

A scenic mountain landscape featuring a valley with a dense forest of evergreen trees. In the center, a large, calm lake is nestled between the mountains. The sky is filled with white, fluffy clouds, and the overall scene is bathed in soft, natural light. The foreground shows a rocky, gravelly slope.

A Career in Water Quality: My Journey So Far...

Andrew Todd, Ph.D.
Fort Lewis College, November 18th, 2024

LEVEL 1: Growing Up

DENVER, COLORADO

- Fishing trips in Aspen with my dad
- As a teenager, took two Outward Bound / NOLS trips into the Sangre de Cristo Mountains
- Went to Manual High School in Denver where I got super interested in biology (Ms. Hargis)



LEVEL 2: Undergraduate

WILLIAMS COLLEGE

- Thought I was going to be a veterinarian, studied pre-med (biology, chemistry, physics)
- Played a lot of lacrosse
- Didn't explore the Berkshire Mountains as much as I wish I would have...
- Graduated with no idea what I wanted to do when I grew up!



LEVEL 3: First “Environmental” Job

AQUA SIERRA, INC.

- Friend from Manual got me a job at private fisheries consulting firm
- Designed aeration systems for ponds in Colorado
- Drove to Arkansas to pick up fish to stock in Denver
- Learned the basics of lake / pond science and management



LEVEL 4: Graduate School

CU BOULDER

- Decided to go back to get more educated
- M.S. and Ph.D. degrees in Environmental Engineering
- Took an incredible class called Applied Stream Ecology (Dr. McKnight)
- Dissertation was on the impact of ARD on mountain stream ecosystems (in Keystone, CO)



LEVEL 5(a): First Real Environmental Jobs

U.S. FISH AND WILDLIFE

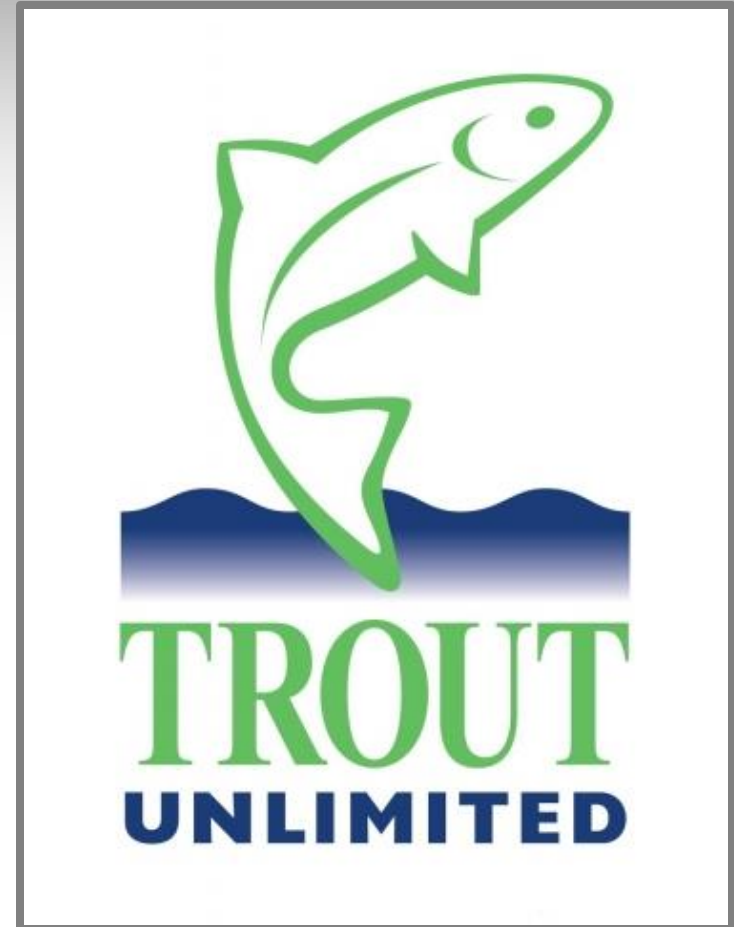
- Title
 - Contaminants Biologist
- Duties
 - Inventory potential radioactive waste in Rocky Flats buffer zone
 - Track, chase, and collar deer fawns at Rocky Mountain Arsenal
 - Evaluate risk of hunting at Rocky Flats



LEVEL 5(b): First Real Environmental Jobs

TROUT UNLIMITED

- Title
 - Aquatics Specialist
- Duties
 - Establish instream flow protections for small trout streams
 - Build the scientific case for our lawyers fights over keeping water in streams (PAWSD)
 - Testify in front of state boards for protective regulations (CWCB, CWQCC)



LEVEL 6: Research

U.S. GEOLOGICAL SURVEY

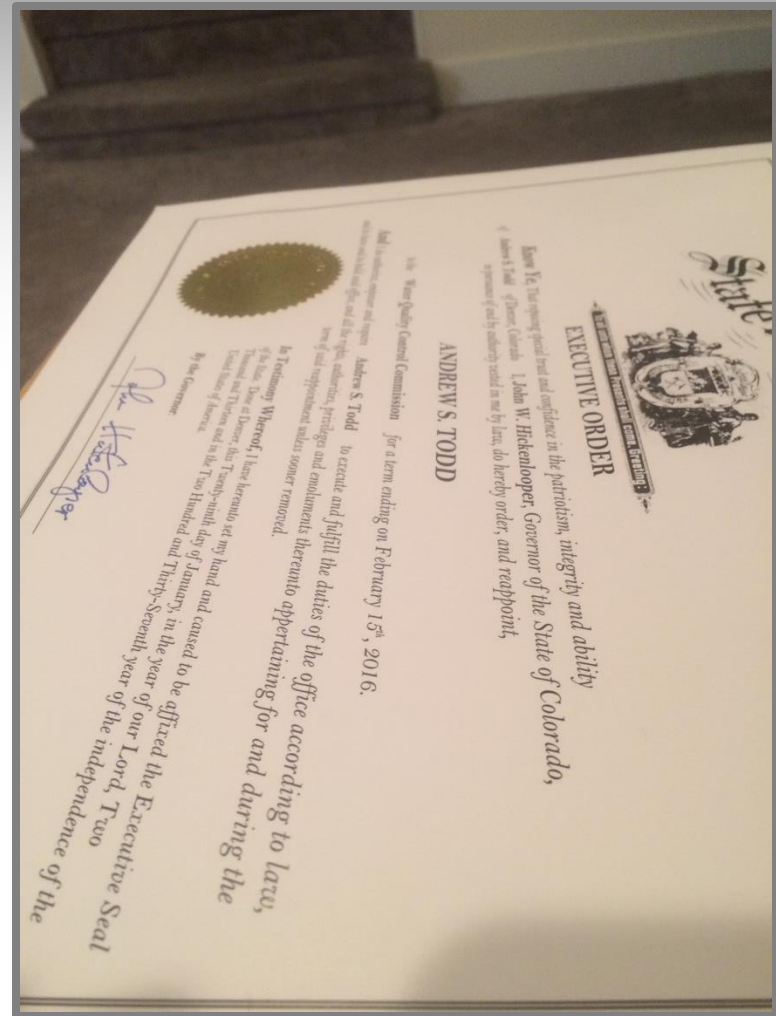
- Title
 - Research Biologist
- Duties
 - Study the impacts of major stressors on cold water fisheries in the Western US
 - Legacy mining
 - Major water projects
 - Climate change



LEVEL 7: Environmental Policy

CWQCC

- Title
 - Commissioner
- Duties
 - Appointed by two governors to serve
 - Commission sets WQ rules for the state of Colorado
 - Nine volunteers from all sectors
 - Served three terms (9 years) including two years as Chair



LEVEL 8a: Technical Assistance

U.S. ENVIRONMENTAL PROTECTION AGENCY

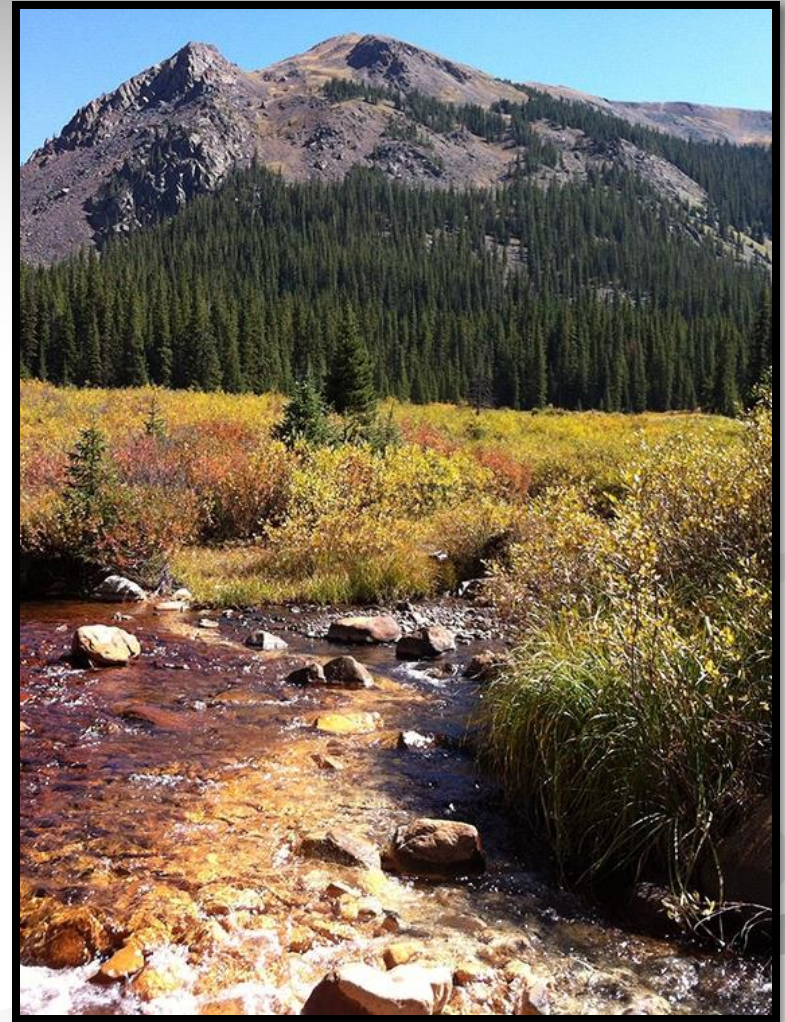
- Title
 - Aquatic Ecotoxicologist
- Duties
 - Predict the ecological benefits of investments in environmental cleanup
 - Several mining Superfund sites, the largest of which was the BPMD
 - Completed the aquatic ecological risk assessment



LEVEL 8b: Regulatory Oversight

U.S. ENVIRONMENTAL PROTECTION AGENCY

- Title
 - WQ Section Supervisor
- Duties
 - Oversee 6 states / 27 tribes in setting protective water quality rules
- Title
 - Life Scientist
- Duties
 - Lead for North and South Dakota, Two Tribes and Endangered Species Act



LEVEL 8+: Startup Nonprofit

RUNNING RIVERS

- Title
 - Founder / Executive Director
- Responsibilities
 - Organize series of trail running / fly fishing races
 - Raise awareness about native fish and the challenges they face
 - Raise money and partner with others to complete projects that advance native fish



LEVEL 9:



Key Water Quality Issues: Colorado Coldwater Streams



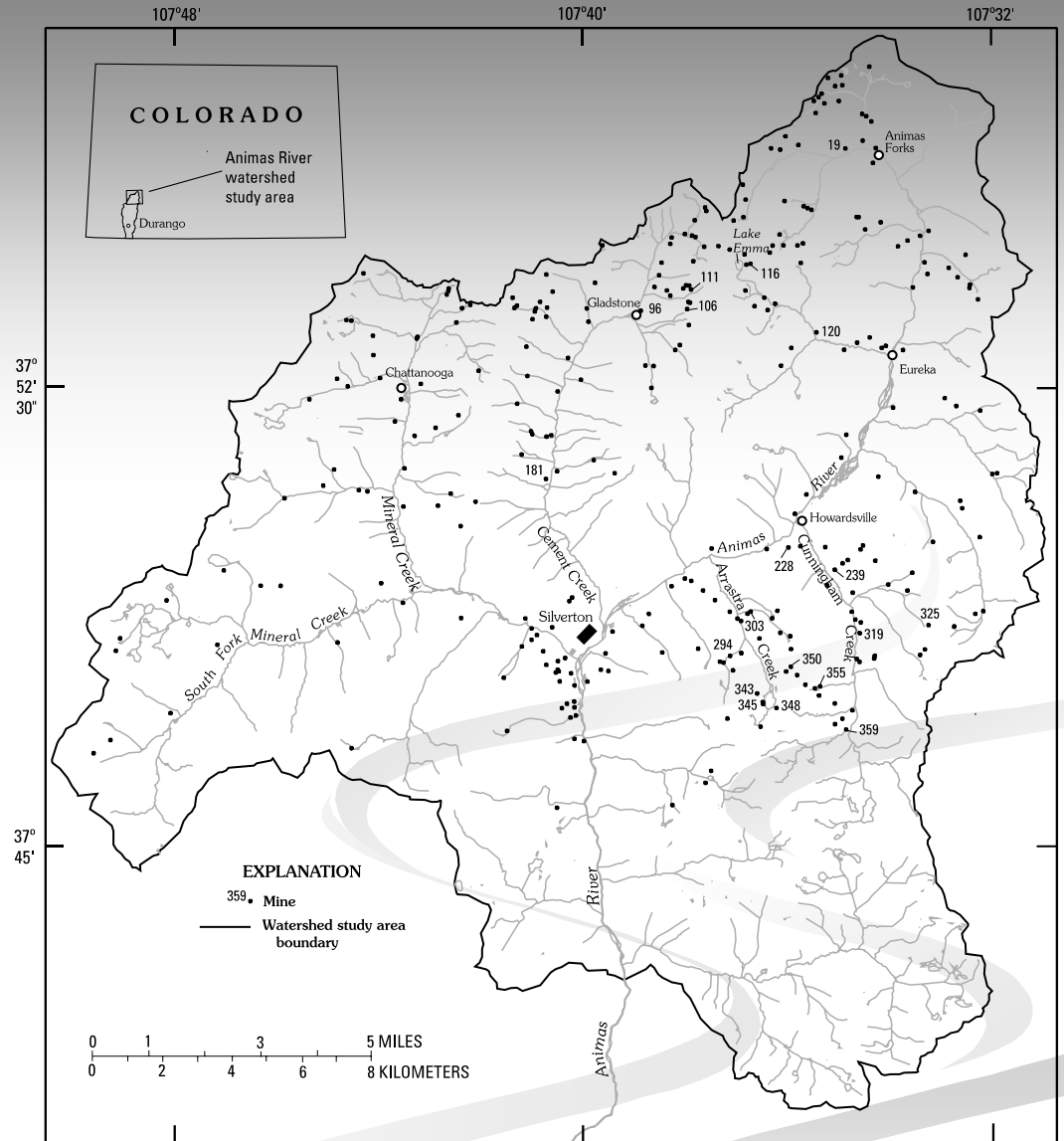
Dealing with our legacy of past pollution

- Natural geological formations contain metal-rich and acid-forming minerals
- 19th and 20th century mining increased unweathered mineral surface area
- These minerals react with water and oxygen to produce acid, which further leaches metals that can be toxic to aquatic life
- There are an estimated 23,000 abandoned mines in Colorado



Bonita Peak MD

- Historic mining
 - 1871 – 1991
 - Hundreds of mines spread throughout the BPMD
- Mining / milling greatly increased the weatherable surface area of reactive rock types
- Added to the NPL list in 2016
 - 48 sites define the BPMD scope



Aquatic Exposure Units (EUs)

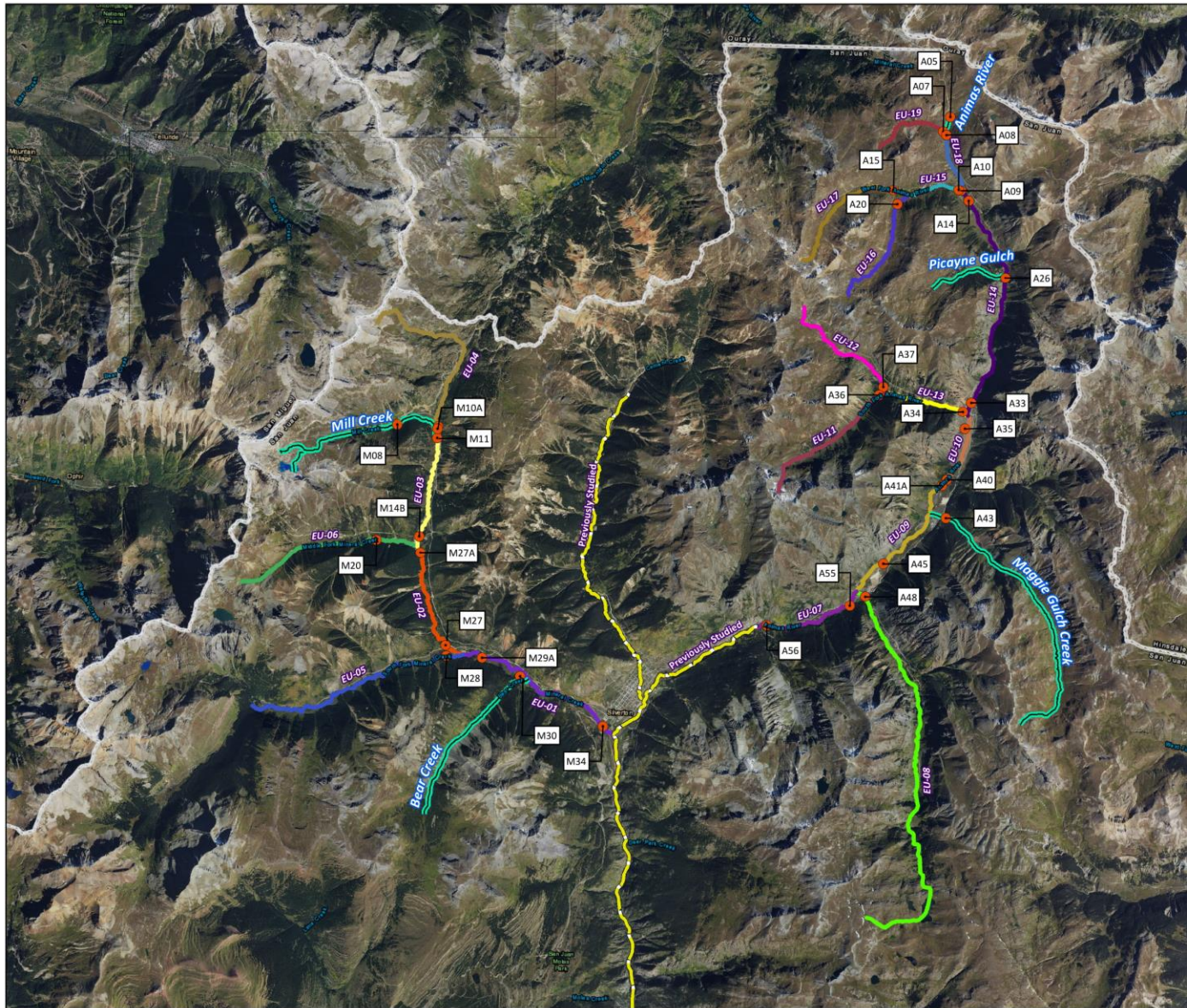


Figure 1-3
Bonita Peak Mining District
Exposure Units and Reference Areas

- | | |
|------------------------------------------|-----------------------------------------|
| EU-01 (Mineral Creek) | EU-12 (Eureka Gulch) |
| EU-02 (Mineral Creek) | EU-13 (South Fork of Animas River) |
| EU-03 (Mineral Creek) | EU-14 (Animas River) |
| EU-04 (Mineral Creek) | EU-15 (West Fork of Animas River) |
| EU-05 (South Fork of Mineral Creek) | EU-16 (Placer Gulch) |
| EU-06 (Middle Fork of Mineral Creek) | EU-17 (Upper West Fork of Animas River) |
| EU-07 (Animas River) | EU-18 (North Fork of Animas River) |
| EU-08 (Cunningham Creek) | EU-19 (Burrows Creek) |
| EU-09 (Animas River) | Reference Areas |
| EU-10 (Animas River) | Previously Studied |
| EU-11 (Upper South Fork of Animas River) | Counties |

Map Date: February 1, 2018

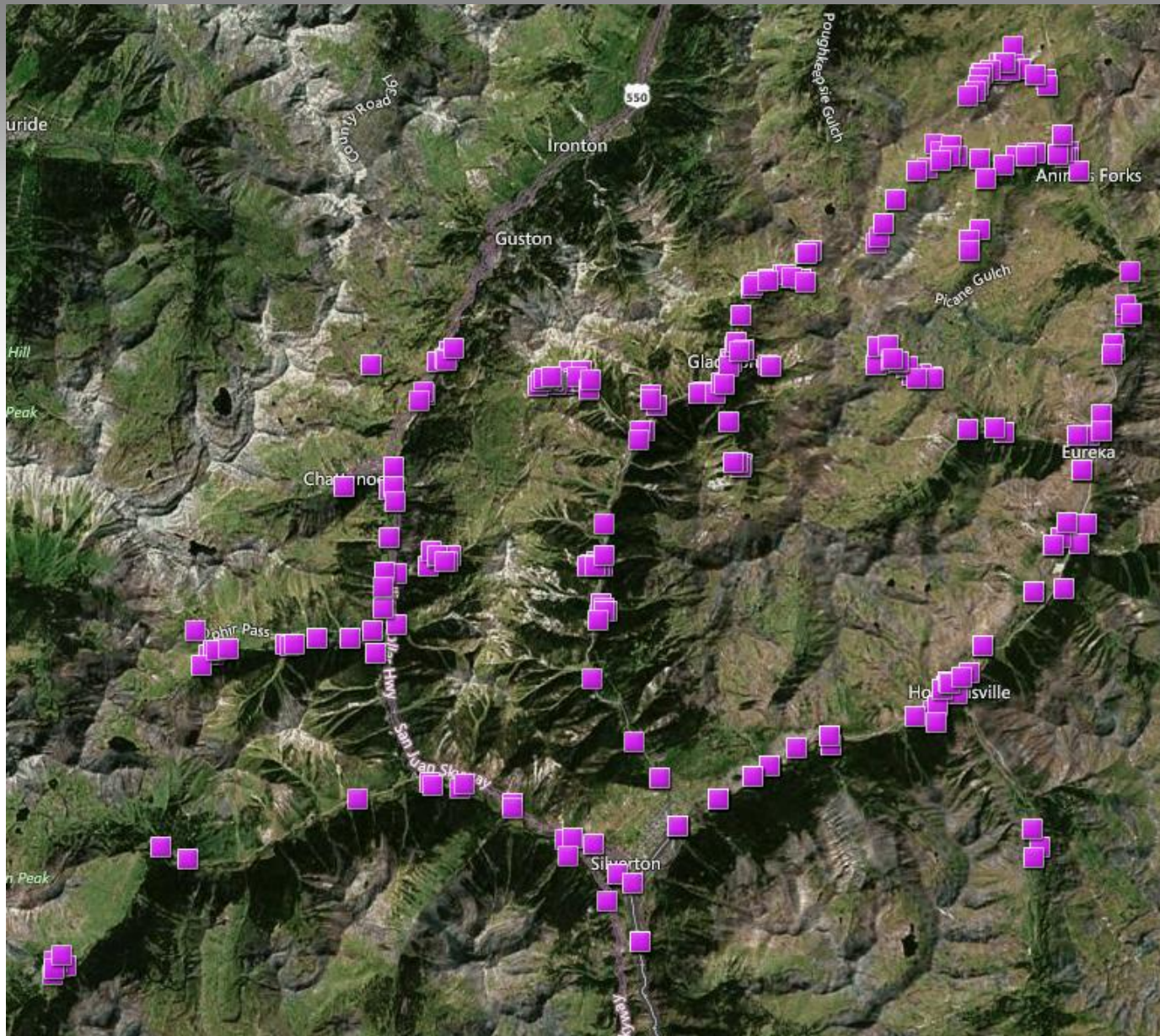
Data Sources:
 Rivers and Streams: CDOW (2004)
 Proposed Sample Locations: U.S. EPA (2016)
 Exposure Units and Reference Areas: U.S. EPA (2016)
 Counties: U.S. Census Bureau (2014)
 Imagery: USDA NAIP (2017)

Map Projection: UTM Zone 13 N, WGS84, Meters

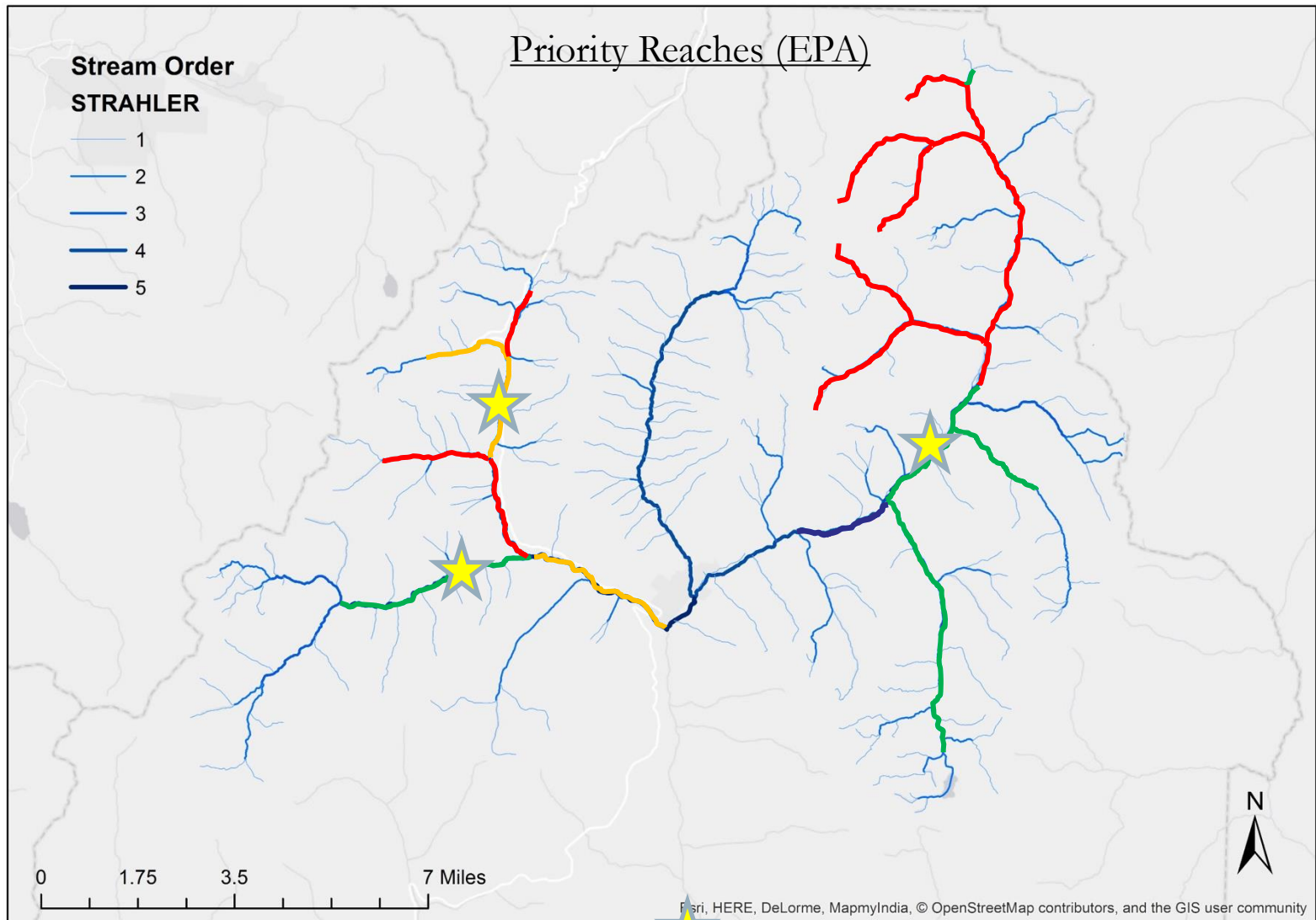


Data Utilized in 2018 BPMD Risk Assessment

- **Multi-media**
 - Surface water chemistry
 - Sediment chemistry
 - Porewater- Interstitial water in the sediments
 - Fishery information- (presence/absence and tissue concentrations)
 - Benthic macroinvertebrates- (community composition and tissue concentrations)
 - Toxicology- (acute surface water toxicity and sediment toxicity)
 - Fish habitat suitability information- (thermal suitability, habitat suitability)
- **Spatially comprehensive**
 - Locations selected to be representative of conditions within each Exposure Unit (EU)



2016 Surface Water Sampling Locations



- Fish absent
- Fish determined to be present in Fall 2016 but residence duration unknown
- Fish determined to be present in Fall 2016 and believed to be resident year-round

Loving our mountains to death

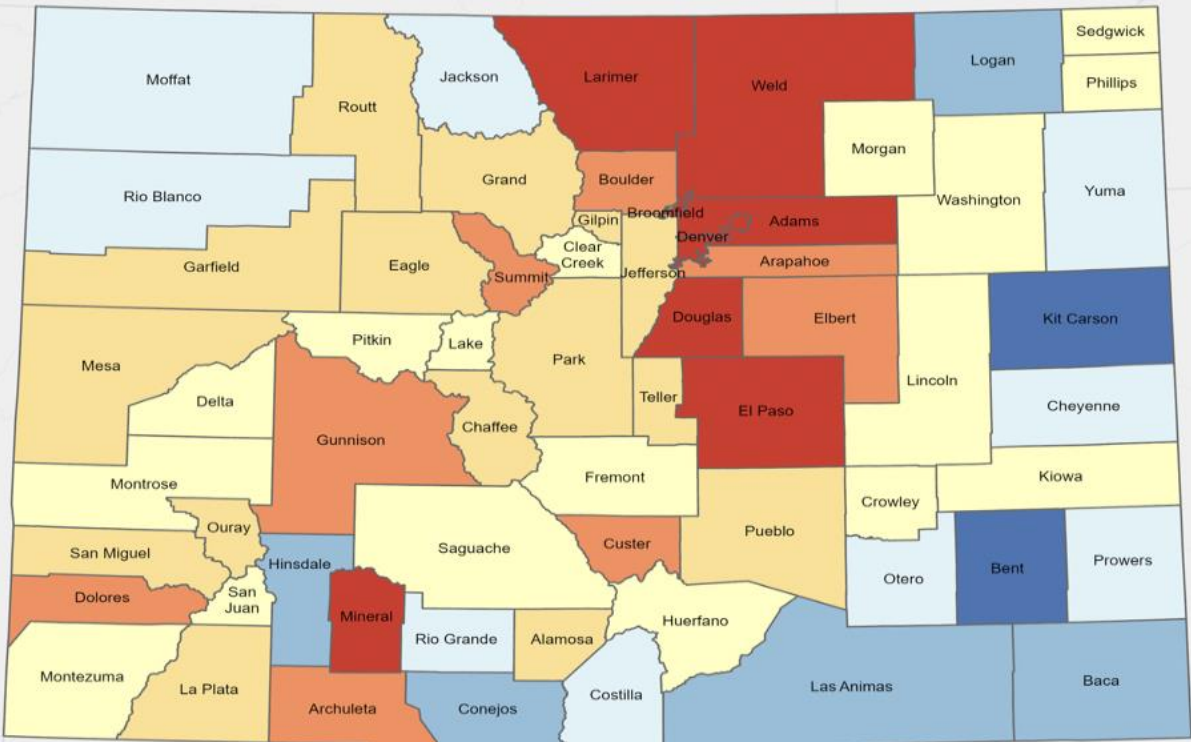
- Colorado's High Country is well known for its recreational opportunities (e.g. skiing, snowboarding)
- Highways open year-round through the mountains require maintenance (e.g. sanding and salting)
- Unless properly mitigated, these can become contaminants in local streams
- Examples: Straight Creek (I-70), Black Gore Creek (Vail Pass), Upper Fraser River (Berthoud Pass)
- Other emerging contaminants (6PPD, 6PPD-q) have the potential to be a year-round WQ stressor

More mountain population...

Population Percent Change by County 2010 to 2020

Percent Change

- > 10% Loss
- 5% to 10% Loss
- 0% to 5% Loss
- 0% to 5% Gain
- 5% to 10% Gain
- 10% to 15% Gain
- > 15% Gain



Source: 2020 US Census

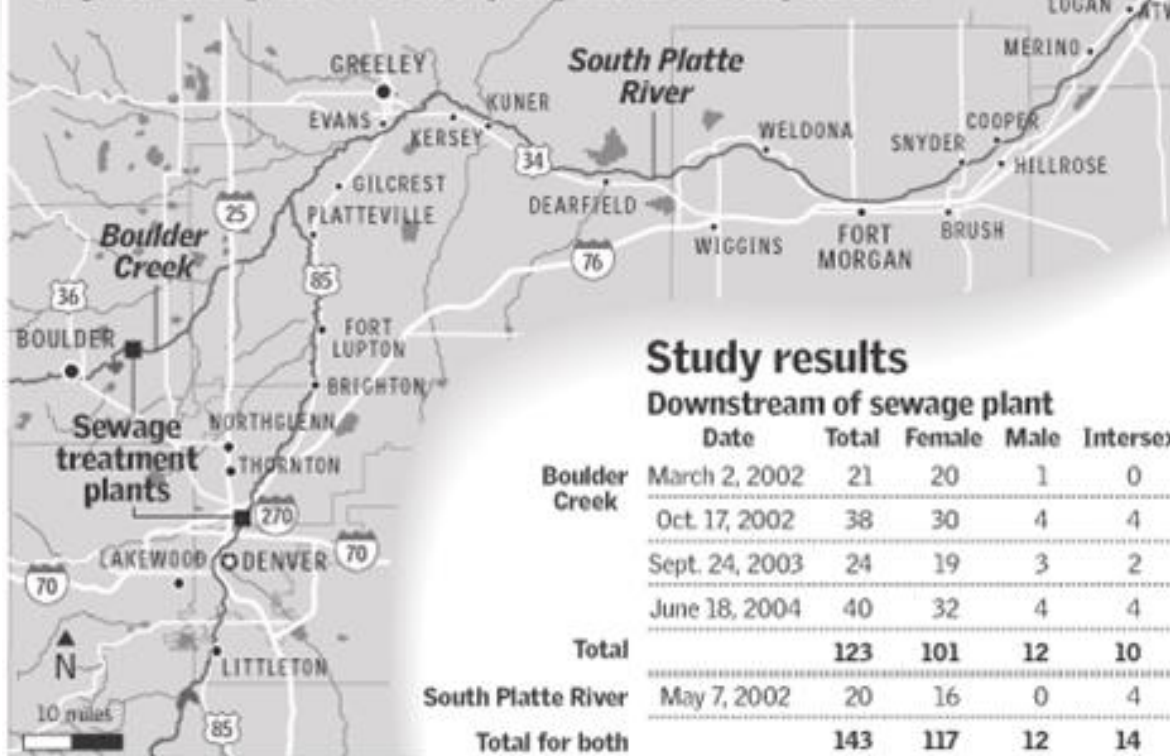
Esri, HERE, Garmin, USGS, EPA, NPS

...means more mountain waste...

- Cities and towns with high concentrations of people must substantially treat large quantities of sewage before returning water to river
- Potential exists to increase contaminants in rivers, including ammonia, metals (e.g. Cu), nutrients (e.g. N and P), pathogens (fecal coliform), water temperature
- Ecological consequences (e.g. eutrophication)
- Emerging contaminants (pharmaceuticals, hormones, caffeine, etc...)

Deformities in fish cause concern

Research on Boulder Creek and the South Platte has uncovered a disturbing problem: Some white sucker fish downstream from Denver and Boulder sewage plants have both male and female reproductive tissue. Researchers also found something else: Females far outnumber males. Now they want to know if chemicals that mimic the female hormone estrogen are to blame. Utilities that provide water to more than two dozen communities from the South Platte don't test for the chemicals. Said biologist John Woodling, who discovered the gender-bending fish: "This is the only thing that has ever really scared me."



The white sucker was used as a test fish because they tolerate a wide variety of conditions, including river stretches containing domestic sewage treatment plant effluents. They were the only fish at the effluent sites.

Study results

Downstream of sewage plant

	Date	Total	Female	Male	Intersex
Boulder Creek	March 2, 2002	21	20	1	0
	Oct. 17, 2002	38	30	4	4
	Sept. 24, 2003	24	19	3	2
	June 18, 2004	40	32	4	4
Total		123	101	12	10
South Platte River	May 7, 2002	20	16	0	4
Total for both		143	117	12	14

Upstream of sewage plant

	Date	Total	Female	Male	Intersex
Boulder Creek	March 2, 2002	13	8	5	0
	Nov. 4, 2002	20	10	10	0
	Sept. 24, 2003	26	14	12	0
	June 18, 2004	20	10	10	0
Total		79	42	37	0
South Platte River	May 7, 2002	6	4	2	0
Total for both		85	46	39	0

Sources: University of Colorado, Colorado Division of Wildlife

Theo Stein, Andrew Lucas | The Denver Post

The Energy Economy

A faded background image of an oil pumpjack in a field, with a building and other structures visible in the distance.

- Oil and gas development
 - Pervasive infrastructure (roads, transmission lines, holding facilities, drainage ponds and pipelines)
- Coalbed Methane
 - Methane gas present in underground coal seams
- Oil shale
 - Water needs for development
- “Produced” waters
 - Large amounts of “produced” water of varying quality extracted during these processes

Increased demand for water

- Major water projects can exacerbate or create additional water quality problems
 - Loss of flushing flows
 - Loss of dilution flows
 - Increased transfer of poorer quality water
 - Water temperature increases
- Recent Federal court decision
 - Gross Reservoir Reservoir and Dam Expansion Project
 - Federal judge earlier in 2024 found the U.S. Army Corps of Engineers violated the Clean Water Act and the National Environmental Policy Act in issuing a dredge-and-fill permit to Denver in 2018

Water Quality / Water Quantity

- **A natural tension exists between Colorado's water quality and water quantity laws**
 - Less water in a stream can create or exacerbate pollution problems
- **Water quantity laws have been in place for more than 150 years, water quality laws less than 50 years**
- **CWQCD / CWQCC limitations**
 - Prohibited from requiring instream flows to dilute pollution
 - Cannot take legal action to impair exercise of a water right

Changing Climate and Water Quality: Colorado Coldwater Streams



Photo courtesy of Blake Beyea, Colorado Water Quality Control Division

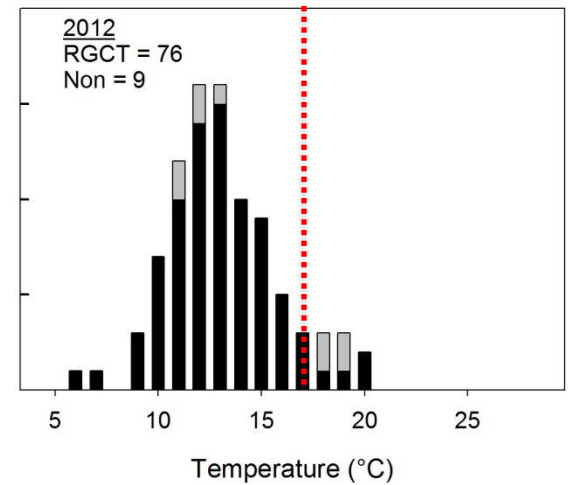
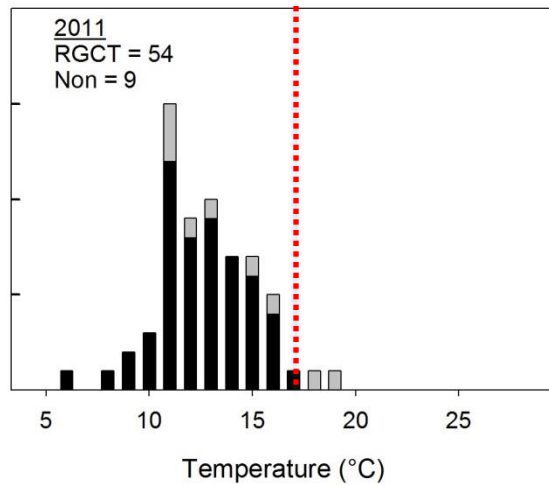
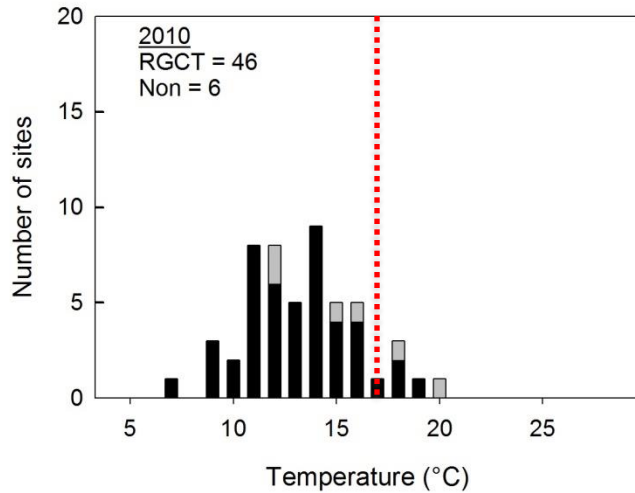
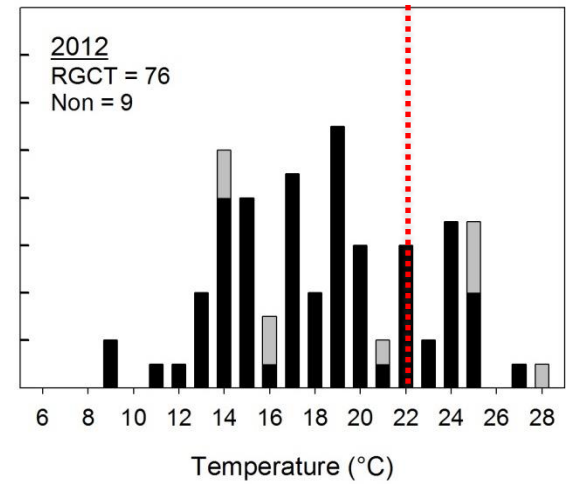
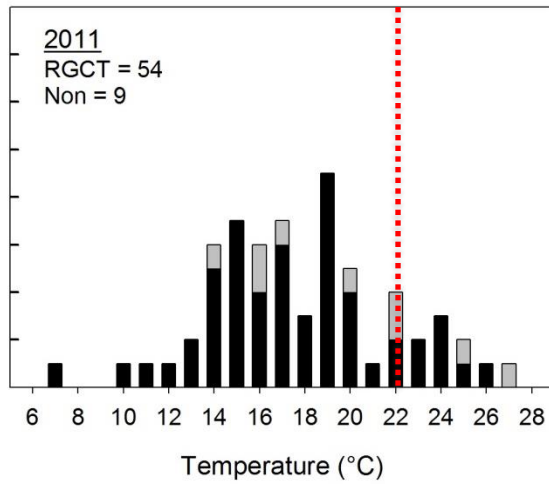
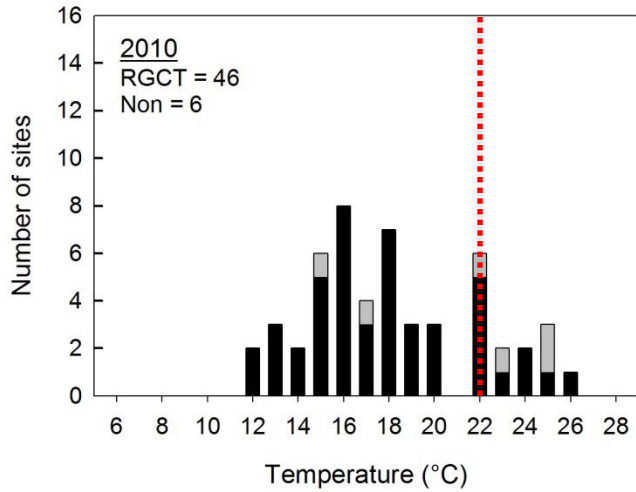
Commonly predicted effects of changing climate to freshwater ecosystems

- Increased water temperature
- Increased evaporation rates
- Earlier spring runoff
- Reduced snowpack
- Higher winter flows
- Lower summer flows
- Greater variability in extreme temperatures
- Greater storm intensity
- Increased frequency of flooding
- Increased frequency of drought
- Increased wildfire
- Increased forest insect pests
- Saltwater intrusion from rising sea levels

The Potential Influence of Changing Climate on the Persistence of the Rio Grande Cutthroat Trout



Will we lose coldwater fisheries if it gets hotter?



Sangre de Cristo Creek

Site ID: 29
 HUC: Alamosa-Trinchera
 Deployed: 5/27/2010
 Drainage Area: 28,392 ha
 Site Elevation: 2473 m
 RGCT Population ID: RGH2-16



Figure 1. Lower monitoring site on Sangre de Cristo Creek.

Population Information
 Genetic Status: Unaltered
 Non-Natives: Brook trout
 Barrier: Partial barrier present

Land Ownership:
 USFS: 0.0%
 State: 0.0%
 Private: 100.0%
 Other: 0.0%

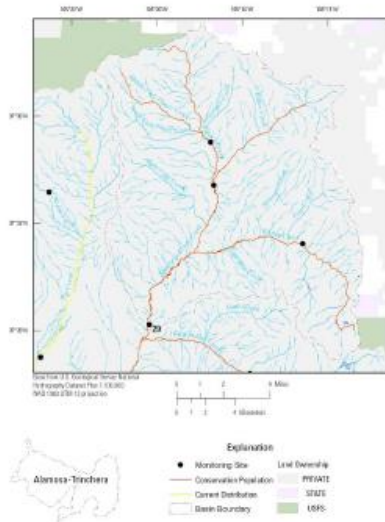


Figure 2. Location of lower monitoring site on Sangre de Cristo Creek.

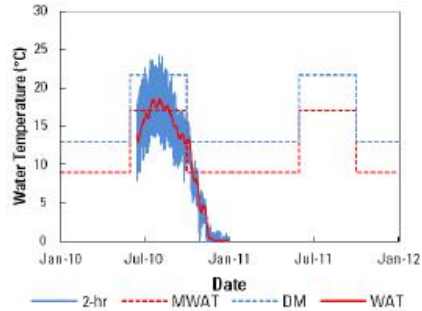


Figure 3. Two hour running mean (blue line) and weekly average water temperature (red line) at lower monitoring site on Sangre de Cristo Creek. Dashed lines Colorado Tier 1 Cold Water Temperature Criteria.

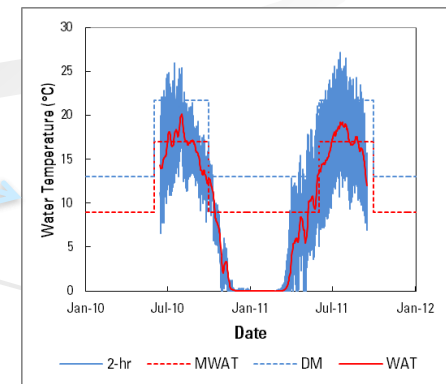
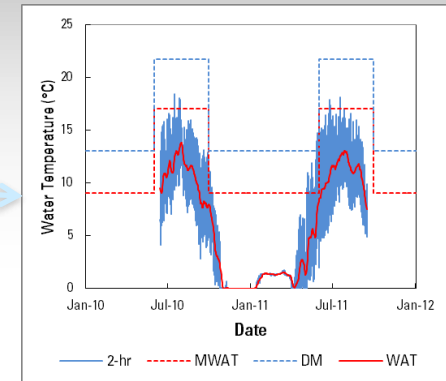
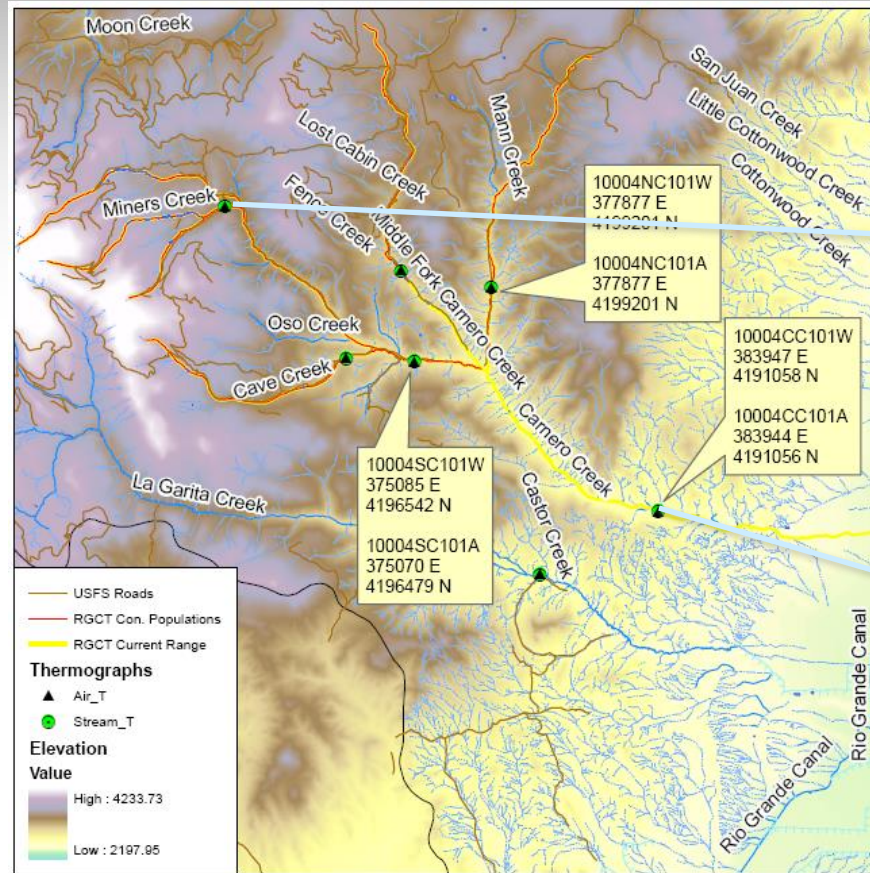
Table 1. Air and stream temperature metrics and discharge in 2010 and 2011.

	Year	2-hr Min (°C)	2-hr Max (°C)	Min WAT (°C)	Max WAT (°C)	Baseflow Discharge (cfs)
Water	2010	-0.06	24.32	0.05	18.49	3.48*
Data	2011	Exposed	Exposed	Exposed	Exposed	1.41†
Air	2010	-19.75	28.23	-7.35	19.30	-----
Data	2011	-32.14	31.27	-13.55	19.28	-----

*110 days of data (6/04/2010–9/21/2010); †data logger exposed in 2011 and no data is presented; ‡211 days of data (6/04/2010–12/31/2010); §269 days of data (1/01/2011–9/26/2011); ¶measured on 9/22/2010 and was precipitation affected; †measured 9/27/2011 and was not precipitation affected



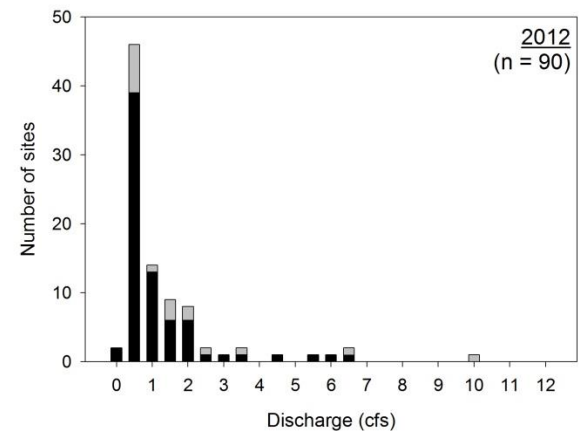
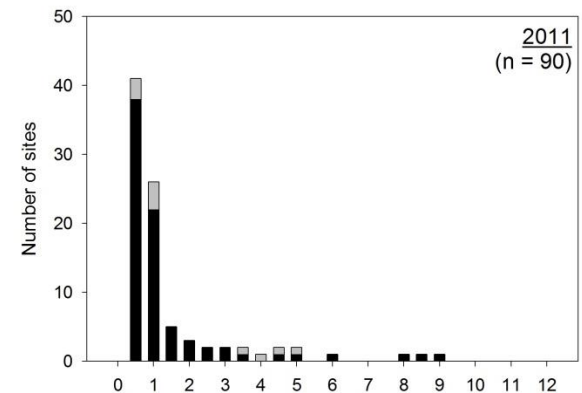
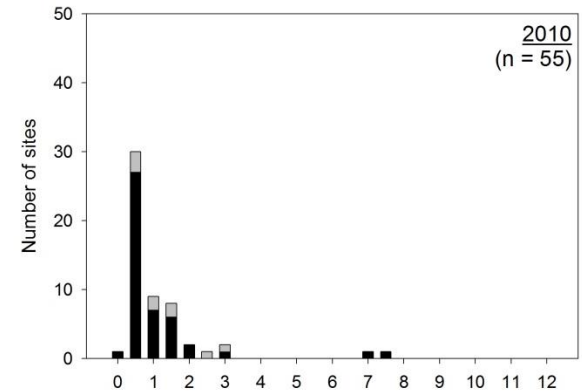
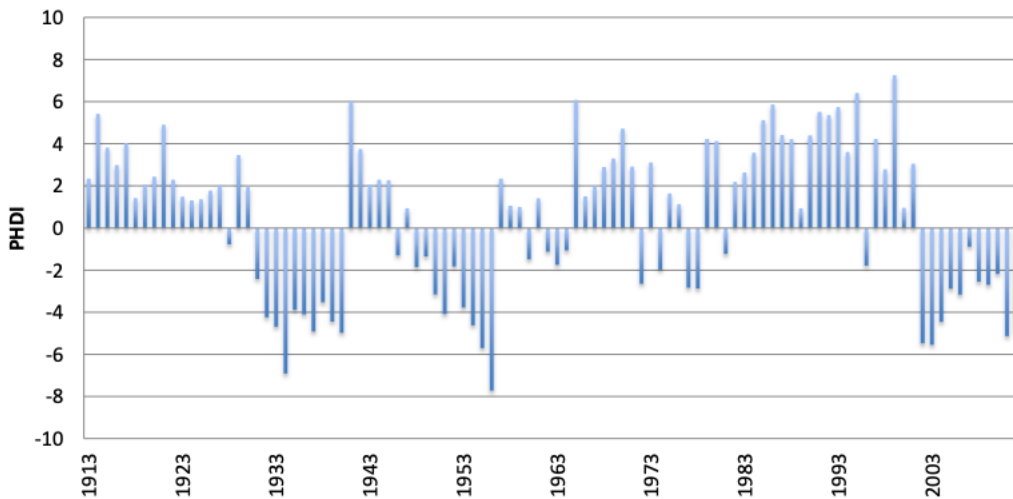
Will our traditional restoration strategies be undermined ?



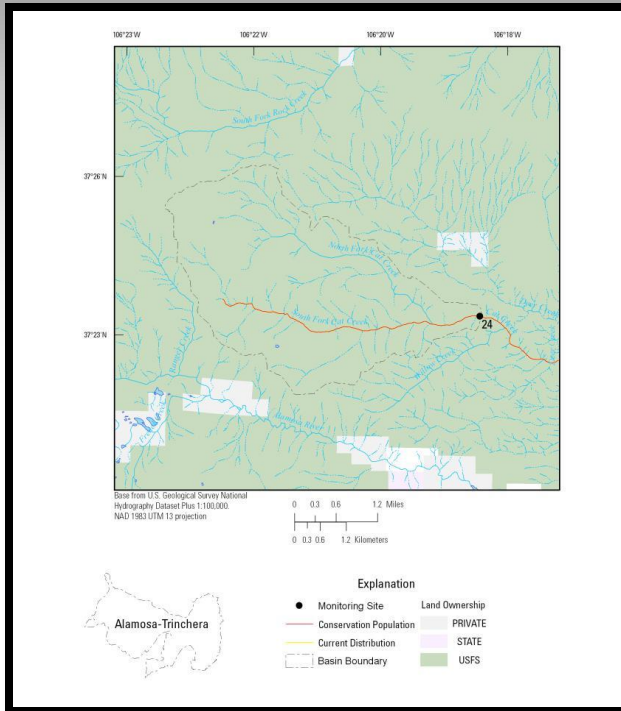
Re-establishing metapopulations of the Rio Grande cutthroat trout may be complicated by temperature conditions in the connecting mainstem habitats.

What will happen if it gets drier?

Historical Palmer Hydrological Drought Index for the Rio Grande Headwaters (September)



Little Margin for Error in Some Streams in Extreme Low Flow Years...



More, and more intense wildfires?



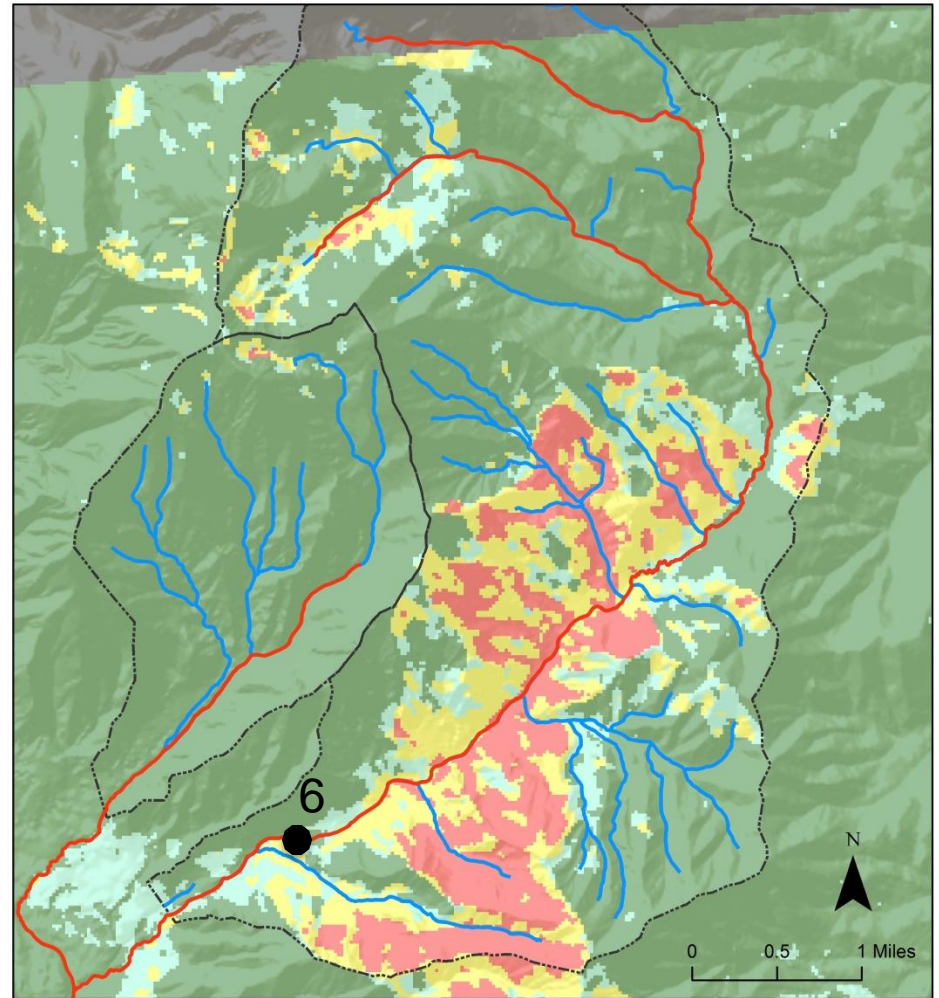
RGCT Density at Station #6

2004: 460 fish / mile

2005: 481 fish / mile

2008: 457 fish / mile

2011: 191 fish / mile



Medano Creek is one of the larger RGCT populations (by stream miles), and this has likely reduced the impact of the Medano Creek Fire. Unburned upper reaches of the creek likely have served as a source of fish for re-colonization post-fire. Smaller populations are more vulnerable to complete loss during such stochastic events.

Personal Lessons I've Learned Along The Way

THINGS I'VE LEARNED...

- Try lots of different things.
- Work hard at whatever you do.
- Be authentic.
- Swing for the fences.
- Think creatively about the problems and how you might help to solve them.
- Seek out great mentors.
- Educate the people around you.
- Try not to get overwhelmed.
- Ask for help along the way.
- Never give up.





Questions about Bonita Peak Mining District, aquatic toxicology, trout, water quality, being a Fed, running / fly fishing ?