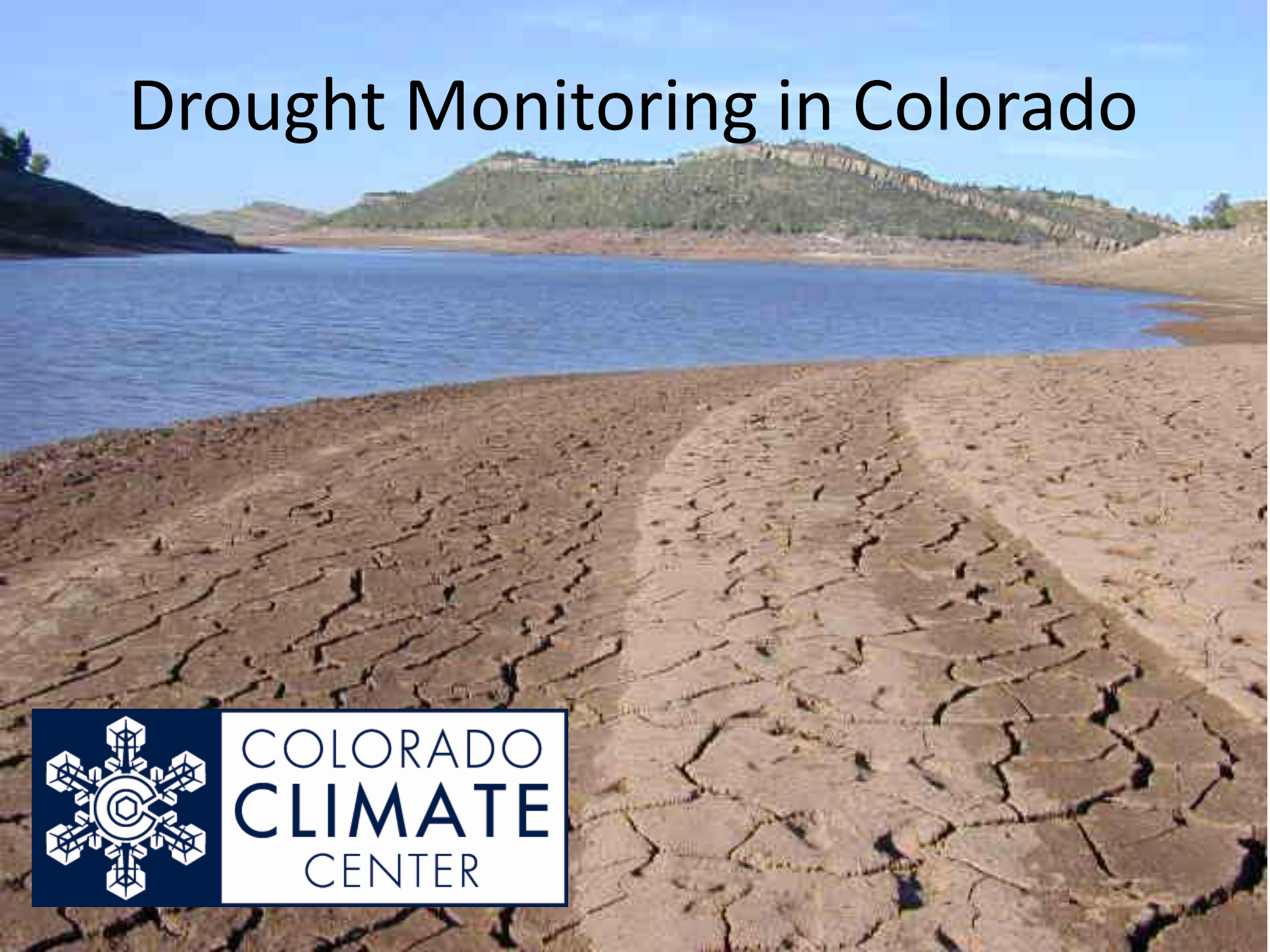
Drought Monitoring in Colorado



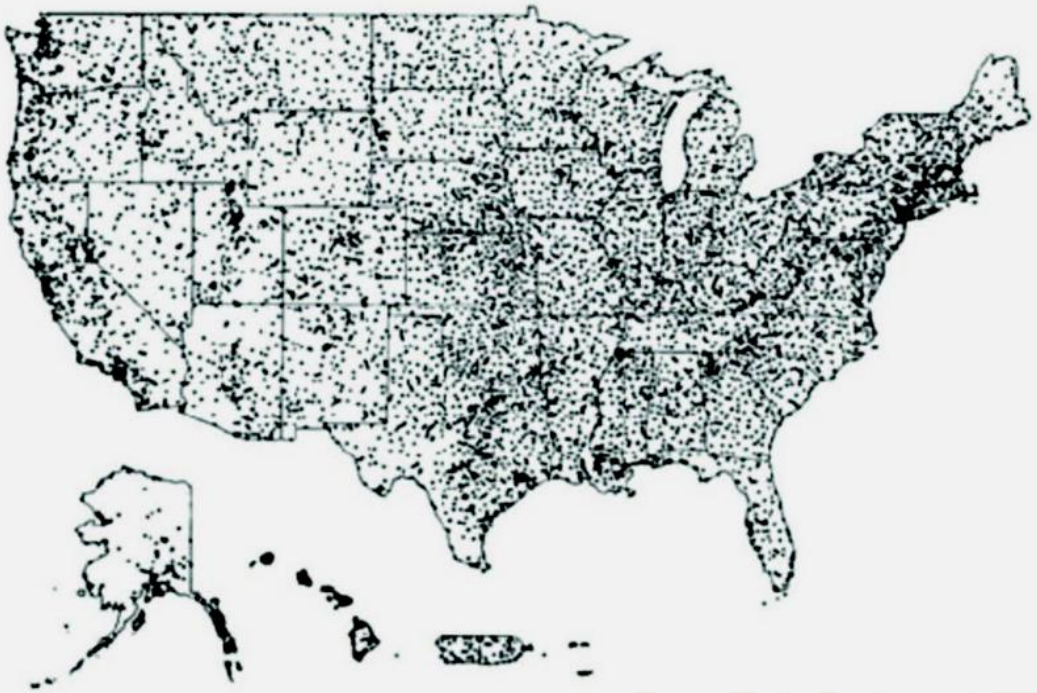
COLORADO
CLIMATE
CENTER

Overview

- Background on climate monitoring.
- Description of Drought Indices Used for Colorado
  - Colorado Modified Palmer Drought Severity Index (CMPDSI)
  - Surface Water Supply Index (SWSI)
  - Standardized Precipitation Index (SPI)
  - U.S. Drought Monitor (USDM)
- What resources are available for tracking drought?

Weather data are important for many and varied applications

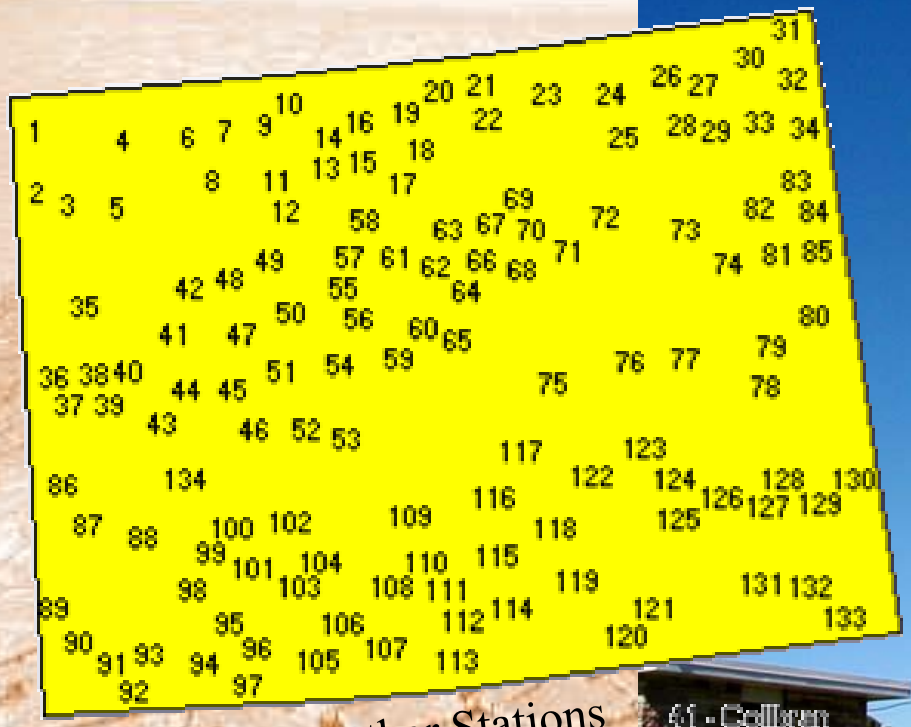
NWS COOP stations are the backbone network for long-term climate monitoring



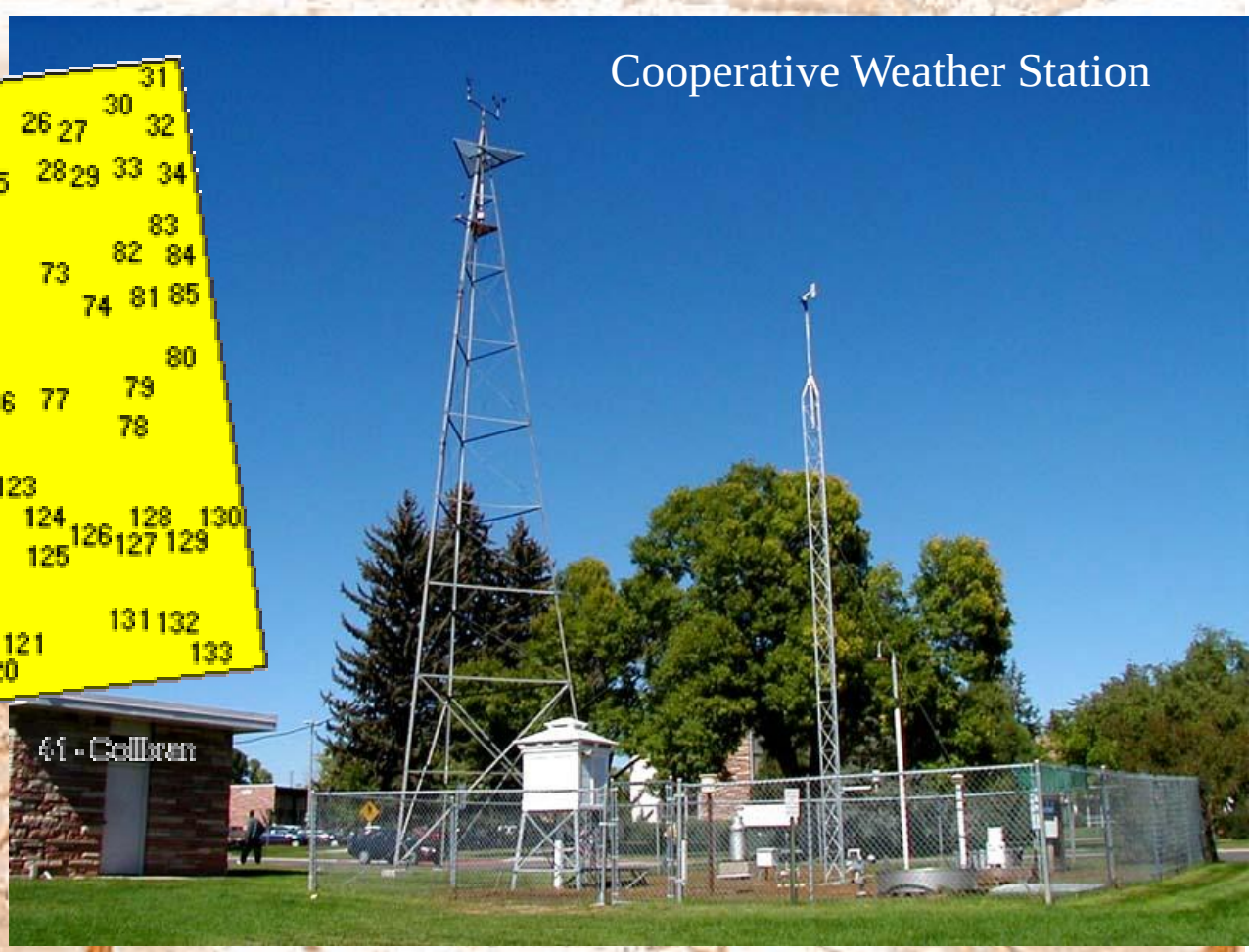
From Kelly Redmond, WRCC

Approximately 5000 daily max/min temperature stations, 8000 daily precipitation stations, 3000 automated hourly precipitation stations.

National Weather Service Cooperative Weather Stations



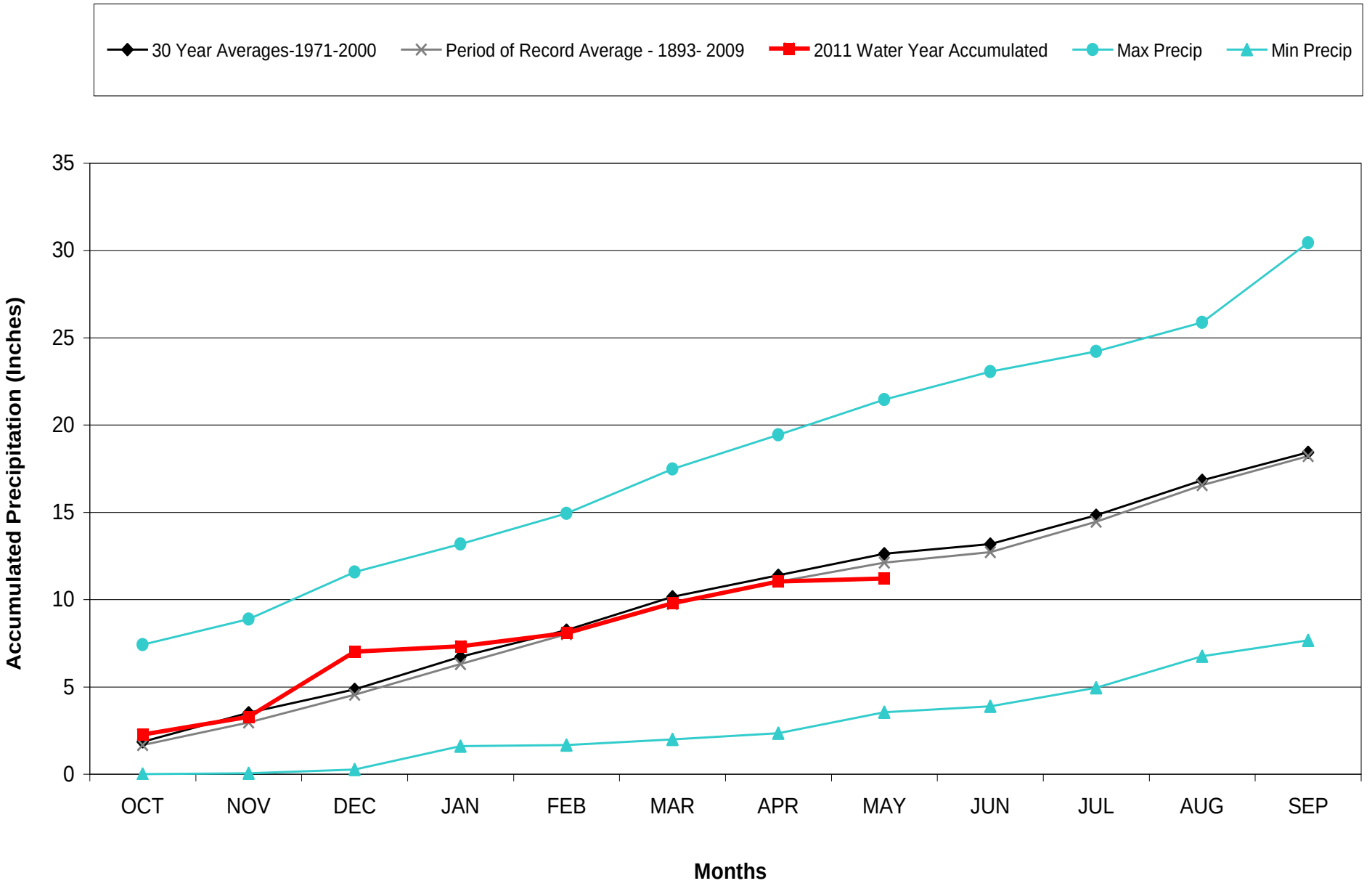
Cooperative Weather Stations in Colorado

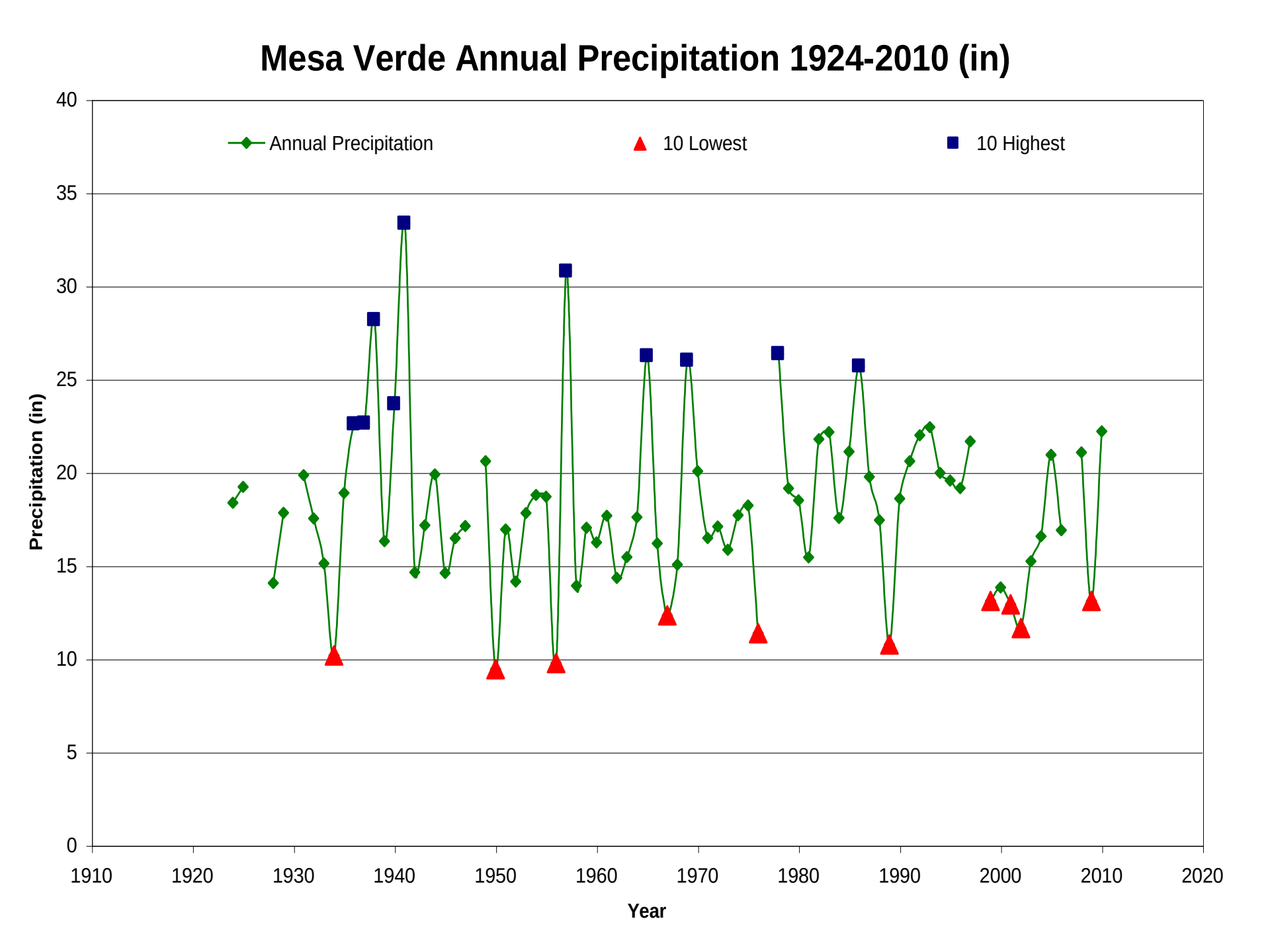


http://www.wrcc.dri.edu/summary/Climsmco.html

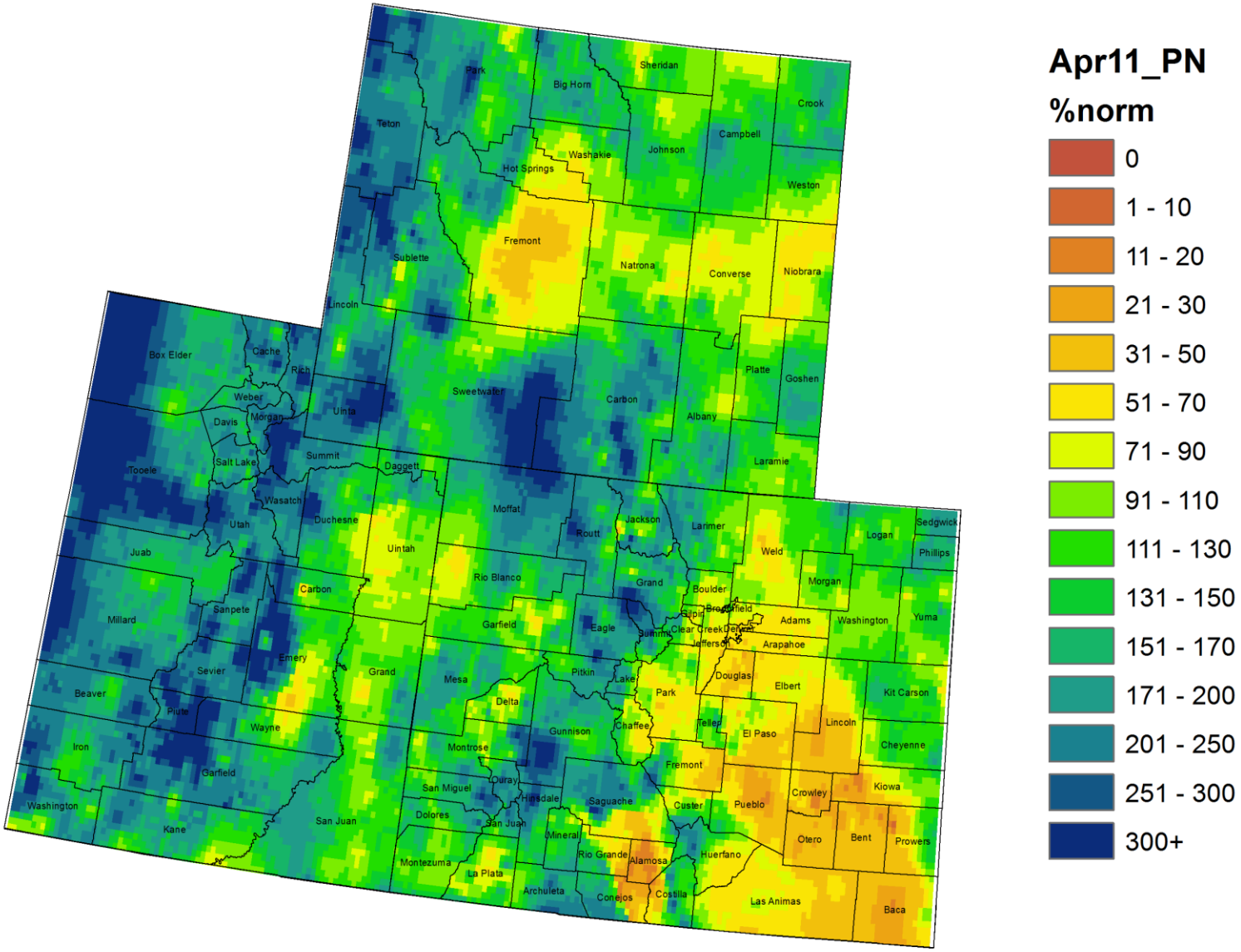
Holyoke NWS Cooperative Site

Mesa Verde NP
2011 Water Year

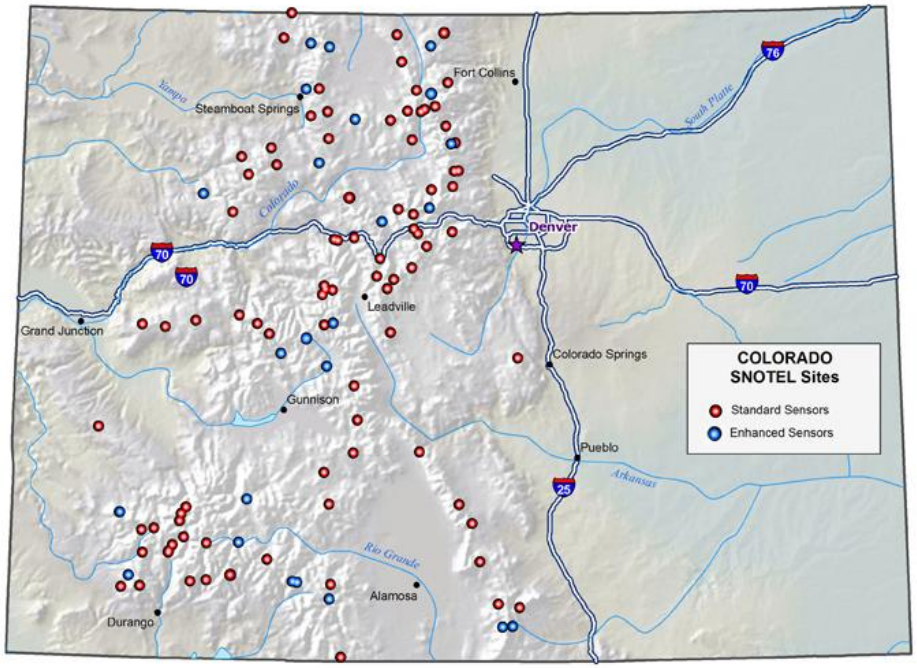



Mesa Verde Annual Precipitation 1924-2010 (in)
Annual Precipitation
10 Lowest
10 Highest
Precipitation (in)
Year
0
5
10
15
20
25
30
35
40
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020

Colorado, Utah and Wyoming April 2011 Precipitation as Percentage of Normal

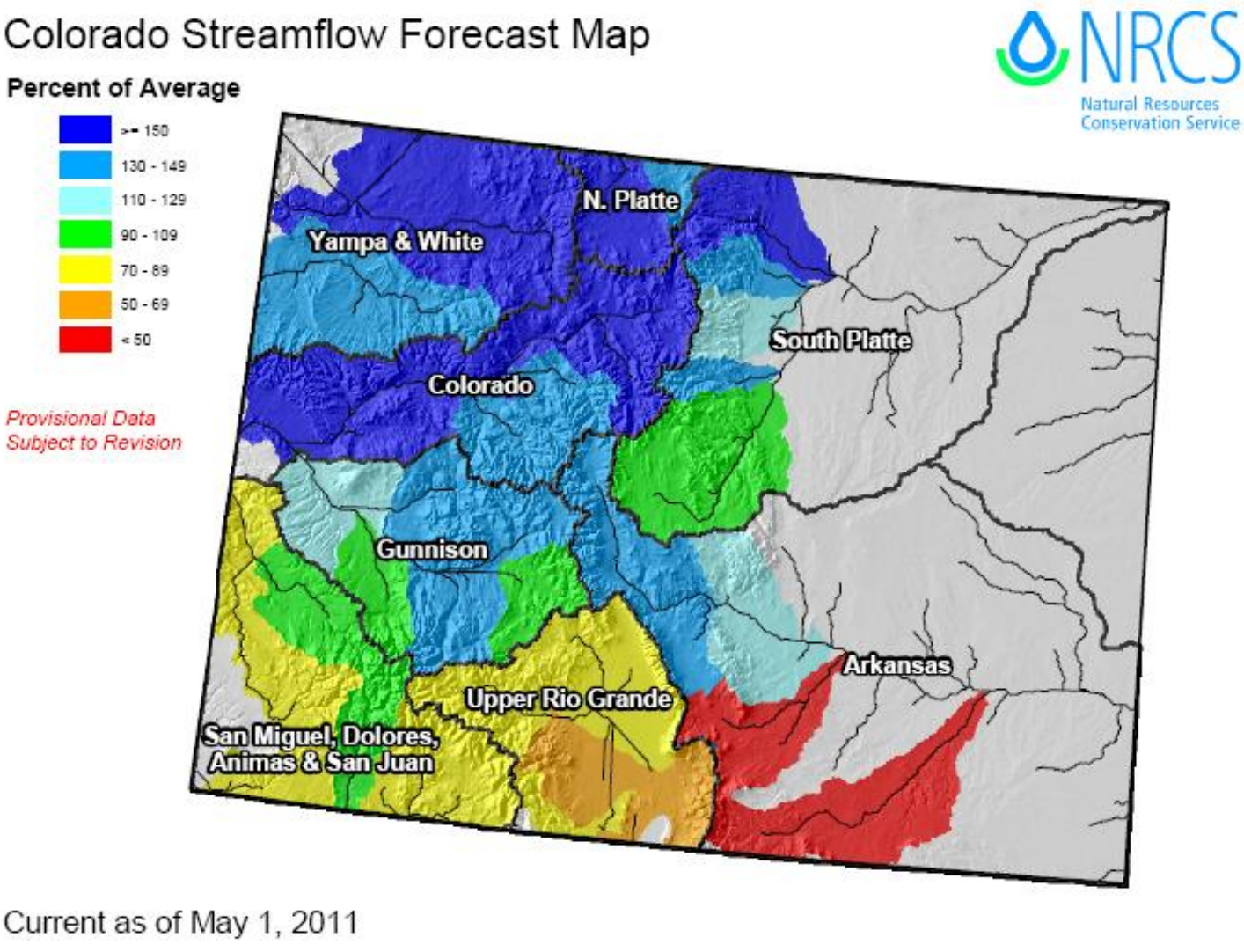


USDA, Natural Resources Conservation Service



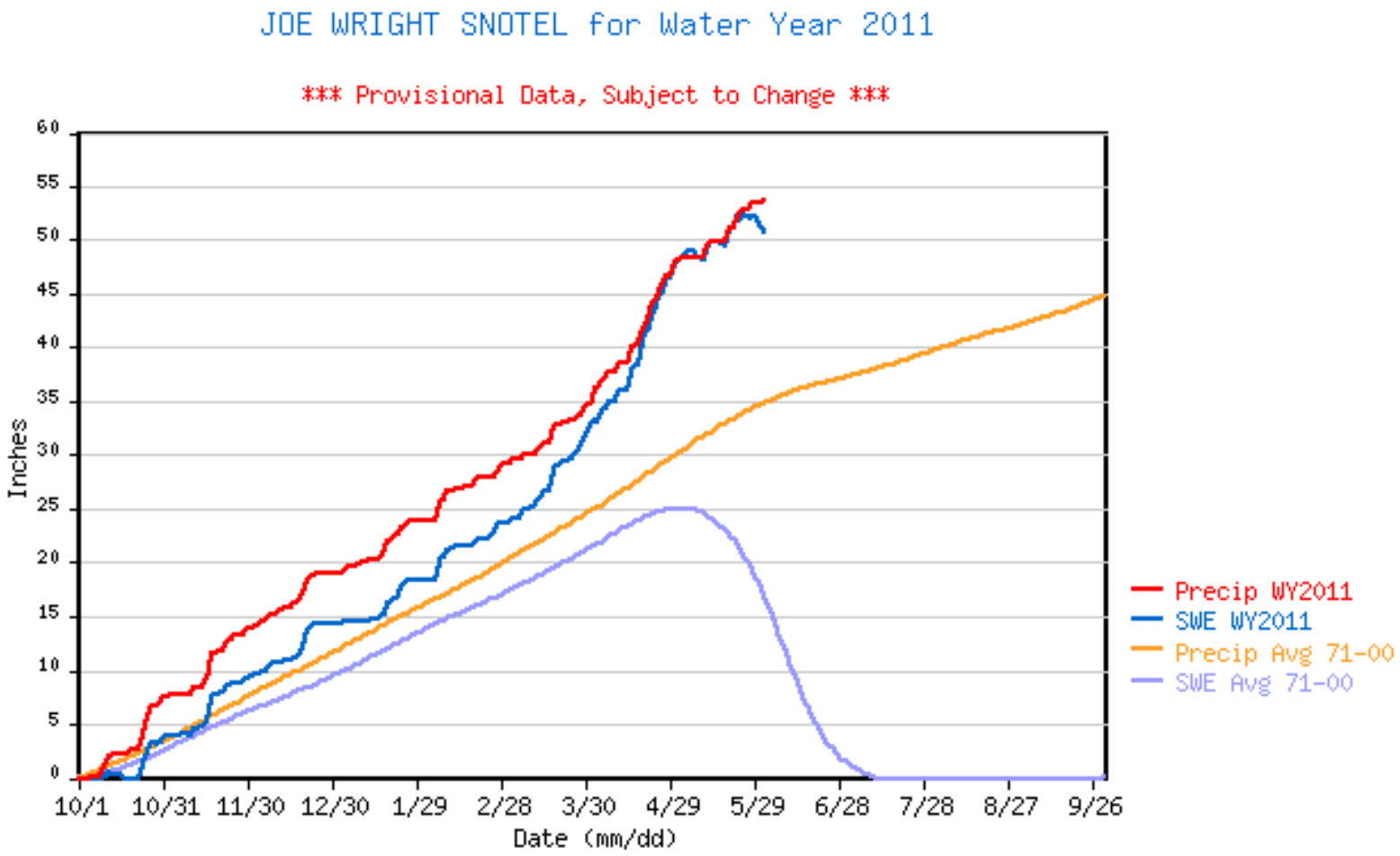
NRCS Snotel Sites for Colorado

NRCS Colorado Streamflow Forecast



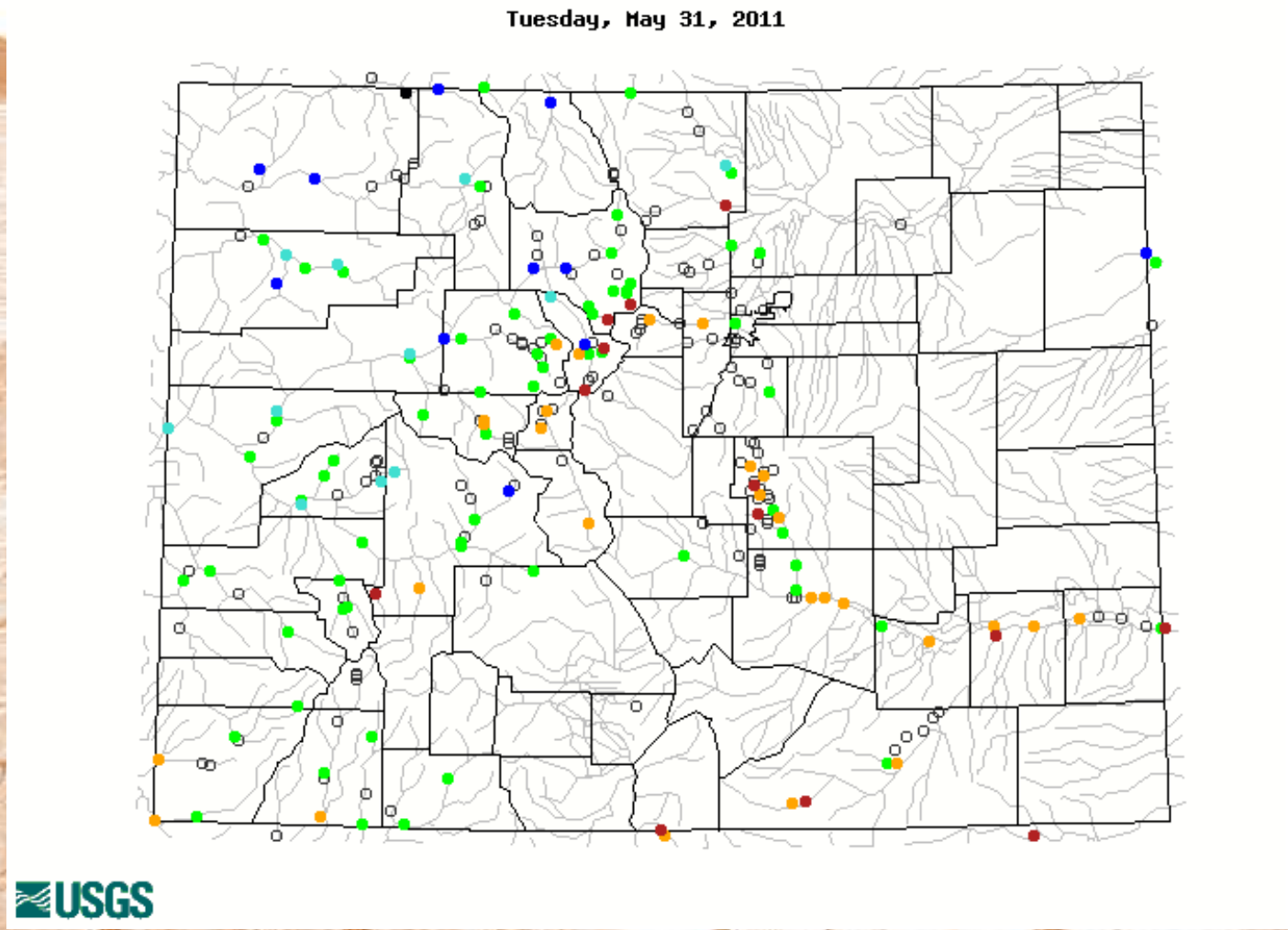
http://www.co.nrcs.usda.gov/

Joe Wright Snotel WY2011



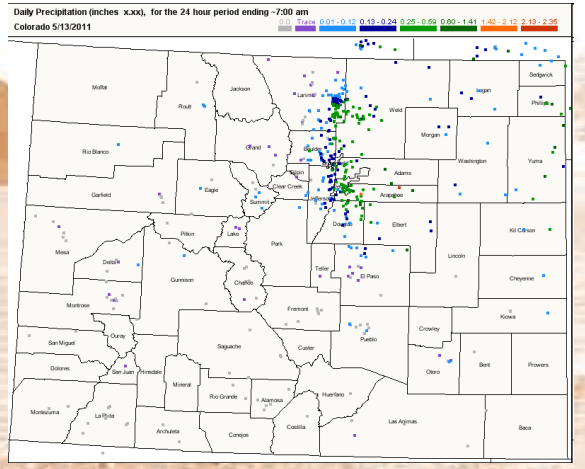
http://www.wcc.nrcs.usda.gov/snow/

U.S. Geological Survey

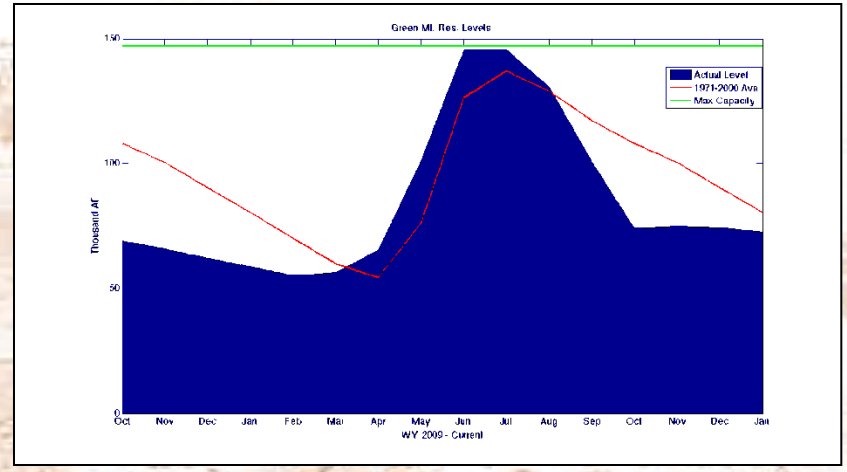


http://waterwatch.usgs.gov

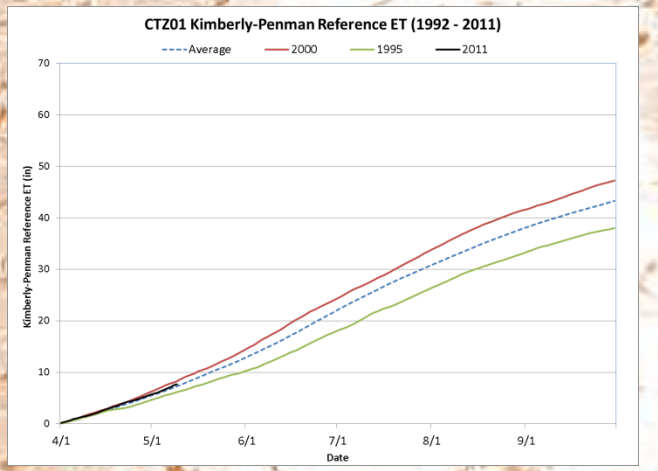
Others



CoCoRaHS High Density Precipitation Monitoring



Reservoir Storage Monitoring



CoAgMet Evapotranspiration Monitoring

Why Do We Like Indices?

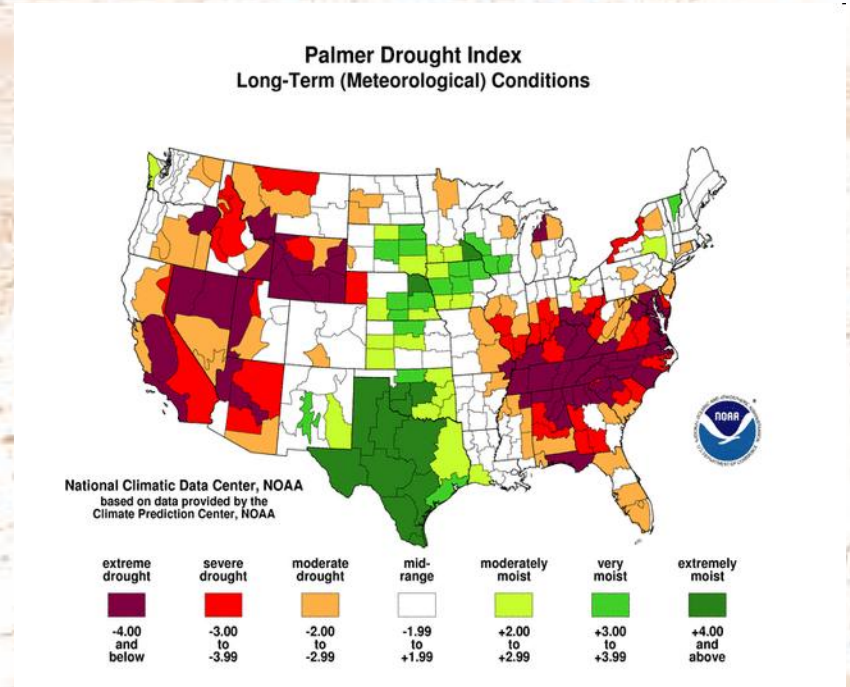
- Combination of several data sources.
- Simplification of historical context.
- Allow decision makers to quickly assess the severity, duration and frequency of drought.

Palmer Drought Severity Index (PDSI)

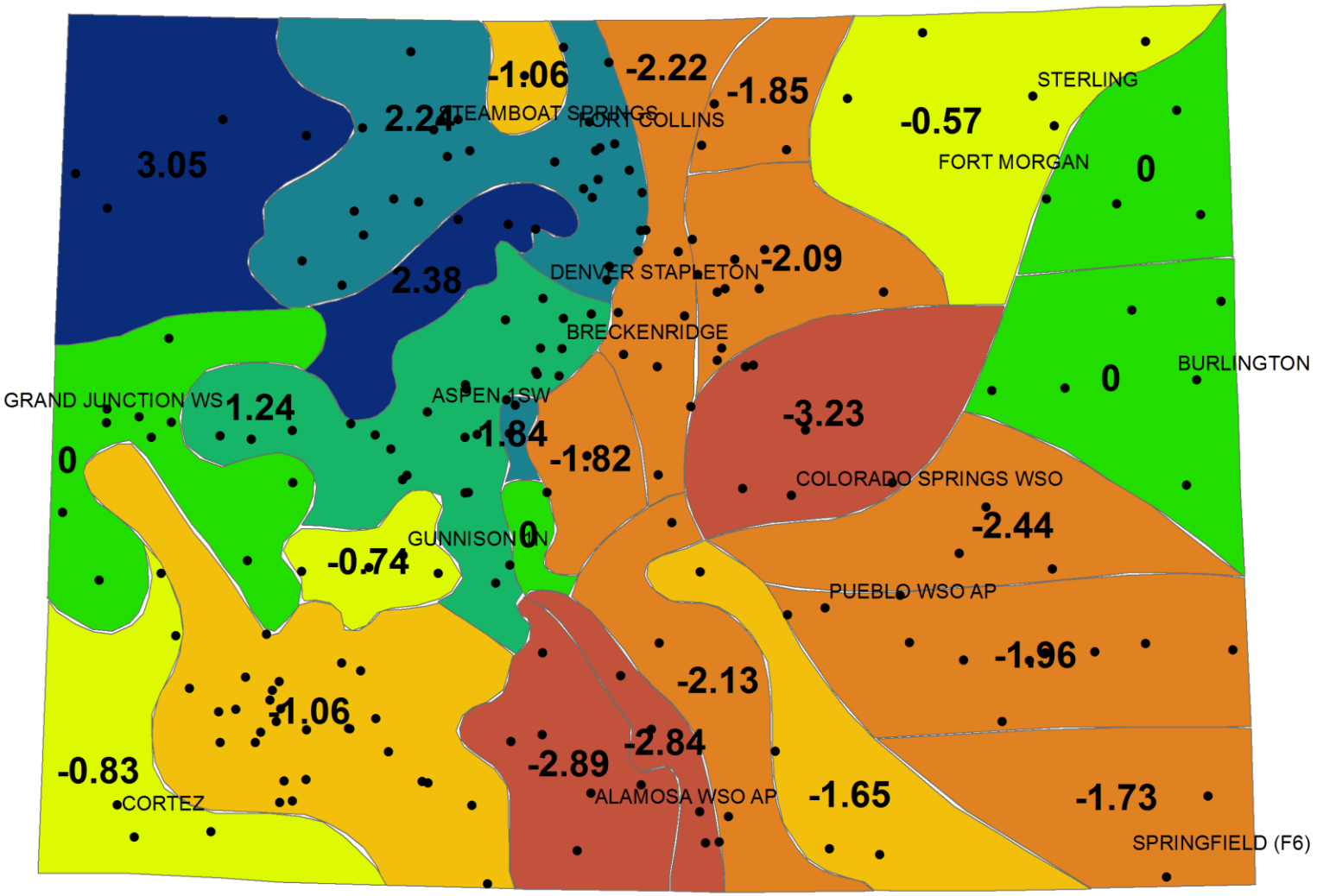
- Developed by Wayne Palmer in 1965.
- Simple water balance approach.
- Data requirements include temperature and precipitation.
- Climatically dependent coefficients must be determined that describe the normal conditions for that area.
- Index ranges from -6 to +6
- Colorado modifications increased the number of regions the index is calculated for (originally only 5).
- PDSI has been criticized for spatial comparability.
- PDSI has a “memory” around 12 months.
- For more information, see Palmer, 1965.

National Palmer Drought Severity Index

- Very useful on the national scale
- Not so useful locally in Colorado
- Not enough spatial detail for our complex climate, so we refined it
  - CMPDSI (Colorado Modified Palmer Drought Severity Index)



Preliminary Modified Palmer Drought Severity Index for Colorado
April 2011

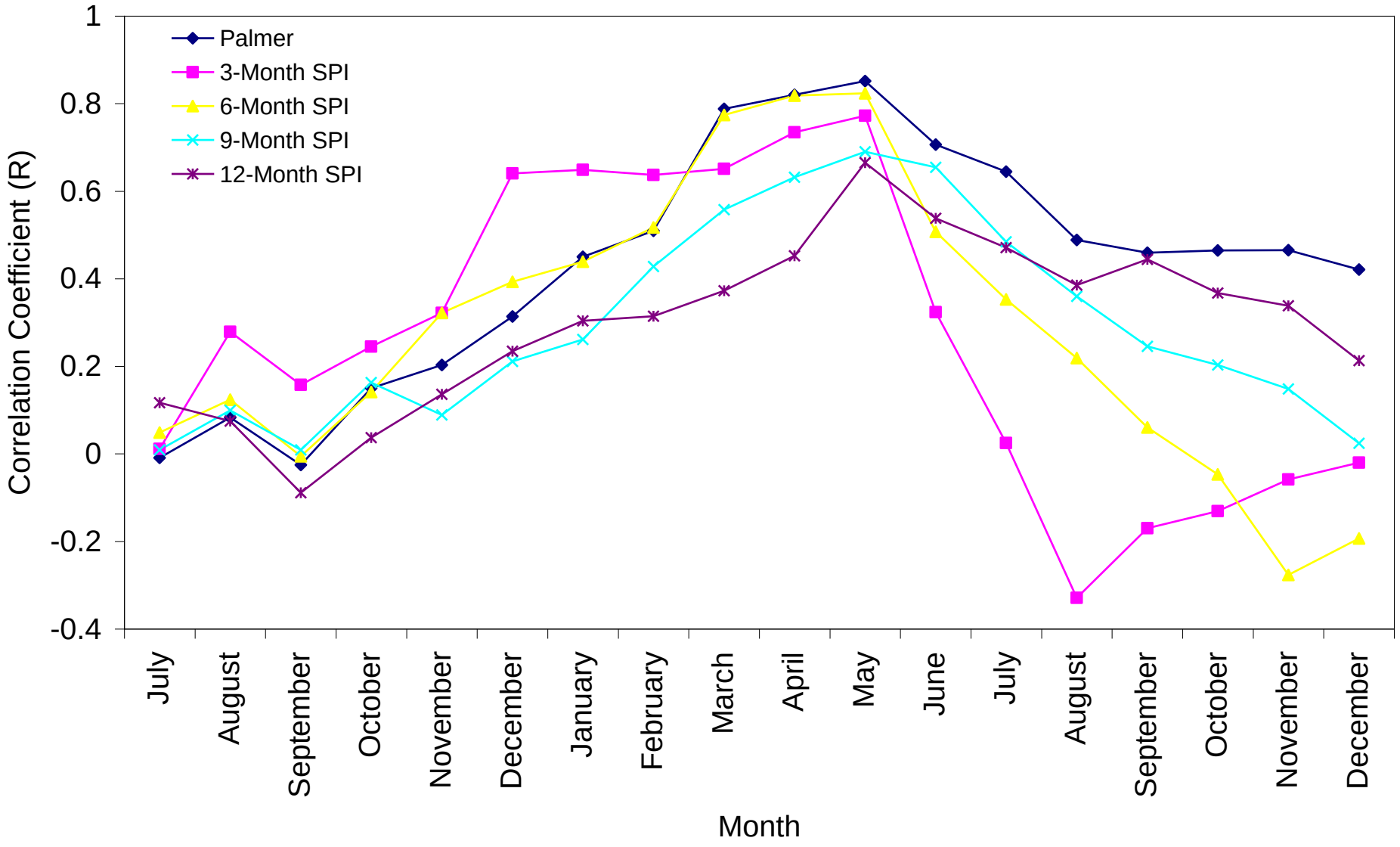


CMPDSI

- What do the values mean?

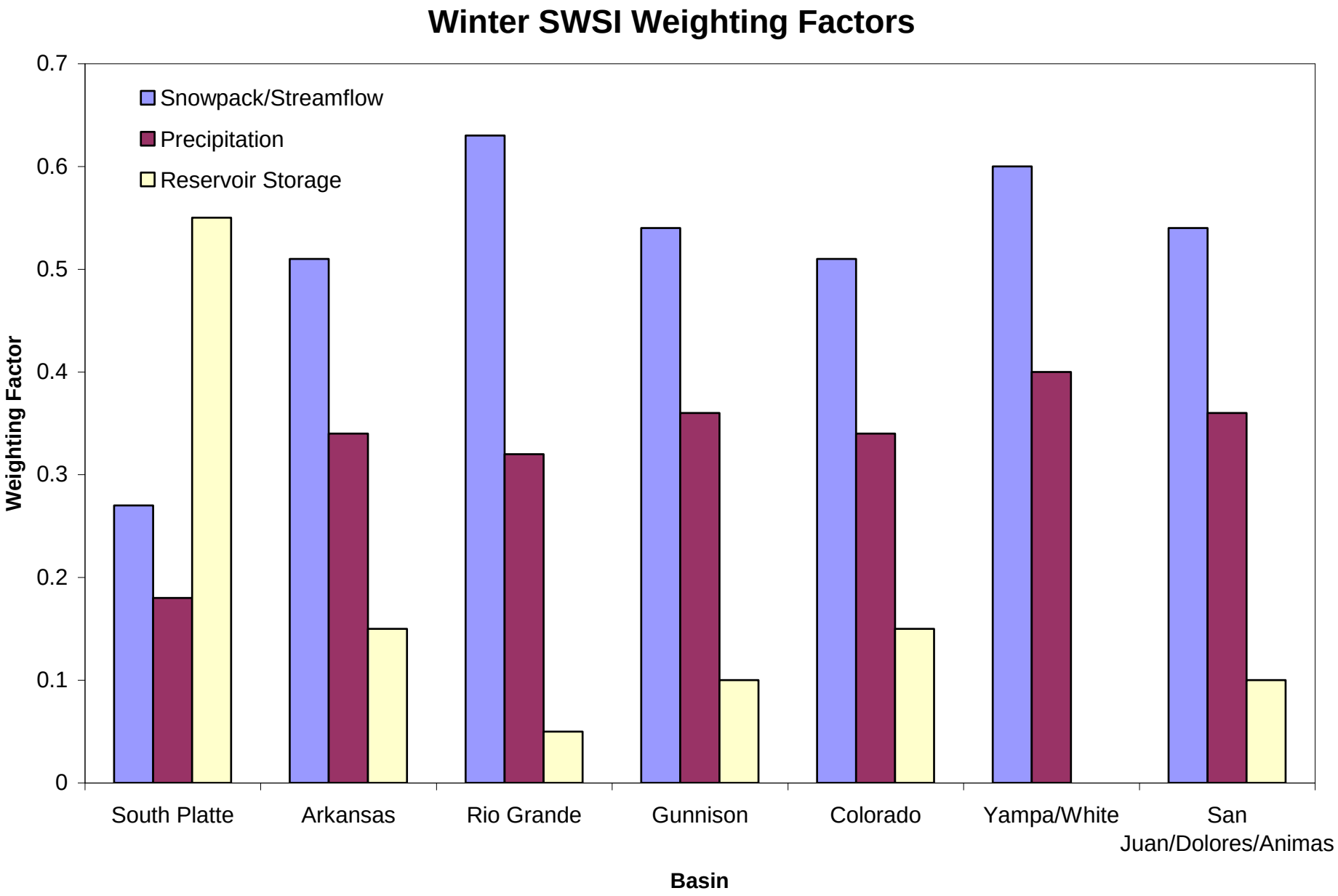
CMPDSI Value	Percentile Rank	Characteristic
-1.0 - -1.9	21-30	Abnormally Dry
-2.0 - -2.9	11-20	Moderate Drought
-3.0 - -3.9	6-10	Severe Drought
-4.0 - -4.9	3-5	Extreme Drought
≤ -5.0	0-2	Exceptional Drought

Palmer Region 1- Baca County Monthly Correlations of Index to Wheat Yield

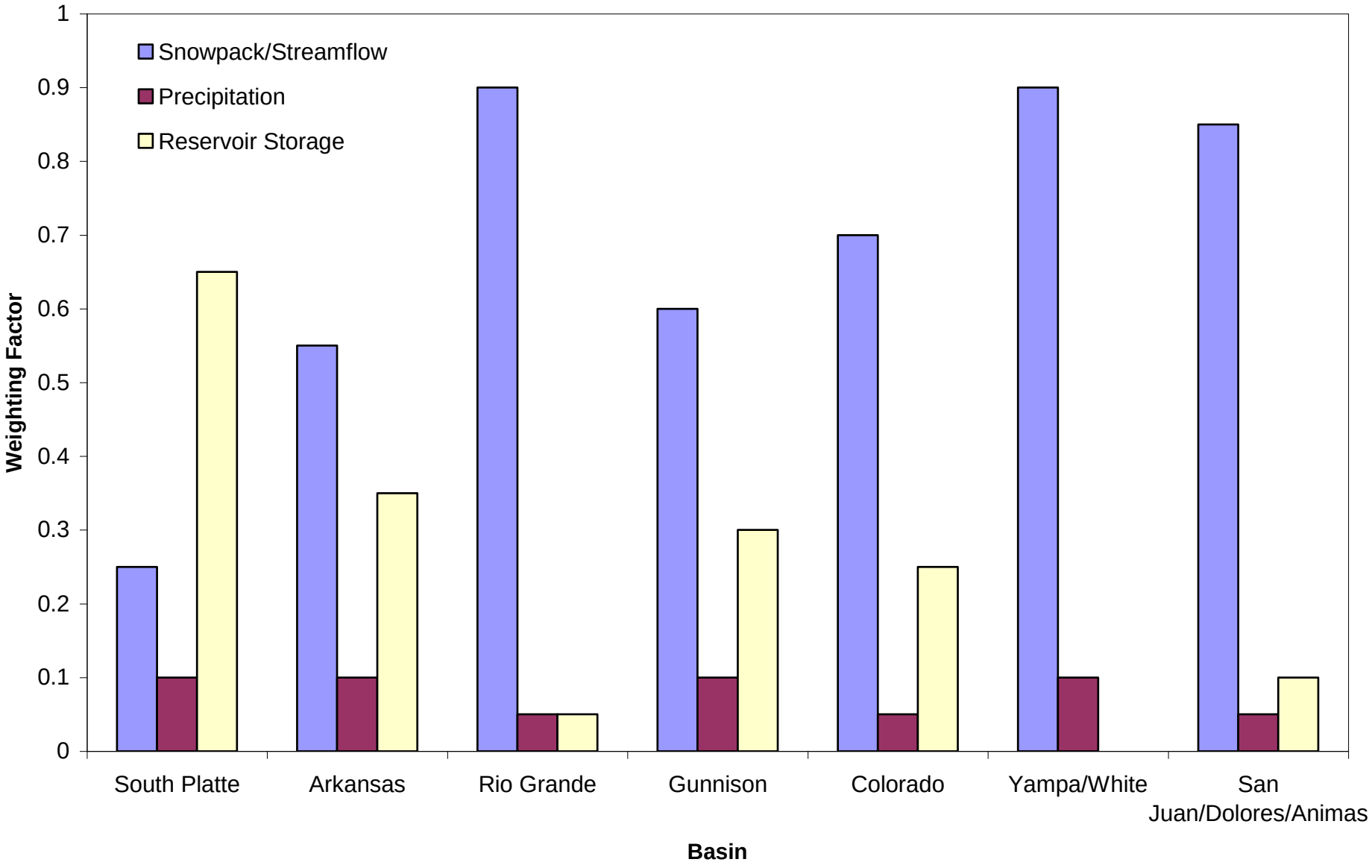


Surface Water Supply Index

- Winter (Dec-May): Snowpack, Water Year Precipitation and Reservoir Storage
- Summer (Jun-Nov): Streamflow, Previous Month Precipitation, and Reservoir Storage.
- Value indicates the abundance of water supply of a particular basin.
- Each of the components is weighted by overall impact in the basin.
  - Weighting factors change with season and basin (winter versus summer -- snowpack or streamflow)
  - This leads to discontinuities as seasons change.


Winter SWSI Weighting Factors
Snowpack/Streamflow
Precipitation
Reservoir Storage
Weighting Factor
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
South Platte
Arkansas
Rio Grande
Gunnison
Colorado
Yampa/White
San Juan/Dolores/Animas
Basin

Summer SWSI Weighting Factors



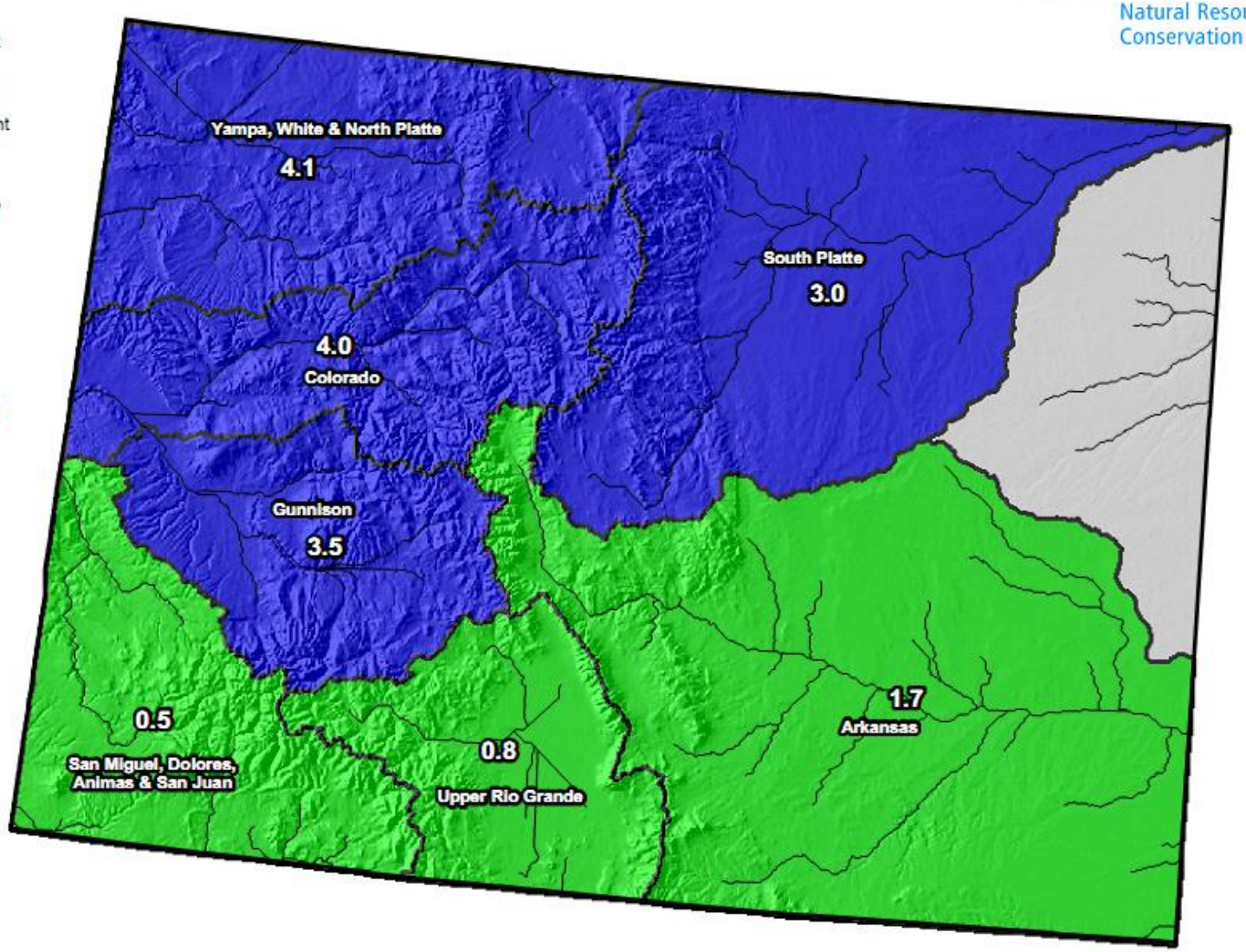
Colorado Surface Water Supply Index (SWSI) Map

NRCS
Natural Resources
Conservation Service

Legend

- Extreme Drought
- Severe Drought
- Moderate Drought
- Near Normal
- Abundant Supply

Provisional Data
Subject to Revision



Current as of May 1, 2011

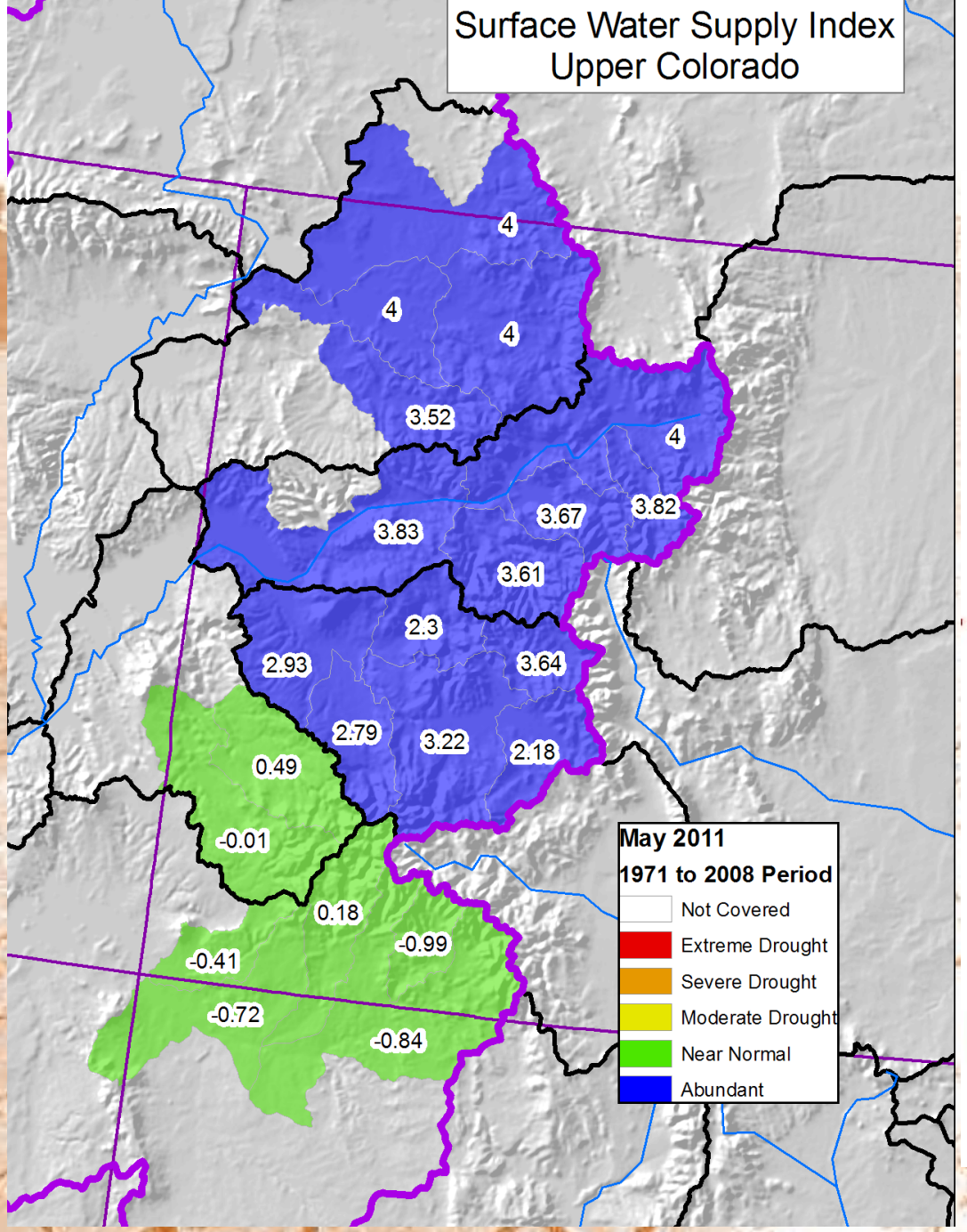
SWSI

- What do the values mean?

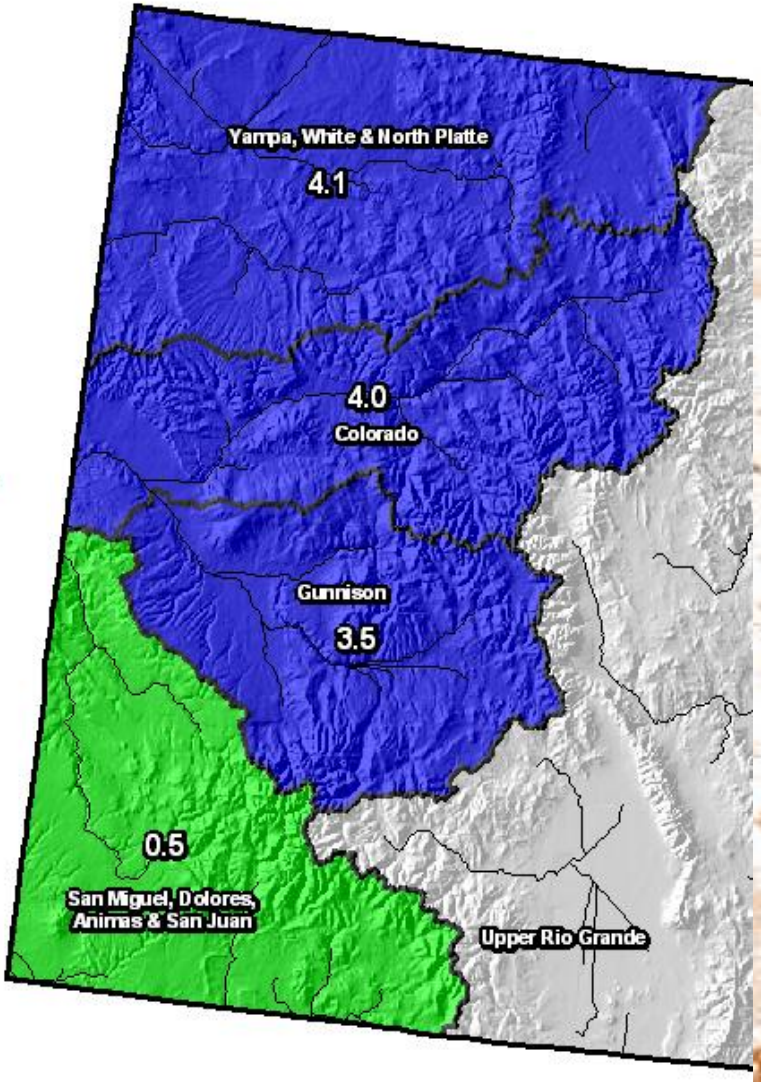
SWSI	Percentile Rank	Characteristic
-1.0 - -1.9	21-30	Abnormally Dry
-2.0 - -2.9	11-20	Moderate Drought
-3.0 - -3.9	6-10	Severe Drought
-4.0 - -4.9	3-5	Extreme Drought
≤ -5.0	0-2	Exceptional Drought

Revised SWSI

- Similar to “old” SWSI
  - Uses streamflow forecasts and reservoir storage instead of independent hydro-climatic factors (precipitation, streamflow, snowpack) with subjective weighting factors.
  - Based on finer spatial scale (8 digit HUC).
  - Performance of this revised index is on-going.



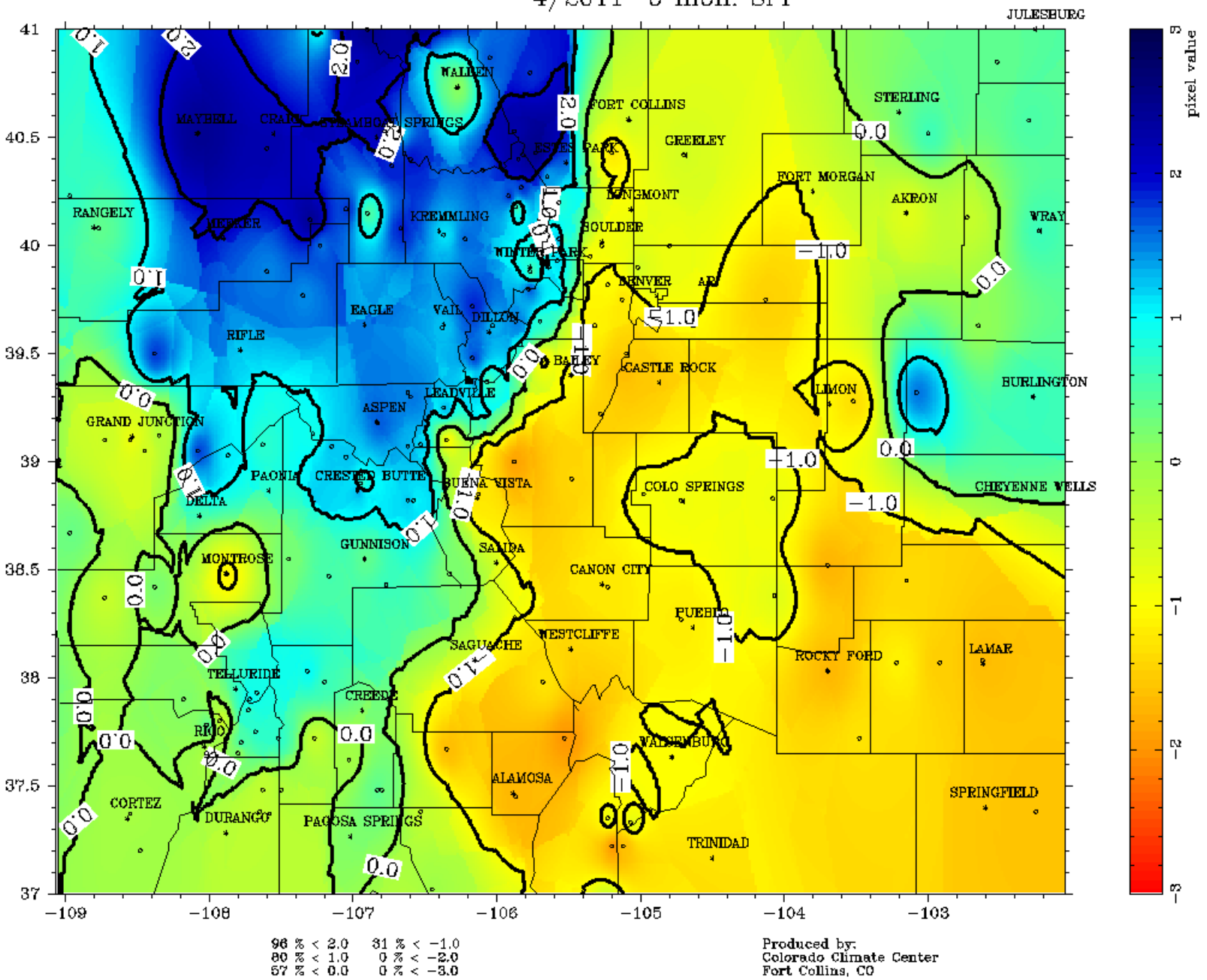
Colorado SWSI
May 2011



Standardized Precipitation Index (SPI)

- Developed at CCC in 1993 to monitor drought on various time scales.
- Can be compared across widely varied climates.
- Precipitation time series of length (n) are generated. (n = 1, 3, 6, 9, 12, 24, 36 months)
- Data is transformed to a normal distribution with mean = 0, variance = 1.
- The SPI is essentially the number of standard deviations an event is above or below the mean value.
- Index ranges from -3 to +3
- For more information see McKee, et al. 1993

Colorado


4/2011 6 mon. SPI
JULESBURG
STERLING
FORT COLLINS
GREELEY
FORT MORGAN
AKRON
WRAY
LONGMONT
BOULDER
DENVER
AP
BURLINGTON
LIMON
CASTLE ROCK
COLO SPRINGS
CHEYENNE WELLS
CANON CITY
PUEBLO
ROCKY FORD
LAMAR
SPRINGFIELD
TRINIDAD
WALSENBURG
WESTCLIFFE
SALIDA
BUENA VISTA
LEADVILLE
ASPEN
CRESTED BUTTE
GUNNISON
PAONIA
DELTA
GRAND JUNCTION
MONTROSE
TELLURIDE
OURAY
CREEDE
SAGUACHE
ALAMOSA
PAGOSA SPRINGS
DURANGO
CORTEZ
RIFLE
EAGLE
VAIL
DILLON
BAILEY
KREMMLING
WALDEN
STEAMBOAT SPRINGS
CRAIG
MAYBELL
RANGELY
MEEKER
ESTES PARK
WINTER PARK
41
40.5
40
39.5
39
38.5
38
37.5
37
−109
−108
−107
−106
−105
−104
−103
pixel value
3
2
1
0
−1
−2
−3
96 % < 2.0
80 % < 1.0
57 % < 0.0
31 % < −1.0
0 % < −2.0
0 % < −3.0
Produced by:
Colorado Climate Center
Fort Collins, CO

SPI

- What do the values mean?
  - SPI values relate directly to percentile rankings.
    - How does our current amount of precipitation rank against the past 30 years?

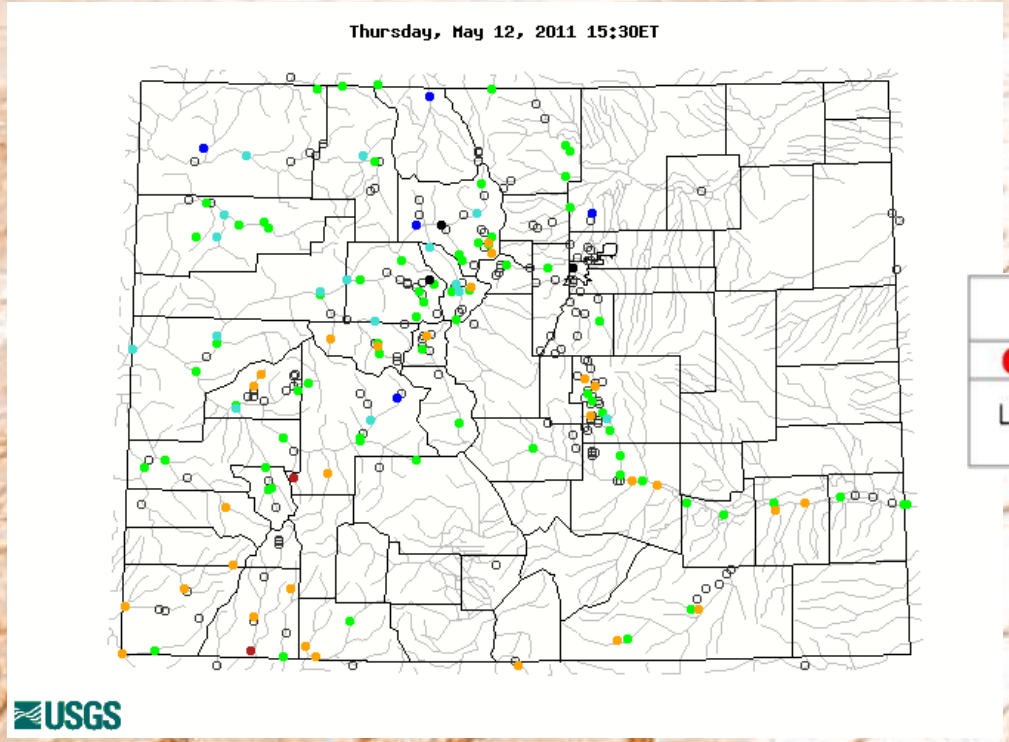
SPI Value	Percentile Rank	Characteristic
-0.5 - -0.7	21-30	Abnormally Dry
-0.8 - -1.2	11-20	Moderate Drought
-1.3 - -1.5	6-10	Severe Drought
-1.6 - -2.0	3-5	Extreme Drought
≤ -2.0	0-2	Exceptional Drought

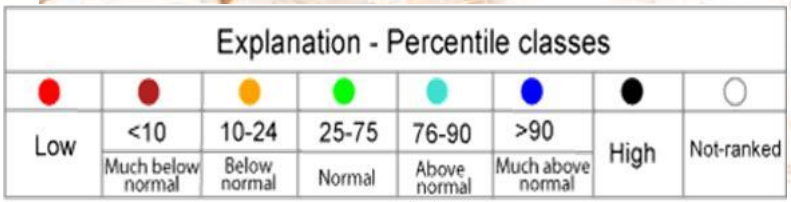
SPI

- What SPI time scale is the most important?
  - Depends on how you're using it.
    - Short term: Agriculture, rangeland, etc.
    - Long term: Fisheries, hydrologists, reservoir operations, etc.
    - *Monitoring drought: look at all time scales, the differences will indicate long vs. short term drought.*

Streamflow Conditions

- CDWR and USGS monitor stream gages across the state and provide real-time access to some gages.



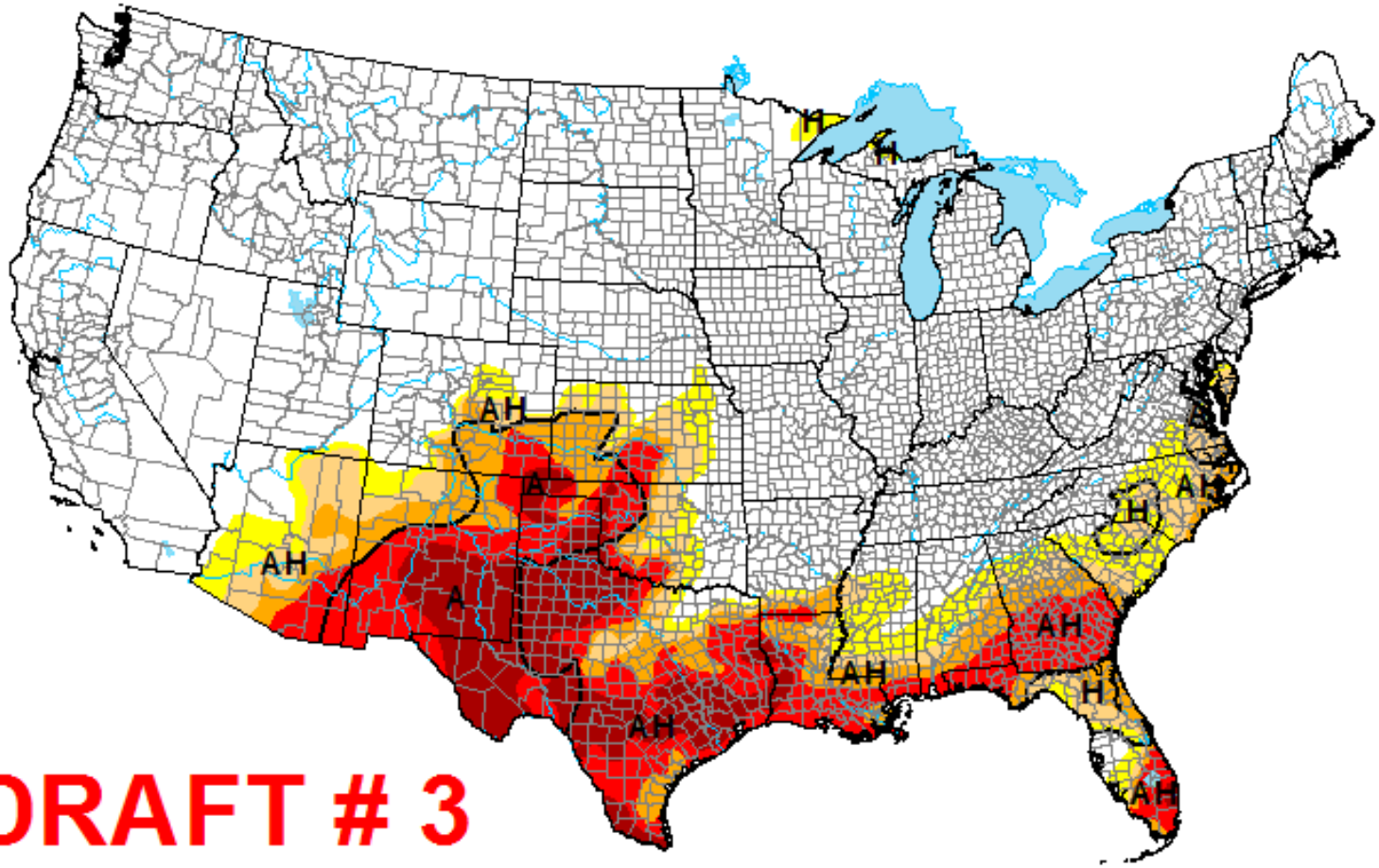


U.S. Drought Monitor

- National depiction of drought which is revisited weekly.
- Integration of numerous drought monitoring products, drought impacts and local expertise.
  - Highlights Agricultural vs. Hydrologic Drought
- Used by Farm Service Agency to grant disaster assistance.

U.S. Drought Monitor

May 31, 2011
Valid 8 a.m. EDT



DRAFT # 3

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

Drought Impact Types:
- Delineates dominant impacts
- A = Agricultural (crops, pastures, grasslands)
- H = Hydrological (water)
- (No type = Both impacts)

U.S. Drought Monitor

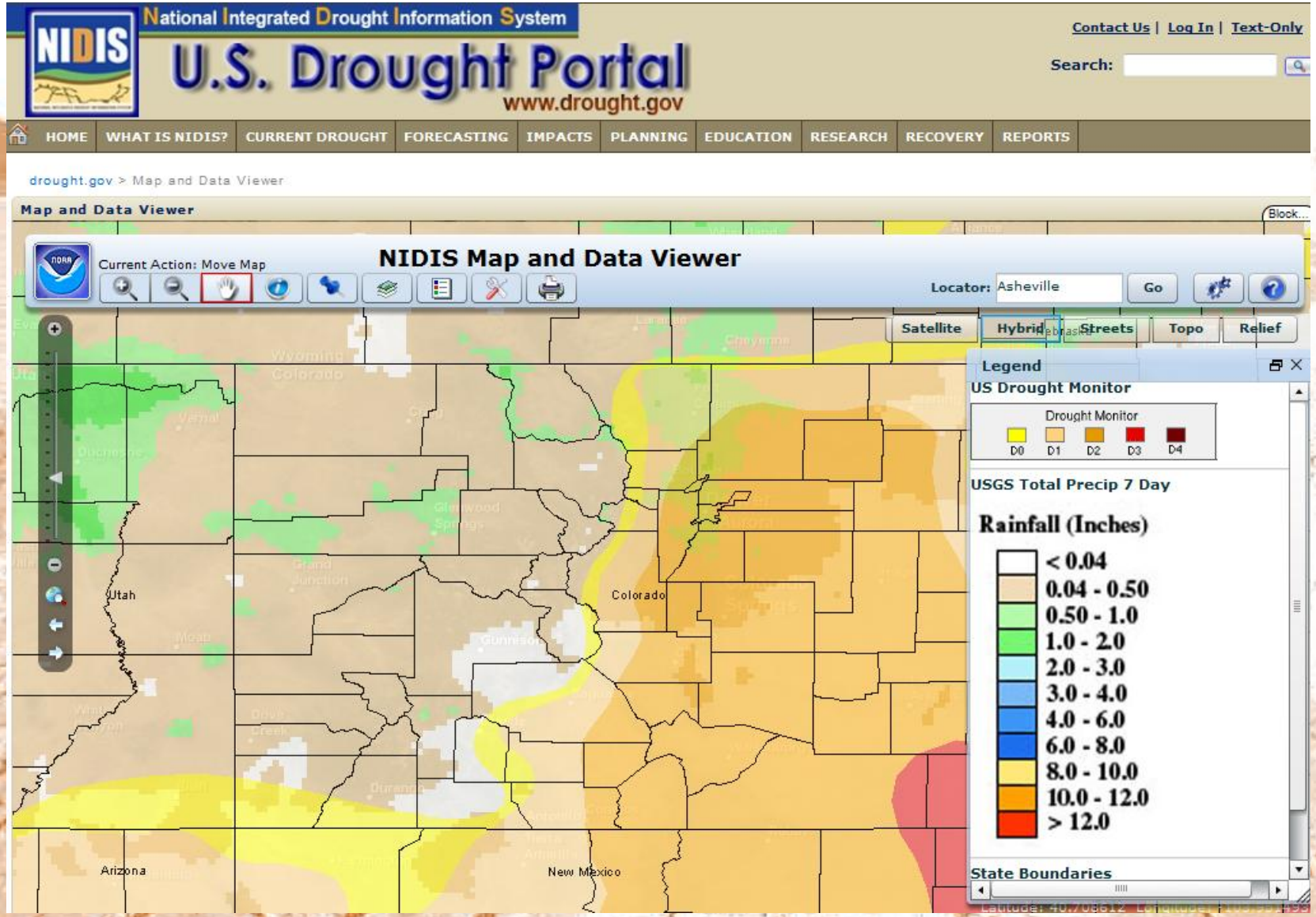
- What do the values mean?

US Drought Monitor	Percentile Rank	Characteristic
D0	21-30	Abnormally Dry
D1	11-20	Moderate Drought
D2	6-10	Severe Drought
D3	3-5	Extreme Drought
D4	0-2	Exceptional Drought

Drought Monitoring Resources

- Colorado Climate Center: Weekly webinars (during peak SWE/runoff) to assess current conditions and make USDM changes.
  - http://ccc.atmos.colostate.edu/drought_webinar_registration.php
- WATF: Water Availability Task Force
  - CWCB run group that meets monthly to assess current drought conditions.
  - http://cwcb.state.co.us/public-information/flood-water-availability-task-forces/Pages/main.aspx
- NIDIS Drought Portal
  - Access to various data types.
  - Portal: www.drought.gov
  - Map and Data Viewer http://www.drought.gov/portal/server.pt/community/drought.gov/map_and_data_viewer

NIDIS Drought Portal



www.drought.gov

How do we apply these indices?

Table 1 Drought Response Plan Summary Action Table

Severity Indicators and Impacts (Colorado Modified Palmer Drought Index (CMPDI) or SWSI, SPI, and U.S. Drought Monitor)	Drought Phase and Response Summary	Actions to be Considered
-1 to positive indices in all river basins or modified Palmer climate division -0.5 to positive SPI (six month) D0 Abnormally Dry D0 ranges: CMPDI or SWSI: -1.0 to -1.9 SPI: -0.5 to -0.7 Indicator blend Percentile: 21-30 Impacts: short-term dryness slowing planting, growth of crops or pastures.	Normal Conditions Regular Monitoring	• CWCB/WATF monitors situation on monthly basis, discusses trends with National Weather Service (NWS), State Climatologist, State Engineer, Natural Resource Conservation Service (NRCS), and others as appropriate. • Data reviewed for drought emergence and summarized in Governor's Drought Situation Report. • Implement long-term mitigation actions identified in drought mitigation plan • ITF chairs meet twice yearly to monitor progress on long-term drought mitigation and review any lessons from previous drought periods, and review the response plan.
-1.0 to -2.0 in any river basin or modified Palmer climate division -0.6 to -1.0 SPI (six month) D1 Moderate Drought D1 ranges: CMPDI or SWSI: -2.0 to -2.9 SPI: -0.8 to -1.2 Indicator blend Percentile: 11-20 Impacts: Some damage to crops, pastures; streams, reservoirs, or wells low, some water shortages developing or imminent; voluntary water-use restrictions requested	**Phase 1** More close monitoring of conditions for persisting or rapidly worsening drought; Official drought not yet declared	• ITF chairs alerted of potential for activation, monitoring of potential impacts. • Assess need for formal ITF and DTF activation depending on timing, location, or extent of drought conditions, existing water supply, and recommendation of WATF; DTF is comprised of WATF, ITF chairs, and Lead Agencies. • DTF Lead Agencies (CDA/DOLA/DNR) notified of need for potential activation.

Questions?

- McKee, T. B. , N. J. Doesken, and J. Kleist, 1993: The Relationship of Drought Frequency and Duration to Time Scales. *Preprints, 8th Conference on Applied Climatology*, 17-22 January, Anaheim, California, American Meteorological Society, 179-184.

- McKee, Thomas B, Nolan J. Doesken, and John Kleist, 1999: Historical Dry and Wet Periods in Colorado, *Climatology Report 99-1, Part A: Technical Report, Part B: Appendices*, Dept. of Atmos. Sci., CSU, Fort Collins, CO, July, 1999.

- Palmer, W. C., 1965: Meteorological Drought. U.S. Department of Commerce, Office of Climatoology, U.S. Weather Bureau. *Research Paper No. 45*. Washington, D. C. February 1965.
- Shafer, B.A.; and L.E. Dezman. 1982. Development of a Surface Water Supply Index (SWSI) to assess the severity of drought conditions in snowpack runoff areas. In *Proceedings of the Western Snow Conference*, pp. 164–175. Colorado State University, Fort Collins, Colorado.