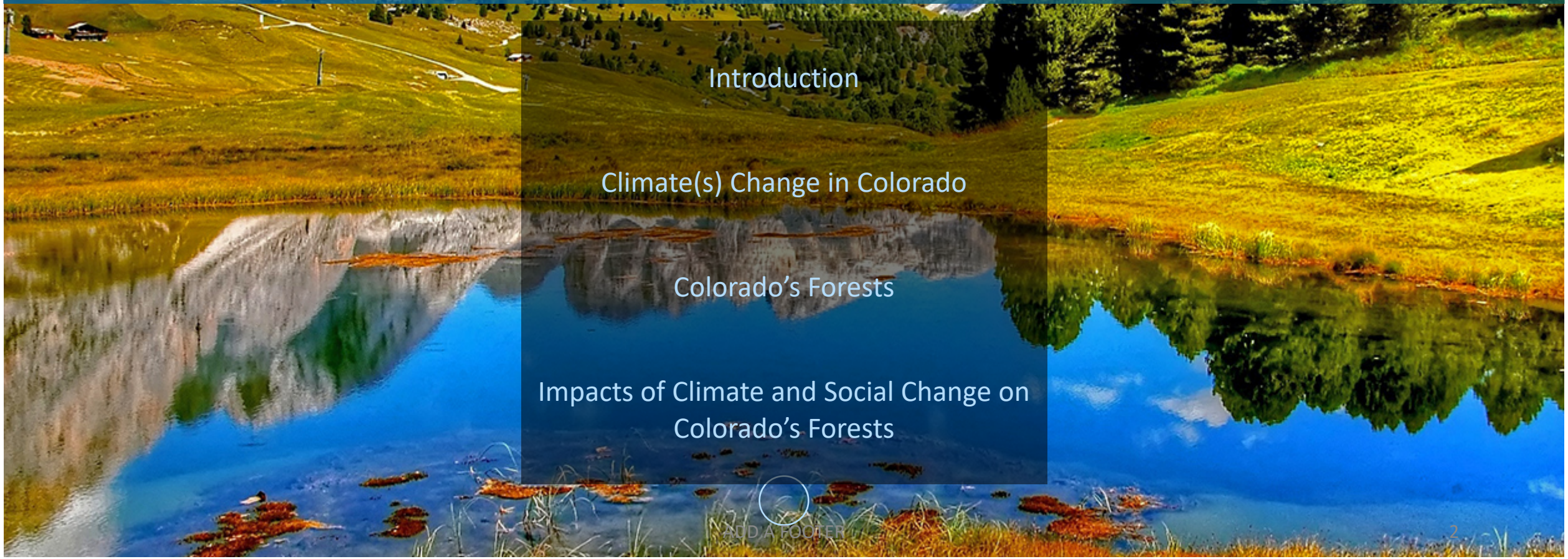
June 2019

Colorado's Forests in a Century of Change

A presentation for the 2020 Colorado State Forest Service Forest Action Plan

Trevor Even, M.A, Ph.D. Candidate – HEI Ecology; Natural Resource Ecology Laboratory, Colorado State University

What do global processes of change mean for Colorado's forests and the communities that rely upon them?



Introduction

Climate(s) Change in Colorado

Colorado's Forests

Impacts of Climate and Social Change on Colorado's Forests

Trevor Lee Even, M.A.

Fort Collins and Colorado State University 2001-2019 (minus a few in the middle)

2012 - B.A. – Cultural Anthropology

2015 - M.A. – Anthropology (Disaster Processes)

2015 – 2018 - North Central Climate Adaptation Science Center

2016- Present - **Ph.D. Student/Candidate**

Human Environment Interactions Ecology (Water Values and Vulnerabilities in CO)

2018-2019 - CSU Sustainability Leadership Fellow

2018 - Present – Spatial Analyst and Vulnerability Assessment Specialist, Adaptation International, LLC.

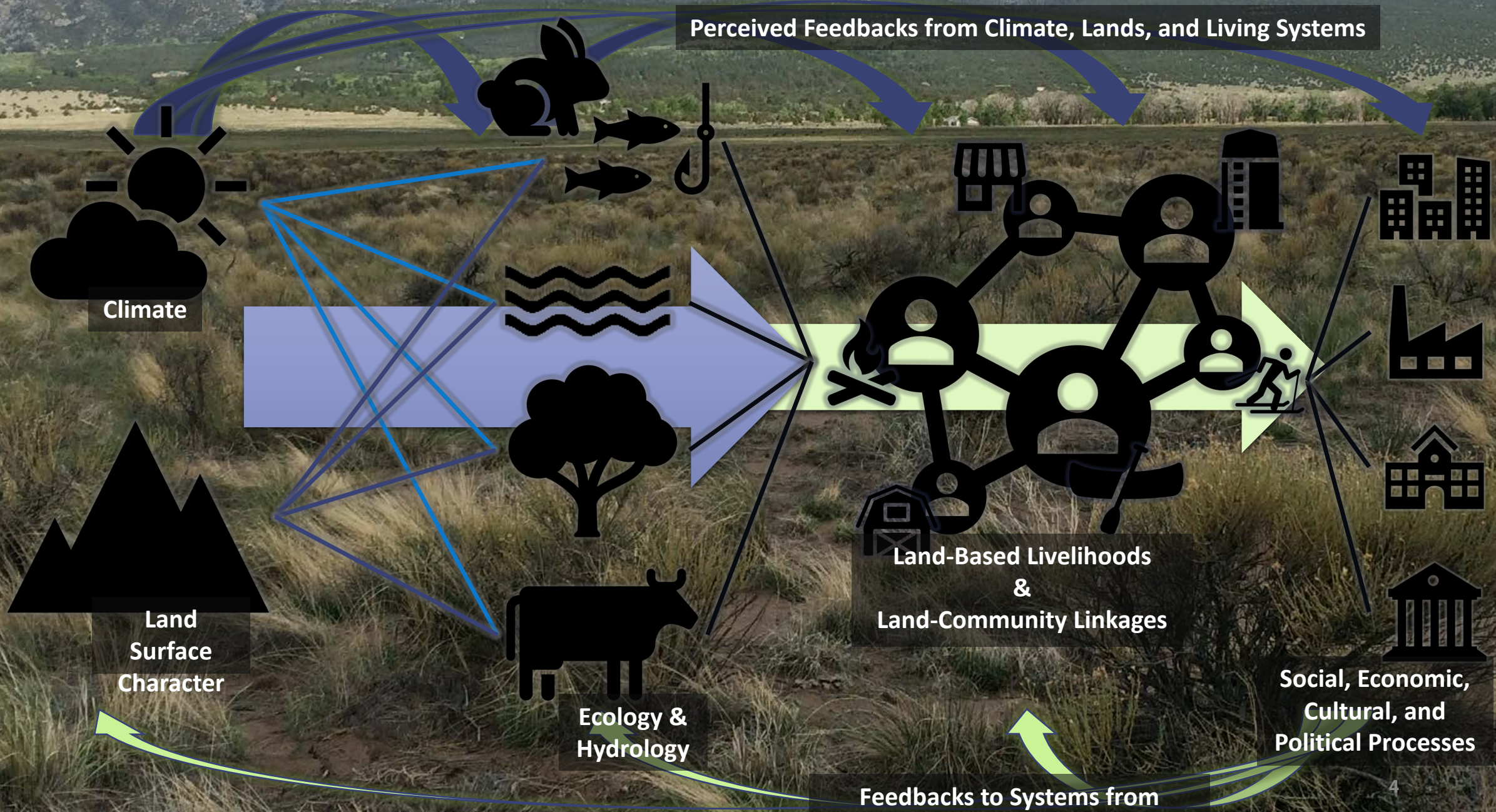
Kathleen Galvin

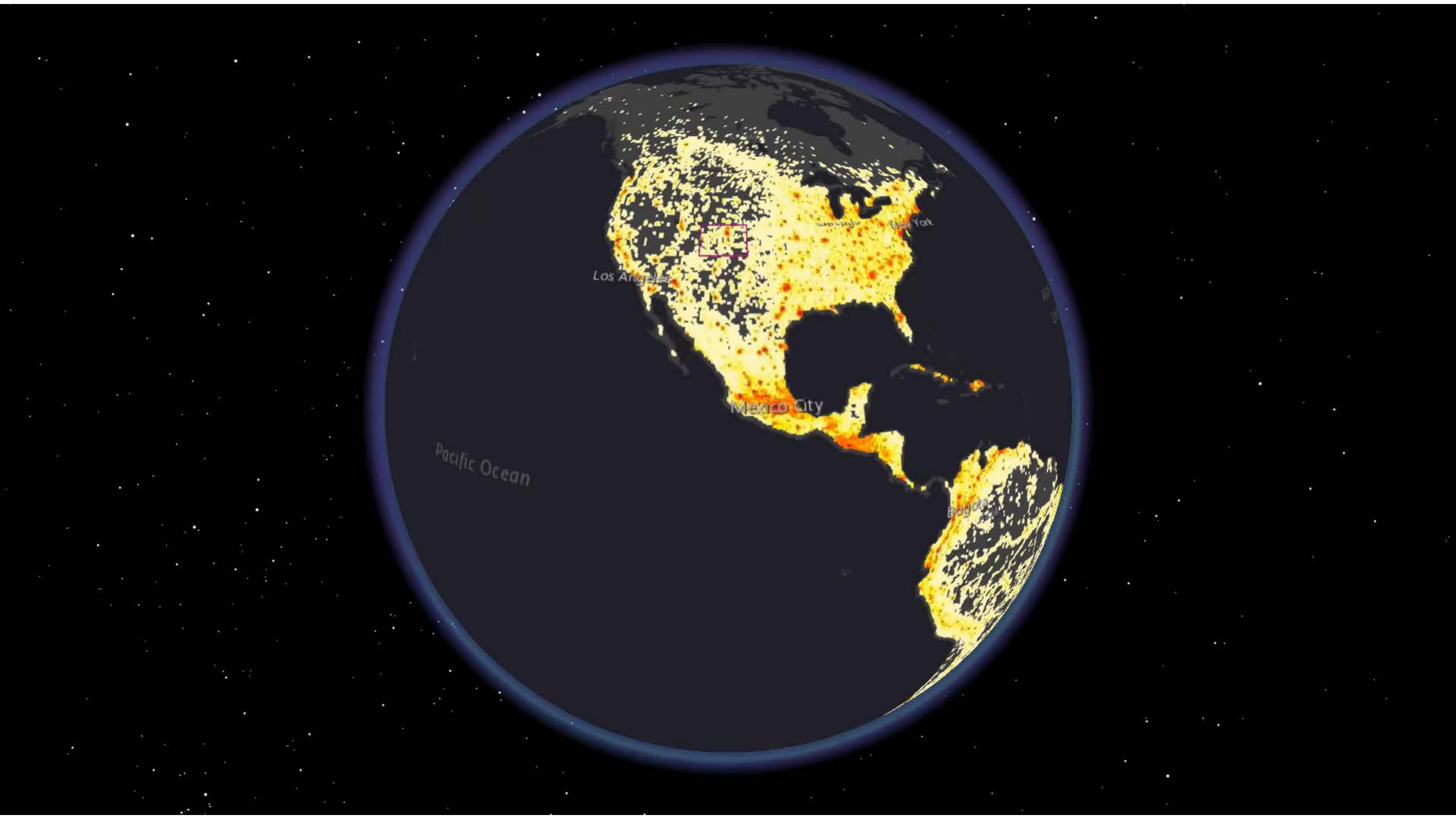
Dennis Ojima

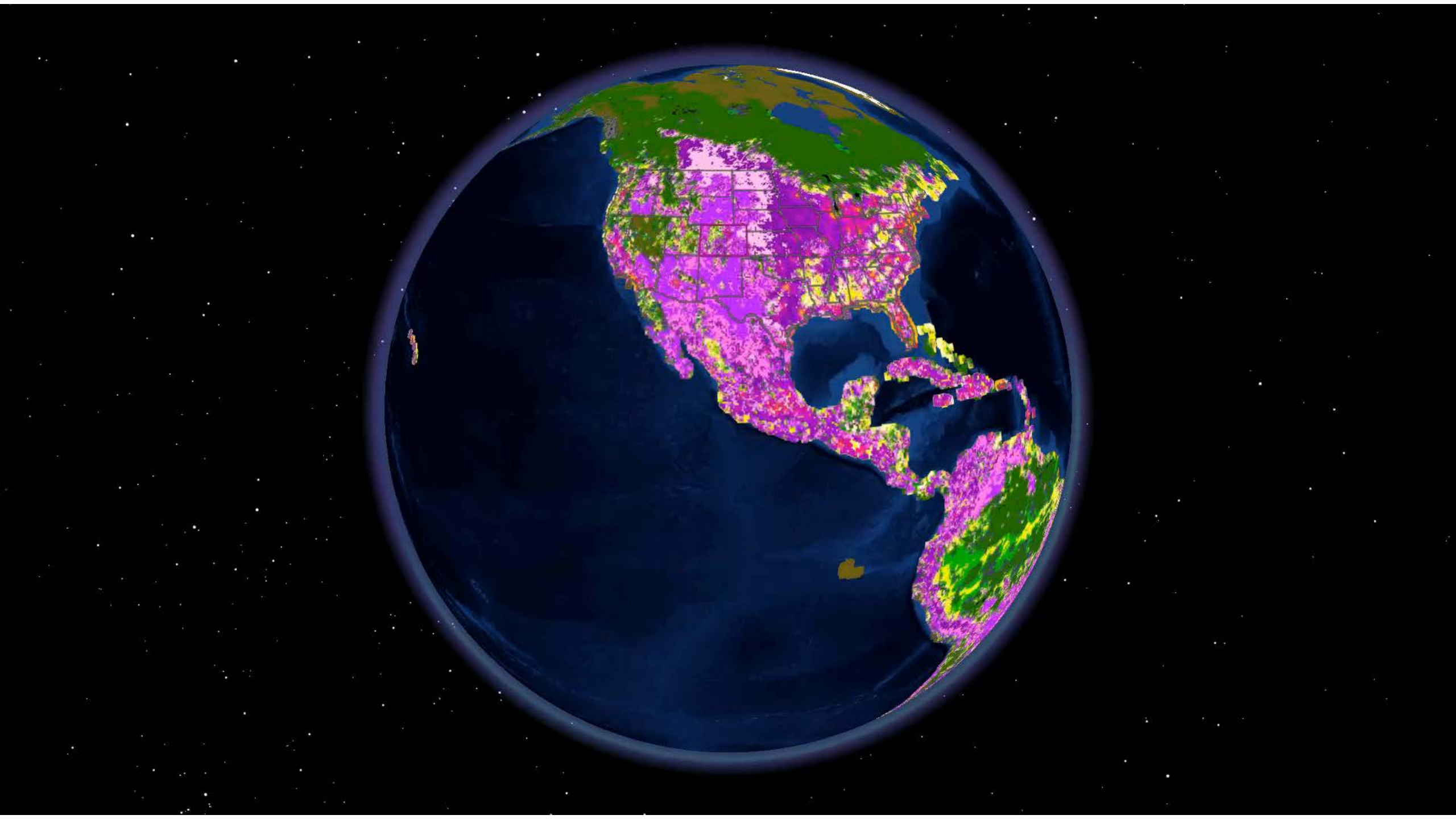
Randall Boone

Reagan Waskom

Vulnerabilities, Risk, and Adaptation in Anthropocene Social-Ecological Systems



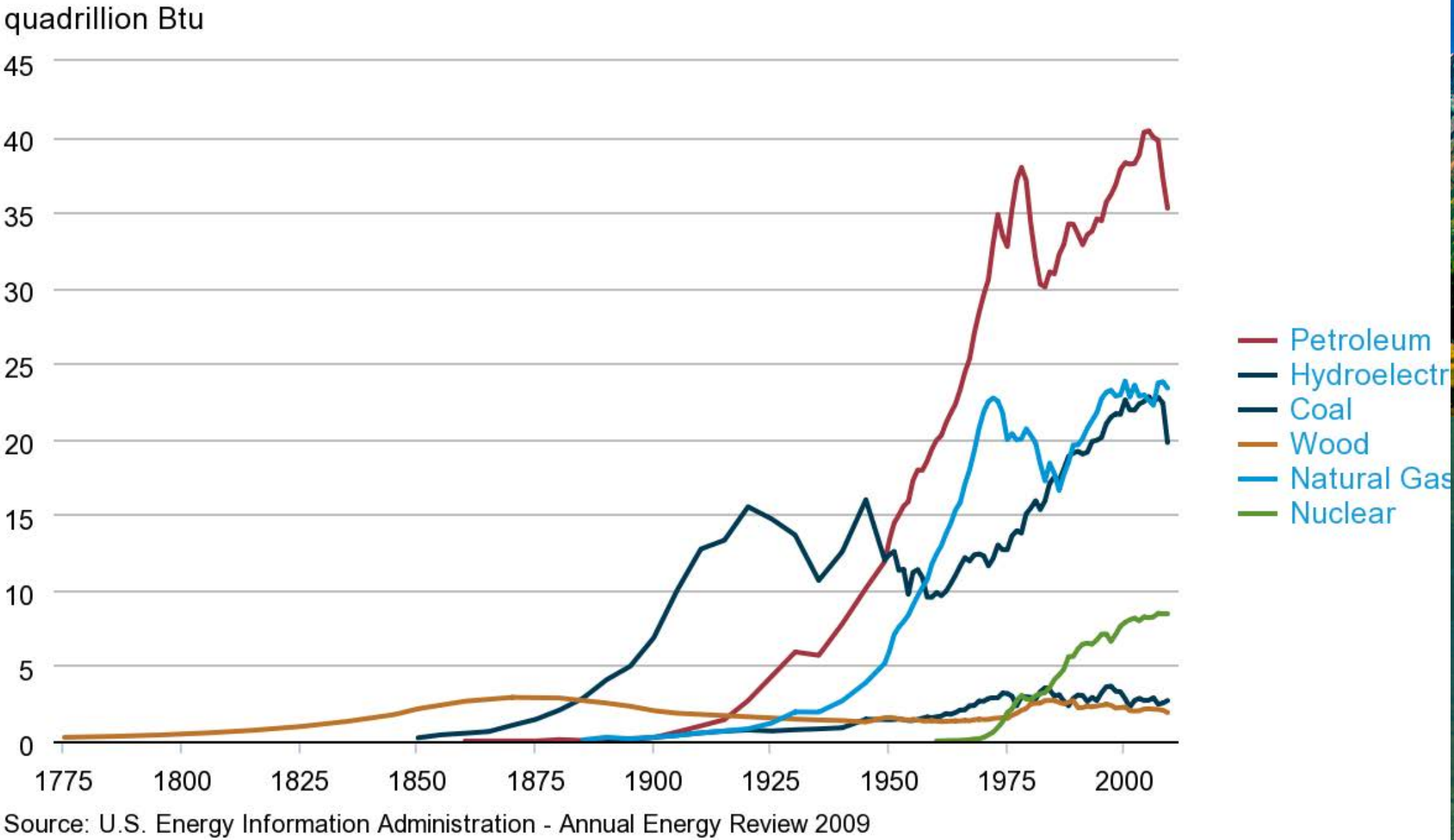

New York
Los Angeles
Mexico City
Pacific Ocean
Bogotá



How we got here?

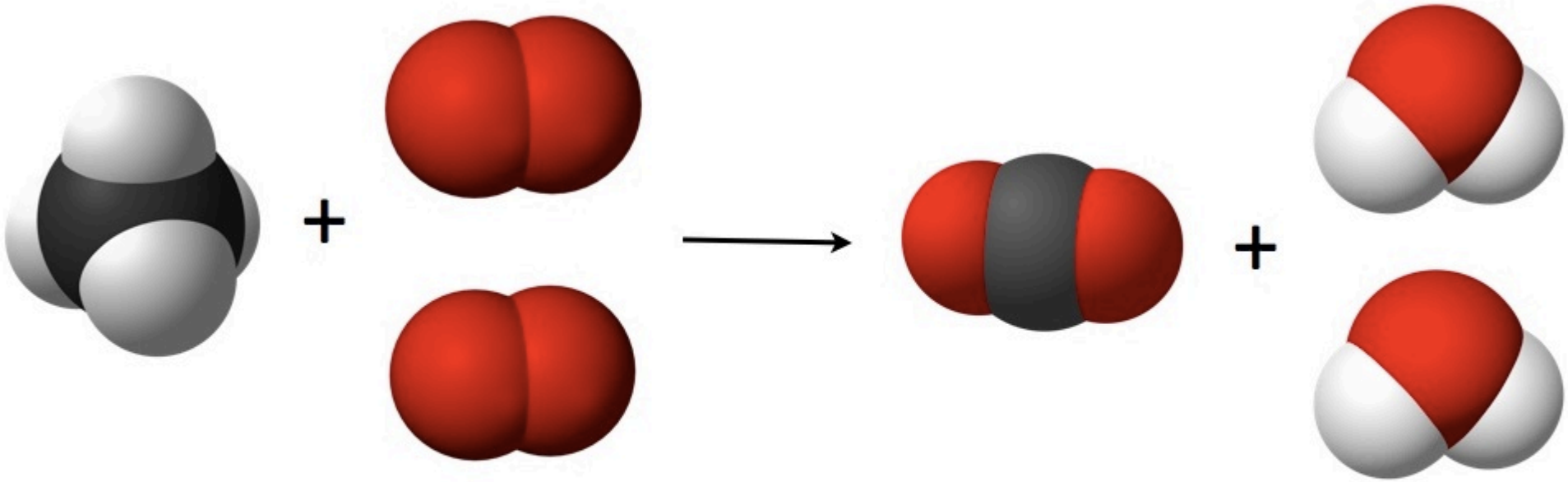
The Global Industrial and Green Revolutions

History of energy consumption in the United States, 1775-2009

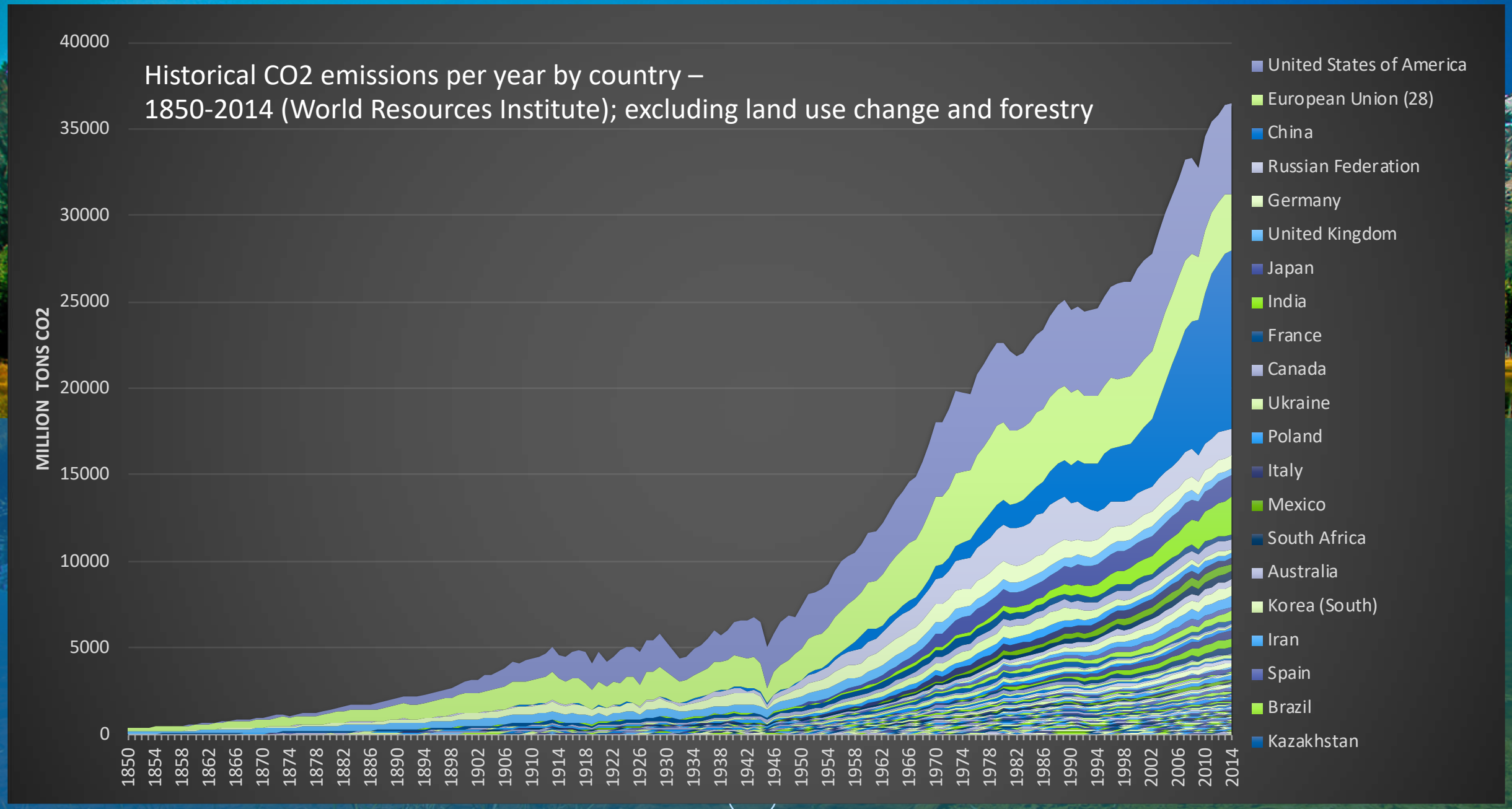


Source: U.S. Energy Information Administration - Annual Energy Review 2009

$$C_xH_y + zO_2 \rightarrow xCO_2 + \frac{y}{2}H_2O$$



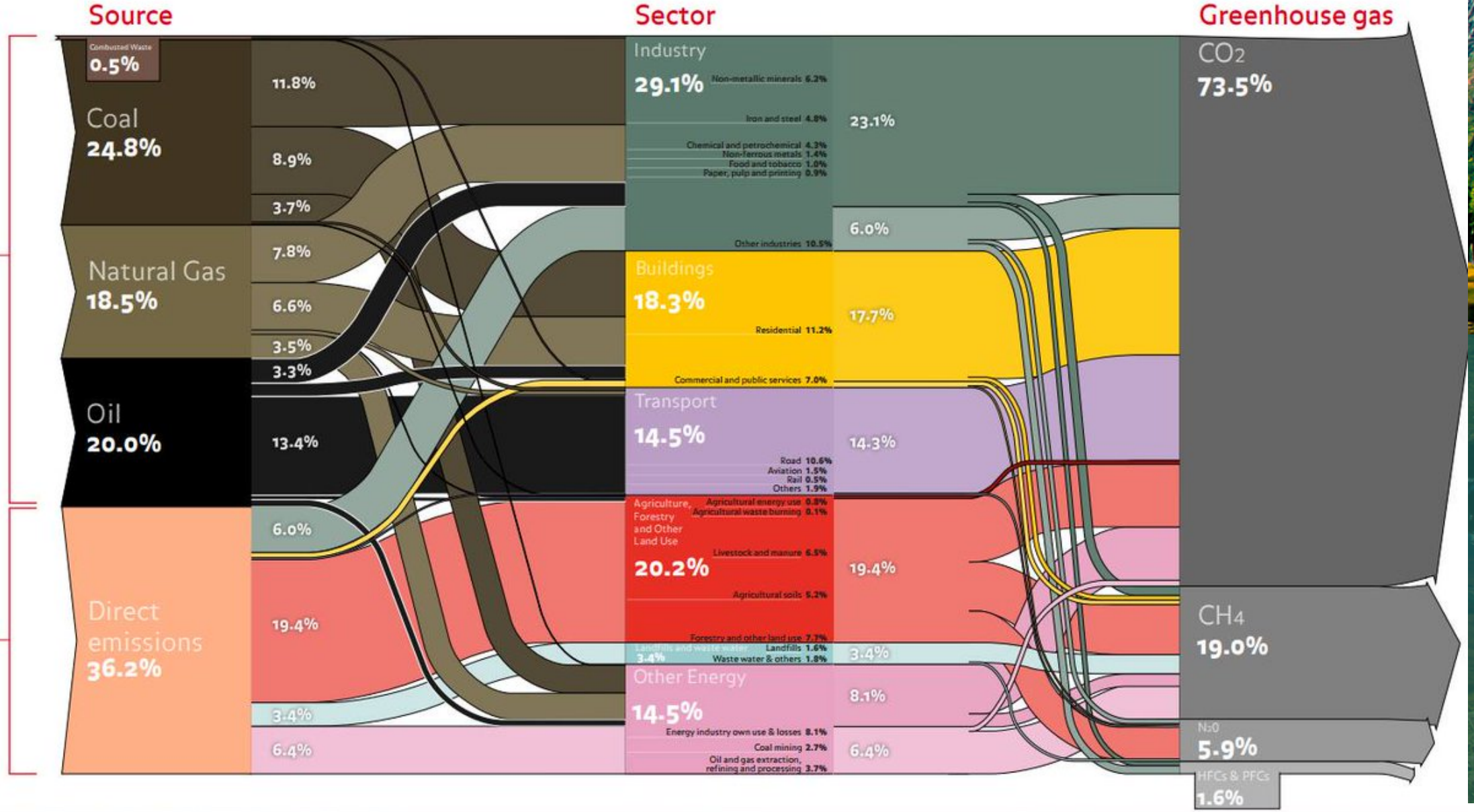
$$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$$

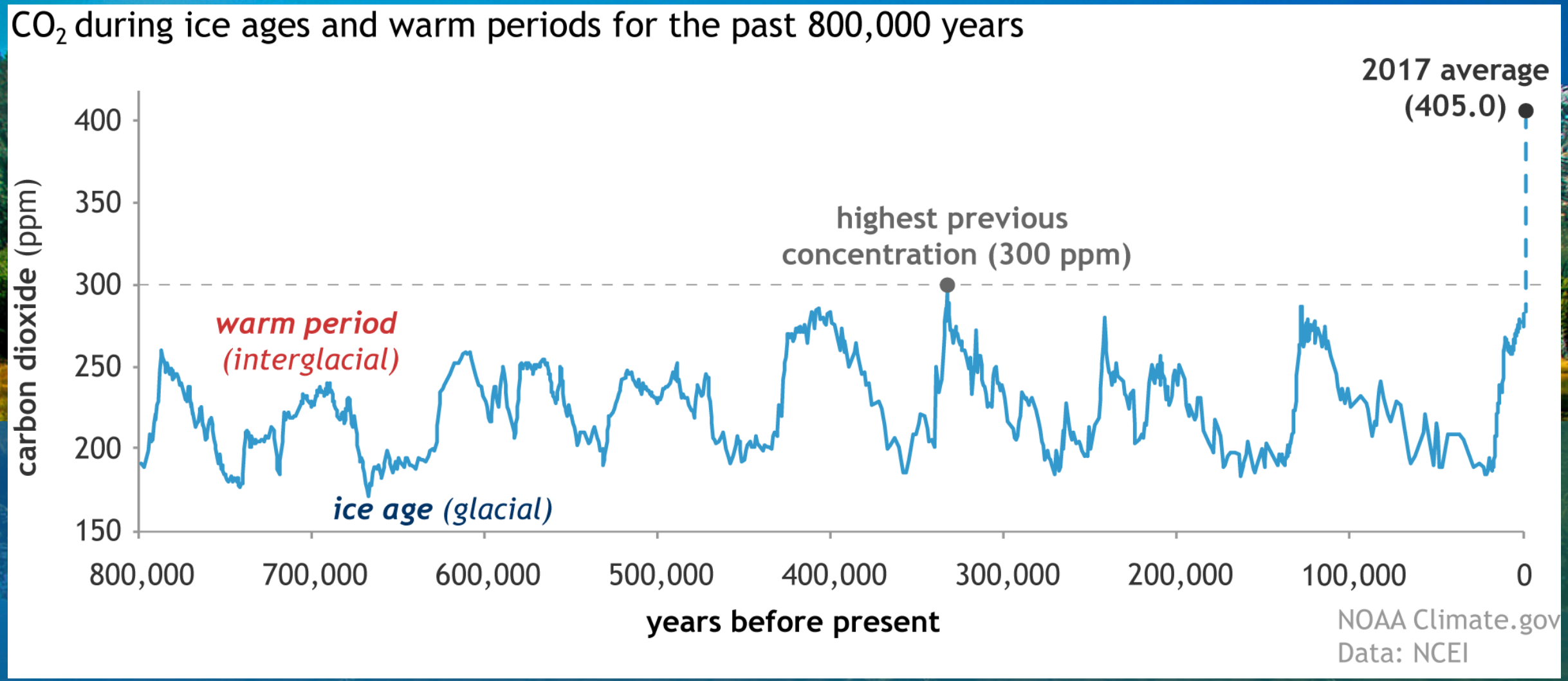

Historical CO2 emissions per year by country –
1850-2014 (World Resources Institute); excluding land use change and forestry
MILLION TONS CO2
40000
35000
30000
25000
20000
15000
10000
5000
0
1850 1854 1858 1862 1866 1870 1874 1878 1882 1886 1890 1894 1898 1902 1906 1910 1914 1918 1922 1926 1930 1934 1938 1942 1946 1950 1954 1958 1962 1966 1970 1974 1978 1982 1986 1990 1994 1998 2002 2006 2010 2014
United States of America
European Union (28)
China
Russian Federation
Germany
United Kingdom
Japan
India
France
Canada
Ukraine
Poland
Italy
Mexico
South Africa
Australia
Korea (South)
Iran
Spain
Brazil
Kazakhstan

Total emissions worldwide (2012)

51,840

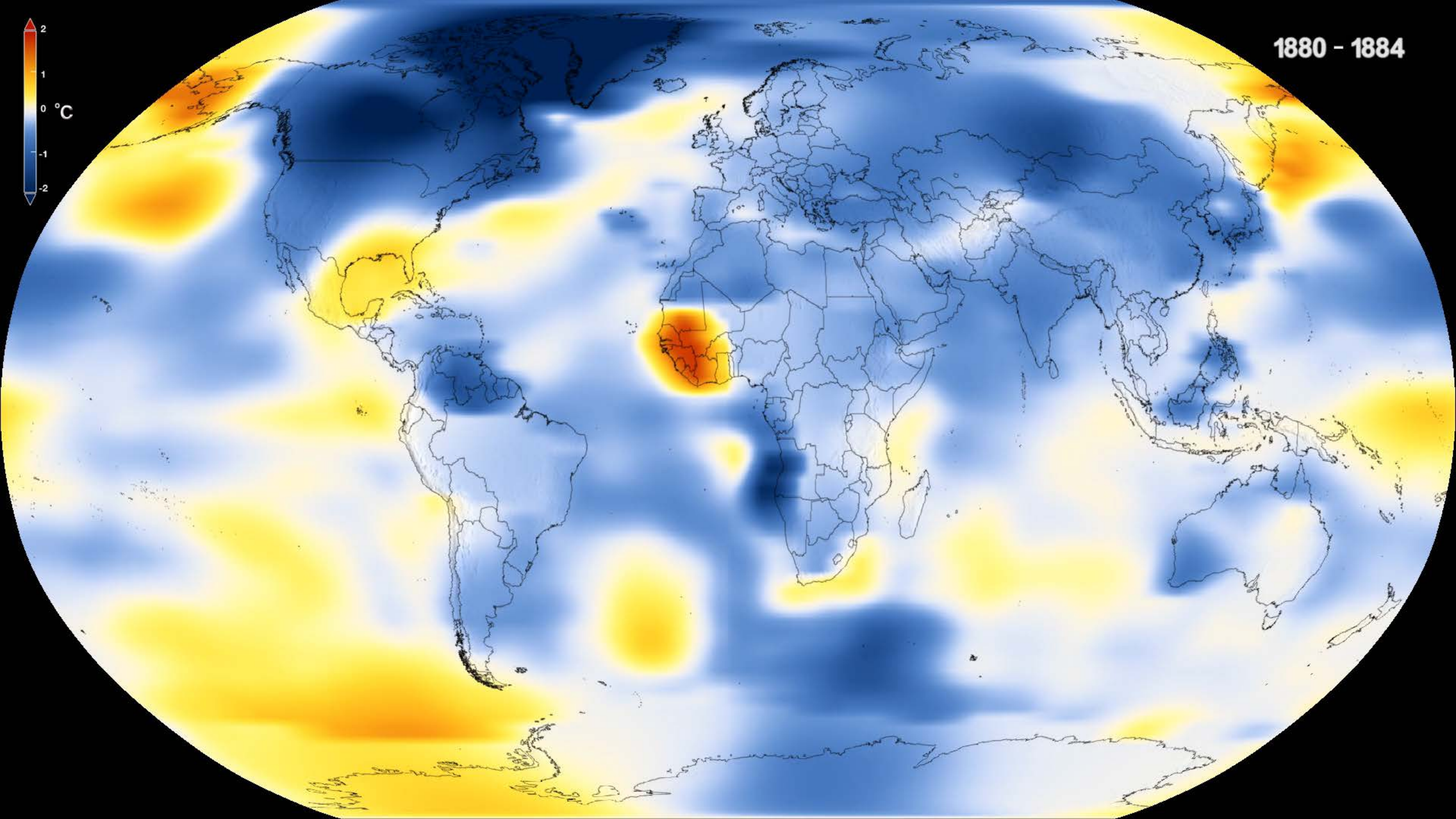
MtCO2 eq





Atmospheric carbon dioxide concentrations in parts per million (ppm) for the past 800,000 years, based on EPICA (ice core) data. The peaks and valleys in carbon dioxide levels track the coming and going of ice ages (low carbon dioxide) and warmer interglacials (higher levels). Throughout these cycles, atmospheric carbon dioxide was never higher than 300 ppm; in 2017, it reached 405.0 ppm (black dot). NOAA Climate.gov, based on EPICA Dome C data (Lüthi, D., et al., 2008) provided by NOAA NCEI Paleoclimatology Program.

https://www.climate.gov/news-features/understanding-climate/climate-change-atmospheric-carbon-dioxide


2
1
0 °C
-1
-2
1880 - 1884

Colorado House Bill 19-1261

[…] it is further declared that:

(a) Climate change adversely affects Colorado's economy, air quality and public health, ecosystems, natural resources, and quality of life;

(b) Colorado is already experiencing harmful climate impacts, including declining snowpack, prolonged drought, more extreme heat, elevated wildfire risk and risk to first responders, widespread beetle infestation decimating forests, increased risk of vector-borne diseases, more frequent and severe flooding, more severe ground-level ozone pollution causing respiratory damage and loss of life, decreased economic activity from outdoor recreation and agriculture, and diminished quality of life. many of these impacts disproportionately affect rural communities, communities of color, youth and the elderly, and working families. reducing statewide greenhouse gas pollution as outlined in this subsection (2) will protect these frontline communities, first responders, and all Colorado residents from these and other climate impacts. […]

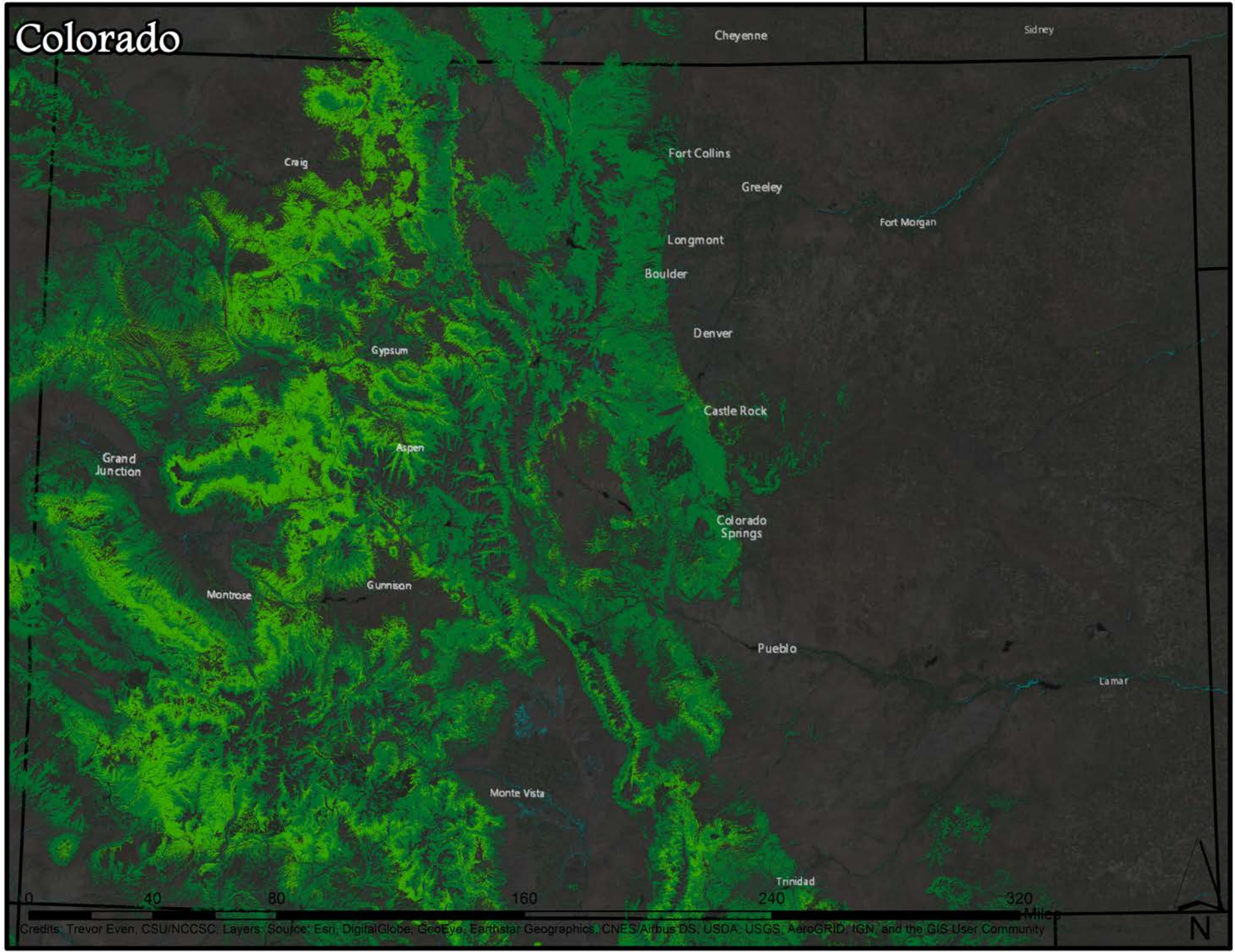
So what does all this mean for Colorado's Forests?

Forest Action Plan Themes

- Rural Forest Conditions
- Urban Forest Conditions
- Drivers of change
- Wildfires (and Drought)
- Watershed health
- Wildlife habitat
- Forest legacy program (Private Forests)
- Forest wood products.

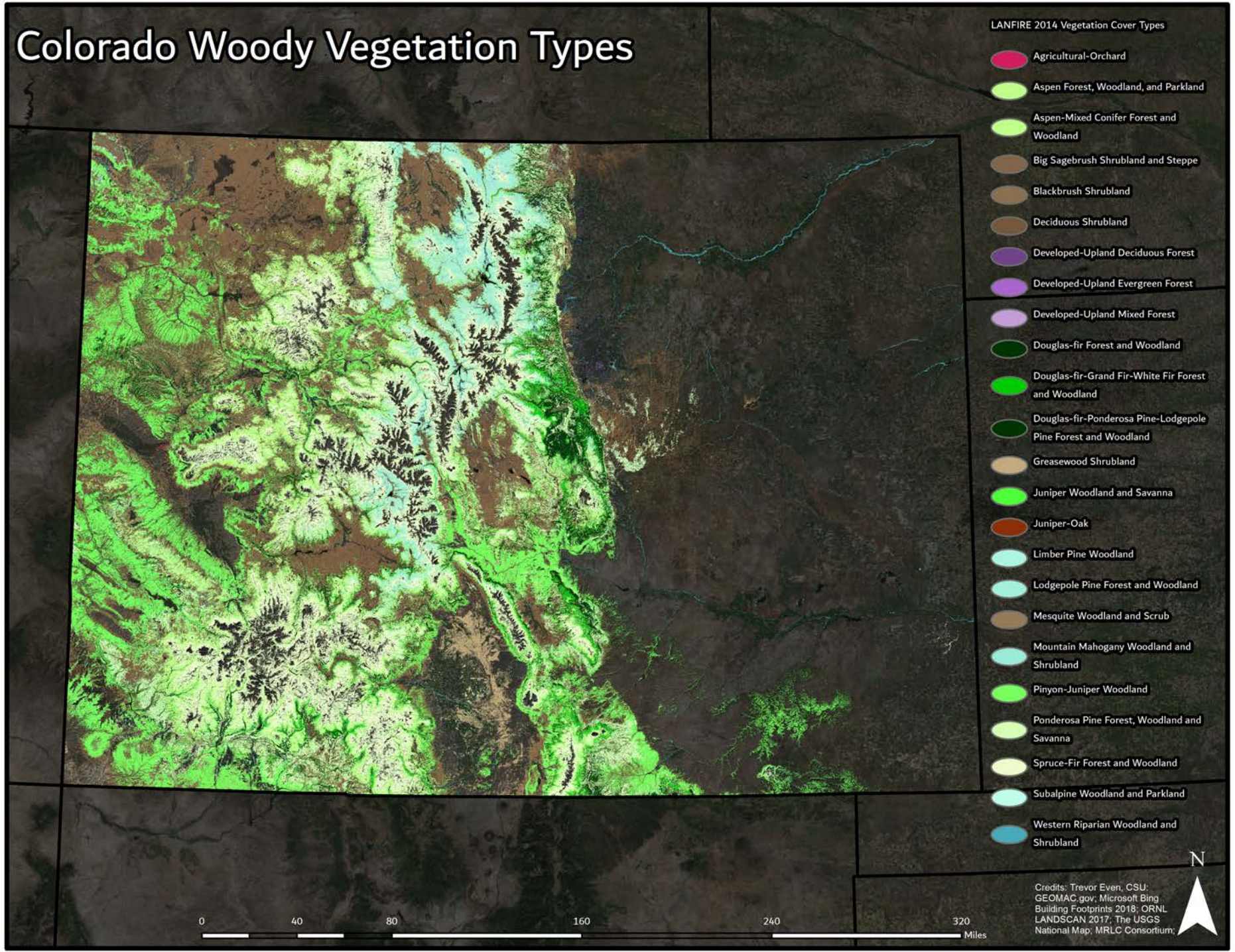
- How and where will we design and implement new projects, and who will be our partners?
- Who will be at risk of future changes in forests, and what roles will they play in response?
- How will we monitor, analyze, communicate about, and respond to different, interconnected drivers of change?
- How will we deal with fires, before, during, and after increasingly large and widespread disturbances?
- How can we protect watersheds amid massive disturbance (and increased need for healthy watershed function)?
- How do we manage and protect wildlife amid multiple pressures?
- What role will private forest lands play, and how can we integrate more private forest land holders into responsive forest management?
- What opportunities and barriers exist for developing economic incentives and timber economies within the framework of fuel mitigation, carbon sequestration, and forest restoration goals?

What do we mean by Urban and Rural Forests?

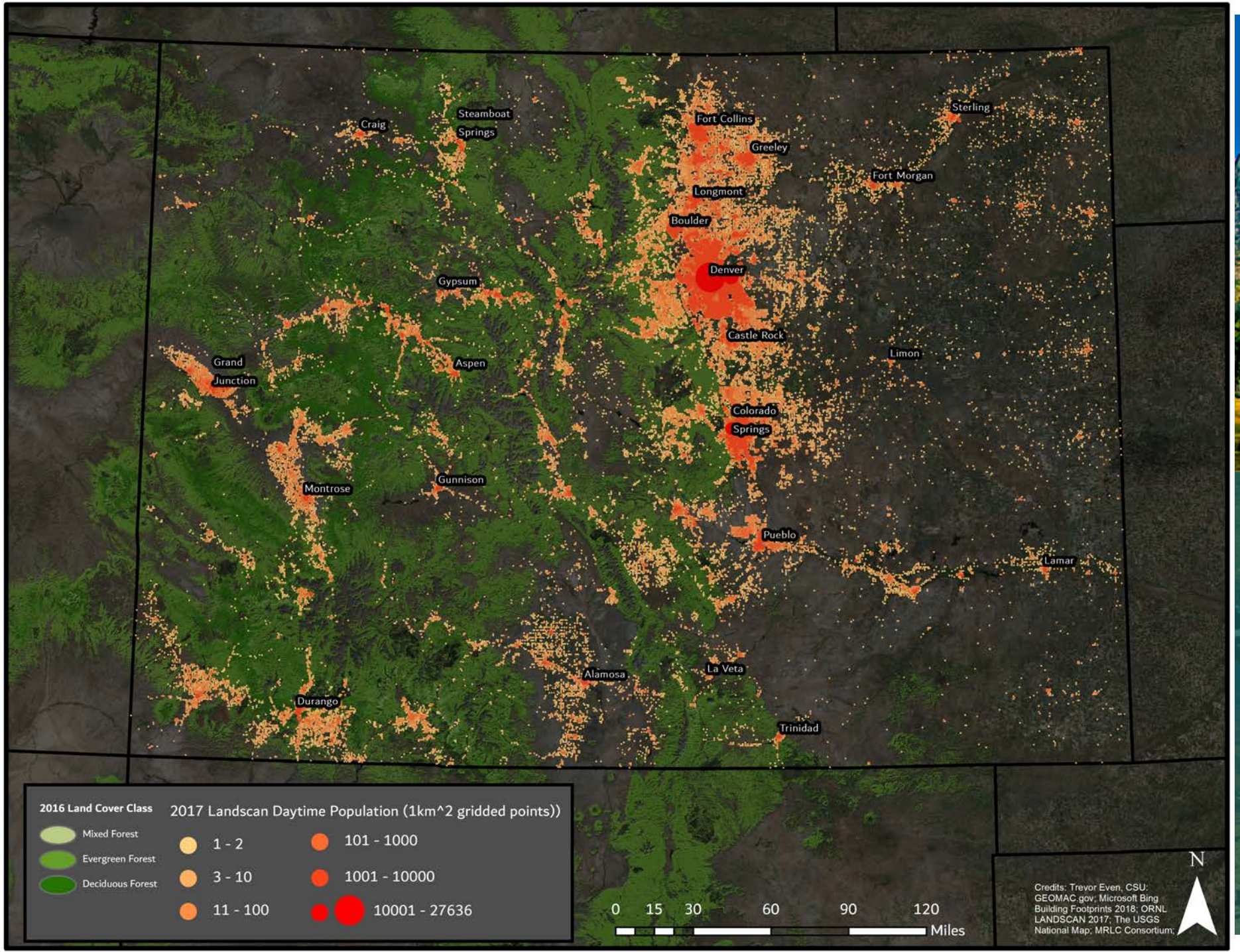


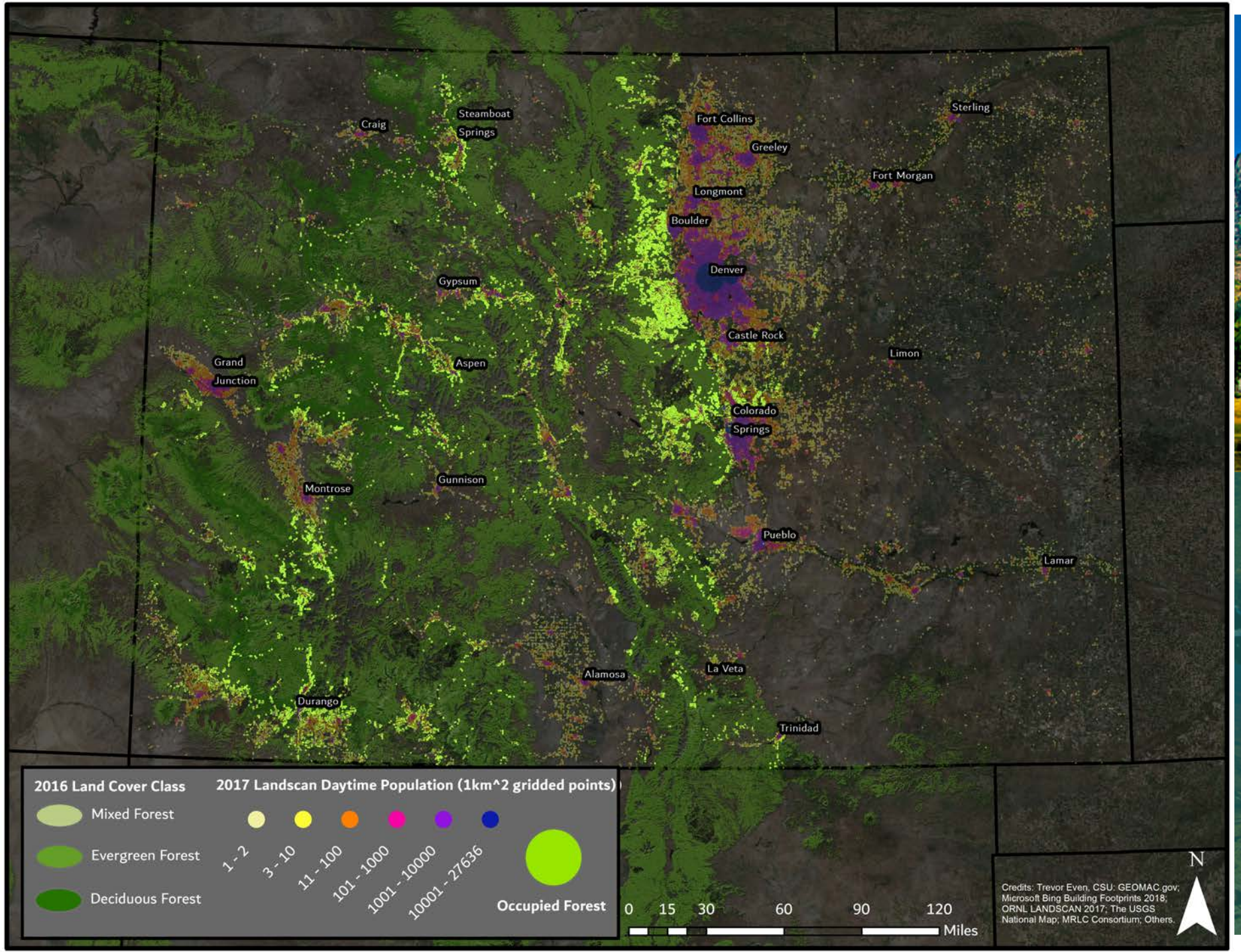
What do we mean by Urban and Rural Forests?

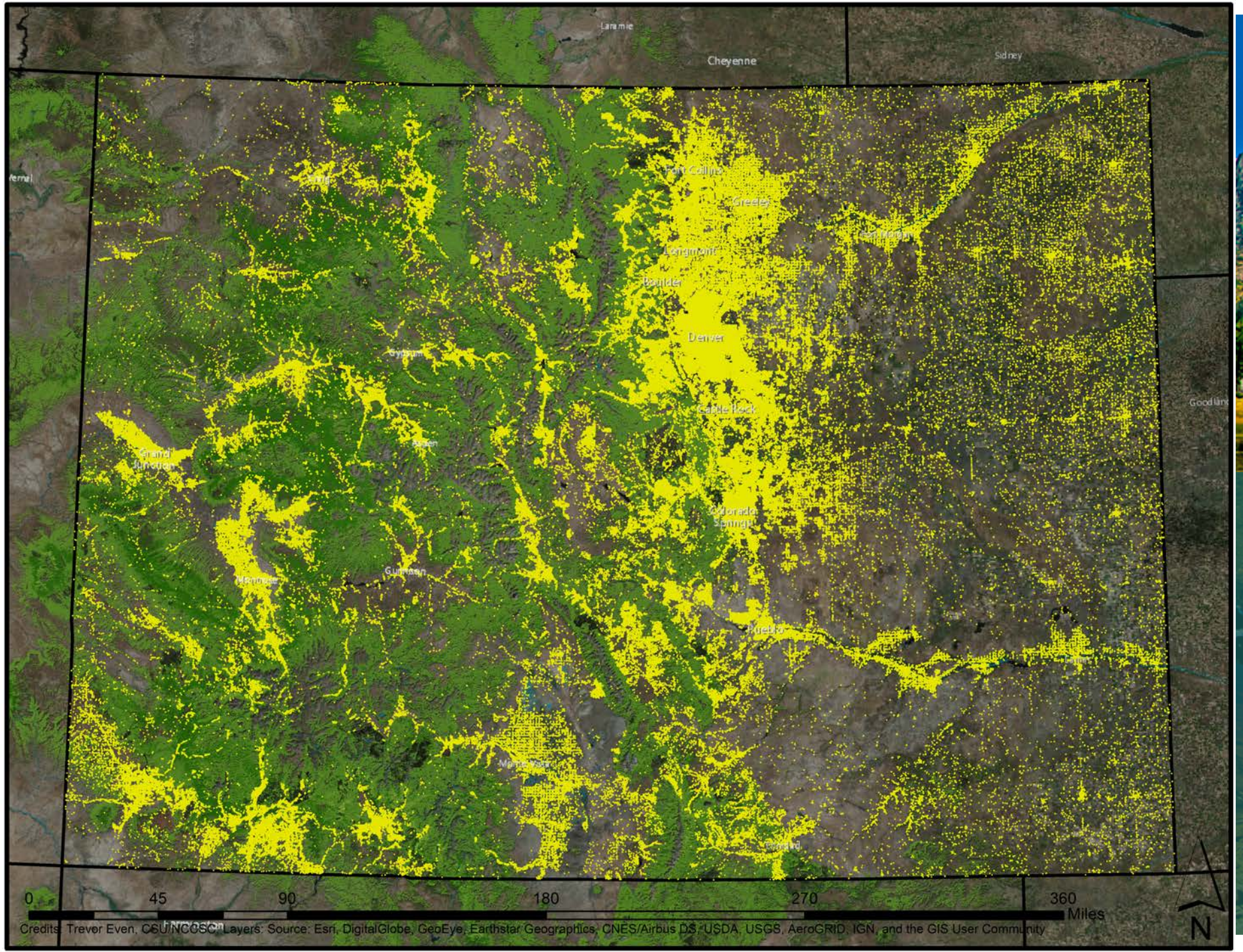
- Wildland forests outside of inhabited areas (Rural or Wildland Forests)
- Sparsely to moderately occupied, high elevation forested areas (Wildland Rural Interface)
- Rural riparian/alluvial forests in the Eastern Plains (Ag/Ranch Interface)
- Densely populated areas within forest landscapes (Interface/Intermix or Ecotone Areas; “Mountain Towns”)
- Low-lying urban forests maintained by municipalities; HOAs; others. (Municipal Forests)
- Woody vegetation maintained near homes and businesses in cities and suburbs (the Micro-Forests)



Driver of Change #1: People

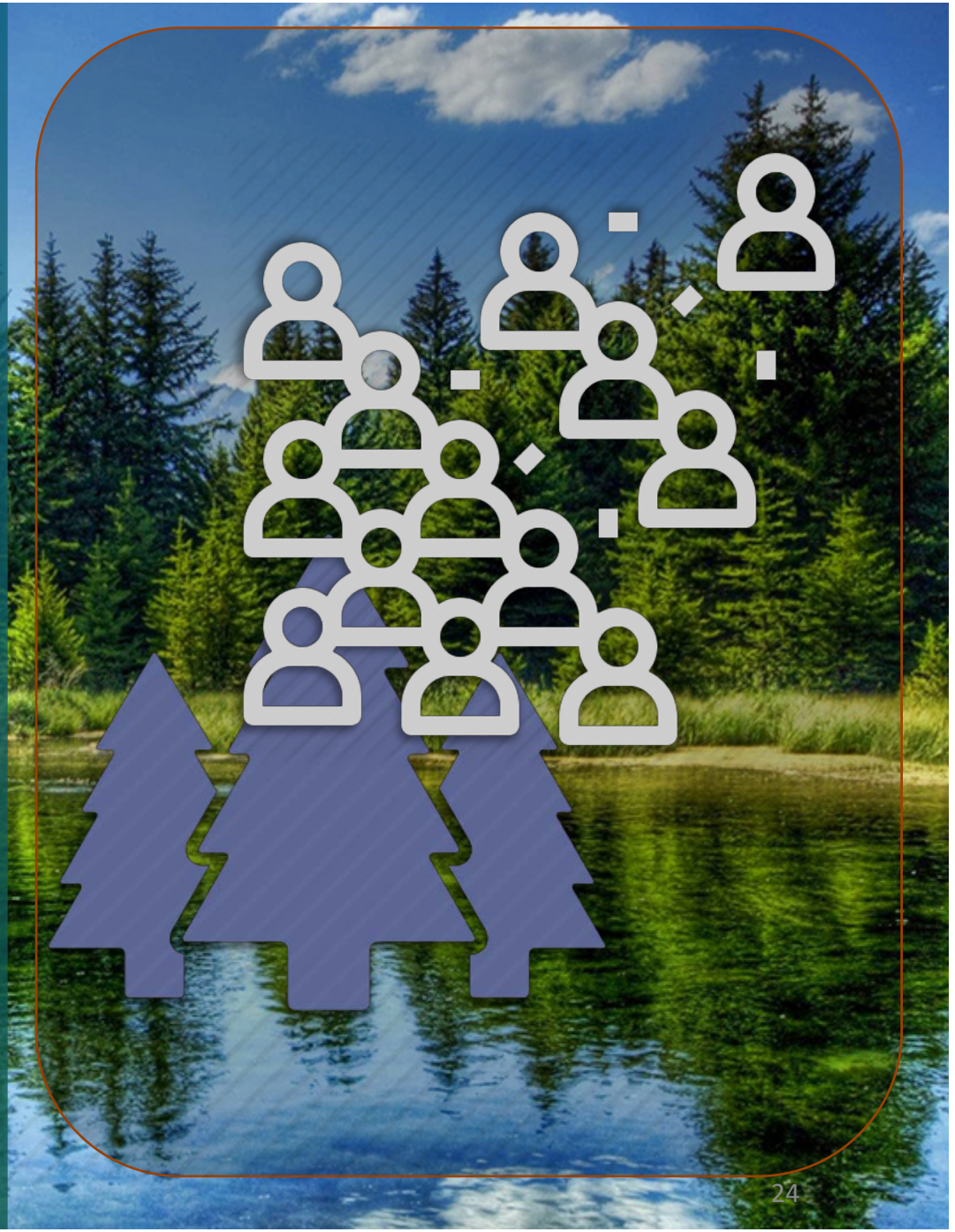

Craig
Steamboat Springs
Fort Collins
Greeley
Sterling
Fort Morgan
Longmont
Boulder
Denver
Gypsum
Castle Rock
Limon
Grand Junction
Aspen
Colorado Springs
Montrose
Gunnison
Pueblo
Lamar
Alamosa
La Veta
Durango
Trinidad
2016 Land Cover Class
Mixed Forest
Evergreen Forest
Deciduous Forest
2017 Landscan Daytime Population (1km^2 gridded points))
1 - 2
3 - 10
11 - 100
101 - 1000
1001 - 10000
10001 - 27636
0 15 30 60 90 120
Miles
N
Credits: Trevor Even, CSU: GEOMAC.gov; Microsoft Bing Building Footprints 2018; ORNL LANDSCAN 2017; The USGS National Map; MRLC Consortium;


Craig
Steamboat Springs
Fort Collins
Greeley
Sterling
Fort Morgan
Longmont
Boulder
Denver
Gypsum
Castle Rock
Limon
Grand Junction
Aspen
Colorado Springs
Montrose
Gunnison
Pueblo
Lamar
Alamosa
La Veta
Durango
Trinidad
2016 Land Cover Class
Mixed Forest
Evergreen Forest
Deciduous Forest
2017 Landscan Daytime Population (1km^2 gridded points)
1 - 2
3 - 10
11 - 100
101 - 1000
1001 - 10000
10001 - 27636
Occupied Forest
0 15 30 60 90 120
Miles
N
Credits: Trevor Even, CSU: GEOMAC.gov; Microsoft Bing Building Footprints 2018; ORNL LANDSCAN 2017; The USGS National Map; MRLC Consortium; Others.

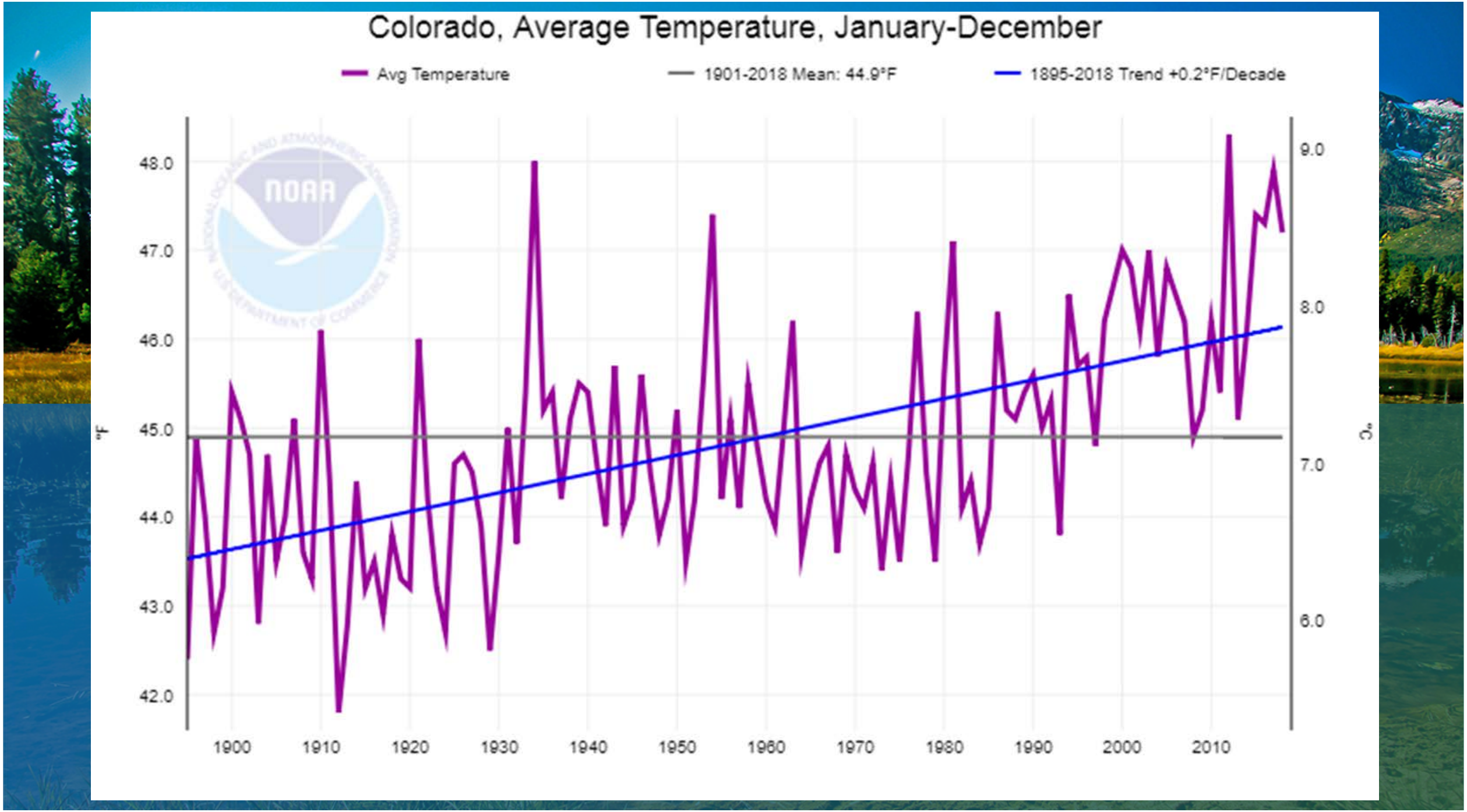

Laramie
Cheyenne
Sidney
Fort Collins
Greeley
Longmont
Boulder
Denver
Castle Rock
Colorado Springs
Pueblo
Grand Junction
Gypsum
Gunnison
Monte Vista
Trinidad
0
45
90
180
270
360
Miles
N
Credits: Trever Even, CSU/NCGSC. Layers: Source: Esri, DigitalBoulder, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

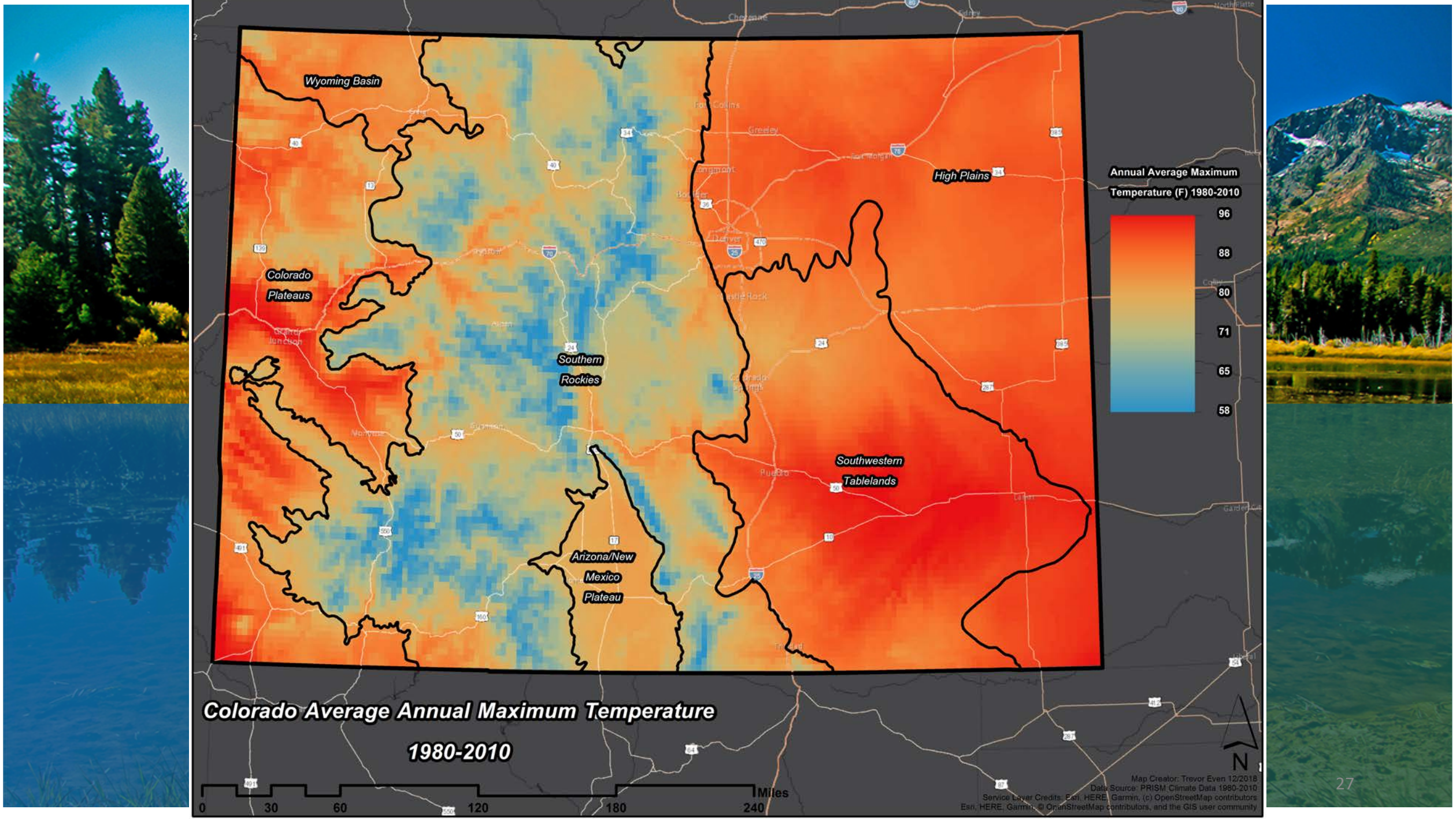
People are System-wide Drivers of Change

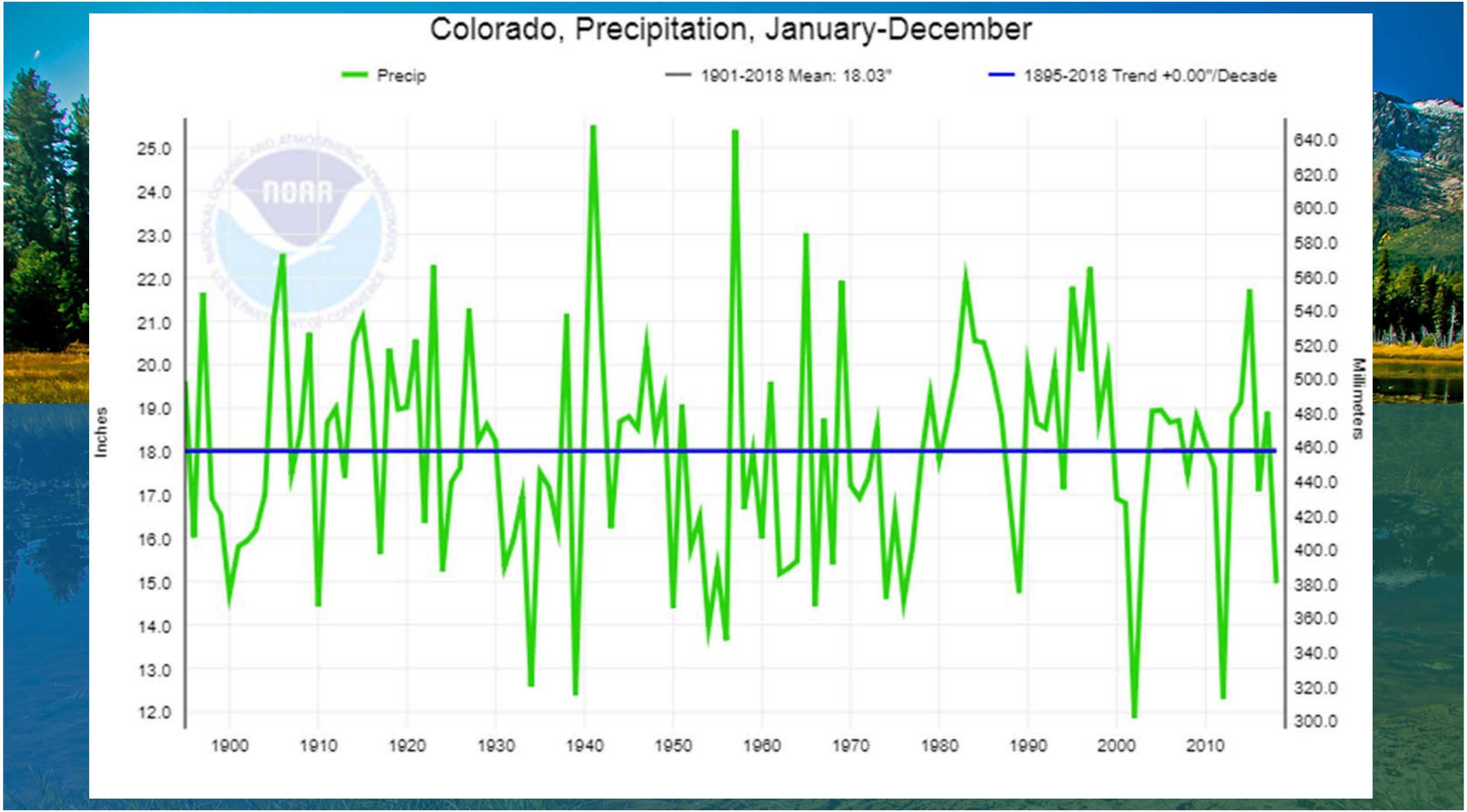
- Human Activity and Occupancy Increases
  - Increased Tourism and Recreation Activity
  - Increased Summer activity (heat relief); increased winter activity ("It's warm enough!")
  - Losses of land-based knowledge?
  - Increased human-wildlife contact and conflict
  - Increased WUI Development; suppression need; mitigation activity costs
  - Increased Water Infrastructure Needs?
  - Increased valuation of riparian, alluvial, and watershed forest ecosystem services?

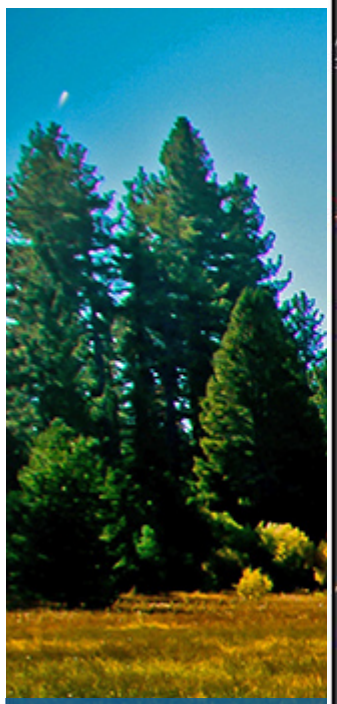


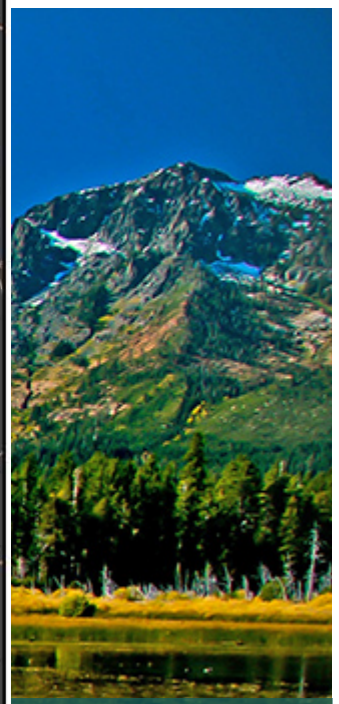
Driver of Change #2: Warming Climate

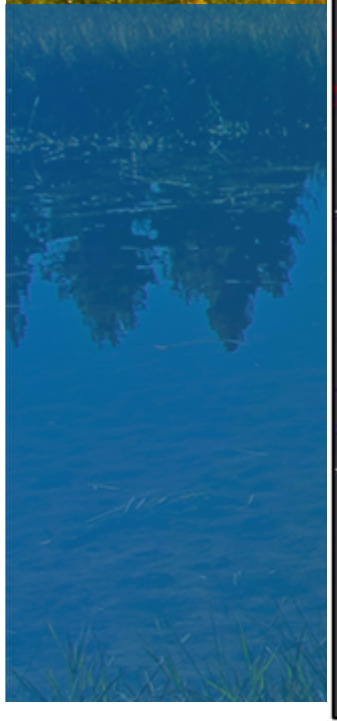

Colorado, Average Temperature, January-December
Avg Temperature
1901-2018 Mean: 44.9°F
1895-2018 Trend +0.2°F/Decade
°F
°C
48.0
47.0
46.0
45.0
44.0
43.0
42.0
9.0
8.0
7.0
6.0
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010

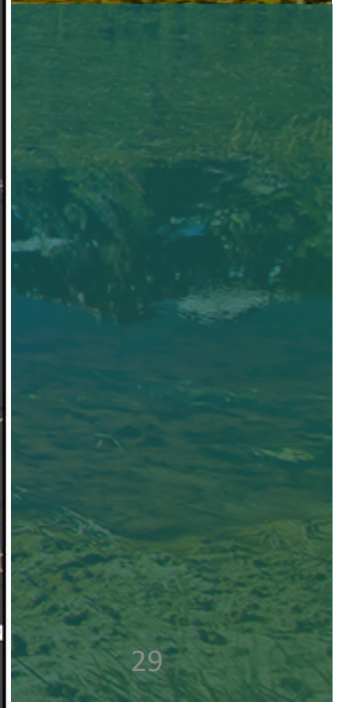

Wyoming Basin
Colorado Plateaus
Southern Rockies
High Plains
Southwestern Tablelands
Arizona/New Mexico Plateau
Annual Average Maximum Temperature (F) 1980-2010
96
88
80
71
65
58
Colorado Average Annual Maximum Temperature
1980-2010
0
30
60
120
180
240
Miles
N
Map Creator: Trevor Even 12/2018
Data Source: PRISM Climate Data 1980-2010
Service Layer Credits: Esri, HERE, Garmin, (c) OpenStreetMap contributors
Esri, HERE, Garmin, © OpenStreetMap contributors, and the GIS user community

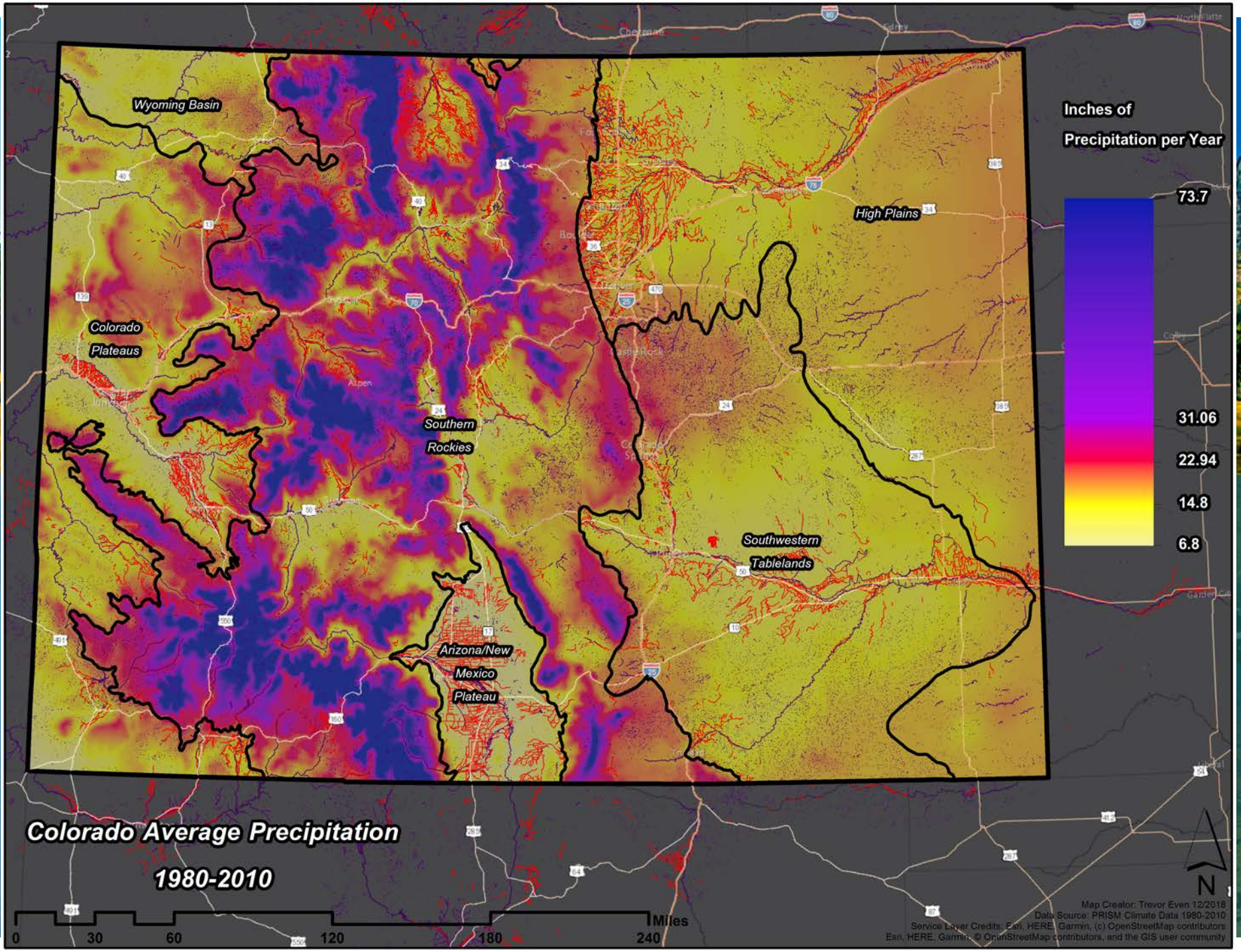

Colorado, Precipitation, January-December
Precip
1901-2018 Mean: 18.03"
1895-2018 Trend +0.00"/Decade
Inches
Millimeters
25.0
24.0
23.0
22.0
21.0
20.0
19.0
18.0
17.0
16.0
15.0
14.0
13.0
12.0
640.0
620.0
600.0
580.0
560.0
540.0
520.0
500.0
480.0
460.0
440.0
420.0
400.0
380.0
360.0
340.0
320.0
300.0
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010

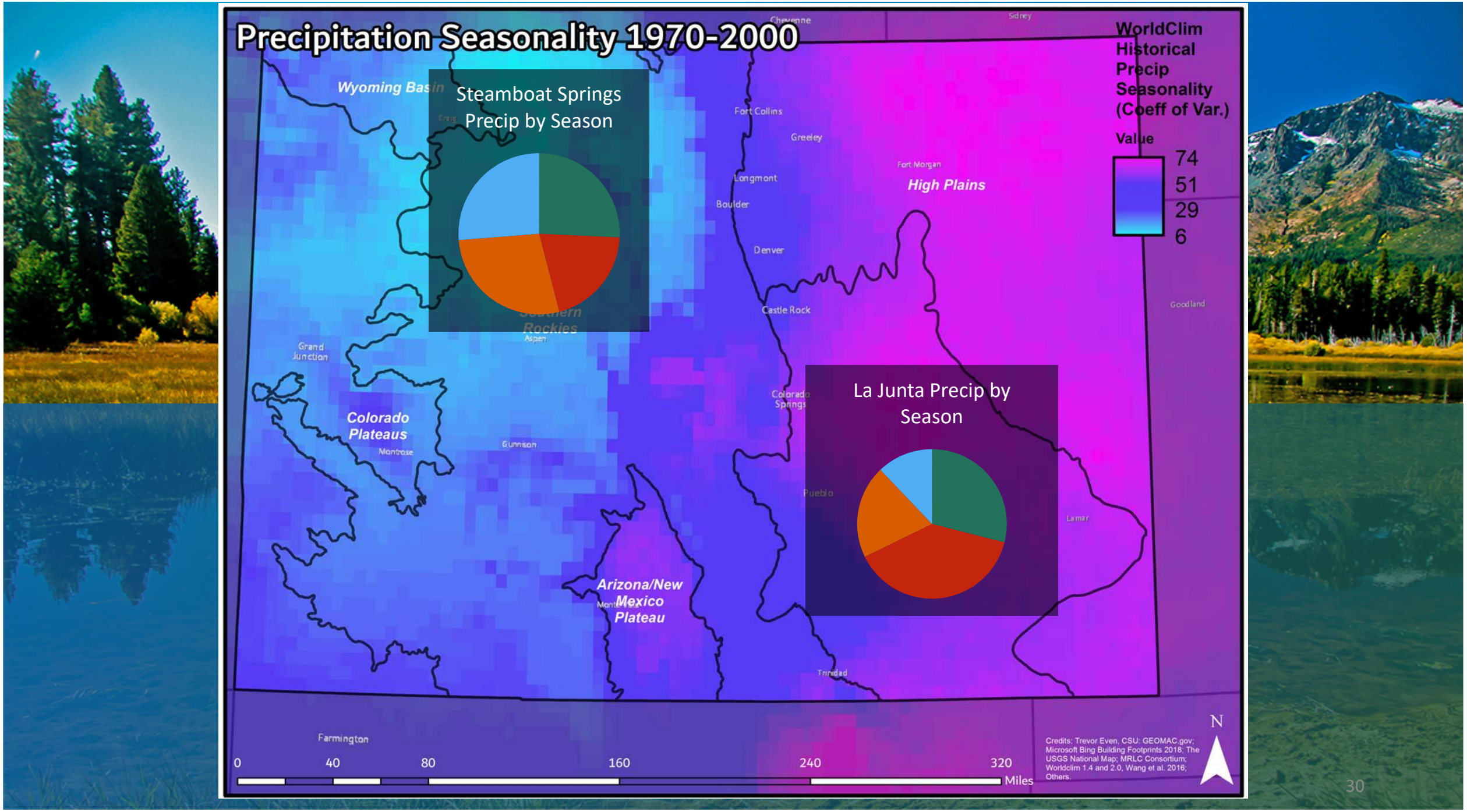


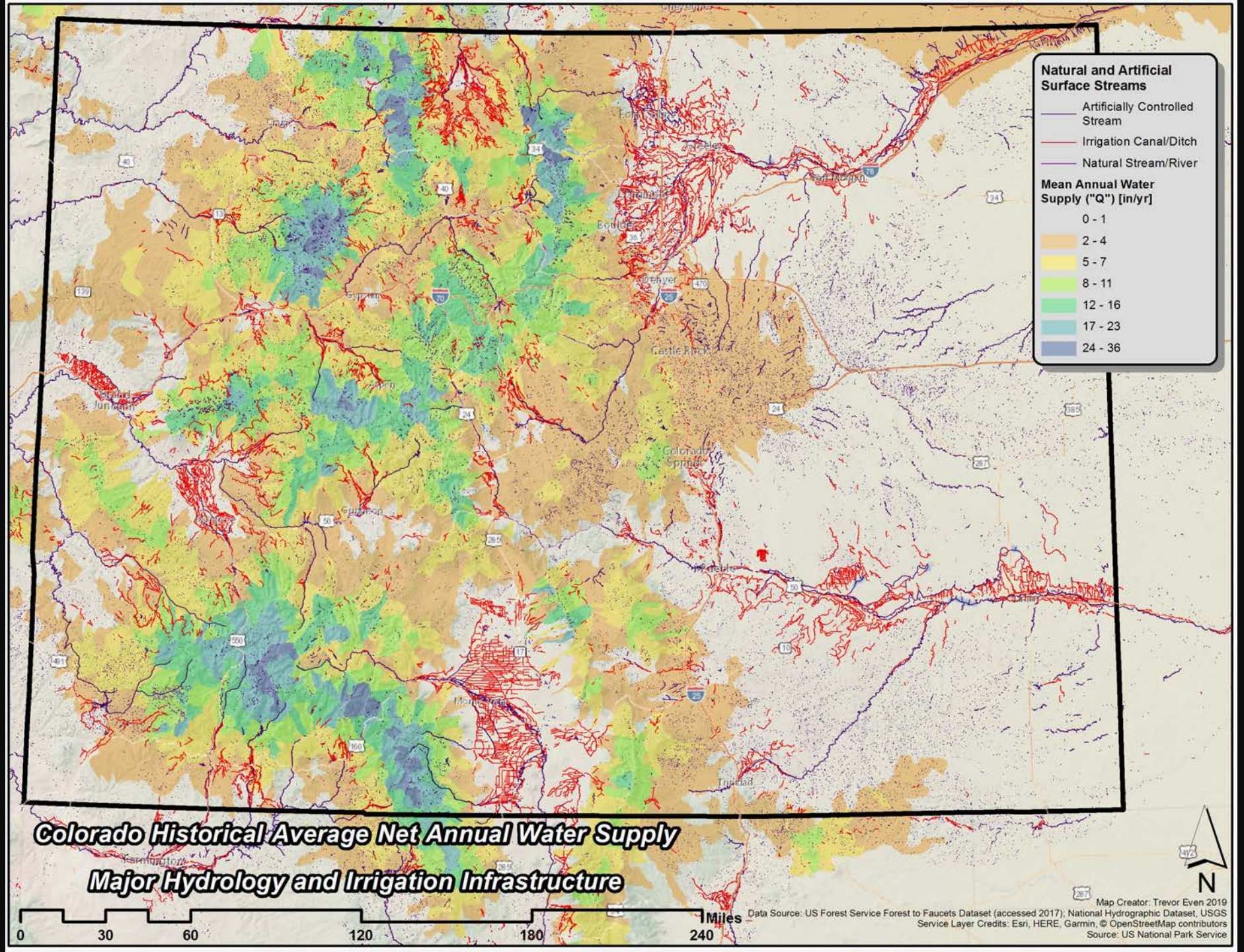


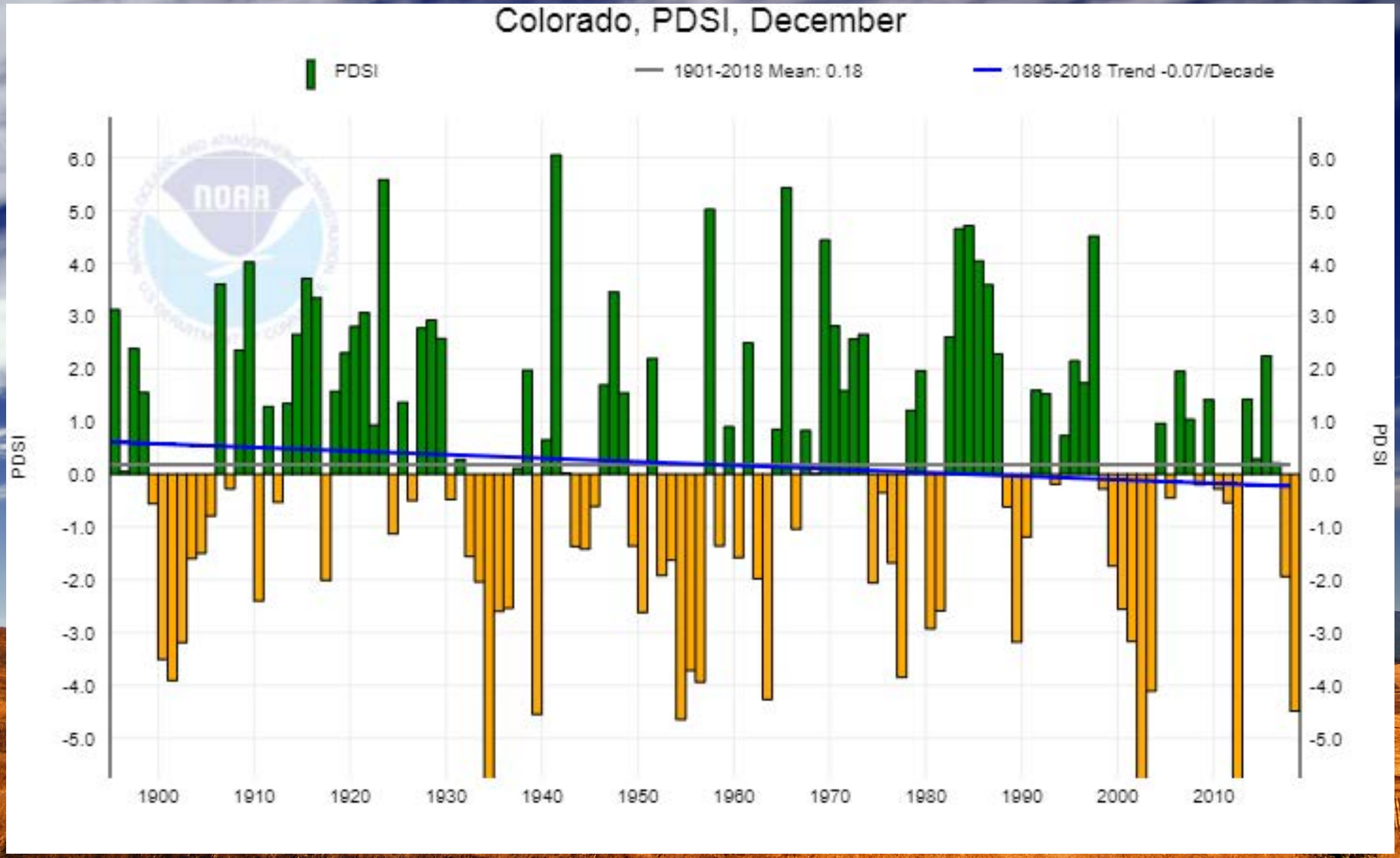


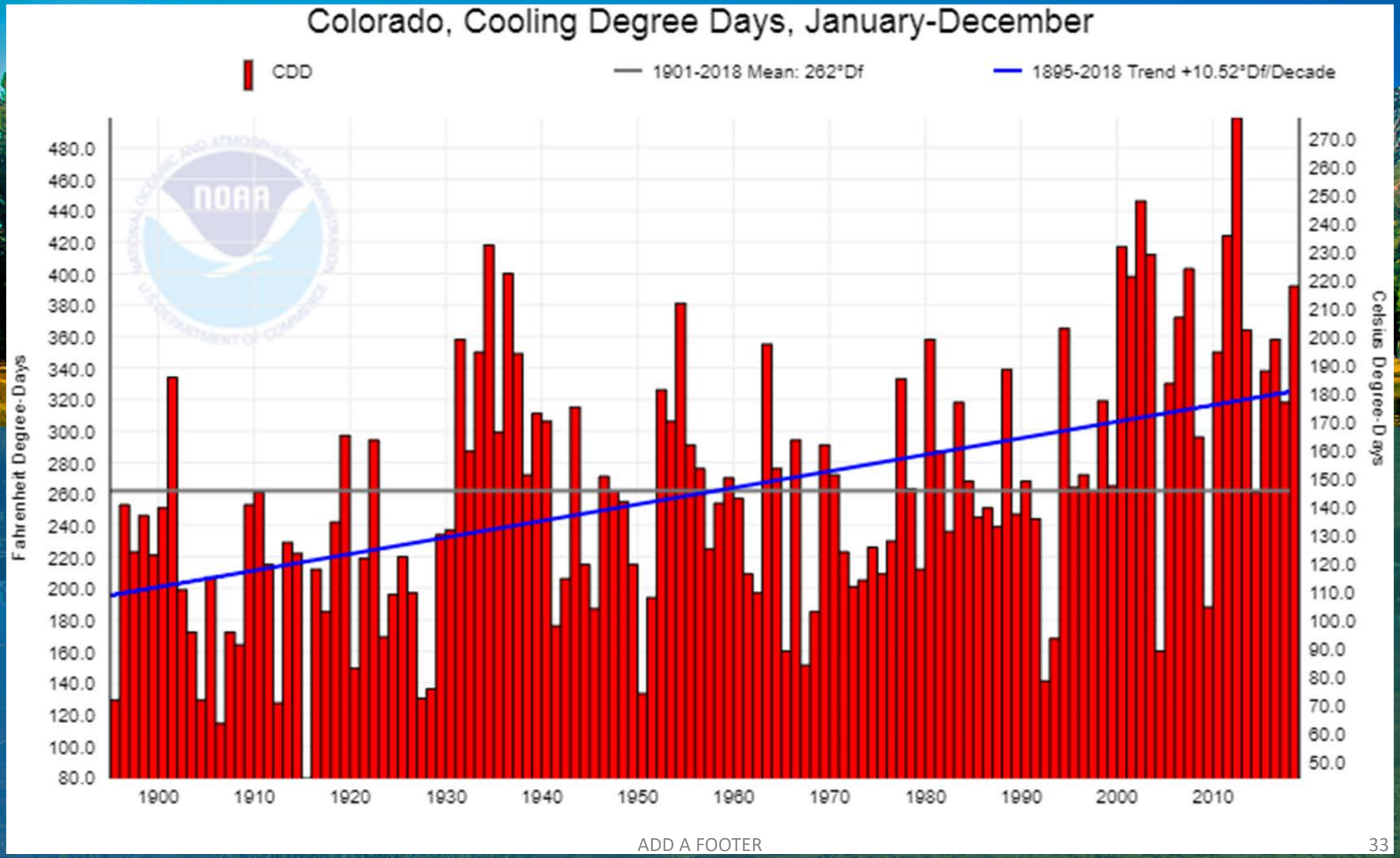



Wyoming Basin
Colorado Plateaus
Southern Rockies
Arizona/New Mexico Plateau
High Plains
Southwestern Tablelands
Inches of Precipitation per Year
73.7
31.06
22.94
14.8
6.8
Colorado Average Precipitation
1980-2010
0
30
60
120
180
240
Miles
N
Map Creator: Trevor Even 12/2018
Data Source: PRISM Climate Data 1980-2010
Service Layer Credits: Esri, HERE, Garmin, (c) OpenStreetMap contributors
Esri, HERE, Garmin, © OpenStreetMap contributors, and the GIS user community


Precipitation Seasonality 1970-2000
Steamboat Springs Precip by Season
La Junta Precip by Season
WorldClim Historical Precip Seasonality (Coeff of Var.)
Value
74
51
29
6
Wyoming Basin
High Plains
Colorado Plateaus
Arizona/New Mexico Plateau
Southern Rockies
Cheyenne
Sidney
Fort Collins
Greeley
Fort Morgan
Longmont
Boulder
Denver
Castle Rock
Goodland
Aspen
Grand Junction
Colorado Springs
Gunnison
Montrose
Pueblo
Lamar
Trinidad
Farmington
0
40
80
160
240
320
Miles
N
Credits: Trevor Even, CSU: GEOMAC.gov; Microsoft Bing Building Footprints 2018; The USGS National Map; MRLC Consortium; Worldclim 1.4 and 2.0, Wang et al. 2016; Others.


Natural and Artificial Surface Streams
Artificially Controlled Stream
Irrigation Canal/Ditch
Natural Stream/River
Mean Annual Water Supply ("Q") [in/yr]
0 - 1
2 - 4
5 - 7
8 - 11
12 - 16
17 - 23
24 - 36
Colorado Historical Average Net Annual Water Supply
Major Hydrology and Irrigation Infrastructure
0
30
60
120
180
240
Miles
N
Map Creator: Trevor Even 2019
Data Source: US Forest Service Forest to Faucets Dataset (accessed 2017); National Hydrographic Dataset, USGS
Service Layer Credits: Esri, HERE, Garmin, © OpenStreetMap contributors
Source: US National Park Service

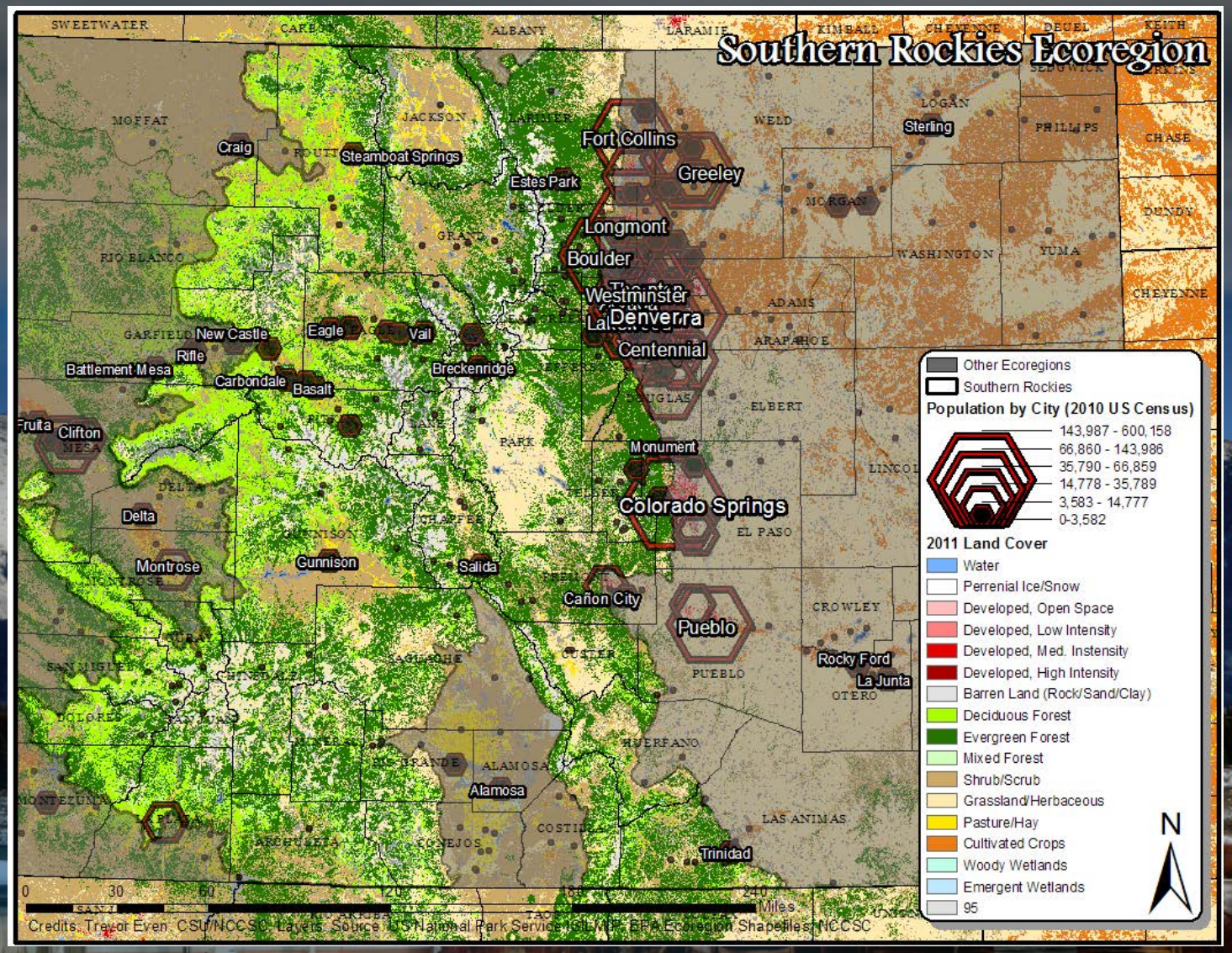

Colorado, PDSI, December
PDSI
1901-2018 Mean: 0.18
1895-2018 Trend -0.07/Decade
6.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010


Colorado, Cooling Degree Days, January-December
CDD
1901-2018 Mean: 262°Df
1895-2018 Trend +10.52°Df/Decade
Fahrenheit Degree-Days
Celsius Degree-Days
480.0
460.0
440.0
420.0
400.0
380.0
360.0
340.0
320.0
300.0
280.0
260.0
240.0
220.0
200.0
180.0
160.0
140.0
120.0
100.0
80.0
270.0
260.0
250.0
240.0
230.0
220.0
210.0
200.0
190.0
180.0
170.0
160.0
150.0
140.0
130.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
50.0
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010

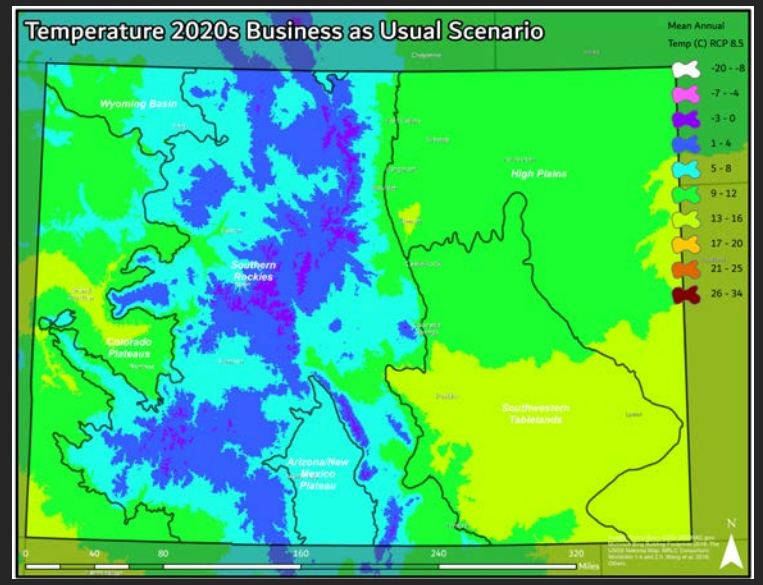
More Change to Come

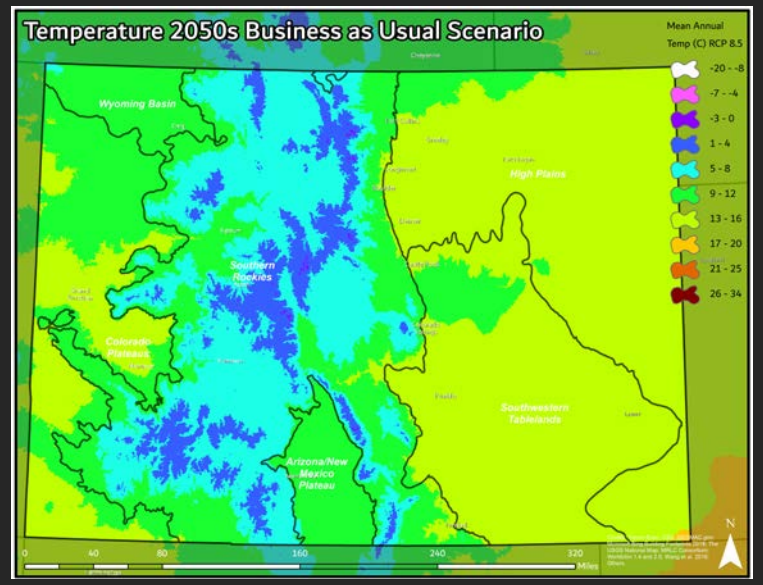
Future changes in weather and climate will put serious pressure on Colorado communities, particularly those in rural and mountain areas.

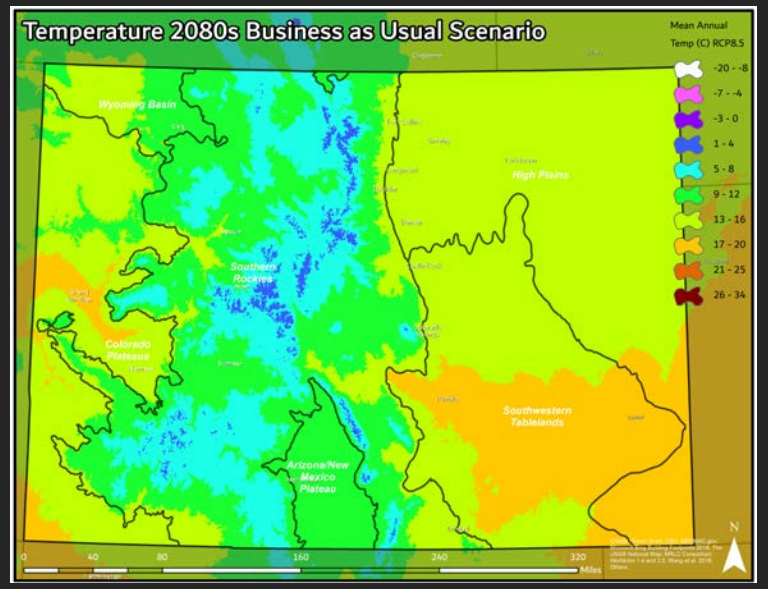
Changes in these areas can have serious implications for the well-being of state as a whole, the state's compliance with interstate water compacts, and its interactions with federal land management and emergency assistance systems.



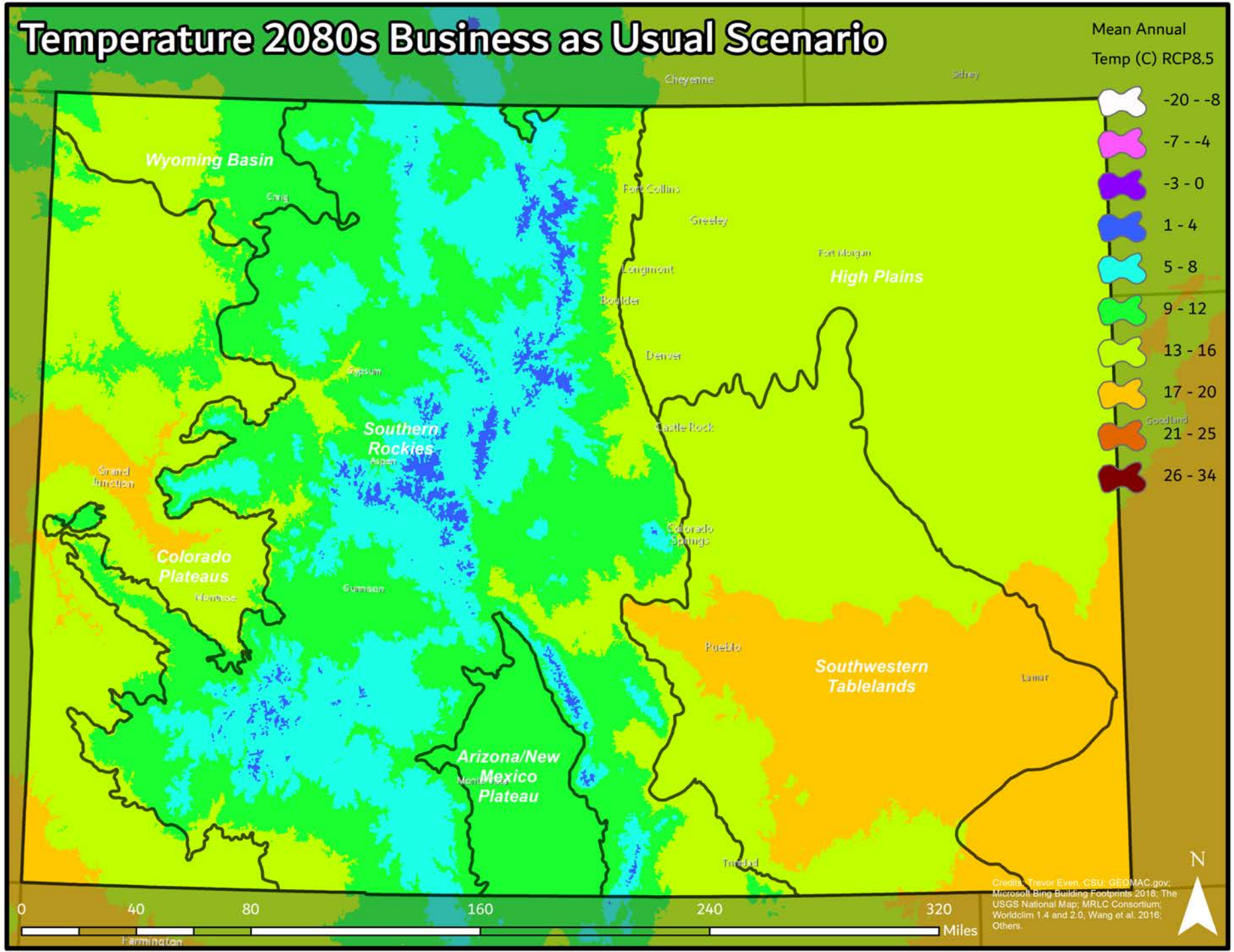
Annual Statistic	Historical	2050 RCP 4.5		2050 RCP 8.5	
		Projected Value	Change from Hist	Projected Value	Change from Hist
Temperature Avg (degF)	38.1	43.2	5.1	44.6	6.5
Precipitation (in)	21.7	21.7	0.1	20.5	-1.2
GDD (tmax-tmin/2 - 50)	1859	2547	688	2740	881
Hot Days (tmax>90)	1.6	14.0	12.4	17.7	16.1
Cold Days (tmin<32)	257.2	223.0	-34.2	212.6	-44.7

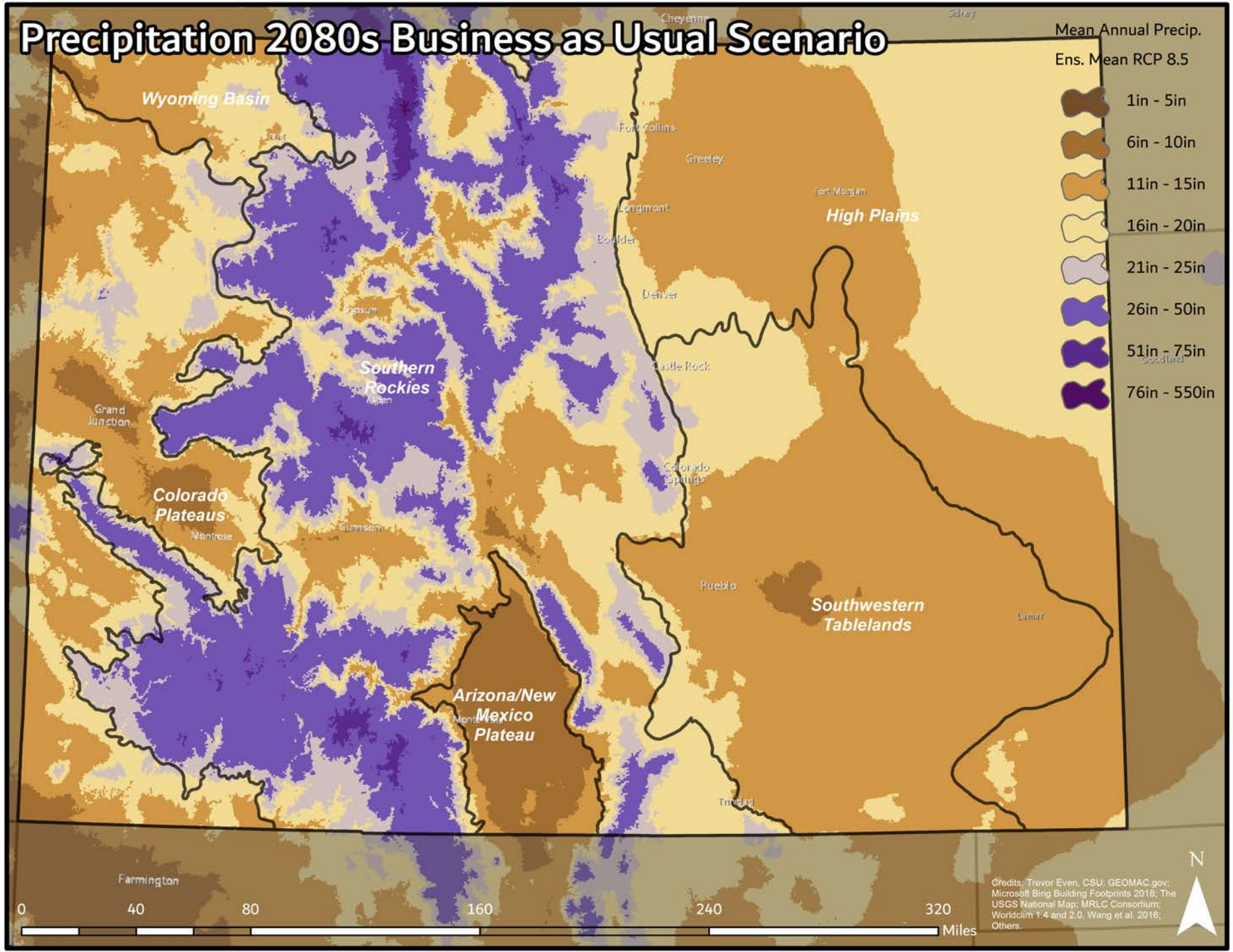




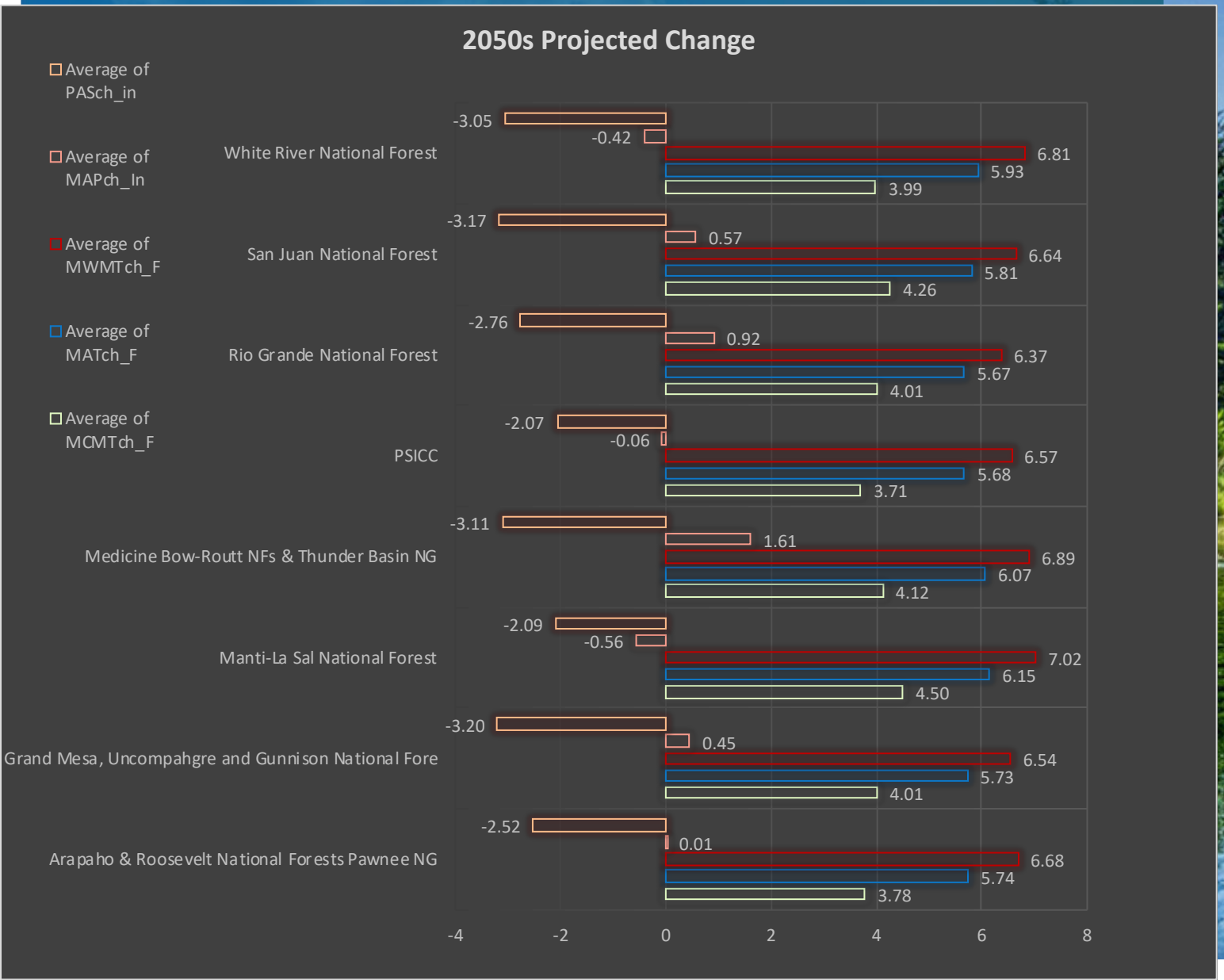


Ensemble Climate Projections for Colorado

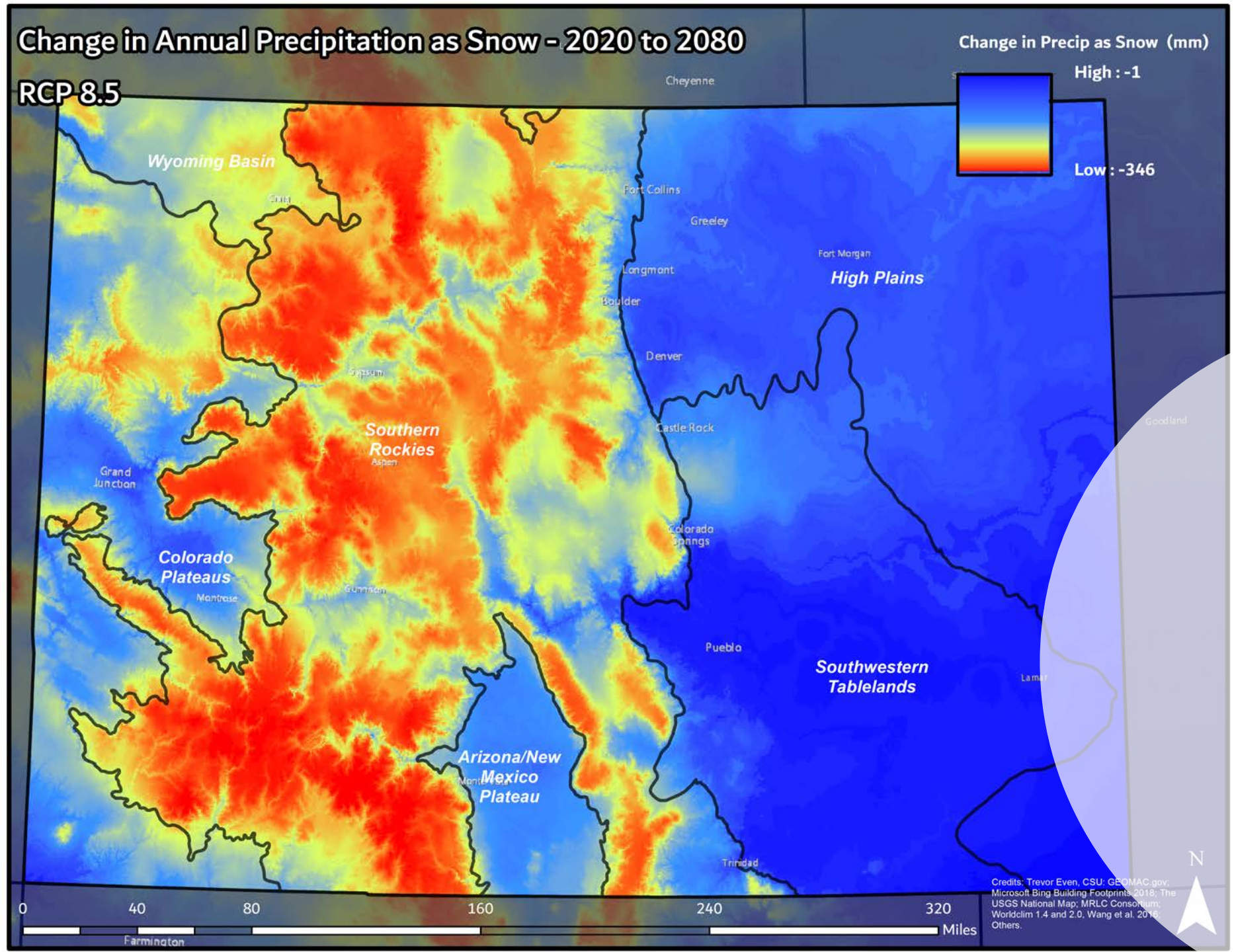

Temperature 2080s Business as Usual Scenario
Mean Annual Temp (C) RCP8.5
-20 - -8
-7 - -4
-3 - 0
1 - 4
5 - 8
9 - 12
13 - 16
17 - 20
21 - 25
26 - 34
Wyoming Basin
High Plains
Southern Rockies
Colorado Plateaus
Southwestern Tablelands
Arizona/New Mexico Plateau
Cheyenne
Sidney
Craig
Fort Collins
Greeley
Fort Morgan
Longmont
Boulder
Denver
Gypsum
Castle Rock
Aspen
Goodland
Grand Junction
Colorado Springs
Gunnison
Montrose
Pueblo
Lamar
Trinidad
Monument
Farmington
0
40
80
160
240
320
Miles
N
Credits: Trevor Even, CSU; GEOMAC.gov; Microsoft Bing Building Footprints 2018; The USGS National Map; MRLC Consortium; Worldclim 1.4 and 2.0; Wang et al. 2016; Others.


Precipitation 2080s Business as Usual Scenario
Mean Annual Precip.
Ens. Mean RCP 8.5
1in - 5in
6in - 10in
11in - 15in
16in - 20in
21in - 25in
26in - 50in
51in - 75in
76in - 550in
Wyoming Basin
Southern Rockies
Colorado Plateaus
High Plains
Southwestern Tablelands
Arizona/New Mexico Plateau
Cheyenne
Sidney
Fort Collins
Greeley
Fort Morgan
Longmont
Boulder
Denver
Castle Rock
Colorado Springs
Pueblo
Limon
Trinidad
Grand Junction
Montrose
Gunnison
Aspen
Glenwood Springs
Goodland
Farmington
0
40
80
160
240
320
Miles
N
Credits: Trevor Even, CSU; GEOMAC.gov; Microsoft Bing Building Footprints 2018; The USGS National Map; MRLC Consortium; Worldclim 1.4 and 2.0, Wang et al. 2016; Others.

2050s Adaptwest Ensemble Mean Change from 2010 Normals for USFS Recreational Areas,
aggregated by National Forest



Changes in Extreme Temperatures



Snowpack Change

Changes in Seasonality

Changes in Seasonal Onset

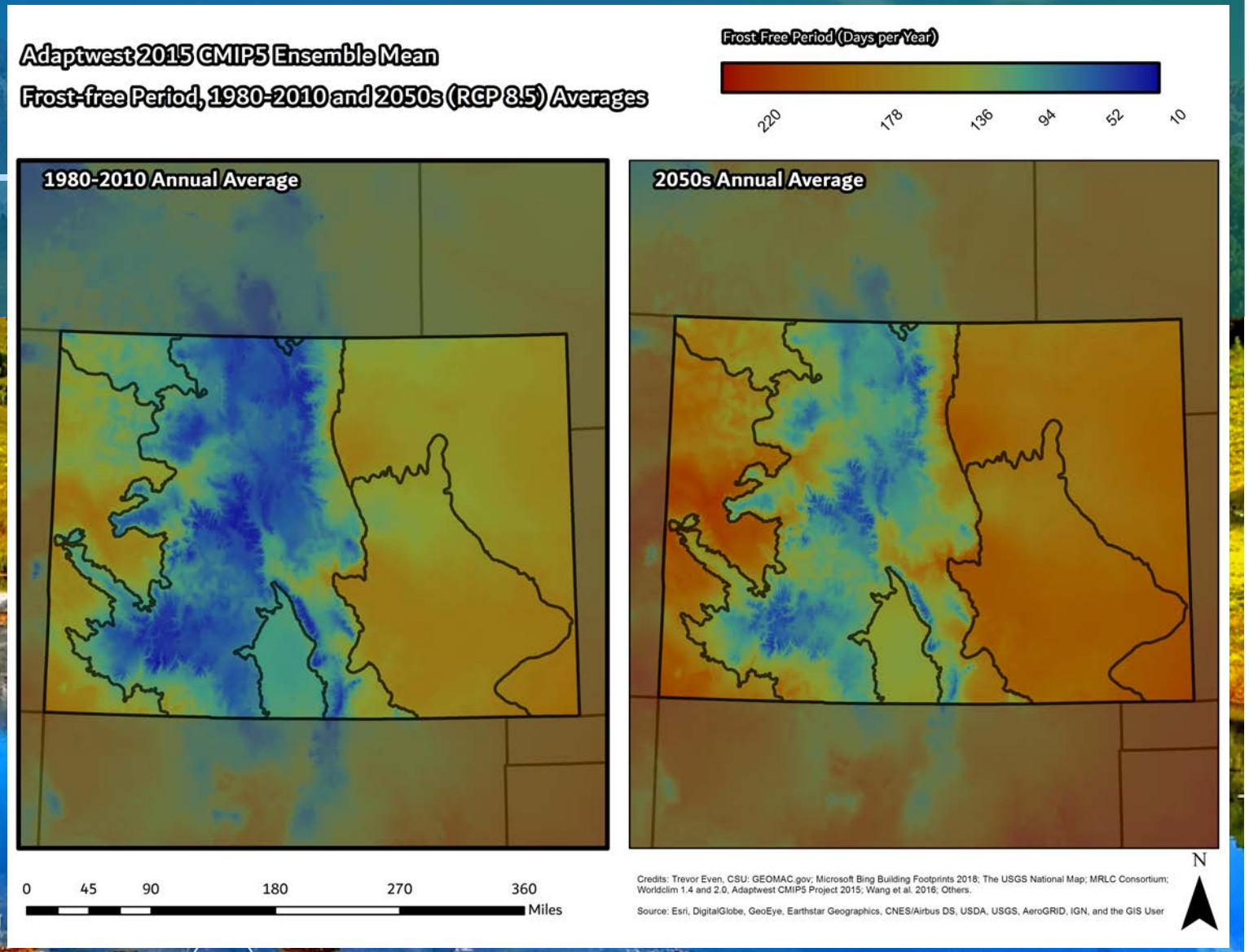
Changes in Runoff Timing and Annual Drought Intensity

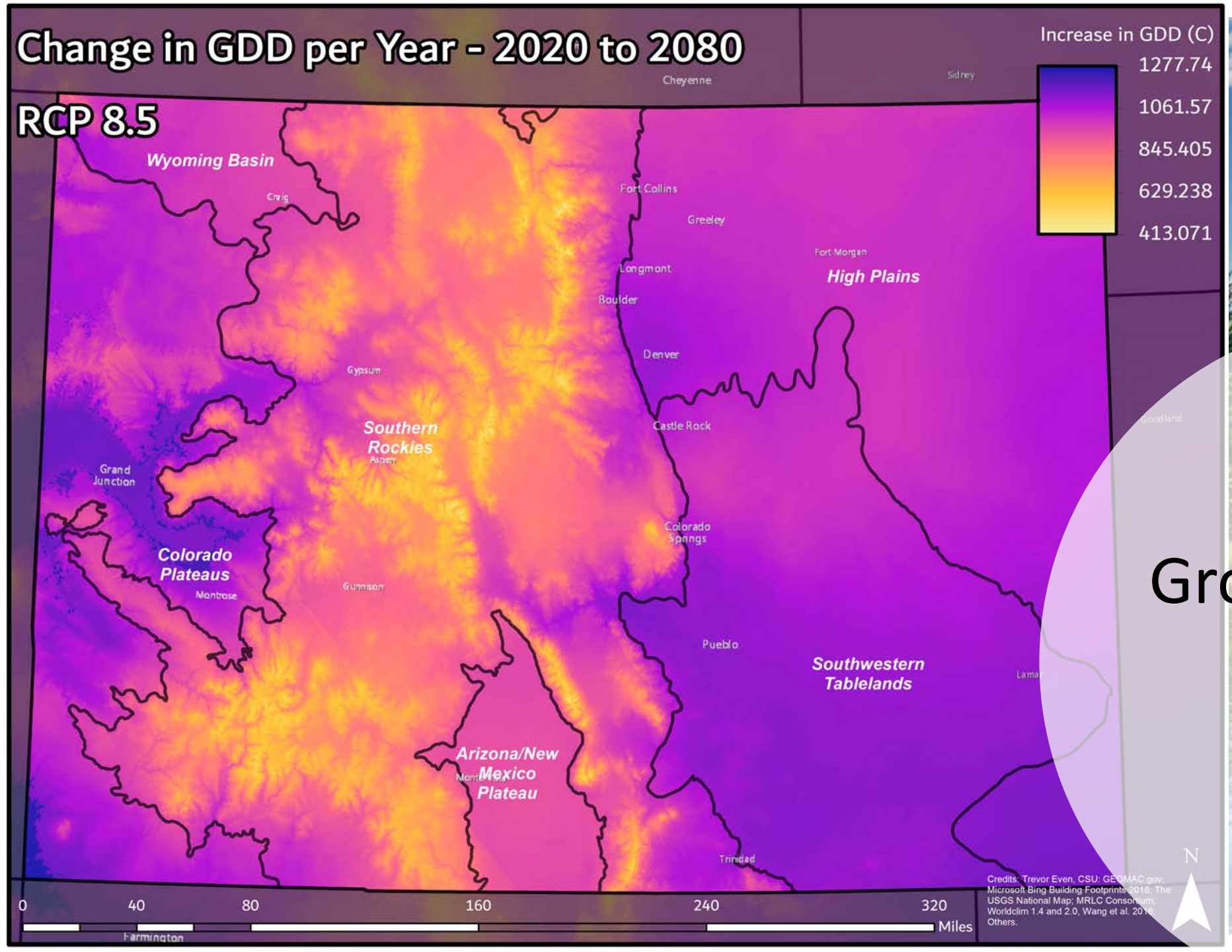
Changes in Phenology

Changes in Wildlife Behavior and Recruitment

False Springs

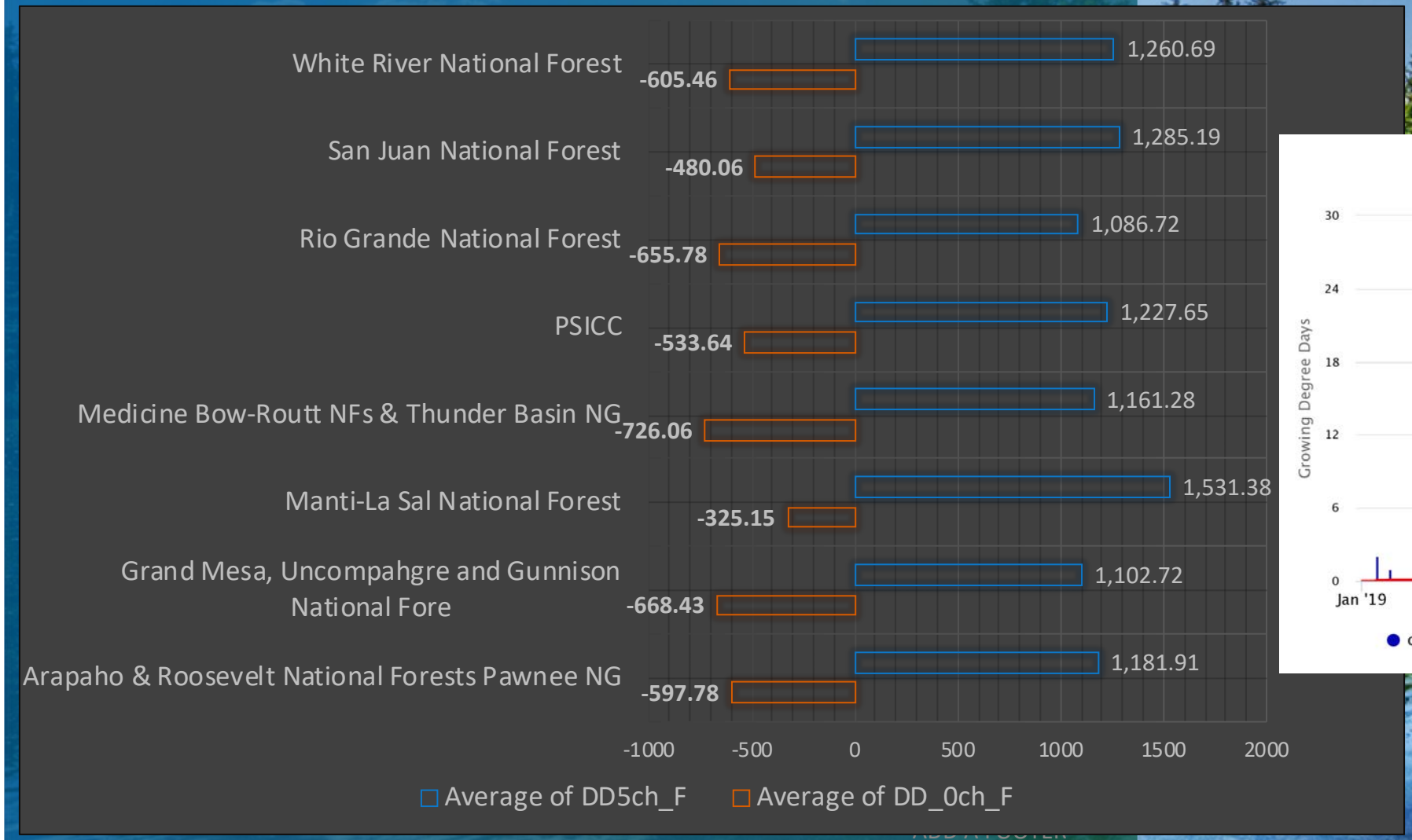
Etc., …

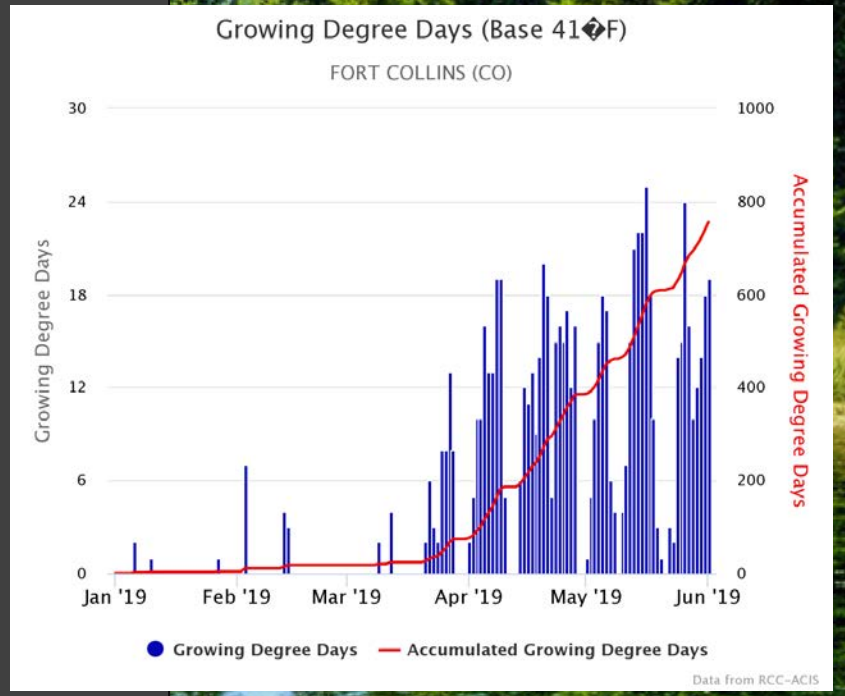


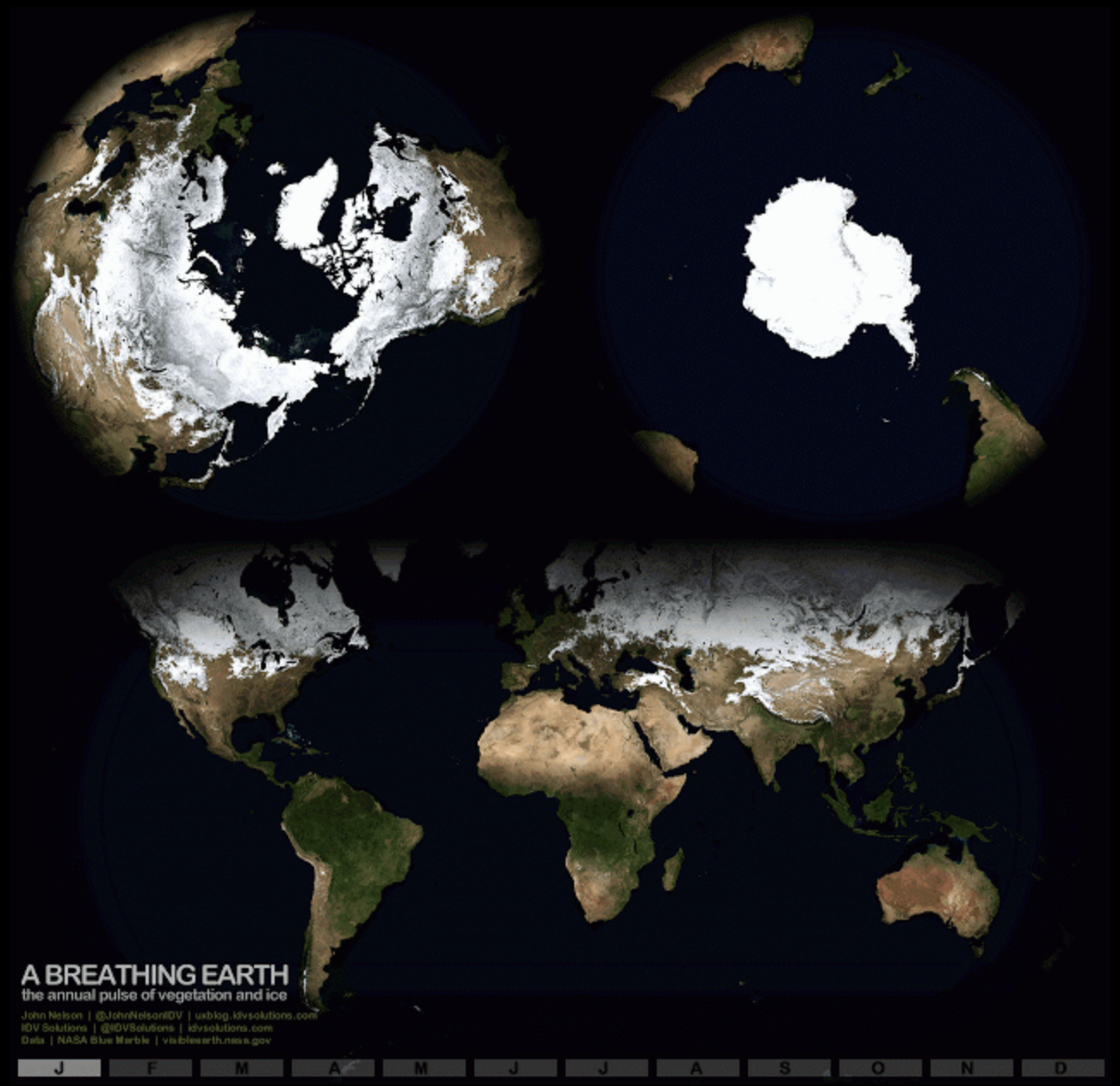


Growing Degree Days

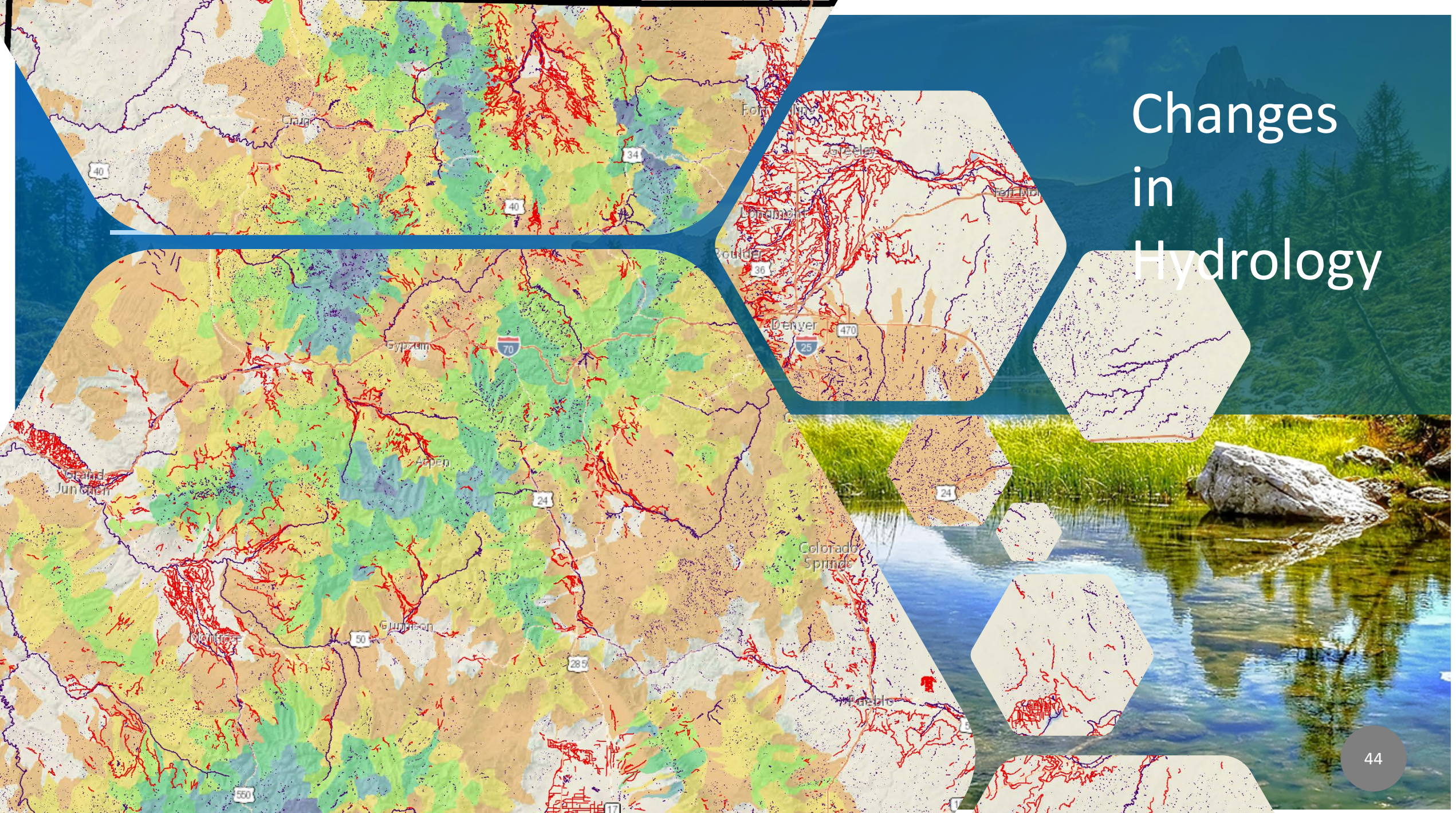
Changes in GDDs and FDDs by the 2050s



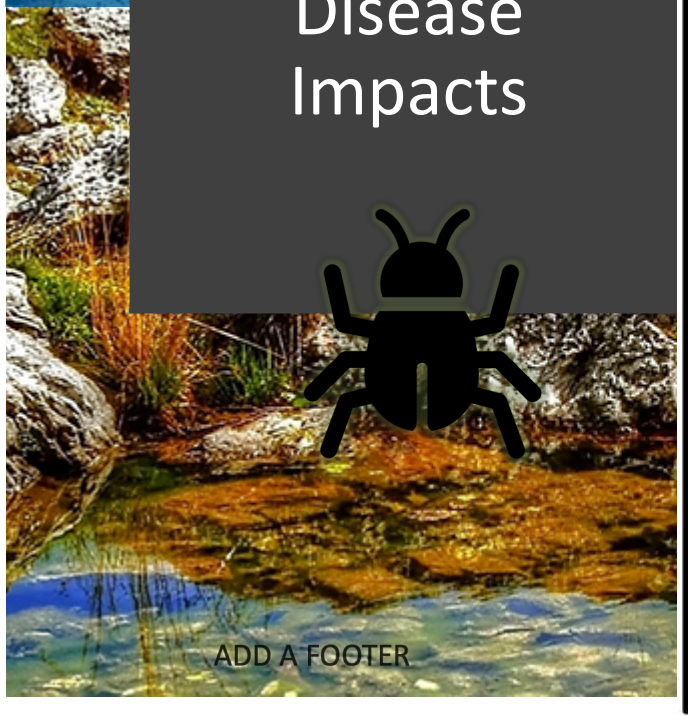


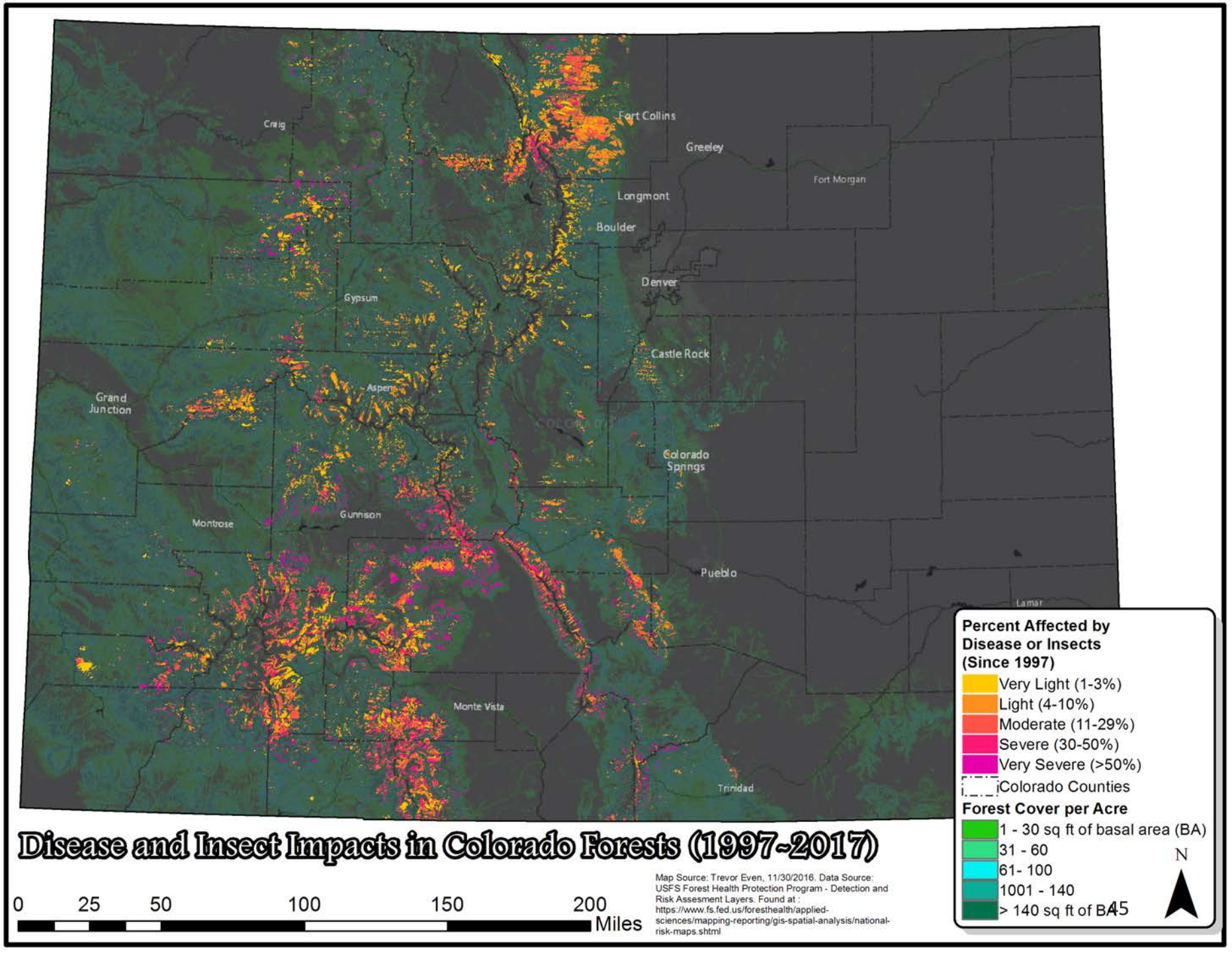

A BREATHING EARTH
the annual pulse of vegetation and ice
John Nelson | @JohnNelsonIDV | uxblog.idvsolutions.com
IDV Solutions | @IDVSolutions | idvsolutions.com
Data | NASA Blue Marble | visibleearth.nasa.gov
J
F
M
A
M
J
J
A
S
O
N
D

Changes in Hydrology

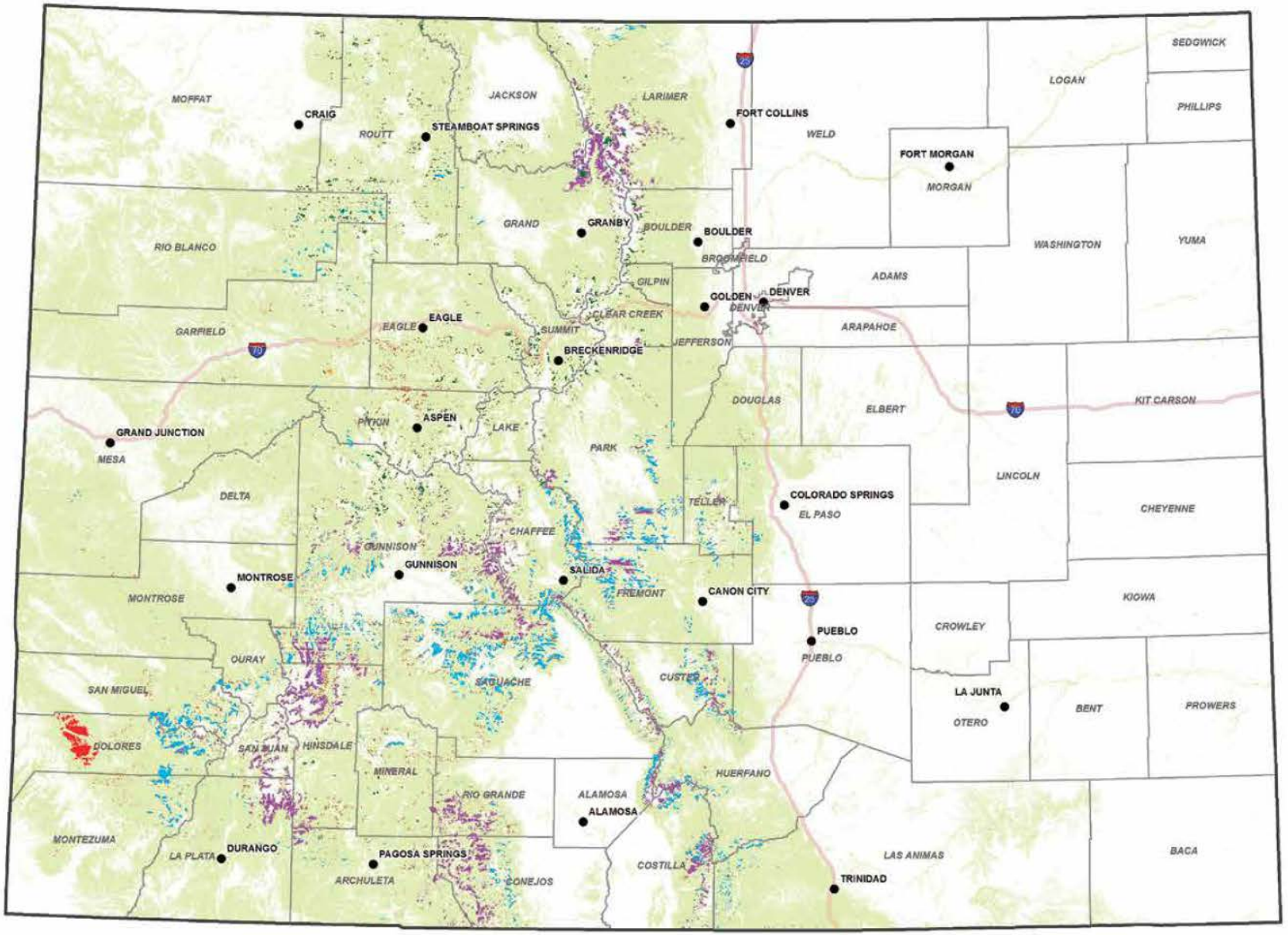


Insect and Disease Impacts





2018 Insect and Disease Activity in Colorado Forests



Data Source: United States Department of Agriculture (USDA) Forest Health Assessment & Applied Sciences Team (FHAAST)

- **Forestland** — *24.4 million acres*
- **Western Spruce Budworm** — *131,000 acres*
- **Douglas-fir Beetle** — *14,000 acres*
- **Spruce Beetle** — *178,000 acres*
- **Western Balsam Bark Beetle** — *24,000 acres*
- **Bark Beetle Complex** — *27,000 acres*

Aerial Survey Data

Due to the nature of aerial surveys, the data on this map only provide rough estimates of location, intensity and the resulting trend information for agents detectable from the air. Some destructive diseases are not represented on the map because these agents are not detectable from aerial surveys. The data presented on this map should only be used as an indicator of insect and disease activity, and should be validated on the ground for actual location and causal agent. Shaded areas show locations where tree mortality or defoliation were apparent from the air. Intensity of damage is variable, and not all trees in shaded areas are dead or defoliated.

The insect and disease data represented on this map are available digitally from the USDA Forest Service, Region 2 Forest Health Management group. The cooperators reserve the right to correct, update, modify or replace GIS products. Using this map for purposes other than those for which it was intended may yield inaccurate or misleading results.

Caution should be used when comparing this year's data to prior years, due to slightly differing sampling tools and variability between observers.

Map created December 2018
For more information:
www.csfs.colostate.edu

COLORADO STATE FOREST SERVICE
COLORADO STATE UNIVERSITY

Changes in Tree Species Distributions and Habitat Suitability

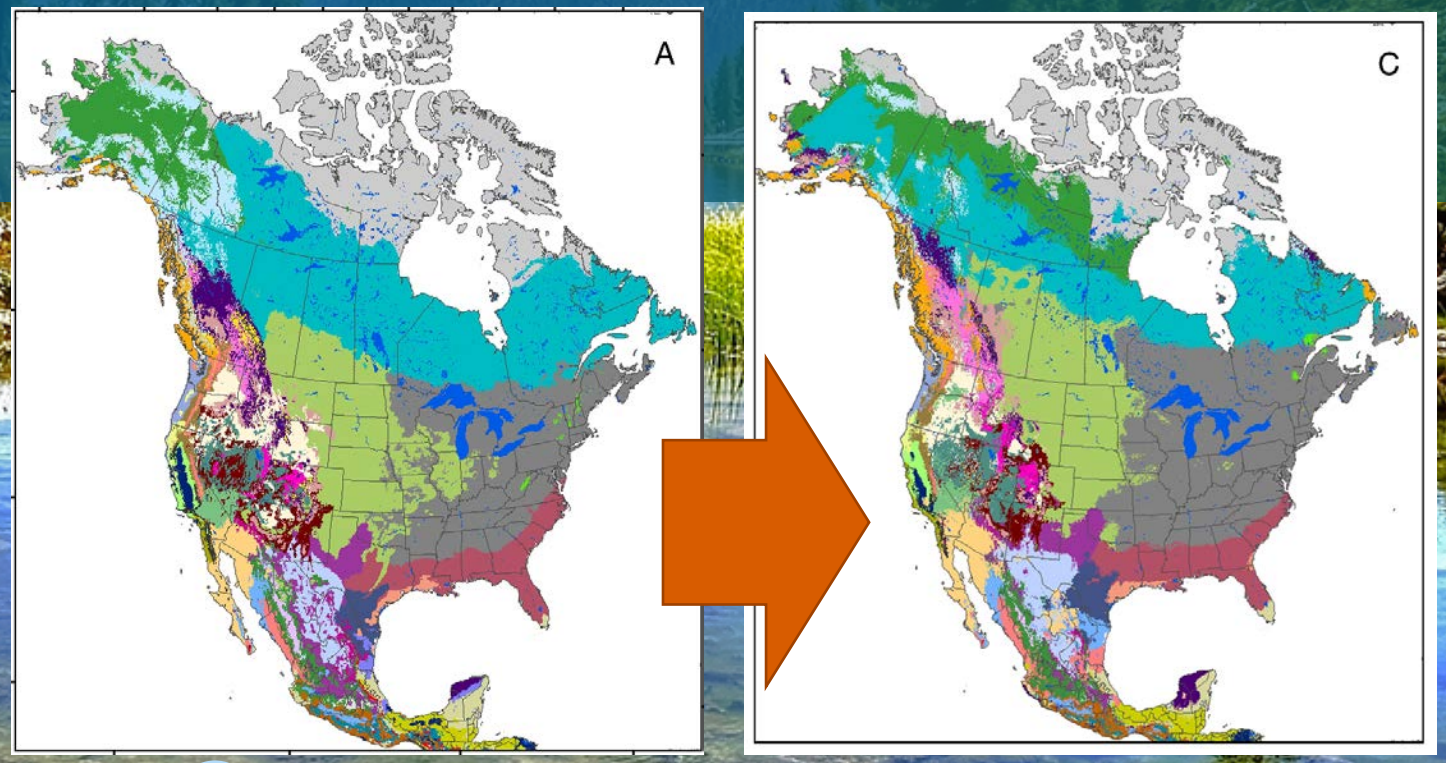
Ecological Applications, 22(1), 2012, pp. 119–141

North American vegetation model for land-use planning in a changing climate: a solution to large classification problems

GERALD E. REHFELDT,[1,4] NICHOLAS L. CROOKSTON,[1] CUAUHTÉMOC SÁENZ-ROMERO,[2] AND ELIZABETH M. CAMPBELL[3]

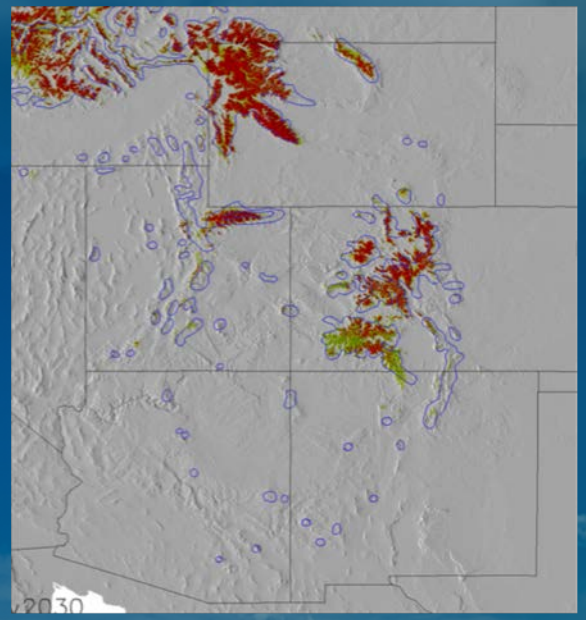
[1]*Rocky Mountain Research Station, USDA Forest Service, Forestry Sciences Laboratory, 1221 South Main, Moscow, Idaho 83843 USA*
[2]*Instituto de Investigaciones Agropecuarias y Forestales, Universidad Michoacana de San Nicolás de Hidalgo (IIAF-UMSNH), Km 9.5, Carretera Morelia-Zinapécuaro, Tarímbaro, Michoacán 58880 México*
[3]*Pacific Forestry Centre, Canadian Forest Service, 506 West Burnside Road, Victoria, British Columbia V8Z 1M5 Canada*

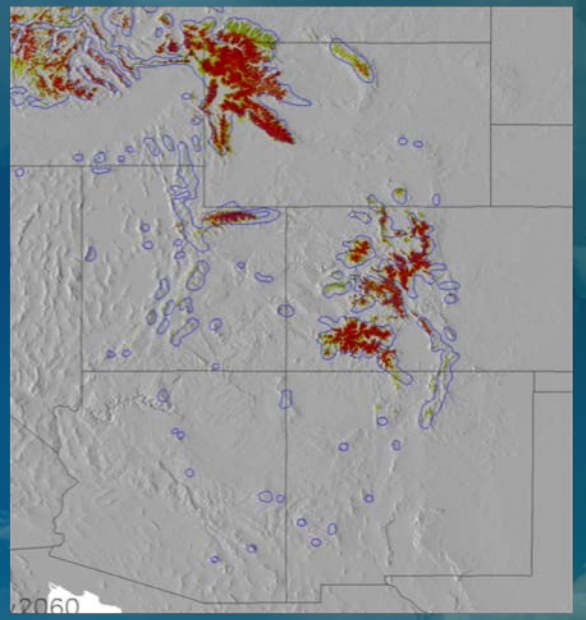
- Increased temperature envelopes alter water availability, relative recruitment rates, exposure to drought conditions, and disturbance regimes.
- Increased drying in already arid systems can preference grass and shrub species; species adapted to burning and drought
- Increased temperatures benefit northward and upslope expansion of some species, while others may have “nowhere to run.”
- High levels of uncertainty due to interactions with management, dispersal species, physical barriers, and local level land use practices.
- Interactions with insects and pathogens (some of which are already showing positive responses to warming) will also play a likely critical but difficult to predict role.

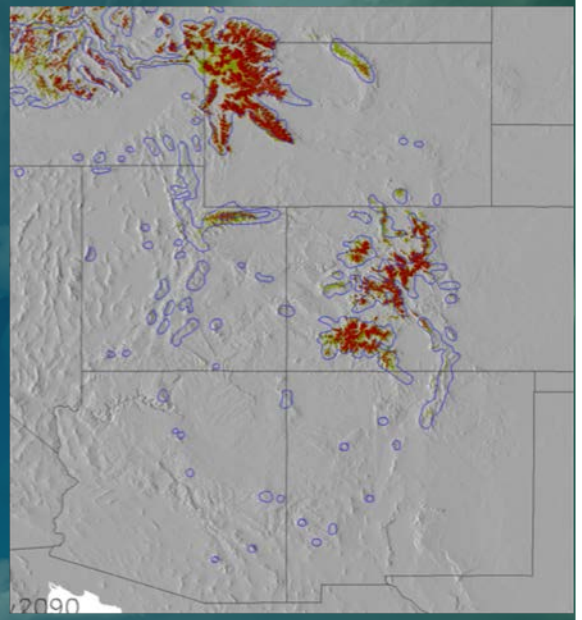


Subalpine-fir

Top Row CGCM3_B1 (Low Emissions Scenario)



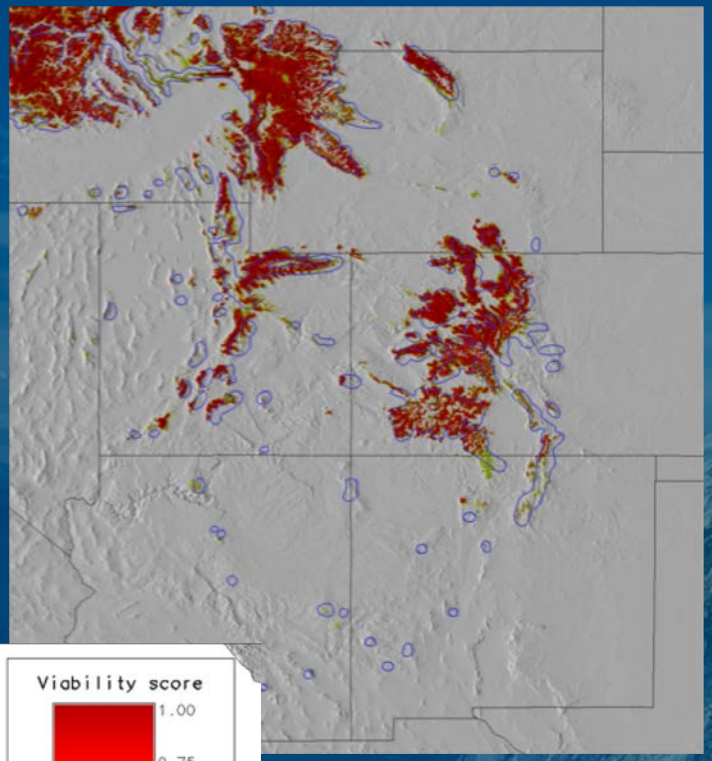




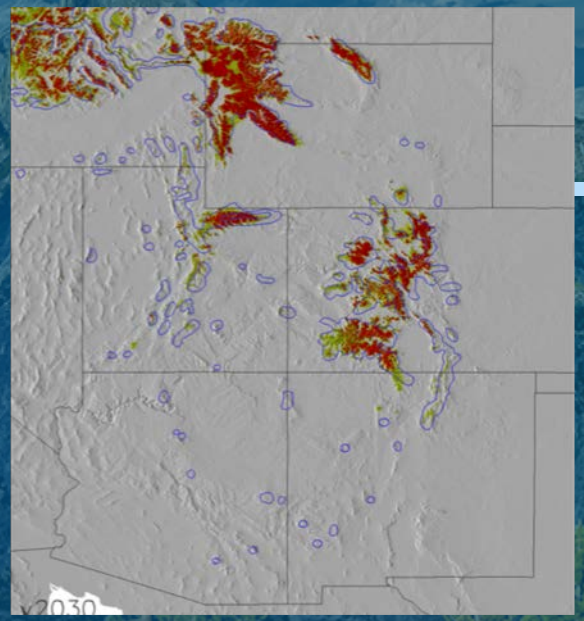
2030

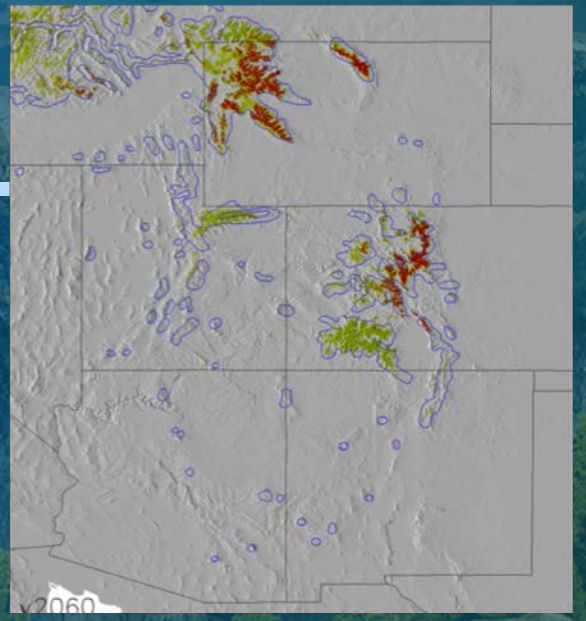
2060

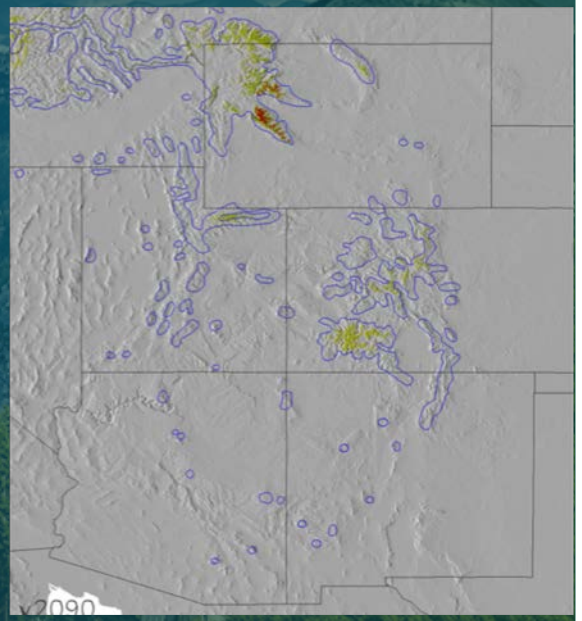
2090



Current Range





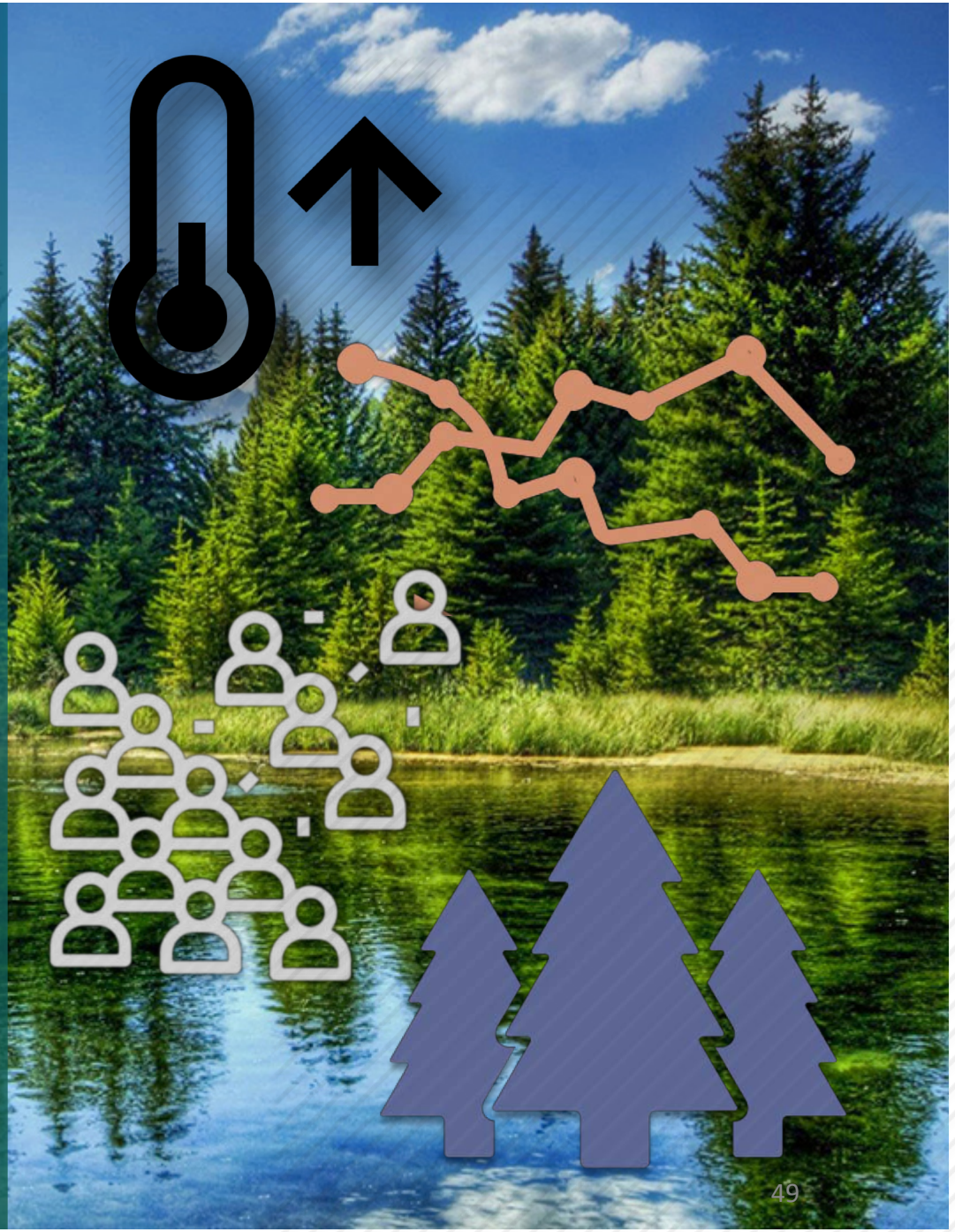


Bottom Row HADCM3_A2 (High Emissions Scenario)

http://charcoal.cnre.vt.edu/climate/species/

Drivers of Change across the Urban-Rural Forest Spectrum

- Human Activity and Occupancy Increases
  - Increased Tourism
  - Increased WUI Development
  - Increased Water Infrastructure Needs?
- Climate Change and Ecosystem Responses
  - Increased temperatures and shorter freeze cycles; higher evaporation; northward/upward species habitat migration
  - Alteration of precipitation profiles (rain v. snow), especially at middle elevations; amplified and shortened runoff cycles; more extreme late-summer drying annually
  - A more variable hydrosphere, with more intense droughts and more intense extreme precipitation
  - Increased vulnerability to insect and disease mortality
  - Increased wildfire incidence
  - Increased drought episodes
  - Increased importance of extreme storm interception by forests, especially in inhabited canyons; increased erosion processes and episode frequency



How do we better perceive and understand the numerous complex drivers of change influencing Colorado's forests?

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. Surface irrigation ended last month for all but the most senior water rights and without any subsurface moisture that is not going very far. Full fire restrictions are in place throughout the SLV on both public and private lands. Tourists are having to restrict their recreational activities. Warm water is affecting the fish, and wildlife is moving to water from the public lands." – Rio Grande County, 07/9/2018

"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. Reports of people early weaning calves, and sending cows to the feedlot and out of state have also been reported" – 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. We irrigate from water collected off our roof (mostly as melted snow in winter) and since the winter had hardly any snow, we have now run out of water. Native plants are doing poorly as well." – Mesa County, 07/19/2018

"Native grasses haven't broken winter dormancy. Pasture has zero growth for 2018 grazing season. Ranchers feeding cattle. Herds being liquidated or put into feedlots." – Otero County, 07/6/2018

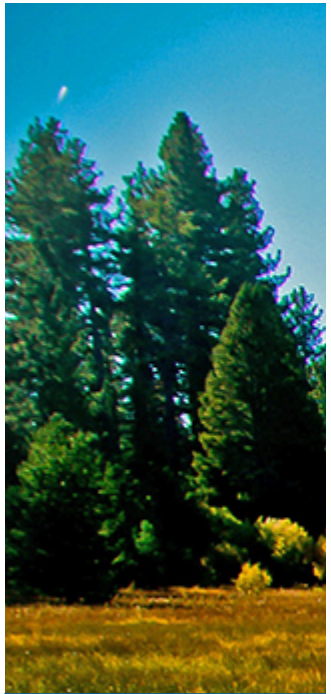
"Very dry in Bent County and the western part of Kiowa County, already starting to cull cows, other people are talking about sending cows and calves to feedlot or early weaning calves and sending both to feedlots separately. The irrigation canals are saying 5 more runs of water in storage, water is not going across the fields and lots of fields are being fallowed or prevent planted. It looks like the dead of winter if it wasn't for the bar ditches being green. The rains have been very spotty and the high heat and winds have killed what moisture has come." – Ben County, 06/28/2018

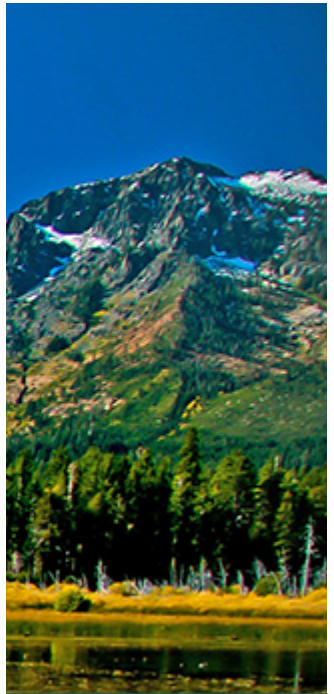
"Still very dry. We've been teased by rain in the distance, but no moisture here. Not even wildflowers are growing here this year. Disappointment Creek is noticeably lower than even a week ago. No green. The ground is very parched ... or as a visitor yesterday put it, "naked." The water truck is still watering the gravel while everybody else wonders how they're going to continue hauling water to cattle. BLM is watching the drought closely on behalf of the Spring Creek Basin Herd Management Area mustangs, ready to haul water when needed, which will be soon." – Redvale, San Miguel County, 05/22/2018

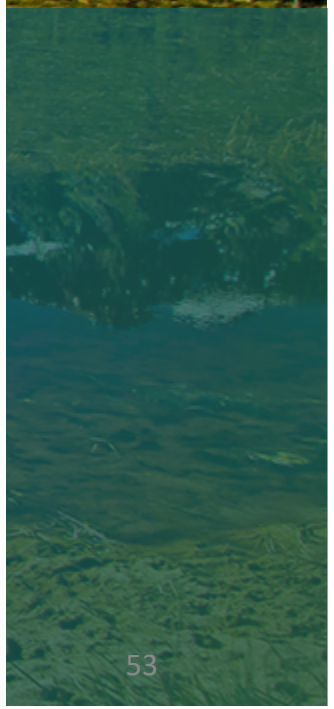
Source: CoCoRaHS Drought Reporting System

Wildfire and Drought

Photo credits: TheDenverChannel.com; Helen H. Richardson, Denver Post 2018.

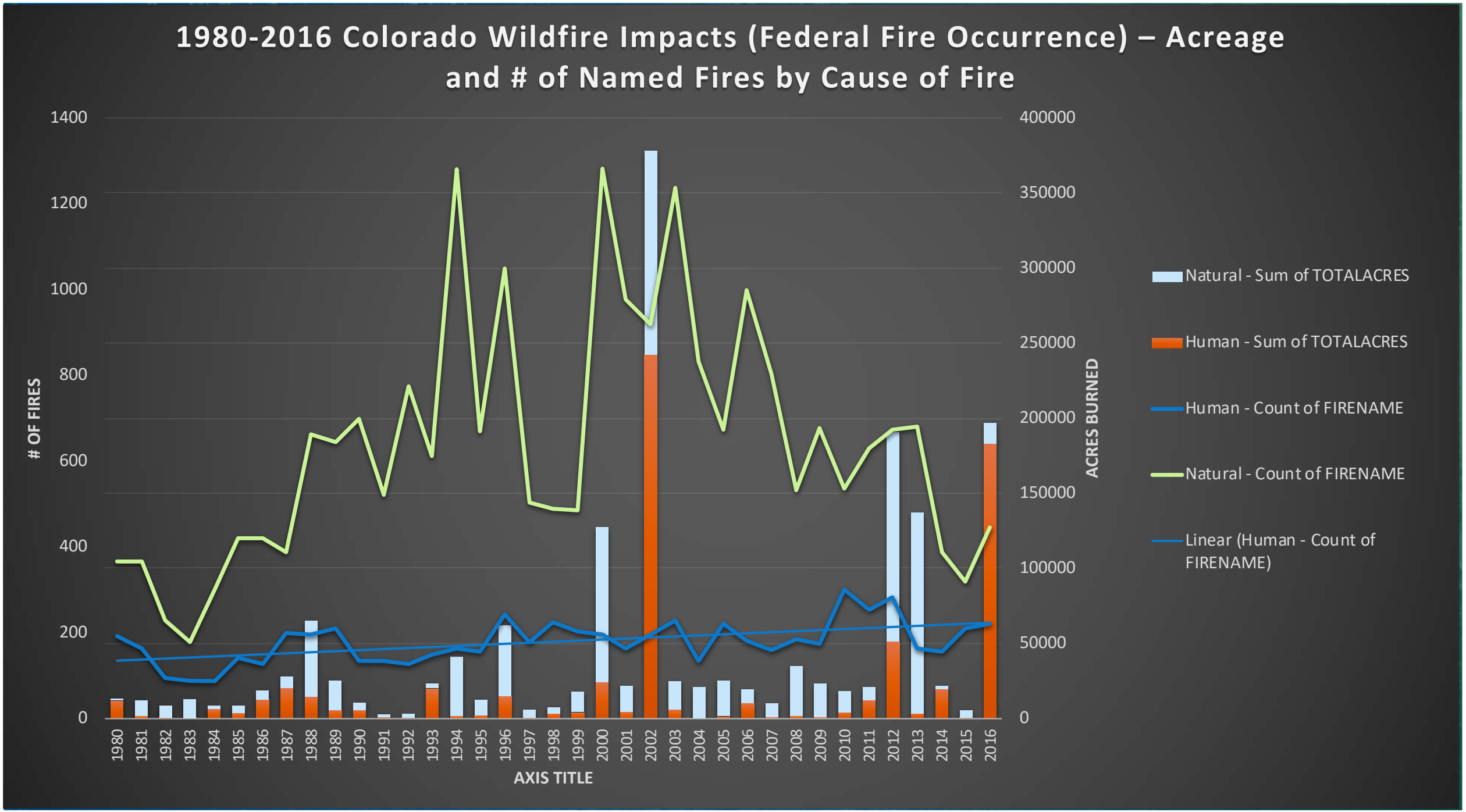


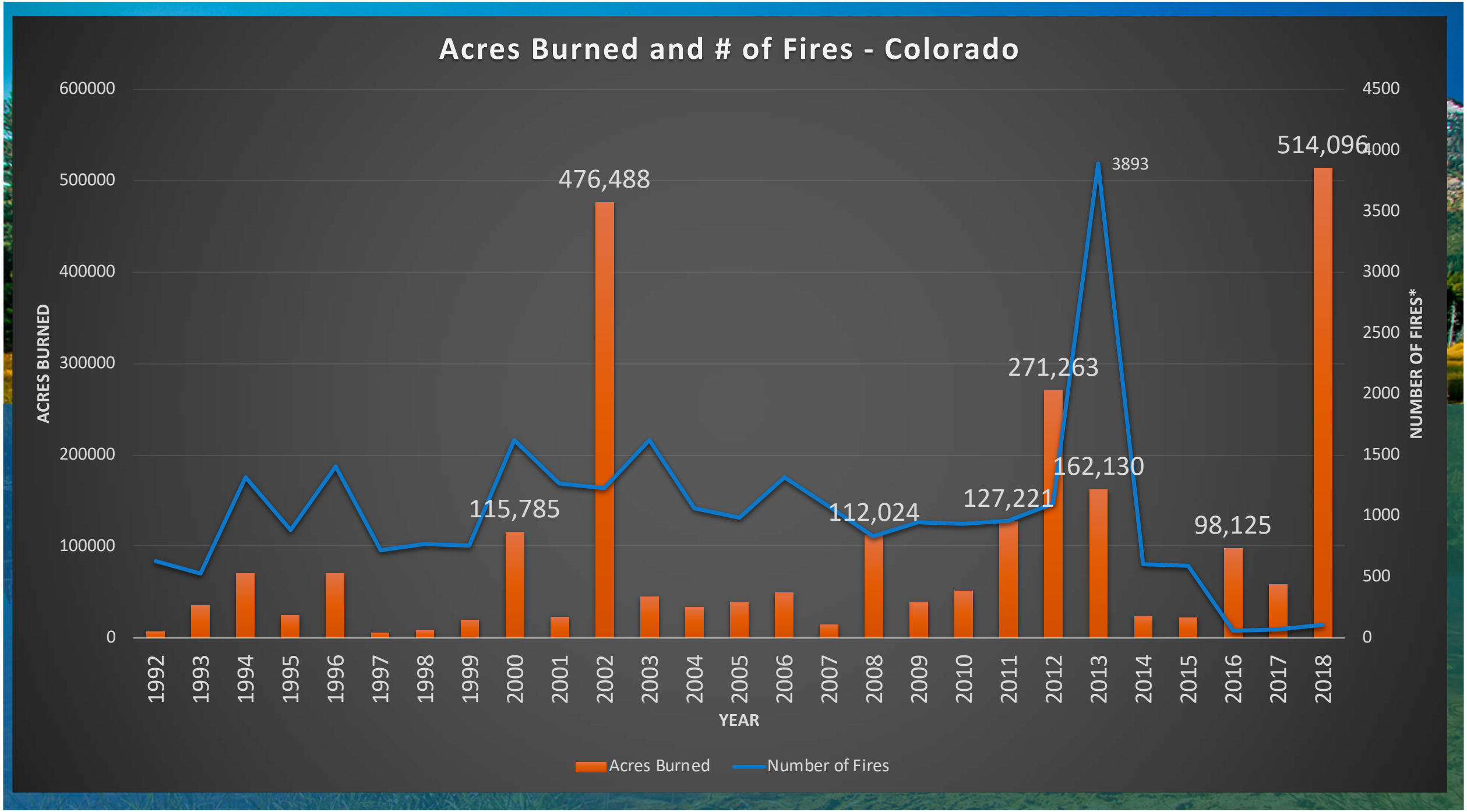




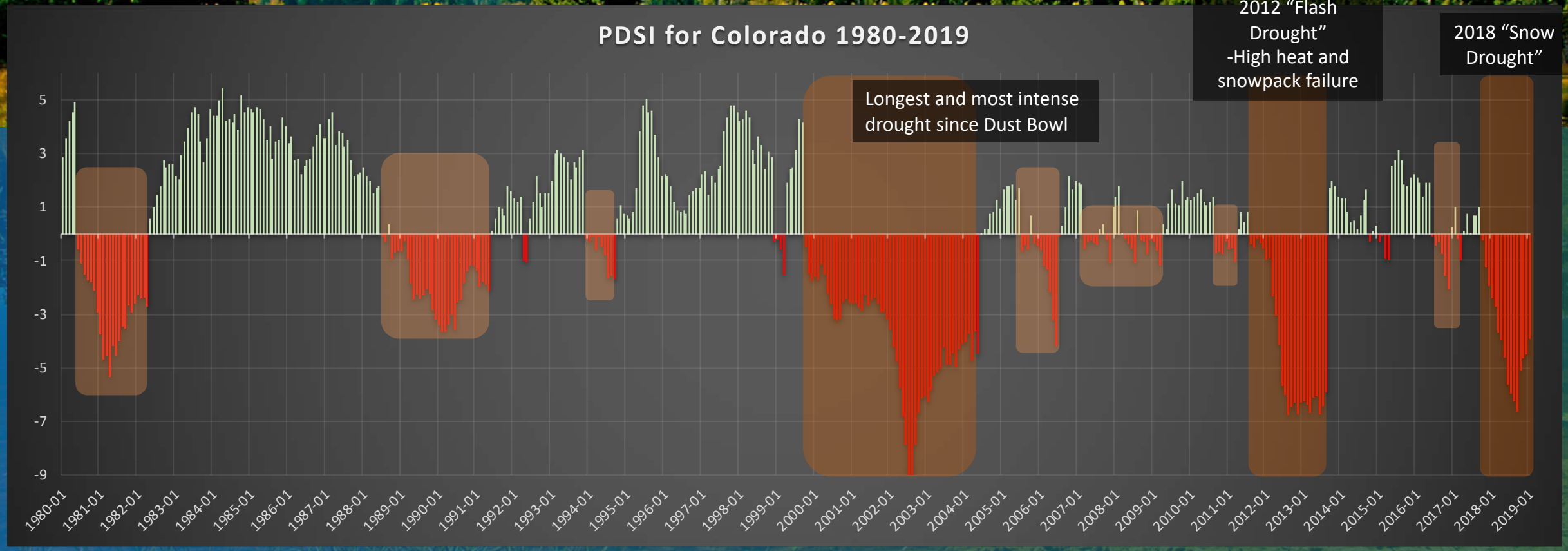
Wildfires 2000-2018

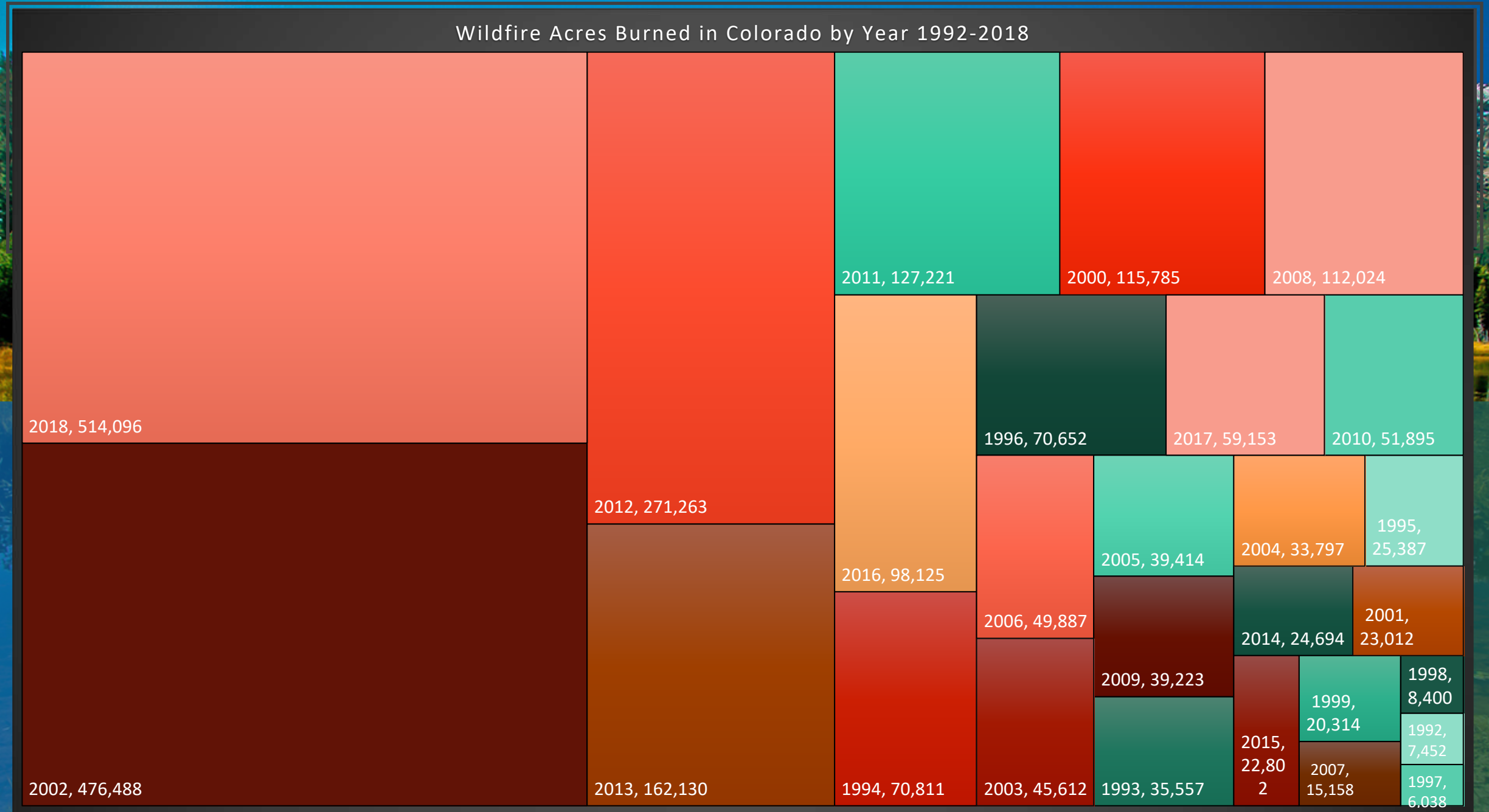
1980-2016 Colorado Wildfire Impacts (Federal Fire Occurrence) – Acreage and # of Named Fires by Cause of Fire

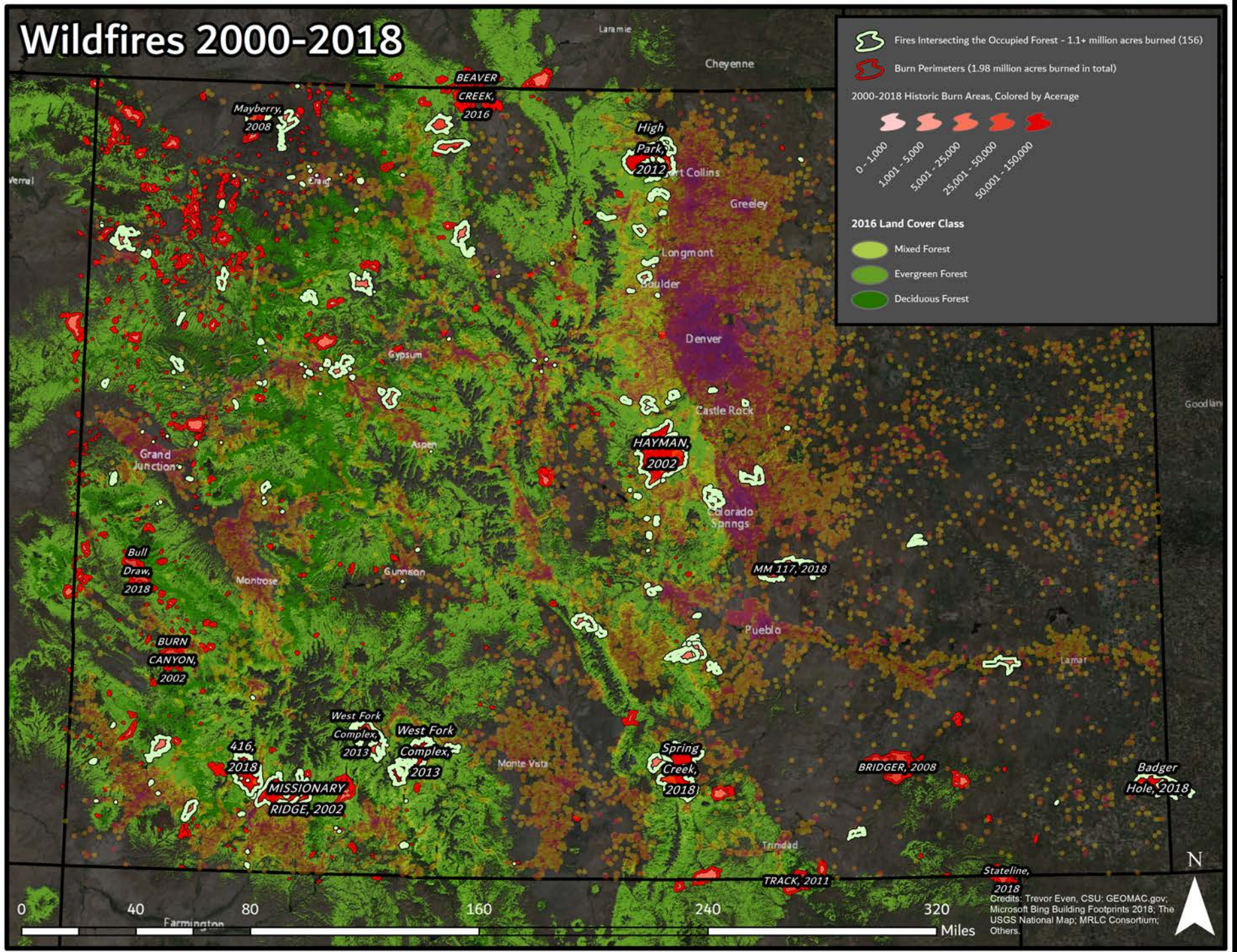


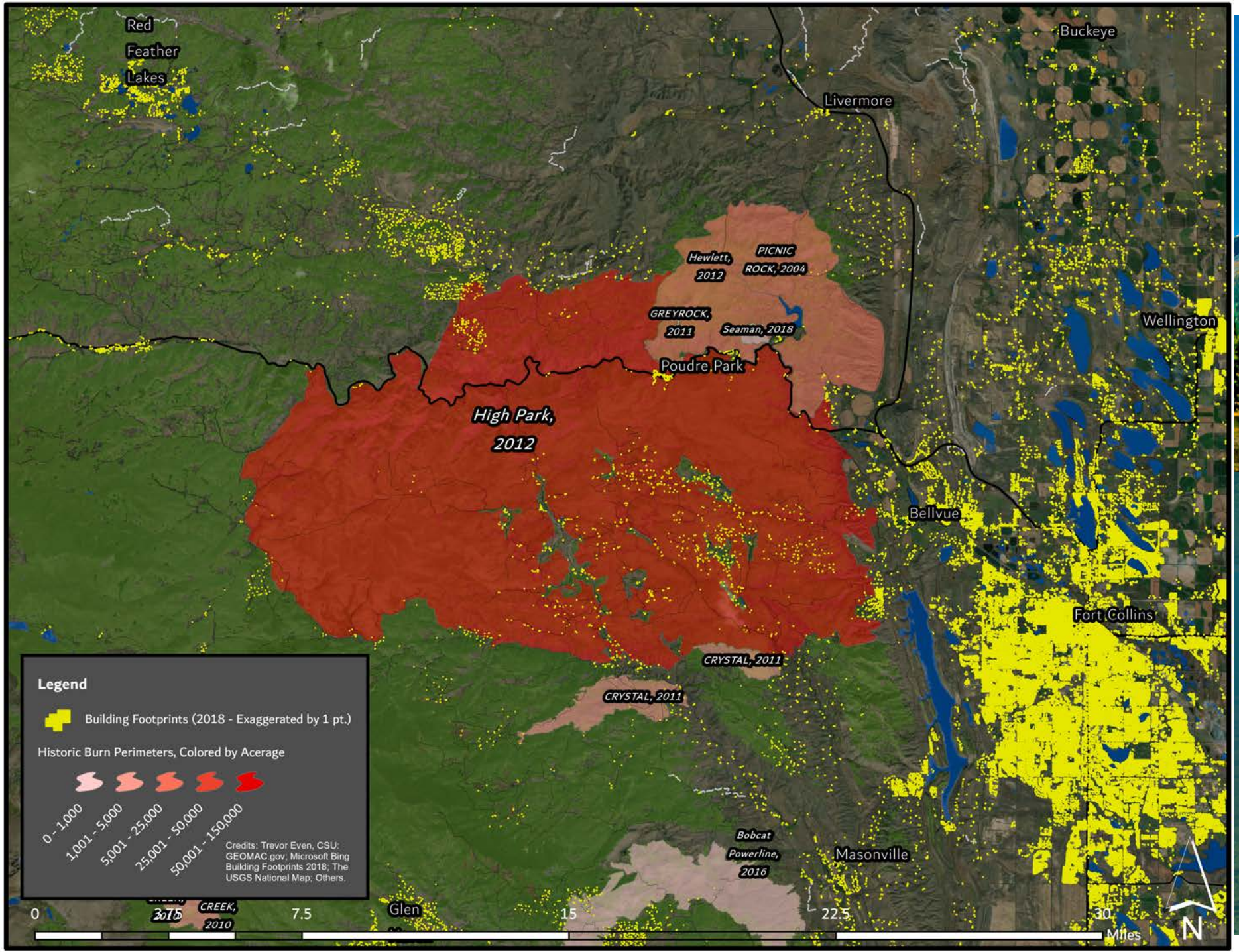

Acres Burned and # of Fires - Colorado
ACRES BURNED
NUMBER OF FIRES*
YEAR
600000
500000
400000
300000
200000
100000
0
4500
4000
3500
3000
2500
2000
1500
1000
500
0
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
115,785
476,488
112,024
127,221
271,263
162,130
98,125
514,096
3893
Acres Burned
Number of Fires

Droughts 1980-2019




Wildfire Acres Burned in Colorado by Year 1992-2018
2018, 514,096
2002, 476,488
2012, 271,263
2013, 162,130
2011, 127,221
2000, 115,785
2008, 112,024
2016, 98,125
1994, 70,811
1996, 70,652
2006, 49,887
2003, 45,612
2017, 59,153
2010, 51,895
2005, 39,414
2009, 39,223
1993, 35,557
2004, 33,797
1995, 25,387
2014, 24,694
2001, 23,012
2015, 22,802
1999, 20,314
2007, 15,158
1998, 8,400
1992, 7,452
1997, 6,038


Wildfires 2000-2018
Fires Intersecting the Occupied Forest - 1.1+ million acres burned (156)
Burn Perimeters (1.98 million acres burned in total)
2000-2018 Historic Burn Areas, Colored by Acerage
0 - 1,000
1,001 - 5,000
5,001 - 25,000
25,001 - 50,000
50,001 - 150,000
2016 Land Cover Class
Mixed Forest
Evergreen Forest
Deciduous Forest
Laramie
Cheyenne
Vernal
Craig
Greeley
Longmont
Boulder
Denver
Gypsum
Castle Rock
Aspen
Grand Junction
Colorado Springs
Montrose
Gunnison
Pueblo
Lamar
Monte Vista
Trinidad
Farmington
Goodland
BEAVER CREEK, 2016
Mayberry, 2008
High Park, 2012
HAYMAN, 2002
Bull Draw, 2018
MM 117, 2018
BURN CANYON, 2002
West Fork Complex, 2013
West Fork Complex, 2013
416, 2018
MISSIONARY RIDGE, 2002
Spring Creek, 2018
BRIDGER, 2008
Badger Hole, 2018
TRACK, 2011
Stateline, 2018
0
40
80
160
240
320
Miles
N
Credits: Trevor Even, CSU; GEOMAC.gov; Microsoft Bing Building Footprints 2018; The USGS National Map; MRLC Consortium; Others.



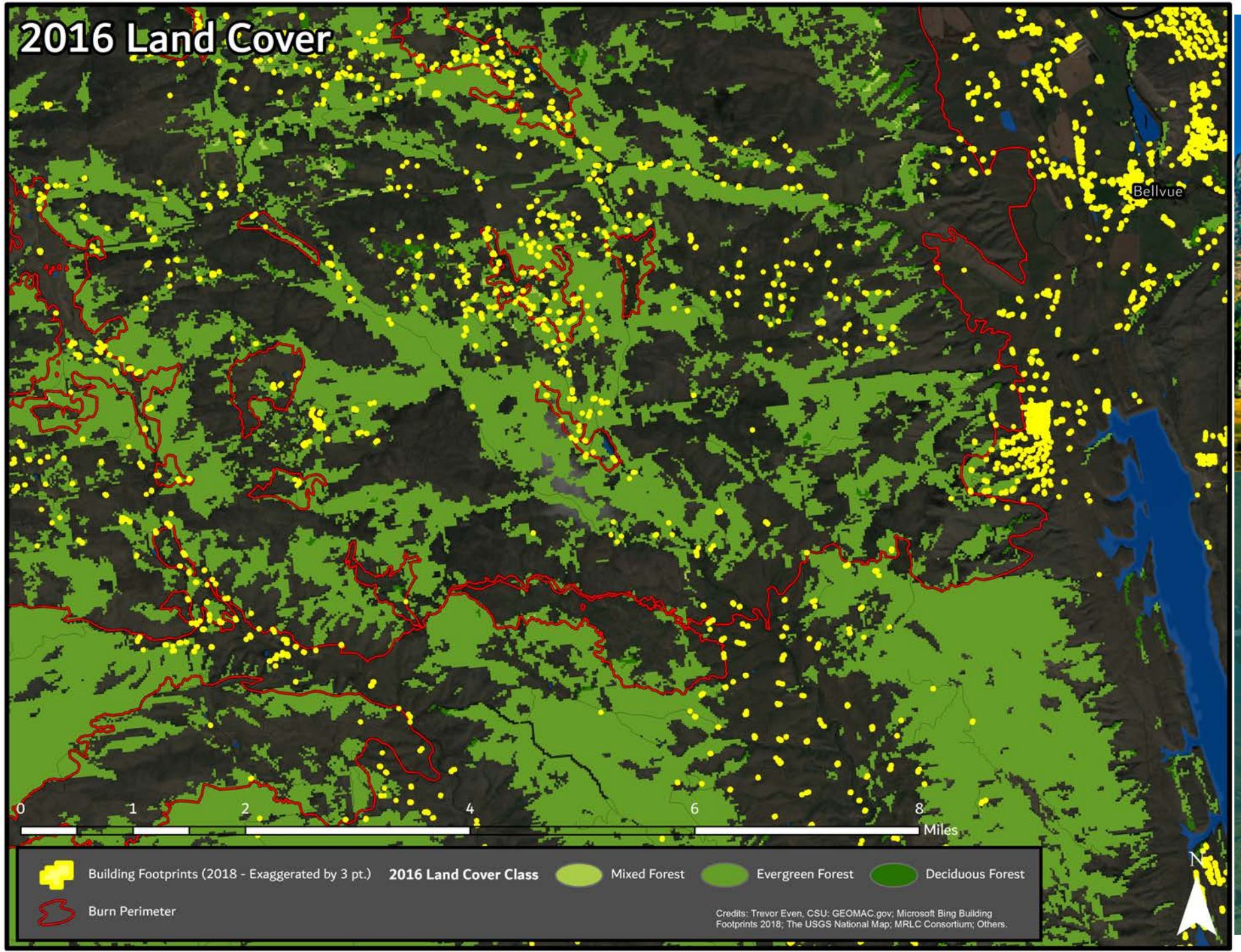
The High Park Fire, 2012

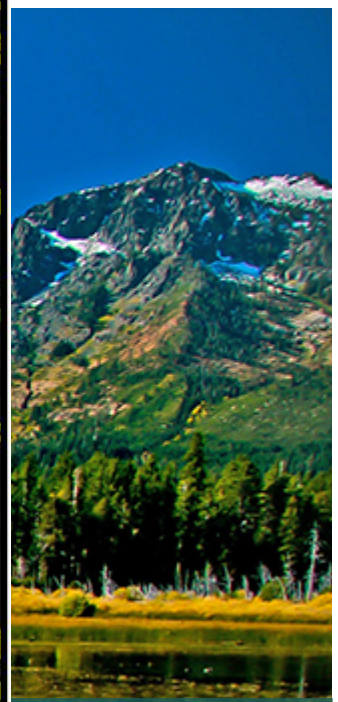
87,000 Acres (40,000 private)

259 out of ~1100 homes

$39.2 Million control costs (Inciweb 2015)

$24 Million repair and restoration as of 2012


2016 Land Cover
Bellvue
0
1
2
4
6
8
Miles
N
Building Footprints (2018 - Exaggerated by 3 pt.)
2016 Land Cover Class
Mixed Forest
Evergreen Forest
Deciduous Forest
Burn Perimeter
Credits: Trevor Even, CSU: GEOMAC.gov; Microsoft Bing Building Footprints 2018; The USGS National Map; MRLC Consortium; Others.



Spring Creek Fire, 2018

108,045 acres burned

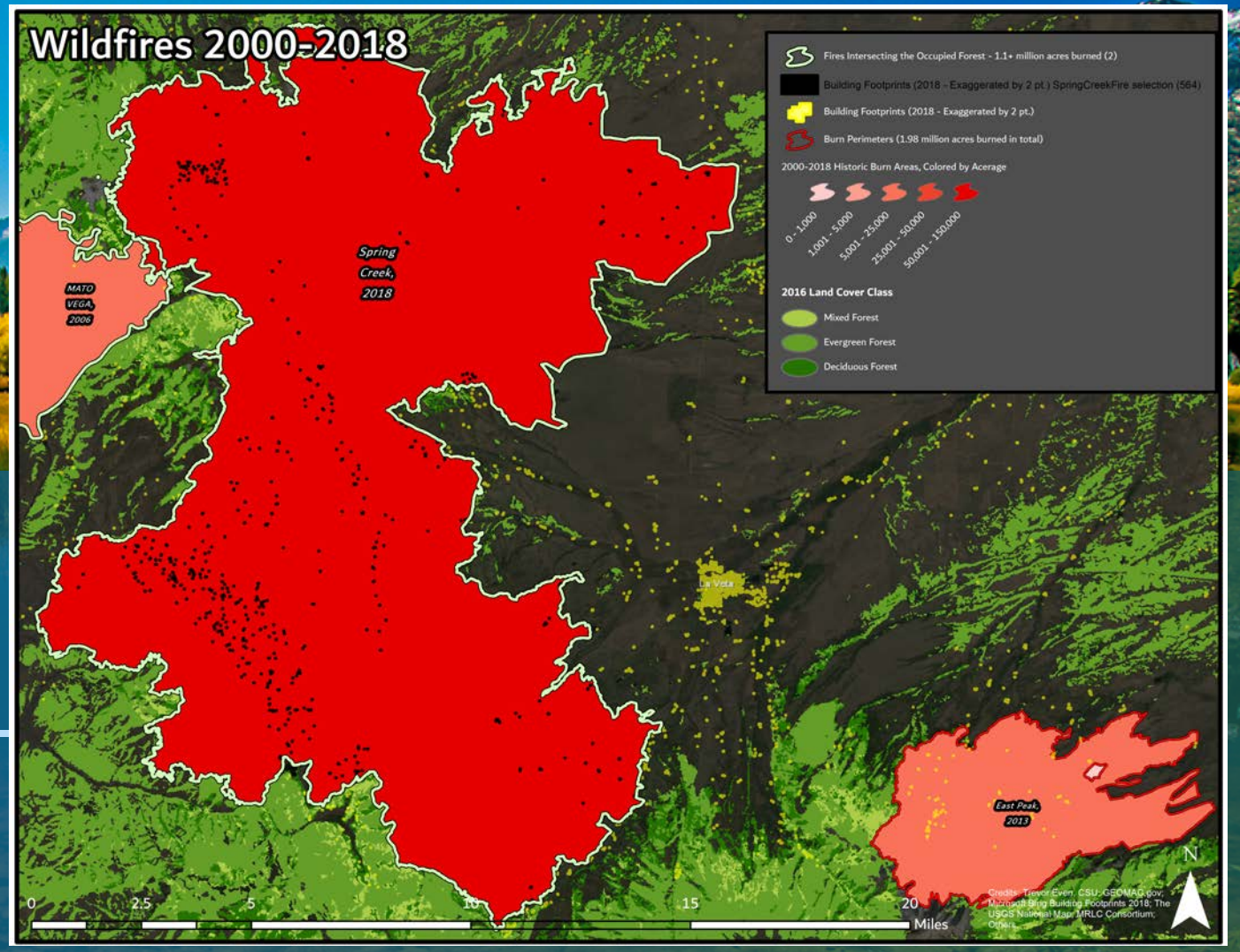
141 Structures Lost; 546 affected

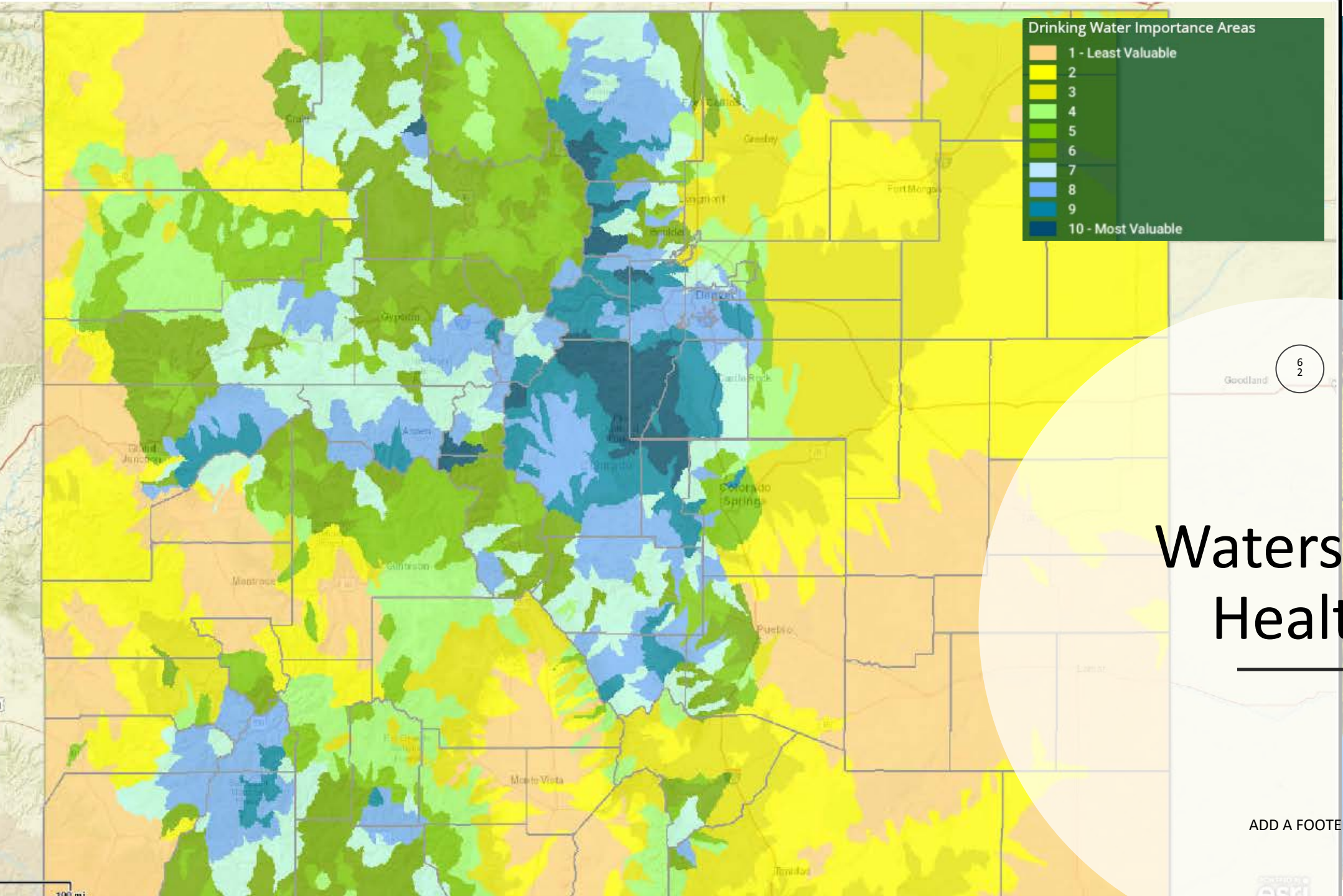
295+ Personnel involved in containment

Burned 12k BLM lands; 4k State land; 80k Private, and 10k Forest Service lands

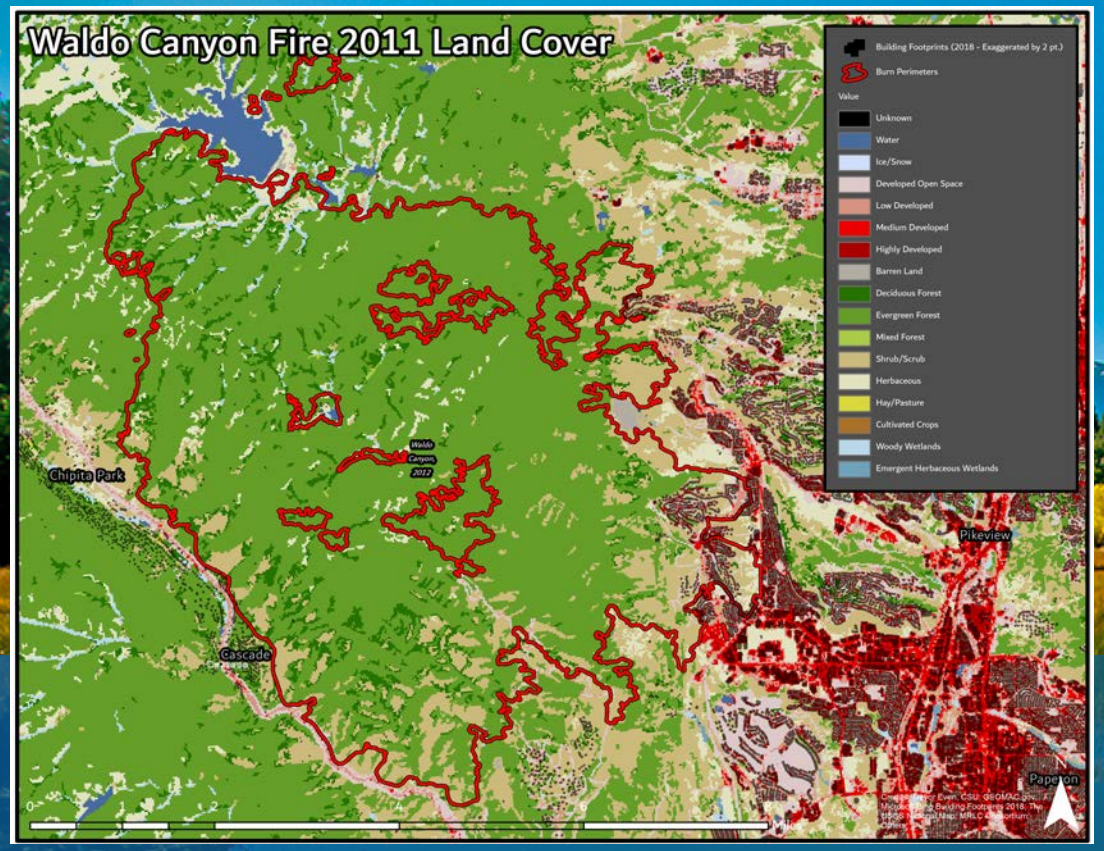
BAER details high intensity soil burn on 23% of acres post-fire; 23% moderate; 54% low/unburned.

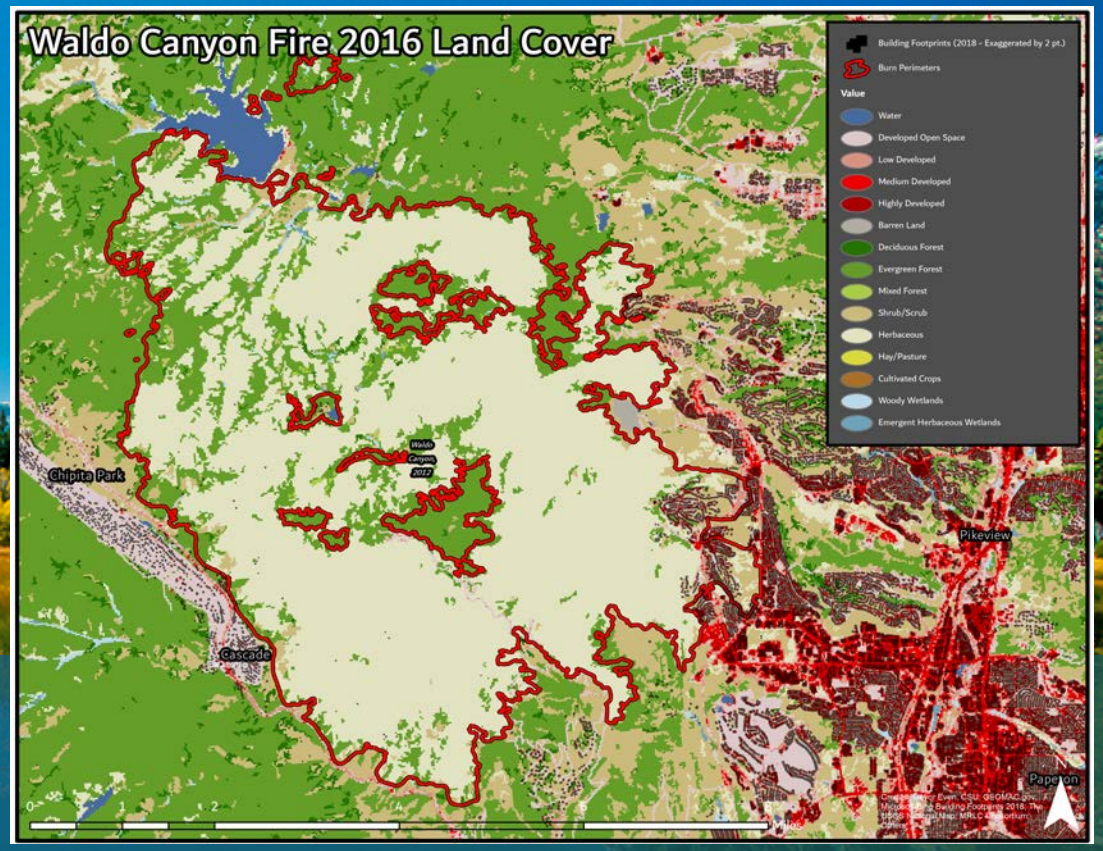
Flood risk, storm risks, water quality, and runoff timing will be affected for the 16 sub-watersheds and 60+ miles of streams affected.





Watershed Health



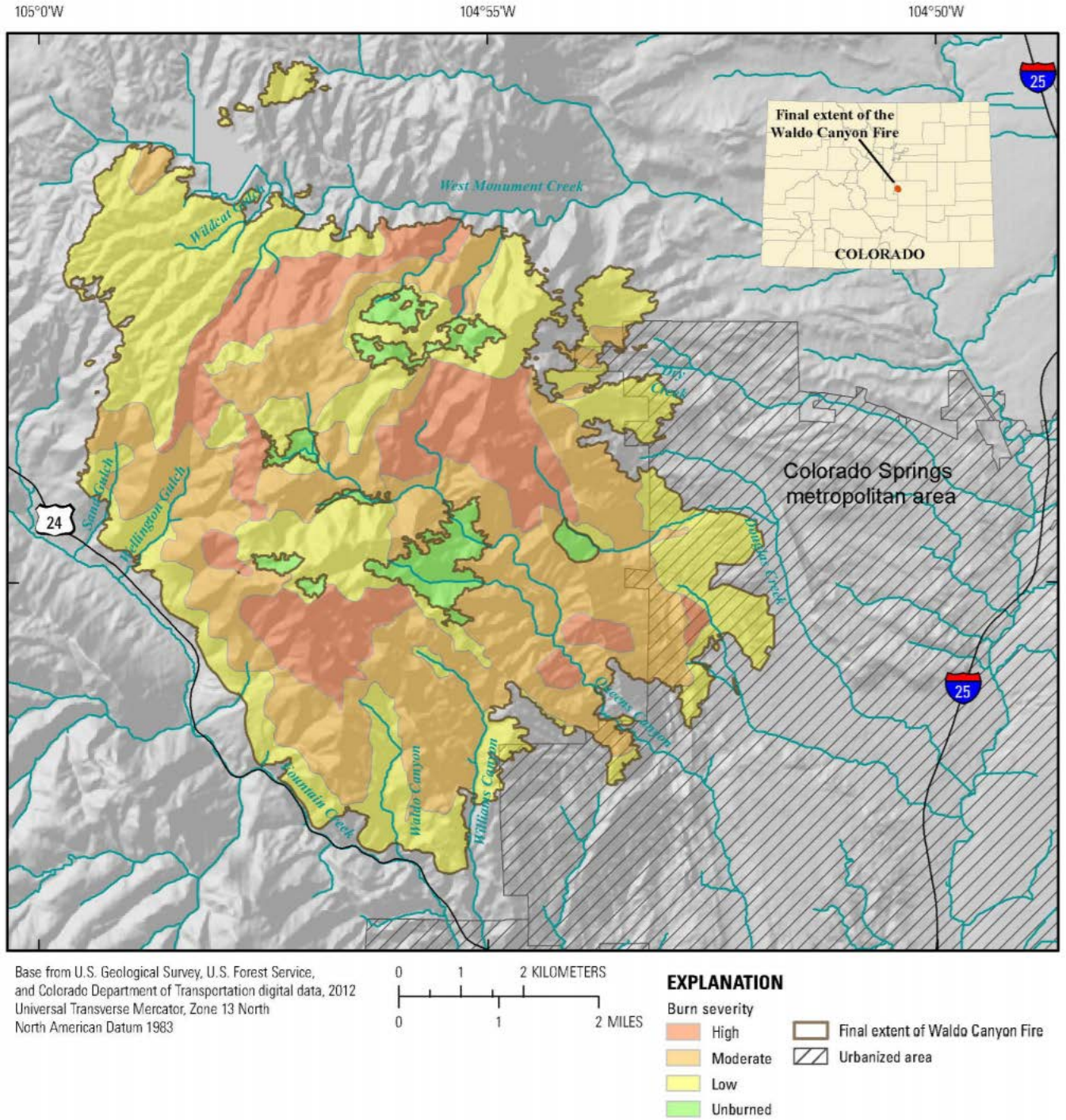


Waldo Canyon Fire Land Change

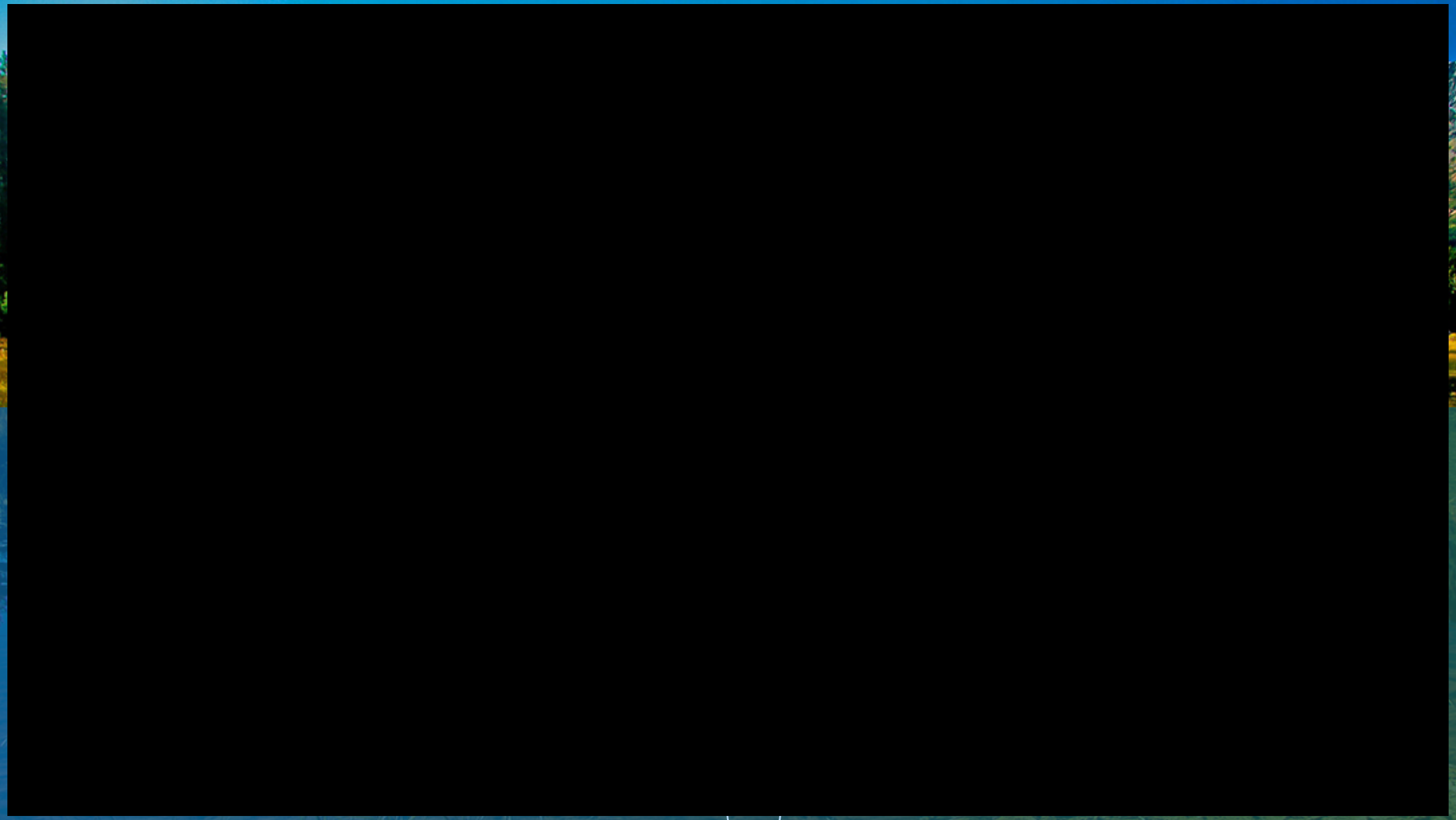
2 deaths; 344 homes destroyed (out of 1455 in Mountain Shadows); 85 more damaged;

Structure to structure ignition played a large role once the fire reached WUI areas

Limited forest recovery at present; near total land change to herbaceous in most areas; extensive restoration operations are underway…



- Massive potential for debris flows following the fire; Highway 24 particularly affected.
- Floods impacted transportation and cities; killing 1 in Manitou Springs in August of 2013.

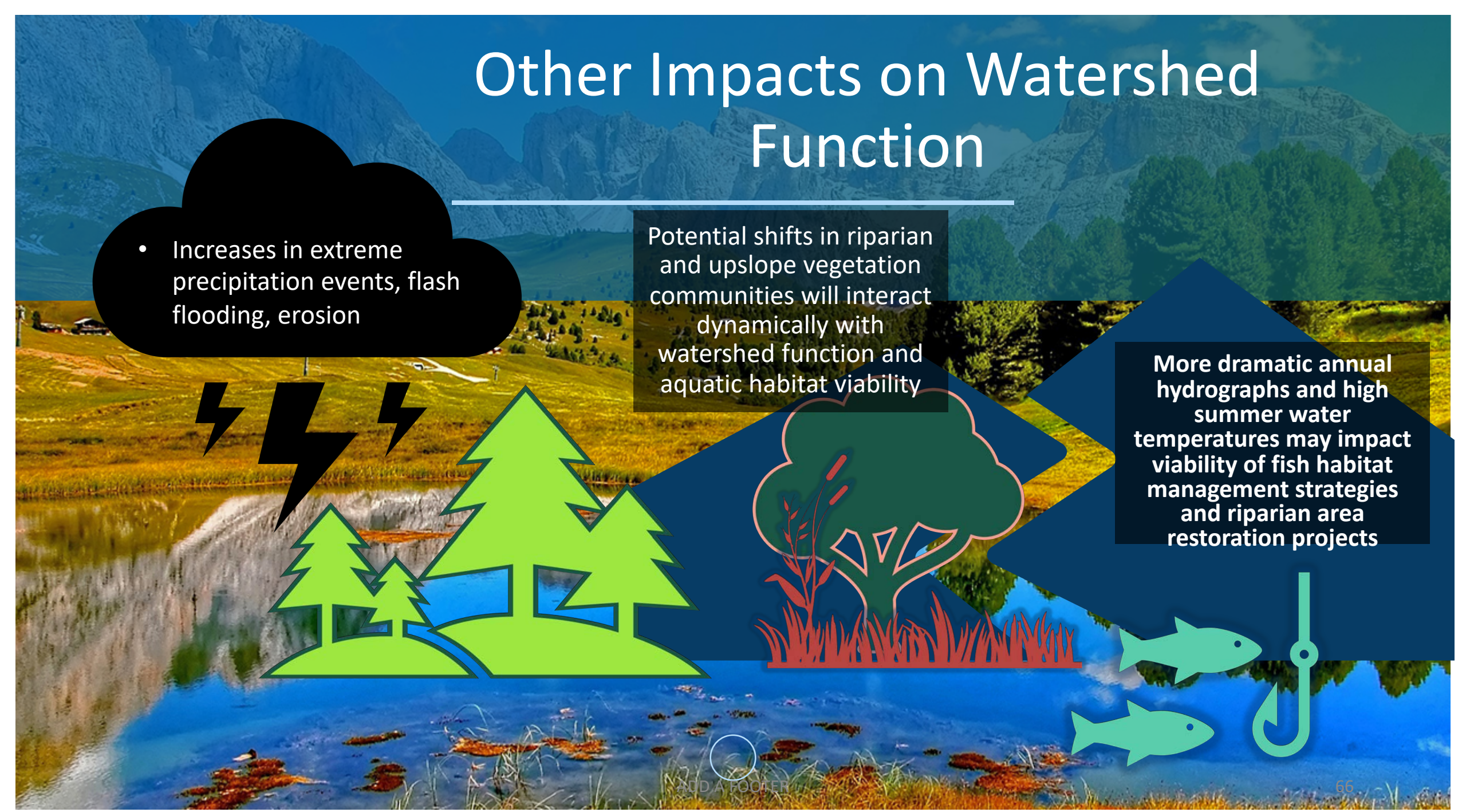


Other Impacts on Watershed Function

- Increases in extreme precipitation events, flash flooding, erosion

Potential shifts in riparian and upslope vegetation communities will interact dynamically with watershed function and aquatic habitat viability

More dramatic annual hydrographs and high summer water temperatures may impact viability of fish habitat management strategies and riparian area restoration projects



Effects on Wildlife

(From CNHP Reports and Others)

- Continued growth in the WUI and in mountain communities will heighten pressure on forest habitat, and increase interactions with people.
- False springs, where growing degree days begin long before the last frost, can lead to “food droughts” in forest ecosystems, driving wildlife into human inhabited areas.
- Ecological drought risk increases will likely result in increased animal mortality and decreased fecundity in browsing animals in some years; in rangeland/forest interface, increased livestock-wildlife interaction
- Migration patterns change for many hunted species, as do hibernation patterns for others. Misalignments in these seasonal behaviors with vegetation may cause serious problems.
- Alpine ecosystems and species face limited prospects for migration-based climate adaptation
- Cold-water fish increasingly habitat limited; many show extreme vulnerability to warming climate.
- Spruce Fir ecosystems face challenges from drought and insects; slow regrowth; poor germination at higher temps; loss of snowpack; however, may move into formerly alpine zones; how will related wildlife species respond?
- Ungulates may benefit from small scale disturbances in forest cover, but also face increased risks from disease due to population pressures. (McKelvey et al. 2018)

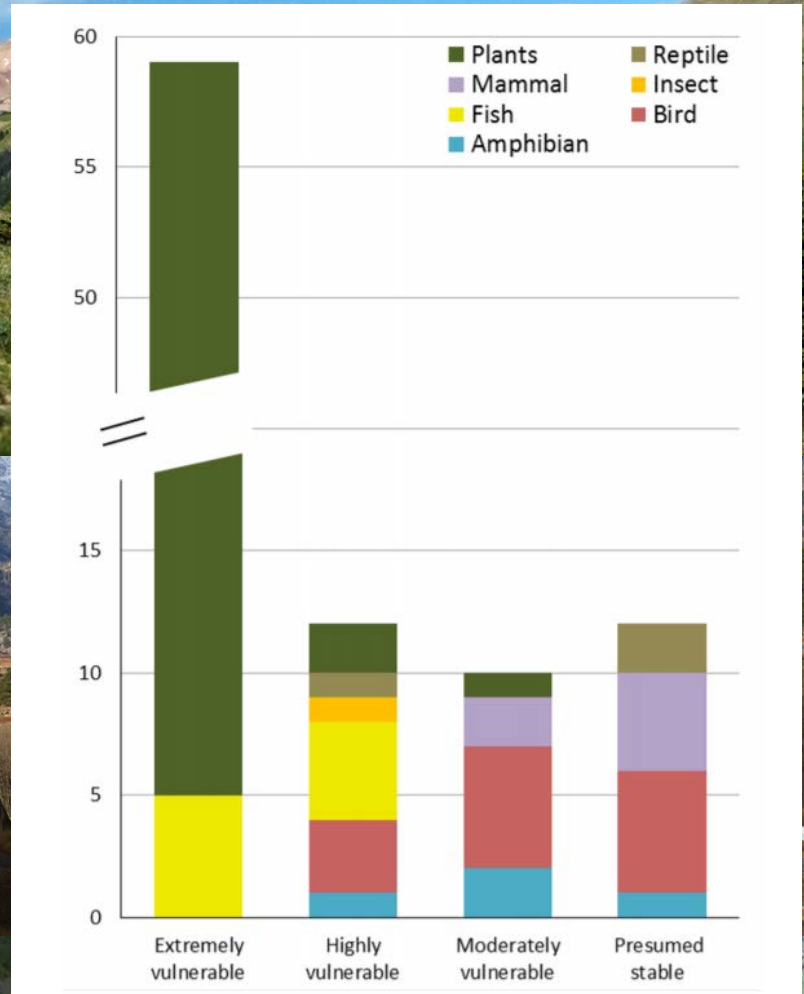


Figure 1.Species vulnerability by scoring category and taxonomic group.

Wildlife and Ecosystem Impacts

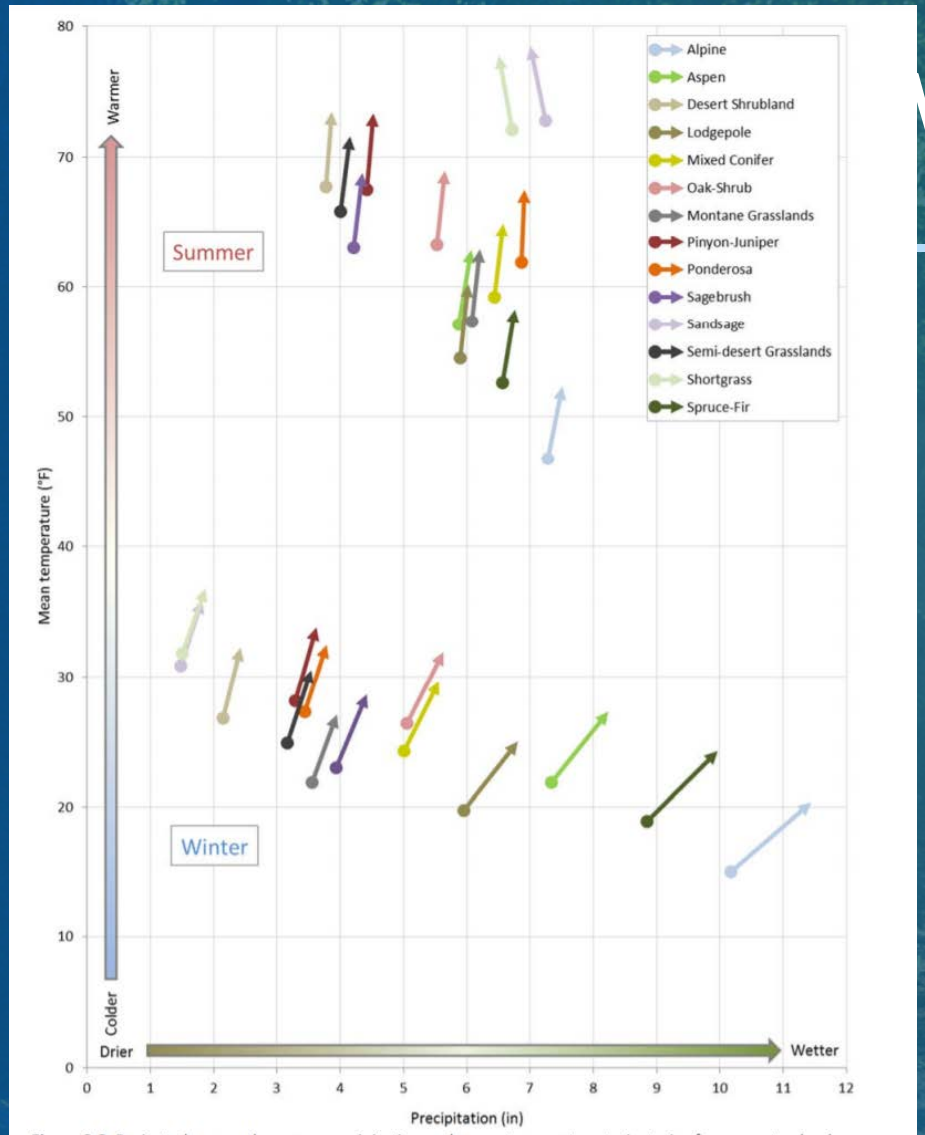


Figure 2.8. Projected seasonal average precipitation and mean temperature trajectories for current upland ecosystem ranges in Colorado by mid-century under a high radiative forcing scenario (RCP8.5). Circles represent current conditions.

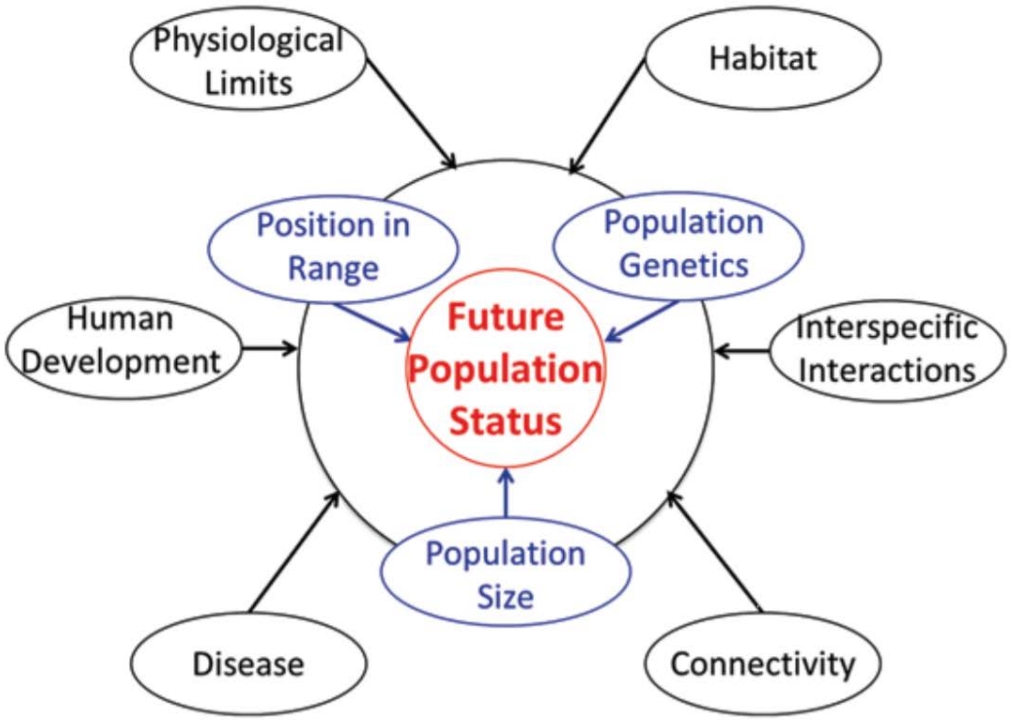
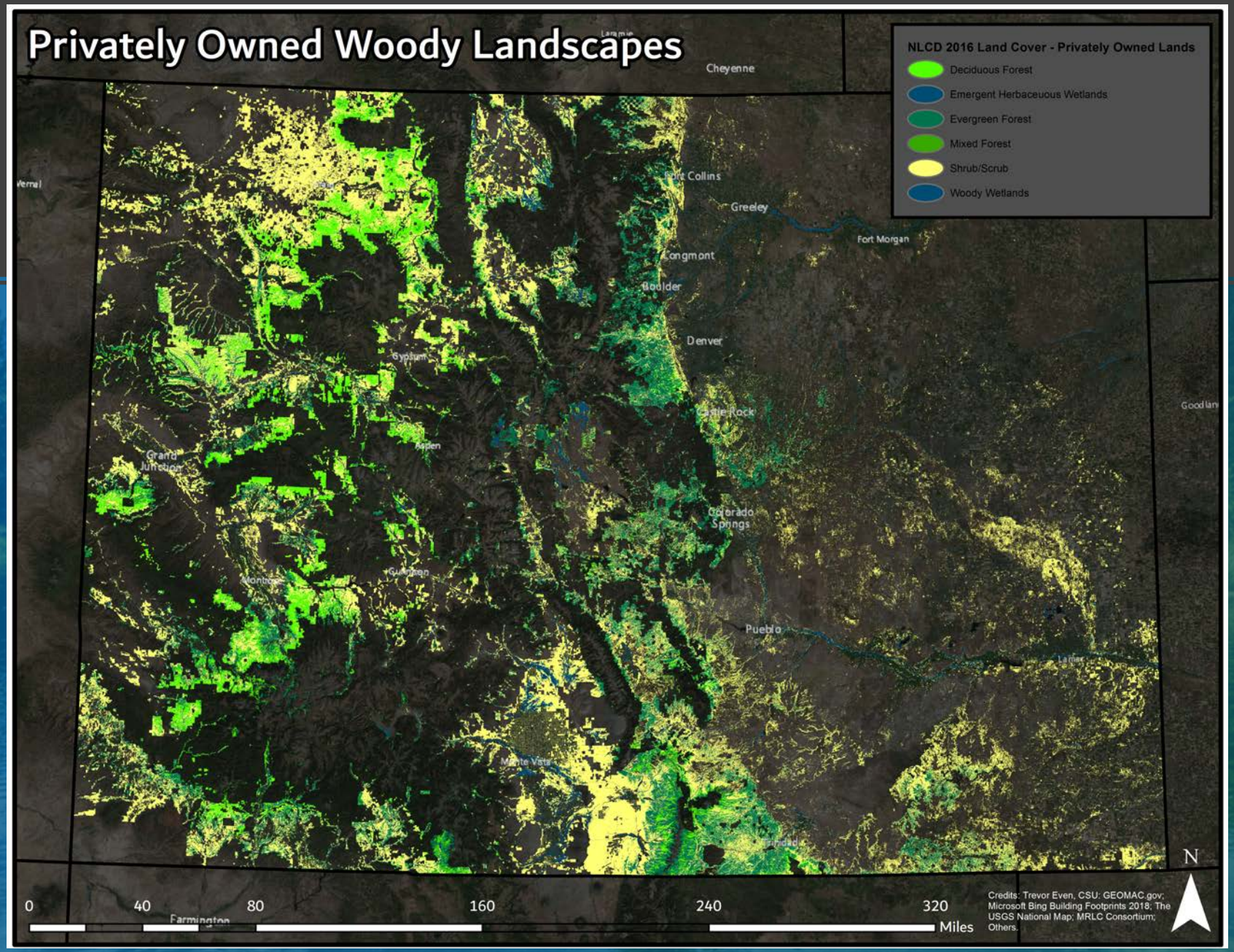


Fig. 8.1 Conceptual diagram of the effects of climate on wildlife populations in the Northern Rockies. Climate pathways (*black*) interact with population characteristics (*blue*) to affect population status (*red*)

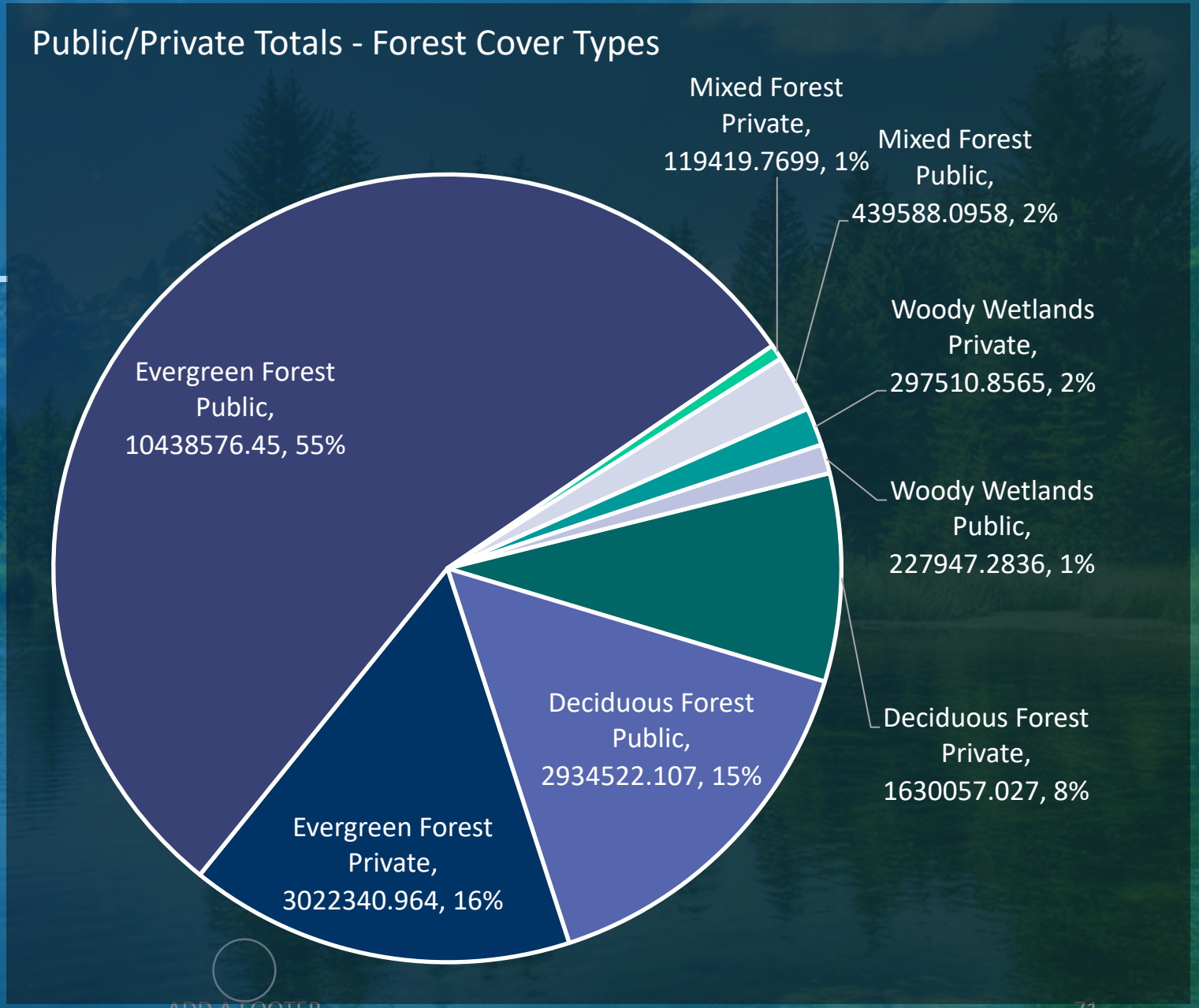
What will we do for Wildlife?

- Assisted migration?
- Post-fire rescue?
- Land use restrictions or pro-wildlife modifications?
- Behavior change?
- Forest, ribarian, shrubland restoration?
- Water allocation?
- Ecosystem and soil-focused ag and ranching?
- State- and Regional-level species protections?

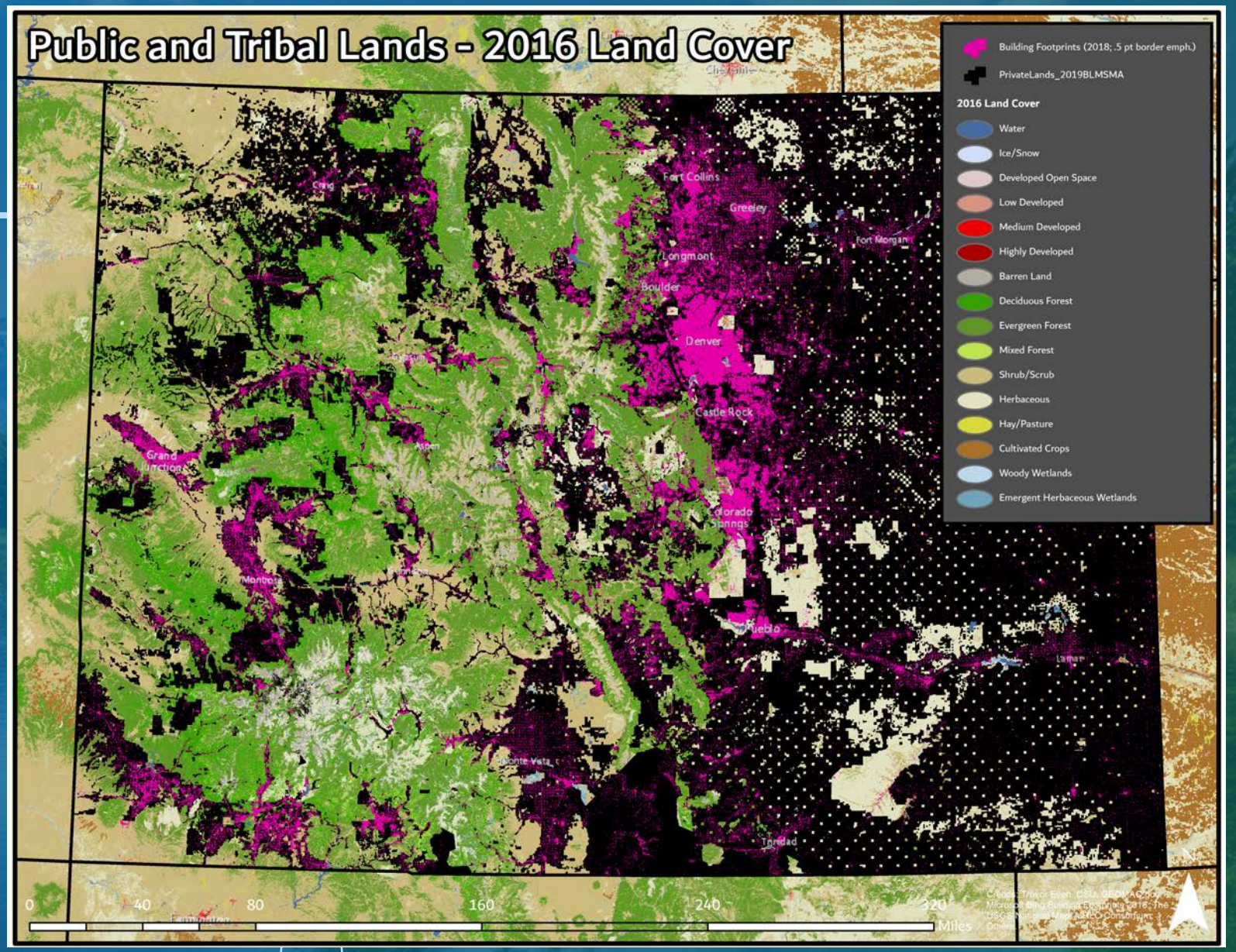

Privately Owned Woody Landscapes
NLCD 2016 Land Cover - Privately Owned Lands
Deciduous Forest
Emergent Herbaceuous Wetlands
Evergreen Forest
Mixed Forest
Shrub/Scrub
Woody Wetlands
Cheyenne
Fort Collins
Greeley
Fort Morgan
Longmont
Boulder
Denver
Gypsum
Castle Rock
Aspen
Grand Junction
Colorado Springs
Pueblo
Monte Vista
Trinidad
Farmington
0
40
80
160
240
320
Miles
N
Credits: Trevor Even, CSU; GEOMAC.gov; Microsoft Bing Building Footprints 2018; The USGS National Map; MRLC Consortium; Others.

Who owns the forest?

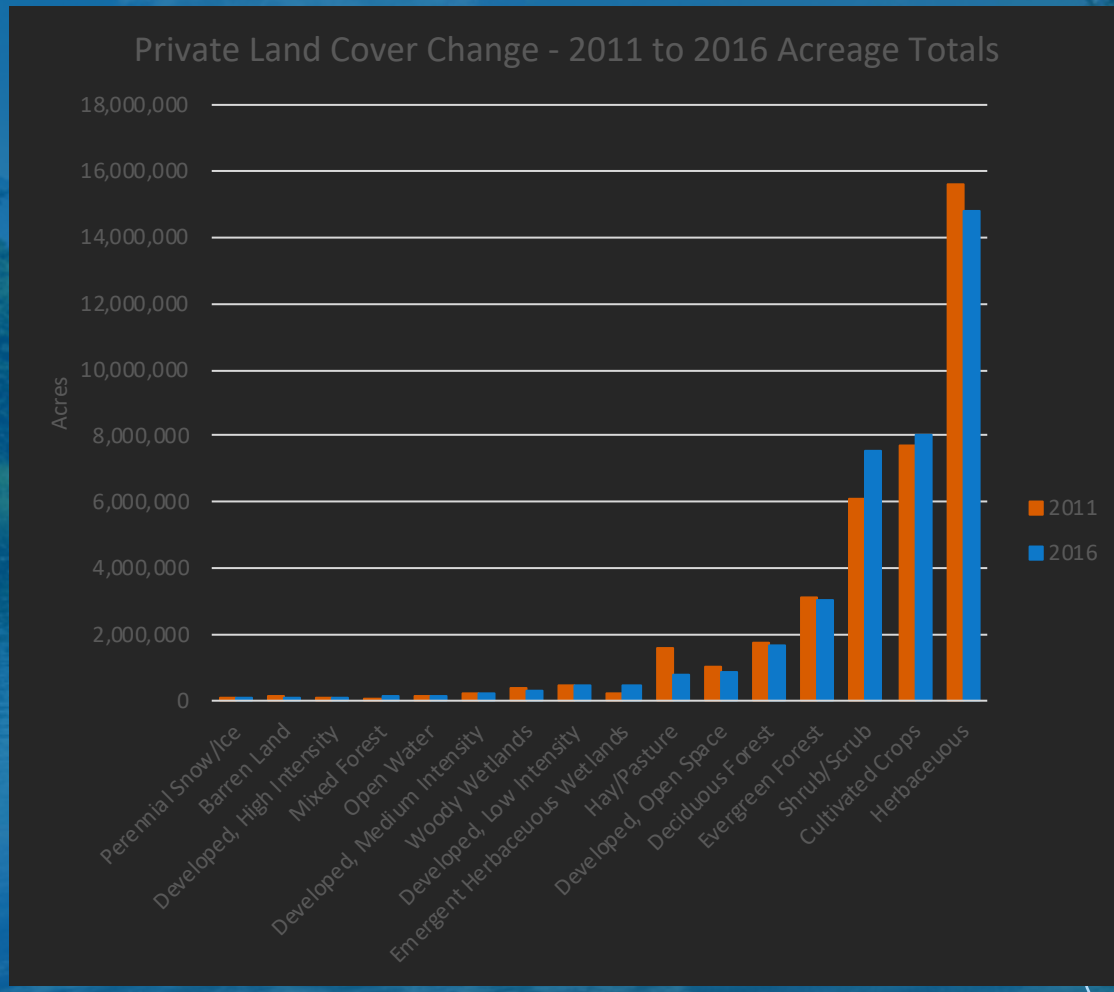
~5 million private acres (26.5%)
~14 million Federal, Tribal, State, or Local acres (73.5%)

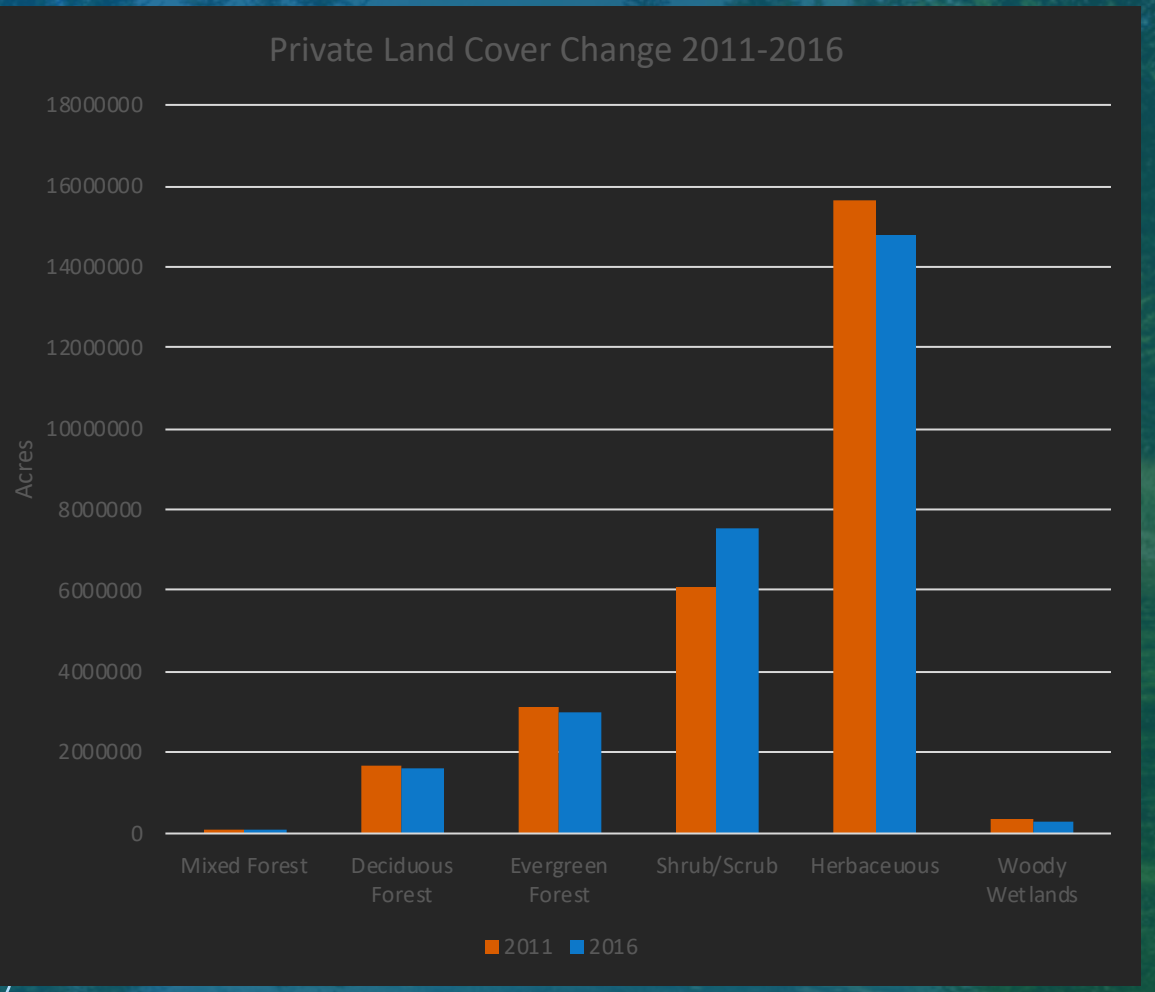


Public Lands in Colorado - 2016 Land Cover Class and Acreage



2019 Private Land Cover Change 2011-2016





Forest Products

- Forest products markets are under-developed in Colorado, though innovation is happening
- Local urban forestry and wood milling companies have emerged in some Front Range and West Slope communities
- Efforts to harvest and market beetle kill face infrastructure and supply chain issues
- Biochar developments?
- Longer growing seasons and more rapid growth cycles may present incentives for some forest product systems
- Long lasting forest products can hypothetically sequester carbon; similarly, managed forest harvesting can ostensibly result in net carbon gains.
- May run out of time for usefulness as older dead trees rot in place…

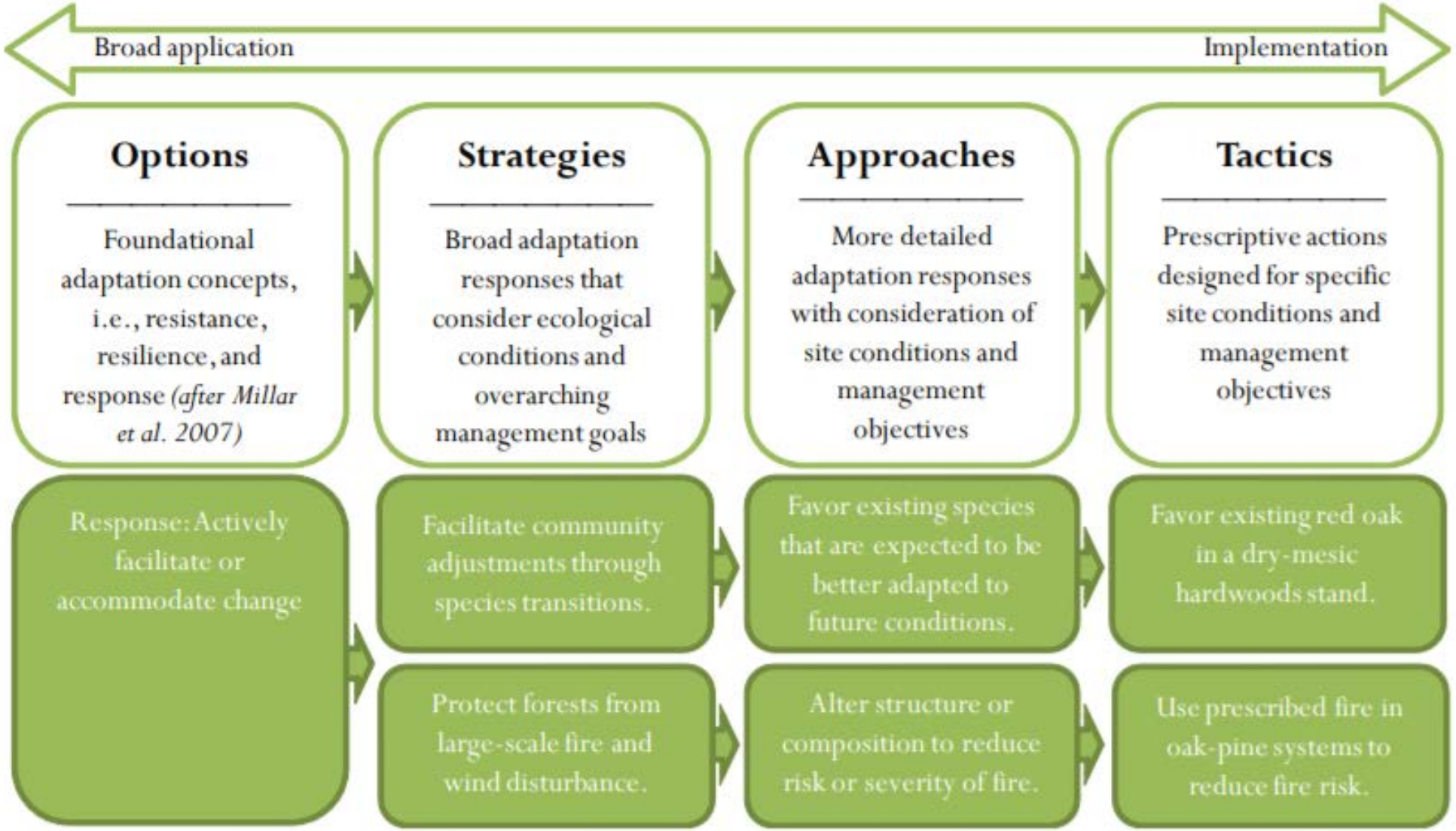
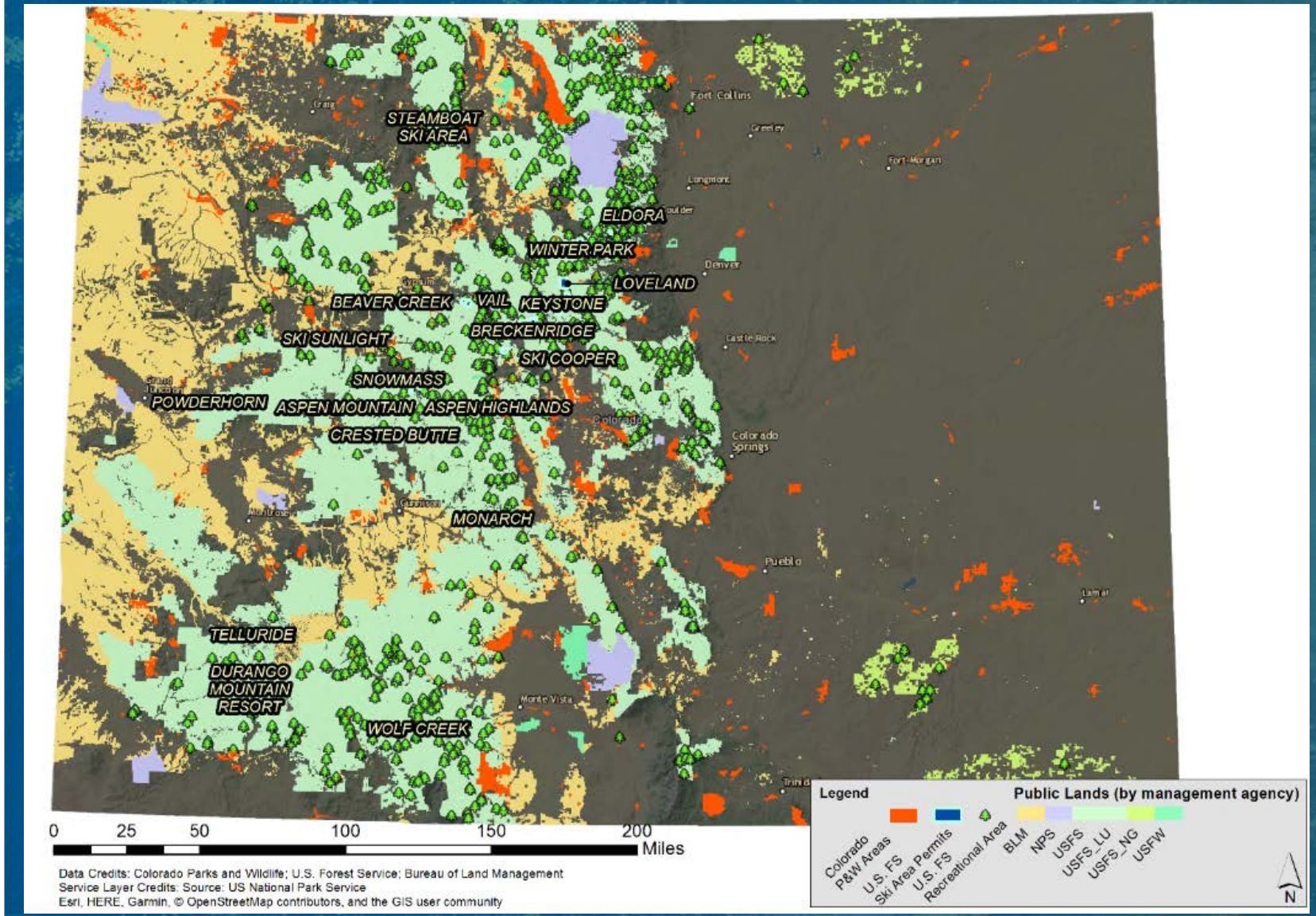


Figure 6.—A continuum of adaptation actions is available to address needs at appropriate scales and levels of management (top). The shaded boxes provide examples of each level of action (bottom). (Modified from Janowiak et al. 2011.)

How will forest management continue to “meet people where they are?”



Recreational land resources in the form of public lands, public recreational facilities, ski slopes (with names in all caps), and National Parks are concentrated heavily in the Western and mountainous areas of the state. Not pictured here: the state's world famous rafting courses scattered across the upper Colorado, Yampa, Gunnison, Arkansas, and other rivers, nor roughly half a dozen privately-owned ski areas.

Multiple wildfires in our area. Fireworks and campfires are banned. Fire Dept is a volunteer service are getting very tired due to the number of responses. Children are kept inside and not allowed to play outdoors due to heat and sun. Craig (NW CO; West of Steamboat Springs) Jul 5 2018

Outdoor Recreation in Colorado (2017)

Total Economic Output:

$62.5 Billion

Total Jobs:

511,000

(18.7% of all jobs statewide)

Salaries and Wages:

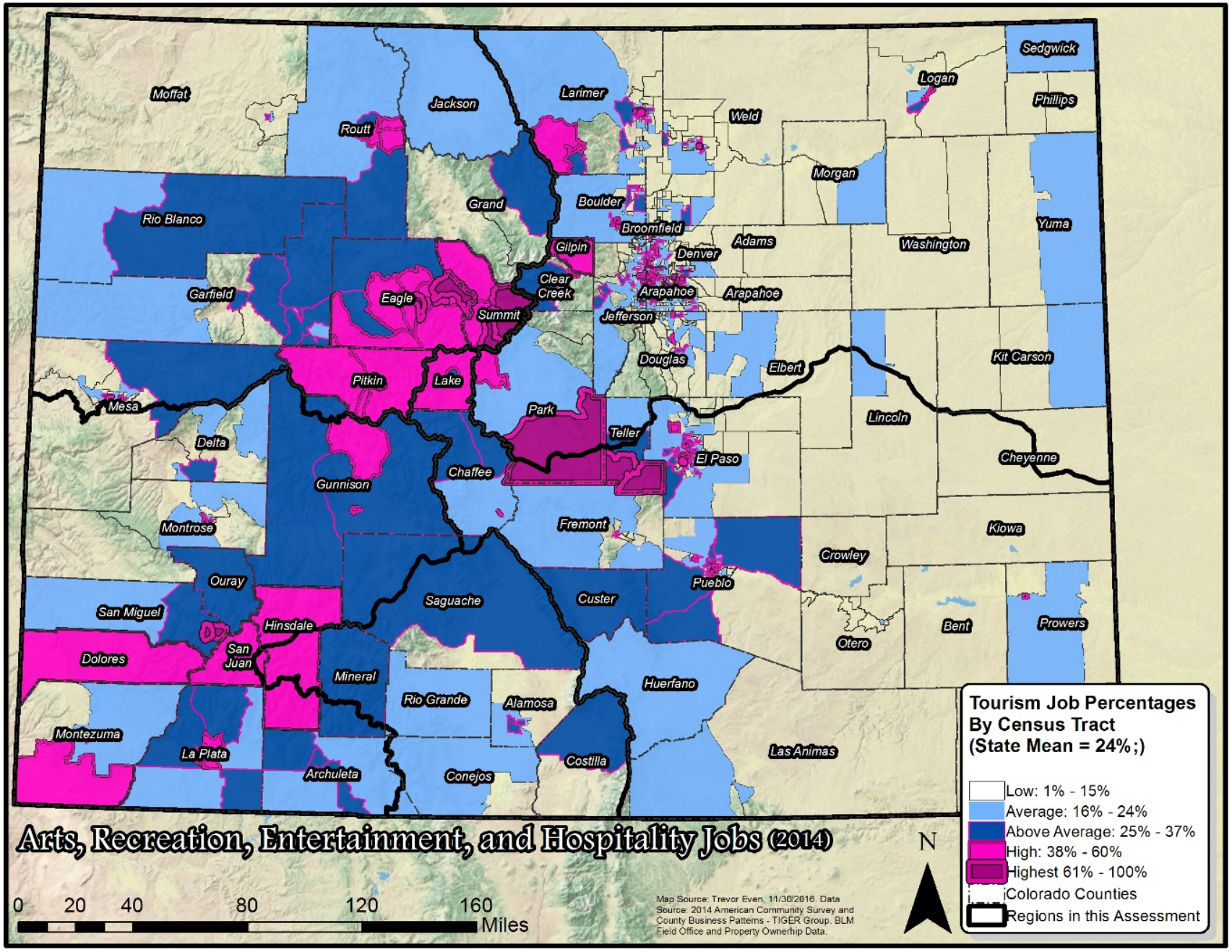
$21.4 Billion

State and local Taxes:

$4.3 Billion

Source: Colorado Parks and Wildlife (2018)

Outdoor Recreation

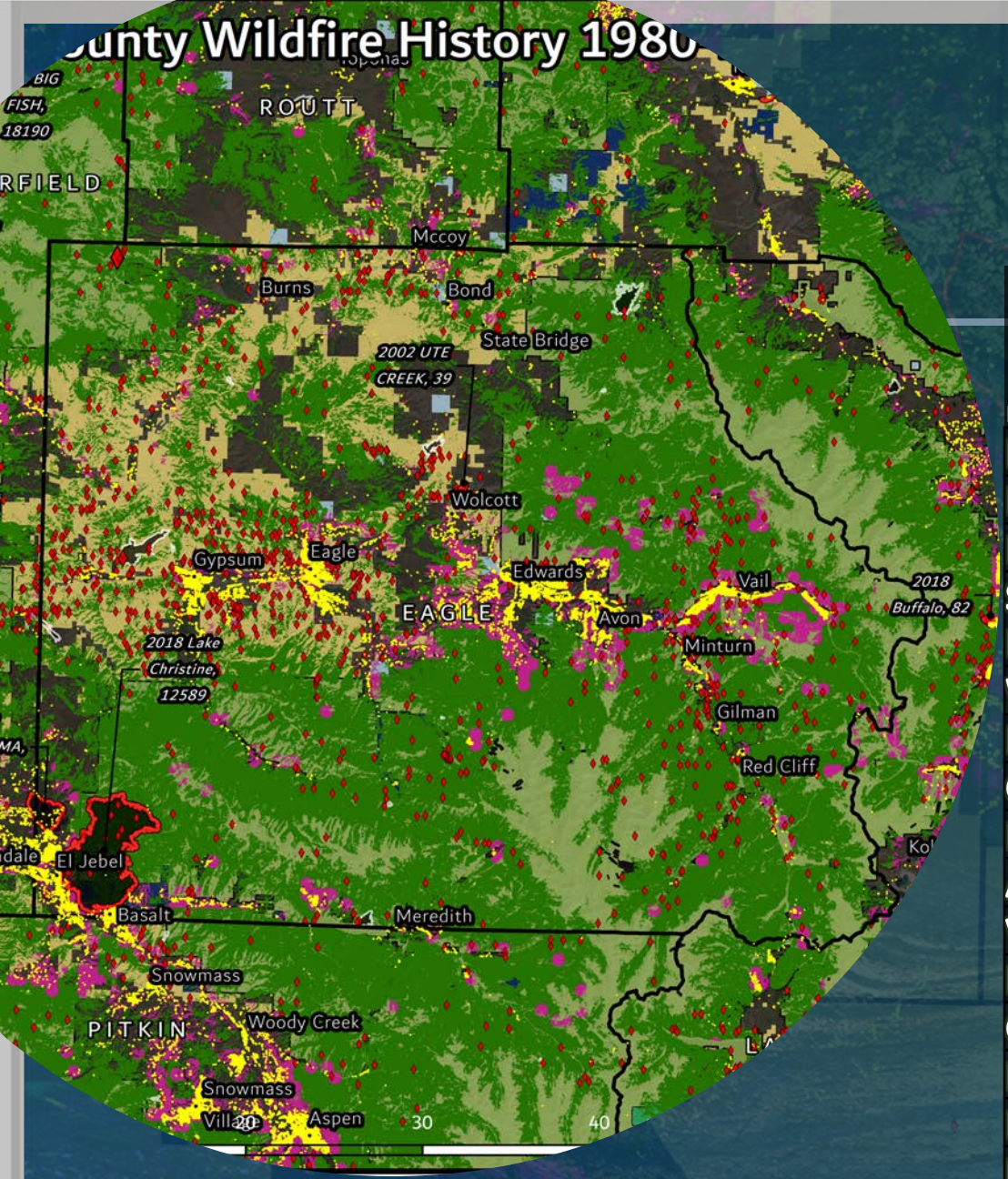


Map 11 - In many areas of Colorado, tourism-related economic activity is the only game in town - i.e., the only option for jobs, and likewise, the main reason for living in a given town in the first place. However, these areas face significant risks when toruism spending declines, or local extreme weather events send visitors elsewhere.

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



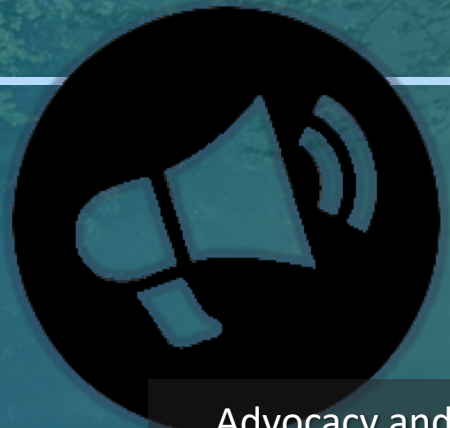
Eagle County by 2050

NameFix	Change in Mean Annual Temperature by 2050 (F)	Change in Mean Annual Precipitation (In.)	Change in Mean Temperature of Warmest Month (F)	Change in Mean Temperature of Coldest Month (F)	Change in Freezing Degree Days (<32 F)	Change in Growing Degree Days (>41 F)	Change in Amount of Precipitation as Snow (In.)
Mccoy	6	0	7	4	-524	1397	-1
Burns	6	0	7	4	-513	1418	-1
Bond	6	0	7	4	-545	1368	-1
State Bridge	6	0	7	4	-551	1359	-1
Wolcott	6	0	7	4	-544	1343	-1
Eagle	6	0	7	4	-497	1400	-1
Gypsum	6	0	7	4	-490	1429	-1
Edwards	6	0	7	4	-529	1343	-1
Avon	6	0	7	4	-554	1305	-2
Vail	6	0	7	4	-614	1215	-3
Minturn	6	0	7	4	-592	1246	-2
Gilman	6	0	7	4	-662	1138	-3
Red Cliff	6	0	7	4	-653	1147	-3
El Jebel	6	-1	7	4	-423	1476	-1
Basalt	6	-1	7	4	-439	1444	-2

Critical Adaptations in Outdoor Recreation

Spatial Diversification

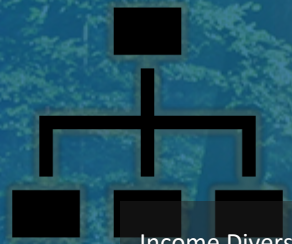
Consolidation



Advocacy and Lobbying

Forest and Watershed Stewardship

Global Marketing



Income Diversification

Year-round Recreational Planning

Artificial Snow-Making

Cooperative Agreements

Full-Cycle Hazard Planning (esp. Recovery!)

The Road(s) Ahead…

- Flexibility
- Responsivity and Knowledge-generation
- Diversity
- Place-based
- Framework-driven
- Long-term Resilience
- Value-driven

THANK YOU!