

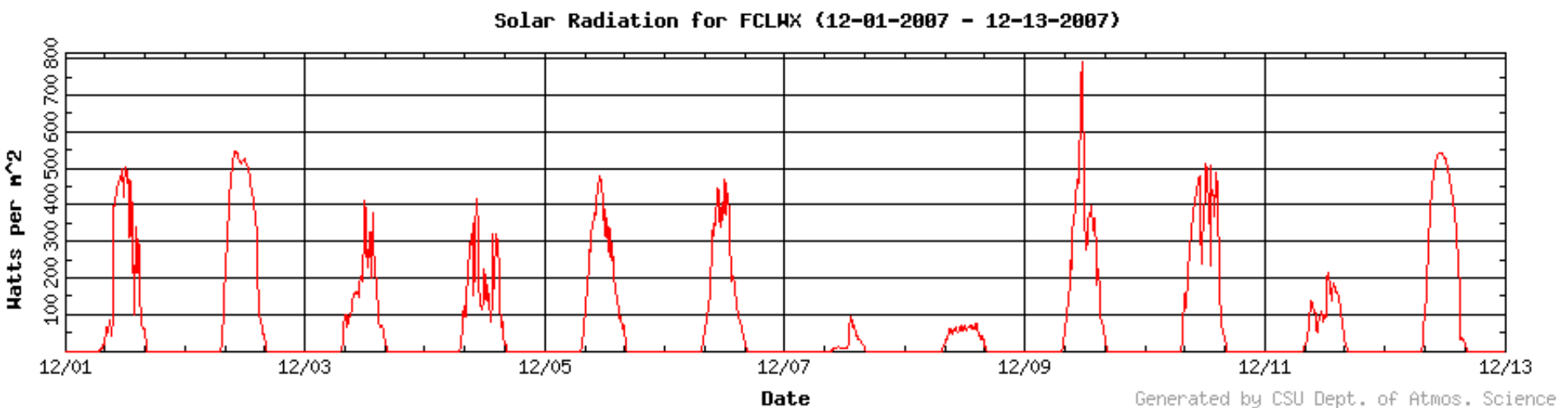
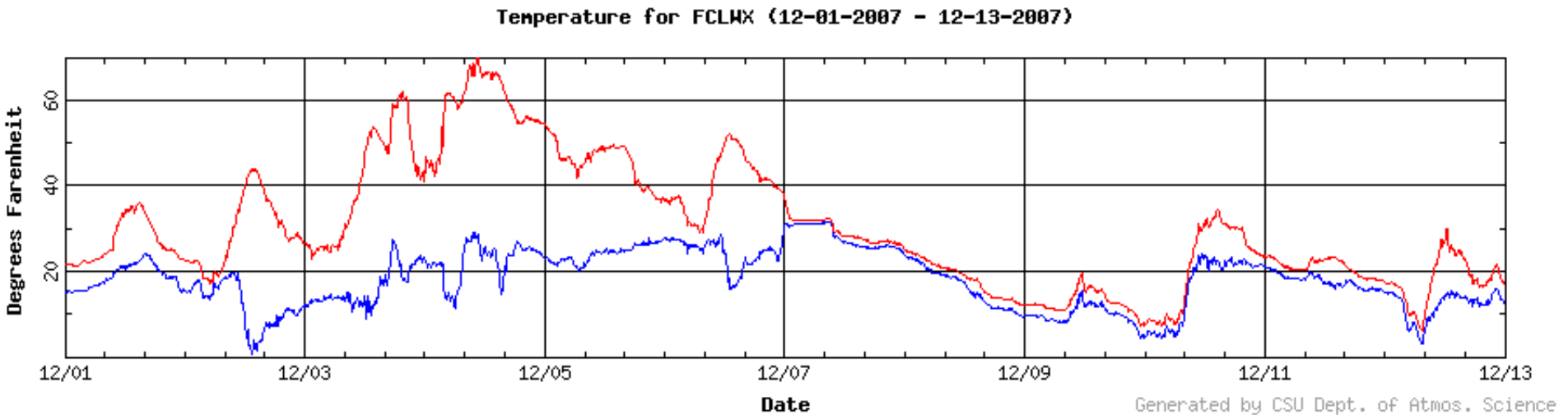
Drought Characteristics in Colorado 1890 to 2008

**Nolan Doesken
State Climatologist
Colorado Climate Center**

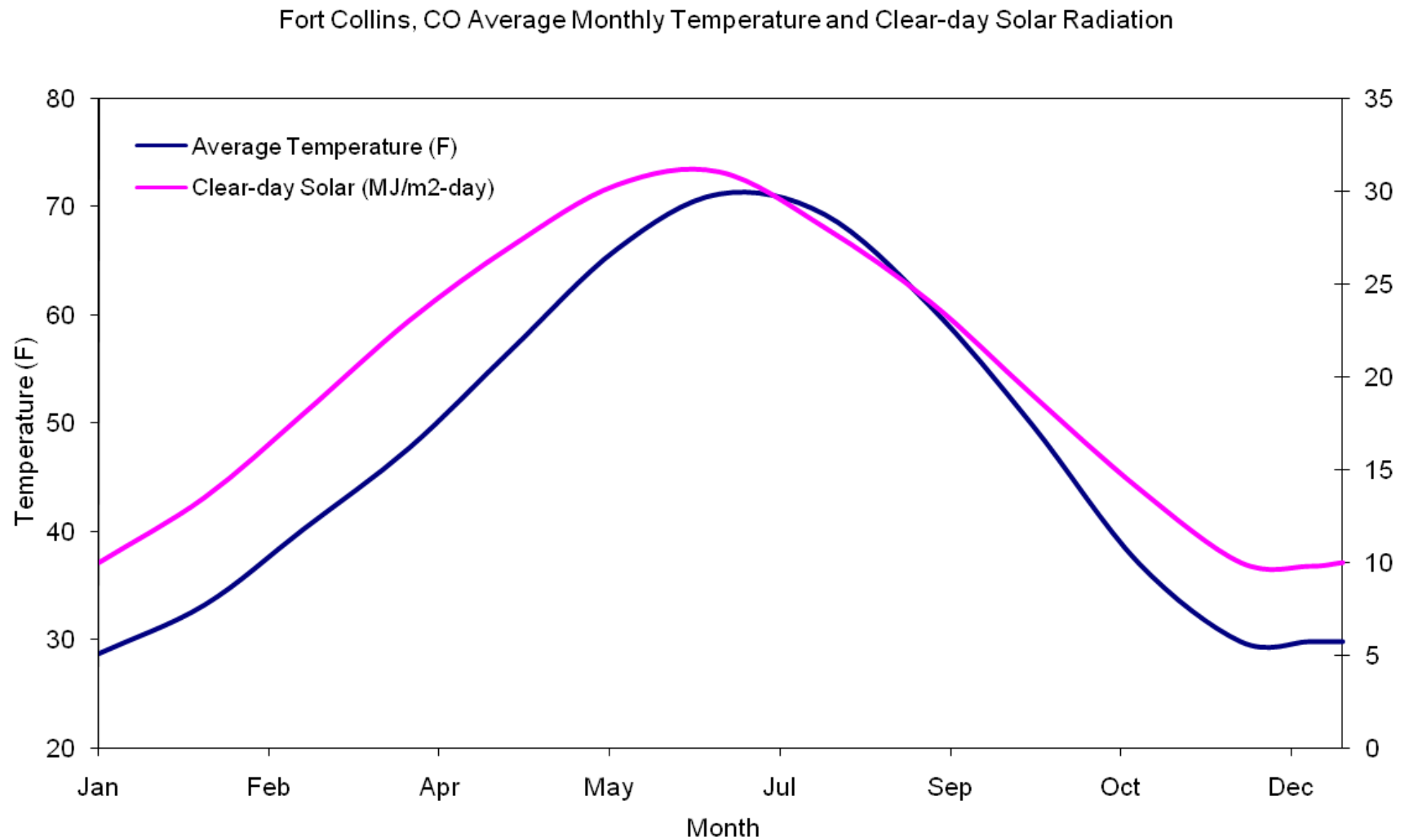
**Presented at Governor's Conference on Managing Drought &
Climate Risk, October 8–10, 2008, Denver, CO**



Seasonal changes and year-to-year variations are a natural and exciting part of our climate!

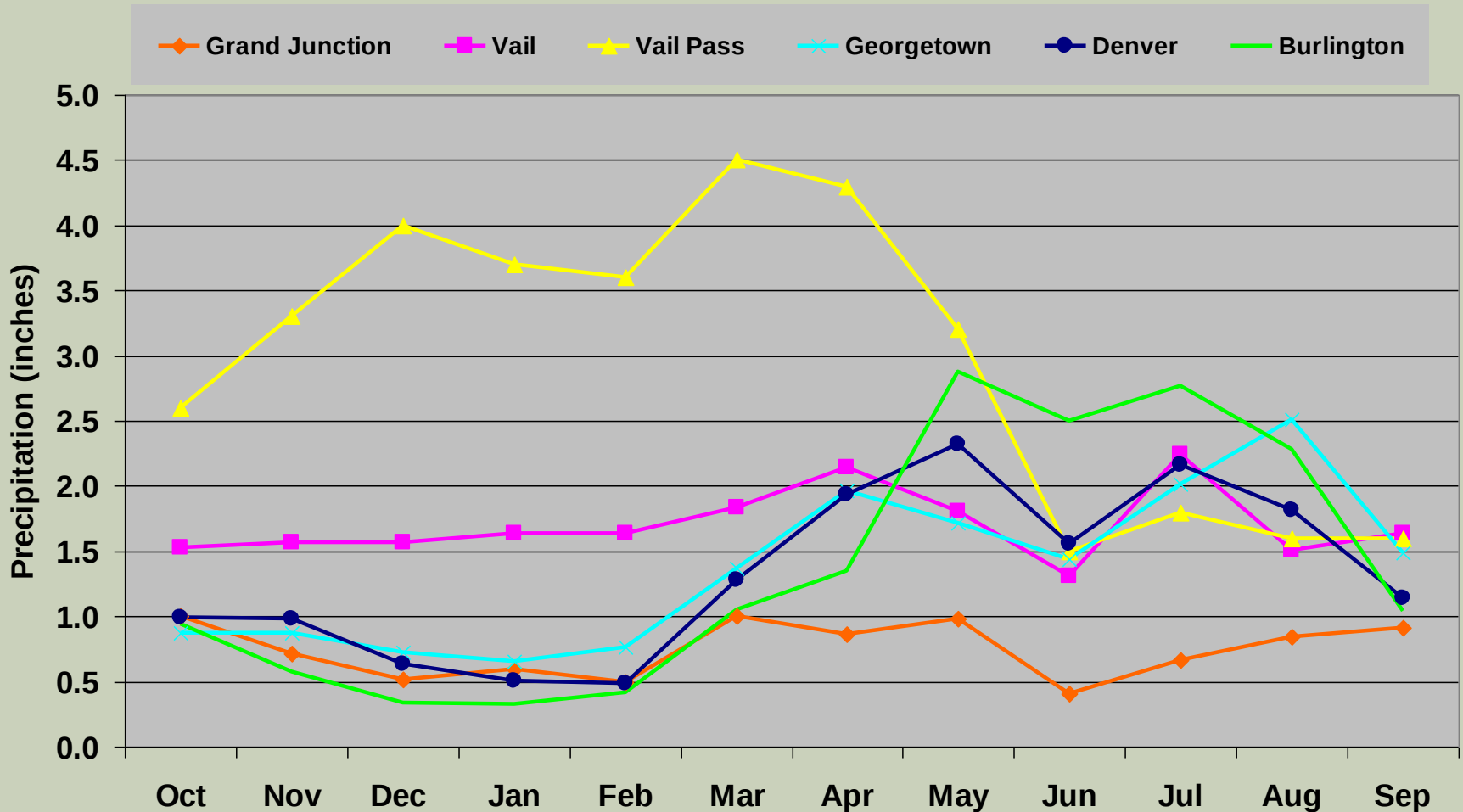


Fort Collins Average Monthly Temperature and Clear-Day Solar Radiation

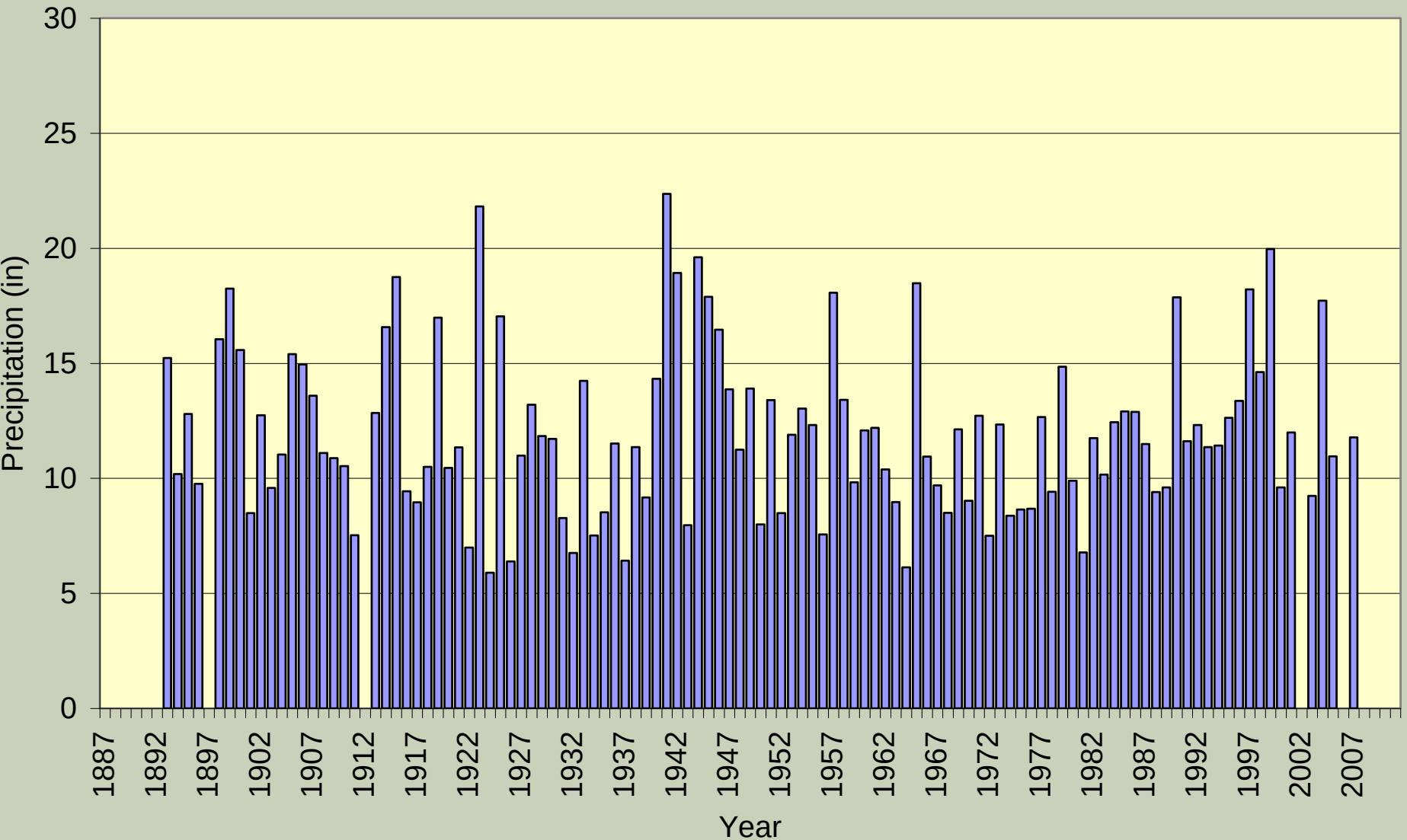


Average Monthly Precipitation Across the State

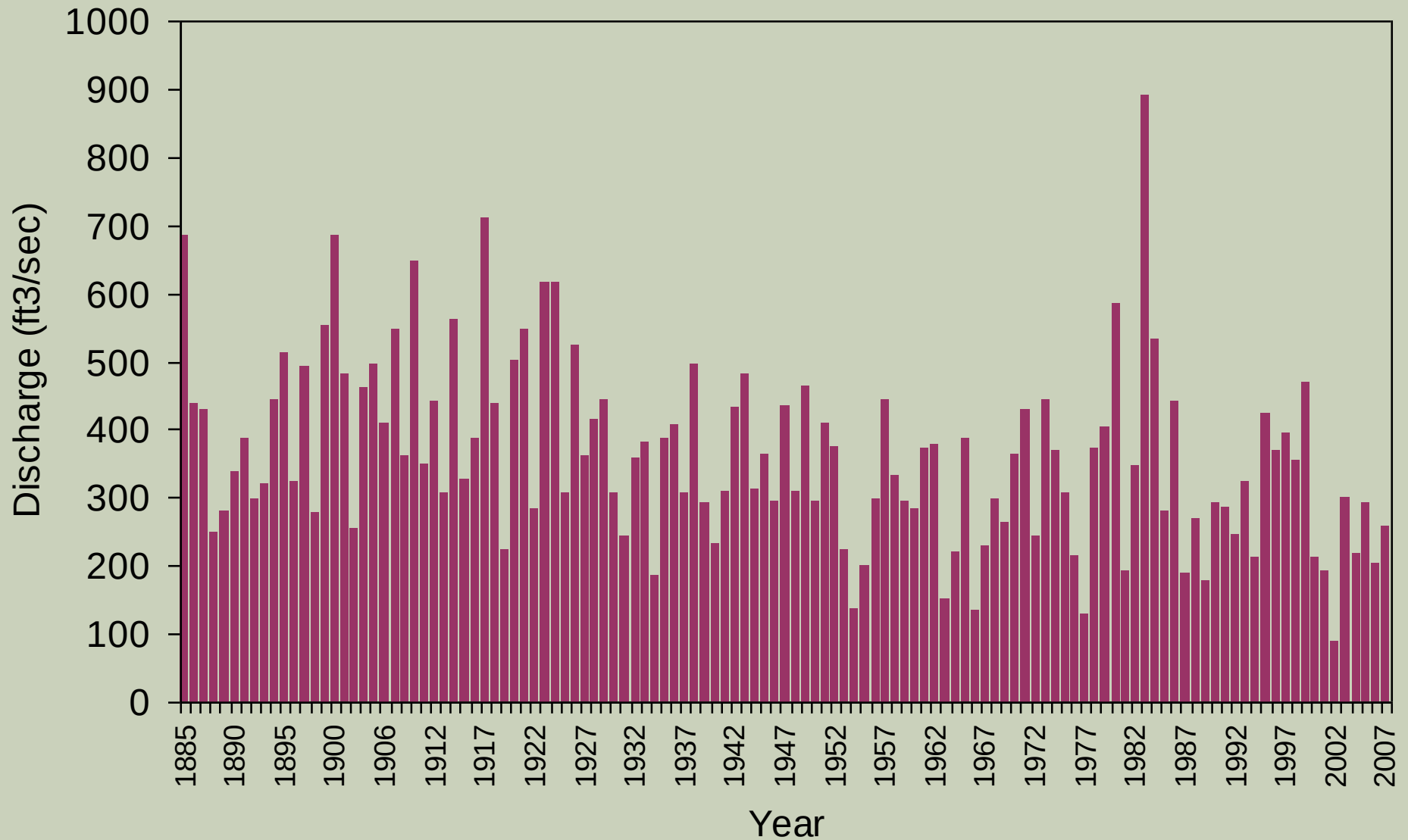
Water Year Average Precipitation for Selected Stations



Rocky Ford Annual Precipitation



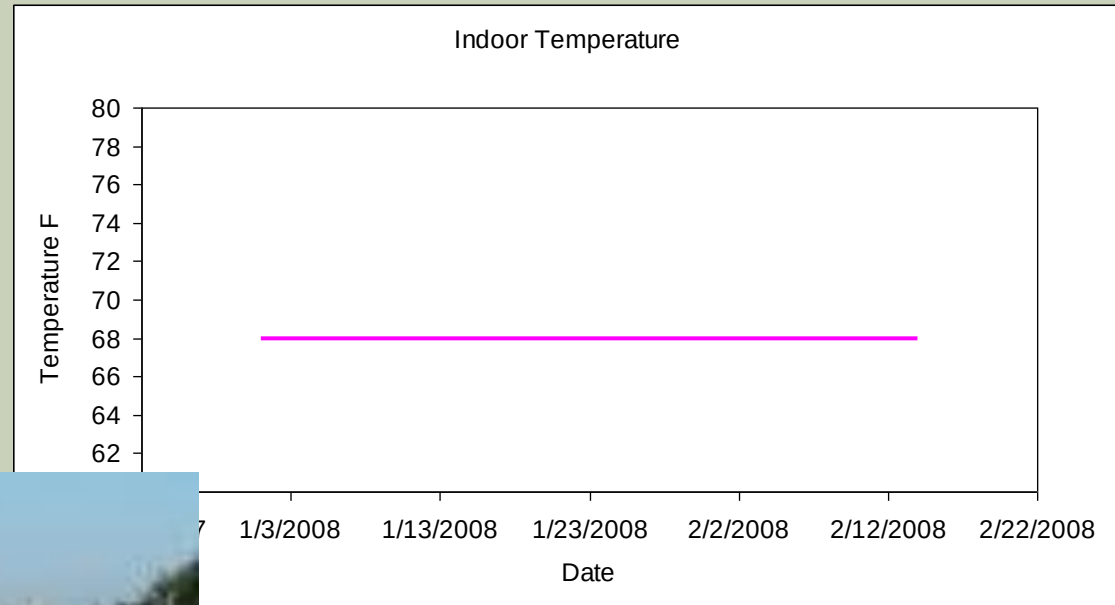
Poudre River at Canyon Mouth Annual Discharge (ft³/sec)



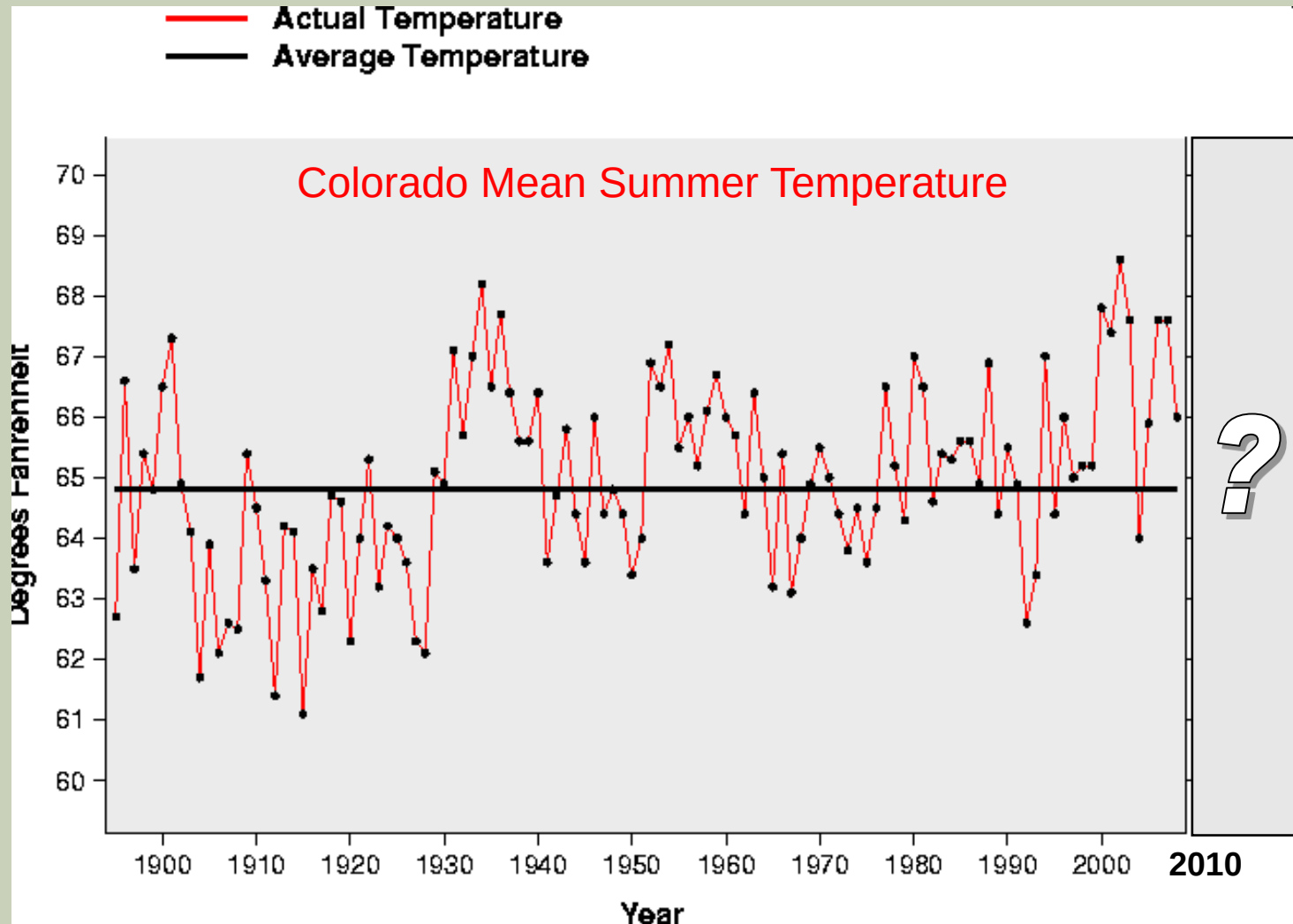
Natural systems accommodate and survive typical variability



Human built and manages systems strive to minimize variability



Today, we wonder what lies ahead. Can we manage the climate variability we are sure to face?



Climate and Drought Monitoring

Since the 1870's we have attempted to measure and track our climate and it's variations here in Colorado.

(FORM 4.)

WAR DEPARTMENT.
SIGNAL SERVICE, U. S. ARMY.
DIVISION OF TELEGRAMS AND REPORTS FOR THE BENEFIT OF COMMERCE.

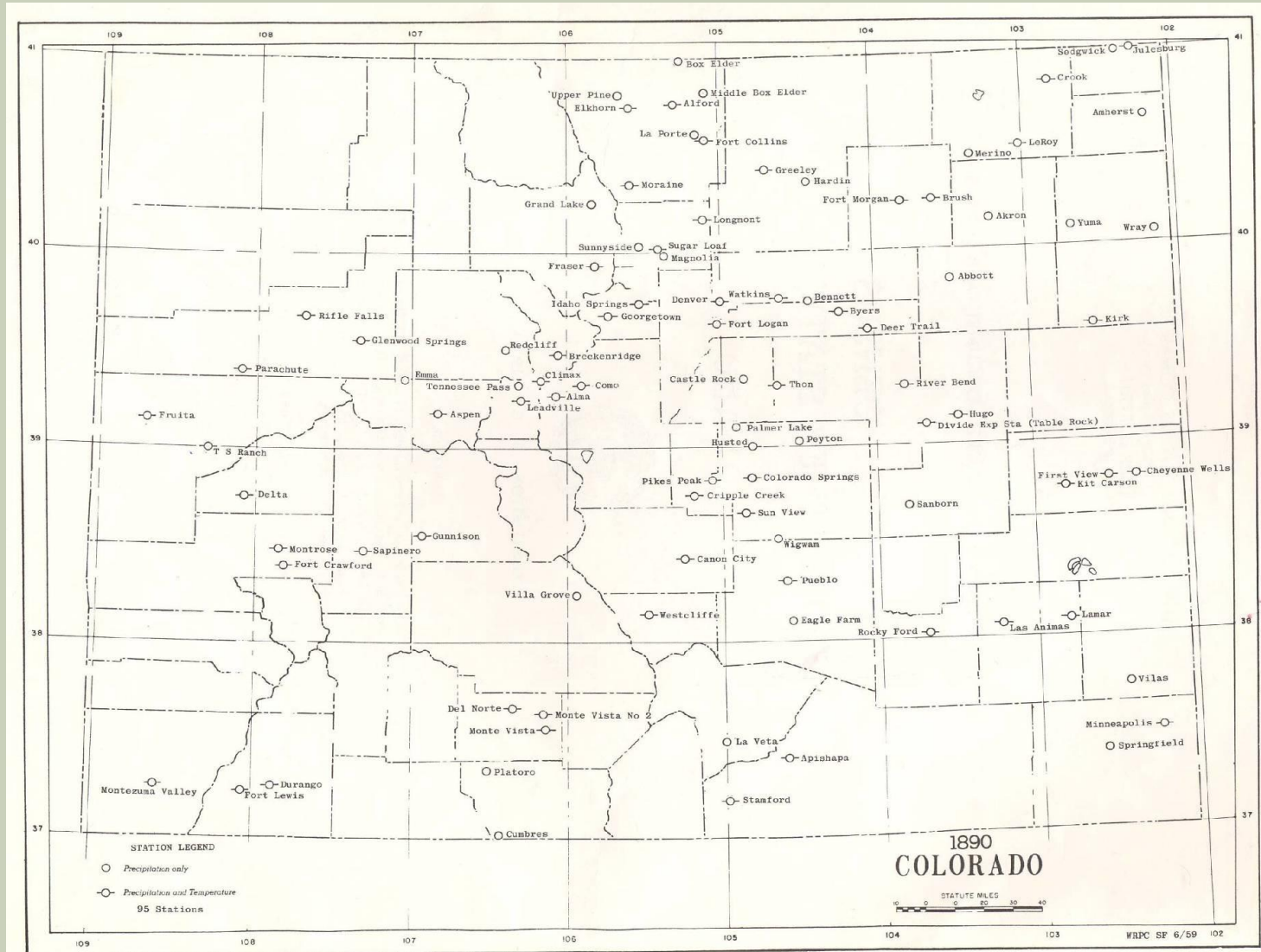
METEOROLOGICAL RECORD for the *Hutch* ending *Nov. 25th 1871* at *Denver* *Col. Ter.*

Date of Observation.	Time of Observation.	Height of Barometer.	Height of attached Thermometers.	Reduced Barometer.	THERMOMETER. (OPEN AIR.) <i>Hygrometer</i>		Direction of wind.	Velocity of wind in miles per hour.	Pressure of wind. Pounds per square foot.	Amount of cloud.	Direction in which upper clouds move.	Rain (or snow) commenced. (Time.)	Rain (or snow) ended. (Time.)	Amount of rain or melted snow.	Remarks.
					Dry Bulb.	Wet Bulb.									
<i>1871</i>															
<i>Sunday Nov 19</i>	<i>5:43 a.m.</i>	<i>25.00</i>	<i>51 22</i>	<i>30.07</i>	<i>22 21 16</i>	<i>16</i>	<i>0</i>	<i>0</i>	<i>0</i>	<i>4/4</i>		<i>6:30 a.m.</i>	<i>Blank</i>		<i>Light Snow - Cloud</i>
	<i>2:45 p.m.</i>	<i>25.09</i>	<i>63 30</i>	<i>29.97</i>	<i>36 30 40</i>	<i>36</i>	<i>2</i>	<i>.02</i>	<i>0</i>						
	<i>4:43 p.m.</i>	<i>25.12</i>	<i>58 14</i>	<i>30.20</i>	<i>14 12 64</i>	<i>14</i>	<i>11</i>	<i>.60</i>	<i>0</i>						<i>Clear</i>
	<i>5:43 a.m.</i>	<i>25.00</i>	<i>51 22</i>	<i>30.07</i>	<i>22 21 16</i>	<i>16</i>	<i>0</i>	<i>0</i>	<i>4/4</i>			<i>6:30 a.m.</i>	<i>8:00 a.m.</i>	<i>Blank</i>	<i>Light Snow - Cloud</i>
	<i>2:43 p.m.</i>	<i>25.09</i>	<i>63 30</i>	<i>29.97</i>	<i>36 30 40</i>	<i>36</i>	<i>2</i>	<i>.02</i>	<i>0</i>	<i>2</i>					<i>Clear</i>
<i>Monday Nov 20</i>	<i>1:43 p.m.</i>	<i>25.12</i>	<i>52 14</i>	<i>30.20</i>	<i>14 12 64</i>	<i>14</i>	<i>11</i>	<i>.60</i>	<i>0</i>						<i>Clear</i>
	<i>5:43 a.m.</i>	<i>24.99</i>	<i>50 21</i>	<i>30.07</i>	<i>21 19 18</i>	<i>21</i>	<i>13</i>	<i>.84</i>	<i>1/4</i>	<i>24</i>					<i>Stratus</i>
	<i>2:43 p.m.</i>	<i>24.88</i>	<i>56 43</i>	<i>29.67</i>	<i>43 34 28</i>	<i>43</i>	<i>18</i>	<i>1.62</i>	<i>4/4</i>	<i>103</i>					<i>Stratus</i>
<i>Tuesday Nov 21</i>	<i>4:43 p.m.</i>	<i>24.88</i>	<i>58 39</i>	<i>29.70</i>	<i>39 34 53</i>	<i>39</i>	<i>2</i>	<i>.02</i>	<i>4/4</i>	<i>343</i>					<i>Stratus</i>
	<i>5:43 a.m.</i>	<i>24.70</i>	<i>55 31</i>	<i>29.59</i>	<i>34 29 19</i>	<i>34</i>	<i>2</i>	<i>.00</i>	<i>4/4</i>	<i>97</i>					<i>Stratus</i>
	<i>2:43 p.m.</i>	<i>24.57</i>	<i>62 33</i>	<i>29.30</i>	<i>33 32 70</i>	<i>33</i>	<i>2</i>	<i>.02</i>	<i>4/4</i>	<i>97</i>					<i>"</i>
<i>Wednesday Nov 22</i>	<i>4:43 p.m.</i>	<i>24.71</i>	<i>61 31</i>	<i>29.59</i>	<i>31 30 89</i>	<i>31</i>	<i>10</i>	<i>.50</i>	<i>4/4</i>	<i>32.3</i>		<i>3 p.m.</i>	<i>11 p.m.</i>	<i>.26</i>	<i>Light Snow</i>
	<i>5:43 a.m.</i>	<i>24.54</i>	<i>55 25</i>	<i>29.47</i>	<i>25 24 87</i>	<i>25</i>	<i>6</i>	<i>.18</i>	<i>4/4</i>	<i>90</i>		<i>10:30 a.m.</i>			<i>Stratus</i>
	<i>2:43 p.m.</i>	<i>24.31</i>	<i>63 34</i>	<i>29.06</i>	<i>34 33 89</i>	<i>34</i>	<i>5</i>	<i>.12</i>	<i>4/4</i>	<i>30</i>					<i>Light Snow</i>
<i>Thursday Nov 23</i>	<i>4:43 p.m.</i>	<i>24.20</i>	<i>60 31</i>	<i>28.97</i>	<i>31 30 89</i>	<i>31</i>	<i>4</i>	<i>.40</i>	<i>3/4</i>	<i>SE</i>					<i>"</i>
	<i>5:43 a.m.</i>	<i>24.36</i>	<i>56 32</i>	<i>29.17</i>	<i>32 32 100</i>	<i>32</i>	<i>4</i>	<i>.08</i>	<i>4/4</i>	<i>101</i>		<i>8 a.m.</i>		<i>.21</i>	<i>Cloudy</i>
	<i>2:43 p.m.</i>	<i>24.37</i>	<i>70 42</i>	<i>29.04</i>	<i>42 37 53</i>	<i>42</i>	<i>2</i>	<i>.02</i>	<i>2/4</i>	<i>337</i>					<i>Heavy Snow</i>
<i>Friday Nov 24</i>	<i>4:43 p.m.</i>	<i>24.32</i>	<i>65 27</i>	<i>29.23</i>	<i>27 27 100</i>	<i>27</i>	<i>2</i>	<i>.02</i>	<i>4/4</i>						<i>Fog</i>
	<i>5:43 a.m.</i>	<i>24.37</i>	<i>58 32</i>	<i>29.17</i>	<i>32 28 64</i>	<i>32</i>	<i>7</i>	<i>.24</i>	<i>1/4</i>	<i>98</i>					<i>Stratus</i>
	<i>2:43 p.m.</i>	<i>24.42</i>	<i>70 49</i>	<i>29.03</i>	<i>49 39 31</i>	<i>49</i>	<i>2</i>	<i>.02</i>	<i>2/4</i>	<i>32.7</i>					<i>Stratus</i>
<i>Saturday Nov 25</i>	<i>9:43 a.m.</i>	<i>24.60</i>	<i>68 17</i>	<i>29.60</i>	<i>17 15 75</i>	<i>17</i>	<i>18</i>	<i>1.62</i>	<i>3/4</i>						<i>Light snow fl</i>

2381 **Denver November 19-25, 1871**

Henry A. Fenton, Observer

The Colorado Legislature established a state weather service in the mid-1880's



Colorado Weather Stations in 1890

In 1891, a civilian “U.S. Weather Bureau” was created.



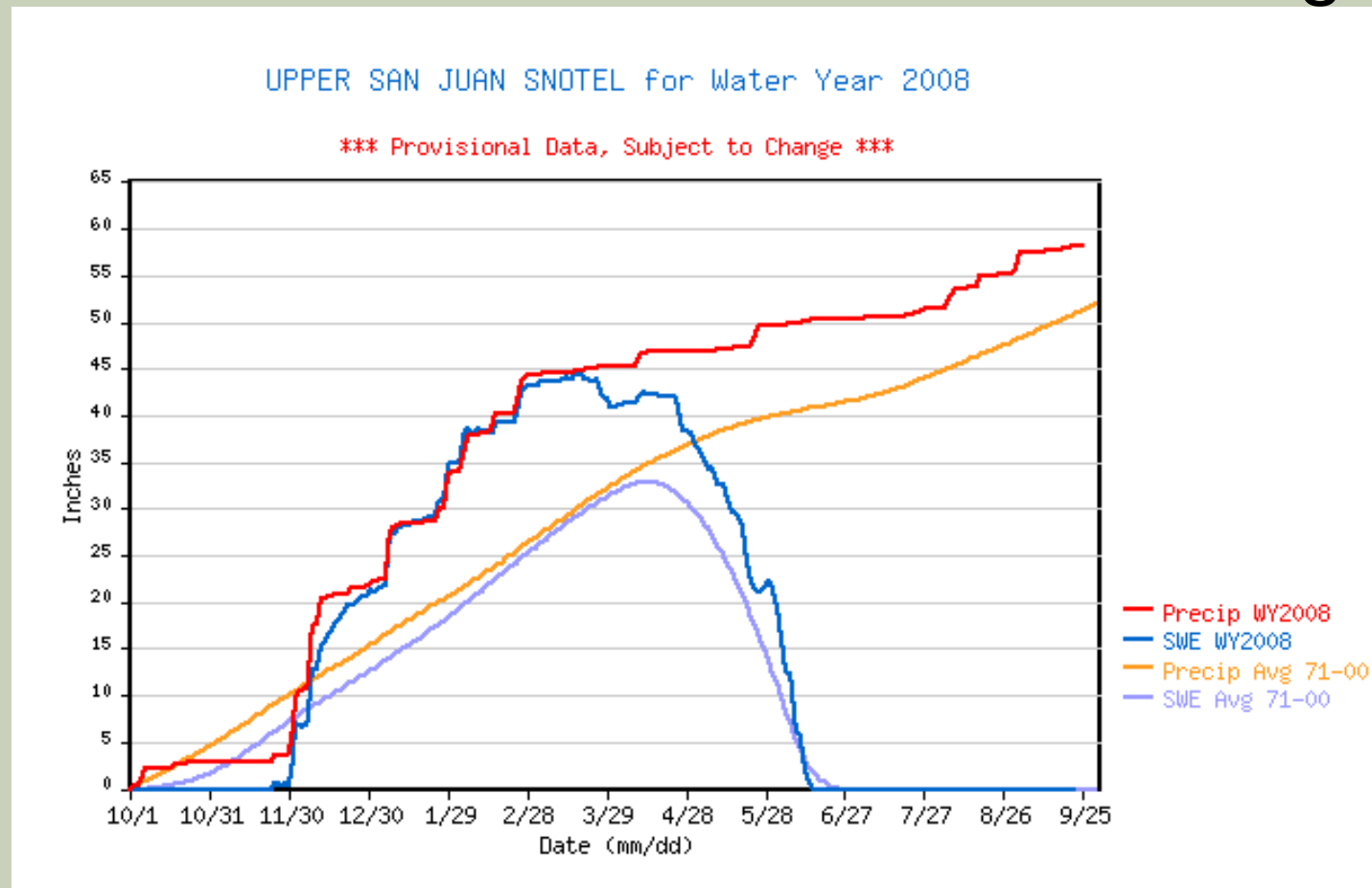
Systematic streamflow measurements began about this same time



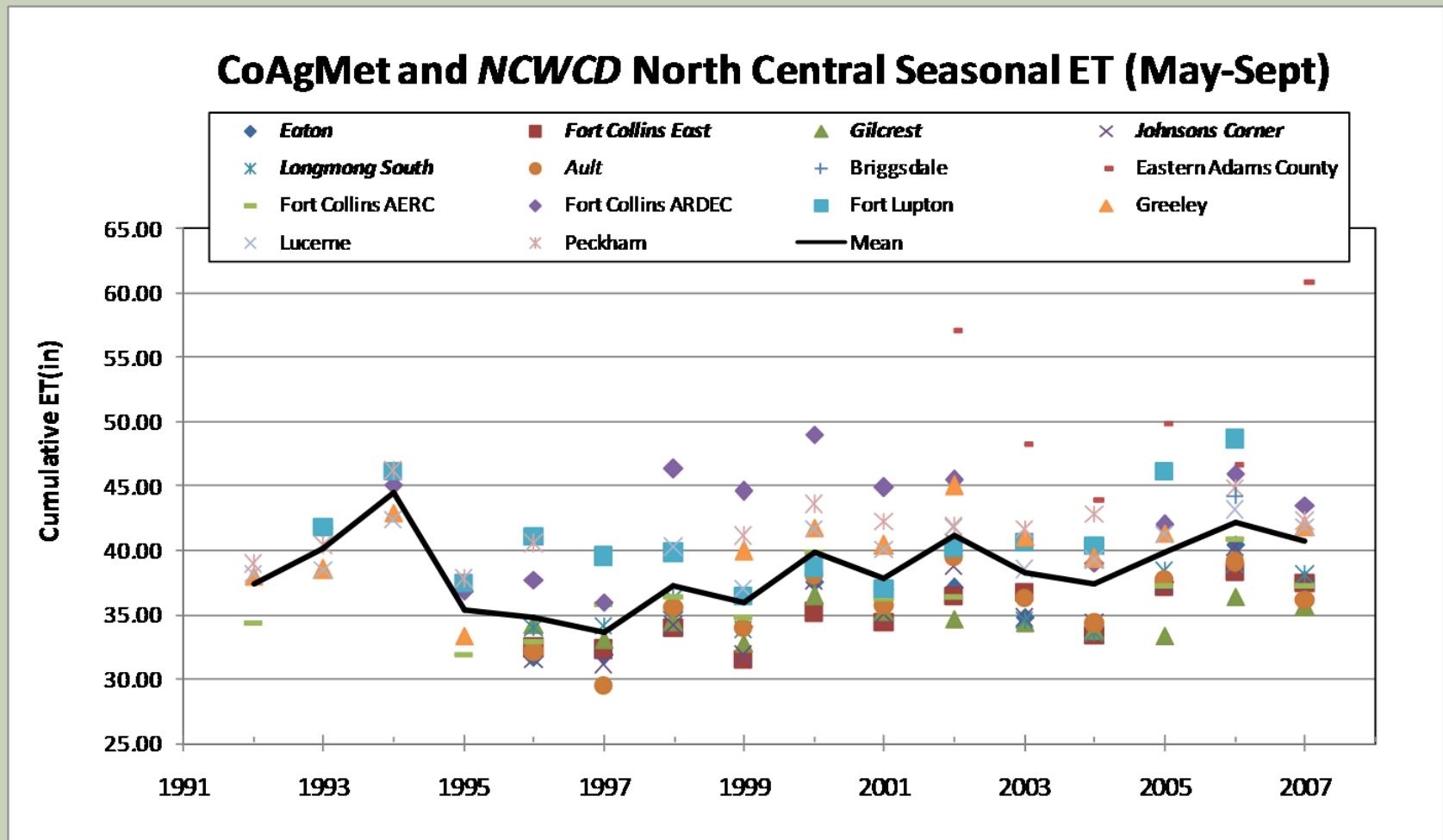
Later came measurements of mountain snowpack, followed by water supply forecasts.



More recently, electronic sensors and automation have resulted in expansion of climate and water resources monitoring.



The Colorado Agricultural Meteorological Network (CoAgMet) and similar monitoring systems managed by Northern Colorado Water Conservancy District provide assessments of evapotranspiration to help track water use.



Climate and Drought: What have we learned???



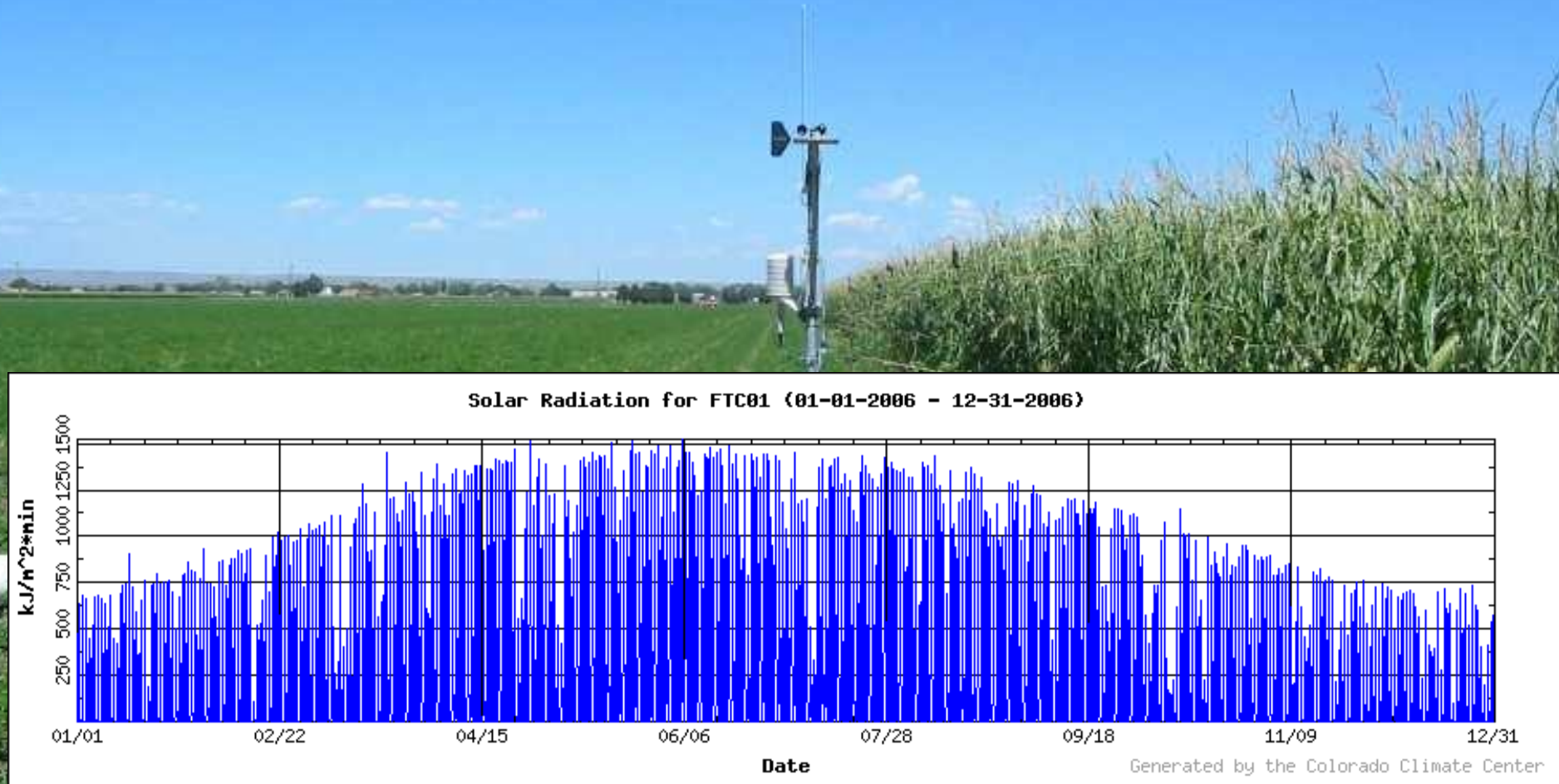
Our climate is controlled by:

- High elevation
- Mid-Latitude location
- Complex topography as we straddle the Continental Divide

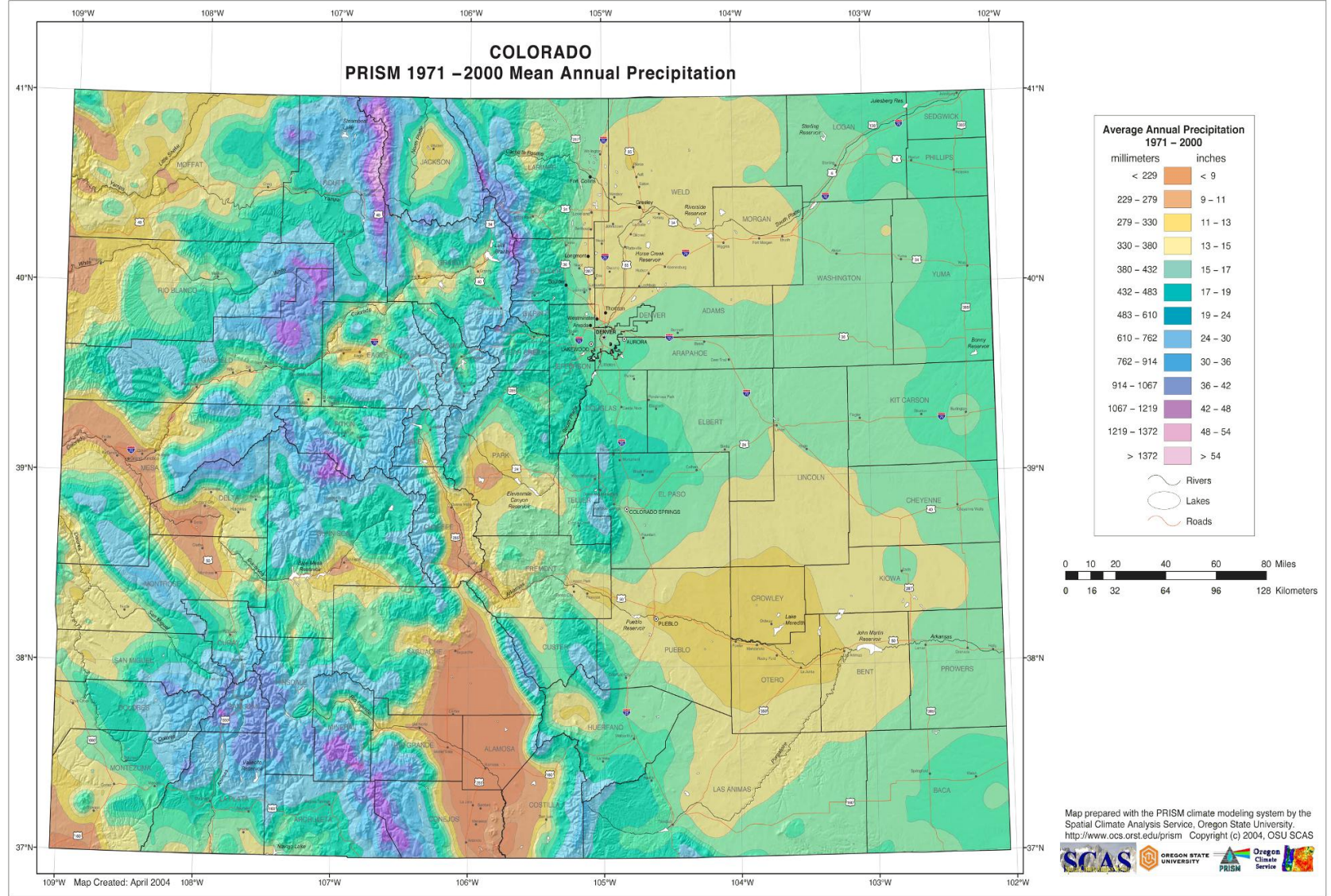
What is the Result?



Generous sunshine and low humidity, i.e. people like it here

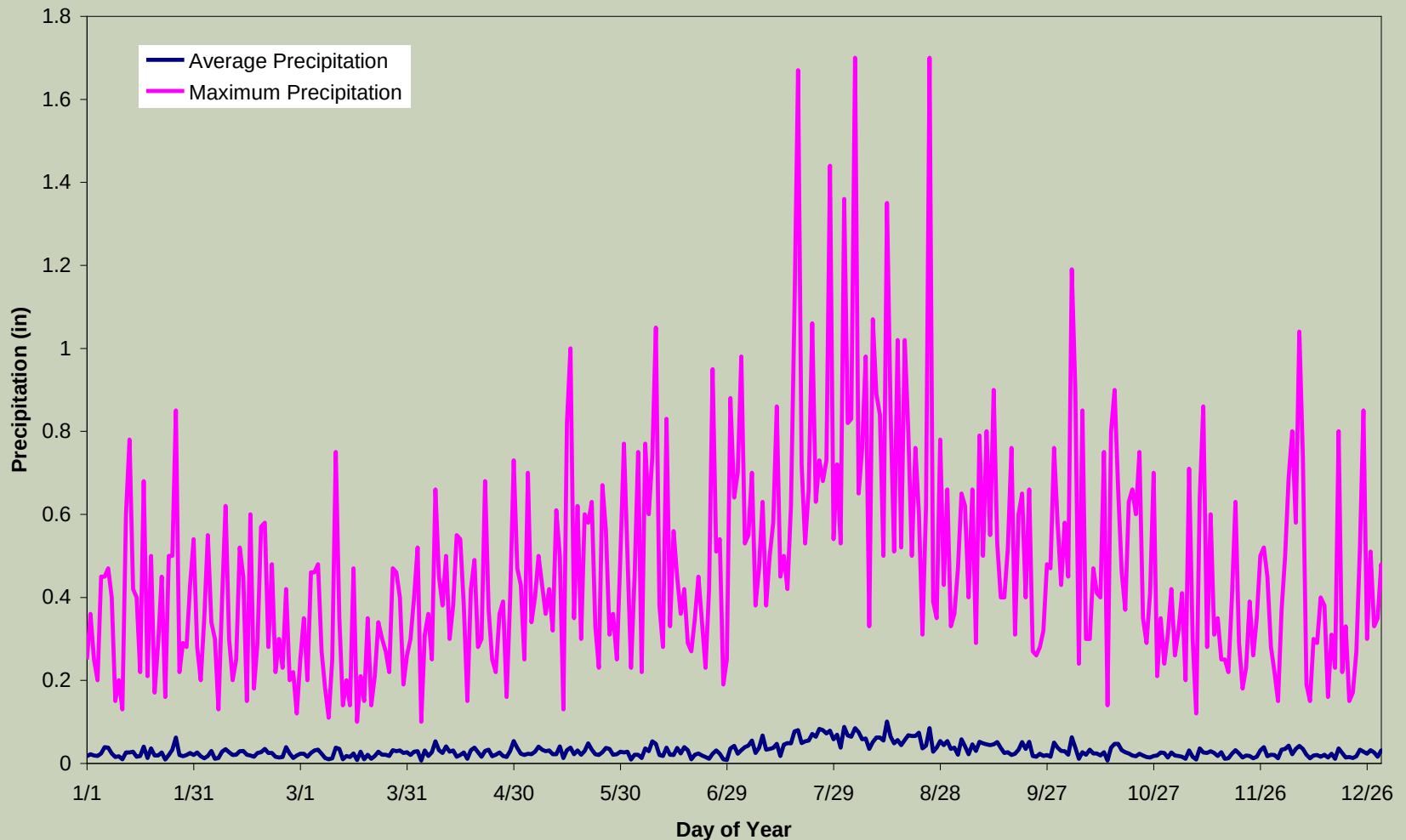


Precipitation patterns are dominated by topography



Large daily variations and dramatic seasonal cycles rule

Cochetopa Creek Daily Mean and Maximum Precipitation

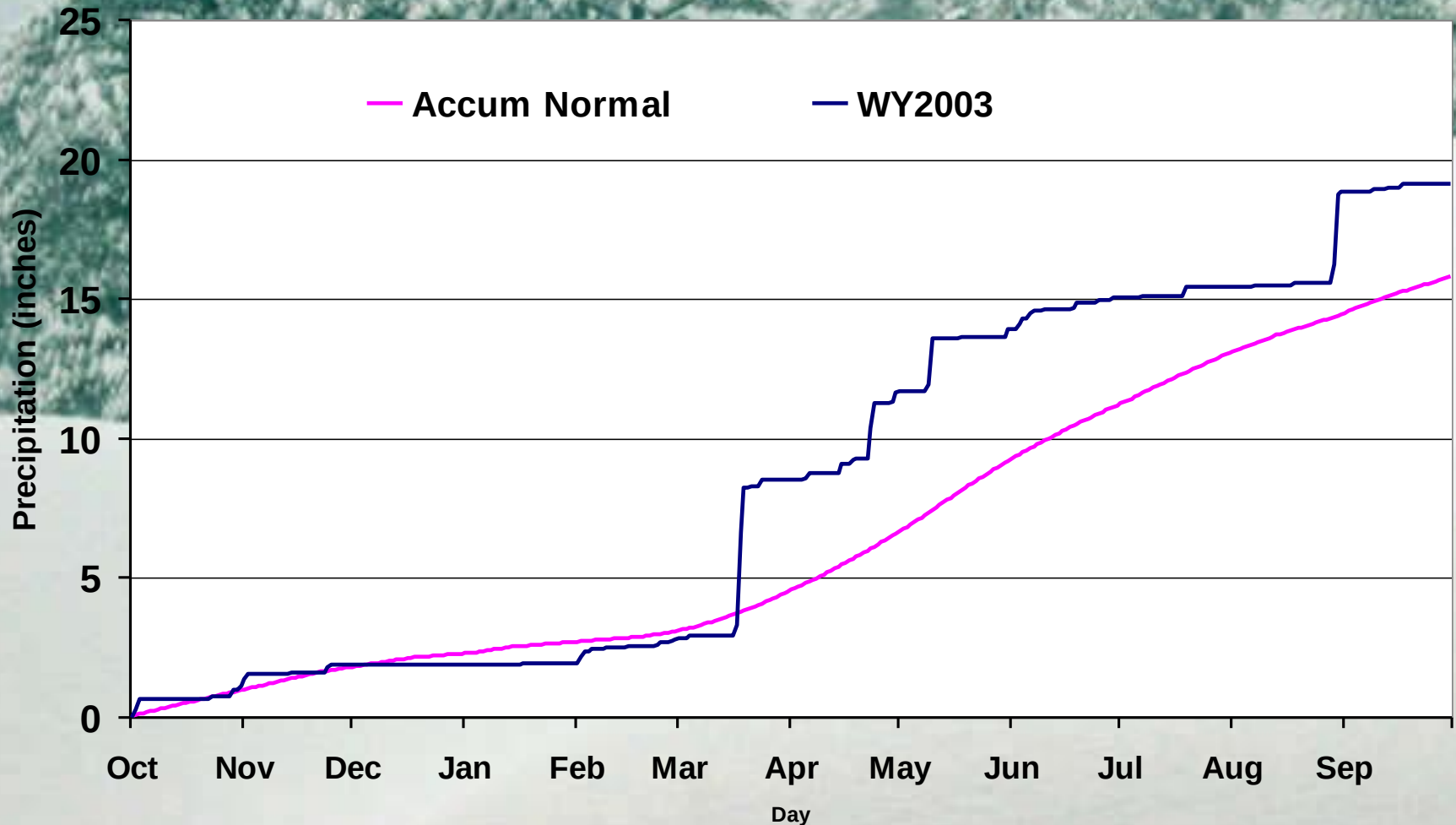


**Frequent but highly variable
precipitation
(for every “upslope,”
there’s a “downslope”)**



A few storms contribute a large fraction of the annual precipitation in many years

Fort Collins Daily Accumulated Precipitation

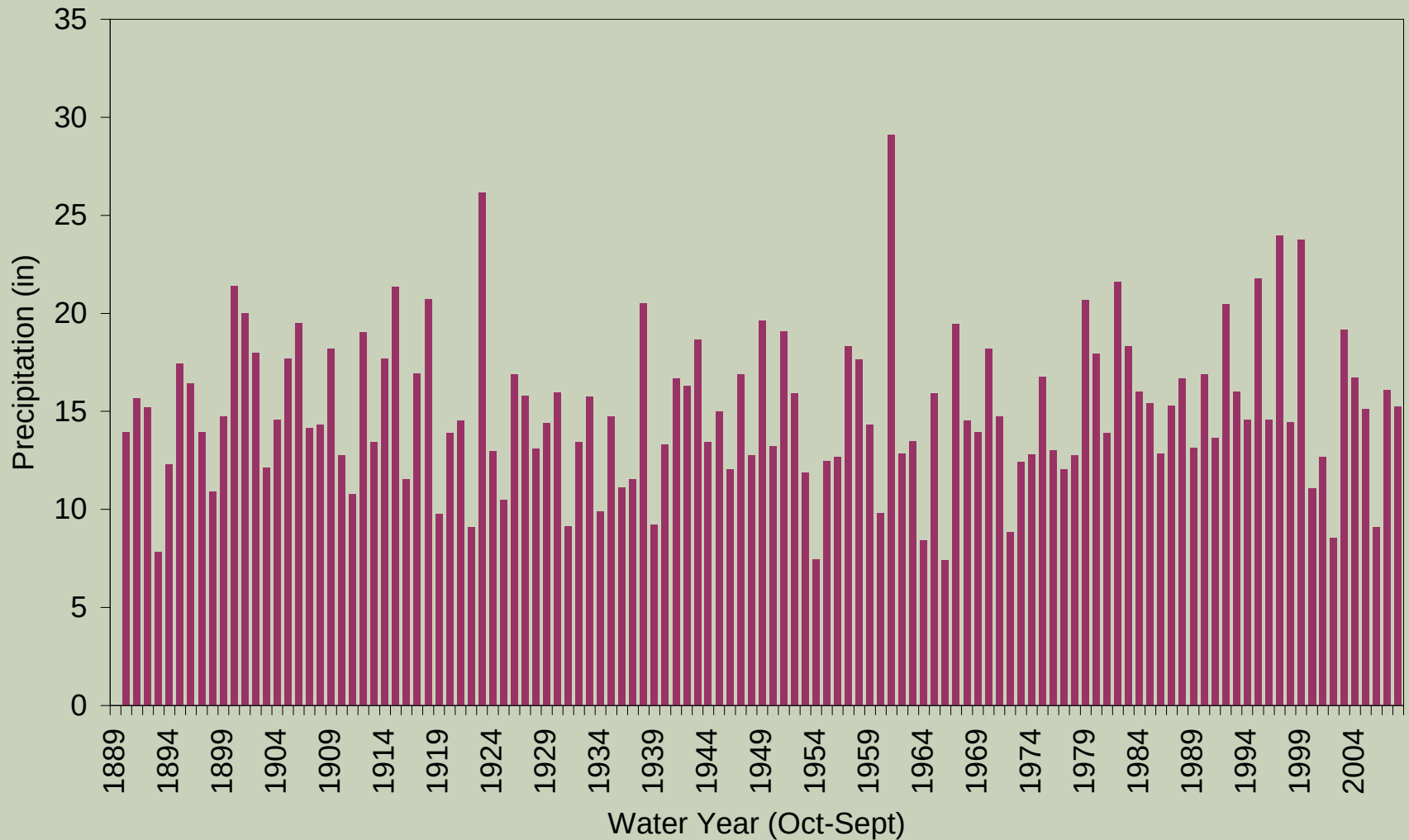


**The majority of high elevation
precipitation falls as snow**



No two years are ever alike!

Fort Collins, CO Water Year Precipitation



It continues to be difficult to predict weather conditions more than 7-10 days in the future

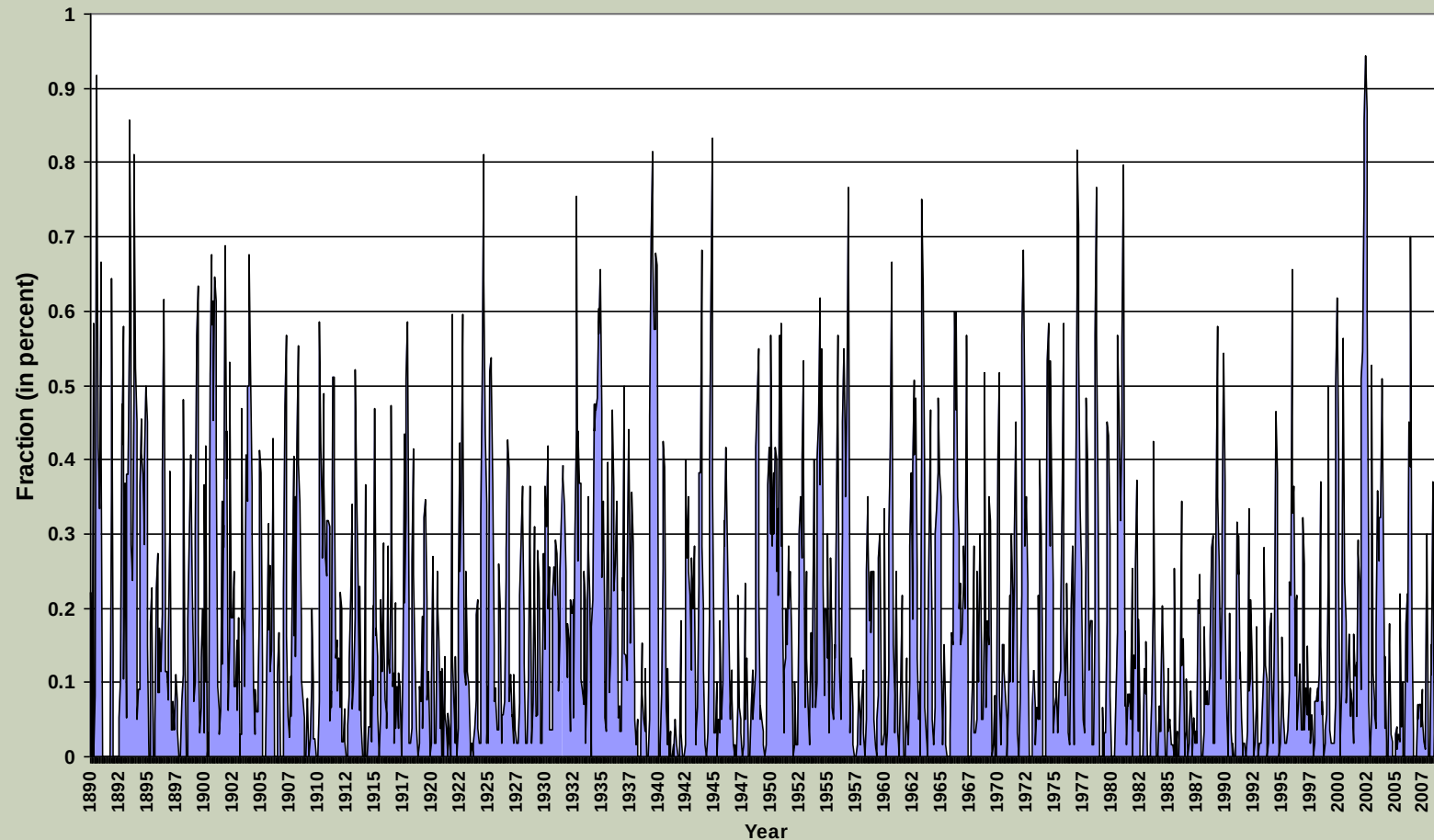


Talking “drought” in a dry state, especially in a state where recreation is a big part of the economy, can be problematic...



Drought is a frequent visitor to Colorado.
Short term (up to 3 months) moisture deficits occur
nearly every year.

Fraction of Colorado in Drought
Based on 3 month SPI
(1890 - August 2008)



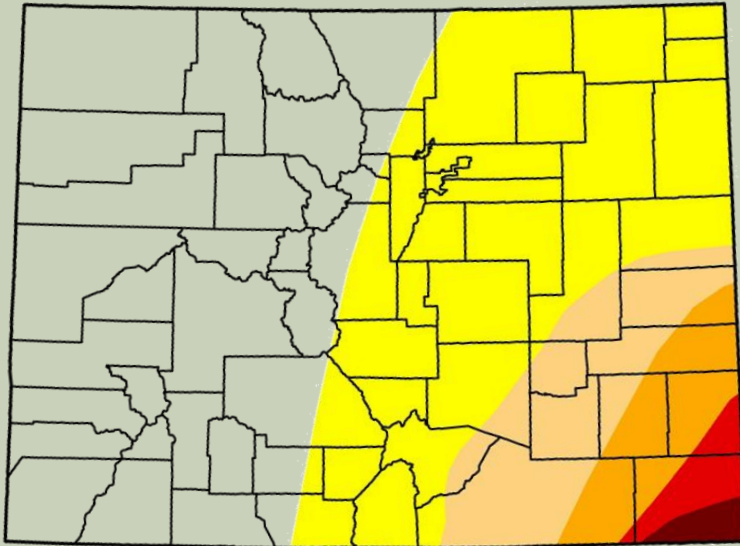


Short term drought can have significant impacts, especially when it occurs at normally wet times of year

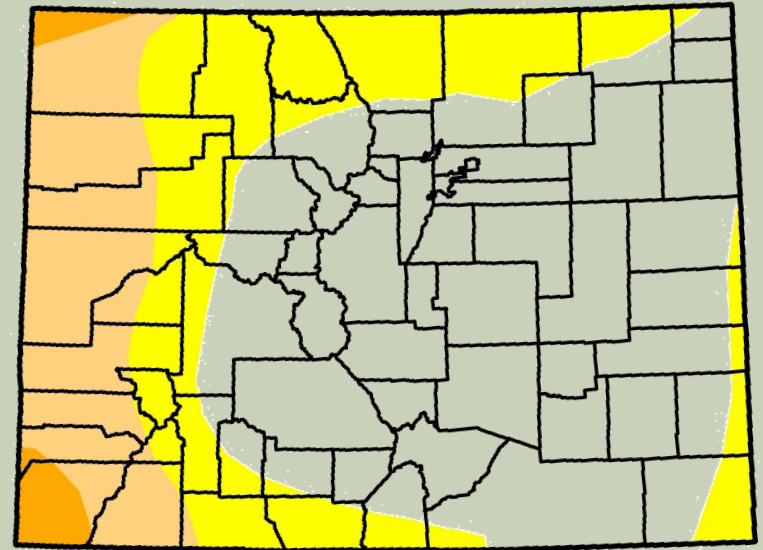
- Winter snow shortages affecting winter recreation
- Spring shortages affecting winter wheat production
- Summer drought increasing wildfire risk and dryland crop production

Drought often does not affect the entire state

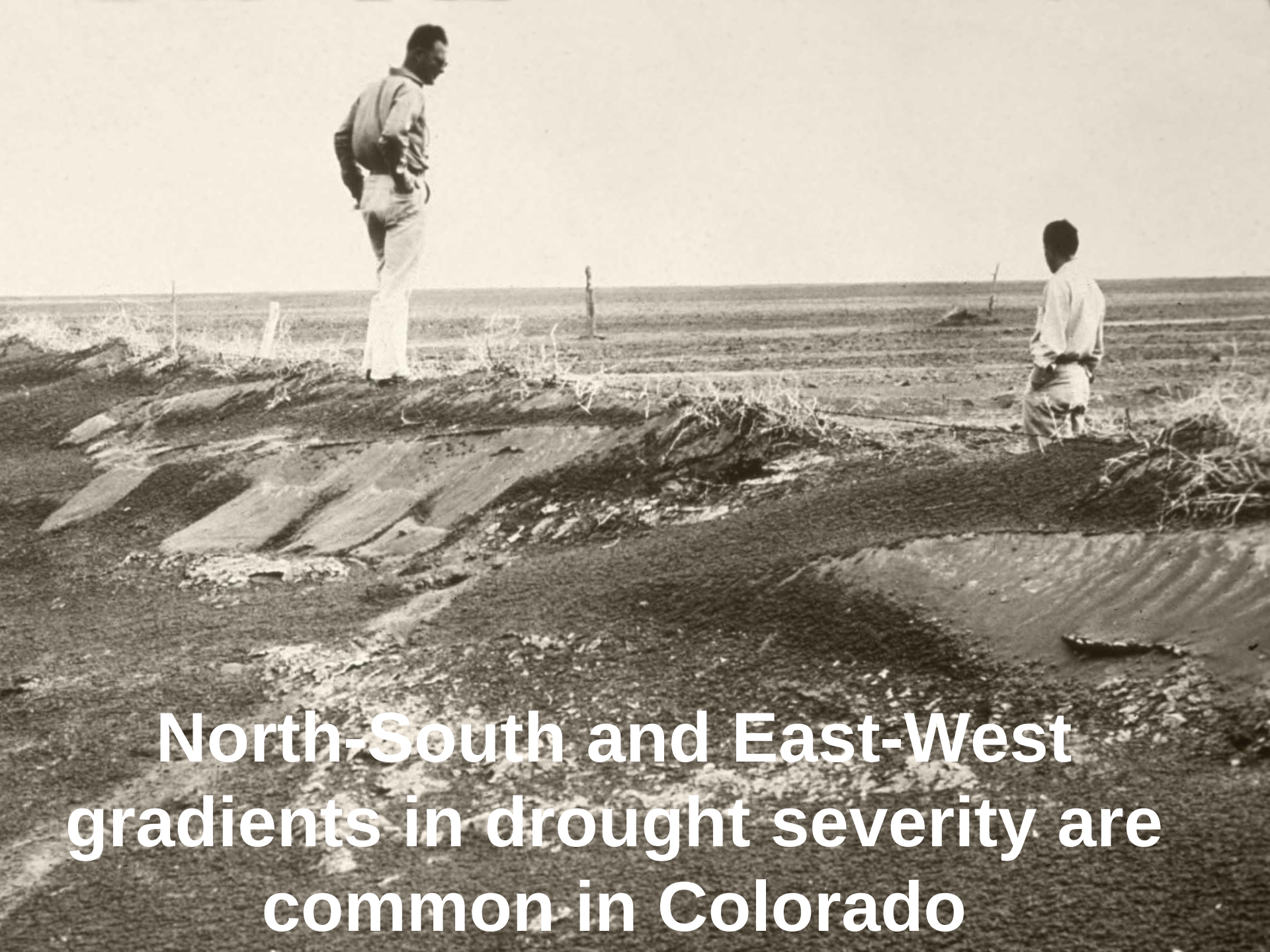
July 8, 2008



July 10, 2007



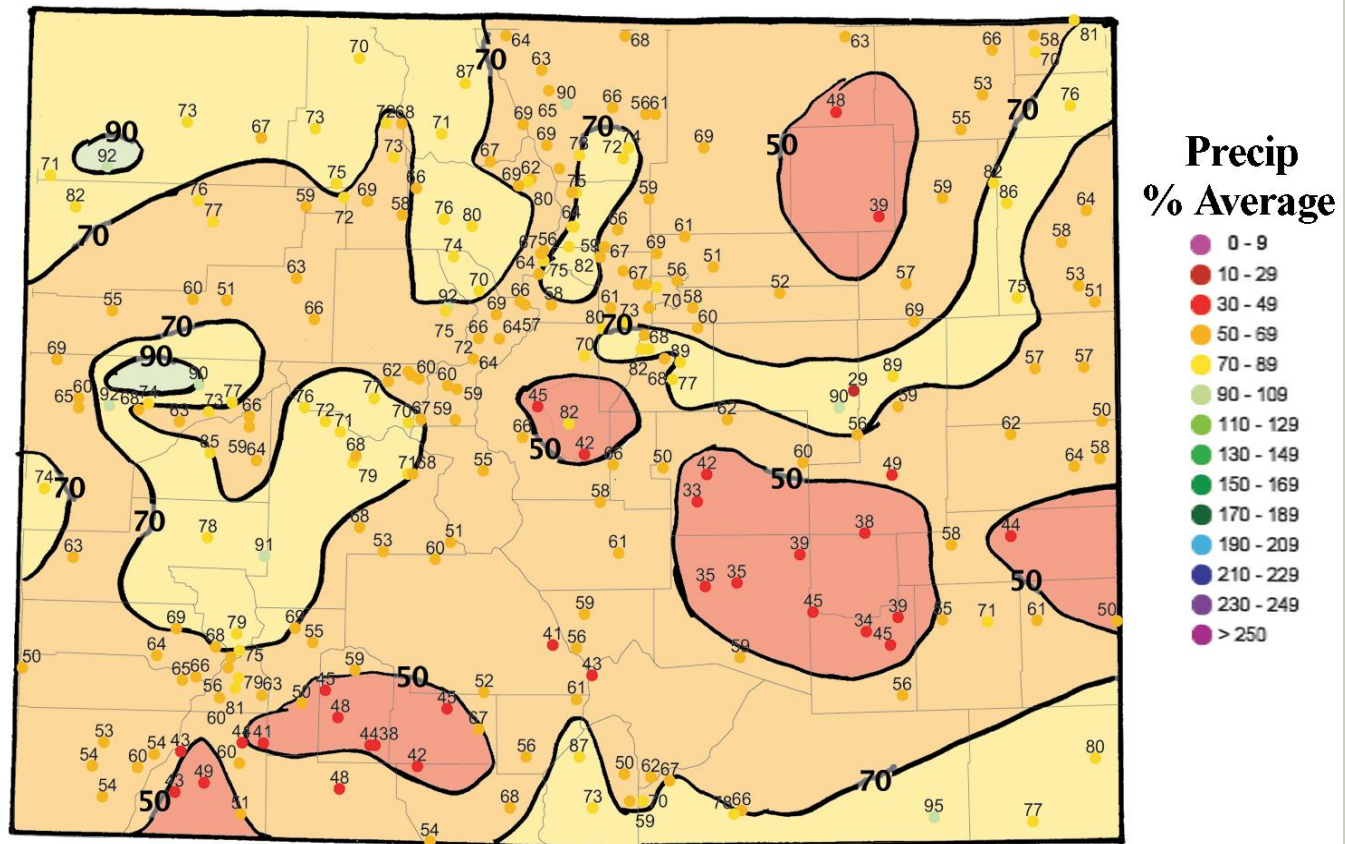
- D0: Abnormally Dry
- D1: Drought-Moderate
- D2: Drought-Severe
- D3: Drought-Extreme
- D4: Drought-Exceptional



**North-South and East-West
gradients in drought severity are
common in Colorado**

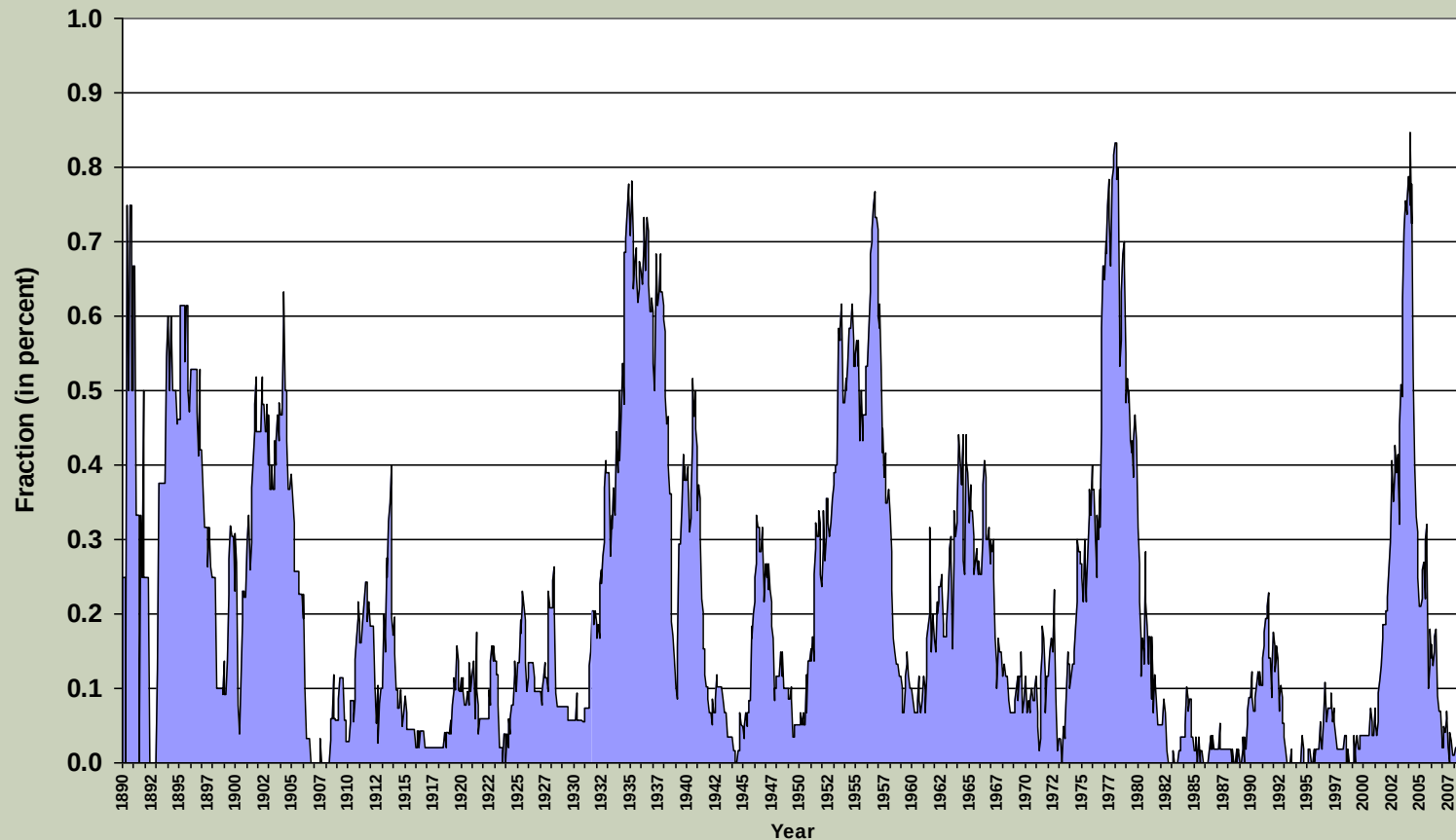
There is no “typical” drought, each has its own story.
Annual precipitation less than 60% of average usually
results in severe drought.

Water Year 2002
(Oct. 2001 - Sept. 2002)
Precipitation Percent of Average for 1961-1990 Averages

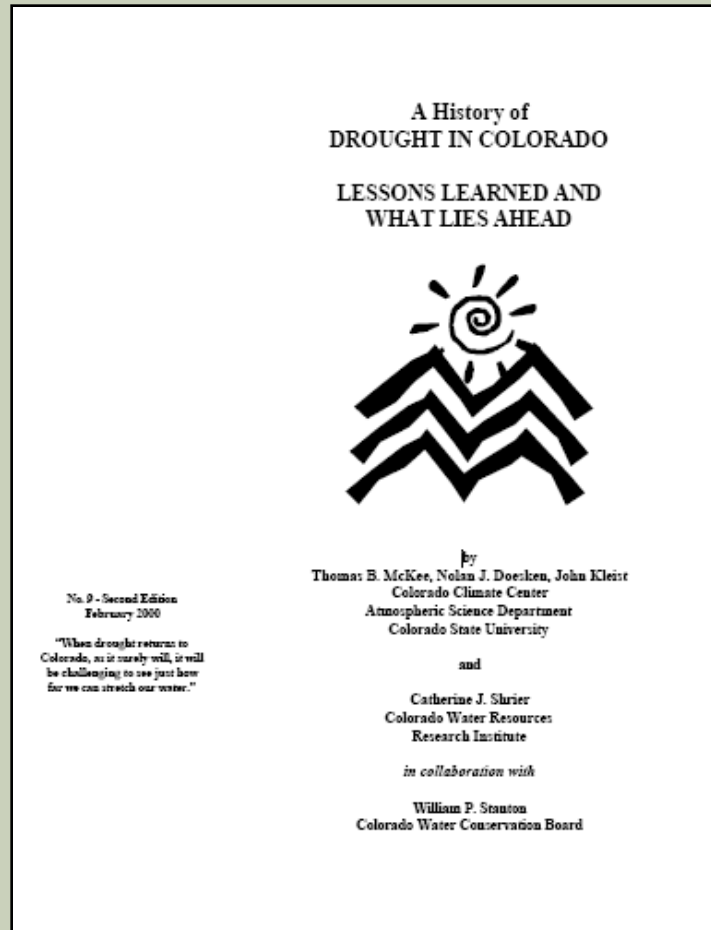


Multi-year droughts have the greatest impact.
They occur infrequently but regularly.

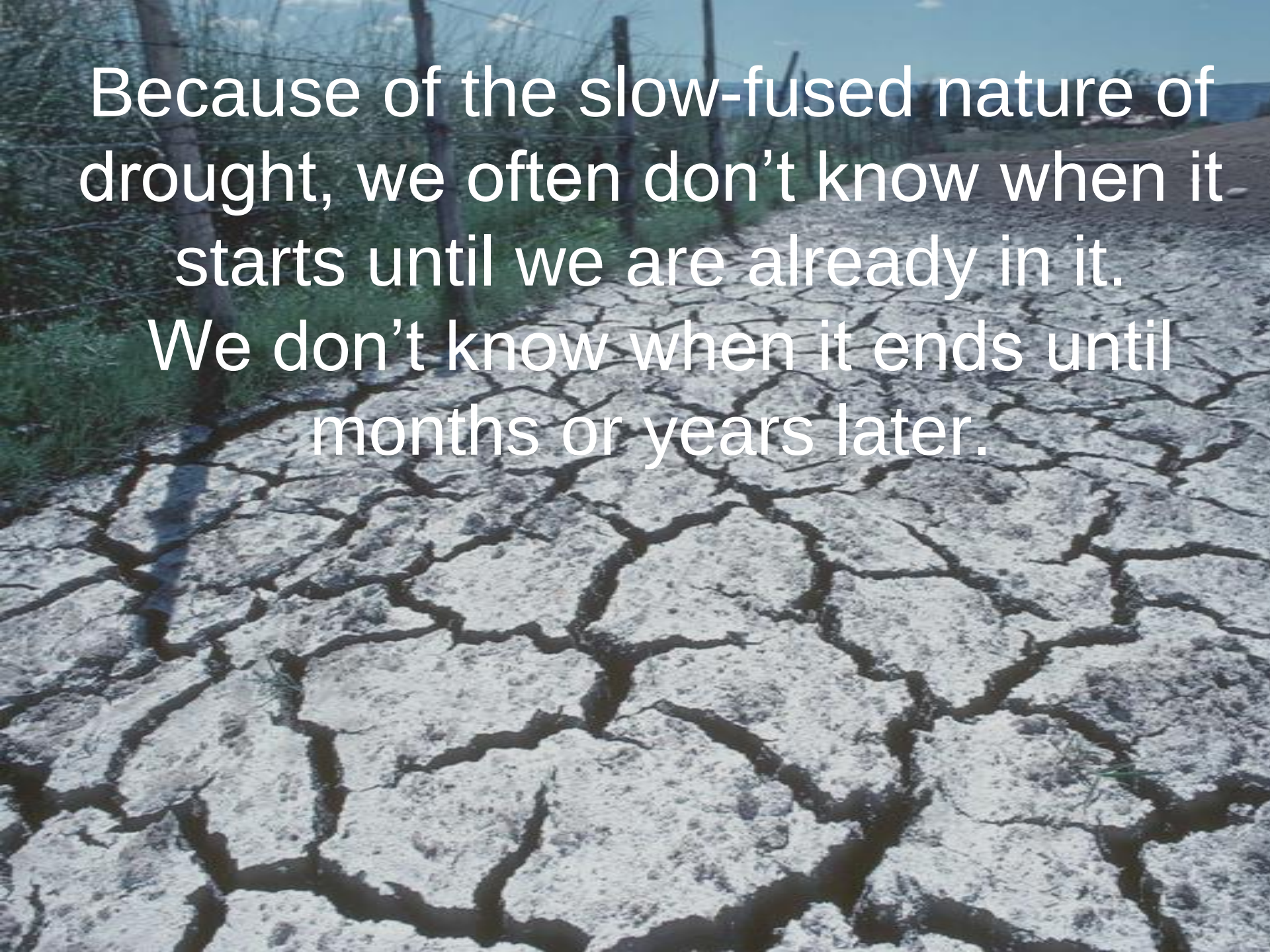
Fraction of Colorado in Drought
Based on 48 month SPI
(1890 - August 2008)



The Drought of 2002 followed some of the script of “worst scenario drought” but was relatively brief compared to what it could be.



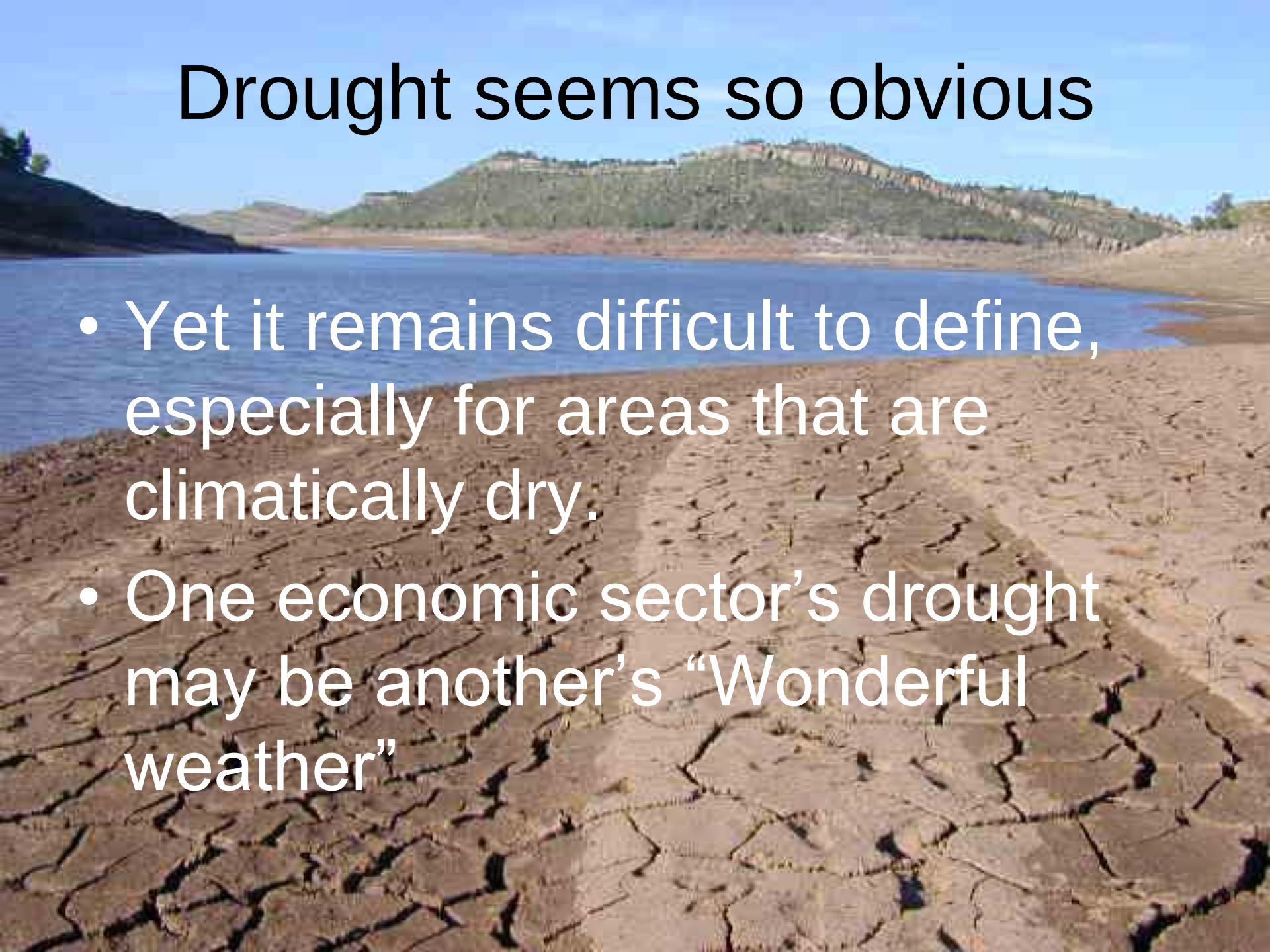
<http://ccc.atmos.colostate.edu/pdfs/ahistoryofdrought.pdf>

The background image shows a landscape affected by drought. The foreground is dominated by parched, cracked soil that has formed a mosaic of irregular polygons. In the mid-ground, a wire fence with wooden posts stretches across the frame. Beyond the fence, there are some sparse, dry-looking plants and a clear, bright sky. The overall scene conveys a sense of aridity and environmental hardship.

Because of the slow-fused nature of drought, we often don't know when it starts until we are already in it. We don't know when it ends until months or years later.

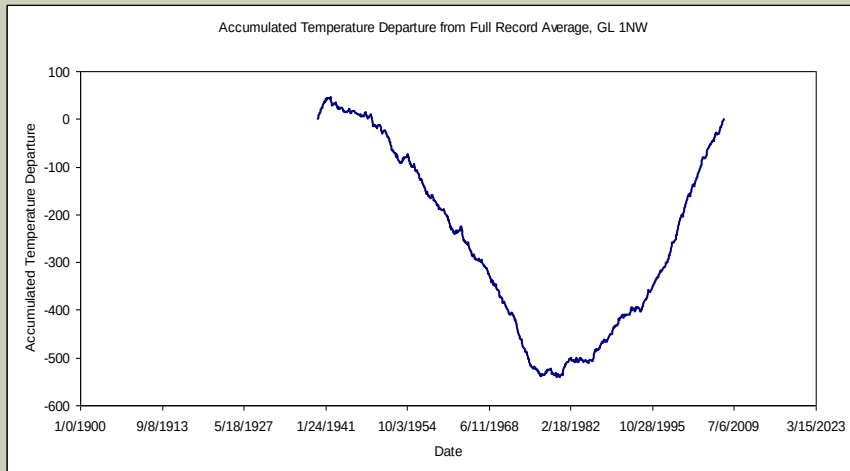
Drought seems so obvious

- Yet it remains difficult to define, especially for areas that are climatically dry.
- One economic sector's drought may be another's "Wonderful weather"

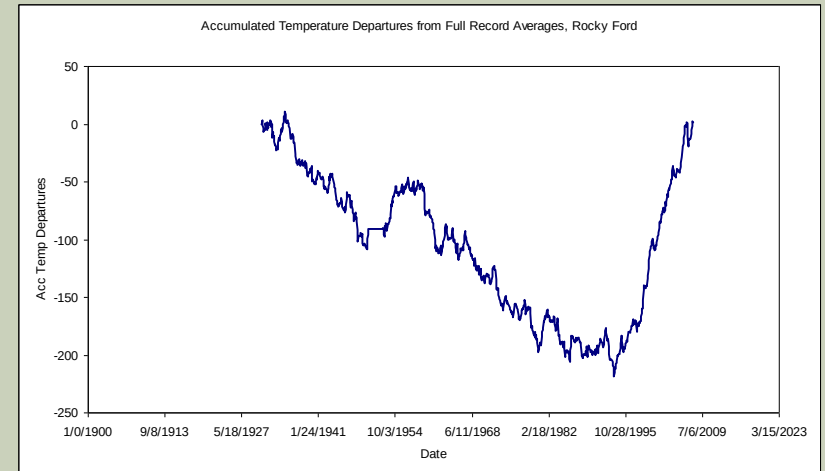


Current data show signs of warming in Colorado

- Since 1997, most of Colorado shows a warming trend
- Accumulated departures from normal illustrate this

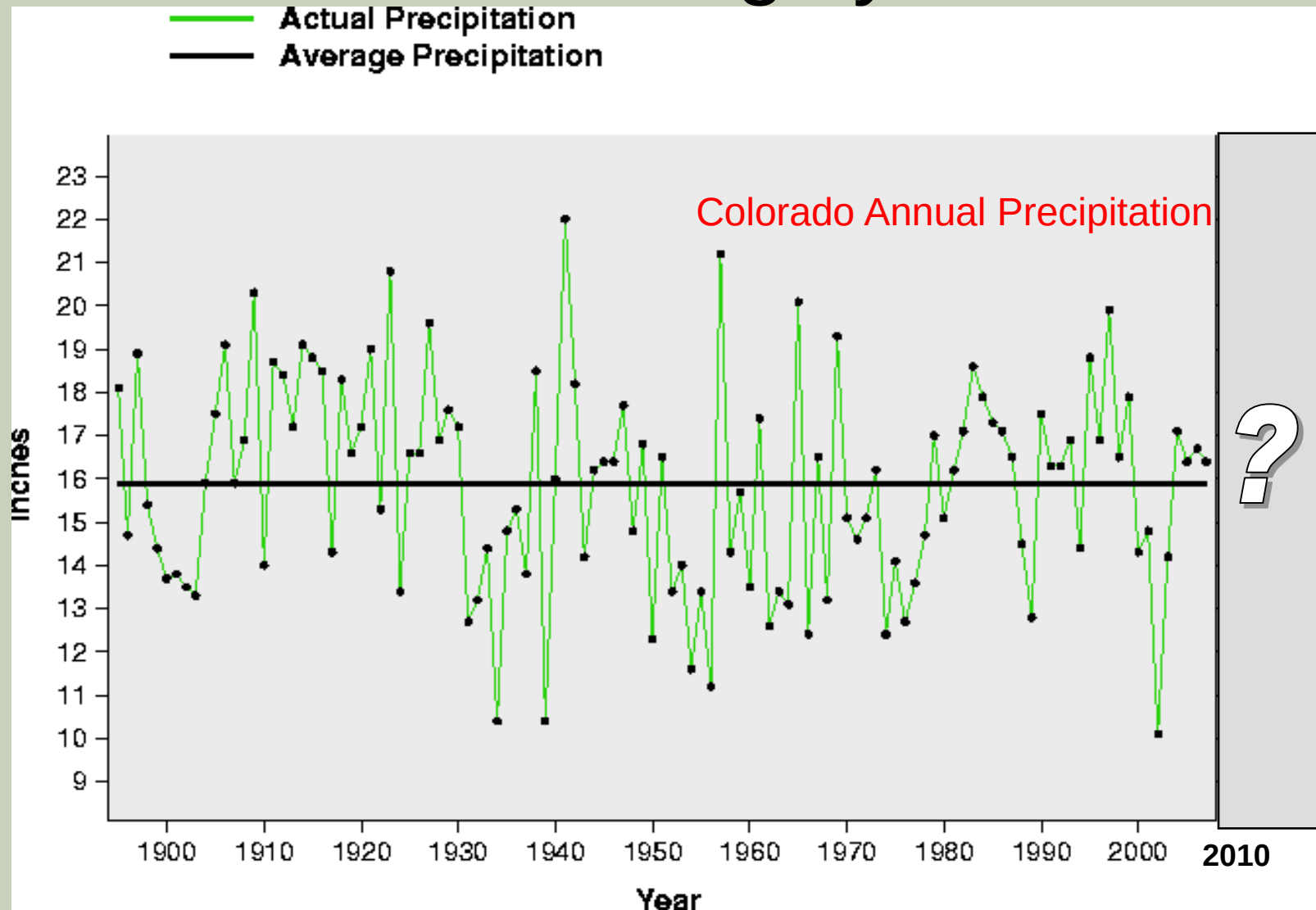


Grand Lake 1NW



Rocky Ford

Future precipitation is uncertain, but sure to be highly variable.



Warmer temperatures COULD
mean more precipitation will
evaporate leaving less for
streamflow



Coming Soon: Climate Trends Website

Colorado State University

Colorado Climate Center

Home Products & Services Resources About the CCC AASC

Colorado Climate Center > Climate Trends > Home

Search by Google

Welcome to the Colorado Climate Trends Website

Climate Trends Station Map Station Info Data Access Links & Resources About

Climate Trends of Colorado

Welcome! The climate of Colorado is a valued natural resource affecting our lives and livelihoods. By nature, climate is variable. No two years are ever exactly alike. Instrumental observations of our climate dating back to the late 1800s give a sense of our average climate, typical variations, extremes and long-term trends. (For a description of historic weather observations in Colorado, click here). Tracking temperatures and precipitation through history reveal seasonal patterns, cold and warm periods, and episodes of drought and abundant water.

Today there is great interest in climate change. If our state is warming, these data will show it. This Website lets you view, graph and download historic temperature and precipitation data for selected weather stations in Colorado having the longest and most consistent historical data. Historic consistency is critical for accurately assessing climate trends. There have been hundreds of weather stations operated in Colorado since the 1890s, but very few have data that are complete and consistent. Even the best stations selected for this site are imperfect.

For each station shown here, a description of the history of the station is provided so that data users will know what factors may have affected the long-term time series. To learn more about factors that compromise long term weather records, click here.

Are you aware of other high quality long-term weather data for Colorado? Let us know (click here)

[Feedback](#)

National Weather Service Co-op Program

Weather observations in Colorado using thermometers and rain gauges date back to the late 1800s. Some of the earliest weather stations were established in the largest cities during the 1870s by the U.S. Signal Service. In the 1880s Colorado formed a "State Weather Service" and began setting up more basic weather stations in smaller towns and rural areas. By 1890, the first nationwide civilian weather service was formed within the U.S. Department of Agriculture. State networks, such as Colorado's were combined to form a single nationwide volunteer weather observing network. This same network continues today managed by the National Weather Service. What began as a few dozen stations in the 1880s grew to over 200 in the 1940s and 50s and continues today.

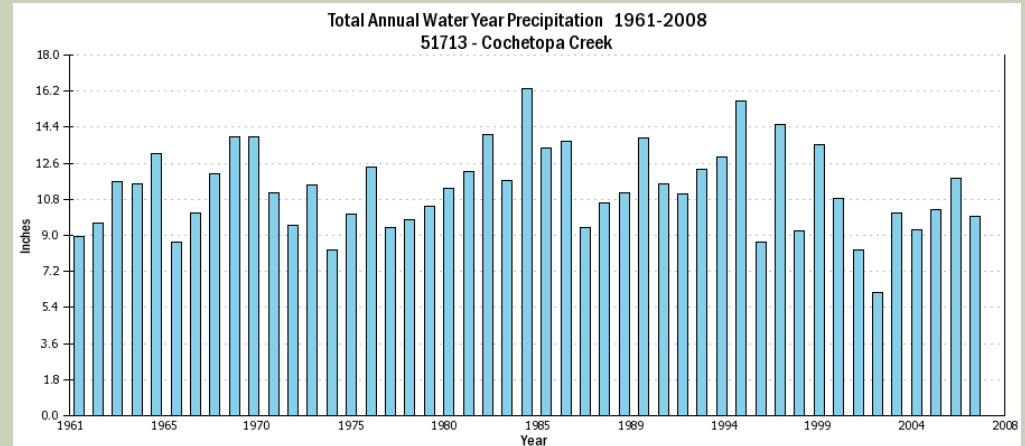
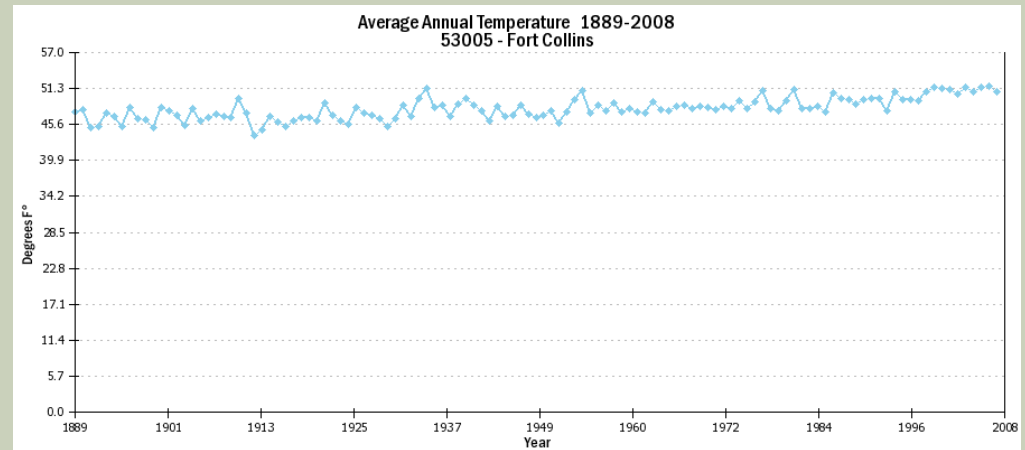
Learn More About the [NWS Co-op Program](#)

Project Sponsors

Access Colorado long-term station data and station history

Generate and download graph images

Customizable data frequency for graphing (monthly, water year, calendar year, etc)



<http://climatetrends.colostate.edu>

A Suggestion...

Join
CoCoRaHS!!



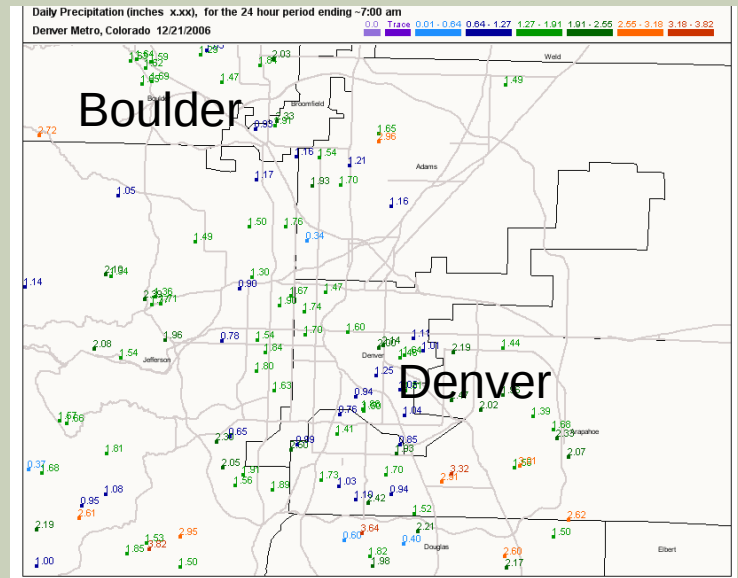
Join CoCoRaHS !!

Help monitor drought and water supplies in Colorado.

Individual, family and community awareness is the beginning of effective drought early warning and response!



Five Minutes a Day!



12,000+ Volunteer observers nationwide

CoCoRaHS
Community Collaborative Rain, Hail & Snow Network
www.cocorahs.org

In Memory of Odie Bliss (1956-2008)

- Colorado State University from September 1974 – August 2008
- Thirty years of dedicated service as Colorado Climate Center office coordinator providing extraordinary climate information services to the citizens of Colorado

Odie, we miss you.



NOLAN DOESKEN

Colorado State Climatologist, Colorado State University

Nolan Doesken is the State Climatologist for Colorado and Senior Research Associate at Colorado State University. Nolan began work at the Colorado Climate Center at CSU in 1977 as Assistant State Climatologist. Much of his work over the past 31 years has involved in collecting and utilizing weather data to help make practical everyday and long-term plans and decisions. Drought monitoring, research and climate/water education are particularly high priorities. Mr. Doesken oversees the Colorado Agricultural Meteorological Network (CoAgMet) and the historic Fort Collins Weather Station. Following the Fort Collins flash flood of July 1997, Nolan founded the Community Collaborative Rain, Hail and Snow network (CoCoRaHS) to increase citizen participation in climate monitoring in Colorado and across the nation.