

Ecosystem Vulnerability of Spruce-Fir Forest Systems under Changing Environmental Conditions

Consideration and tools to enhance adaptive
management options

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Colorado Climate is Changing and
Extremes are Increasing (i.e., fires, droughts, droughts, pest
outbreaks, floods, etc) and Impacts are Projected to Increase



Changing Environmental and Climate Conditions

- Numerous independent lines of evidence demonstrate that warming has continued over the past 2 decades.
- Because current warming trends are being super-imposed on a naturally varying climate, these are exacerbating natural semi-arid conditions in Colorado
- Environmental consequences are being observed in water availability, disturbance patterns, and extreme events

What can local voices tell us about weather-related impacts in rural and mountain areas?

“While there have been some scattered rain showers around the San Luis Valley, there has not been enough to make a difference. The drought is persisting. Pastures are becoming short, cattlemen are in quiet desperation looking for pasture and hay that is affordable. The heat has crops well ahead of normal by anywhere from 2-3 weeks. ... Warm water is affecting the fish, and wildlife is moving to water from the public lands.” – Rio Grande County, 07/9/2018

“Very dry in Bent County and the western part of Kiowa County, already starting to cull cows, other people are talking about sending cows and calves to feedlot or early weaning calves and sending both to feedlots separately. ... The rains have been very spotty and the high heat and winds have killed what moisture has come.” – Ben County, 06/28/2018

“The wind has been horrible, very hot and dry, irrigation water is not going across the field like it should and people are taking cattle to the sale barn...” – Lamar, Prowers County, 07/10/2018

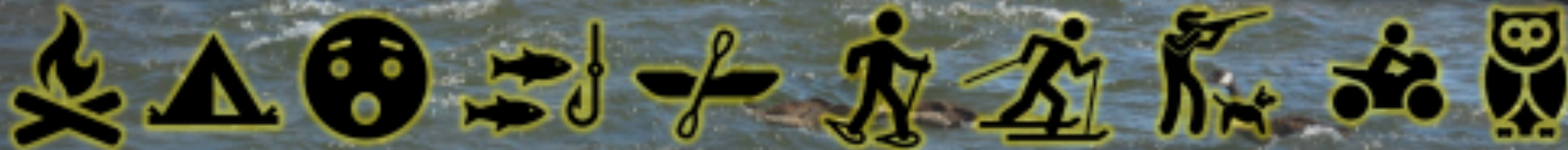
“One fruit tree is dying, vegetable garden is mostly dead, because Grand Junction (nearest station to us) has had <14% of normal rain so far this summer...” – Mesa County, 07/19/2018

Outdoor Recreation Impacts

Still dry. The little amount of snow we have is melting. Looks like our Blue Spruce Tree is not perky, a sign that it might need water (in January?). Fire will be an issue in the summer if we don't get moisture. Irrigation water will be limited. All of those things will keep the tourists away and are already affecting skiers, the airlines, and probably the area hotels. – La Plata County (Jan 2018), CoCoRaHS



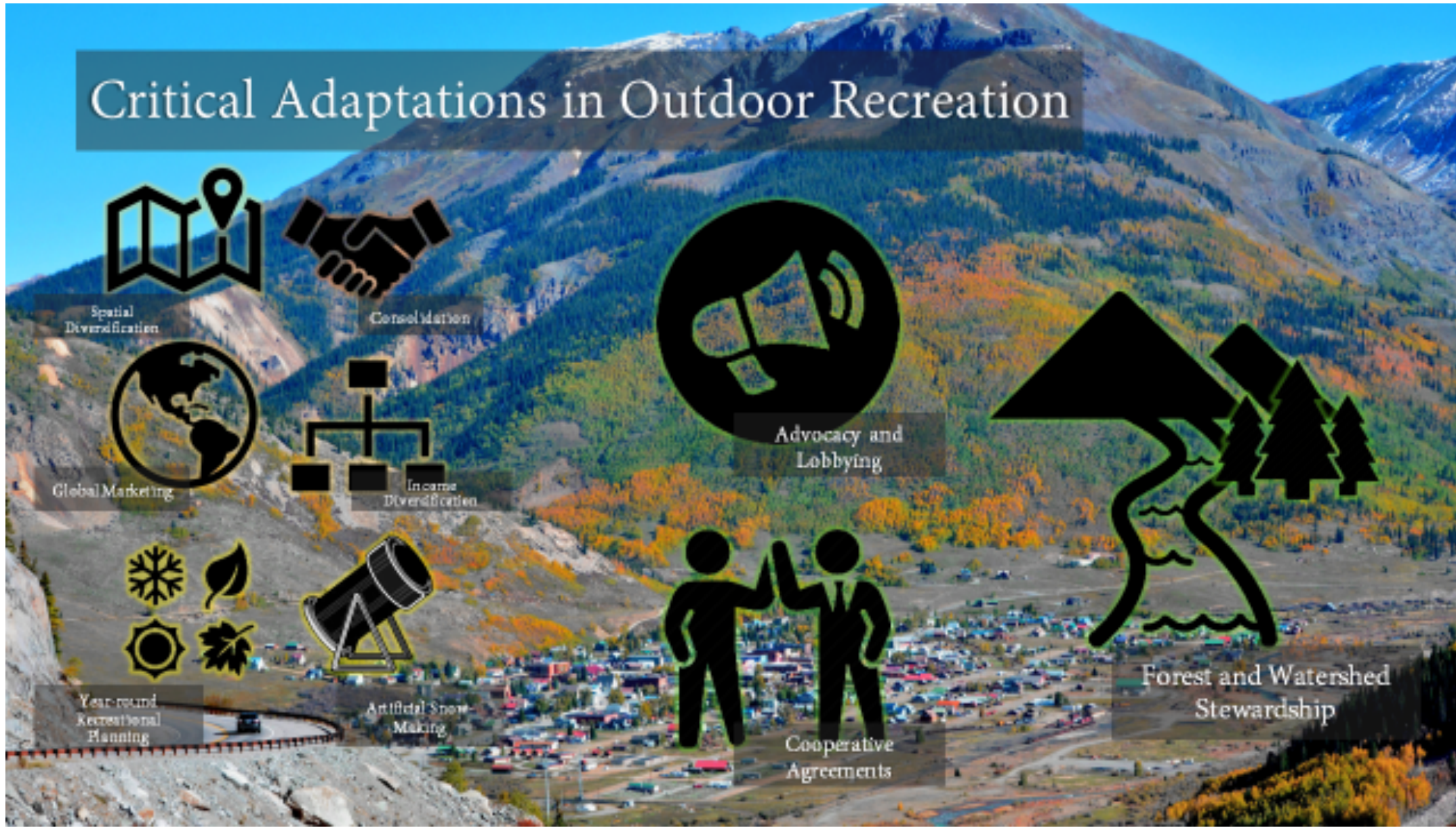
Park County is still in a fire ban. No campfires were allowed during the recent hunting season. No charcoal grills are permitted, as well as other restrictions on recreational and tourism activities such as OHV use and target shooting. Increased workload for police and fire departments to monitor "illegal fires". Residents are very concerned about wildfires. Agriculture is affected because there is little or no water storage and the snowpack is low. Wildlife has been affected: the bears have not all gone into hibernation. - Park County (November 2016), CoCoRaHS



CRITICAL VOICES
(Even and Ojima 2018)

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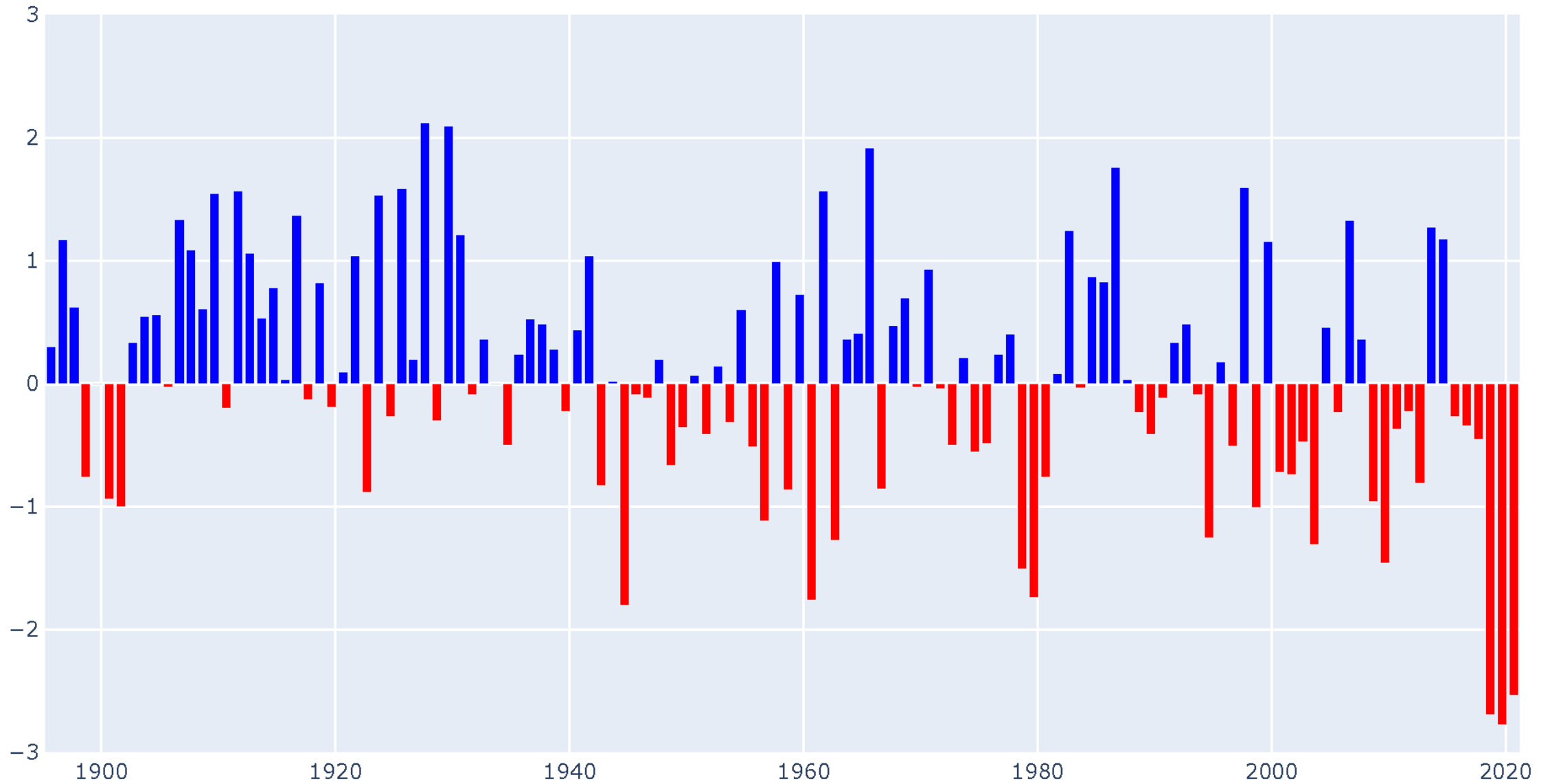


Climate Summary of Colorado State Forest
 Historical and Projections for 2045-2054
 Based on CCSM4 @ NCAR

Colorado State Forest - Climate Projection Summary - Hist vs 2050

Annual Statistic	Historical	2050 RCP 4.5		2050 RCP 8.5	
		Projected Value	Change from Hist	Projected Value	Change from Hist
Temperature Avg (degF)	32.0	35.3	3.3	36.7	4.7
Precipitation (in)	31.6	31.9	0.3	32.1	0.5
GDD: (tmax+tmin)/2 - 50	1216	1642	426	1768	552
Hot Days: tmax>90	0.0	0.3	0.3	0.5	0.5
Cold Days: tmin<32	299.7	272.3	-27.4	263.7	-36.0
<i>Data Source: CCSM4-LOCA model</i>					

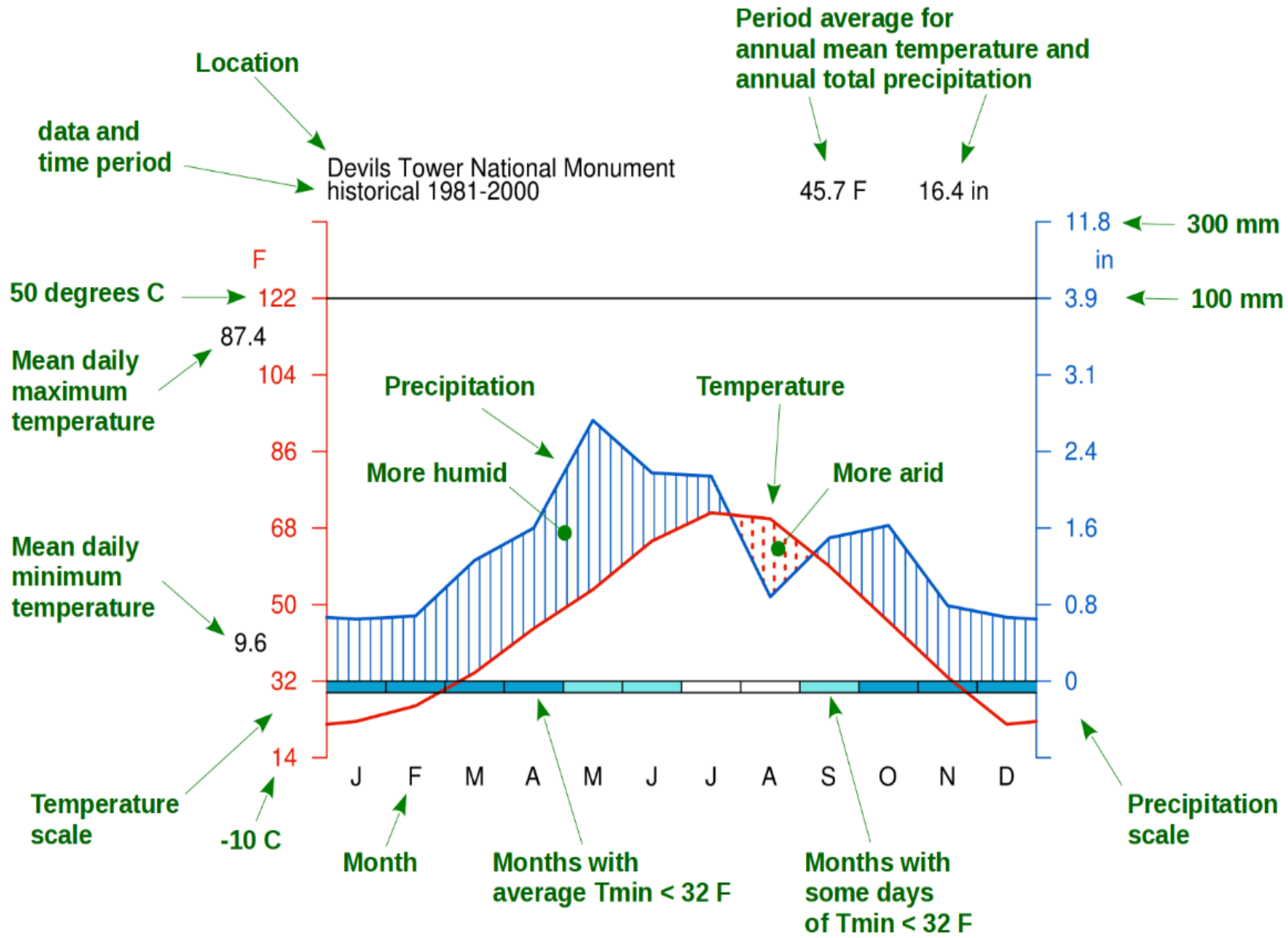
Standardized Precipitation-Evapotranspiration Index (SPEI) Colorado climate division 2, 03 months ending in September



Distribution: pearson, trained on 1931-1990

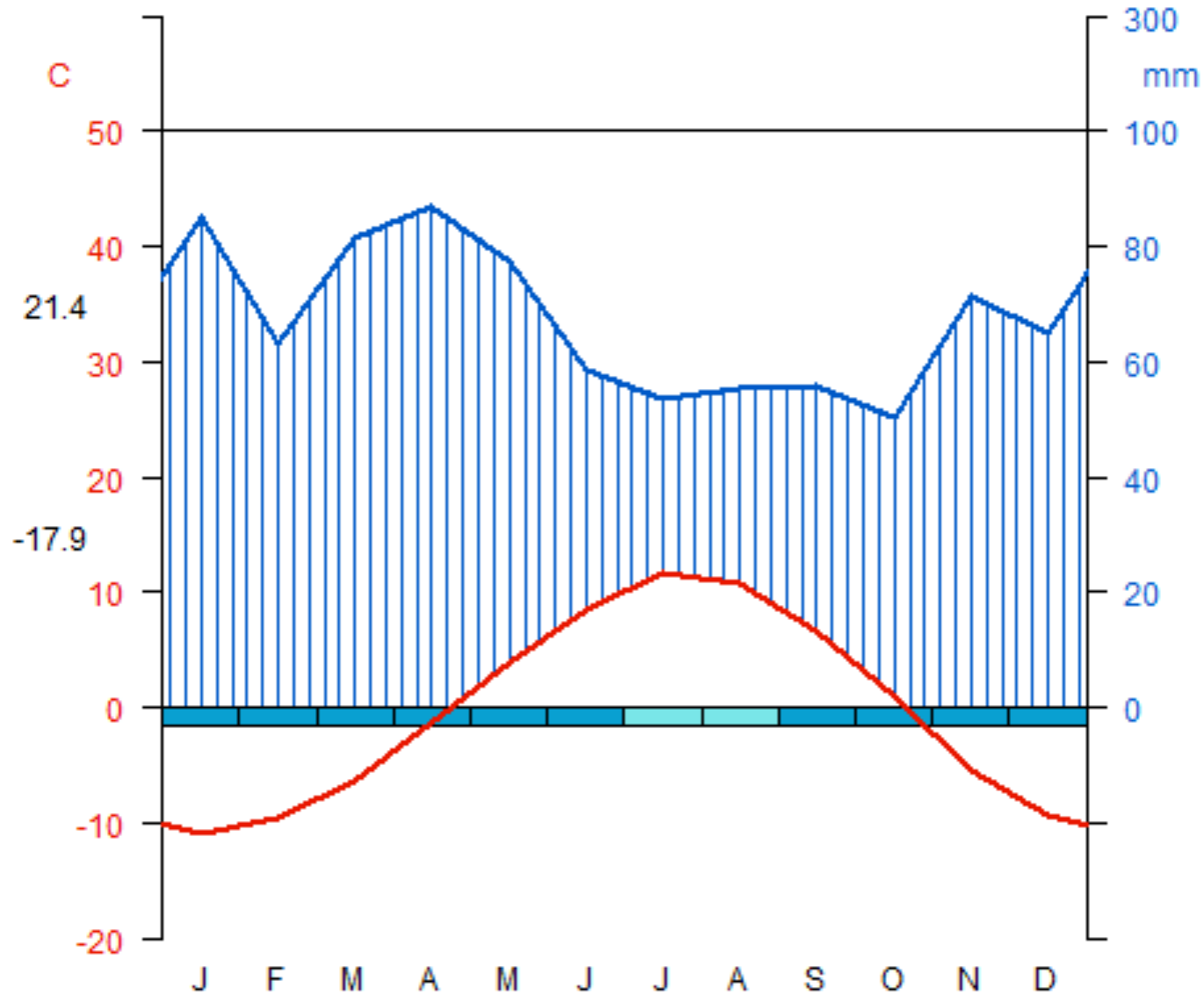
Data source: NCEI nclimgrid

Graph: Russ Schumacher/Colorado Climate Center/CSU



ColoSF_Boundary - CCSM4-historical
1976-2005

0C 803 mm



Historical Climate (1976-2006)

Climate Summary:

Average annual T: 32 °F

Annual PPT: 31.6 in

Climate class:

Continental Cool

Climate

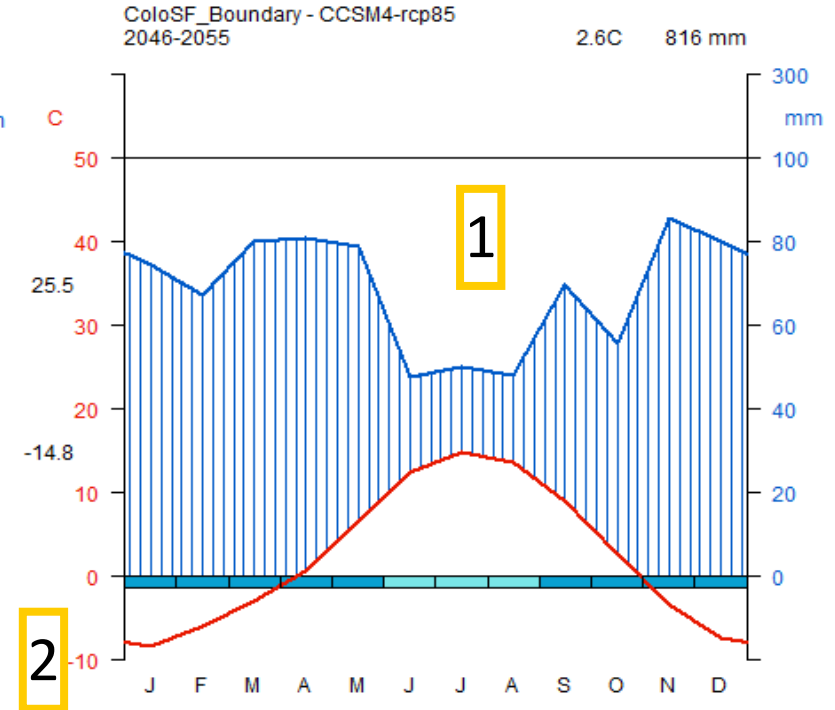
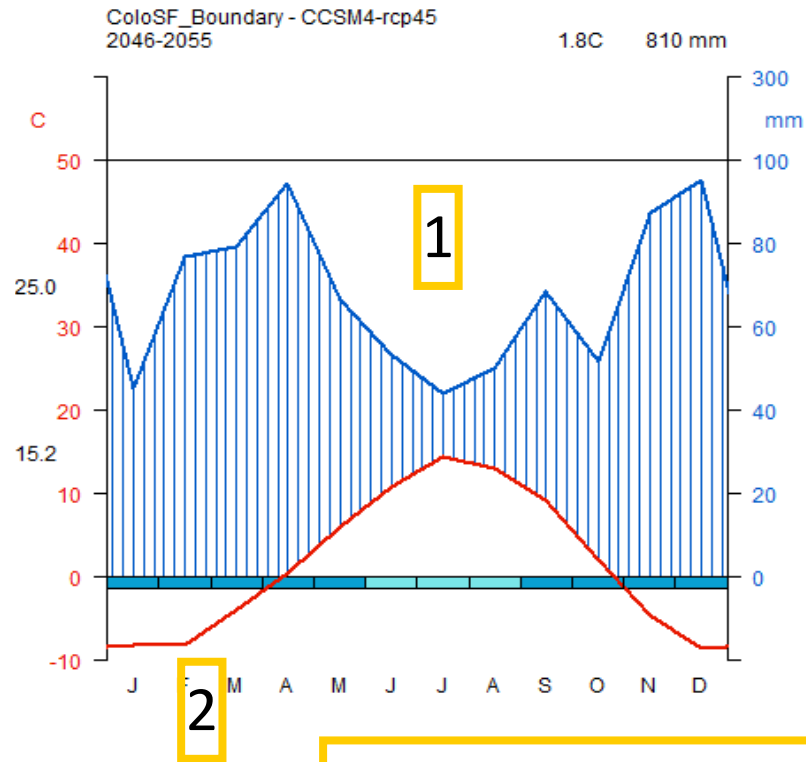
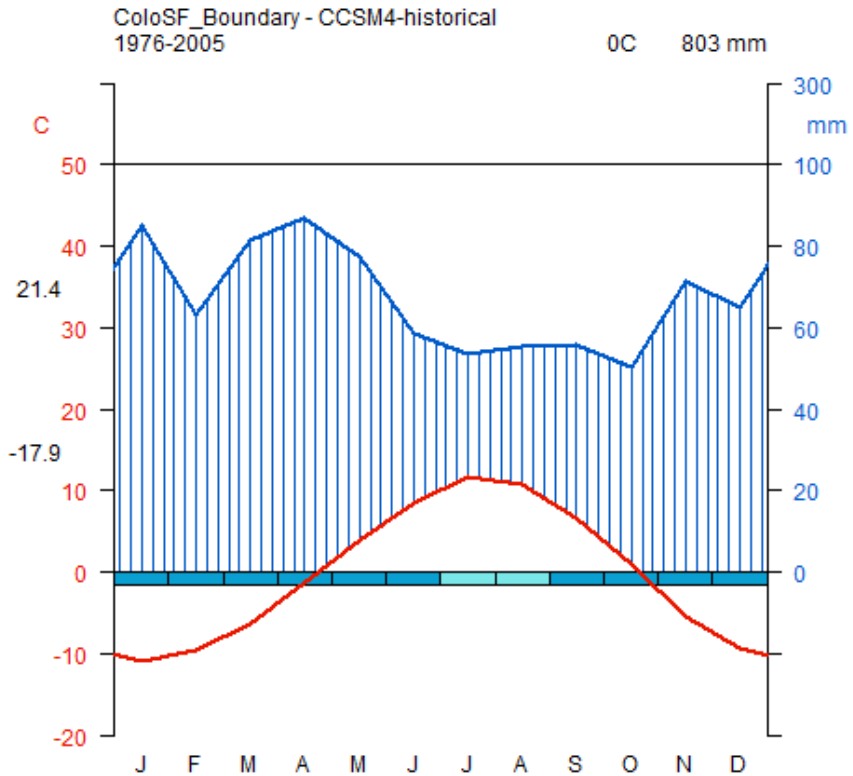
Vegetation type:

Conifer Forest

Historical Climate (1976-2006)

Projected Climate Cooler projection (RCP 4.5 2046-2055)

Projected Climate Hotter projection (RCP 8.5 2046-2055)



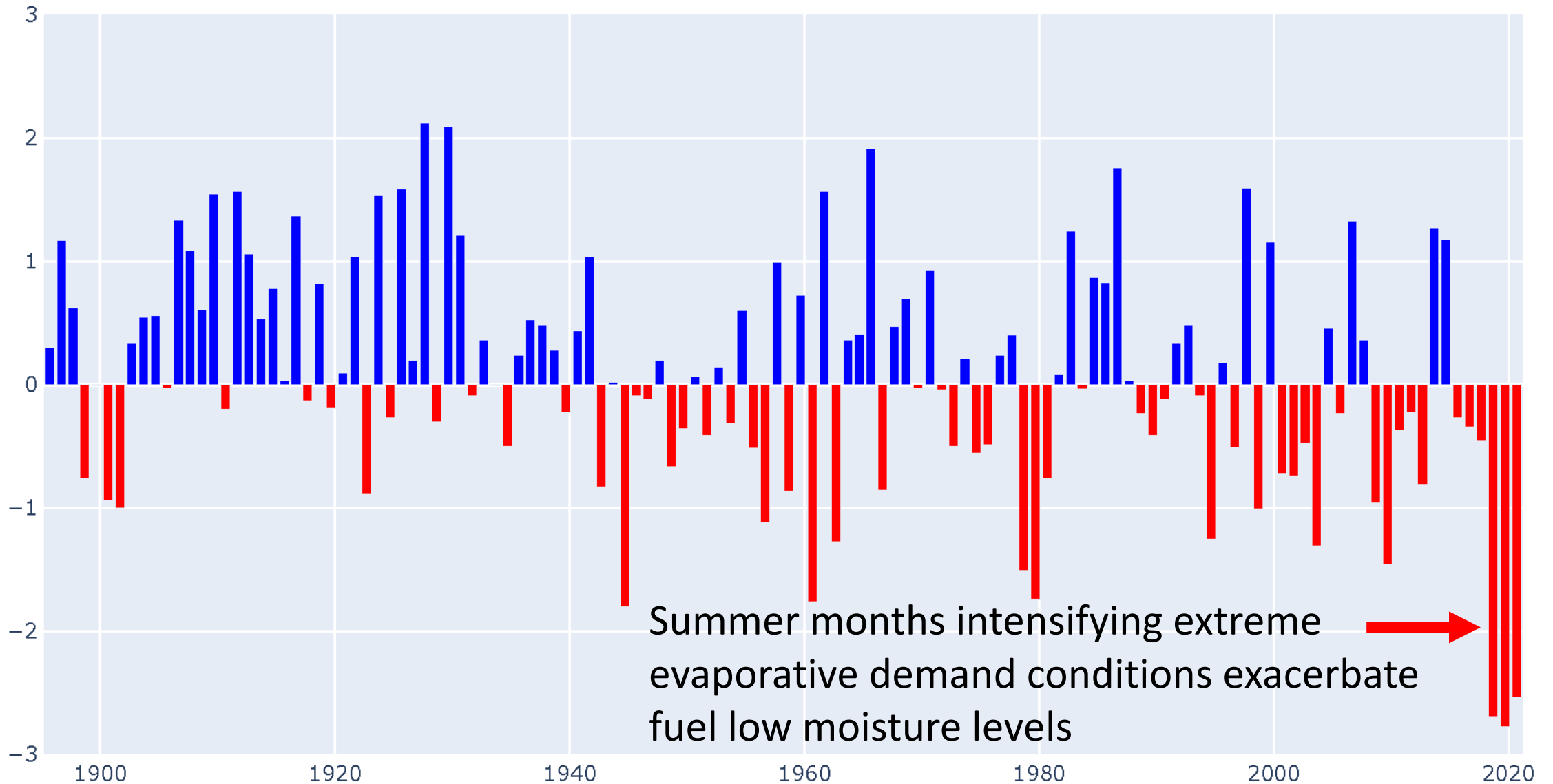
Climate change summary: 1. Growing season precipitation reduction; 2. warmer winters

Climate change summary:

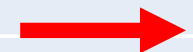
T average: RCP 4.5 (35.4 °F) RCP 8.5 (36.7 °F)

P annual : RCP 4.5 (3.18 in) RCP 8.5 (3.21 in)

Standardized Precipitation-Evapotranspiration Index (SPEI) Colorado climate division 2, 03 months ending in September



Summer months intensifying extreme evaporative demand conditions exacerbate fuel low moisture levels



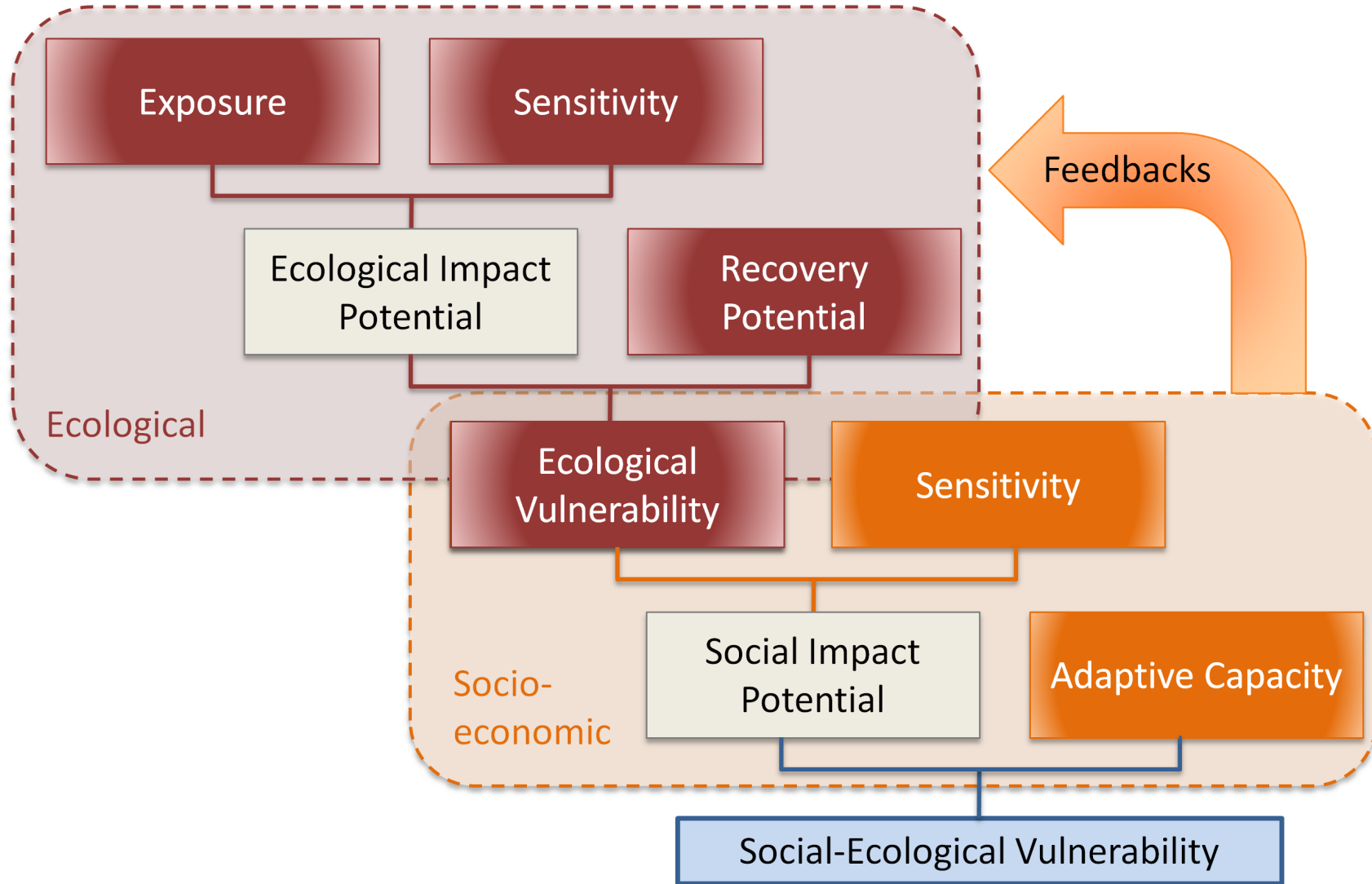
Distribution: pearson, trained on 1931-1990
Data source: NCEI nclimgrid
Graph: Russ Schumacher/Colorado Climate Center/CSU

Adaptation: Key Messages

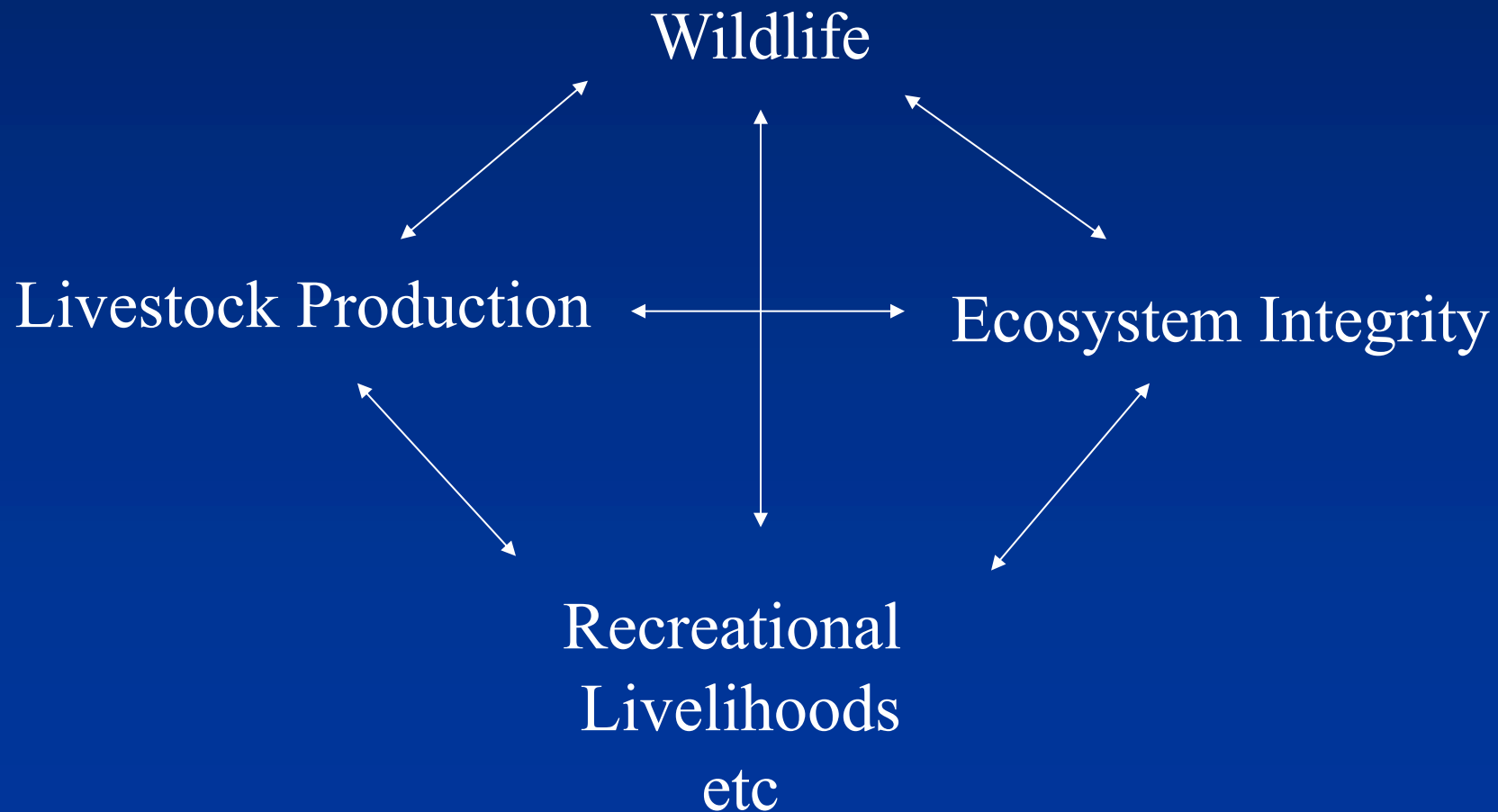
- There is no "one-size fits all" adaptation, but there are similarities in approaches across regions and sectors. Sharing best practices, learning by doing, and iterative and collaborative processes including stakeholder involvement, can help support progress
- Vulnerability to climate change is exacerbated by other stresses such as pollution, habitat fragmentation, and poverty. Adaptation to multiple stresses requires assessment of the composite threats as well as tradeoffs amongst costs, benefits, and risks of available options
- The effectiveness of climate change adaptation has seldom been evaluated, because actions have only recently been initiated and comprehensive evaluation metrics do not yet exist.

ISSUES

- Multiple Stresses
- Multiple Scales of natural resource connections in Space-Time-Biological dynamics
- People and livelihood considerations related to changing social-ecological conditions
- Complex Adaptive Systems of the Coupled Human-Environmental System



Assessing Ecosystem Interactions – Trade-Offs or Complementarities



Working premise: The Colorado environment is a semi-arid and will respond to pressures from human activities and climate variation. Those responses can cross **CRITICAL THRESHOLDS** that affect ecosystem function, ability to provide things we need (goods and services), or the quality of life.

How do we assess VULNERABILITY?

- **DETERMINE NATURE OF THE EXPOSURE**
- **ANALYSES OF SENSITIVITY (Susceptibility)**
- **IMPACT: CRITICAL RESPONSE ANALYSIS**
- **ADAPTIVE CAPACITY ASSESSMENT**
- **SCENARIO DEVELOPMENT**
- **MONITORING**

ADAPTATION DESIGN

- Adaptive Management practices are **local** and need to take into account the complex, non-linear behaviour of **socio-ecological systems**
- Use of appropriate **scenarios** and **downscaling techniques** of climate change effects
- Full risk/uncertainty **assessments**
- Projects need to be linked to **capacity building & technology transfer**
- Co-development of an **integrative management plan** should treat the system as a **socio-ecological system**

Communication is a key component of adaptive capacity

- Communication
 - Social network (who has information and how is it exchanged?)
 - What is the nature of decision making?
 - How can climate information be packaged to be accessible and useful?
 - Need to increase climate literacy so land managers and communities understand basic terminology
 - Narrative is important – language and communication makes a difference in terms of how messages resonate

Scale and timing are a challenge

- Scale:
 - Need to work across scales / at multiple scales
 - Increase adaptive capacity through organizing ourselves and making decision at larger scales across jurisdictions
- Timing:
 - How fast can we make decisions (or provide science to support decisions) with respect to how fast the world is changing around us?

Integrated Ecosystem Assessment

- Simultaneously considers and interrelates different components of the ecosystem (eg. plants, herbivores, predators).
- Transcends livelihood and enterprise needs.
- Humans are interactive components of the ecosystem.
- Assesses trade-offs among ecosystem components, or among stakeholders to find balanced solutions.
- Uses ecosystem science to inform decision making processes.

Summary

- Climate change is here and affecting our mountain systems
- Planning that merges current management actions with climate change considerations is the prudent thing to start
- Collaborative approaches that meet the mixture of forest usage and accommodates multiple livelihood and enterprise level needs can reduce unintended consequences of “one-size-fits-all” solutions