

Putting soil moisture on the NWCC Interactive Map: Instructive for the NSMN effort?

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Angus Goodbody (NWCC), Cara McCarthy (NWCC), Rashawn Tama (NWCC), Kent
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Challenges for the NSMN effort

- **administrative structure & coordination**
- merging in situ network data with remotely-sensed values
 - research ongoing... (e.g. Steven Quiring & Trent Ford's efforts)
- **diverse user groups → different data needs**
 - drought assessment/mitigation
 - streamflow and reservoir storage forecasting
 - watershed modeling
 - research (basin hydrology, precipitation feedbacks, global climate, soil physical dynamics, etc.)
 - crop production, irrigation
 - fire hazard
 - flooding & erosion assessment/mitigation
 - engineering/structural applications (foundation leakage, road conditions, etc.)
 - soil ecosystems
 - ground-truthing satellite or model estimates
- identify key deliverables & timeline for each
- develop standards for data quality, sensor installations and maintenance
- determine template for presentation/delivery of data
 - example: NWCC Interactive Map...
 - (not advocating for this template, just offering it as an example of decision-making process)



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THIS PRESENTATION



Adding soil moisture to the NWCC Interactive Map

- **Questions**

- **which depth to use?**

- 2", 8", 20" sensors available at nearly all SNOTEL & SCAN sites
 - depth-integrated? If so, how calculated/weighted? Same weighting for all sites?

- **which frequency?**

- hourly SM values available and quality-controlled at majority of sites
 - Interactive map uses daily (midnight) values

- **which parameters are most useful?**

- current volumetric water content (VWC)?
 - % normal (or) departure from normal?
 - % saturation?

- **how long a period-of-record (POR) until data are included?**

- POR for most SNOTEL/SCAN sites: ~ 5 - 15 years



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Adding soil moisture to the NWCC Interactive Map

- **Compromises**
 - **SM values need to be contextualized**
 - e.g. Tyson & Ronald's talks
 - daily (midnight) max values from POR used as proxy for % saturation (still in production)
 - hourly values = better as daily values may miss SM peaks (in future)
 - **data processing limitations to analysis**
 - pull from main database, try not to require additional 'flat file' values
 - **soils lab data not available for many sites**
 - use period-of-record data for saturation values
 - **no clear solution for depth-integration**
 - user can select any available depth
 - depth-integrated value can be added later
 - **no clear solution for regionalizing data**
 - basin % normal and % saturation are averages of values from sites in each basin
 - **short POR requires the incorporation of recently-installed sensors**
 - 5 year minimum used
 - **uses data that have not yet been quality-controlled**
 - effort ongoing for all SNOTEL & SCAN hourly SM/ST data
 - **uses daily (midnight) values instead of hourly data**
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 - not as problematic for SCAN



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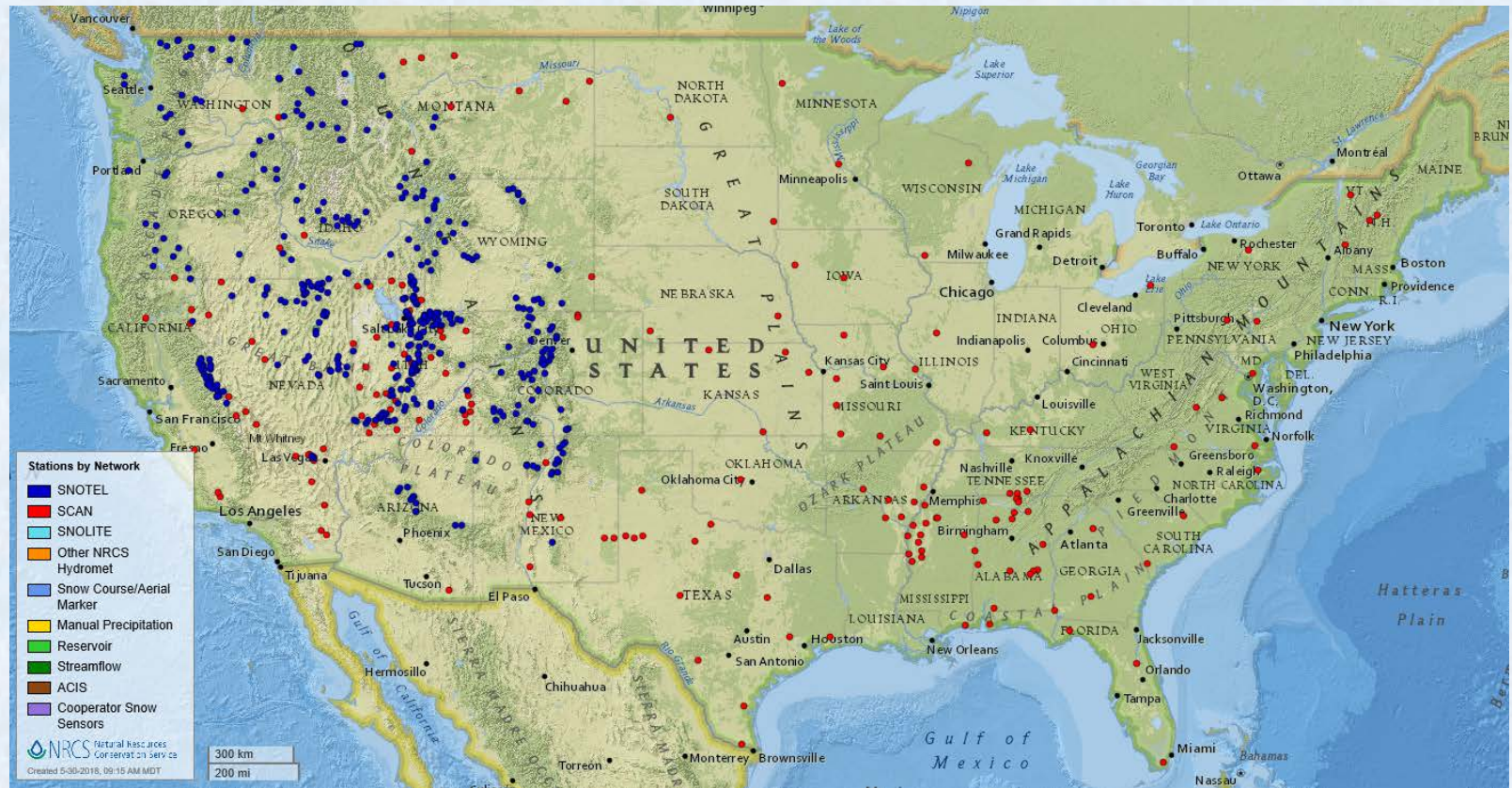
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Background

- Interactive Map uses daily data from multiple networks
- can select variety of parameters, statistics, time intervals, etc.



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MAP CONTROLS

Map Mode:

Station Inventory	Station Conditions
Basin Conditions	Station/Basin Conditions

Conditions

Element

Snow Water Equivalent

- Snow Water Equivalent
- Delta
- Water Year Peak
- Date of Water Year Peak

Snow Depth

- Snow Depth
- Delta
- Water Year Peak
- Date of Water Year Peak

Snow Density

- Snow Density
- Delta

Precipitation

- Precipitation

Soil Moisture 20 in. ▾

- Soil Moisture
- Delta
- Water Year Peak
- Date of Water Year Peak

Soil Temperature 20 in. ▾

- Soil Temperature
- Delta
- Water Year Peak
- Date of Water Year Peak

Reservoir

- Reservoir Storage
- Delta

Streamflow Active Forecast Points Only

- Adjusted Volume - Observed
- Adjusted Volume - Forecast
- Exceedance Probability: 50% ▾

Parameter

Value

- Value

Percent of Central Tendencies

- Percent of POR Average
- Percent of POR Median

Percent of Water Year Peak

- Percent of Water Year Peak
- Percent of Average Water Year Peak
- Percent of Median Water Year Peak

Anomaly

- POR Median Departure

Compared to Period of Record

- Percentile
- Maximum Rank
- Minimum Rank
- Records

MAP CONTROLS

Central Tendencies

- POR Average
- POR Median

Period of Record

- Minimum
- Maximum
- Year of Minimum
- Year of Maximum
- Number of Observations

Date, Frequency, and Duration

Frequency: Daily ▾

Time: End of Day ▾

Date

Year: 2018 ▾ + -

Month: May ▾ + -

Day: 1 ▾ + -

Go to Now Relative date in URL

Data/Display Options

Reference Period

- Period of Record
- Fixed: 1981 ▾ to 2010 ▾

Minimum Years for Display: 5

Color Sets

- Colors for Sequential Parameters ▾
- Colors for Divergent Parameters ▾

Scale Range

- Default [0% - 200%]
- Range of Data [0% - 1,967%]
- Custom: -

Opacity

Stations/Basins: 100

Basins (no data): 100

Basemap: 100

Mask: 0

Station Selection

Location

States All None Counties All None

Alabama
Alaska
Arizona
Arkansas
California
Colorado
Florida
Georgia
Louisiana
Maine
Maryland
Massachusetts
Michigan
Minnesota
Mississippi
Missouri
Montana
Nebraska
Nevada
New Hampshire
New Jersey
New Mexico
New York
North Carolina
North Dakota
Ohio
Oklahoma
Oregon
Pennsylvania
Rhode Island
South Carolina
South Dakota
Tennessee
Texas
Utah
Vermont
Virginia
Washington
West Virginia
Wisconsin
Wyoming

HUCs:

Include Associated Outside Stations

Minimum Elevation: ft.

Maximum Elevation: ft.

Collection Networks

- Active Sites Only

Check All Uncheck All

USDA-NRCS Real-Time Networks

- SNOTEL (444)
- SCAN (211)
- SNOLITE (2)
- Other NRCS Hydromet (0)

USDA-NRCS Non-Real-Time Networks

- Snow Course/Aerial Marker (0)
- Manual Precipitation (0)

Other Networks

- Reservoir (0)
- Streamflow (0)
- ACIS (0)
- Cooperator Snow Sensors (0)

Map Layers

Base Map

Overlays

Watershed Boundaries (Ready)

- Region (2-Digit HUC)
- Subregion (4-Digit HUC)
- Basin (6-Digit HUC)
- Subbasin (8-Digit HUC)

State Watershed Boundaries (Ready)

- Arizona
- Colorado
- Idaho
- Montana
- Nevada
- New Mexico
- Oregon
- Washington
- Wyoming

Political Boundaries (Ready)

- States

Labels

Station Labels

- Name
- ID
- Elevation
- Parameter

Watershed Labels

- Name
- HUC
- Parameter

Leaflet | Tiles © Esri — National Geographic, Esri, DeLorme, NAVTEQ, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, IPC

Background

- Interactive Map uses daily data from multiple networks
- can select variety of parameters, statistics, time intervals, etc.

The screenshot displays the MAP CONTROLS interface, which is divided into several sections:

- MAP CONTROLS (Top):** Includes a 'Map Mode' section with a table:

Station Inventory	Station Conditions
Basin Conditions	Station/Basin Conditions
- Conditions:** A list of parameters such as Snow Water Equivalent, Snow Depth, Snow Density, Precipitation, Soil Moisture, Soil Temperature, Reservoir, and Streamflow. Each parameter has a dropdown menu for units (e.g., '20 in.').
- Central Tendencies:** Options for POR Average, POR Median, and Period of Record (Minimum, Maximum, Year of Minimum, Year of Maximum, Number of Observations).
- Date, Frequency, and Duration:** Fields for Frequency (Daily), Time (End of Day), Date (Year, Month, Day), and a 'Go to Now' button.
- Data/Display Options:** Reference Period (Fixed: 1981 to 2010), Minimum Years for Display (5), Color Sets (Sequential and Divergent Parameters), Scale Range (Default [0% - 200%]), and Opacity sliders for Stations/Basins, Basins (no data), and Basemap.
- Station Selection:** A 'Location' section with dropdowns for States and Counties, and a 'HUCs' field.
- Value:** Options for Value, Percent of Central Tendencies (POR Average, POR Median), Percent of Water Year Peak, and Anomaly (POR Median Departure, etc.).
- Collection Networks:** A list of networks with checkboxes: Active Sites Only, USDA-NRCS Real-Time Networks (SNOTEL, SCAN, SNOLITE, etc.), USDA-NRCS Non-Real-Time Networks (Snow Course, Manual Precipitation), and Other Networks (Reservoir, Streamflow, ACIS, etc.).
- Map Layers:** A list of map layers including Base Map, Overlays (Watershed Boundaries, State Watershed Boundaries, Political Boundaries), Station Labels, and Watershed Labels.

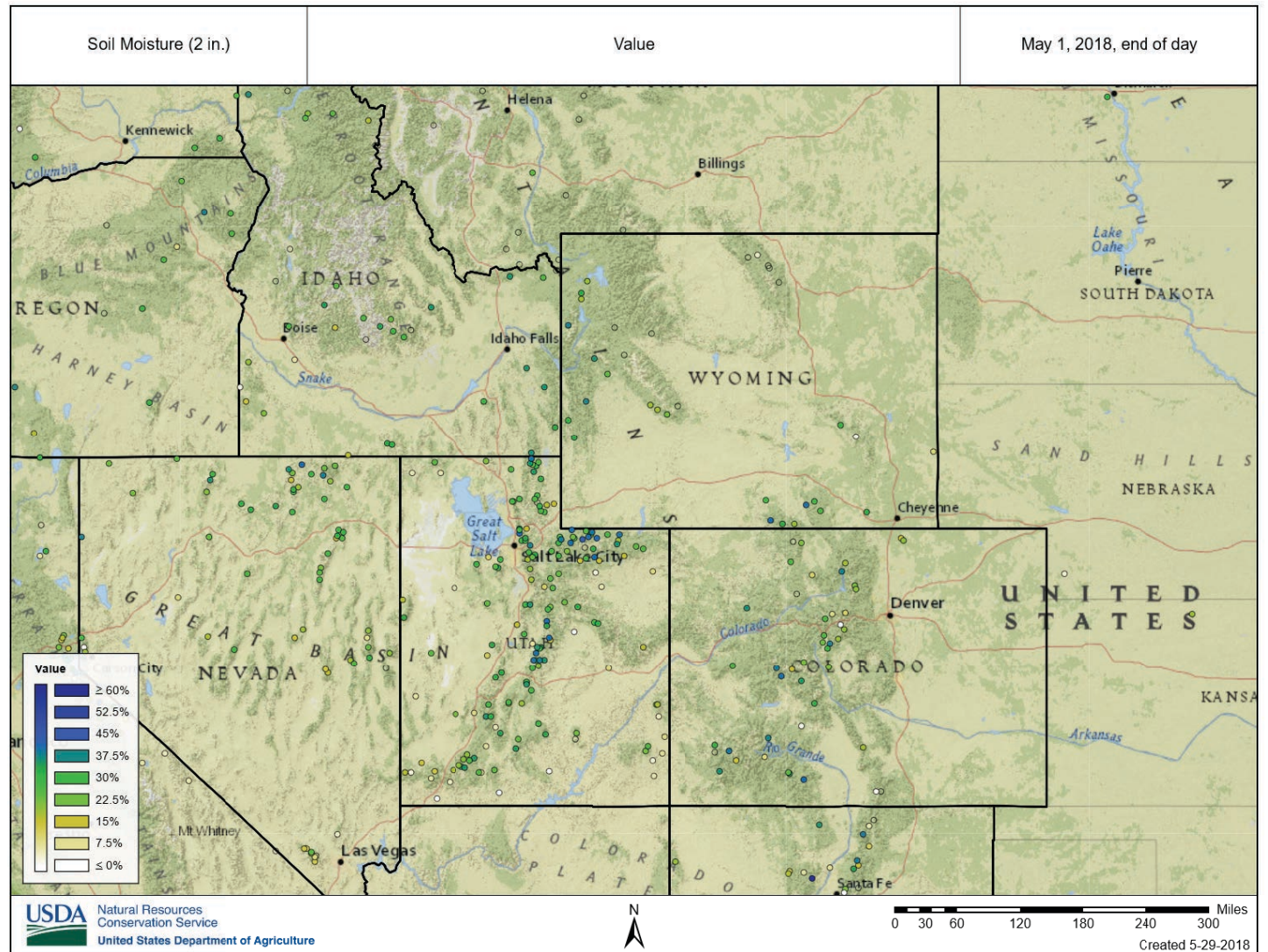


EXAMPLES

Surficial soil moisture

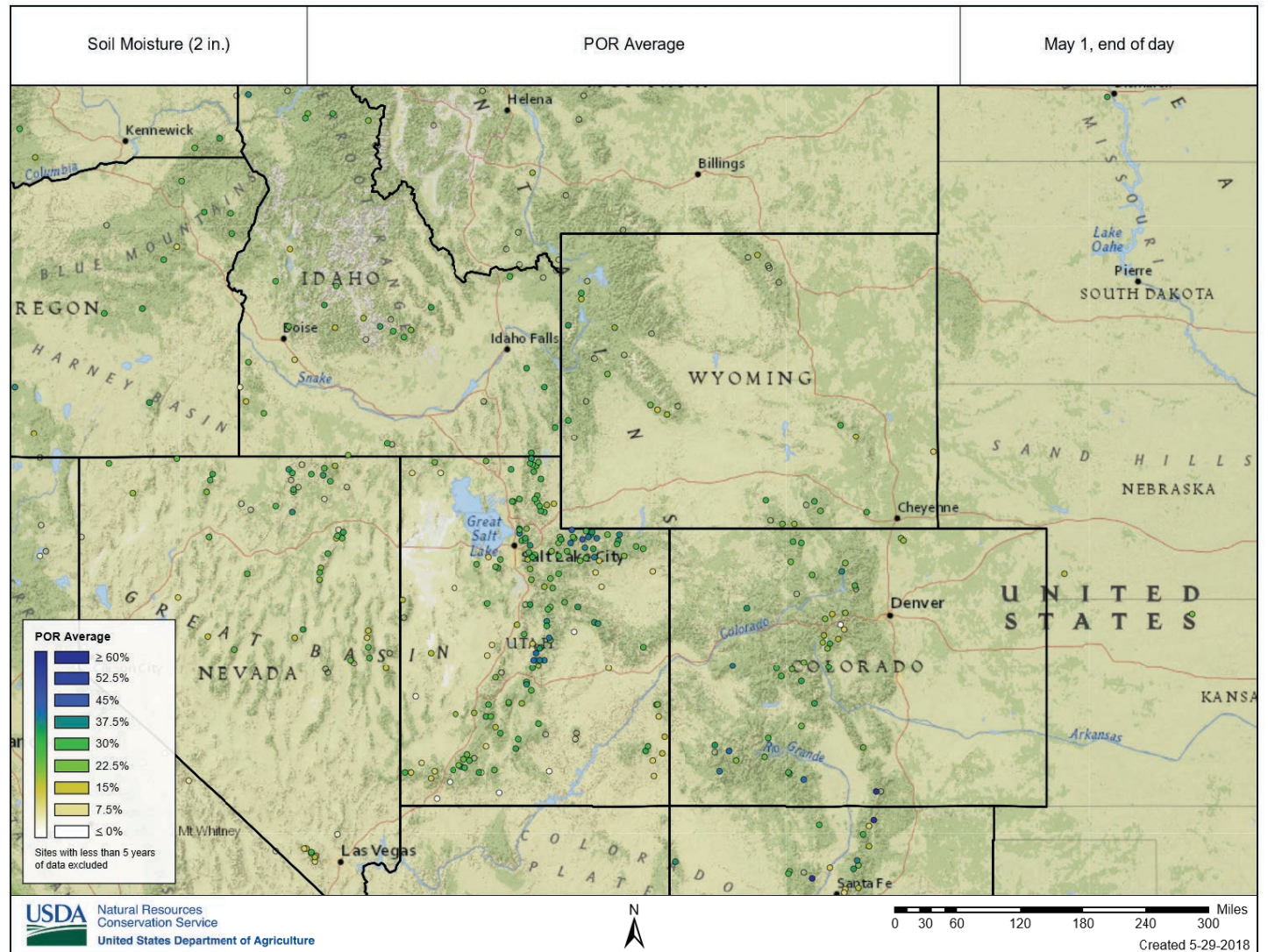
- VWC at 2" (5 cm) depth
- SNOTEL & SCAN networks
- Stevens HydraProbe sensors

Can discern regional trends but hard to contextualize...



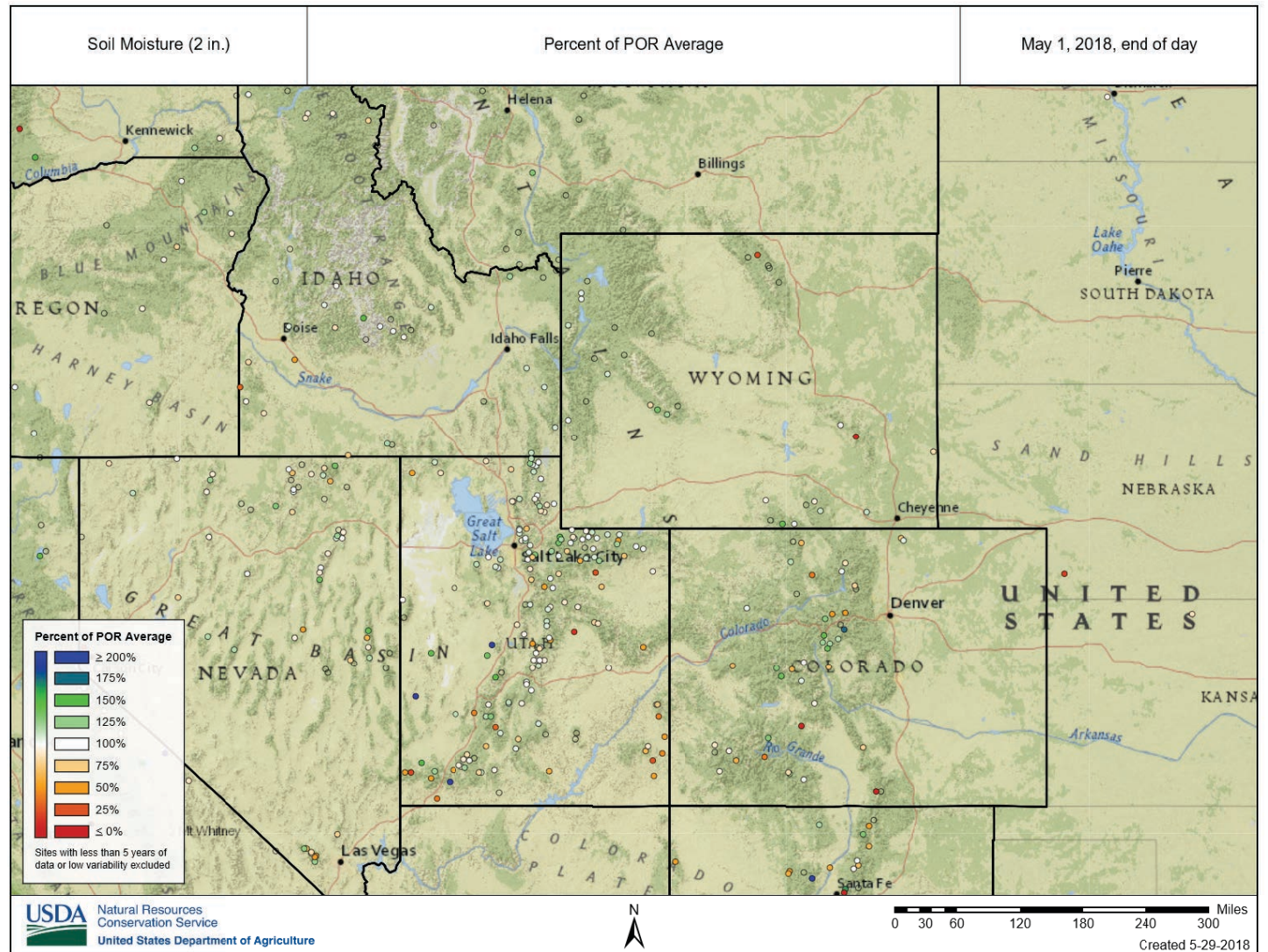
POR average

- from daily (midnight) values
- POR data quality-controlled for each site (ongoing)
- POR range: 5 to ~20 years (minimum of 5 to be used on map)



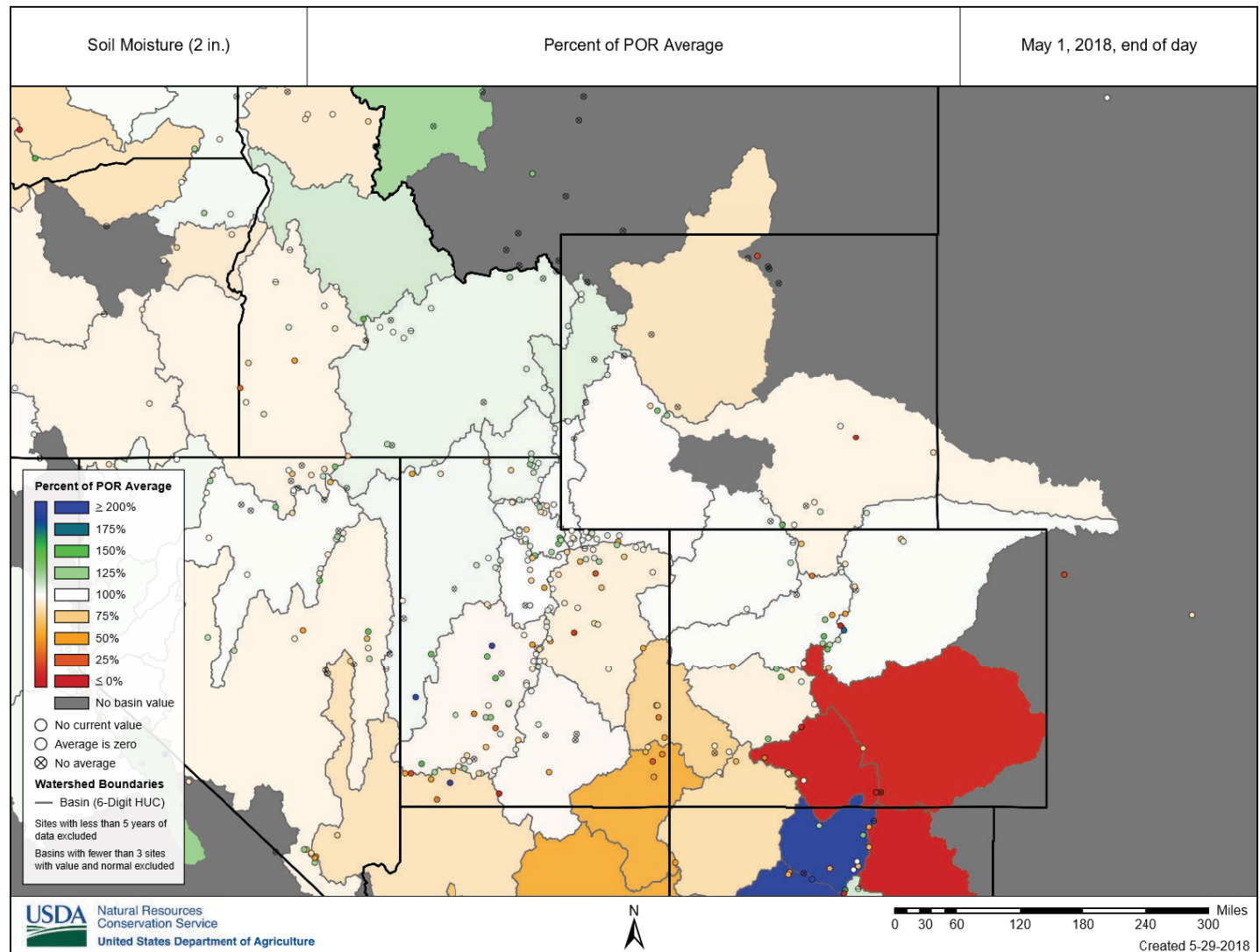
Percent normal

- for a given date & depth
- can specify different depths



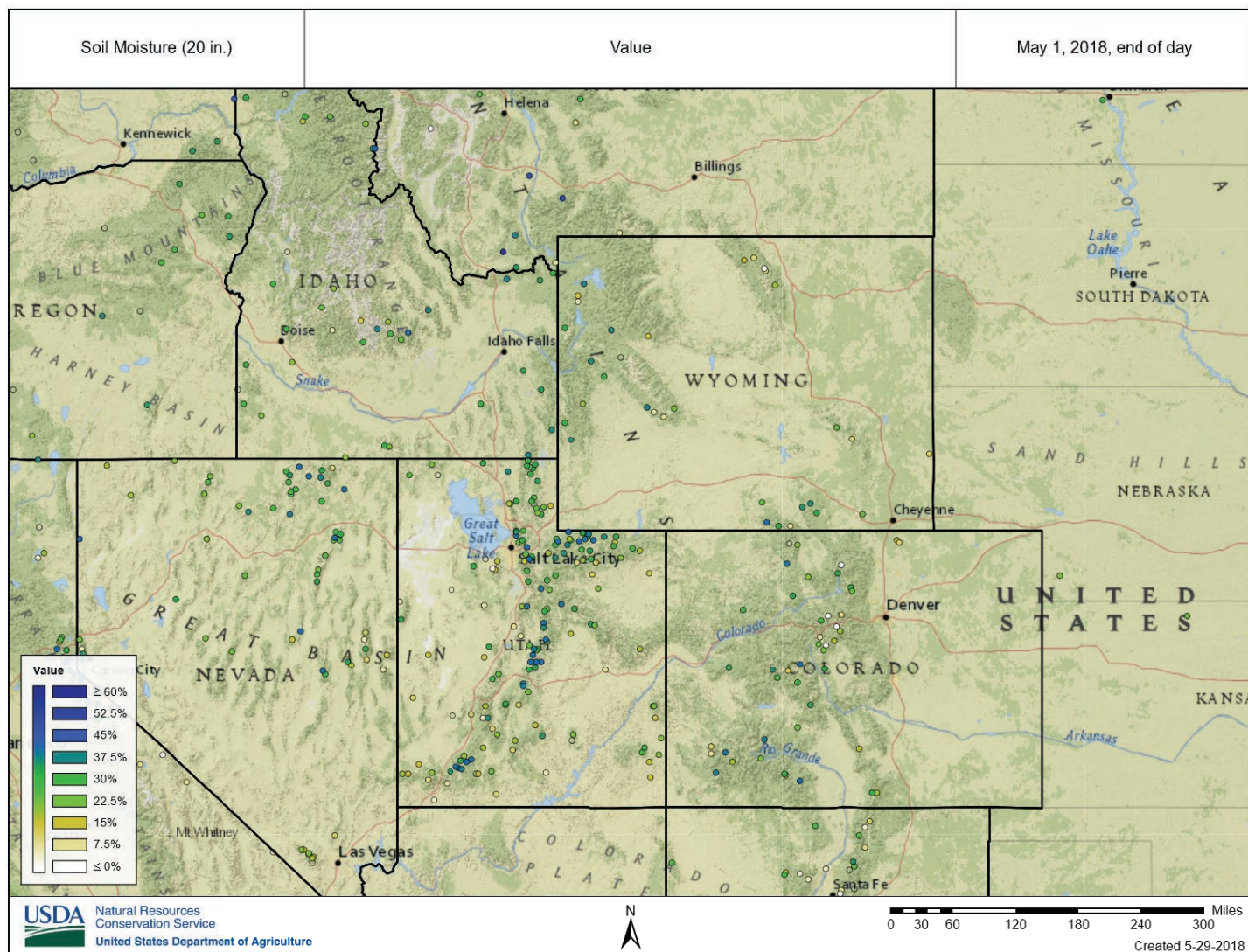
Percent normal for basins

- 6-digit HUCs
- = avg of sites in basin
- minimum for including basins on map
 - 3 sites
 - % normal values available for those sites for at least 5 years



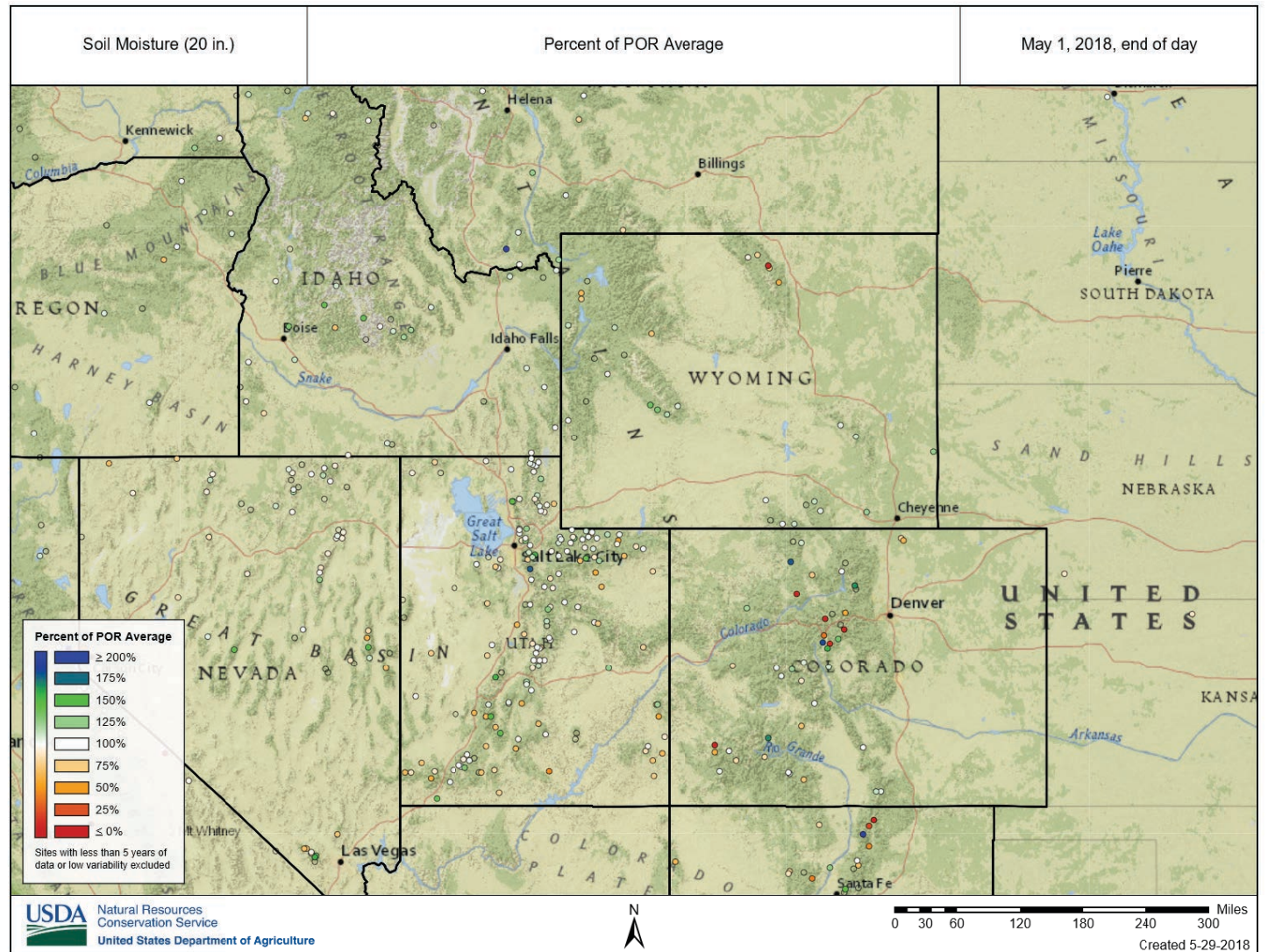
Soil moisture at depth

- 20" (50 cm) sensor
- lower variability
- more representative of longer-term conditions (drought, excessive SM, etc.)
 - e.g. Trent's results



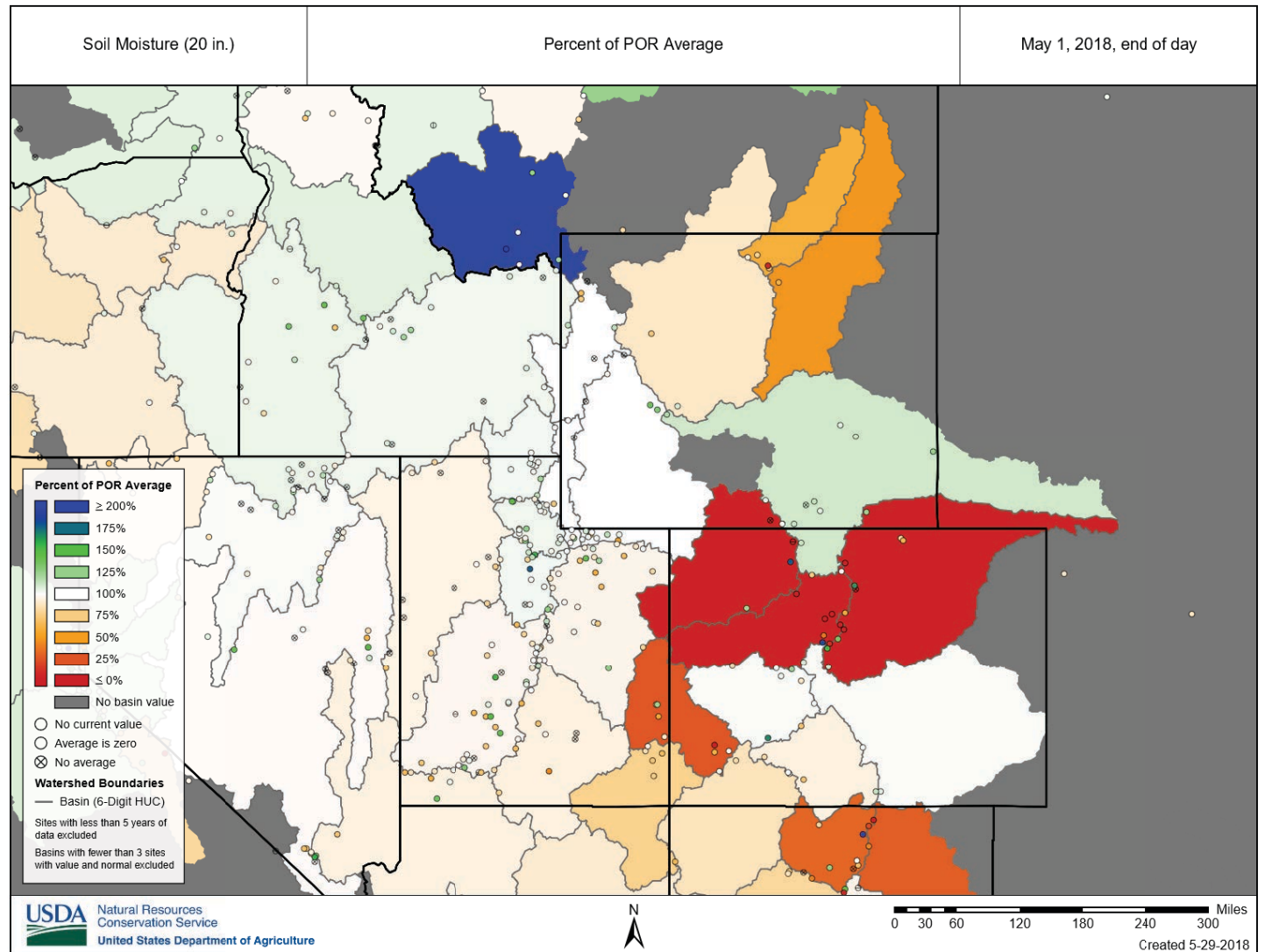
Percent normal

- lower variability than surficial sensors
- accords well with other site data (e.g. longer term precipitation trends)



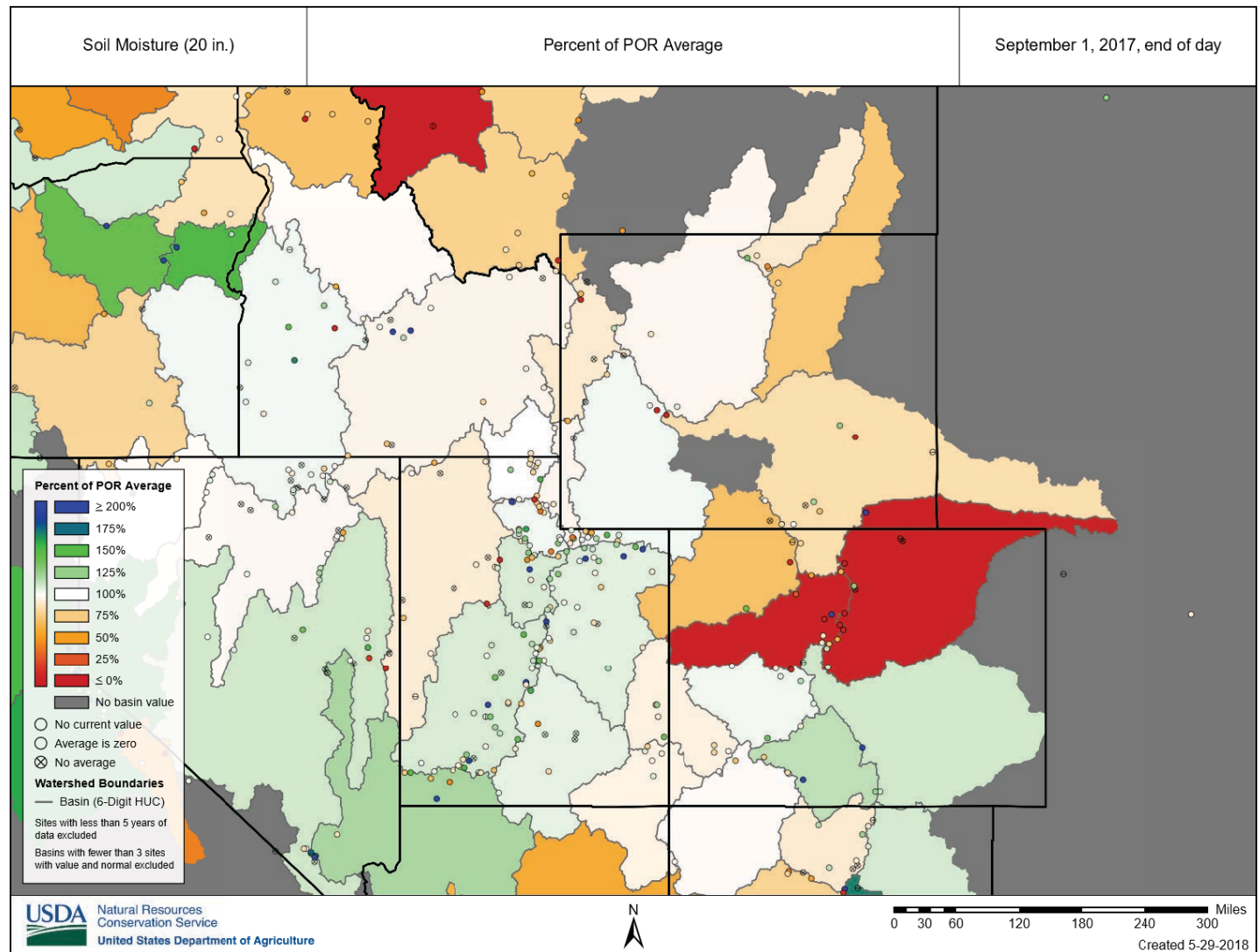
Percent normal

- 20" sensor



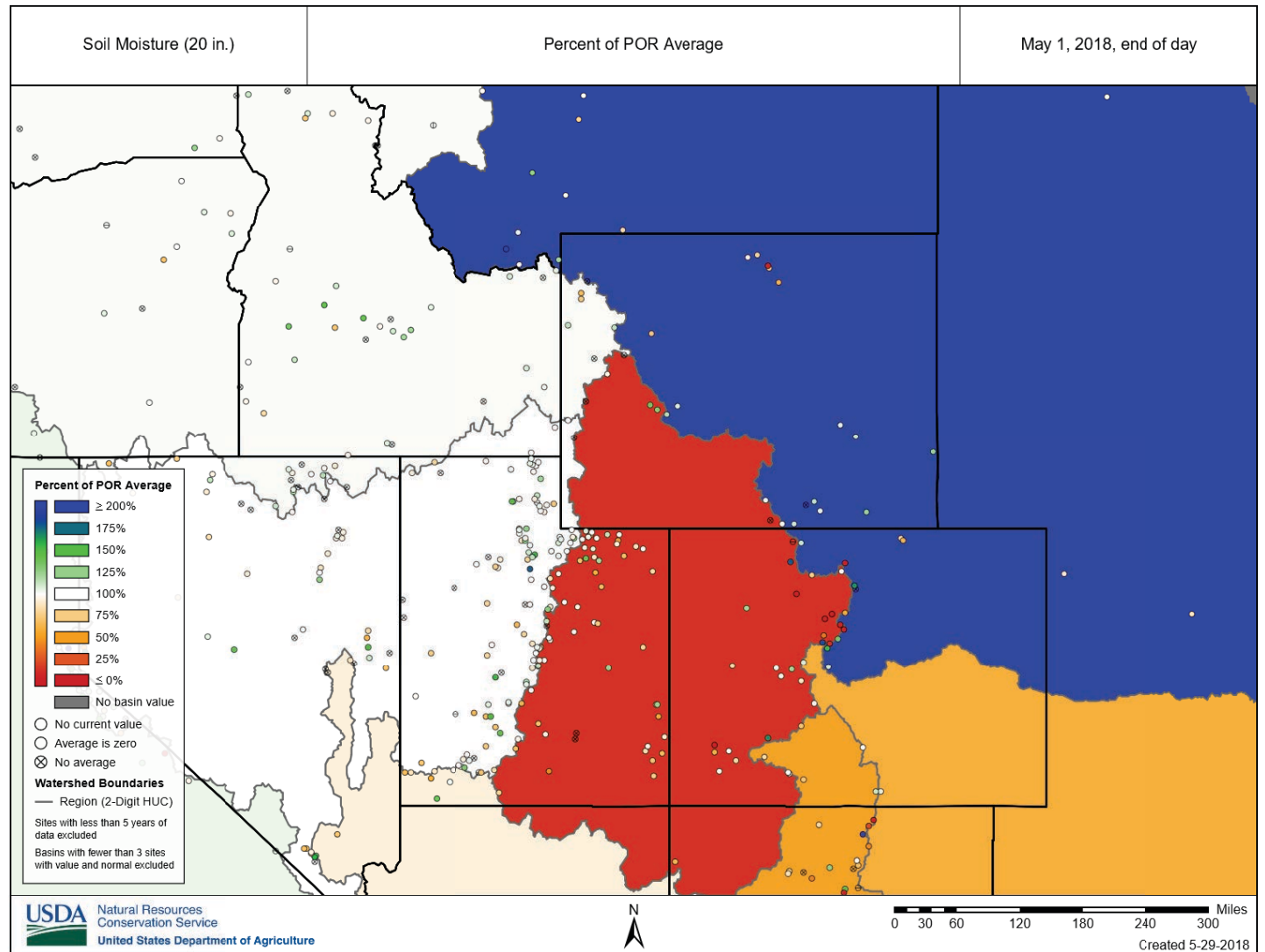
Percent normal

- 20" sensor
- same as previous, but for Sept. 1 instead of May 1
- better reflection of growing season conditions



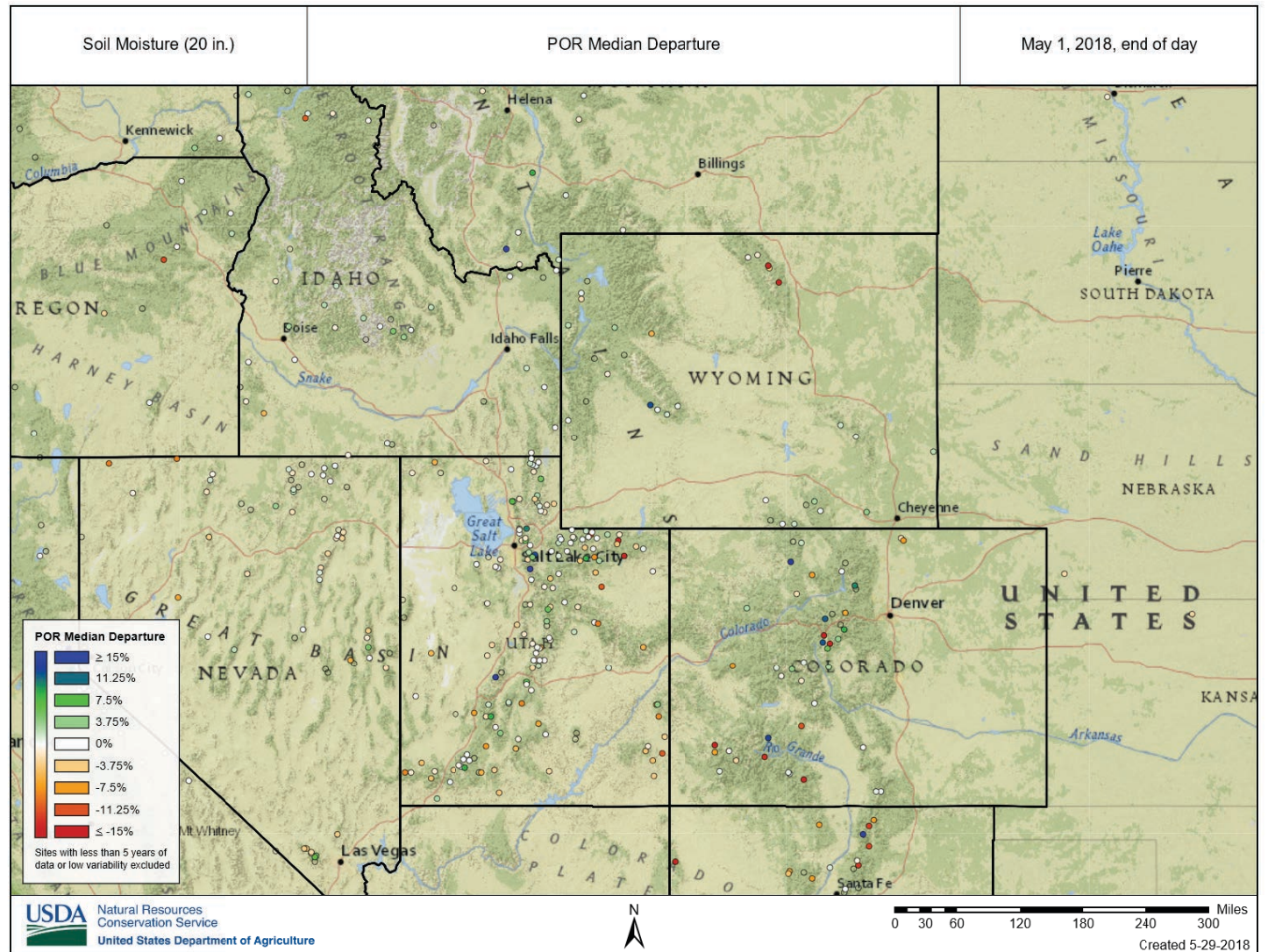
Percent normal

- 20" sensor
- May 1 data
- can generalize to large watersheds (2-digit HUCs)
- NWCC can also generate custom watersheds (e.g. combination of 6-digit HUCs of interest)



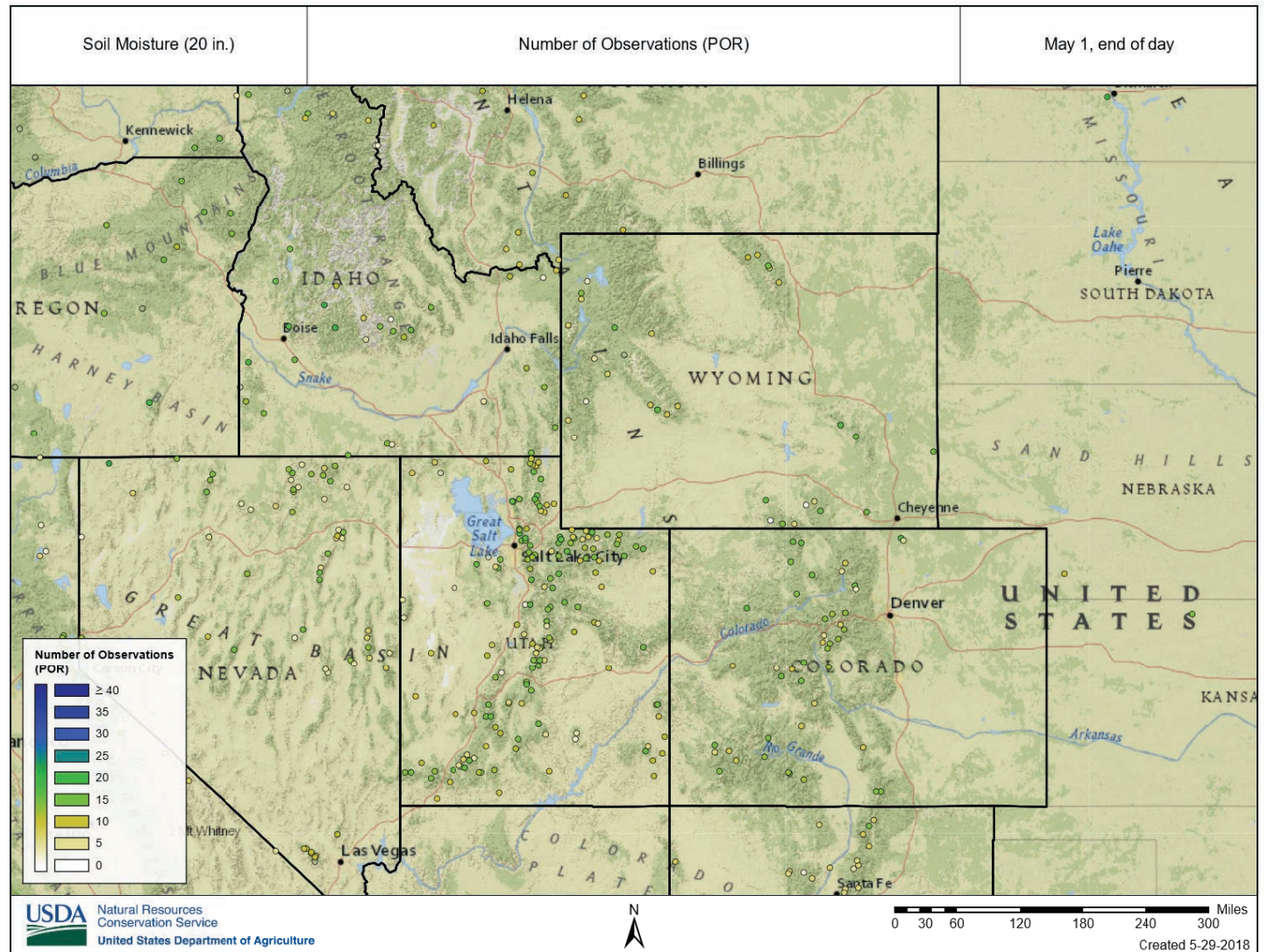
Departure from normal

- 20" sensor
- can identify anomalies



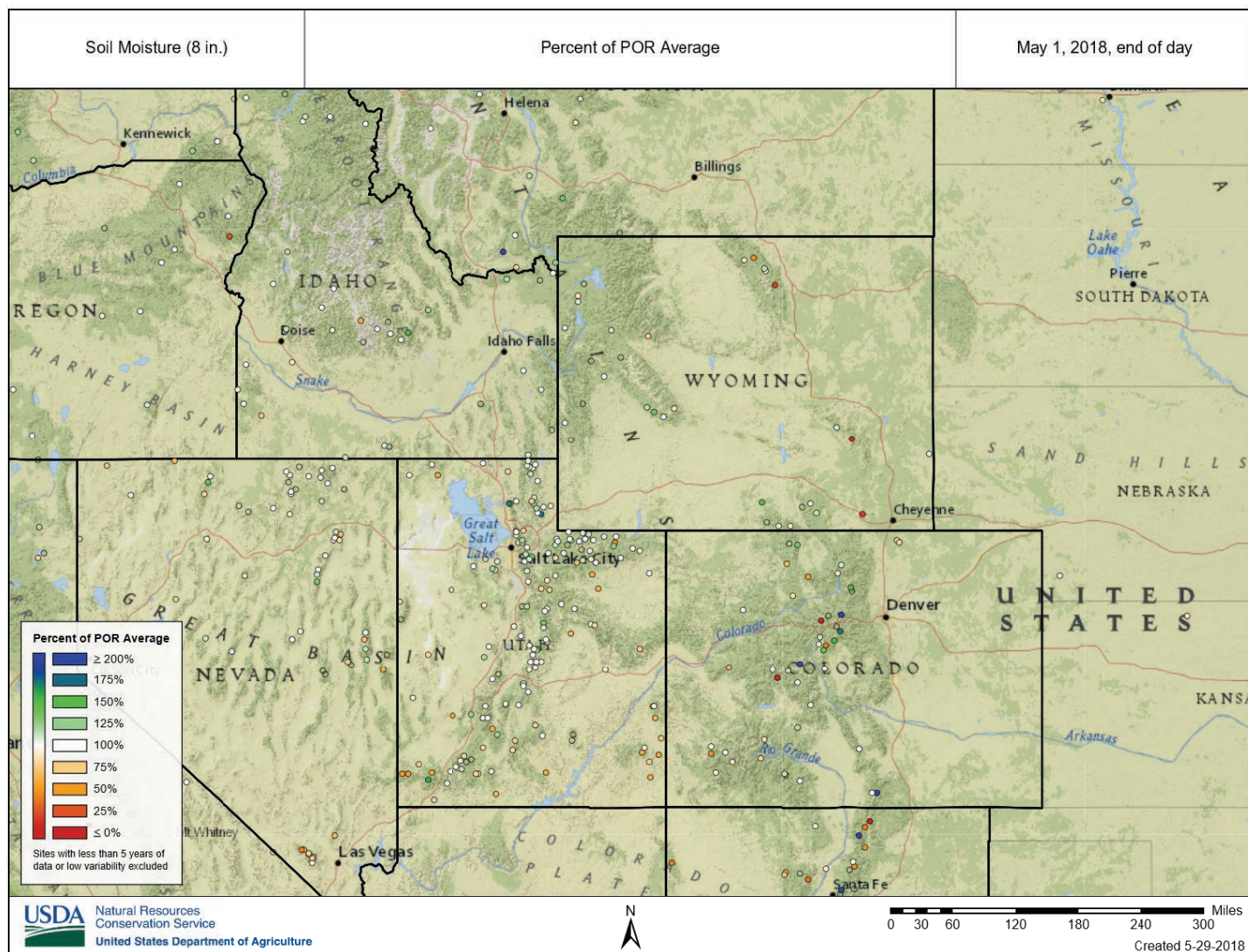
Length of POR

- most sites between 5-15 years



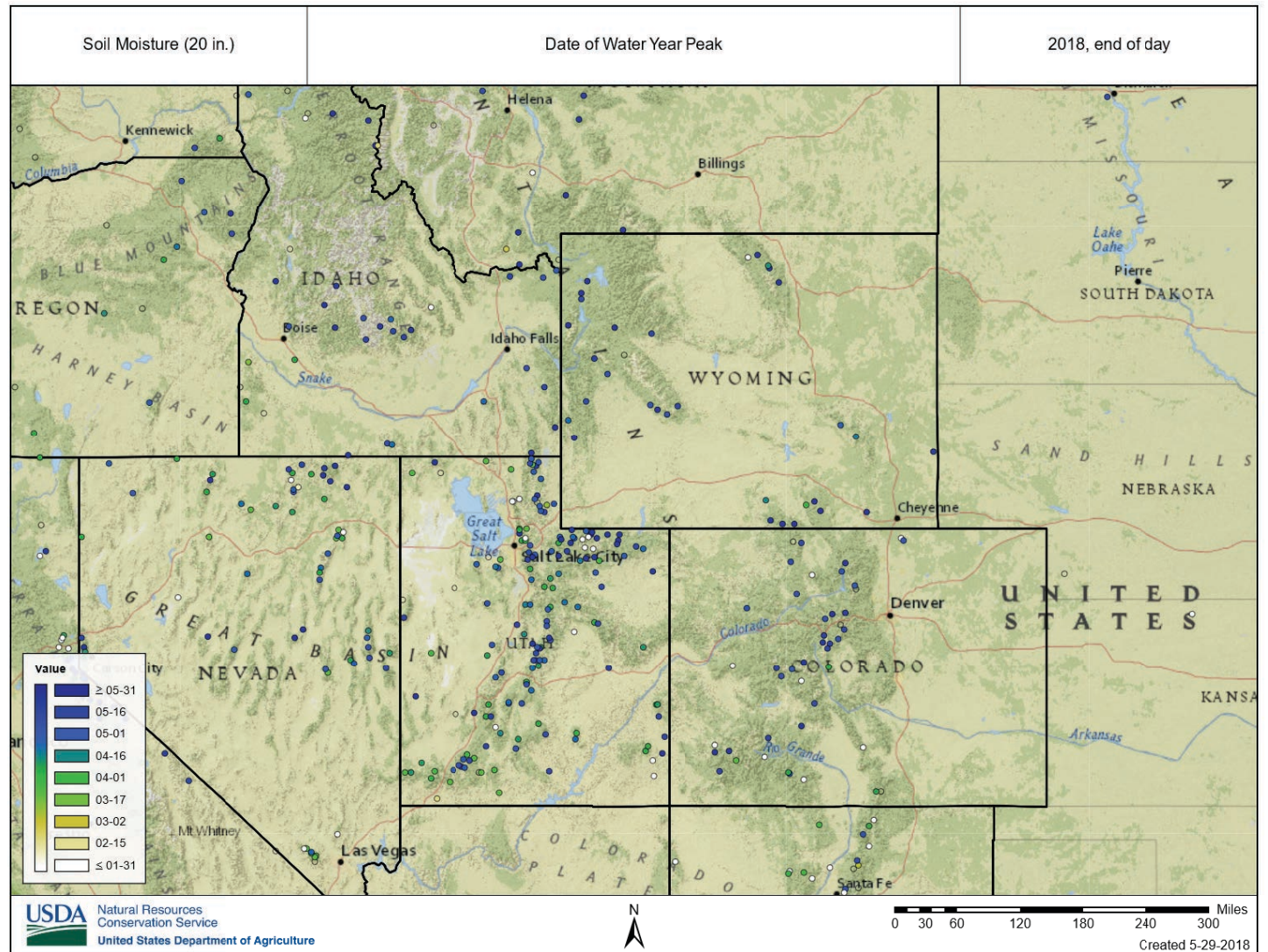
Other depths

- 8" (20 cm) sensor
- rooting zone
- ~integrative of highly variable surficial soils (2" data) and long term trends in SM (20" data)



Timing of peak soil moisture

- may be helpful in identifying early snowmelt, etc.



Need to be able to contextualize by % saturation

- Saturation ~ 40% VWC for some soils, but much lower for many
- % normal values may show ~average conditions, but does not actually provide information on how wet/dry the soils are...
 - e.g. Sept. 1 SM values (next slides)
- Saturation values determined from POR data, not lab results
 - best determined manually per site, but need automatable process
 - use POR max from *hourly* (not daily) dataset
 - need to use hourly because may miss large events in daily (midnight) data
 - still in development...

Need to be able to contextualize by % saturation

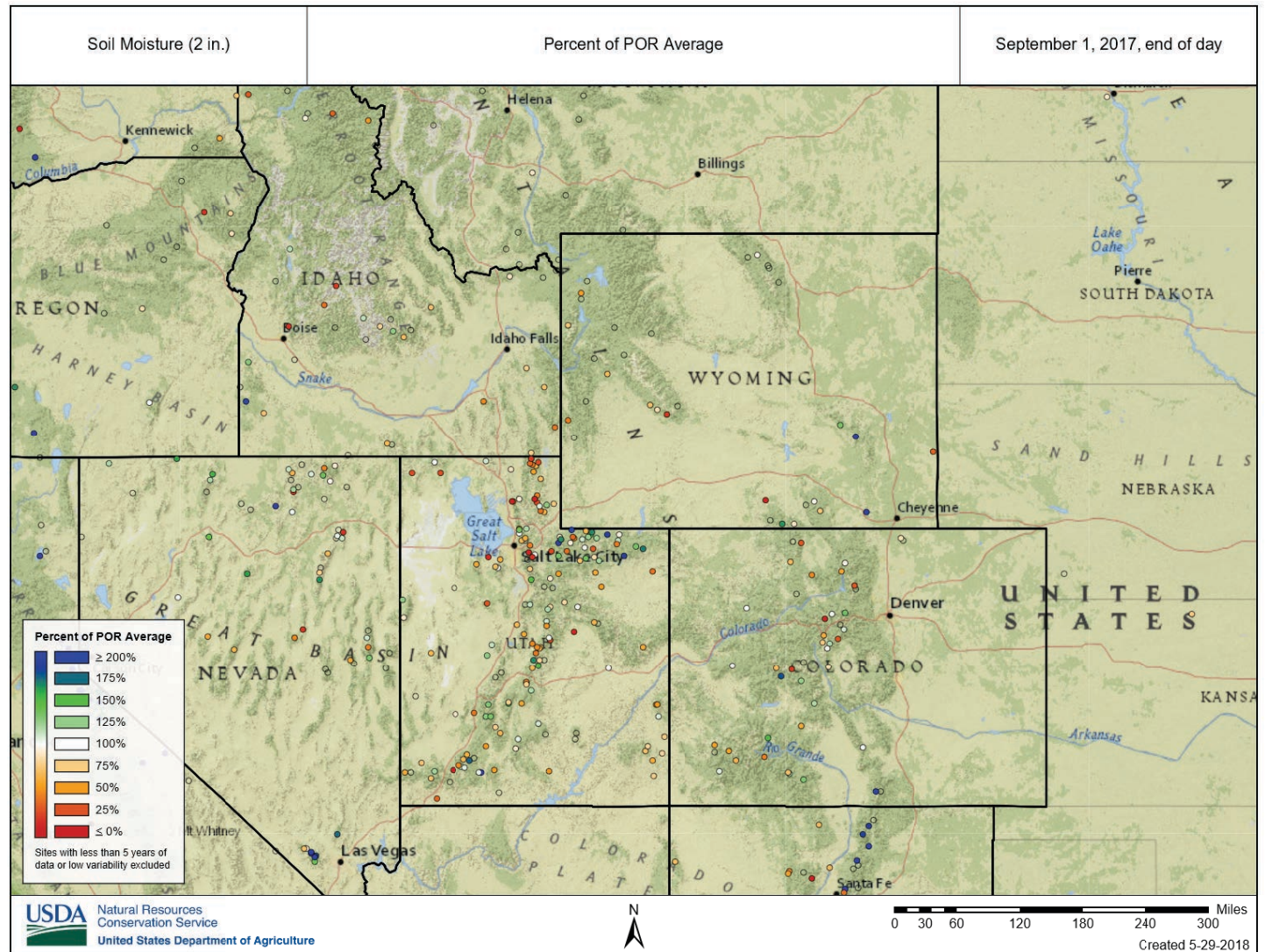
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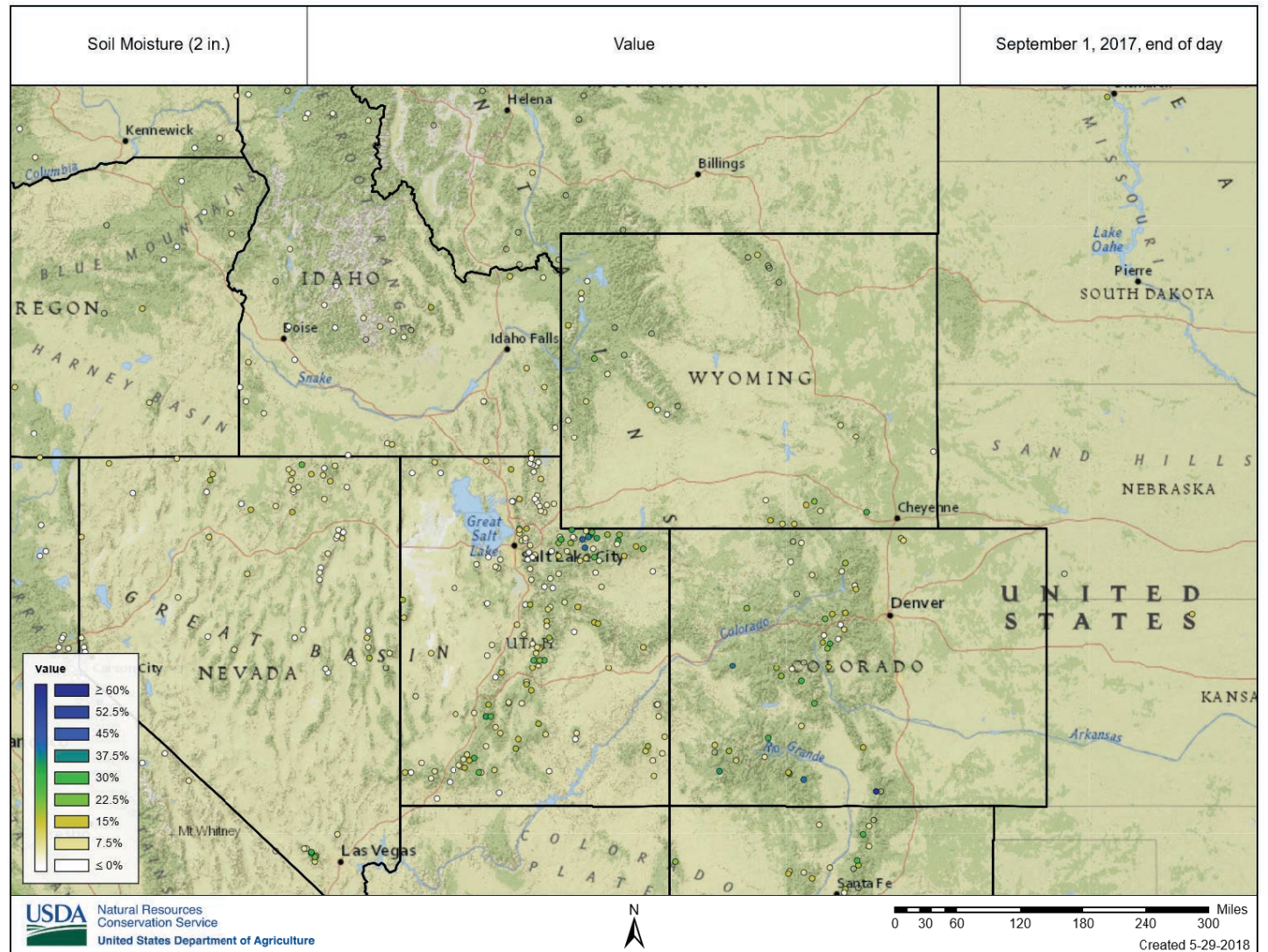
Percent normal for Sept. 1

- 2" sensor
- lots of variability due to topo, site conditions, local storms, ET, etc.
- no information regarding degree of dryness for that particular soil horizon at that date
- need % saturation values



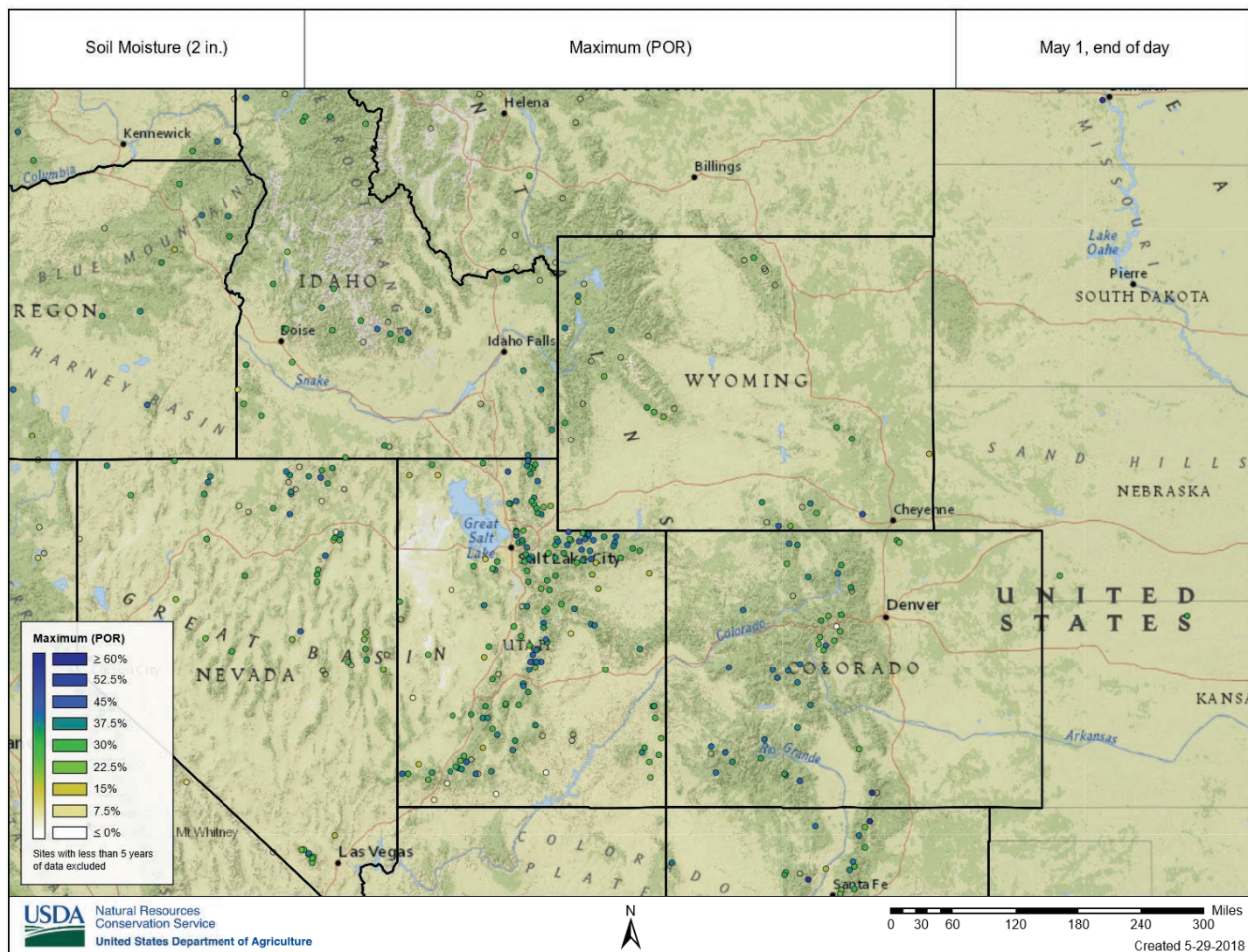
VWC for Sept. 1

- same, for SM values instead of % normal



Maximum VWC for that day

- 2" sensor
- from daily data
- still in development...
 - max values from hourly POR to be used in final version
 - % saturation not yet available
 - % saturation = $(\text{current VWC} / \text{max VWC})$



Application to NSMN

- Pros
 - users can select soil depth most relevant to their application
 - 2" may be most beneficial for merging with remotely-sensed data
 - 20" may be most useful for drought monitoring
 - (better example = Chen Zhao's poster...)
 - regionalizes point data to basins
 - % normal only
 - diverse functionality & output
 - % normal
 - % saturation (forthcoming)
 - other... (soil moisture deficit?)
 - can ingest outside networks
 - data framework already developed



Application to NSMN

- Cons

- only includes SNOTEL & SCAN networks for in situ data, no remotely-sensed data
- no depth-integrated SM value (yet)
- no clear best-practice approach to regionalizing values
 - for eastern states, etc.
 - from remotely-sensed data
 - SNOTEL sites may not be representative
- too complicated / too many options?

Challenges for the NSMN effort: Revisited

- administrative structure & coordination
- merging in situ network data with remotely-sensed values
- diverse user groups → different data needs
- identify key deliverables & timeline for each
- develop standards for data quality, sensor installations and maintenance
- determine template for presentation/delivery of data...
 - is this a desirable approach (build outward from in situ data)?
 - merit in delivering product with flexible output (e.g. different sensor depths)?
 - context = key (% normal, % saturation, departure from normal, etc.)



Questions & Discussion

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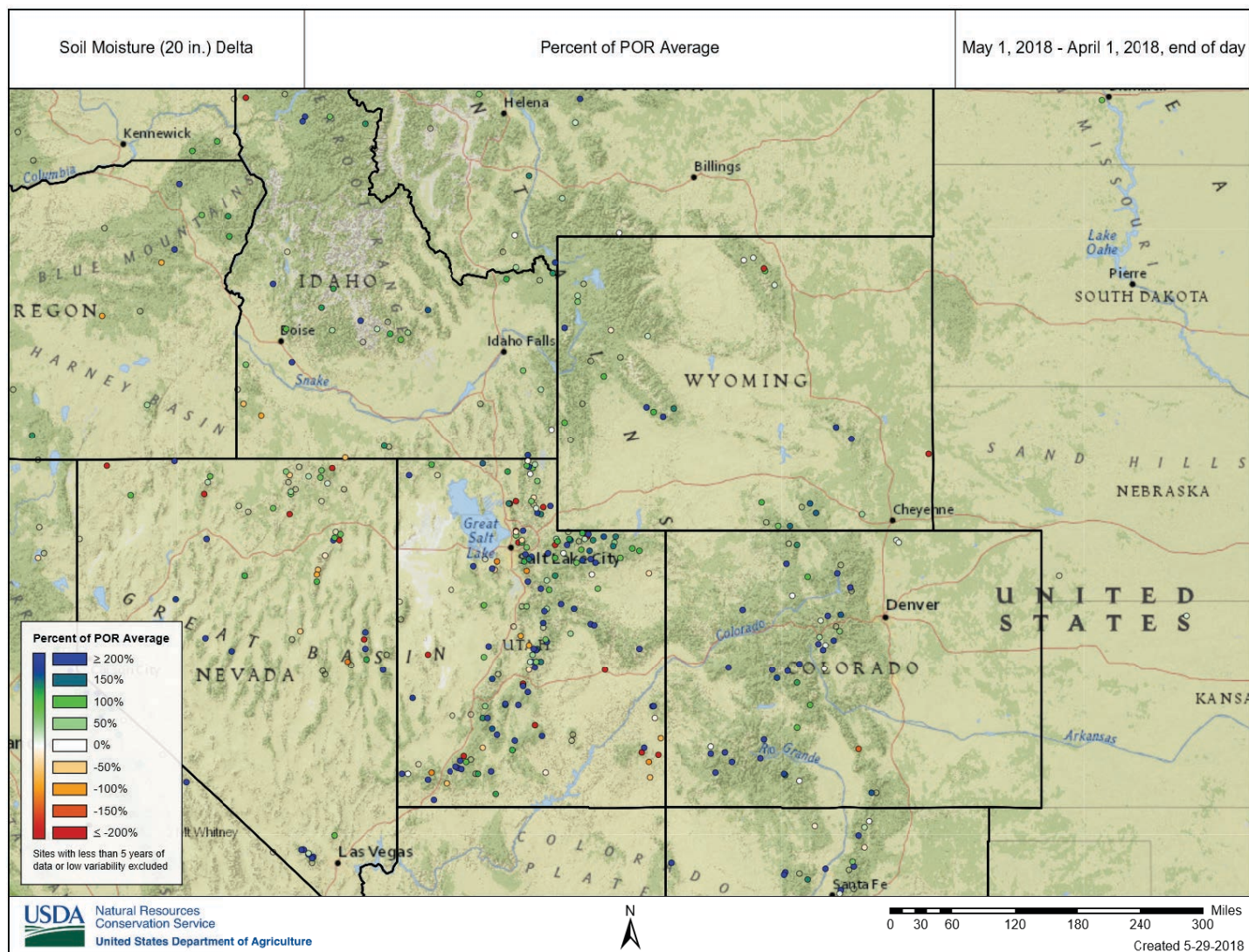


Textbox

- ***
- **
- **

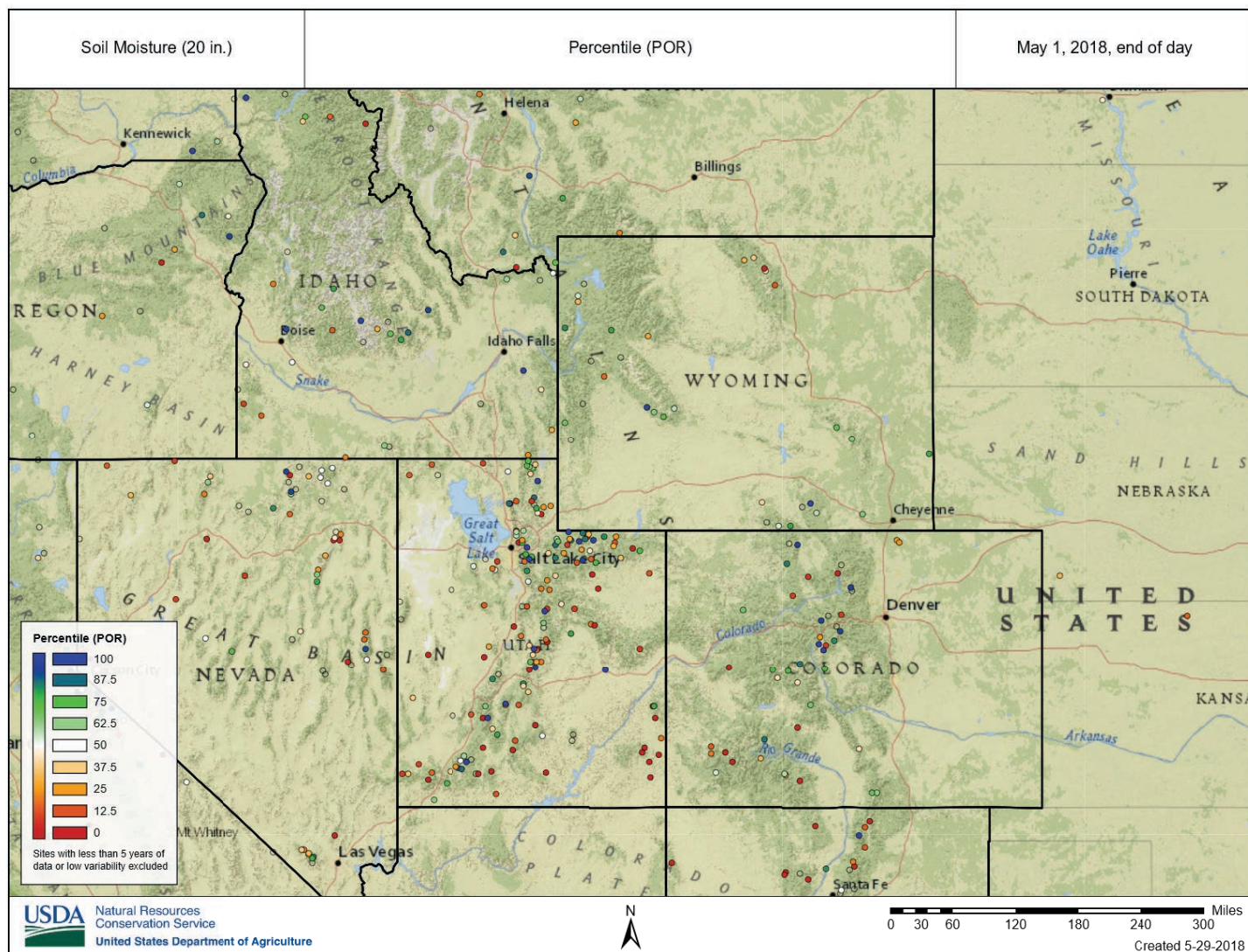
Changes in % normal over time

- 30 day interval (customizable)
- 20" depth



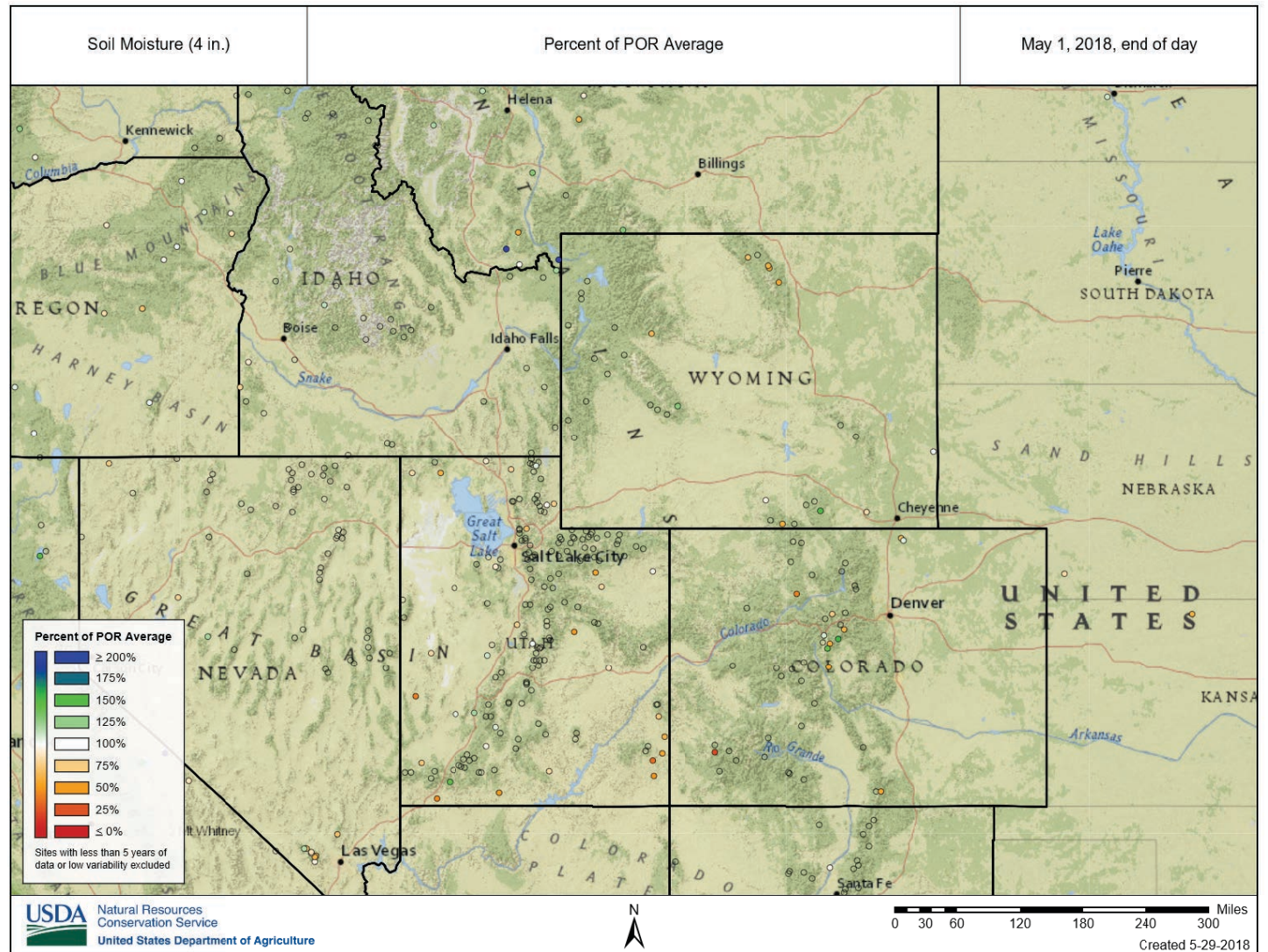
Soil moisture percentiles

- 20" sensor
- provides historical context



Other depths

- 4" sensor
- similar to 2"
- available in SCAN, not SNOTEL



Other depths

- 40" sensor
- available in SCAN, not SNOTEL

