Conservation Success Index: Rio Grande Cutthroat Trout

ONCORHYNCHUS CLARKII VIRGINALIS

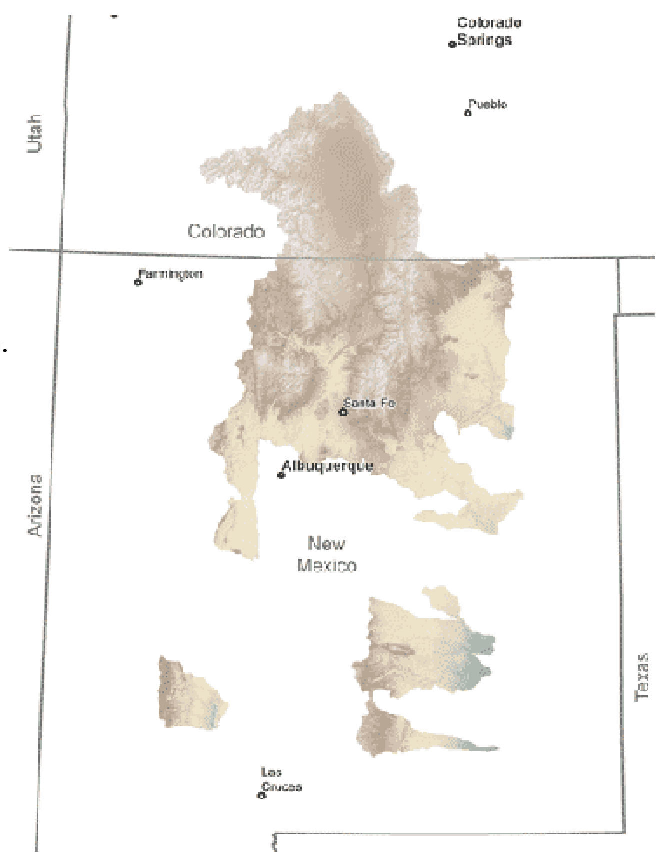
Rev. 2.0 - 9/2009

SPECIES SUMMARY

The Rio Grande cutthroat trout (RGCT) is native to the Rio Grande, and Pecos and Canadian rivers of Colorado and New Mexico. In *Trout and Salmon of North America*, Robert Behnke also notes that RGCT may have been native to streams of the Davis Mountains of west Texas, but even if true they have long since been extirpated from that state. Currently, the subspecies is restricted primarily to smaller headwater streams of the Rio Grande drainage in south-central Colorado, and smaller tributaries of the Rio Grande, and Pecos and Canadian rivers in New Mexico. Unlike many other cutthroat trout subspecies, there were no large lake populations and therefore very little if any lacustrine specializations within this Rio Grande subspecies.

Many of the same factors causing declines in the status of inland cutthroat subspecies throughout the West have affected RGCT. Introductions of non-native trout species have been a primary cause for declines. Rainbow trout and non-native cutthroat are especially problematic because of the likelihood of hybridization and subsequent genetic introgression of non-native genes into RGCT populations. The major causes of habitat degradation consist of livestock grazing, timber harvest and associated activities such as road construction, and diversion of water for irrigation. Livestock grazing can remove streamside riparian vegetation and increase erosion of fine sediments into spawning areas. Timber harvest also may increase input of fine sediments into streams and may remove sources of larger wood materials that are needed for building pools and creating complex stream habitat. Roads alter watershed hydrology and may interfere with fish passage if culverts or other stream-road crossings are improperly designed. Adequate supplies of high quality cold water are often in short supply, but especially in the arid Southwest. Irrigation diversions are a concern, more commonly on private lands.

Historic Range Relief Map



Key CSI Findings

- 21% of subwatersheds within the historic range still contain RGCT
- About 10% of historically occupied stream habitat currently contains populations
- Nearly 90% of populations occur in isolated stream segments
- Most currently occupied stream habitats were ranked at "good" or "excellent" condition
- Increasing severity and duration of drought, floods, and wildfire is negatively impacting future population persistence
- Metapopulations and fluvial life histories, both important traits for long term population persistence, are lacking in RGCT

In a 2007 assessment of RGCT, agency and tribal biologists comprising the Rio Grande Cutthroat Trout Conservation Team estimated that a total of 120 "conservation populations" of RGCT remained within the entire historic range. Nearly all populations are isolated with little if any chance of movement among tributaries within drainages. Isolation increases the likelihood of population loss following disturbances such as flood, drought, or wildfire. On the other hand, the isolated nature of these populations may decrease the potential for hybridization or other negative interactions with introduced trouts.

Photo courtesy William Schudlich

Table of CSI results for 20 CSI indicators within currently occupied and historic range. Range-wide condition and population integrity indicators (first 10 indicators) were scored only for subwatersheds containing existing populations. Remaining habitat and future security indicators were scored with all subwatersheds within the historic range. All indicators are scored from 1 (poorest) to 5 (best): see detailed methods for scoring and rule sets for this subspecies.

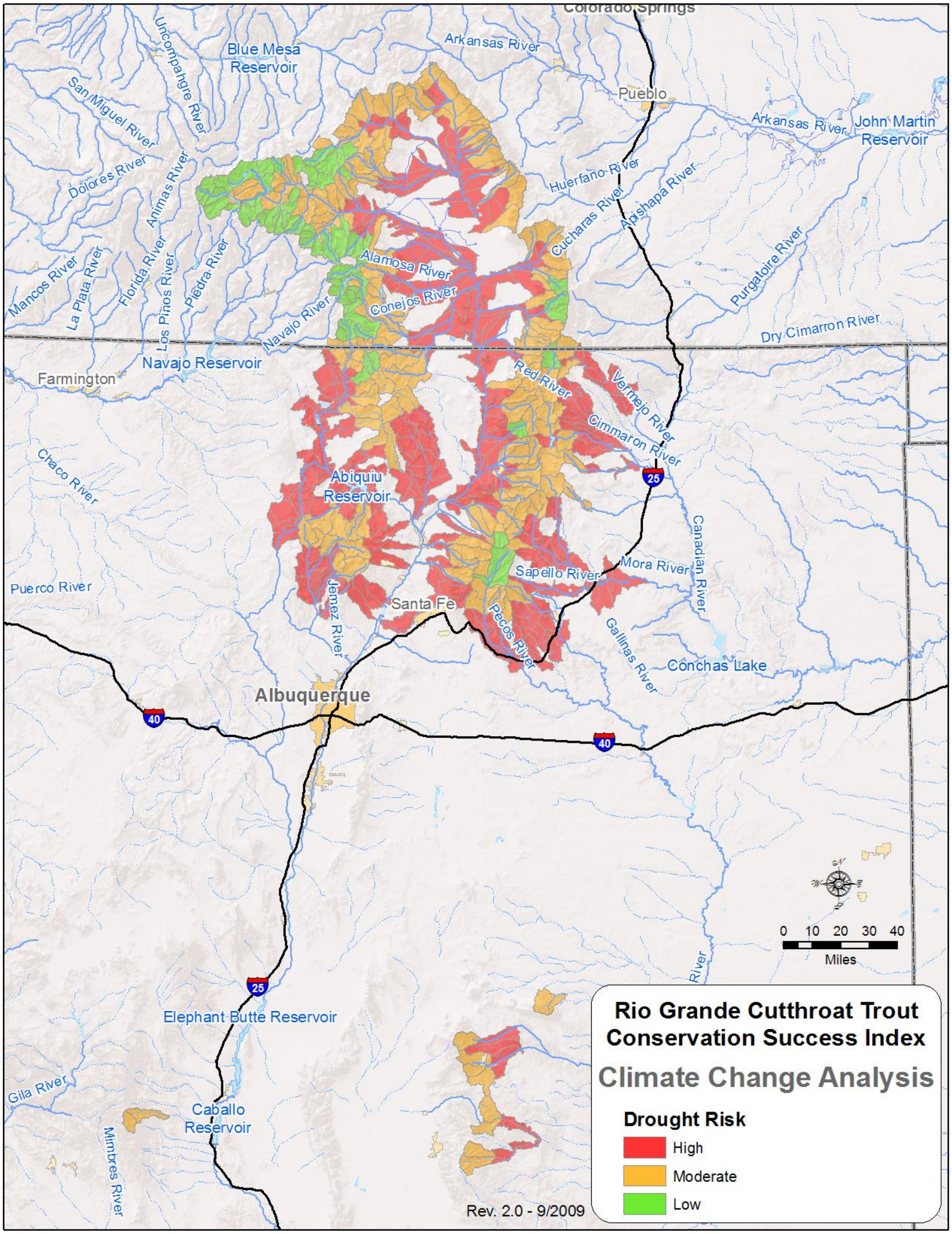
		Number of Subwatersheds Receiving Scores					**Total Subwatersheds Scored**
	CSI Indicator	**1**	**2**	**3**	**4**	**5**	
Range-wide Conditions	Percent historic stream habitat occupied	8	19	17	16	26	86
	Percent subbasins (4th) occupied	0	0	86	0	0	86
	Percent subwatersheds (6th) occupied	36	50	0	0	0	86
	Percent habitat by stream order occupied	37	1	2	4	42	86
	Percent historic lake area occupied	7	0	0	1	78	86

Population Integrity	Population Density	9	0	17	35	8	69
	Population Extent	77	8	0	1	0	86
	Genetic Purity	0	6	1	16	63	86
	Disease vulnerability	4	0	6	8	68	86
	Life history diversity	7	0	75	0	4	86
Habitat Integrity	Land Stewardship	247	3	52	4	111	417
	Watershed connectivity	21	40	34	80	242	417
	Watershed conditions	26	21	87	177	106	417
	Water quality	170	28	70	63	86	417
	Flow regime	24	20	33	79	261	417
Future Security	Land conversion	0	4	17	36	359	416
	Resource extraction	32	22	40	33	289	416
	Energy development	16	9	82	174	136	417
	Climate change	139	99	19	33	127	417
	Introduced species	45	20	34	294	24	417

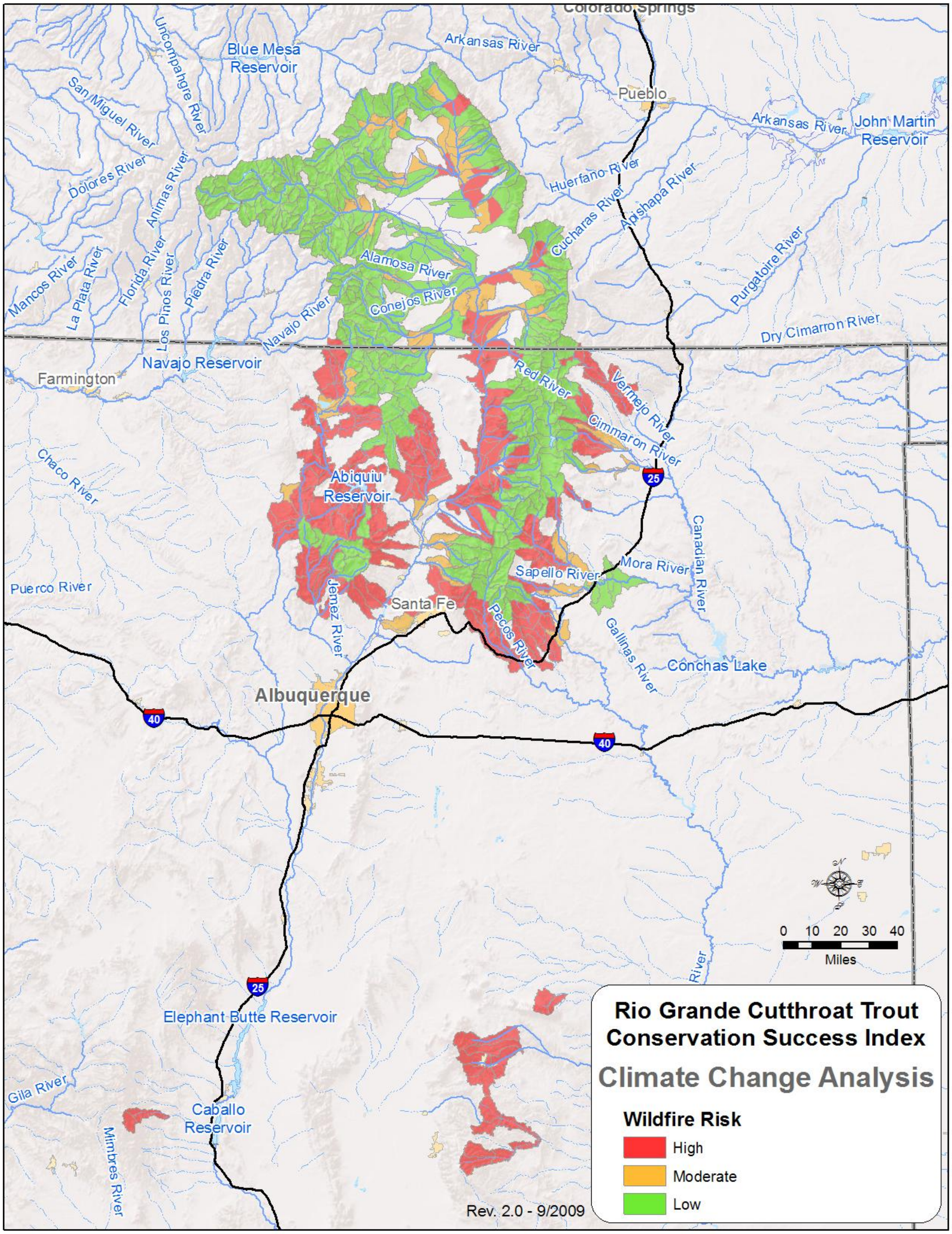
Our CSI analysis indicates that the RGCT, like other southwestern trouts, is likely to be severely impacted by climate change. Although it is difficult to attribute any single storm or drought event to climate change alone, most populations of RGCT will be increasingly vulnerable to wildfire, flood, and drought, all factors that are likely to expand in severity and duration during a warming climate. It is likely that the large number of small, fragmented RGCT populations will be particularly vulnerable because they are restricted to short reaches of relatively low stream flow. Drought already has become a major factor in declines of RGCT populations since 2002, including the loss of several small populations. Thus, it is important to understand the 2007 RGCT range-wide assessment results within an existing and future context of rapidly changing environmental conditions.

To improve future conservation status, some populations should be expanded and connected to enhance the likelihood of developing fluvial life histories and interconnected metapopulations. The ability of fish to move within tributaries and larger stream systems increases their chance to survive disturbances and may be especially important during periods of rapidly changing climate. Approximately 25% of subwatersheds within the historic range were at high risk from climate change impacts that include increased summer temperature, increased wildfire, and increased risk of winter flooding. Climate change also may affect interactions between RGCT and introduced fishes in uncertain ways. The best long-term conservation strategy should strive to create a range of isolated to interconnected populations free of introduced salmonids within all major drainages historically occupied by RGCT.

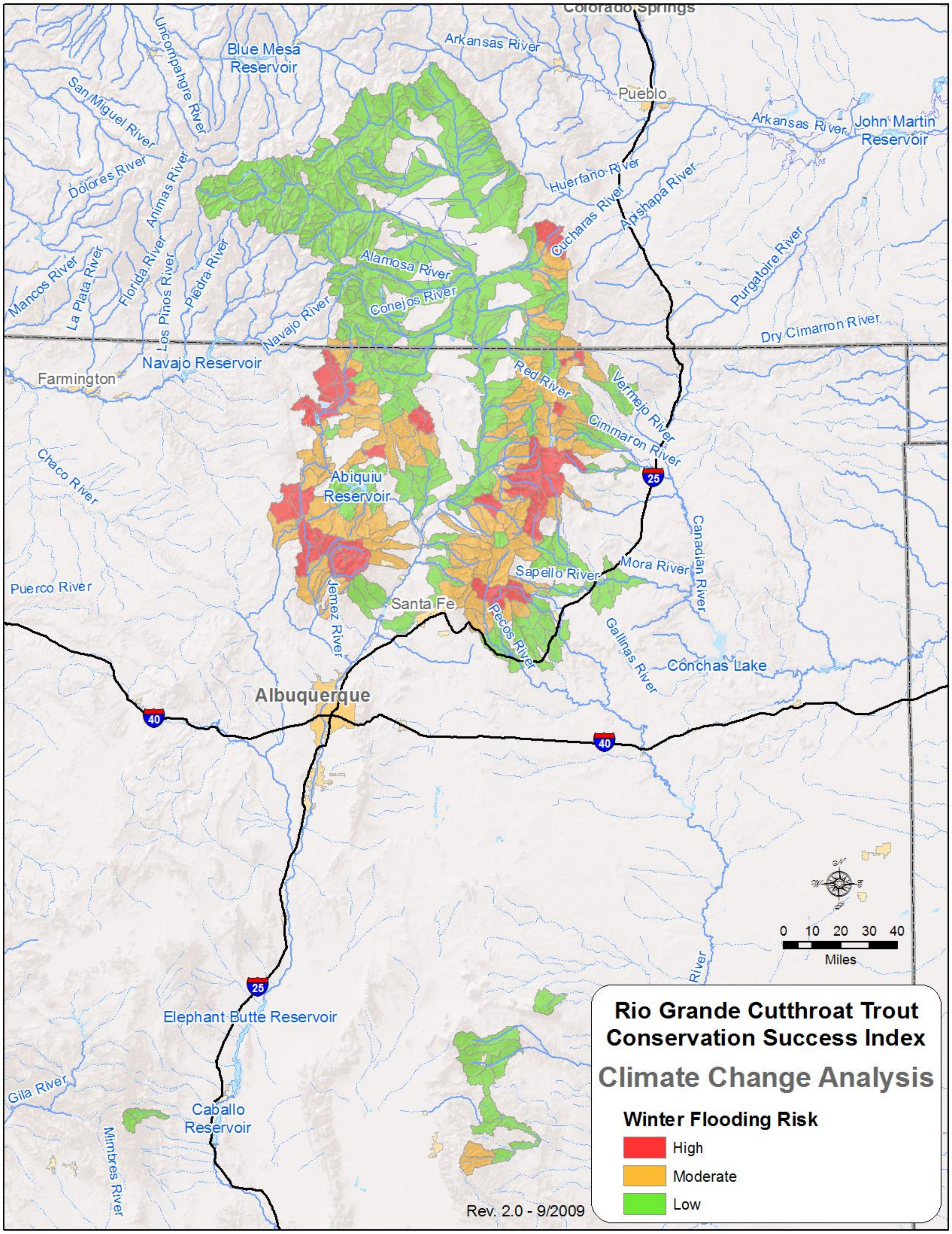
Prepared by Jack E. Williams, TU, 4/16/2008



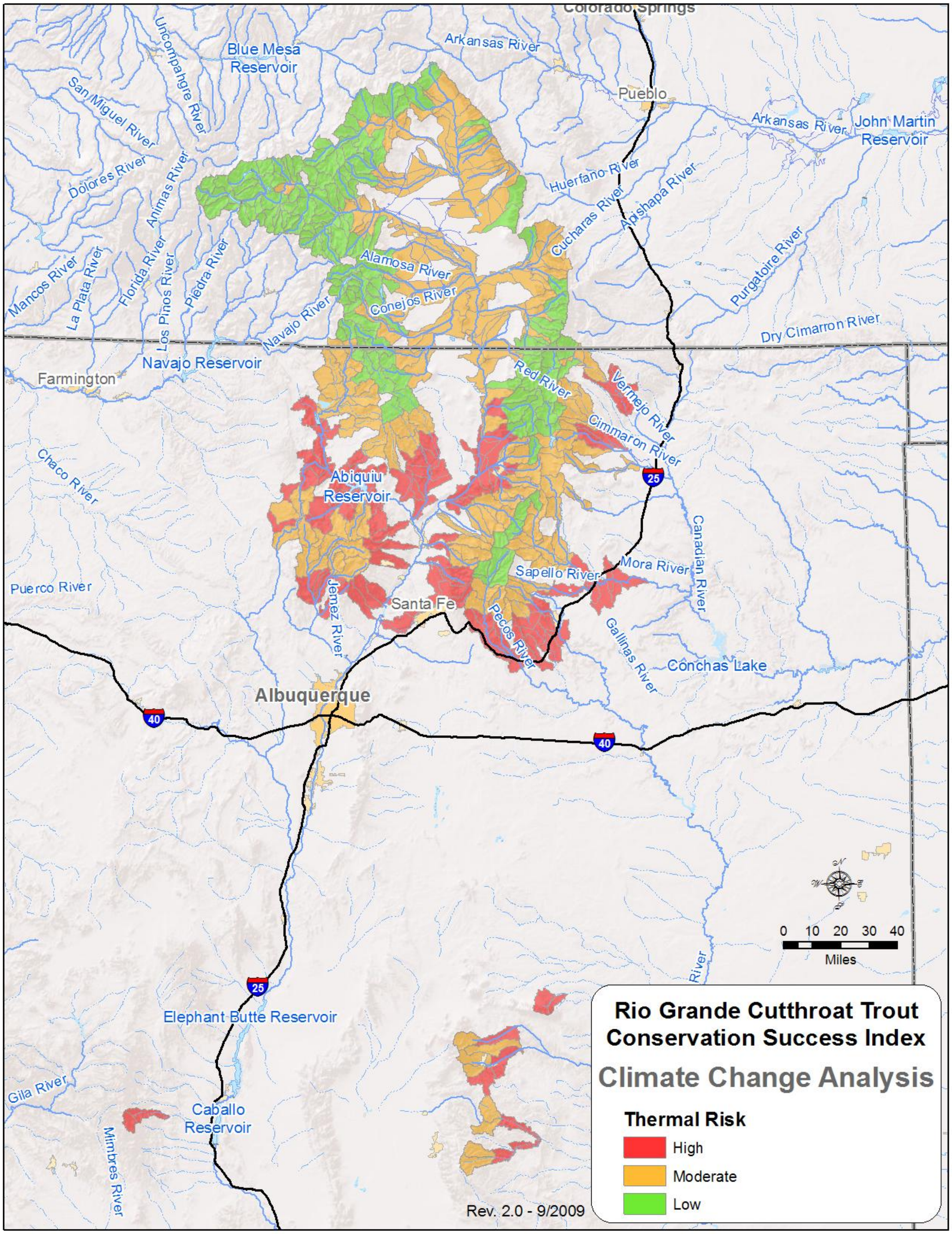
Rio Grande Cutthroat Trout
Conservation Success Index
Climate Change Analysis
Drought Risk
High
Moderate
Low
Rev. 2.0 - 9/2009
0 10 20 30 40
Miles
Colorado Springs
Pueblo
Arkansas River
Blue Mesa Reservoir
John Martin Reservoir
Uncompahgre River
San Miguel River
Dolores River
Animas River
Huerfano River
Apishapa River
Cucharas River
Purgatoire River
Mancos River
La Plata River
Florida River
Los Pinos River
Piedra River
Alamosa River
Conejos River
Navajo River
Navajo Reservoir
Dry Cimarron River
Farmington
Red River
Vermejo River
Cimmaron River
Chaco River
Abiquiu Reservoir
Canadian River
Sapello River
Mora River
Puerco River
Jemez River
Santa Fe
Pecos River
Gallinas River
Conchas Lake
Albuquerque
Elephant Butte Reservoir
Gila River
Caballo Reservoir
Mimbres River



Rio Grande Cutthroat Trout
Conservation Success Index
Climate Change Analysis
Wildfire Risk
High
Moderate
Low
0 10 20 30 40
Miles
Rev. 2.0 - 9/2009
Colorado Springs
Pueblo
Blue Mesa Reservoir
Arkansas River
John Martin Reservoir
Uncompahgre River
San Miguel River
Dolores River
Animas River
Huerfano River
Apishapa River
Cucharas River
Purgatoire River
Mancos River
La Plata River
Florida River
Los Pinos River
Piedra River
Alamosa River
Conejos River
Navajo River
Dry Cimarron River
Navajo Reservoir
Farmington
Red River
Vermejo River
Cimmaron River
Chaco River
Abiquiu Reservoir
Canadian River
Sapello River
Mora River
Puerco River
Jemez River
Santa Fe
Pecos River
Gallinas River
Conchas Lake
Albuquerque
Elephant Butte Reservoir
Gila River
Caballo Reservoir
Mimbres River



Colorado Springs
Arkansas River
Blue Mesa Reservoir
Uncompahgre River
San Miguel River
Pueblo
Arkansas River
John Martin Reservoir
Dolores River
Animas River
Huerfano River
Apishapa River
Cucharas River
Mancos River
La Plata River
Florida River
Los Pinos River
Piedra River
Alamosa River
Conejos River
Navajo River
Purgatoire River
Dry Cimarron River
Navajo Reservoir
Farmington
Red River
Vermejo River
Cimmaron River
Chaco River
Abiquiu Reservoir
Canadian River
Sapello River
Mora River
Puerco River
Jemez River
Santa Fe
Pecos River
Gallinas River
Conchas Lake
Albuquerque
40
40
25
25
0 10 20 30 40
Miles
Elephant Butte Reservoir
Gila River
Caballo Reservoir
Mimbres River
River
Rio Grande Cutthroat Trout
Conservation Success Index
Climate Change Analysis
Winter Flooding Risk
High
Moderate
Low
Rev. 2.0 - 9/2009


Rio Grande Cutthroat Trout
Conservation Success Index
Climate Change Analysis
Thermal Risk
High
Moderate
Low
0 10 20 30 40
Miles
Rev. 2.0 - 9/2009
Colorado Springs
Pueblo
Blue Mesa Reservoir
Arkansas River
John Martin Reservoir
Uncompahgre River
San Miguel River
Dolores River
Animas River
Huerfano River
Apishapa River
Cucharas River
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Mancos River
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Santa Fe
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Gallinas River
Conchas Lake
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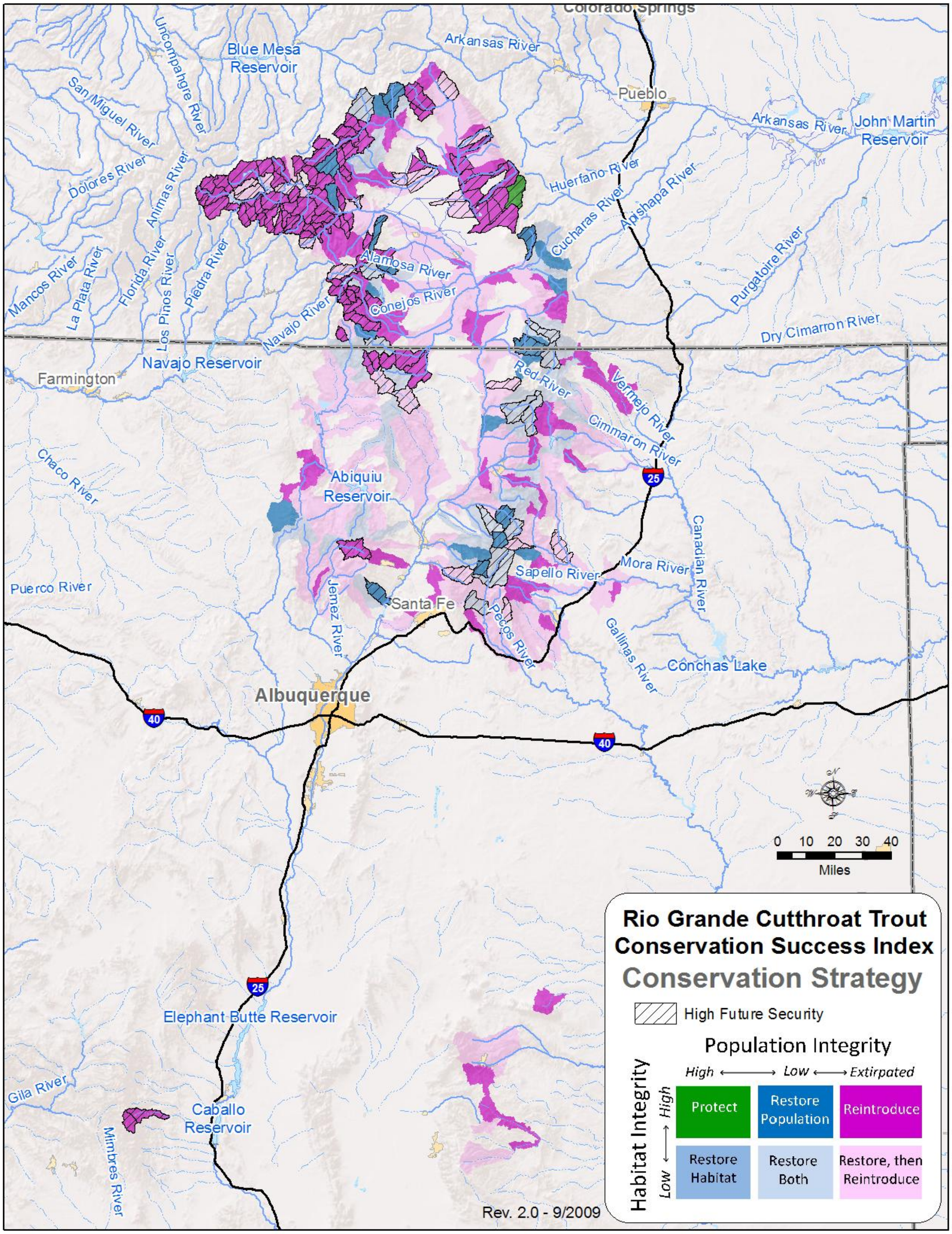
Elephant Butte Reservoir
Gila River
Caballo Reservoir
Mimbres River



Colorado Springs
Blue Mesa Reservoir
Arkansas River
Uncompahgre River
San Miguel River
Pueblo
Arkansas River
John Martin Reservoir
Dolores River
Animas River
Huerfano River
Cucharas River
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Conejos River
Navajo River
Purgatoire River
Dry Cimarron River
Navajo Reservoir
Farmington
Red River
Vermejo River
Cimmaron River
Chaco River
Abiquiu Reservoir
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Canadian River
Mora River
Sapello River
Puerco River
Santa Fe
Jemez River
Pecos River
Gallinas River
Conchas Lake
Albuquerque
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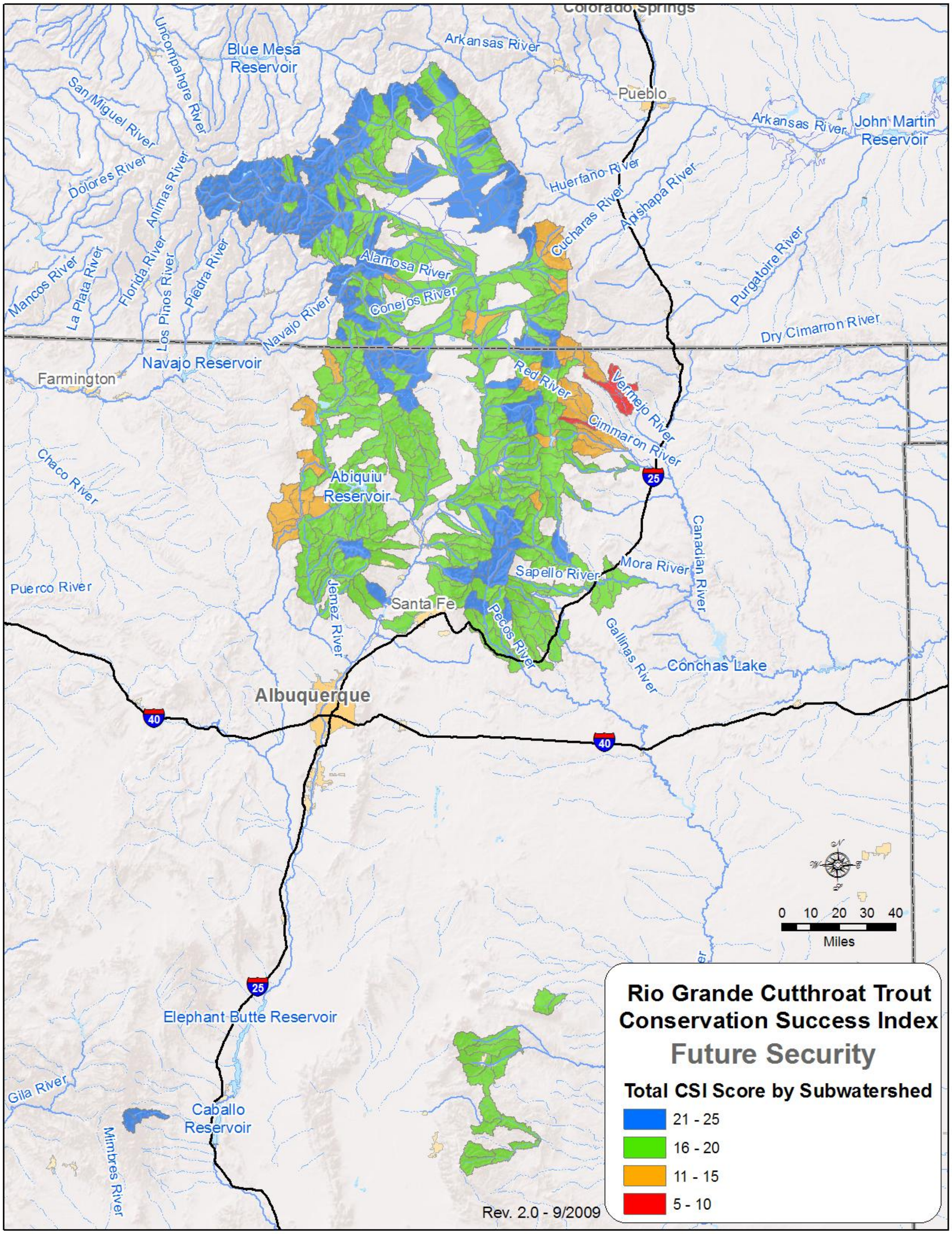
40
0 10 20 30 40
Miles
25
Elephant Butte Reservoir
Gila River
Caballo Reservoir
Mimbres River
Rev. 2.0 - 9/2009
Rio Grande Cutthroat Trout
Conservation Success Index
Conservation Strategy
High Future Security
Population Integrity
High Low Extirpated
Habitat Integrity
High
Low
Protect
Restore Population
Reintroduce
Restore Habitat
Restore Both
Restore, then Reintroduce


Rio Grande Cutthroat Trout
Conservation Success Index
Future Security
Total CSI Score by Subwatershed
21 - 25
16 - 20
11 - 15
5 - 10
Rev. 2.0 - 9/2009
0 10 20 30 40
Miles
Colorado Springs
Pueblo
Blue Mesa Reservoir
Arkansas River
John Martin Reservoir
Uncompahgre River
San Miguel River
Dolores River
Animas River
Huerfano River
Apishapa River
Cucharas River
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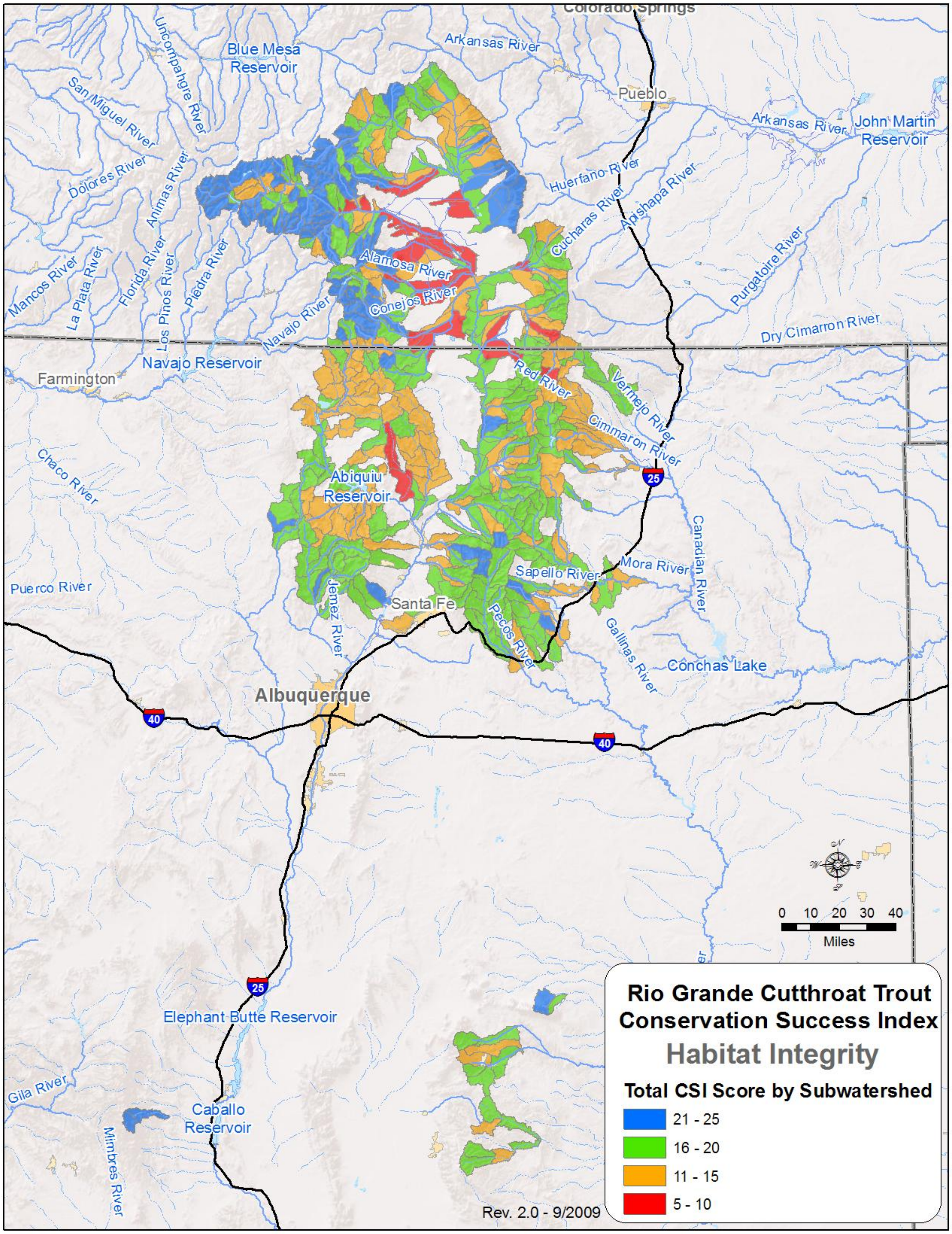
Rio Grande Cutthroat Trout
Conservation Success Index
Habitat Integrity
Total CSI Score by Subwatershed
21 - 25
16 - 20
11 - 15
5 - 10
0 10 20 30 40
Miles
Rev. 2.0 - 9/2009
Colorado Springs
Pueblo
Arkansas River
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25
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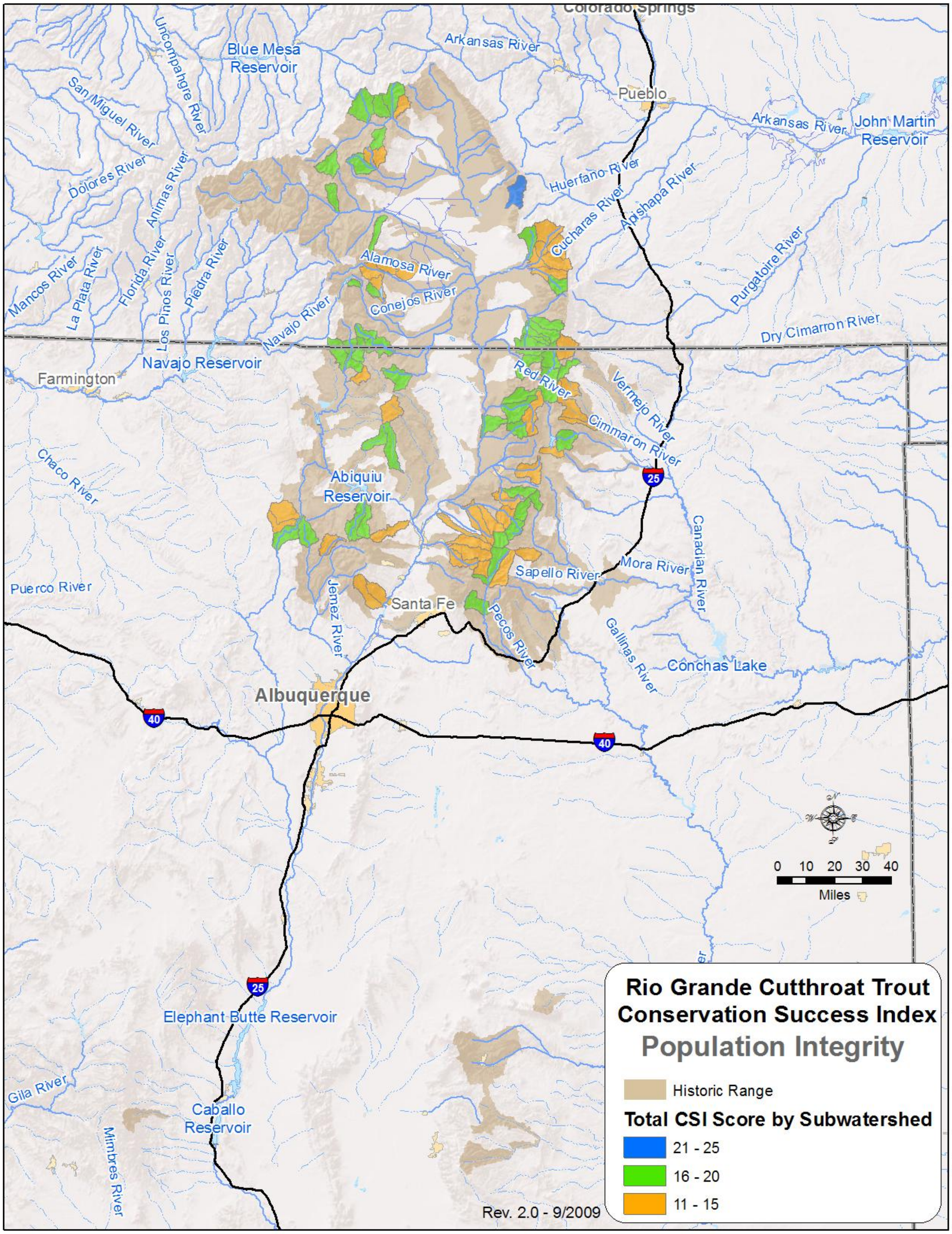
Rio Grande Cutthroat Trout
Conservation Success Index
Population Integrity
Historic Range
Total CSI Score by Subwatershed
21 - 25
16 - 20
11 - 15
Rev. 2.0 - 9/2009
0 10 20 30 40
Miles
Colorado Springs
Pueblo
Arkansas River
Blue Mesa Reservoir
John Martin Reservoir
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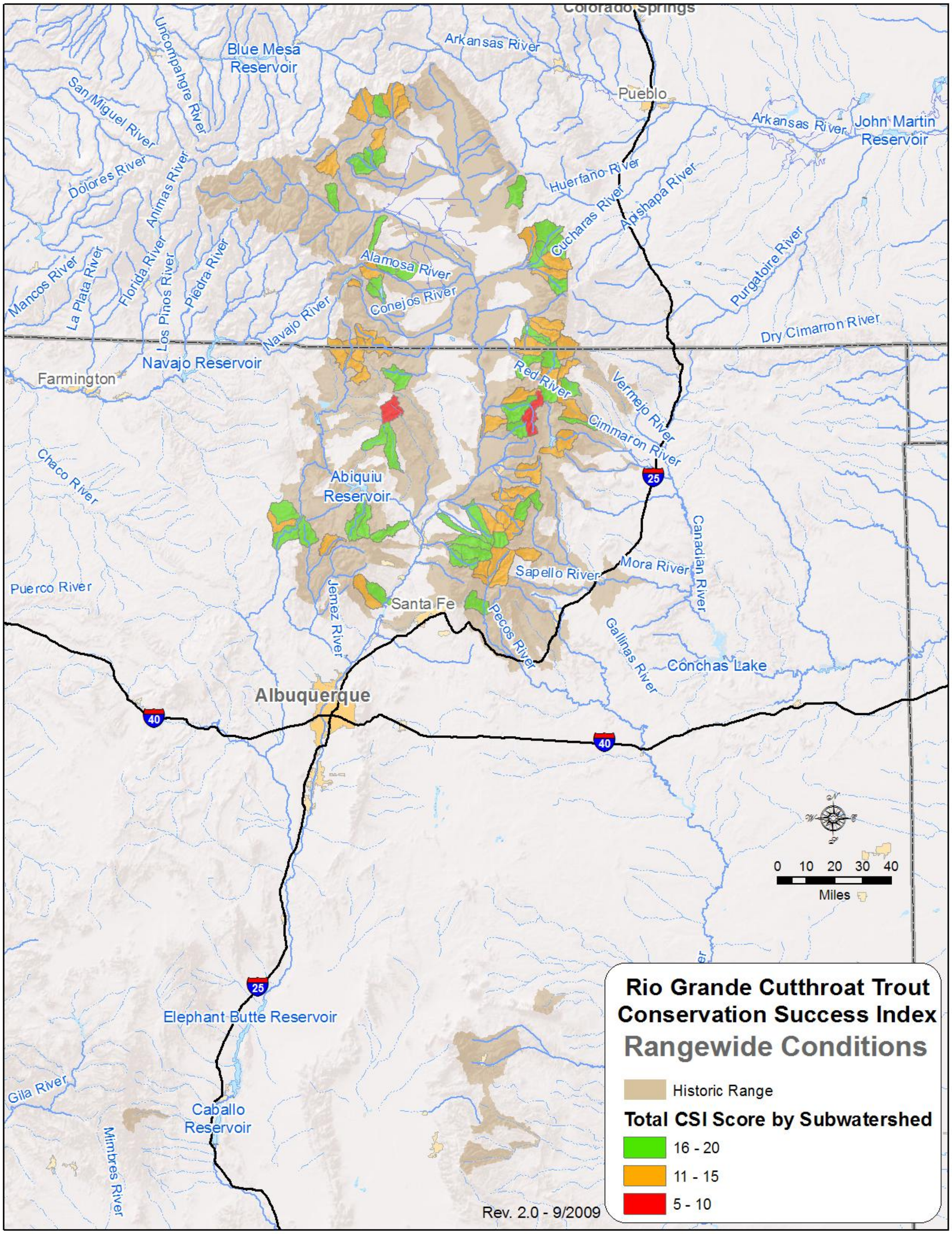

Rio Grande Cutthroat Trout
Conservation Success Index
Rangewide Conditions
Historic Range
Total CSI Score by Subwatershed
16 - 20
11 - 15
5 - 10
Rev. 2.0 - 9/2009
0 10 20 30 40
Miles
Colorado Springs
Pueblo
Farmington
Albuquerque
Santa Fe
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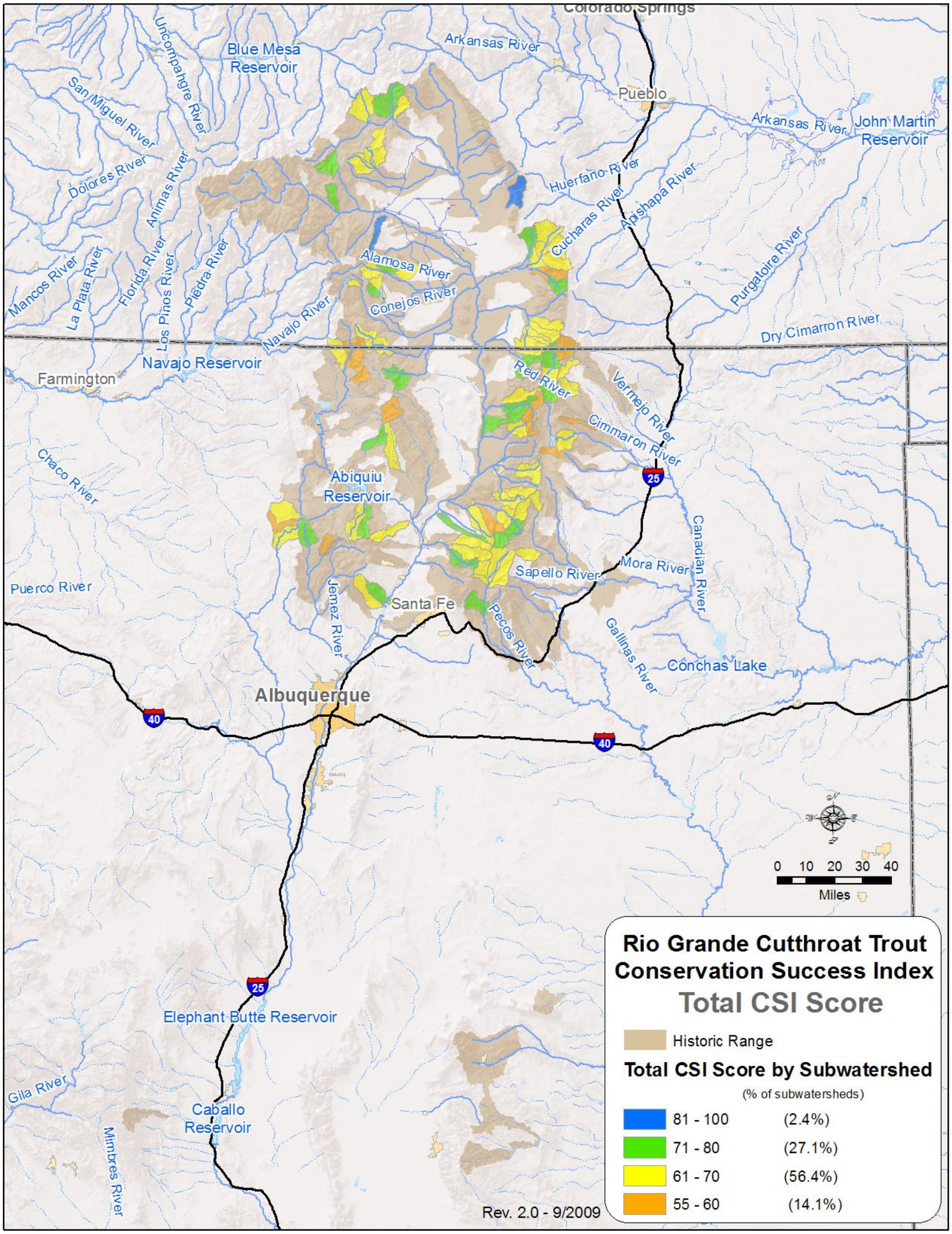

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Mora River
Sapello River
Puerco River
Jemez River
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Pecos River
Gallinas River
Conchas Lake
Albuquerque
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25
25
0 10 20 30 40
Miles
Elephant Butte Reservoir
Gila River
Caballo Reservoir
Mimbres River
Rev. 2.0 - 9/2009
Rio Grande Cutthroat Trout Conservation Success Index
Total CSI Score
Historic Range
Total CSI Score by Subwatershed
(% of subwatersheds)
81 - 100 (2.4%)
71 - 80 (27.1%)
61 - 70 (56.4%)
55 - 60 (14.1%)

Conservation Success Index
Rio Grande Cutthroat Trout Rule Set

February 2008

Range-wide Conditions

Scored for conservation populations as defined by assessment.

Historic habitat is all perennial streams and connected, natural lakes across historic range. Lakes less than 2 hectares that are connected to streams are considered stream habitat while lakes greater than 2 hectares or isolated lakes are calculated as lake habitat.

1. Percent historic stream habitat occupied.

Occupied stream habitat	CSI Score
0 – 9%	1
10 – 19%	2
20 – 34%	3
35 – 49%	4
50 – 100%	5

Source: Alves, John E., et al. Range-Wide Status of Rio Grande Cutthroat Trout (*Oncorhynchus clarki virginalis*): 2007. 2007. Rio Grande Cutthroat Trout Conservation Team.

2. Percent subbasins occupied.

Percent subbasins occupied	CSI Score
1-49%	1
50-69%	2
70-79%	3
80-89%	4
90-100%	5

Source: Alves et al. 2007.

U.S. Geologic Survey, Subbasins (4^{th} order HUCs), 1:2,000,000, July 2005.

3. Percent historically occupied subwatersheds currently occupied within subbasin.

Percent subwatersheds occupied by subbasin	CSI Score
1 – 20%	1
21-40%	2
41-60%	3
61-80%	4
81-100%	5

Source: Alves et al. 2007.

U.S. Department of Agriculture, Forest Service, Natural Resources Conservation Service, Wyoming Geographic Information Science Center, Sub-watersheds, 6th order HUCs.

4. Habitat by stream order occupied.

Occupied 2nd order streams and higher	CSI Score
0 – 9%	1
10 – 14%	2
15 – 19%	3
20 – 24%	4
25 – 100%	5

Source: Alves et al. 2007.

US Geological Survey, National Hydrography Dataset Plus, 1:100,000.

5. Historic lake habitat occupied.

Historic lake populations only considered natural lakes while current populations have been identified in reservoirs thus leading to an increase in lake habitat for some subwatersheds.

Occupied lake habitat	CSI Score
0 – 9%	1
10 – 19%	2
20 – 34%	3
35 – 49%	4
50 – 100%	5

Source: Alves et al. 2007.

US Geological Survey, National Hydrography Dataset Plus, 1:100,000.

Population Integrity

- Scored for conservation populations.
- Lake populations were incorporated as a linear distance.
- Where there are multiple conservation populations within a subwatershed scores are computed as a stream length-weighted average.

1. Density – where multiple populations exist within a subwatershed, density was calculated as stream length weighted average. Use actual values for population total rather than classes listed in assessment.

Fish per mile	Total Population	CSI Score
1 - 50	LT 500	1
1 - 50	GE 500	2
51 - 150	GE 1	3
151 - 400	GE 1	4
GT 400	GE 1	5

Source: Alves et al. 2007.

2. Population Extent – based on table 24. Degree of Network Connectedness

Connectivity	CSI Score
4 (‘Population Isolated’)	1
3 (‘Weakly Networked’)	2
2 (‘Moderately Networked’)	4
1 (‘Strongly Networked’)	5

Source: Alves et al. 2007.

3. Genetic Purity – based on table 12. Genetic Status

Genetic Status	CSI Score
4 (< 80%)	1
3, 6 (80% - 89%, Not Tested – Hybridized)	2
7 (Co-existence)	3
2 (90% - 99%)	4
1, 5 (Unaltered, Not Tested – Unaltered)	5

Source: Alves et al. 2007.

4. Disease Vulnerability – based on table 29. Significant diseases risk influence index
.

Risk Characterization	CSI Score
5 (Population is Infected)	1
4 (Significant Disease Risk)	2
3 (Moderate Disease Risk < 10 km)	3
2 (Minimal Disease Risk > 10 km)	4
1 (Limited Disease Risk)	5

Source: Alves et al. 2007.

5. Life History Diversity – Life History table; resident, fluvial, and ad-fluvial

Conservation population	CSI Score
One life history form present: Resident only	1
Two life histories present: Fluvial and Resident with historic lakes but no current adfluvial forms	3
Two or three life histories present: Fluvial and resident with no lake populations; Any combination with Adfluvial present	5

Source: Alves et al. 2007.

US Geological Survey, National Hydrography Dataset Plus, 1:100,000.

Habitat Integrity

Scored for all subwatersheds in historic range.

1. Land Stewardship – score using AND between two indicators

Protected occupied habitat	Subwatershed protection	CSI Score
none	any	1
1 – 9%	LT 25%	1
1 – 9%	GE 25%	2
10 – 19%	LT 25%	2
10 – 19%	GE 25%	3
20 – 29%	LT 50%	4
20 – 29%	GE 50%	5
GE 30%	any	5

Source: National Atlas, Federal Land Status.

Tele Atlas/GDT, Protected areas, 1:100,000. 2004.

U.S. Department of Agriculture, Forest Service, Geospatial Service and Technology Center. Inventoried Roadless Areas.

2. Watershed Connectivity – includes both perennial and intermittent streams.

Number of stream/canal intersections	Current/historic connectivity 6th	CSI Score
GE 12	LT 50%	1
8 – 11	50 – 74%	2
5 – 7	75 – 89%	3
1 – 4	90 – 94%	4
0	95 – 100%	5

Current/historic connectivity 4$^{th:}$

- GT 90%: +1
- LT 50%: -1

Score for worst case

Source: Alves et al. 2007.

US Army Corps of Engineers, Dams, March 22, 2006.

US Geological Survey, National Hydrography Dataset Plus, 1:100,000.

3. Watershed Conditions-

Land conversion	CSI Score
GE 30%	1
20 – 29%	2
10 – 19%	3
5 – 9%	4
0 - 4%	5

CSI score is downgraded 1 point if road density is GE 1.7 and LT 4.7 mi/square mile. If road density is GE 4.7 mi/square mile it is downgraded 2 points.

If Habitat Quality information is available for the subwatershed (based on table 17. Relative quality of occupied stream habitat):

Habitat Quality	CSI Score
Poor	1
Fair	3
Good	4
Excellent	5

CSI Score is downgraded 1 point if Land conversion/Road density score = 2, and downgraded 2 points if Land conversion/Road density score = 1

Finally, CSI Score is downgraded 1 point if Acres of active oil and gas wells > 20%

<u>Source</u>: Alves et al. 2007.

Tele Atlas North America, Inc./Geographic Data Technology, Inc., ESRI. Roads. 2005.

4. Water Quality

Miles 303(d) Streams	Percent Agricultural Land	Number Active Mines	Rd mi/ Str mi	CSI Score
GT 0	58-100%	GE 10	0.5 – 1.0	1
	28-57%	7-9	0.25 – 0.49	2
	16-27%	4-6	0.24 - 0.10	3
	6-15%	1-3	0.05 – 0.09	4
	0-5%	0	0 – 0.04	5

Score for worst case.

<u>Source</u>: Tele Atlas North America, Inc./Geographic Data Technology, Inc., ESRI. Roads. 2005.

U.S. Environmental Protection Agency. 303(d) streams, 1:24,000; 2002.

US Geological Survey, National Hydrography Dataset Plus, 1:100,000.

U.S. Geological Survey, 2005. Colorado Land Cover Data Set. National Land Cover Data Set. 90 meter.

U.S. Geological Survey, 2005, Mineral Resources Data System: U.S. Geological Survey, Reston, Virginia. Active Mines

U.S. Geological Survey, 2005. New Mexico Land Cover Data Set. National Land Cover Data Set. 90 meter.

5. Flow Regime

Number of dams	Miles of Canals	Storage (acre-ft)/stream mile	CSI Score
GE 5	GE 20	GE 2,500	1
3 – 4	10 – 19.9	1,000 – 2,499	2
2	5 – 9.9	250 – 999	3
1	1 – 4.9	1- 249	4
0	0 – 0.9	0	5

Score for worst case.

<u>Source</u>: U.S. Army Corps of Engineers. Dams, March 22, 2006

US Geological Survey, National Hydrography Dataset Plus, 1:100,000.

Future Security

Scored for all subwatersheds in historic range.

1. Land Conversion – modeled based on slope, land ownership, roads, and urban areas.

Land Vulnerable to Conversion	CSI Score
81 – 100%	1
61 – 80%	2
41 - 60%	3
21 - 40%	4
0 – 20%	5

Sources: Colorado State University Natural Resource Ecology Lab. COMaP v4. June 30, 2005. Land ownership/stewardship.

Tele Atlas/GDT, Population centers, 1:300,000; 1997.

U.S. Geologic Survey, Utah, Wyoming, New Mexico GAP Analysis Project (100 meter) Land cover/Land use.

Tele Atlas/GDT, Road network, 1:100,000; 2002.

USGS Digital Elevation Model. 30 meter.

2. Resource extraction

Forest management	Hard Metal Mine Claims	CSI Score
51-100%	51 -100%	1
26 – 50%	26-50%	2
11 – 25%	11-25%	3
1 – 10%	1 – 10%	4
0%	0%	5

Score for worst case.

Source: : Timber management potential identifies productive forest types using the existing vegetation type in the Landfire dataset. The number of mining claims was determined using Bureau of Land Management data, and each claim was assumed to potentially impact 20 acres. Protected areas data were compiled from the ESRI, Tele Atlas North American / Geographic Data Technology dataset on protected areas and the U.S. Department of Agriculture, Forest Service's National Inventoried Roadless Areas dataset.

U.S. Department of Energy, EPCA. Oil and gas reserves, 2005.

3. Energy Development.

Leases or reserves	New Dams 4th	New Dams 6th	CSI Score
51-100%	≥0	≥1	1
26 – 50%	3		2
11 – 25%	2		3
1 – 10%	1		4
0%	0		5

Score for worst case

Source: Wind resources ("Good" and better) from Wind Powering America/National Renewable Energy Lab (NREL). Coal leases are mineable types from the Coal Fields of the United States dataset. Geothermal known and closed lease areas and oil and gas leases and agreements from BLM Geocommunicator.* Potential dam sites are based on Idaho National Laboratory (INL) hydropower potential data. Protected areas data were compiled from the ESRI, Tele Atlas North American / Geographic Data Technology dataset on protected areas and the U.S. Department of Agriculture, Forest Service's National Inventoried Roadless Areas dataset.

4. Climate Change – Based on TU Climate Change analysis, which focuses on 3 identified risk factors related to climate change-

    a. Increased Summer Temperature- loss of lower-elevation (higher-order) habitat
    b. Increased Winter Flooding- Rain-on-snow events lead to more and larger floods

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* Several geospatial data types are available from Geocommunicator, and they have the following definitions:

Lease: Parcel leased for oil and gas production.

Agreement: An 'agreement' between operator and host (private or public) to evaluate geological, logistic, geophysical, etc issues involving a concession. The agreement essentially allows a technical evaluation of lease feasibility.

Unit Agreements: Multiple entities go in collectively on an agreement. Implied: there are limits to the number of agreements that one individual entity can have outstanding, and a unit agreement allows them to get around the limit.

Communitization: Combining smaller federal tracts to meet the necessary minimum acreage required by the BLM (for spacing purposes).

Authorized: Bid on and sold lease or authorization, ready for production.

Lease Sale Parcel: Parcel slated for auction but not yet sold.

Closed: Not retired, just expired and may become available and open to resubmittal.

Other Agreements: Catch-all for other agreement types.

c. Increased Wildfire- earlier spring snowmelt coupled with warmer temperatures results in drier fuels and longer burning, more intense wildfire
d. Drought: moisture loss under climate warming will overwhelm any gains in precipitation and lead to higher drought risk

TU Climate Change Analysis	
Climate Risk Factors	**CSI Score**
High, High, Any., Any	1
High, Any, Any, Any	2
Mod., Mod., Mod, (Mod or Low)	3
Mod, Mod, Low, Low	4
Low, Low, Low, (Mod or Low)	5

Source: Temperature and precipitation data were obtained from the PRISM Group. Elevation data was obtained from the National Elevation Dataset, and LANDFIRE data for the Anderson Fire Behavior Fuel Model 13 was used as input for wildfire risk. The Palmer Drought Severity Index was used for drought risk, but was adjusted for elevation (elevations above 2690 have lower risk) and the deviation from mean annual precipitation (areas with more precipitation on average have lower risk).

5. Introduced Species – primary scoring based on based on table RGCTConPop_Streams
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table (unknown = present)

Present in 4th	Present in 6th	Road Density	CSI Score
Yes	Yes	Any	1
Yes	No	GT 4.7	2
Yes	No	1.7 - 4.7	3
Yes	No	LT 1.7	4
No	No	Any	5

If genetic risk data is not available for the 6th order HUC

Present in 4th	Road Density	CSI Score
Yes	GT 4.7	1
Yes	3.7 – 4.7	2
Yes	2.7 – 3.7	3
Yes	LT 2.7	4
No	any	5

If genetic risk data is not available for the 6th or 4th order HUCs

Road Density	CSI Score
GT 4.7	1
3.7 – 4.7	2
2.7 – 3.7	3
1.7 – 2.7	4
LT 1.7	5

<u>Source</u>: Alves et al. 2007.

Tele Atlas North America, Inc./Geographic Data Technology, Inc., ESRI. Roads. 2005.