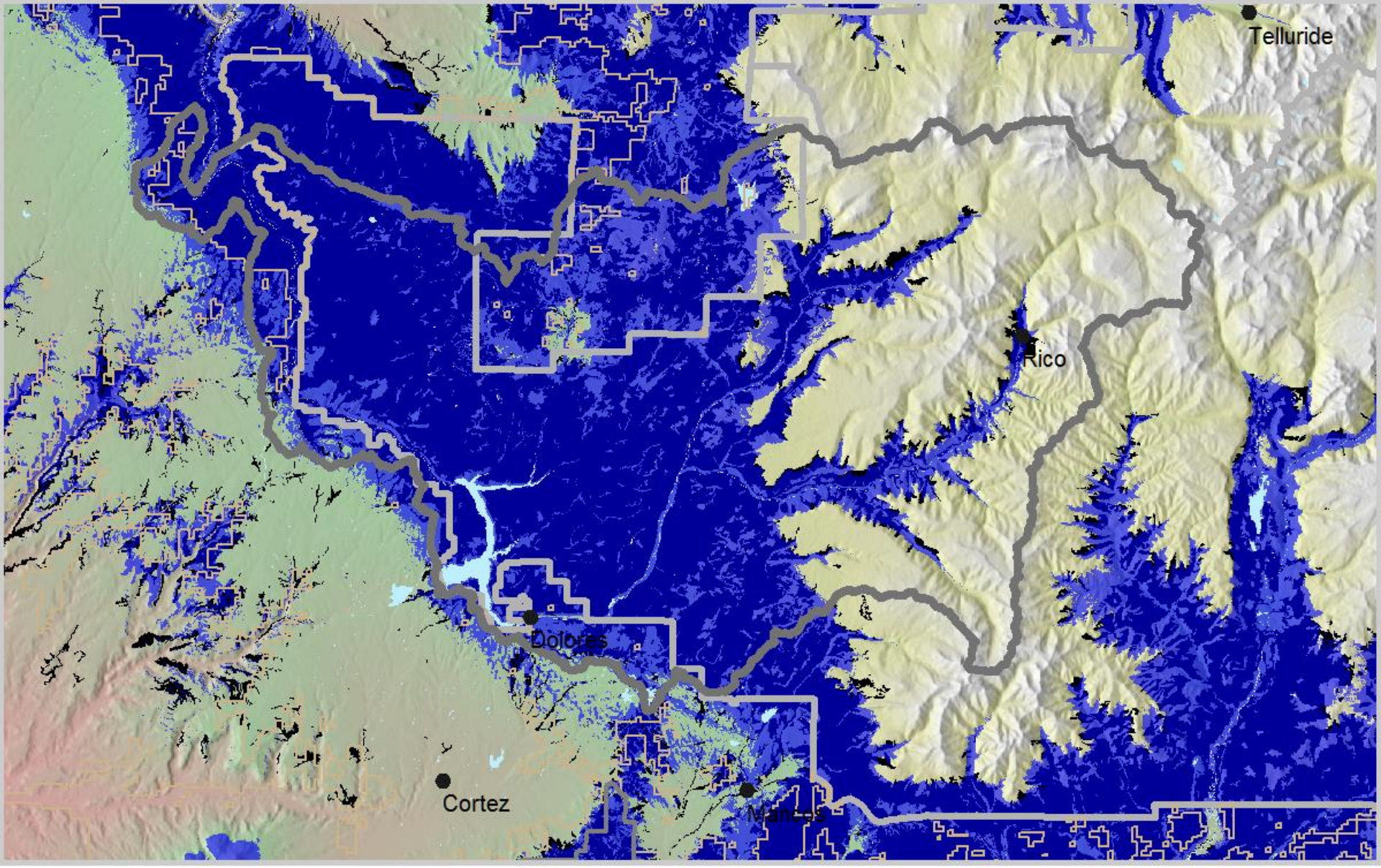
ABLA occurrence in shapefiles (black) vs. reference period votes >=0.5 (blue overlay)

Subalpine fir



PIEN occurrence in shapefiles (black) vs. reference period votes >=0.5 (blue overlay)

Engelmann spruce



QUGA occurrence in shapefiles (black) vs. reference period votes >=0.5 (blue overlay)

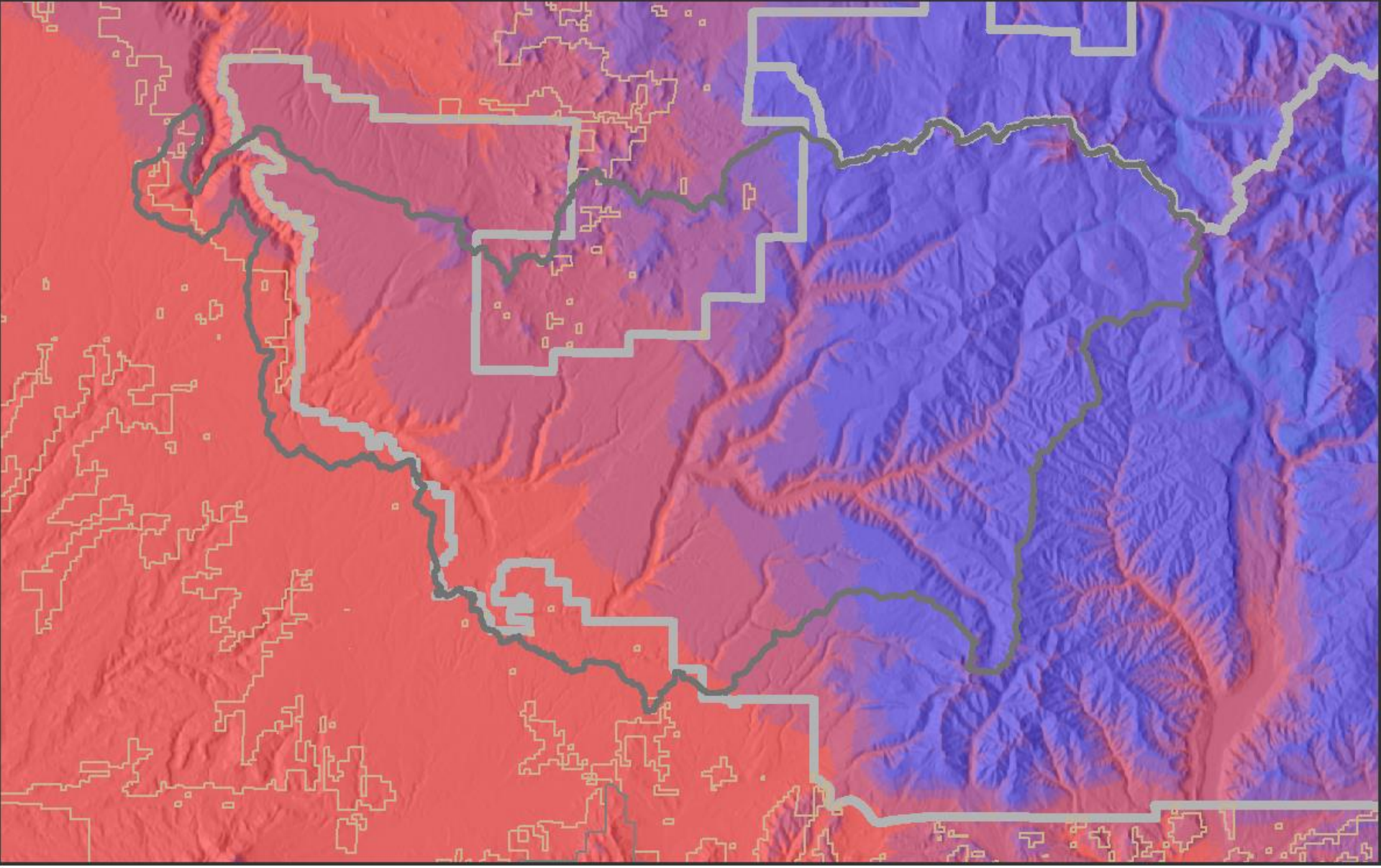
Gambel oak

Process for projecting into the future

3 GCMs x 3 RCPs → 9 climates → downscaled → bioclimate models → 9 outputs → votes averaged

Global climate models used by IPCC:
CCSM4
GFDLCM3
HadGEM2ES

Greenhouse-gas scenarios (RCPs)
RCP 4.5
RCP 6.0
RCP 8.5



Ponderosa pine 2060

Applying bioclimate models

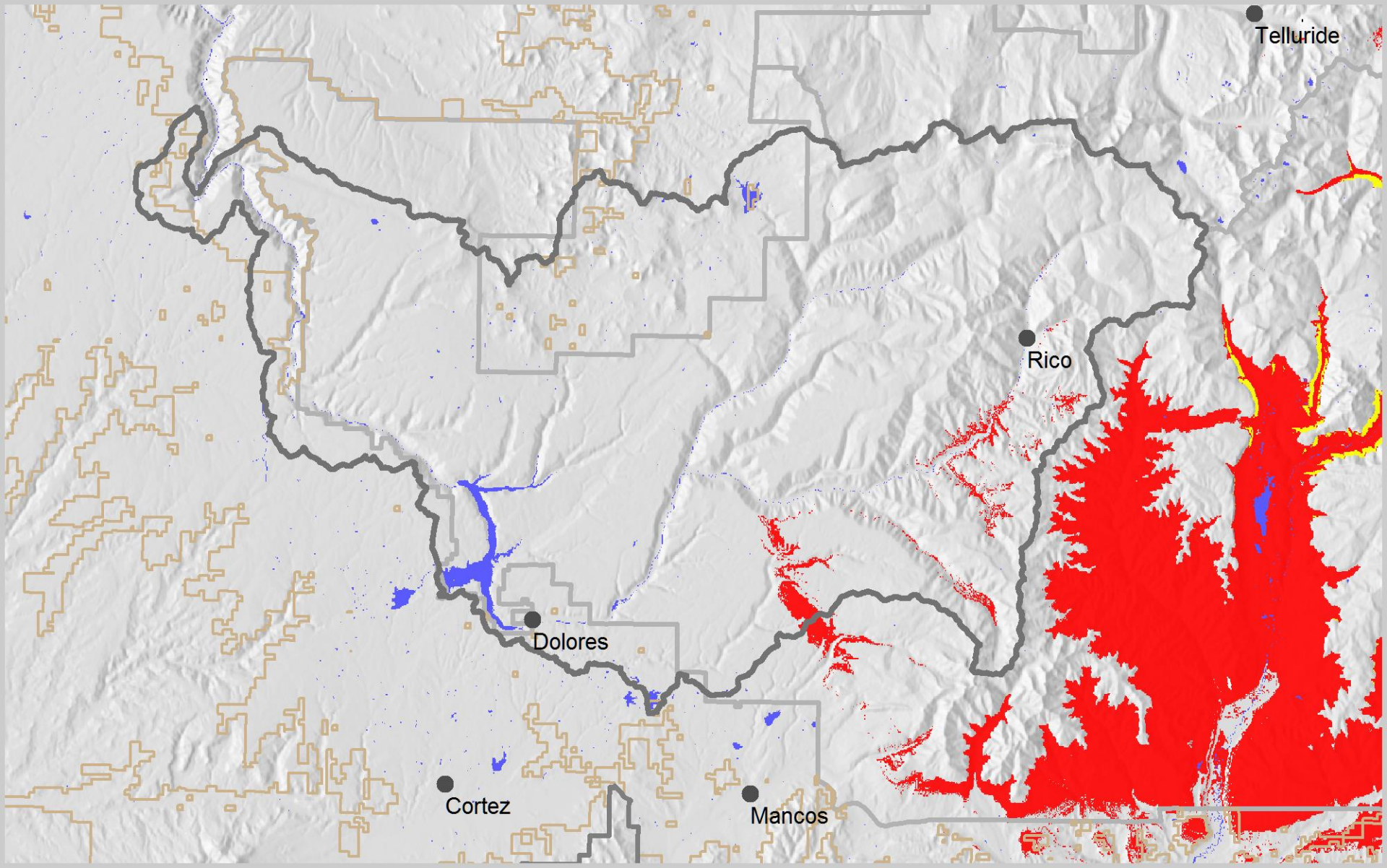
A FOREST MANAGEMENT STRATEGY

Project Change

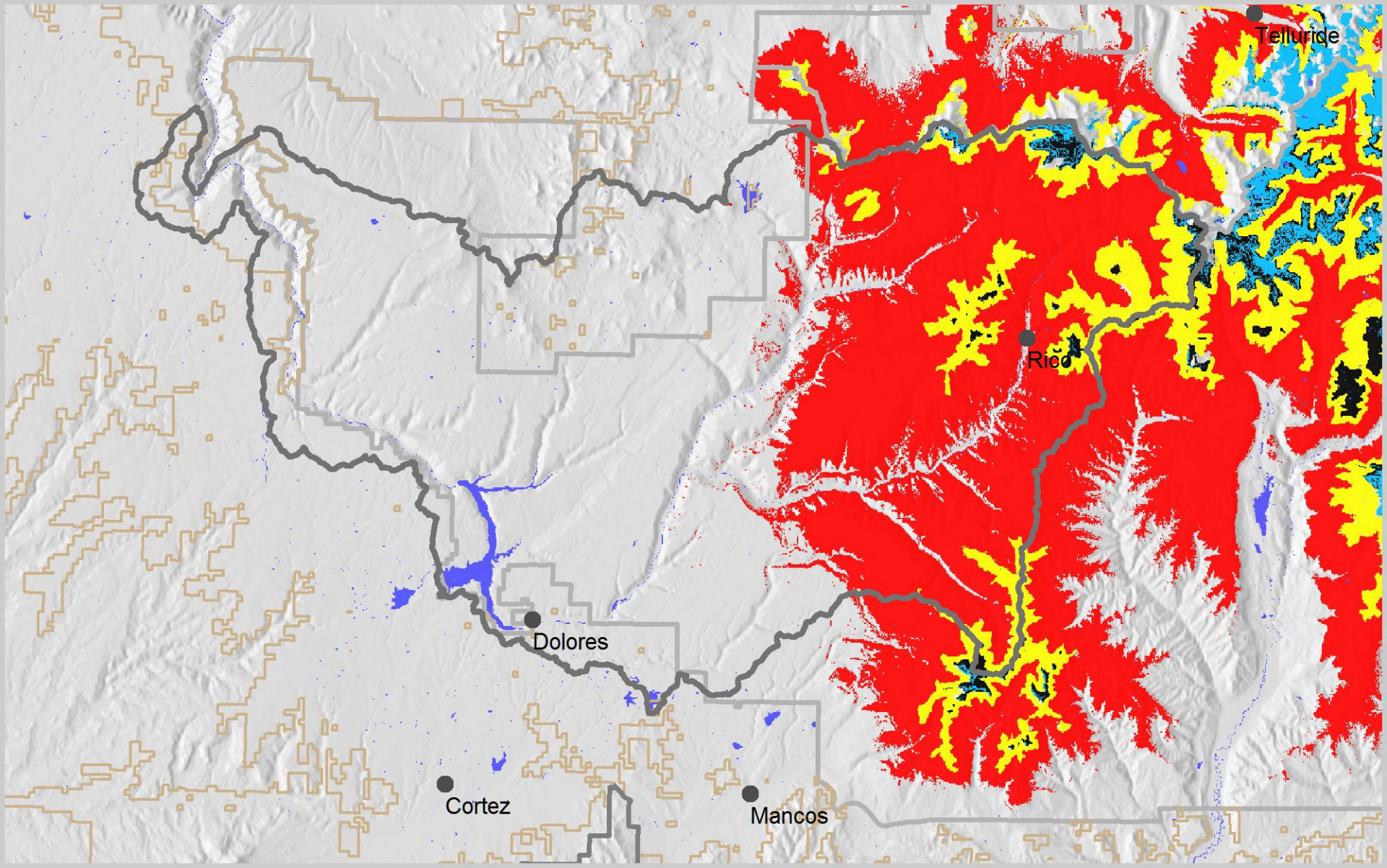
1. Make grids of suitability based on reference and future climates.
2. Use difference in model output between reference and future periods to classify change zones.

   a) Model output ("votes") are 0 (no chance) to 1 (very likely)

Change classes	Reference period votes	2056-2065 votes
LOST	≥ 0.5	< 0.3
THREATENED	≥ 0.5	0.3-0.5
PERSISTENT	≥ 0.5	≥ 0.5
EMERGENT	< 0.5	≥ 0.5

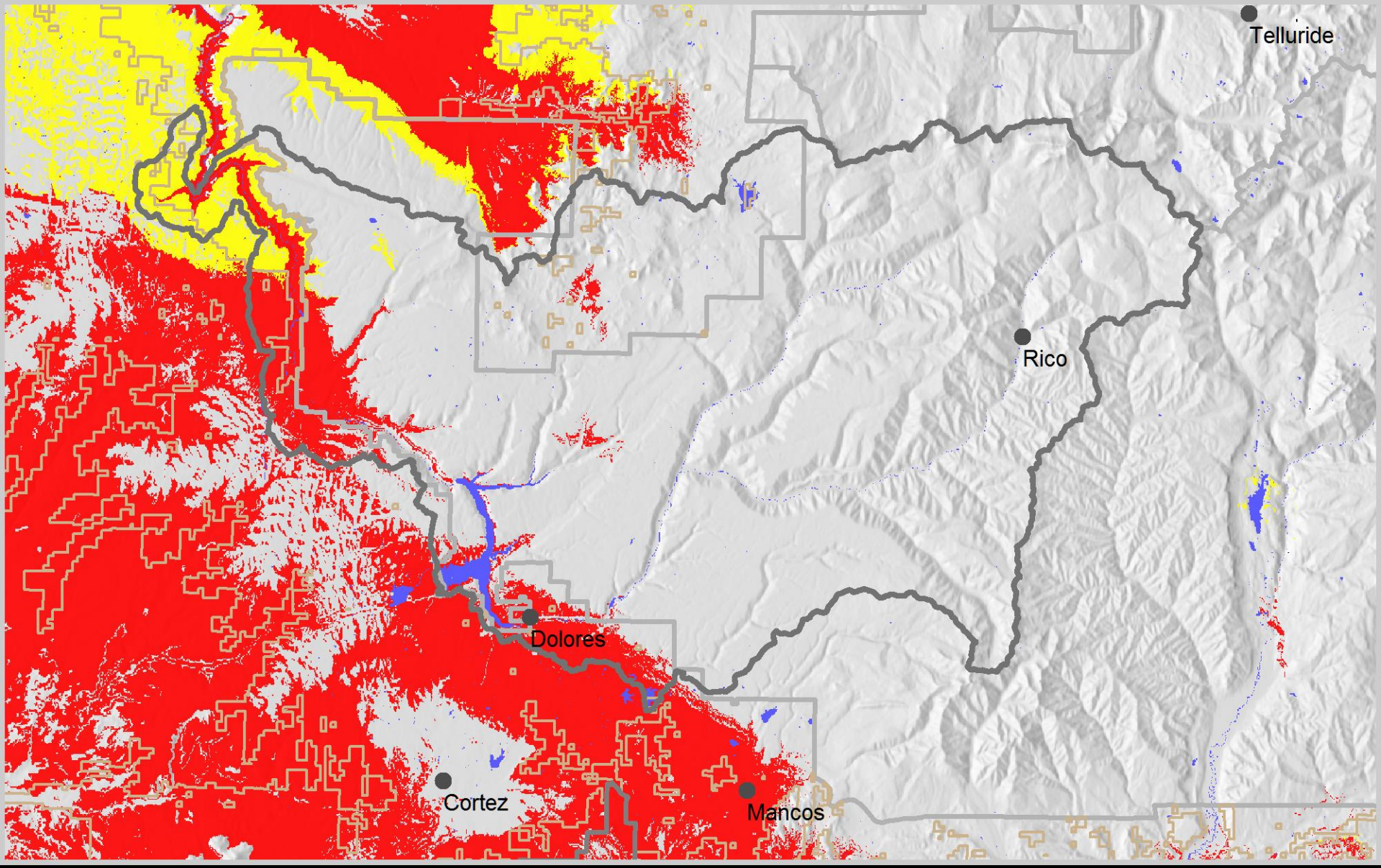

Telluride
Rico
Dolores
Cortez
Mancos
CGH Change Zones for ABCO
Lost
Threatened
Persistent
Emergent

White fir

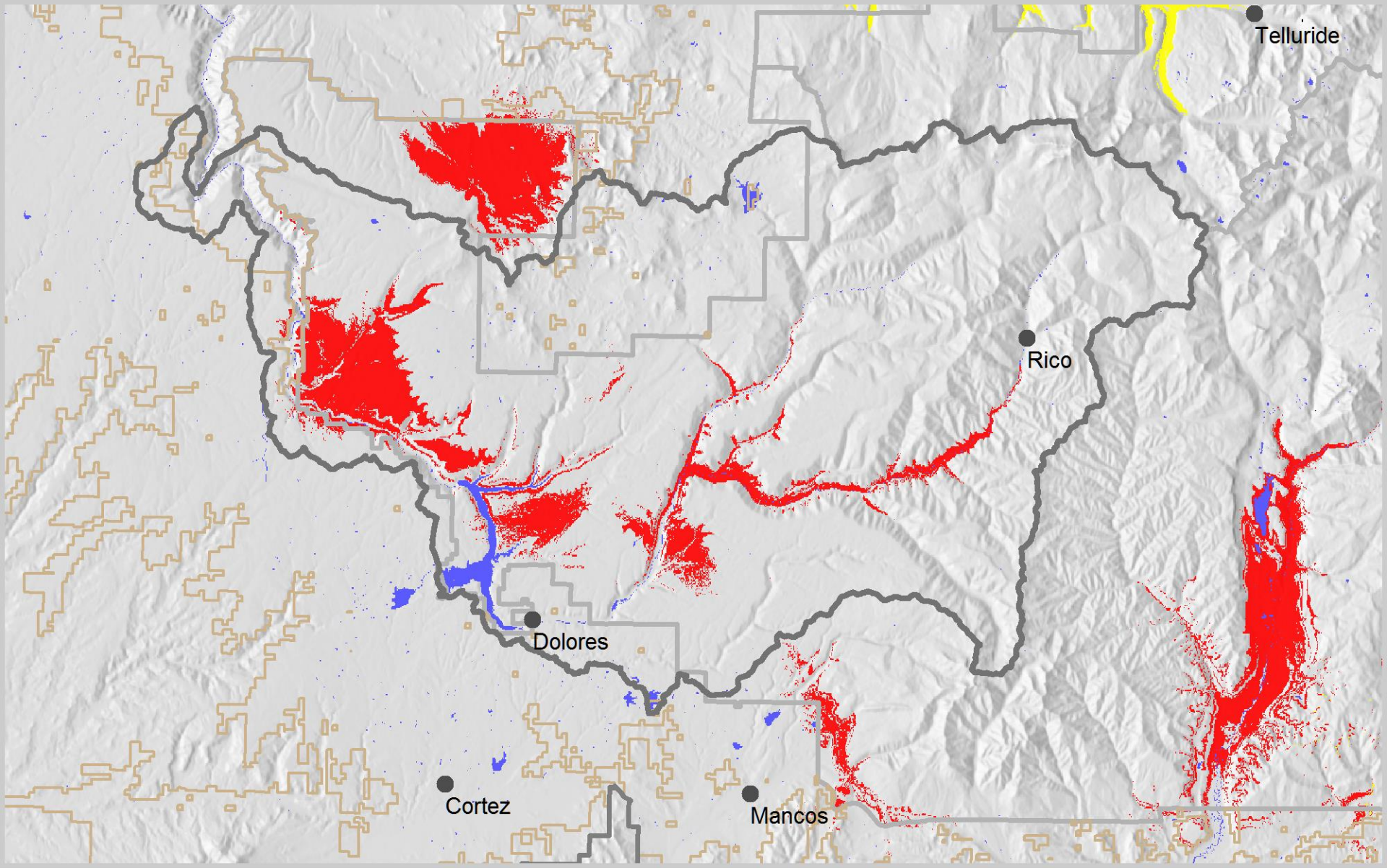


CGH Change Zones for ABLA | Lost | Threatened | Persistent | Emergent

Subalpine fir

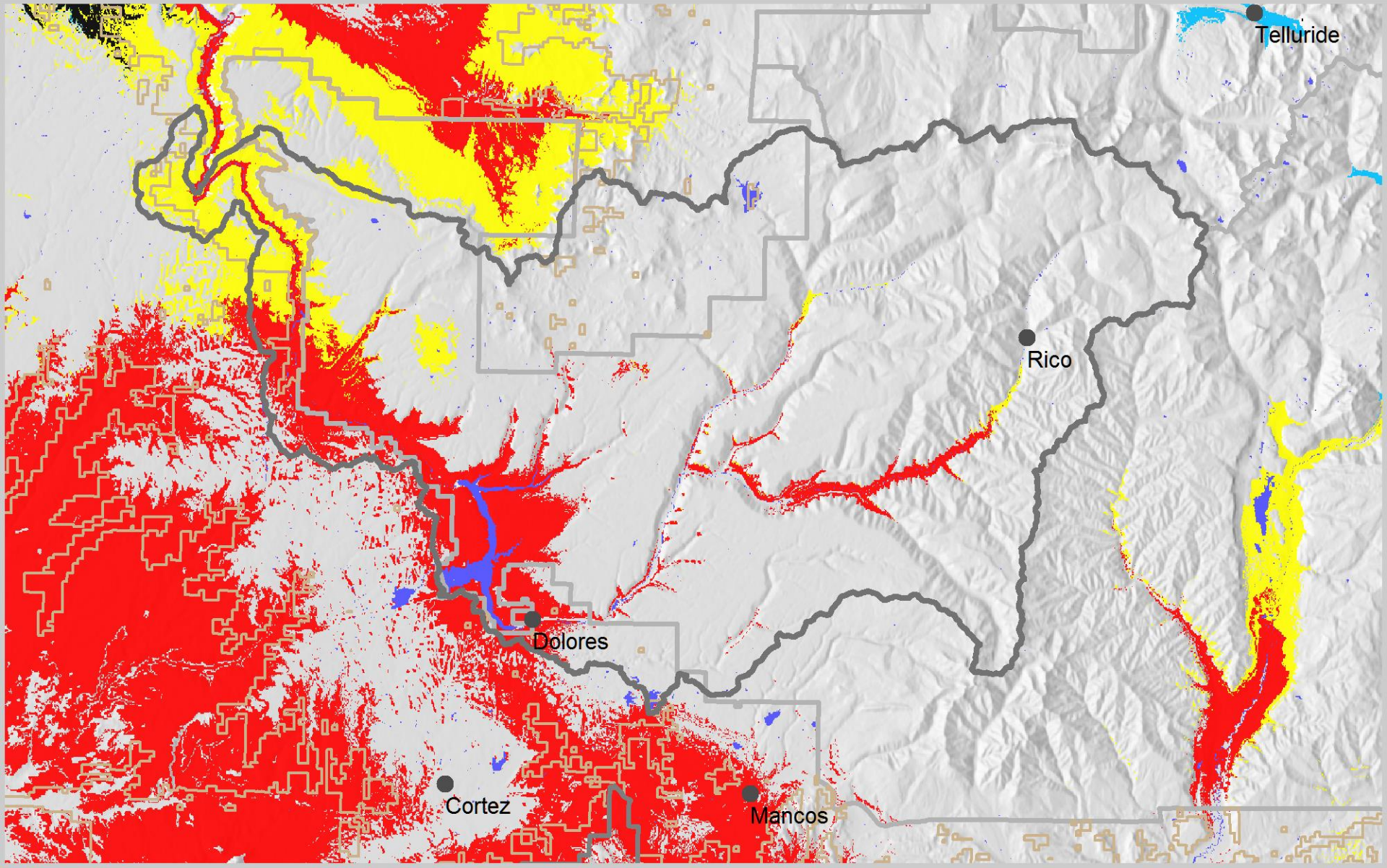


Utah juniper



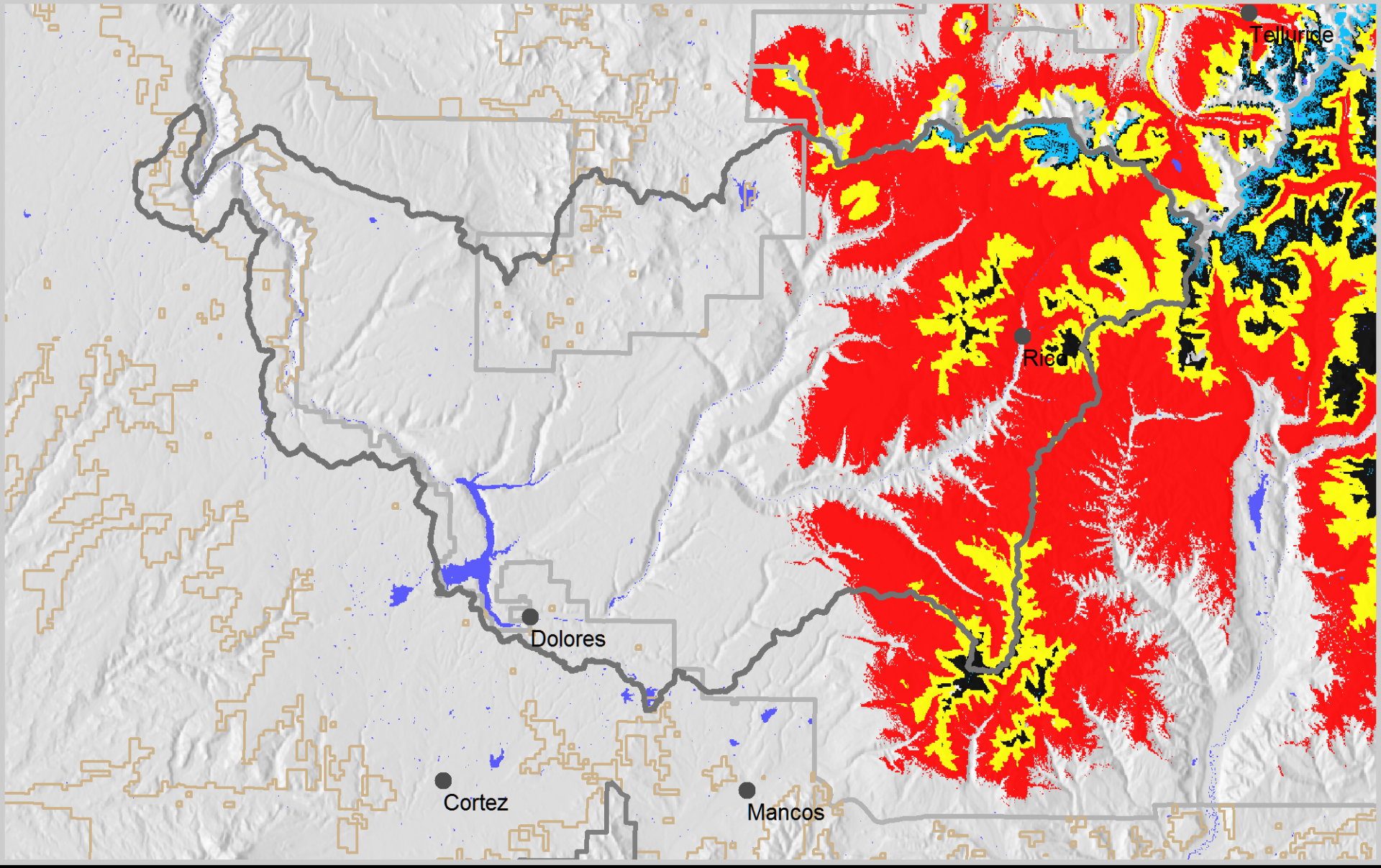
CGH Change Zones for JUSC2 | Lost | Threatened | Persistent | Emergent

Rocky Mountain juniper



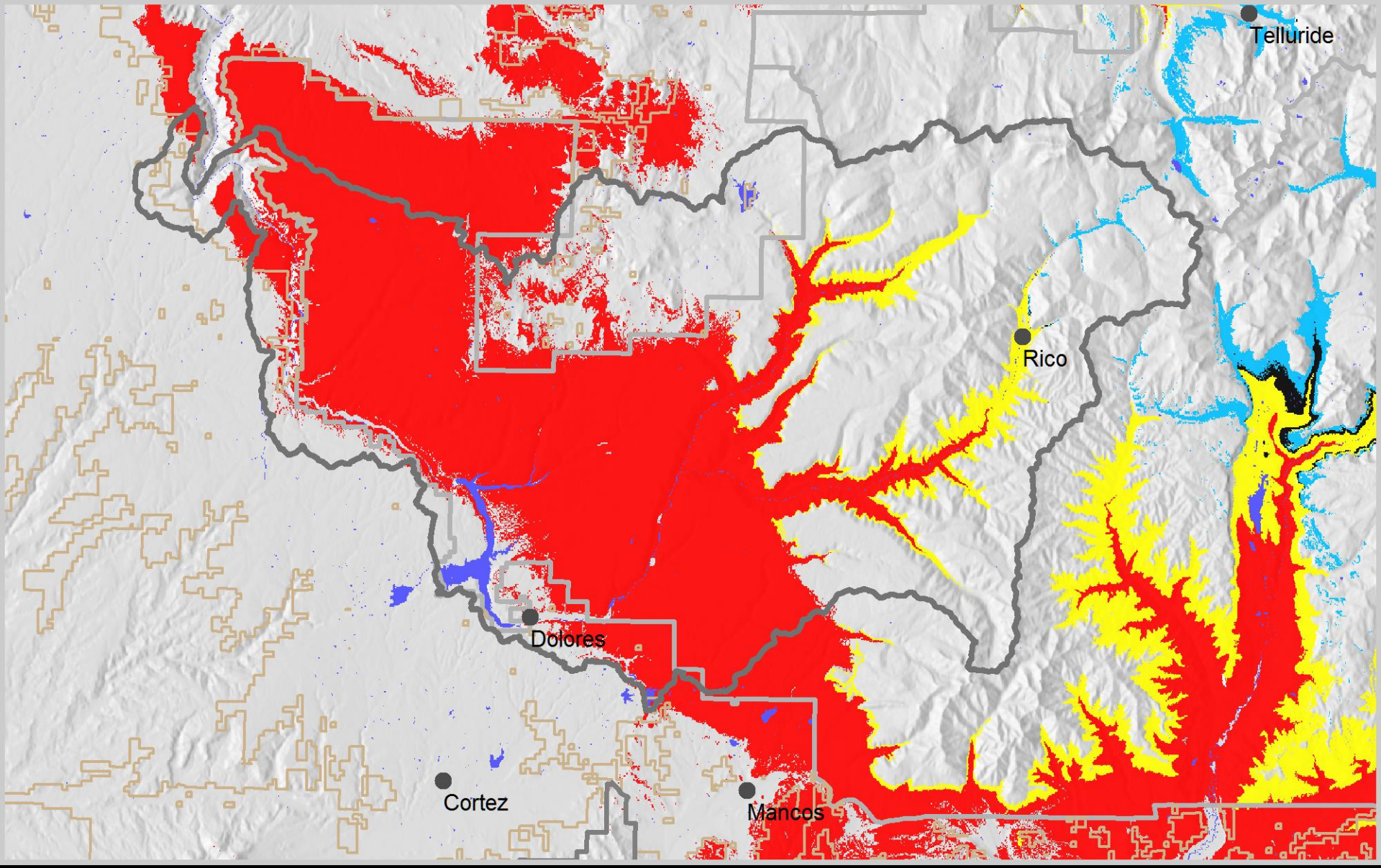
CGH Change Zones for PIED — Lost — Threatened — Persistent — Emergent

Piñon



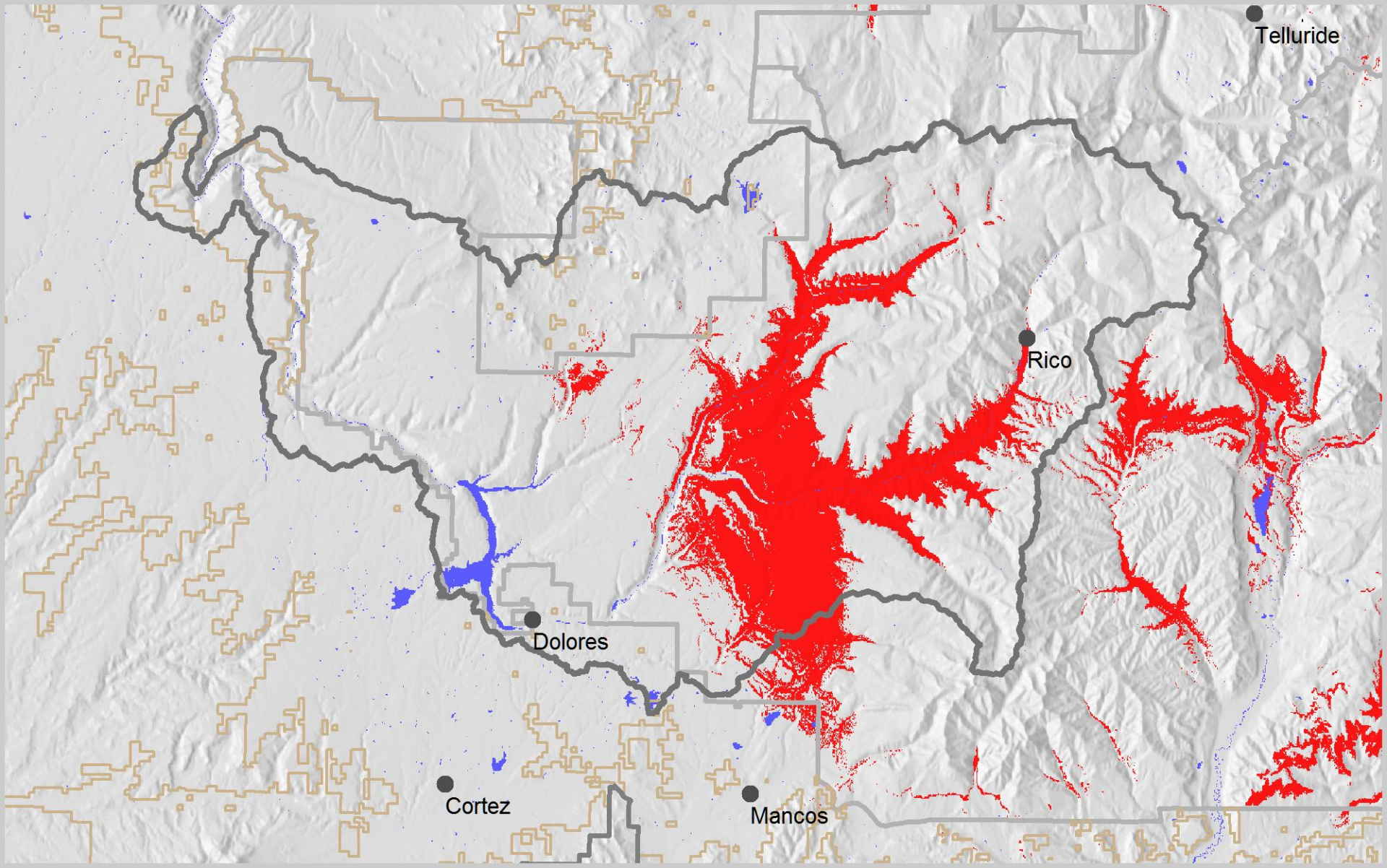
CGH Change Zones for PIEN | Lost | Threatened | Persistent | Emergent

Engelmann spruce

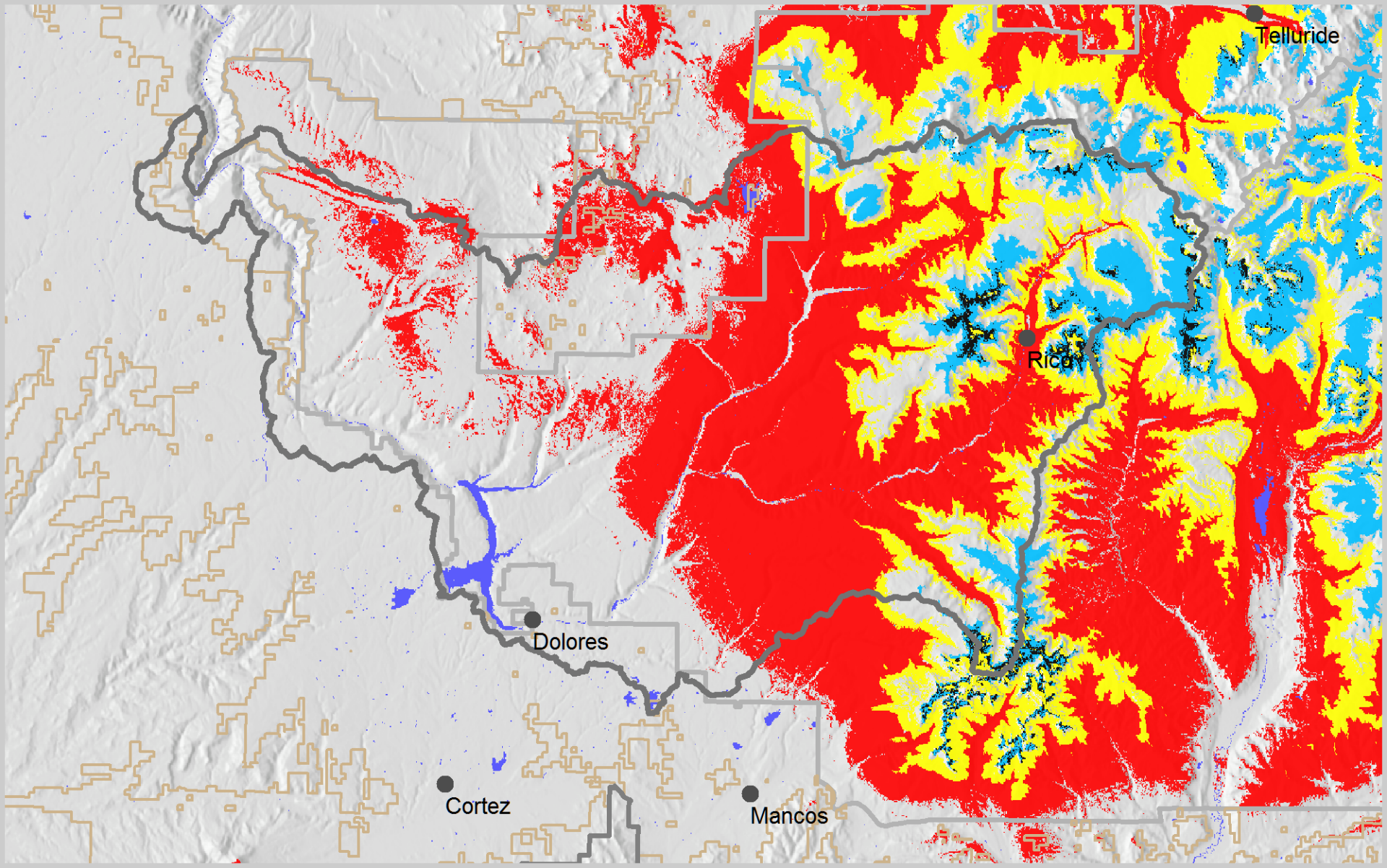


CGH Change Zones for PIPO | Lost | Threatened | Persistent | Emergent

Ponderosa pine

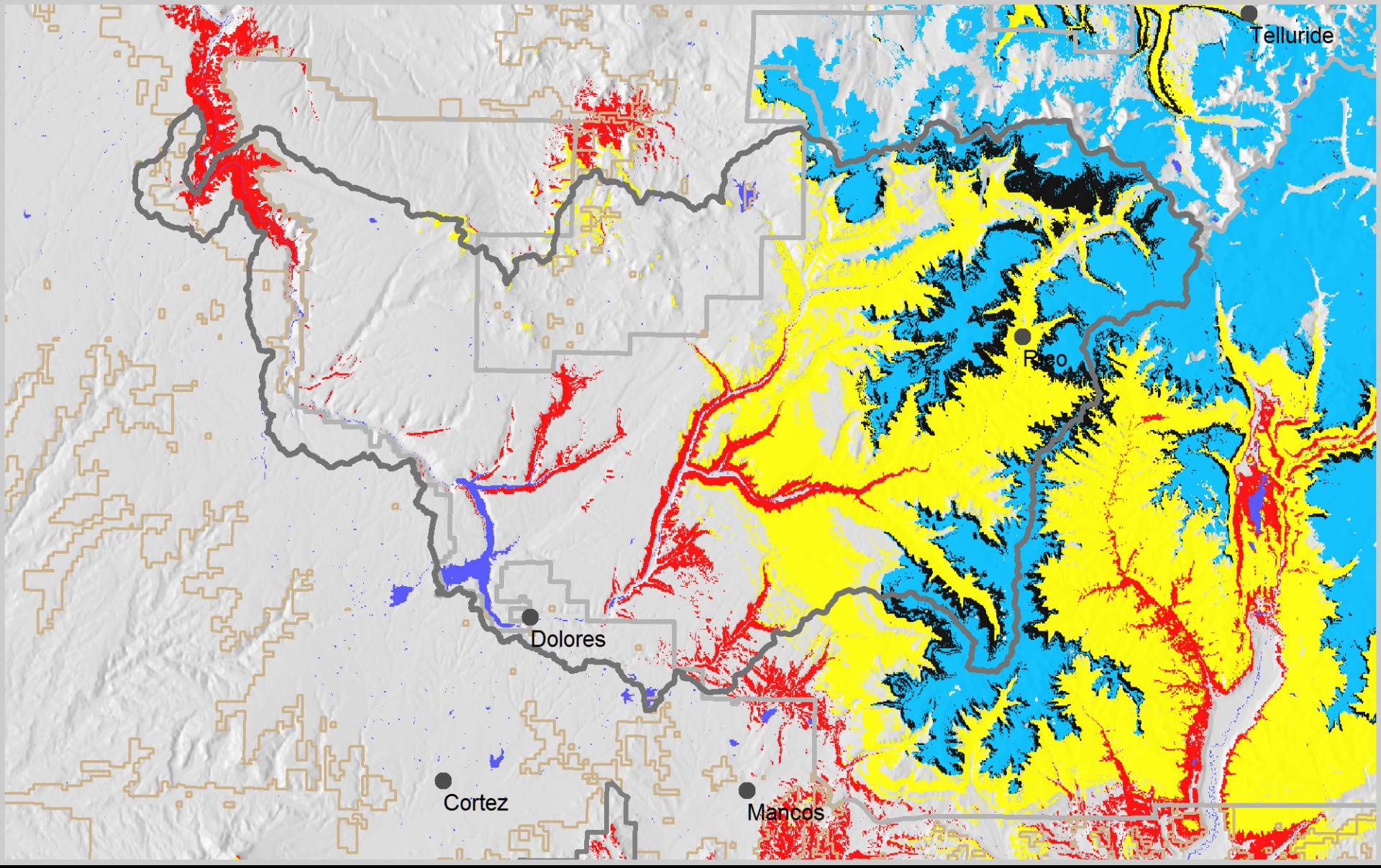

Telluride
Rico
Dolores
Cortez
Mancos
CGH Change Zones for PIPU
Lost
Threatened
Persistent
Emergent

Blue spruce



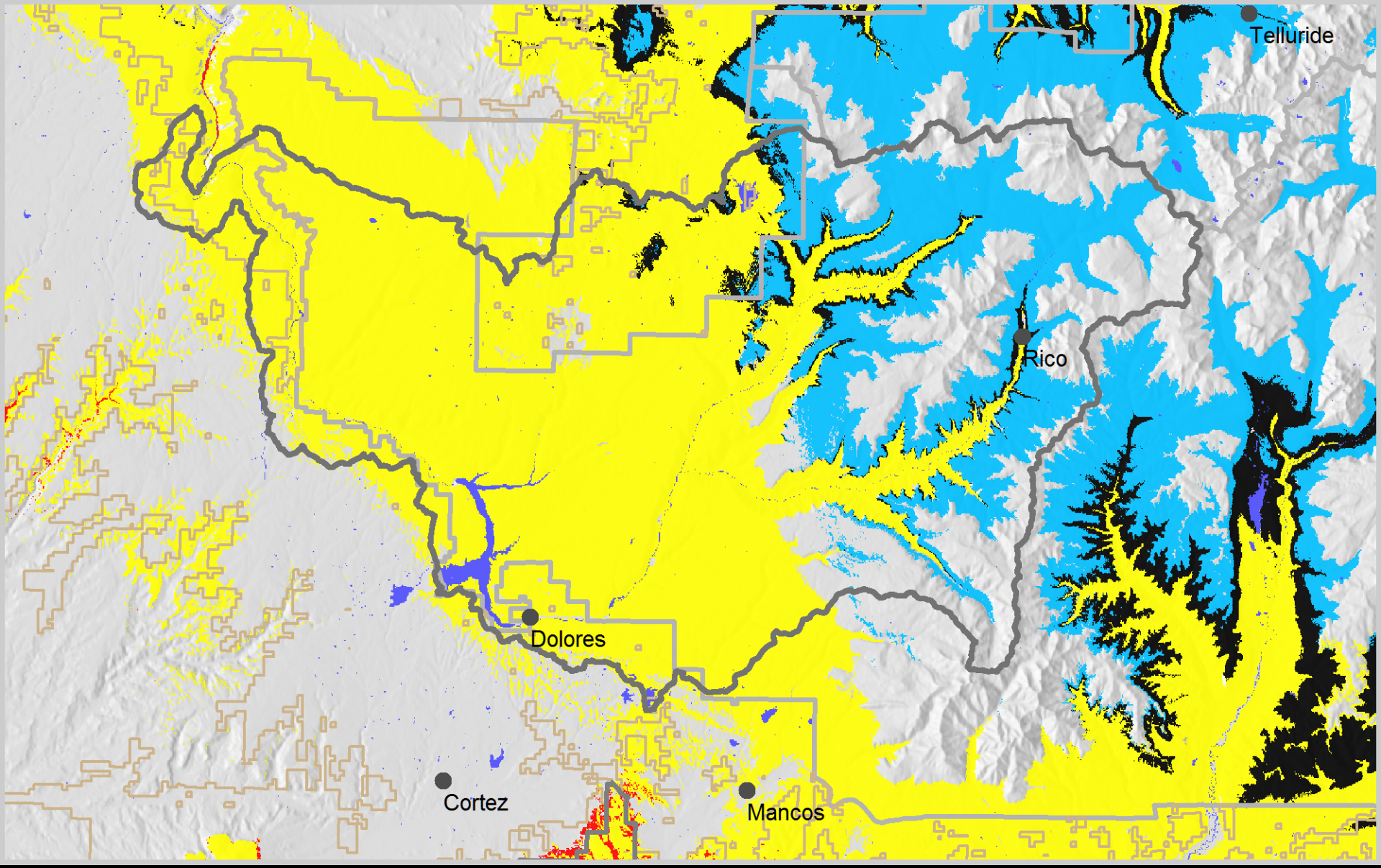
CGH Change Zones for POTR5 | Lost | Threatened | Persistent | Emergent

Aspen



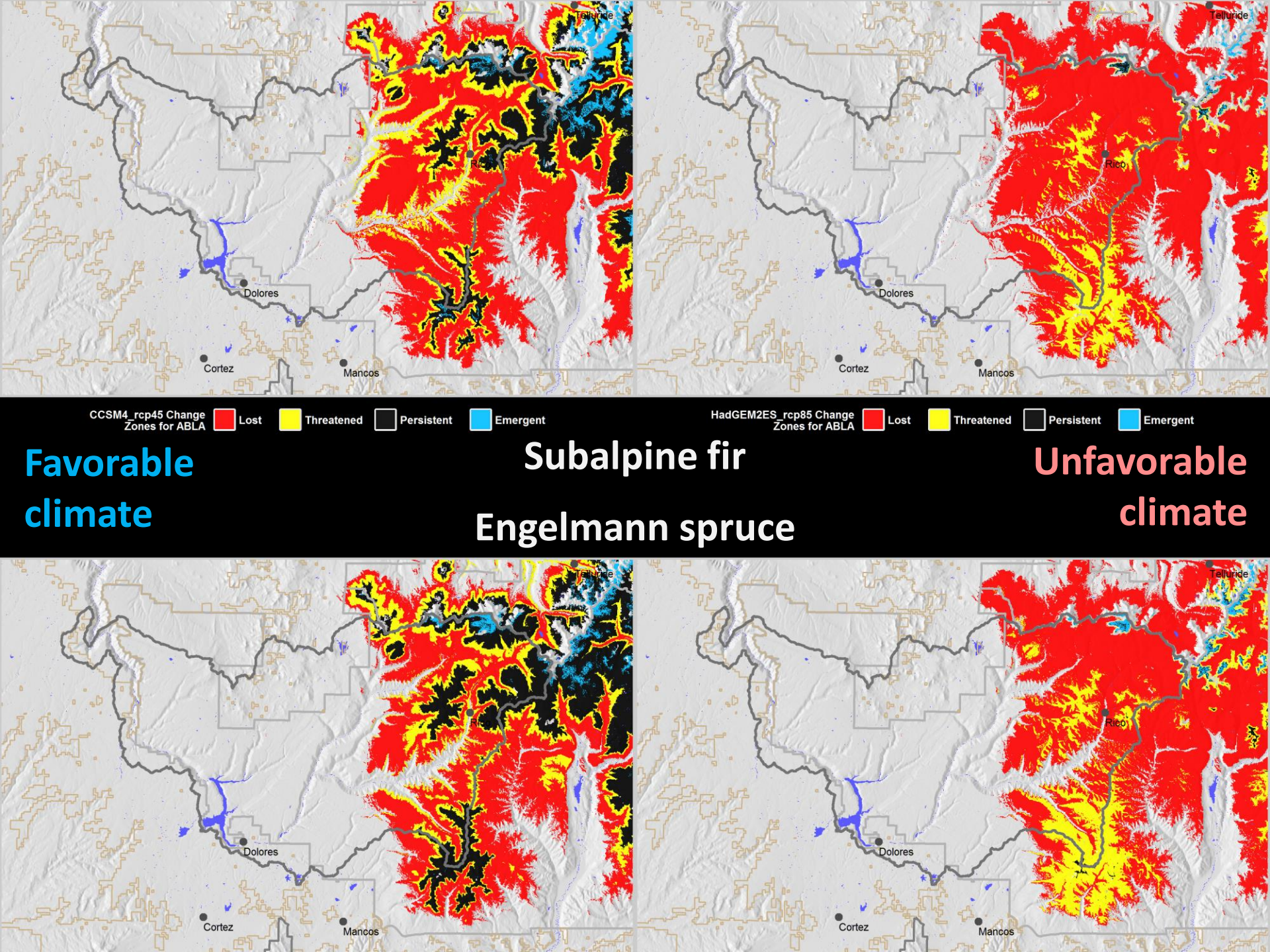
CGH Change Zones for PSME | Lost | Threatened | Persistent | Emergent

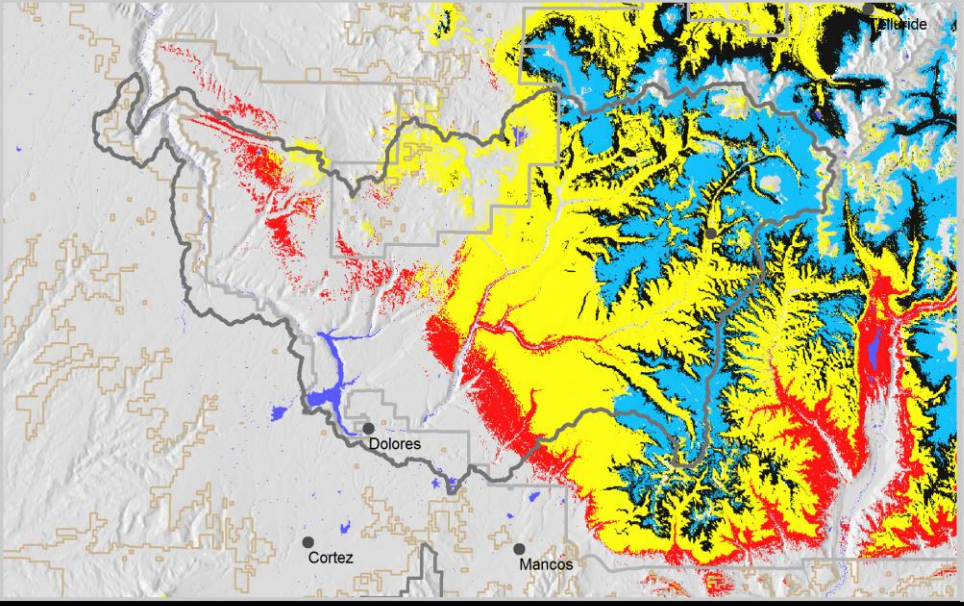
Douglas-fir



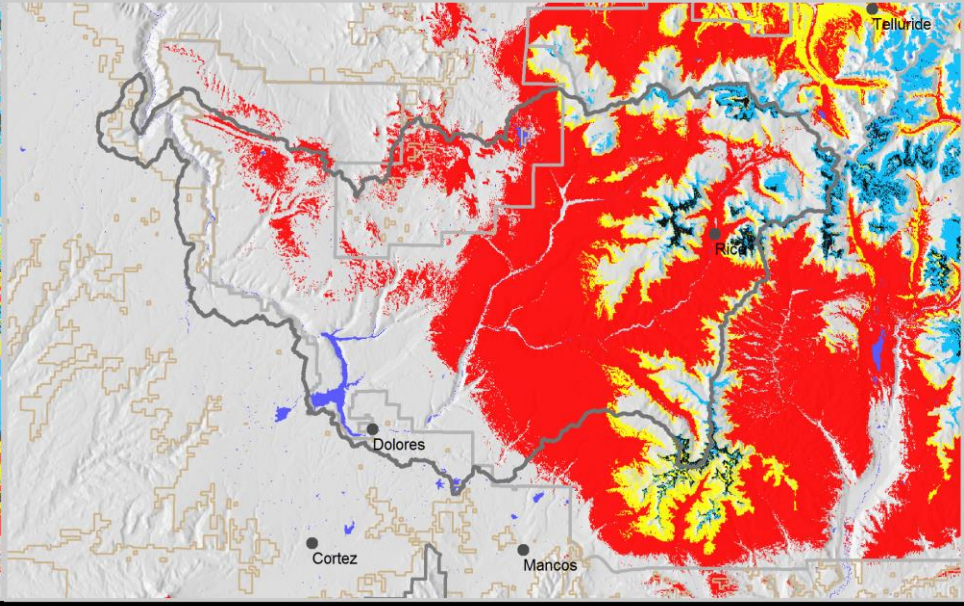
CGH Change Zones for QUGA | Lost | Threatened | Persistent | Emergent

Gambel oak


Telluride
Rico
Dolores
Cortez
Mancos
CCSM4_rcp45 Change Zones for ABLA
Lost
Threatened
Persistent
Emergent
HadGEM2ES_rcp85 Change Zones for ABLA
Lost
Threatened
Persistent
Emergent
Favorable climate
Subalpine fir
Engelmann spruce
Unfavorable climate



CCSM4_rcp45 Change Zones for POTR5 — Lost | Threatened | Persistent | Emergent



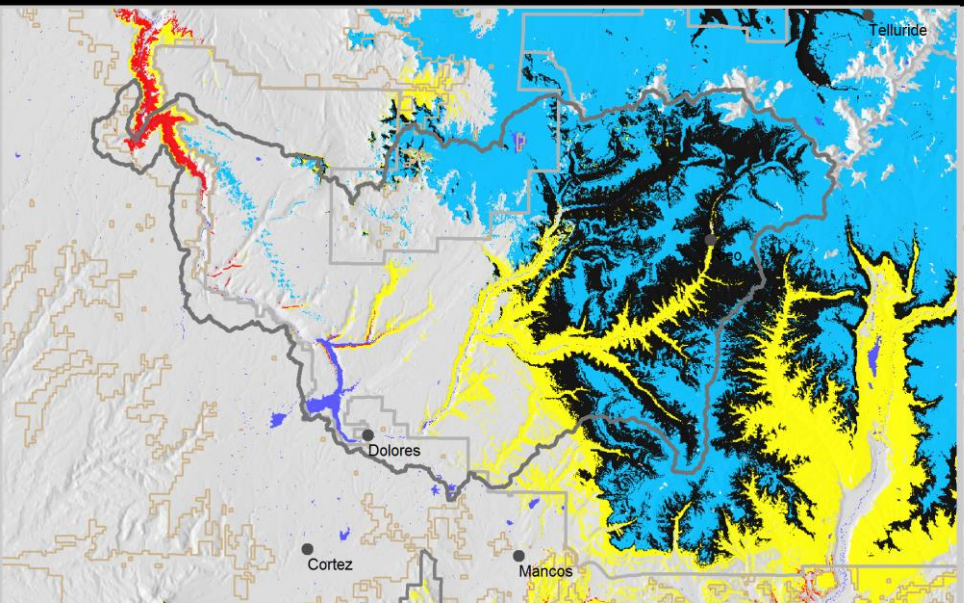
HadGEM2ES_rcp85 Change Zones for POTR5 — Lost | Threatened | Persistent | Emergent

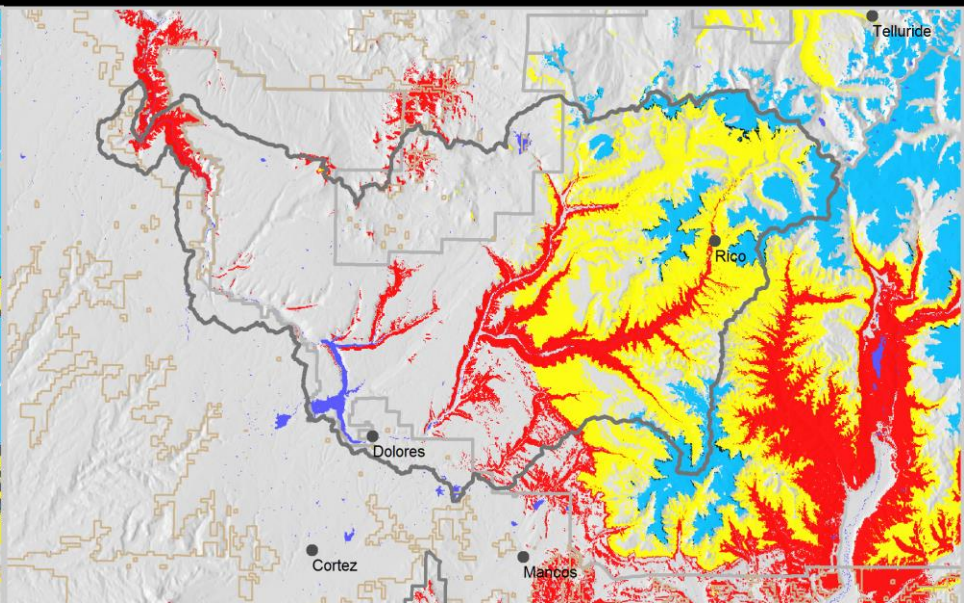
Favorable climate

Aspen

Douglas-fir

Unfavorable climate



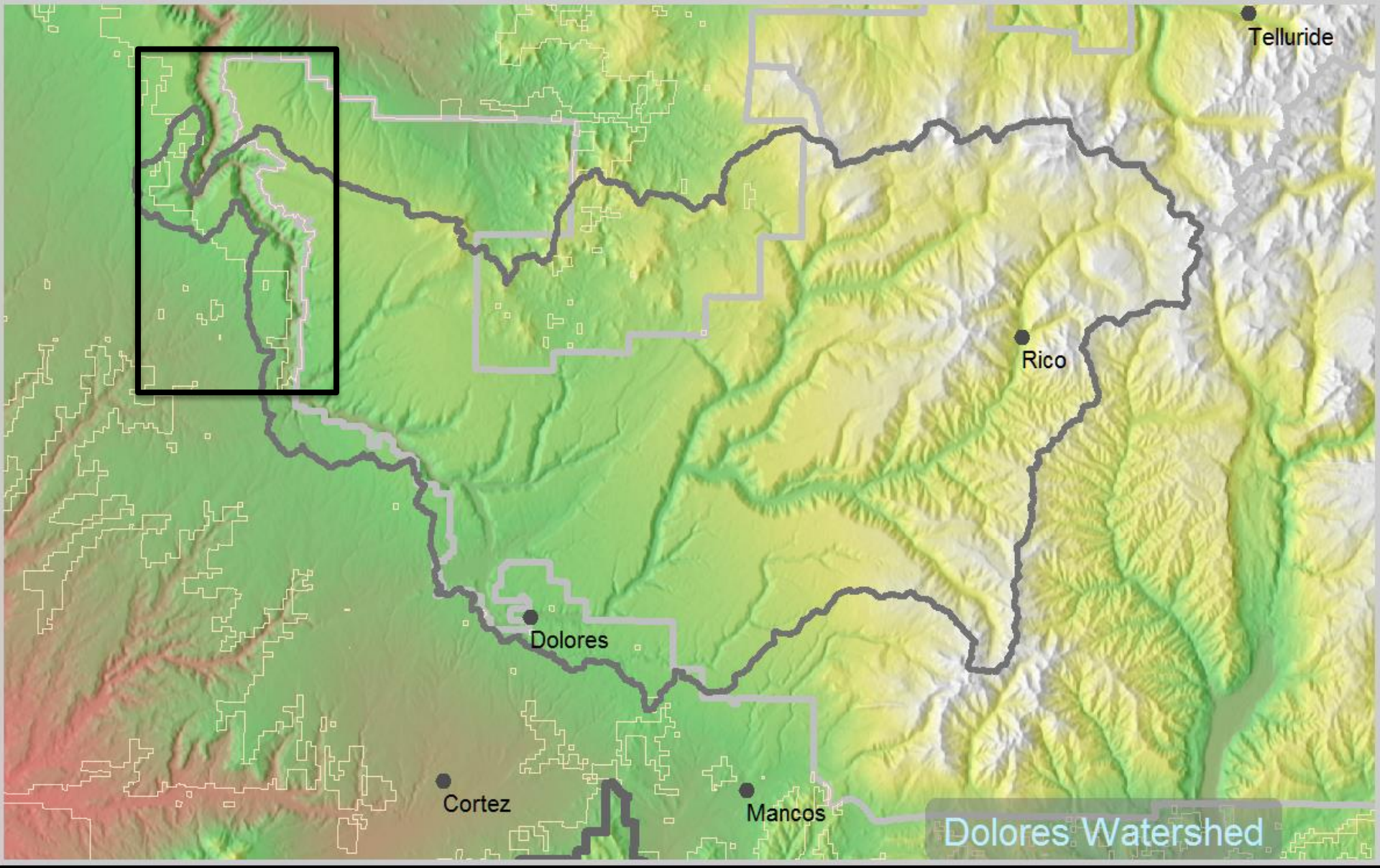


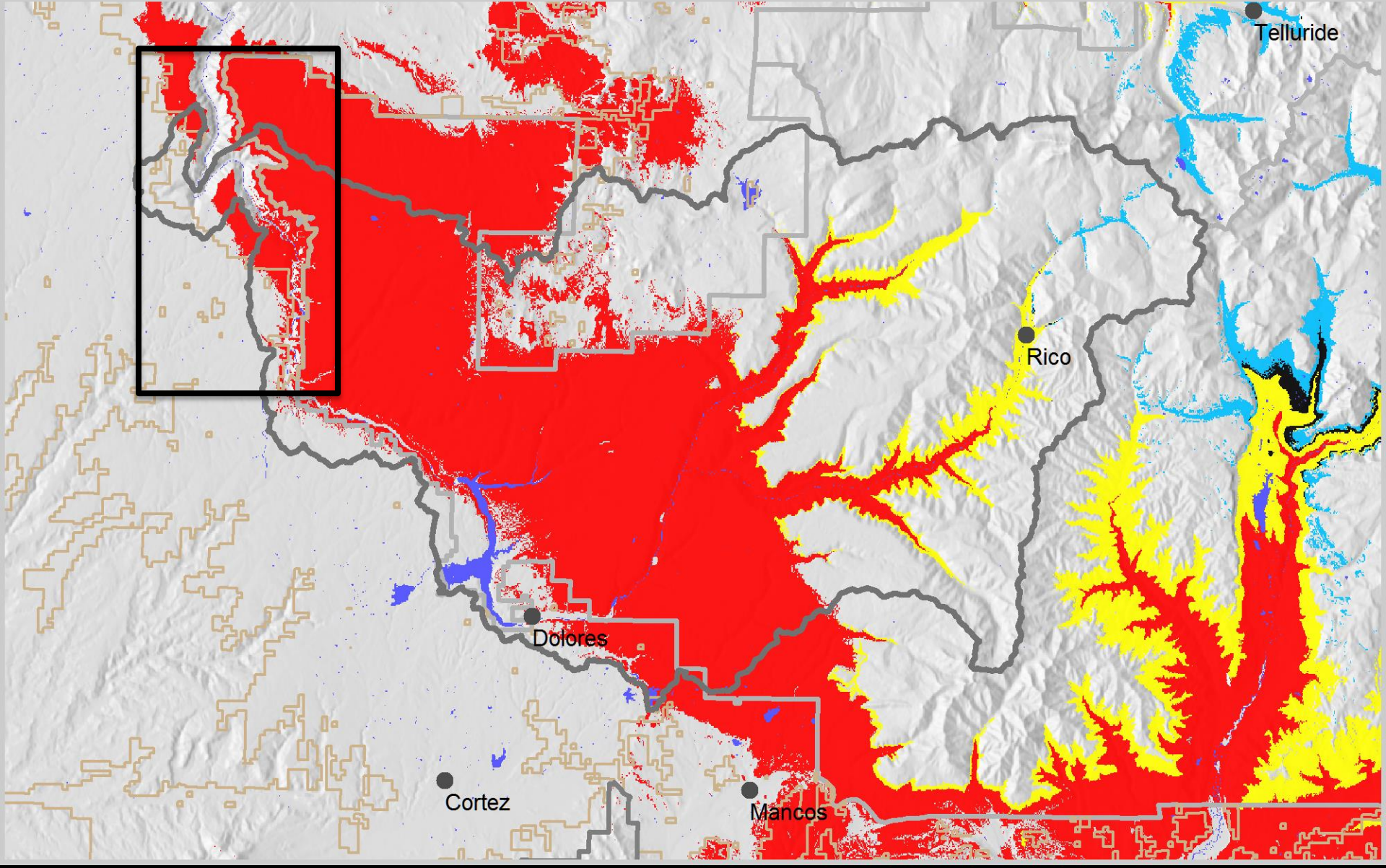
Potential Applications

- Having a good estimate of where species will and will not be suited in the future, we can:
  1. On a given site, apply treatments most appropriate for the future.
  2. Focus efforts where they have the greatest likelihood of long-term success.
  3. Identify sites and strategies to protect special species.
- Planning
  - Forest
  - Landscape assessment
  - Projects

Project area pre-determined

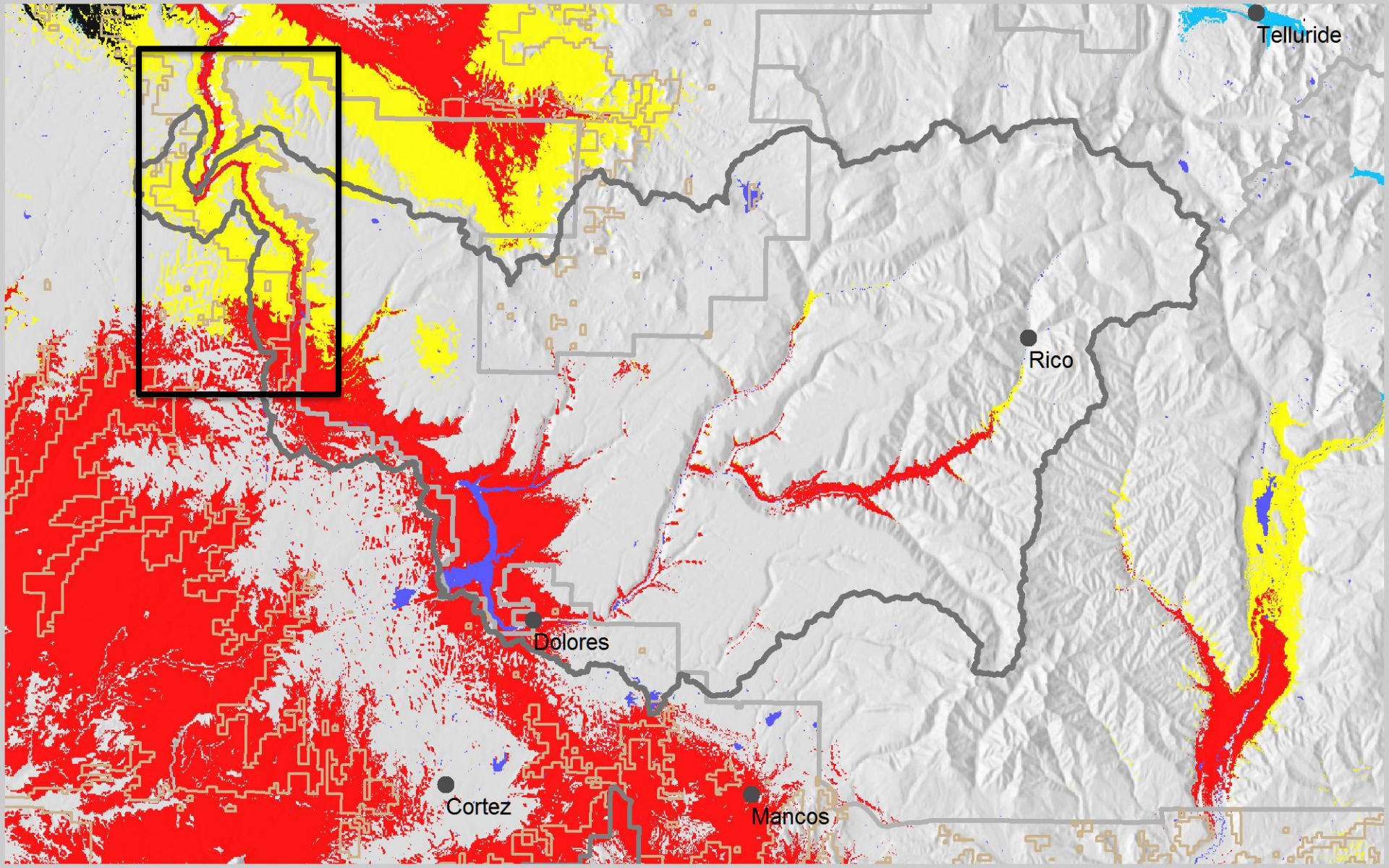
APPLY TREATMENTS APPROPRIATE FOR PROJECTED FUTURE


Telluride
Rico
Dolores
Cortez
Mancos
Dolores Watershed



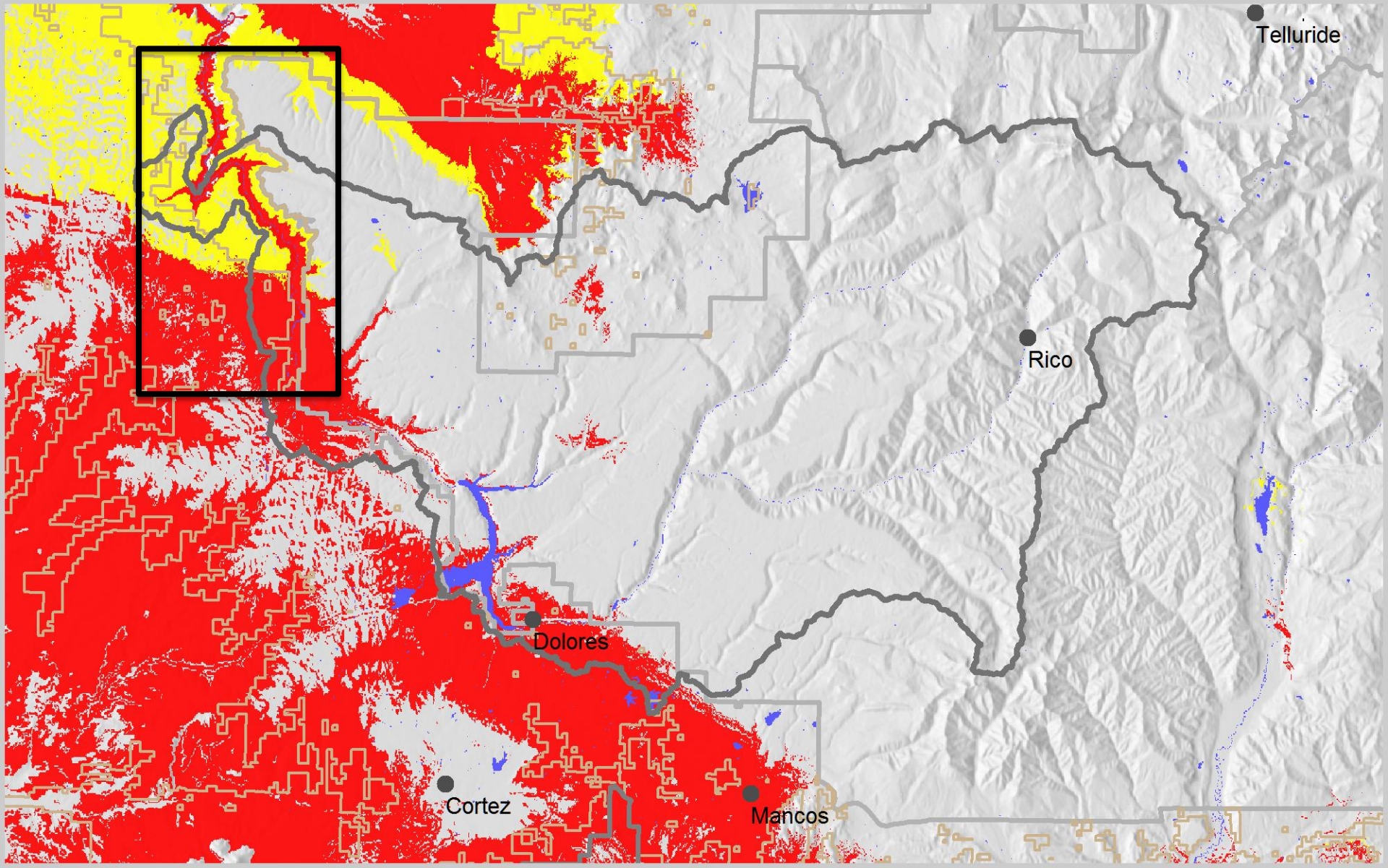
CGH Change Zones for PIPO | Lost | Threatened | Persistent | Emergent

Ponderosa pine



CGH Change Zones for PIED | Lost | Threatened | Persistent | Emergent

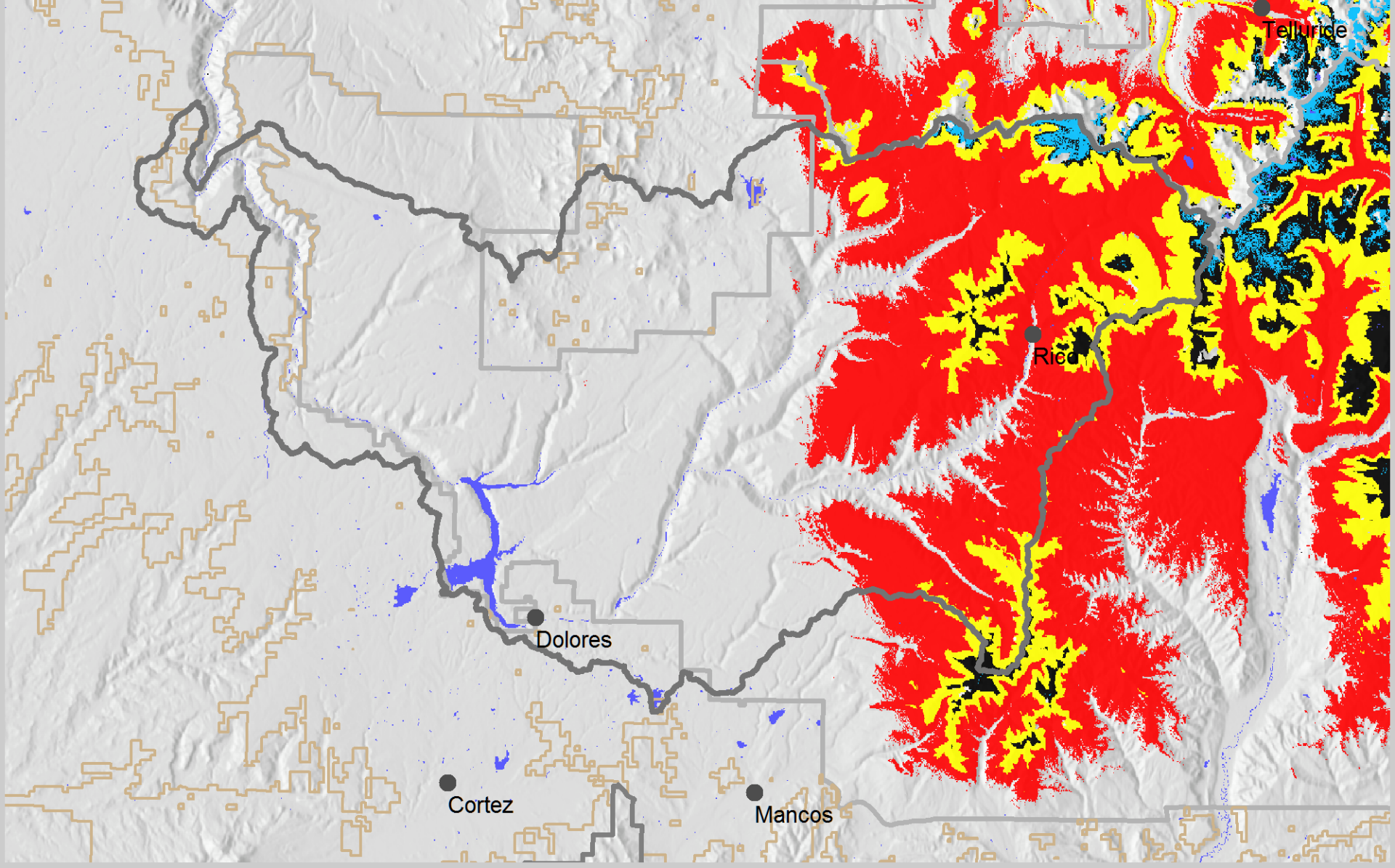
Piñon



Utah juniper

Where should we manage spruce for timber?

IDENTIFY AREAS ON THE LANDSCAPE WHERE TREATMENTS HAVE THE GREATEST CHANCE OF LONG-TERM SUCCESS



CGH Change Zones for PIEN | Lost | Threatened | Persistent | Emergent

Engelmann spruce

Where to manage spruce?

PERSISTENT zone

- Manage as normal.

THREATENED zone

- Manage as 2nd priority, but
- Focus more on resilience.

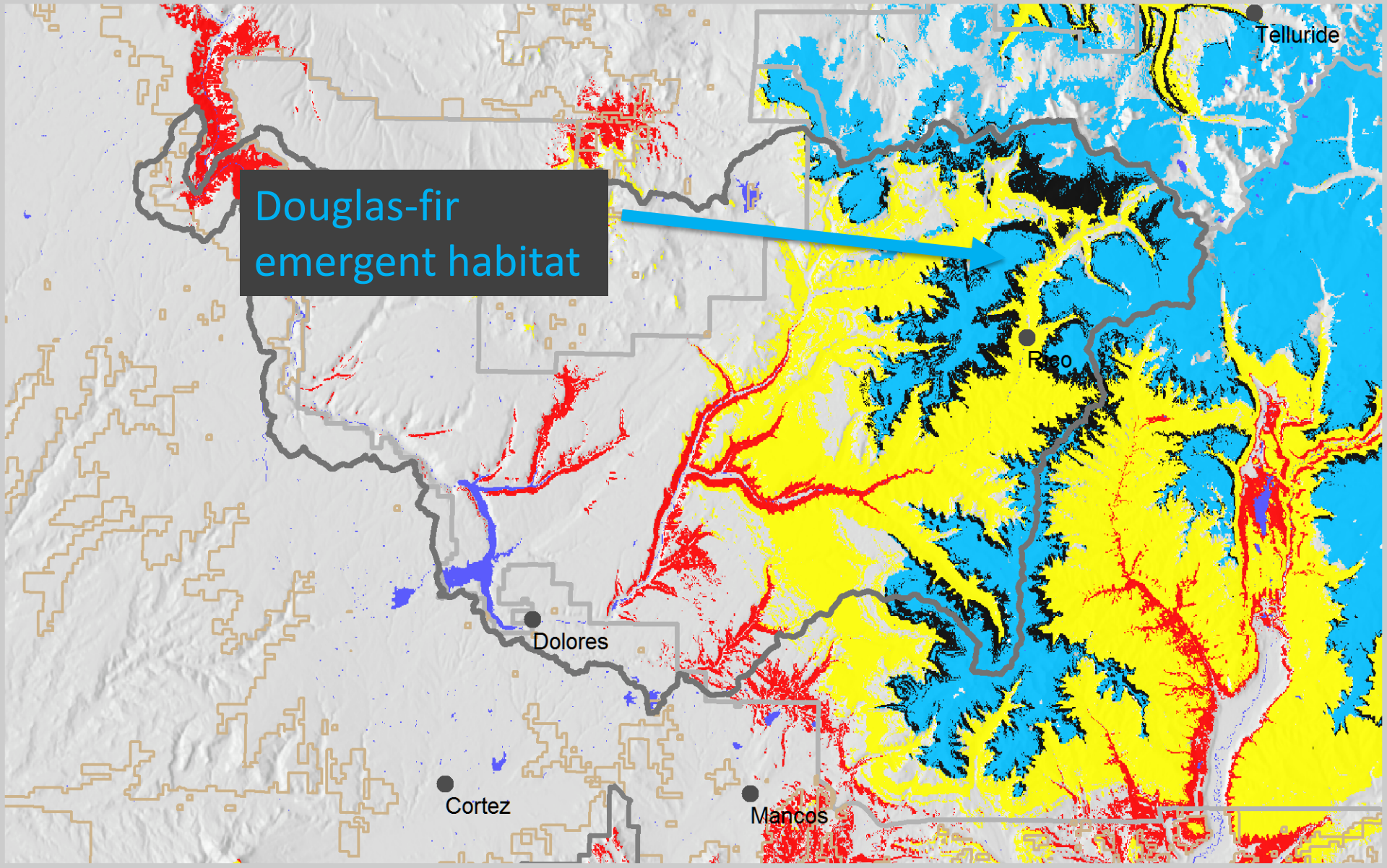
LOST zone

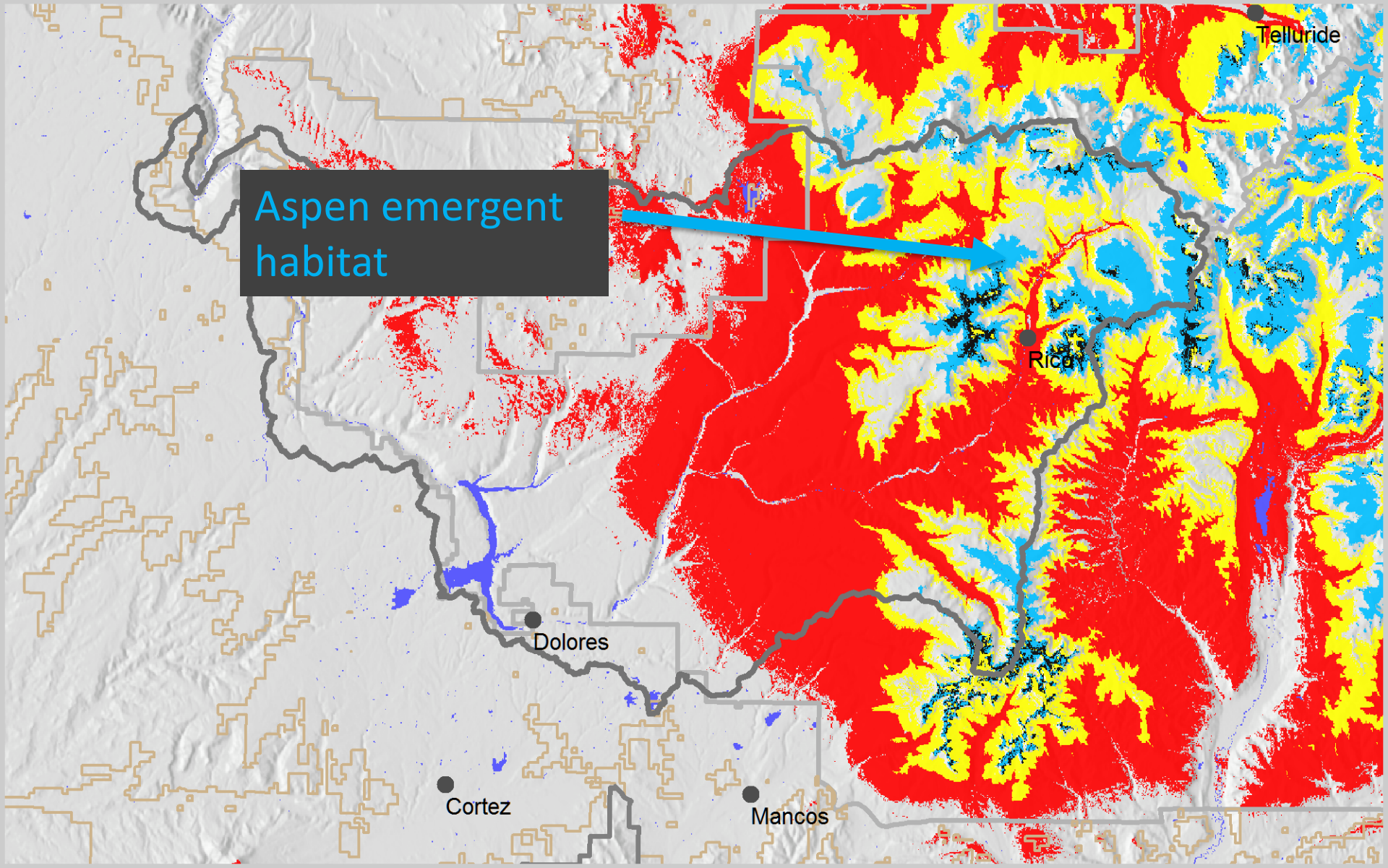
- Avoid investing in the future of spruce.
- Treat for short-term benefits and to
- Begin pushing cover-type to the future.

What about the EMERGENT zone?

ASSISTED AND FACILITATED MIGRATION

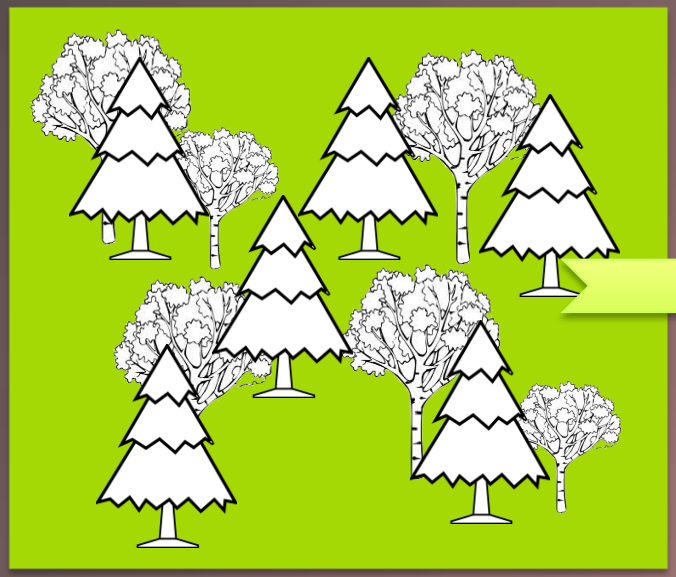
- Assisted migration:
  - Movement of species and populations to facilitate range expansion in direct management response to climate change
- Facilitated migration
  - Enhancing opportunities for self-migration by favoring seed production and dispersal in current habitat and receptive seedbeds in nearby emergent habitat.


Douglas-fir
emergent habitat
Telluride
Rico
Dolores
Cortez
Mancos
CGH Change
Zones for PSME
Lost
Threatened
Persistent
Emergent


Aspen emergent habitat
Telluride
Rico
Dolores
Cortez
Mancos
CGH Change Zones for POTR5
Lost
Threatened
Persistent
Emergent

Facilitating Migration

Persistent or Threatened



Emergent

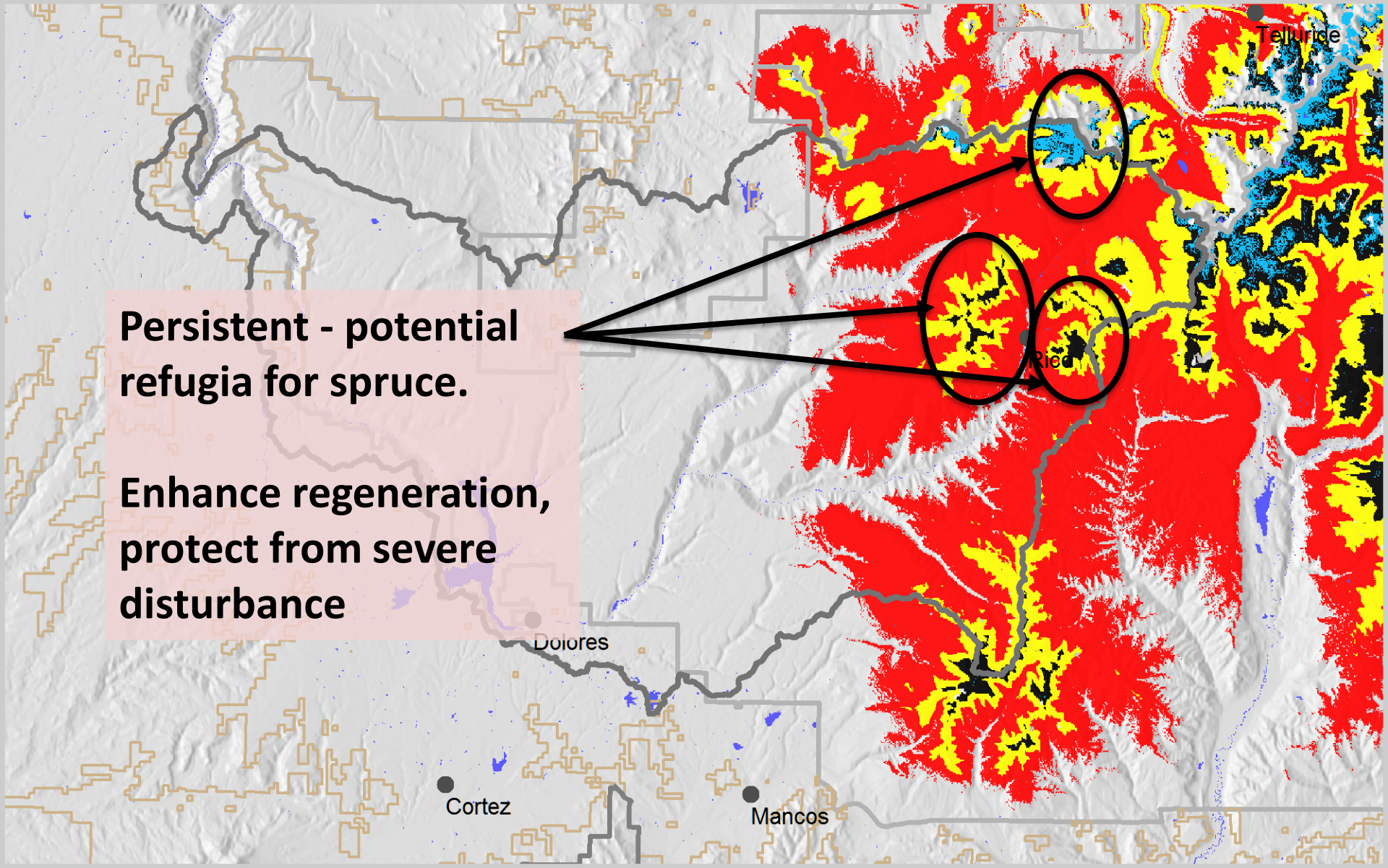
Prevailing wind

Promote existing (female) aspen near Emergent areas to enhance seed production

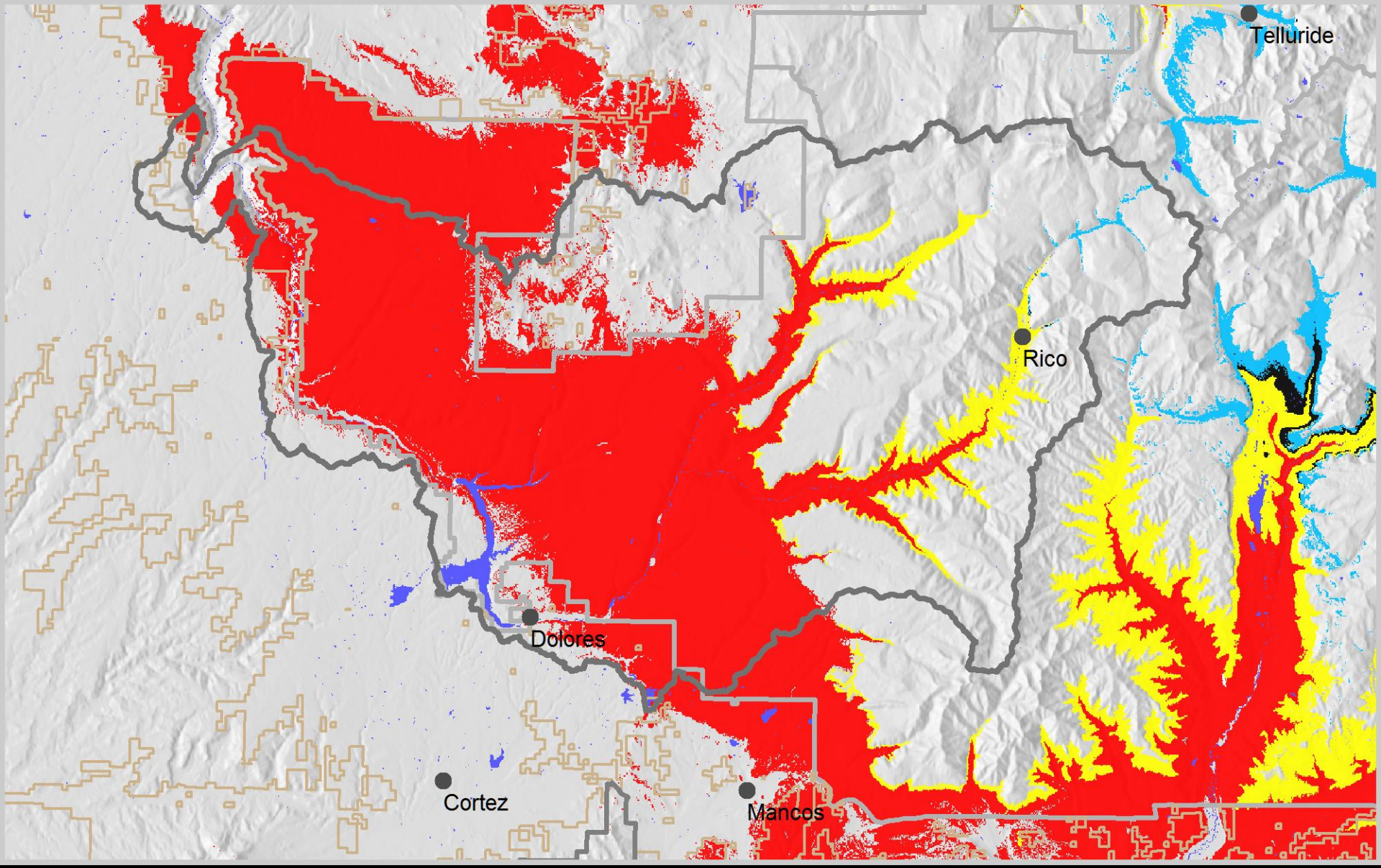
Favor disturbances (esp. fire) in newly suitable areas to facilitate aspen establishment

Climate refugia

PROTECTING SPECIES AT RISK

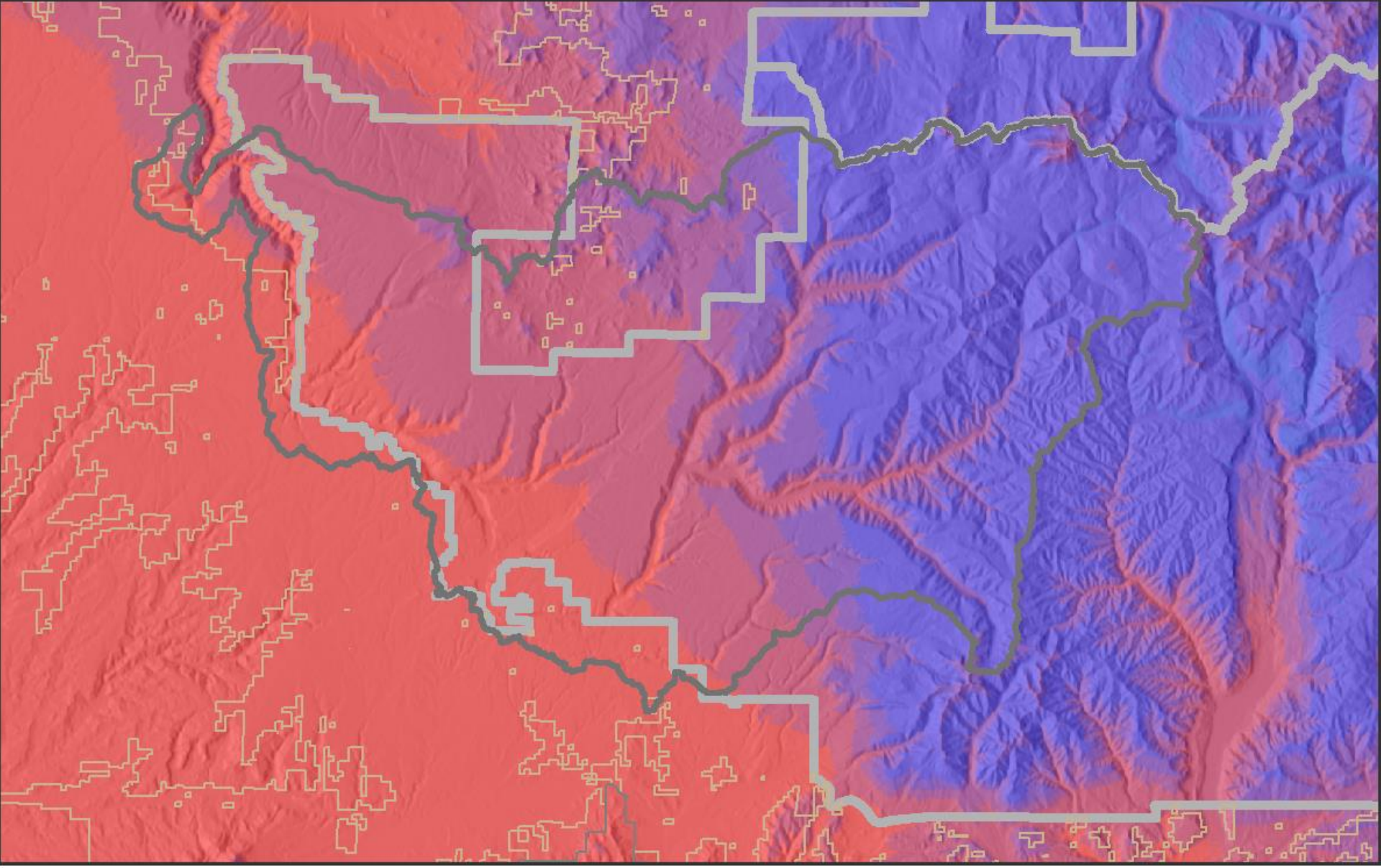


Engelmann spruce

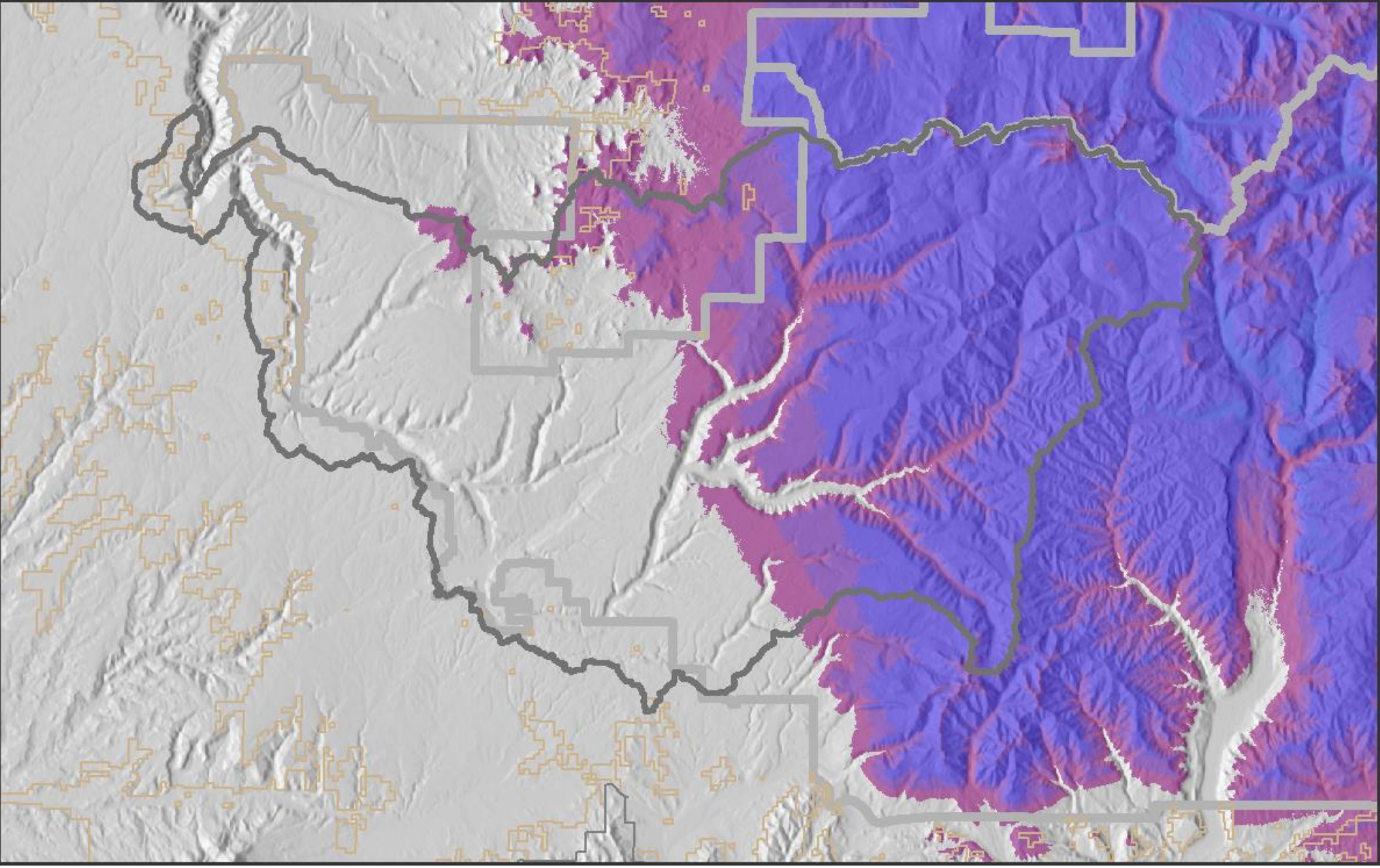


CGH Change Zones for PIPO | Lost | Threatened | Persistent | Emergent

Ponderosa pine



Ponderosa pine 2060


PIPO
Proportion
of votes
0-10
10-20
20-30
30-40
40-50
50-60

Conclusion

- Bioclimate models can be used to:
  - Design treatments most appropriate for the future.
  - Focus resources where there is the greatest likelihood of long-term success.
  - Identify best approaches and sites to manage species at risk.

“If you don’t plan for the future,

you’re planning for the past”