Weather Conditions & Hay Moisture
Potential Implications for Hay Quality

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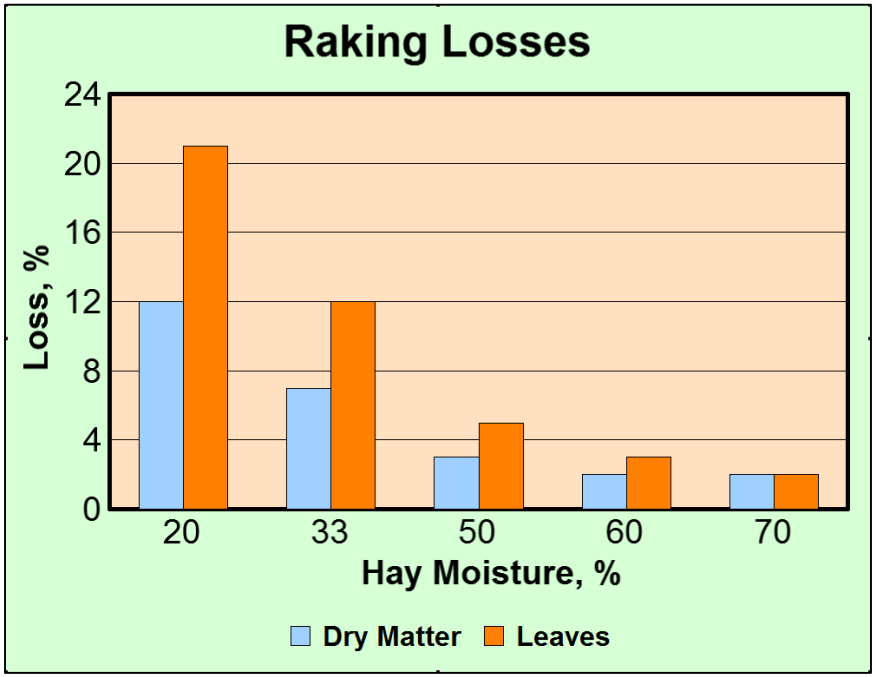
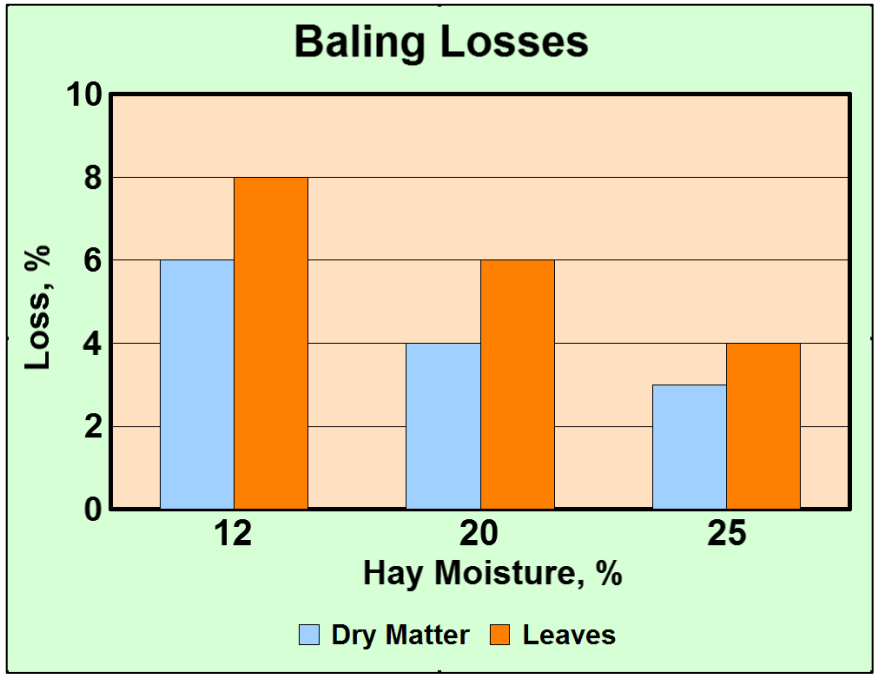
Losses During Haymaking

Accelerate With Lower Moisture Hay



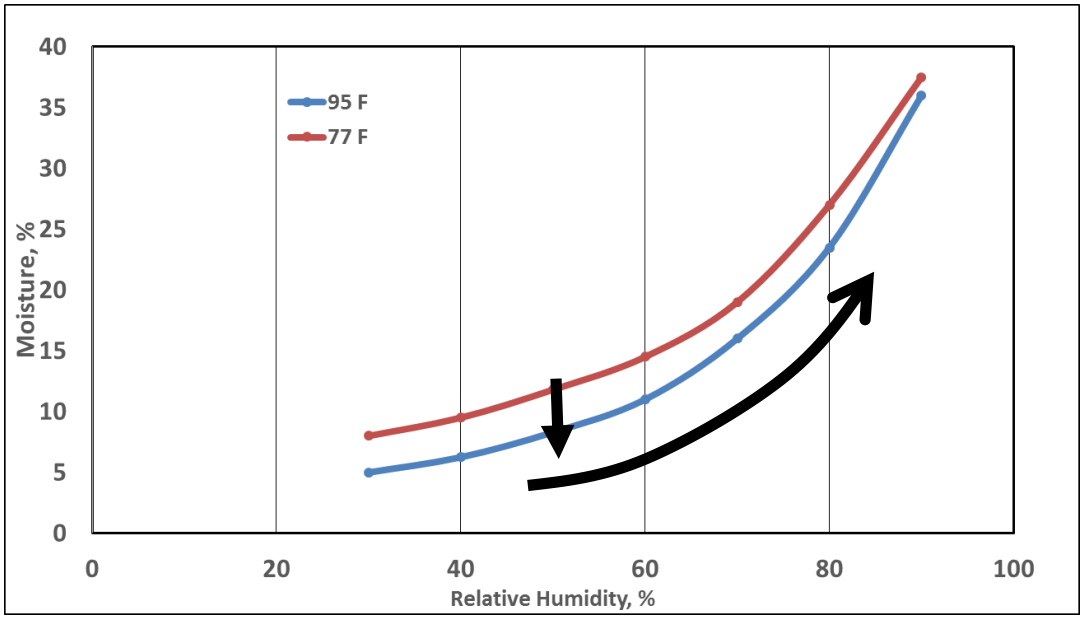


From Pitt, 1979; Hundtoft, 1965; Rotz, 1989

Estimated Harvest Losses of 20-25%

Humidity & Hay Moisture

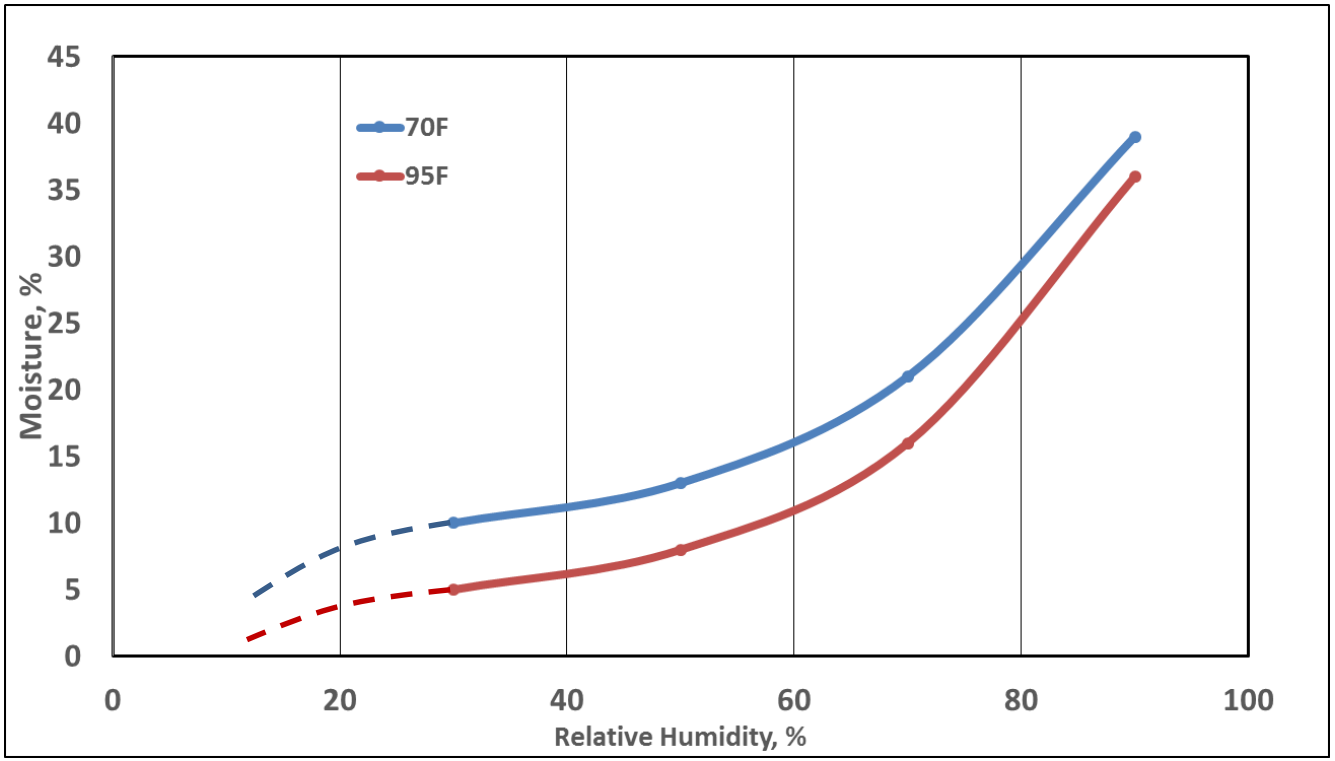
- **Equilibrium Moisture**
  - Hay Placed in Constant Humidity Environments
  - Allowed to Equilibrate
  - Measure Moisture Content
- **Purpose**
  - Storage Conditions
  - Quality
  - Trade



Source: Pitt, 1990; Hill et al., 1976

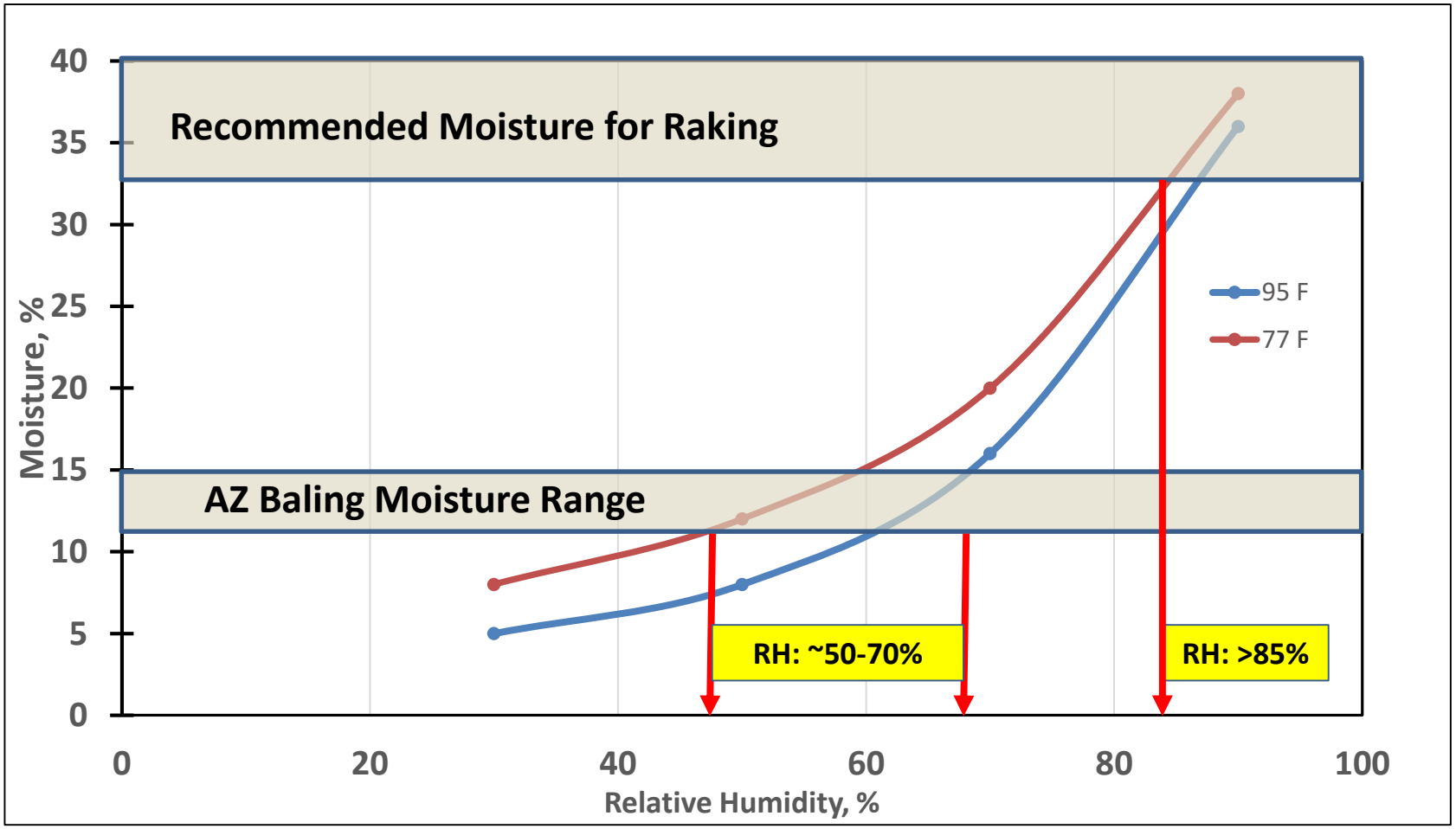
- Moisture increases with humidity
- Moisture decreases with temperature

Relevance to Arizona Hay

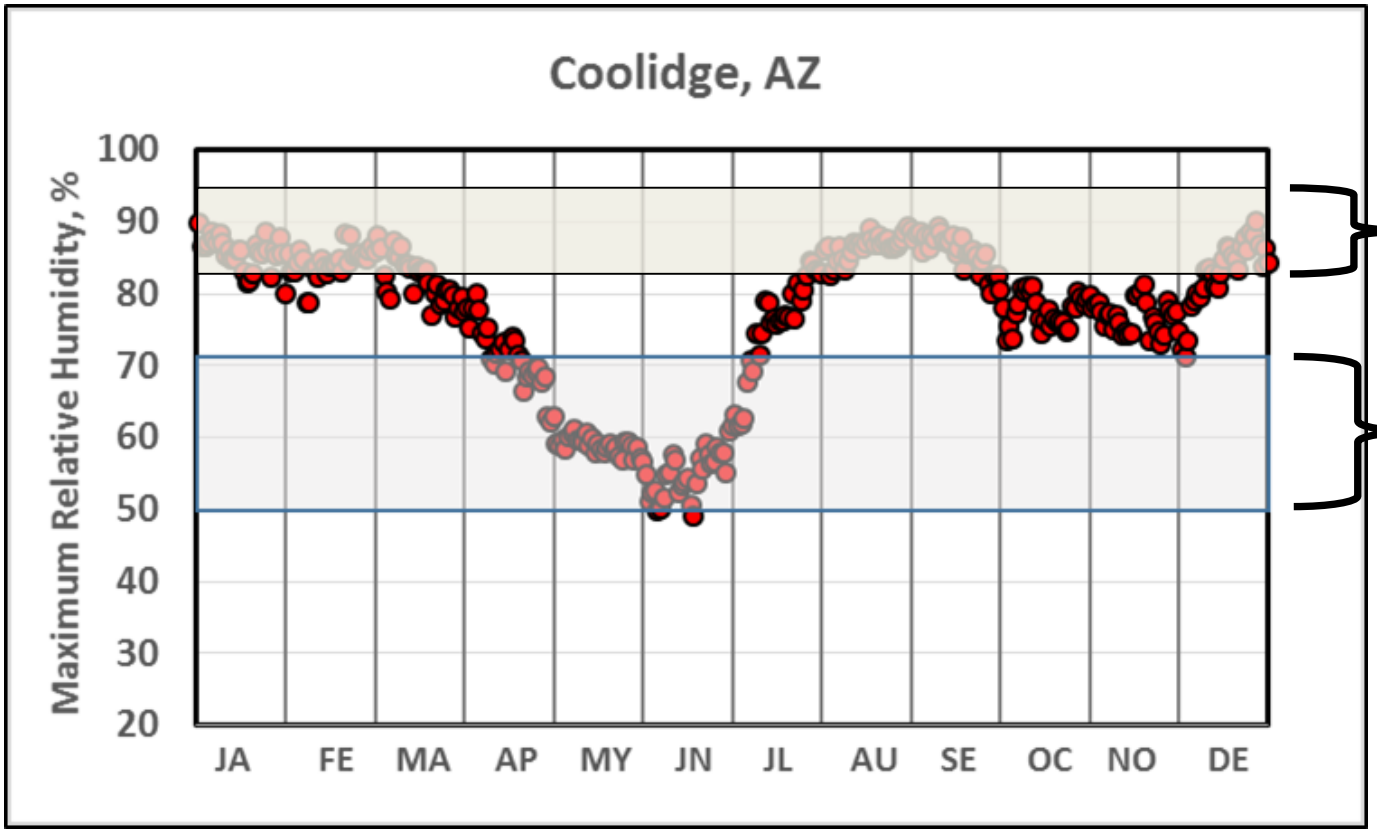


-Lab testing indicates good agreement
-Leaves & stems similar
-Low humidity extension

Hay Operations: Moisture Recommendations



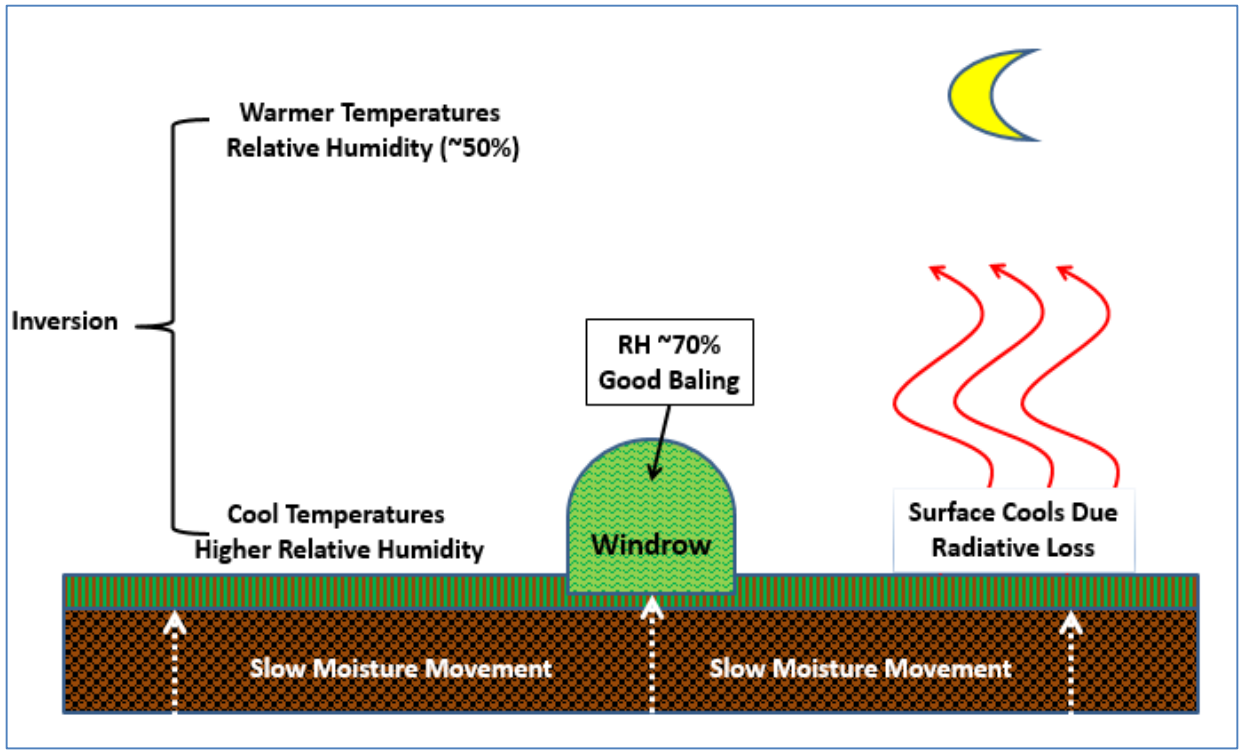
The Challenge!

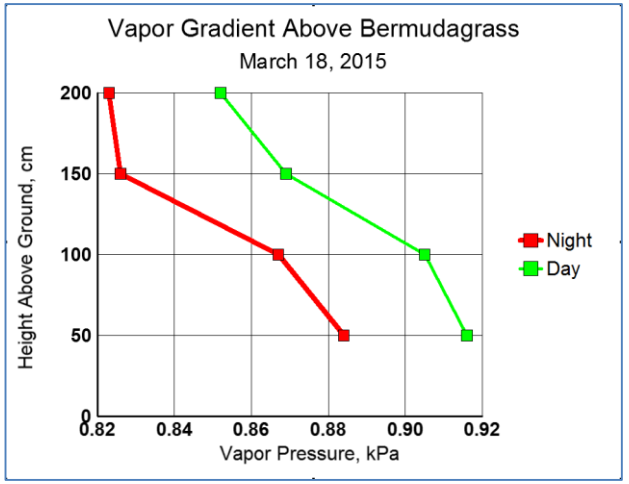


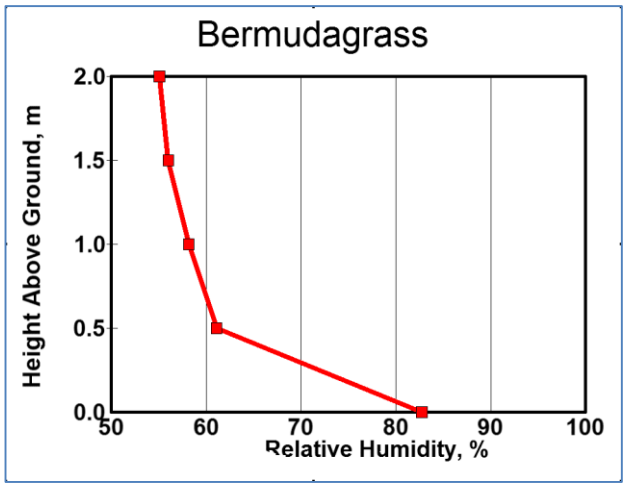
- Average maximum relative humidity barely in bailing range in May & June
- Even more challenges for raking moisture

Near Surface Humidity

Clear, Calm Night



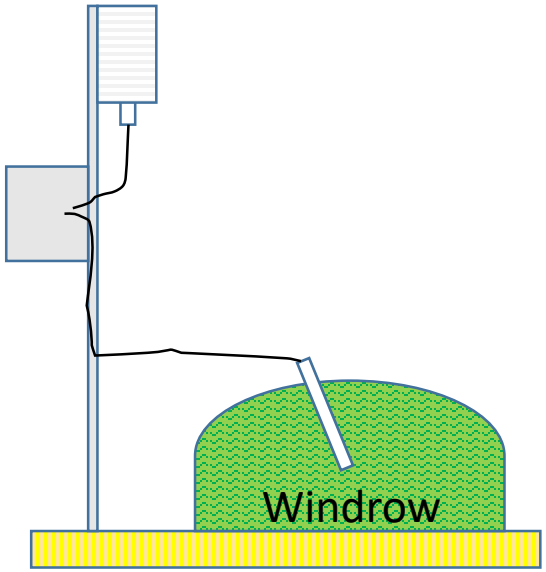


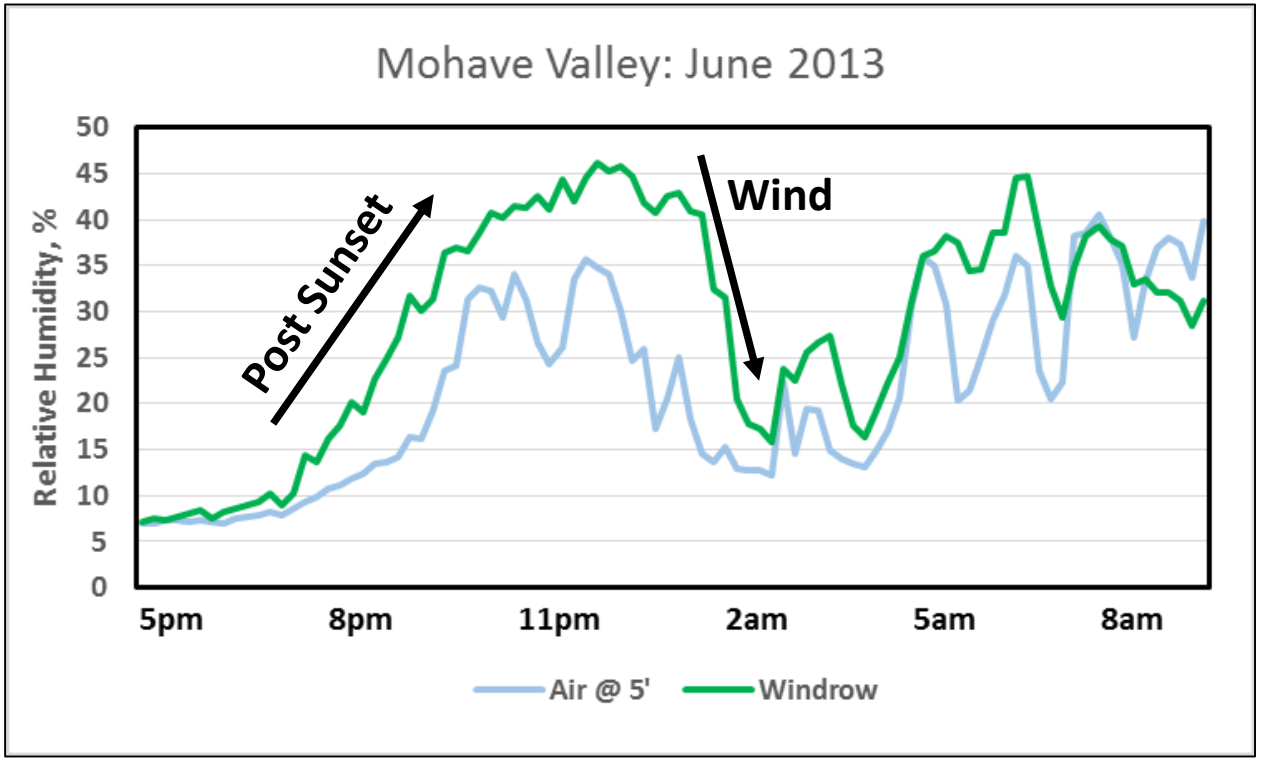


- Water vapor escaping from soil helps humidify near surface atmosphere
- Cooler near surface temperature increase relative humidity

Higher Humidity Near Surface

Temperature & Humidity At 5’ & in Windrow

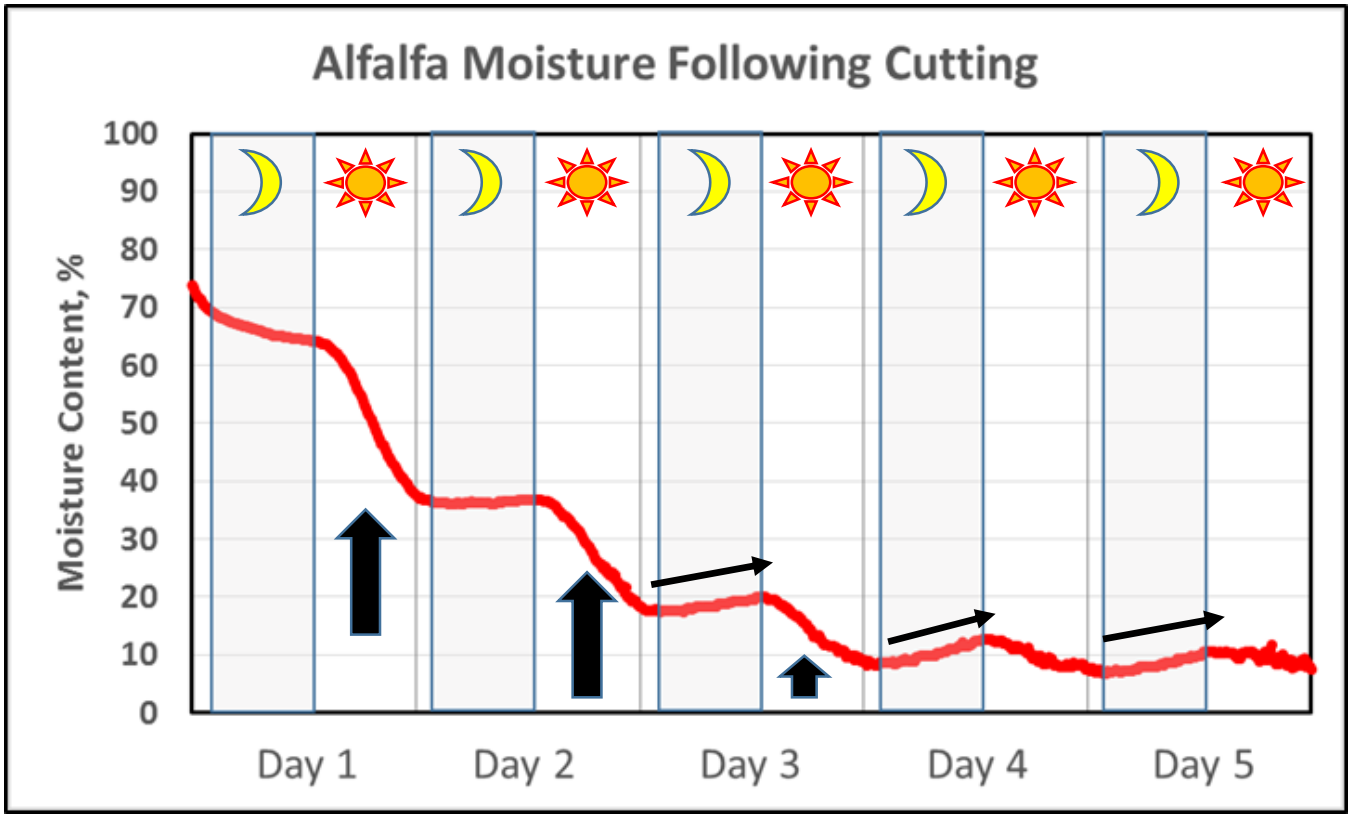




Wind mixes up the stratified near surface atmosphere, greatly reducing near surface humidity at night.

Measuring Hay Drydown

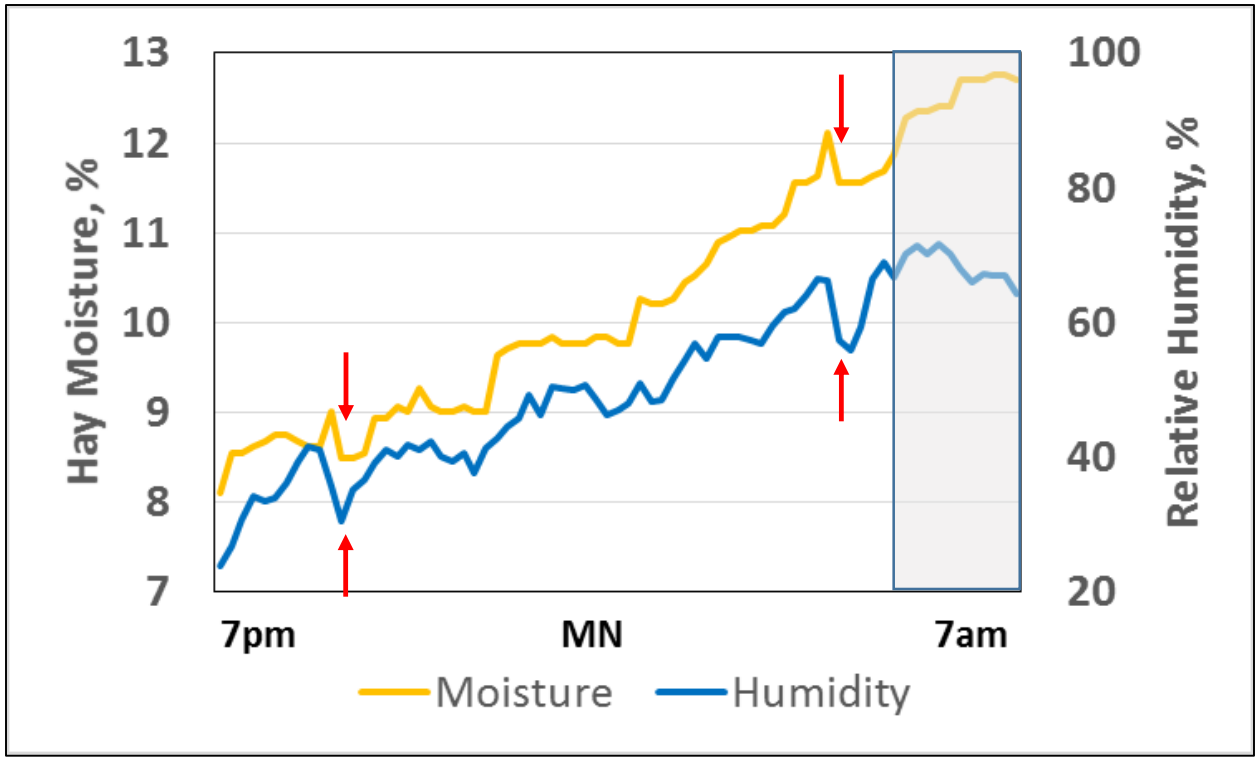
September Cutting, Harquahala, AZ



-Rapid drying during daytime

-Rehydration at night

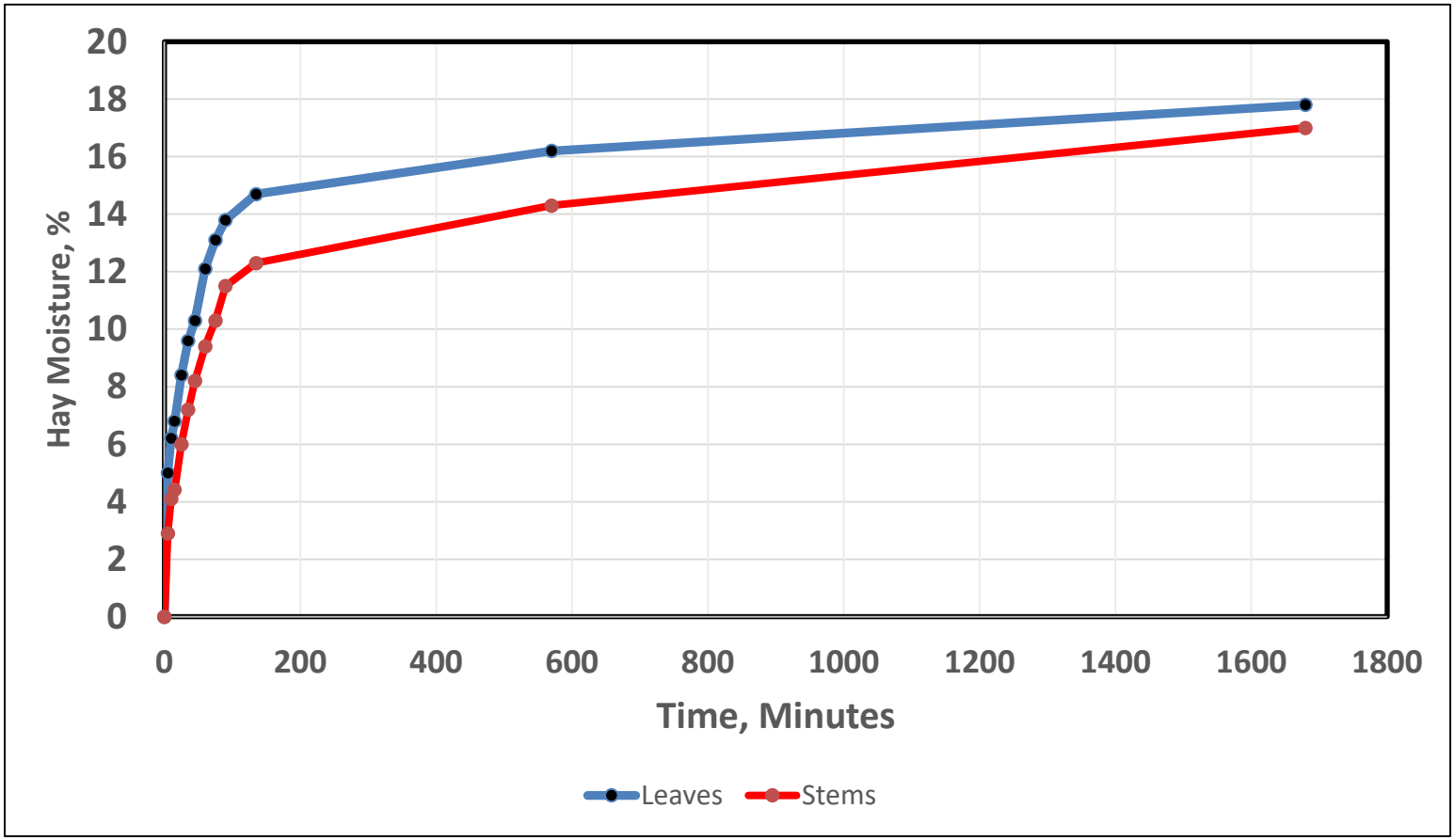
Day 4
A Closer Look at Night Rehydration



-Hay moisture responds rather quickly to change in humidity at night

-Hay approaches 12% moisture at 70% near surface relative humidity

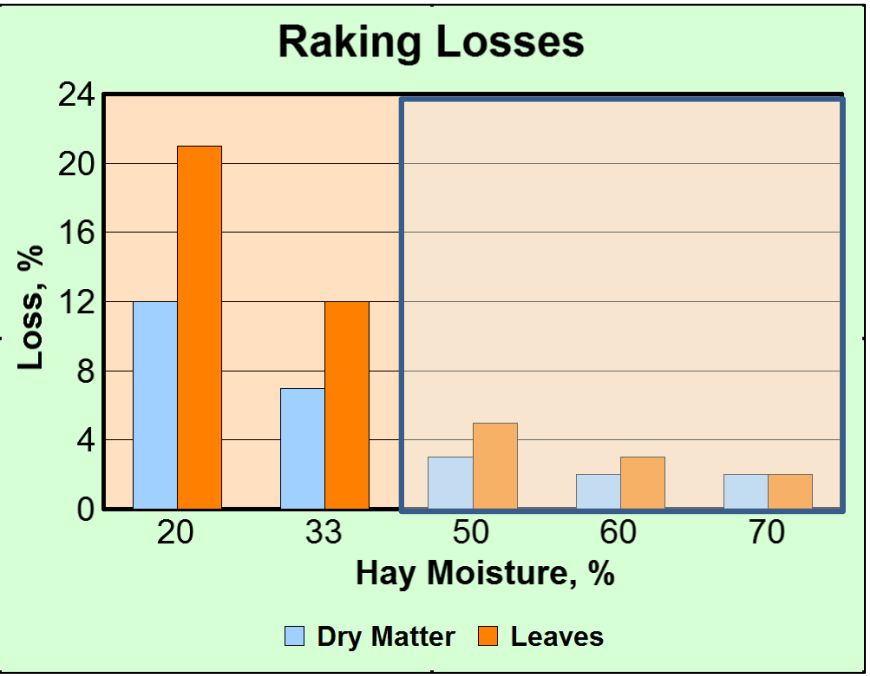
How Fast Can Hay Respond to Change in Humidity?



Oven Dried Hay Transferred to Environment With 75% Relative Humidity

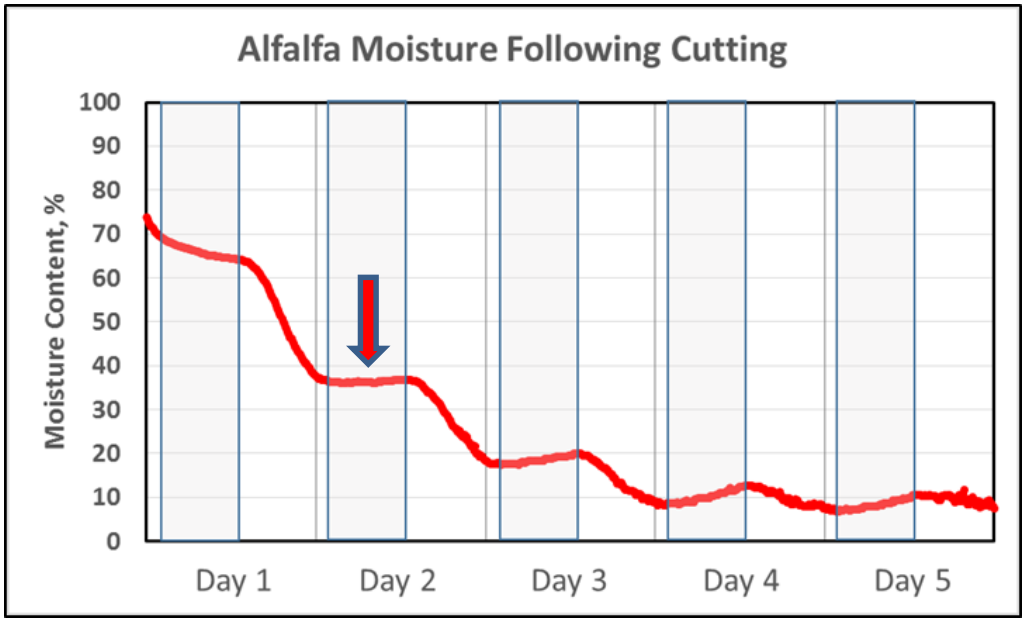
--Leaf Moisture Increased to 10% in ~35 Minutes
--Stem Moisture Increased to 10% in ~75 Minutes

Raking & Moisture



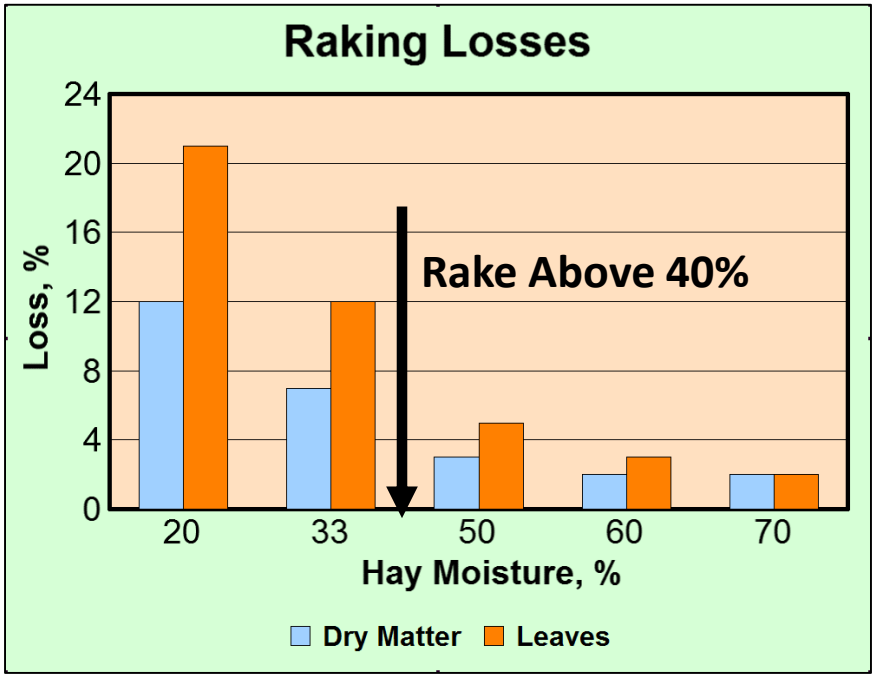
From Pitt, 1979; Hundtoft, 1965; Rotz, 1989

Raking at 40%+ moisture minimizes losses



Arizona hay reaches this level quickly and does not rehydrate to 40% without dew

Self Humidification



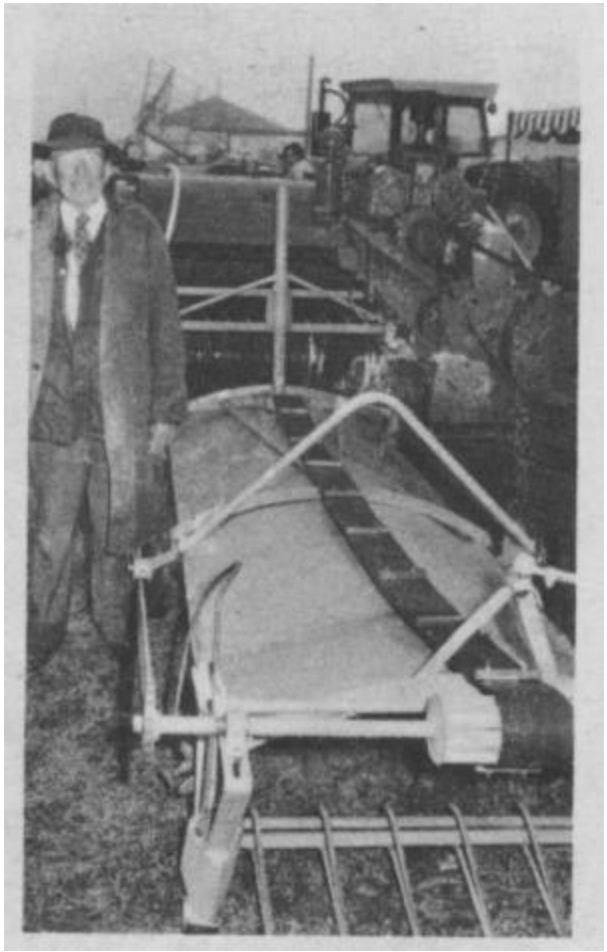
Hay Moisture: ~40%

Component	Moisture	Humidity
Leaves	18%	47%
Stems	64%	92%

Early in dry down process, slower drying stems will have higher equilibrium humidity and should humidify swath/leaves at night.

Possible Management Options

- Humidity Monitoring
  - When to Bale
- Cultural Practices
  - Soil Moisture
  - Windrow Management
- Artificial Humidification
  - Light Water Applications
  - Steam System
  - Dew Simulator



Early Windrow Steam System

Portable Humidity Monitors

Remote Field Assessment

Spectrum Technologies

- Humidity Sensor
- Datalogger
- Cell Phone
- Alerts/Alarms
  - At Selected Humidity
  - Calls/Texts
- Set Point
  - 45-55% Relative Humidity
- Mount at Windrow Height

Artificial Humidification

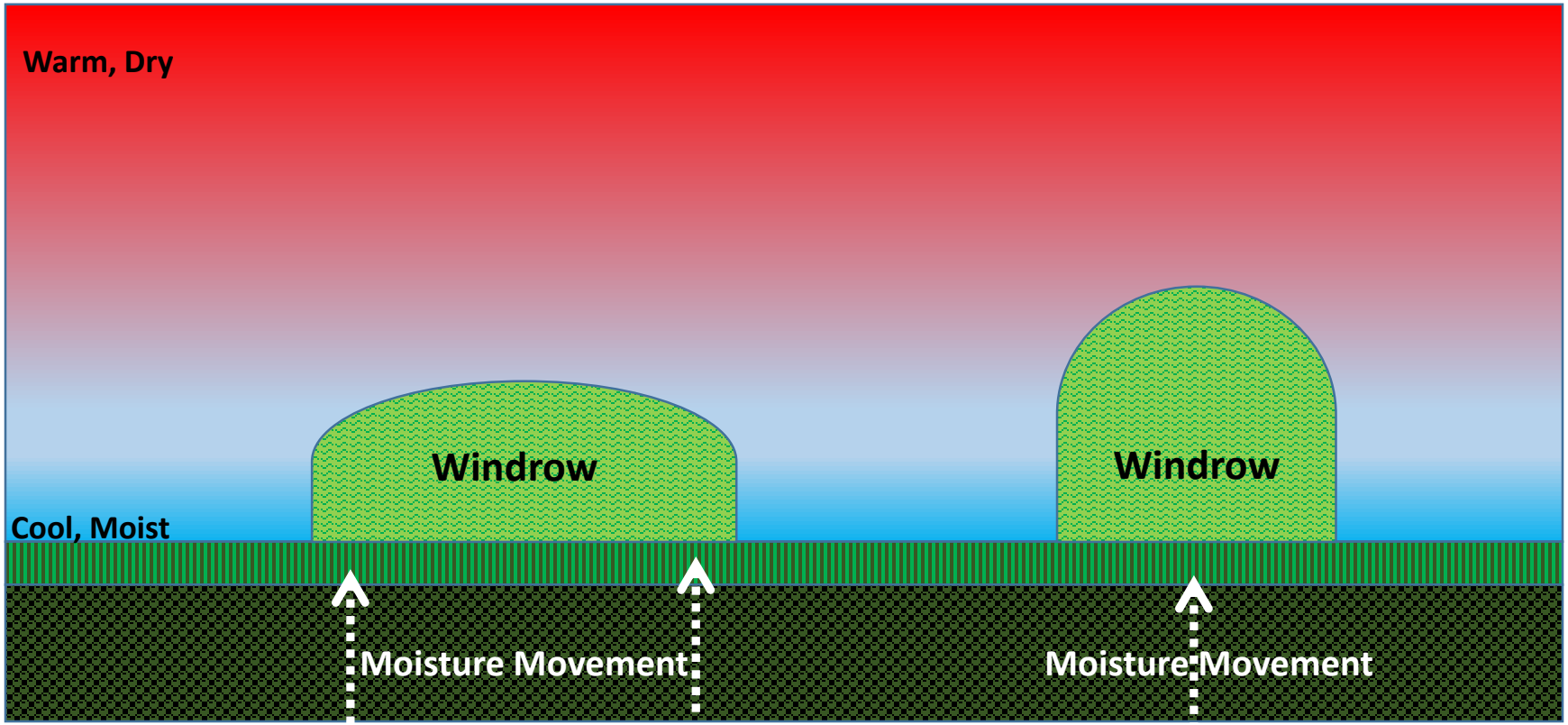
Spraying Water on Windrow

- **Water Application**
  - CA: 40-50 Gal/A
  - AZ: 50 Gal/A
  - UT: 2-4 Gal/100’
- **Lag Time for Baling**
  - 5-30 Minutes
    - Moisture Penetration
    - Humidity & Wind
    - Time of Day
  - Manual Assessment

From: Anderson & Mikelsen, 1973. Spraying Alfalfa With Water Before Baling to Minimize Harvest Losses. Agronomy Journal

Windrow Structure

Short & wide during dry season
Tall & skinny during the wetter season



Artificial Humidification

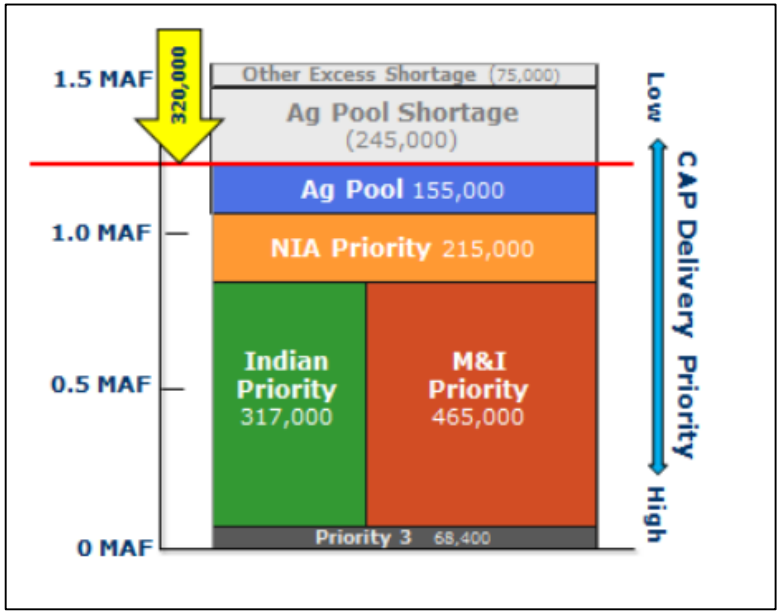
- **Steam Injection**
  - Humidify Hay
- **Baling Period**
  - Flexible/Longer
  - Eliminates Balers
- **Improves Quality**
  - Reduce Leaf Loss
  - Higher RFV
- **Expensive**

Colorado River
Impact of Shortage Declaration

Lake Mead Elevation	Arizona Reduction	Nevada Reduction	Mexico Reduction
1075’	320,000 AF	13,000 AF	50,000 AF
1050’	400,000 AF	17,000 AF	70,000 AF
1025’	480,000 AF	20,000 AF	125,000 AF

-Greater use reductions at lower Mead elevations
-Arizona incurs ~80% of the reductions
-Negatively impacts Central Arizona agriculture
-Mexico reduction must be renewed in 2017

-Below 1025’ Secretary of Interior can intervene!



Central Arizona Project delivery priorities

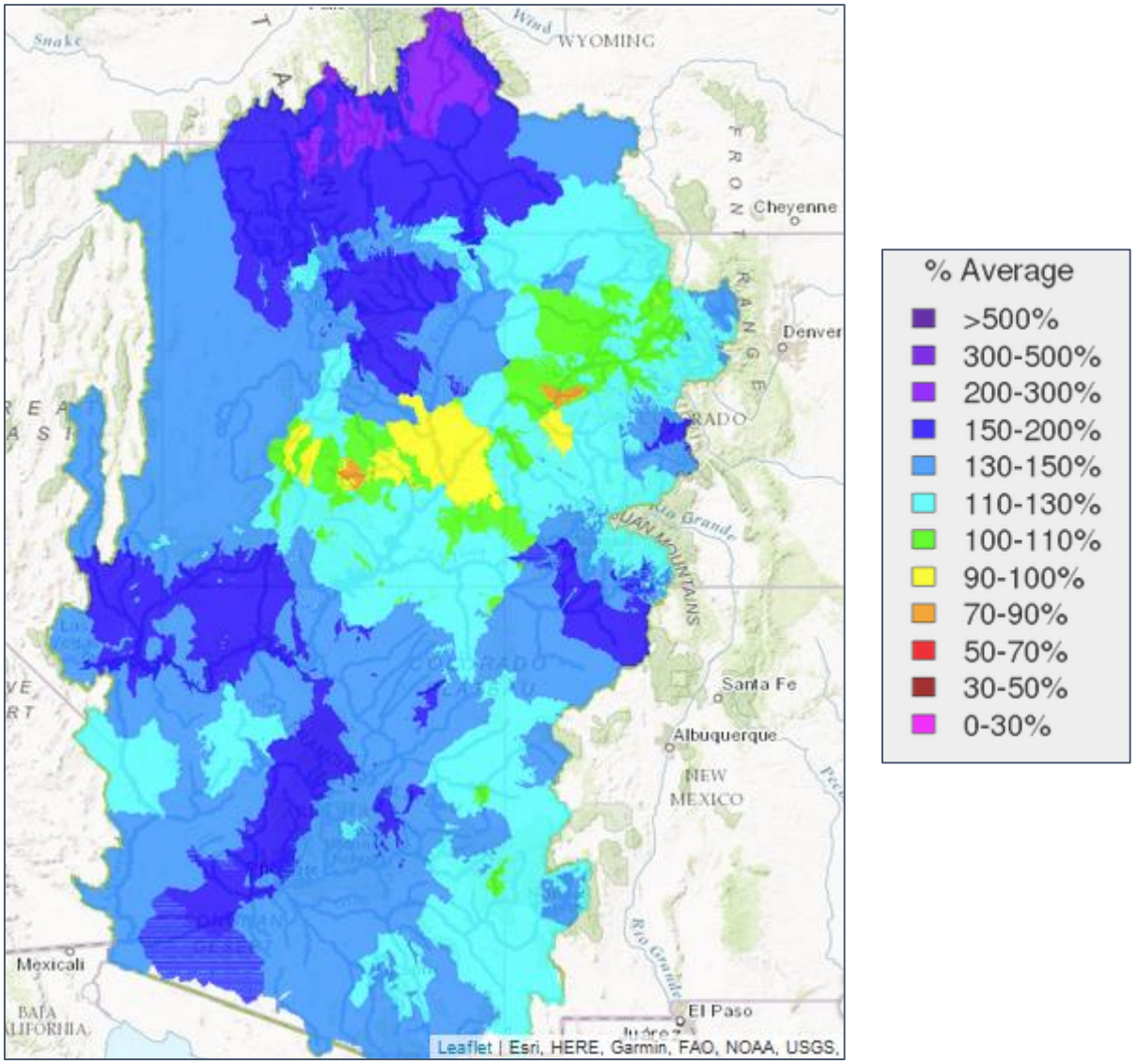
Water Year Precipitation

October through February

-Most locations above normal

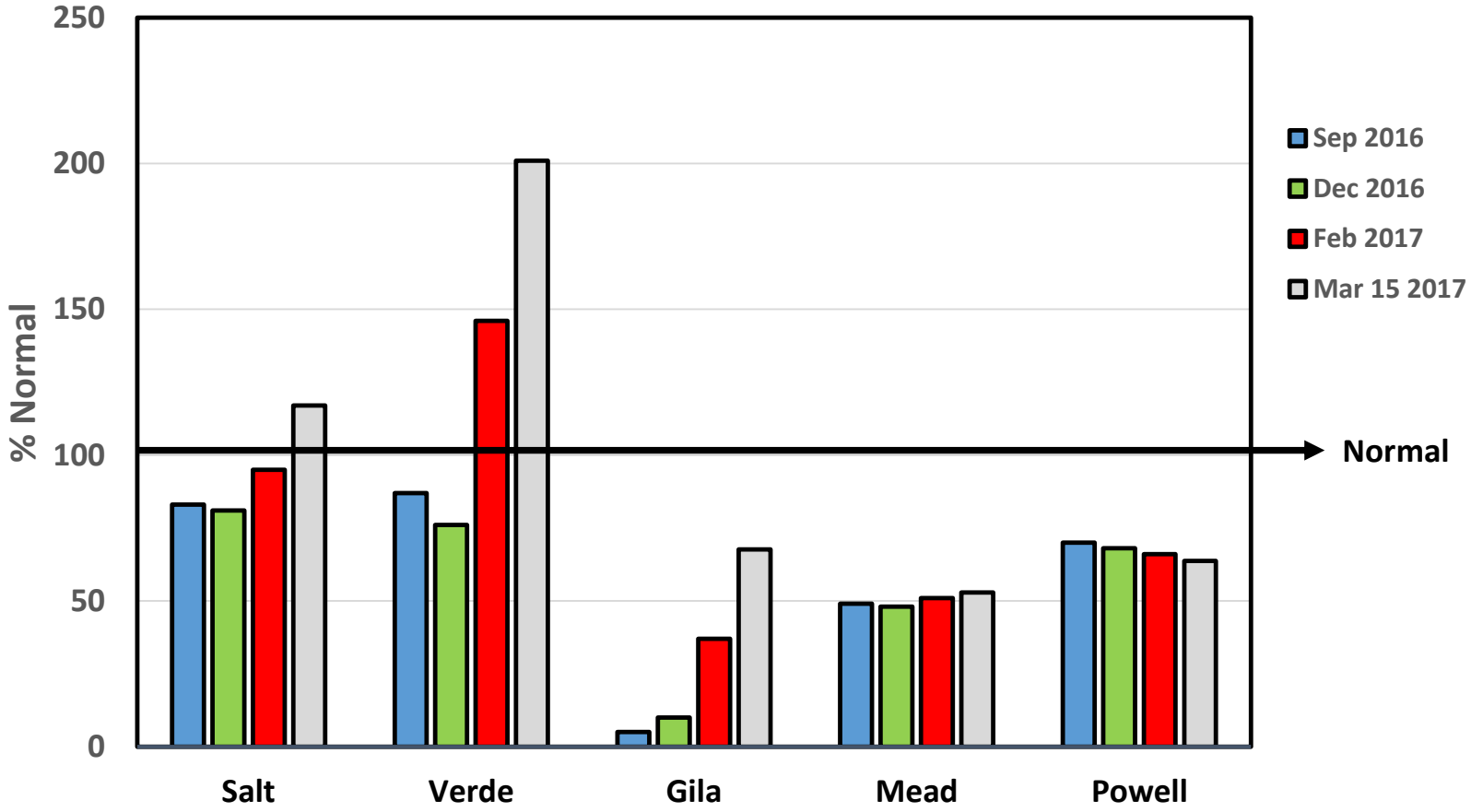
-Upper Green 200-300% normal

-Mead drainage 130-200% normal



Reservoir Status

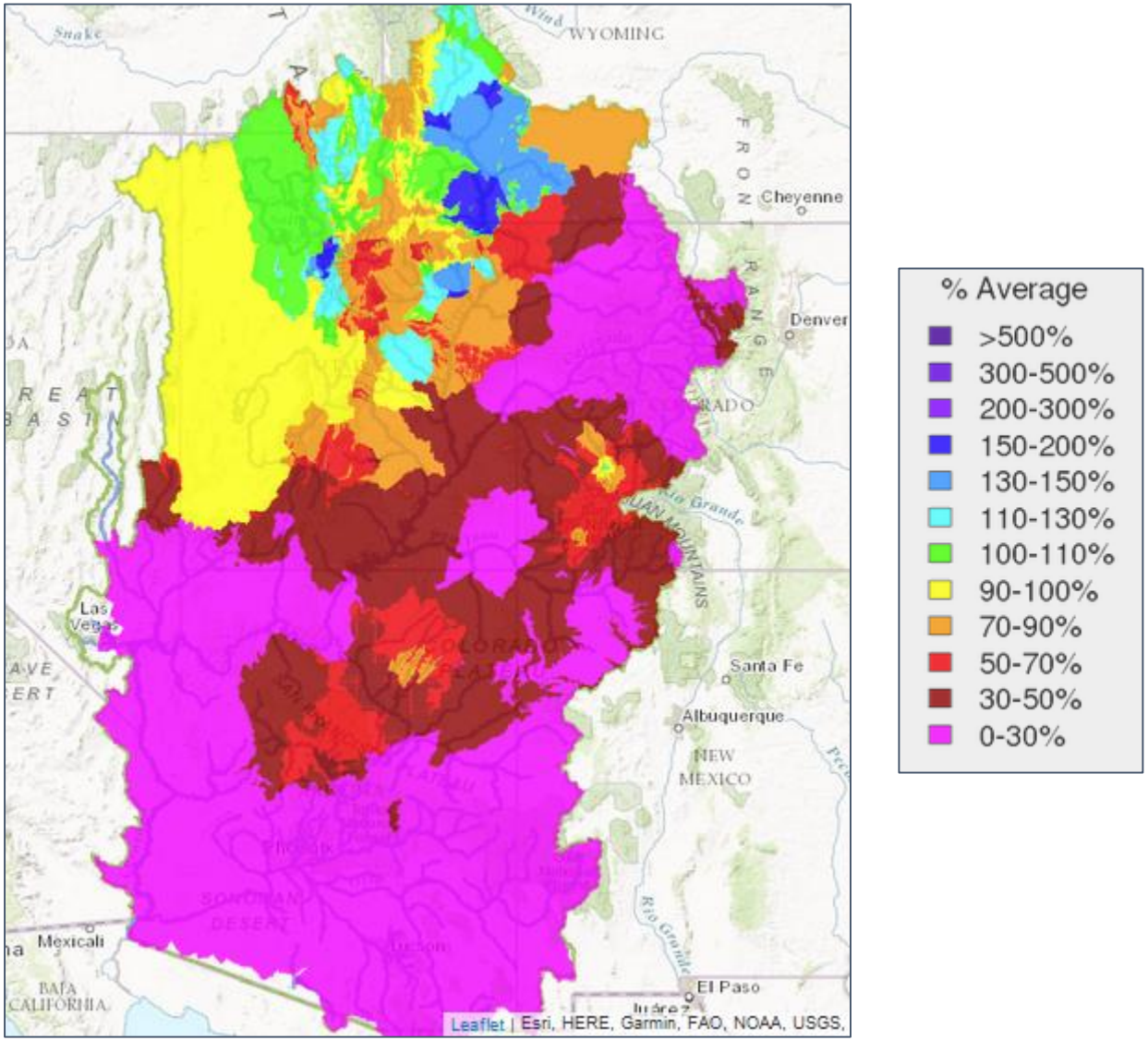
March 15 2017



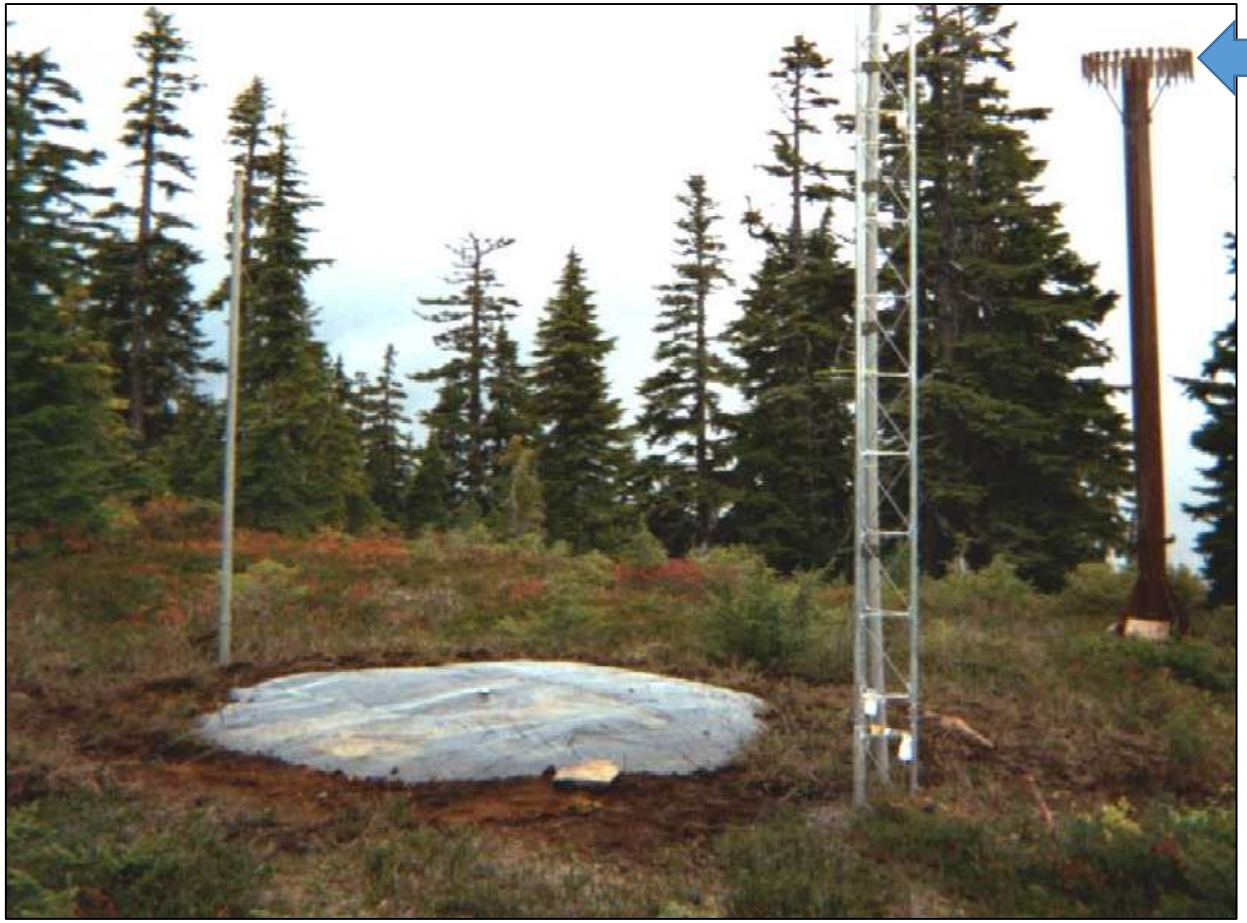
All Arizona Reservoirs Increased Except Lake Powell

March 2017 Precipitation

Very dry except northern Utah and Wyoming



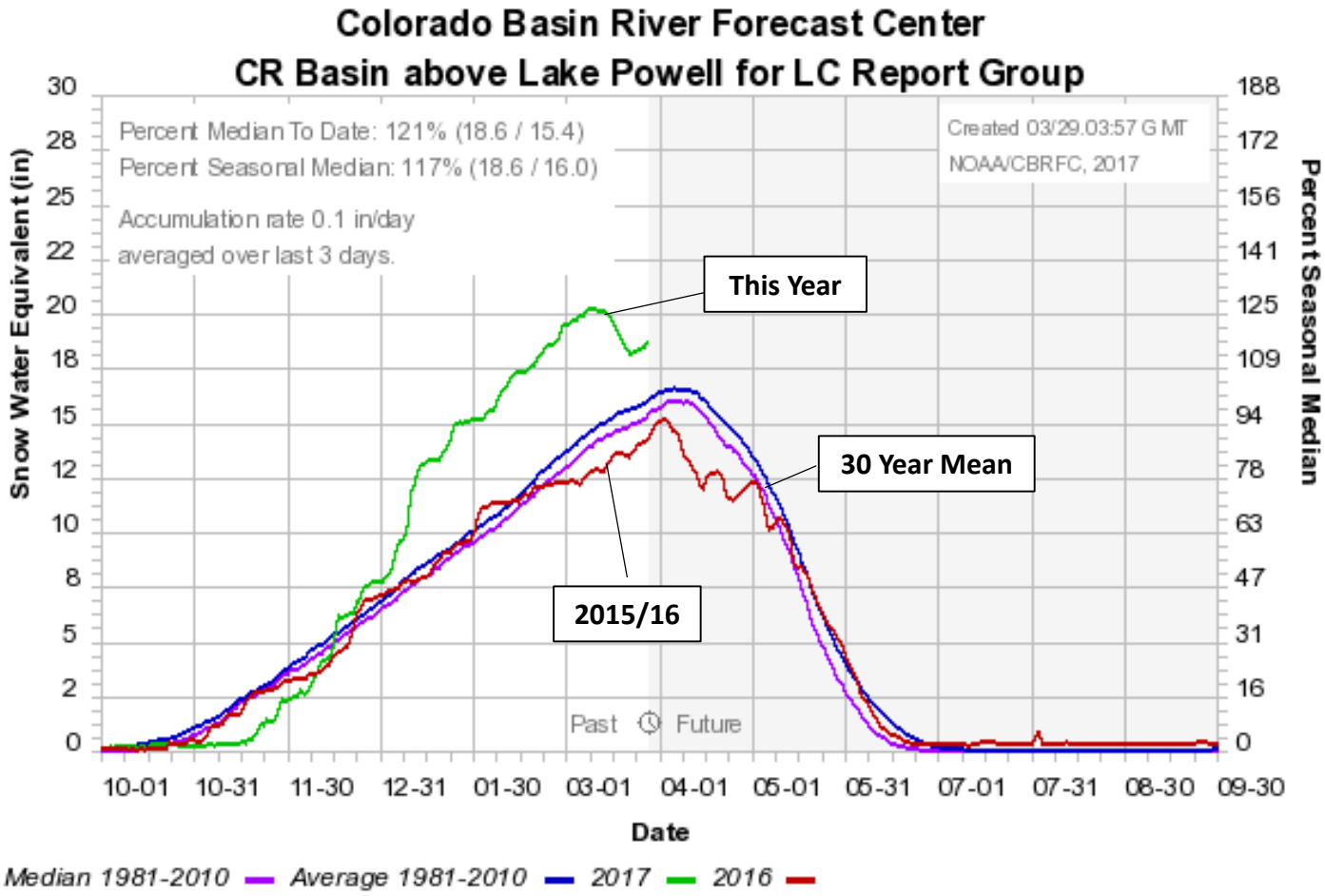
Snow Monitoring



Rain Gauge

Snow Pillows

Colorado Basin Snowpack



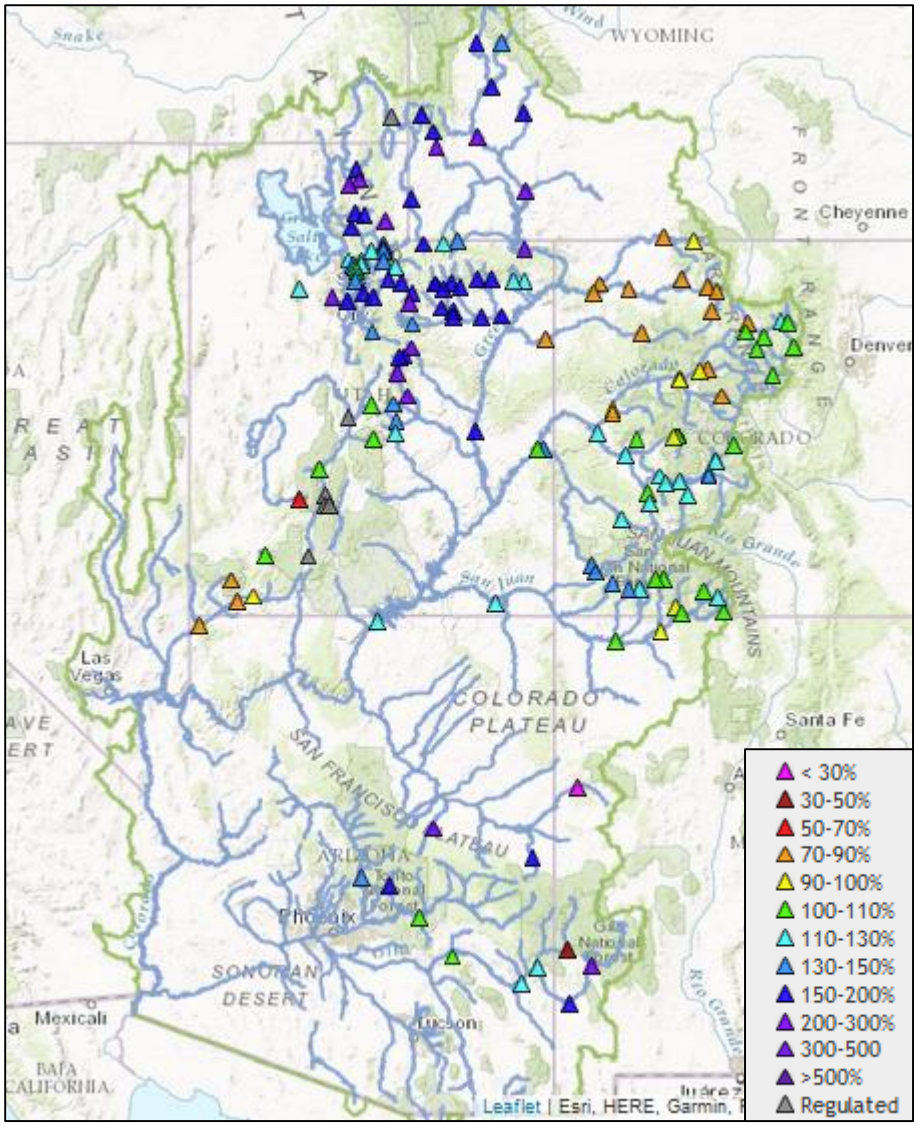
-Snowpack at 116% of normal, already 12% above seasonal peak
-Normal peak snowpack in early April

Spring Flow Projections

Colorado Basin

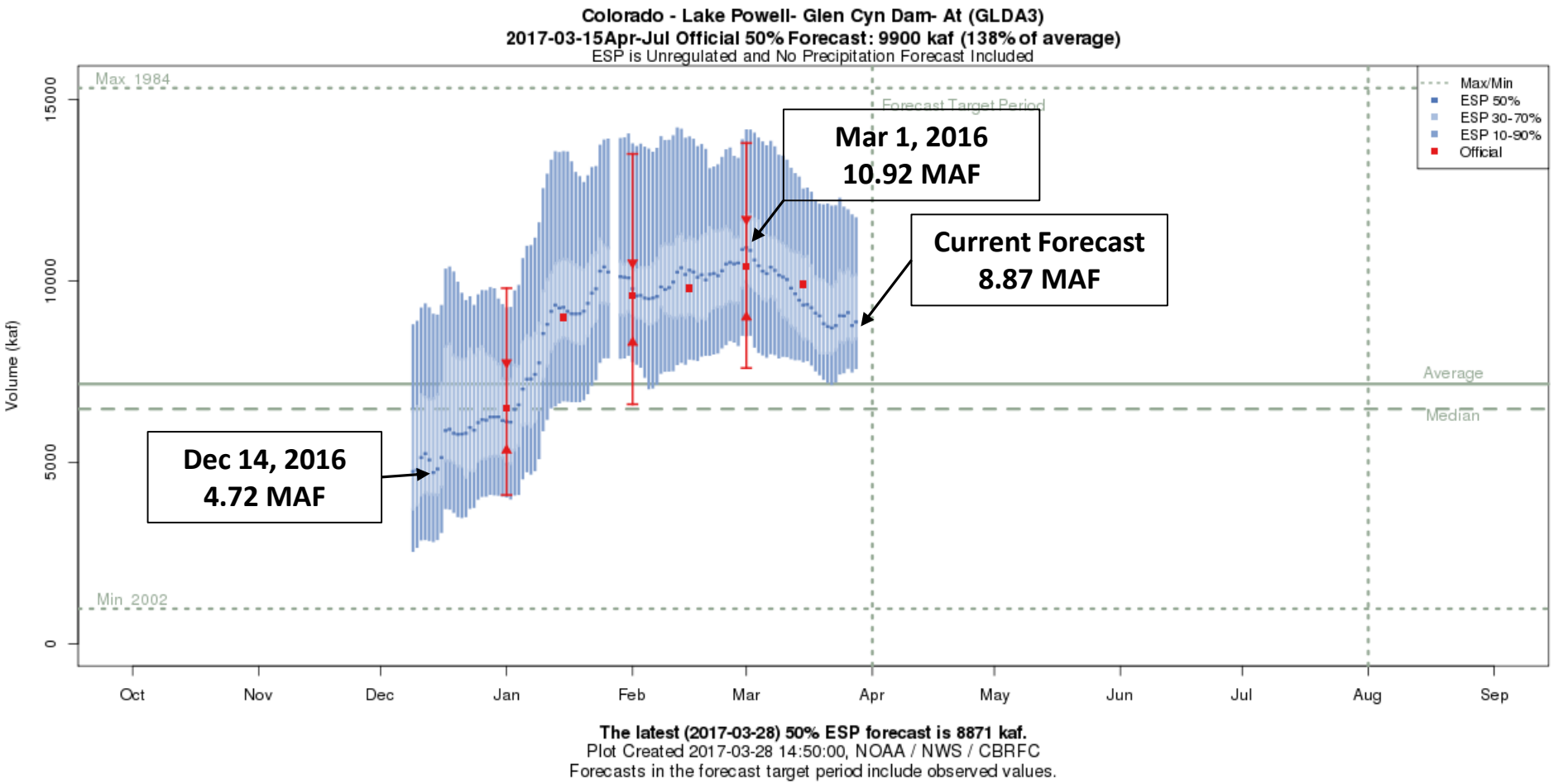
River	March 1	March 15
Colorado	145%	138%
Gunnison	132%	116%
San Juan	120%	124%
Green	169%	160%
Gila	189%	182%
Salt	117%	108%
Verde	144%	134%

Dry March has reduced spring/summer flow projections.



2017 Colorado River Projections

Famine to Feast to ?



Lower Colorado River

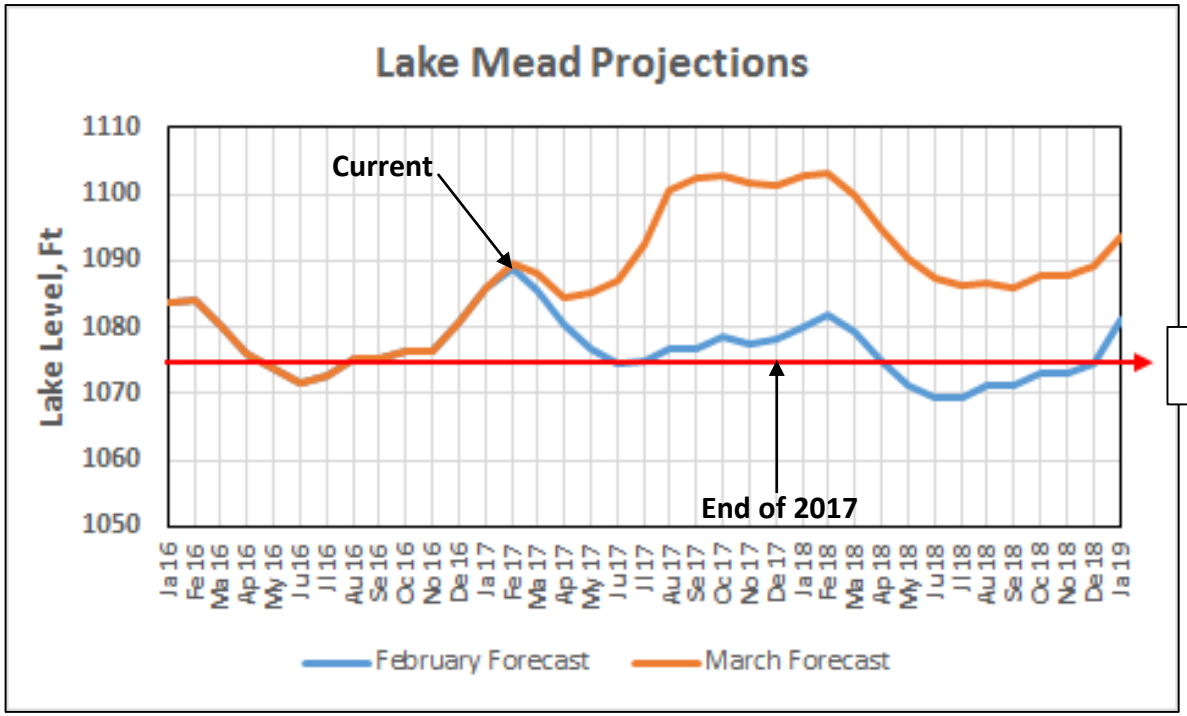
Over Allocation Problem

	Powell Release 8.23 maf	Powell Release 9.0 maf
Inflow	+9.0 maf	+9.77 maf
Outflow (AZ, CA, NV, MX+ Reg)	-9.6 maf	-9.6 maf
Evaporation	-0.6 maf	-0.6 maf
Balance	-1.2 maf	-0.43 maf
Elevation Loss	~12'/year	~4.3'/year

Lake Mead levels will continue to decrease without a reduction in use or a series of wet winters that will allow for higher releases from Lake Powell.

Colorado River Shortage

Lake Mead Elevation Projections



Projections

January: 1074.7' Shortage

February: 1078.0' No Shortage

March: 1101.5' No Shortage

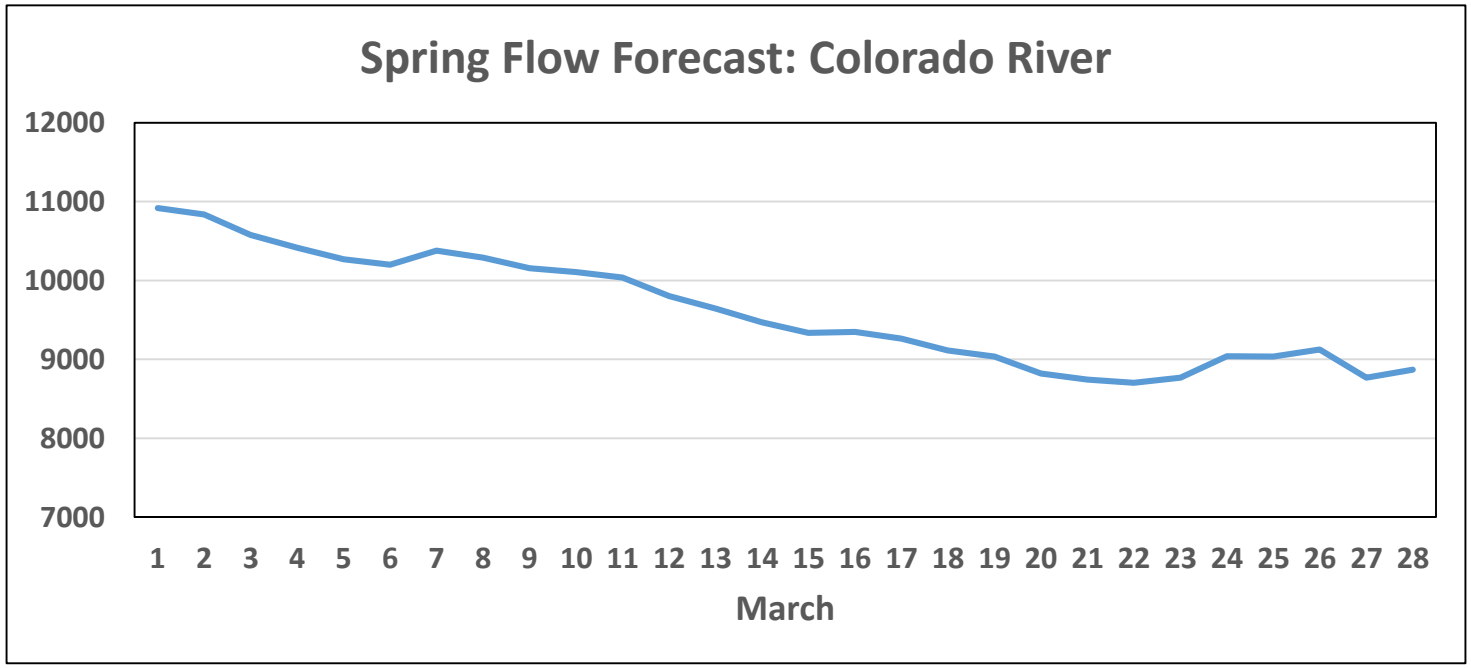
Shortage Elevation

If August projection for December 31, 2017 calls for Lake Mead level below 1075' a shortage is to be declared. The current March forecast is well above 1075' due to projection for lake equalization (release of extra water from Lake Powell).

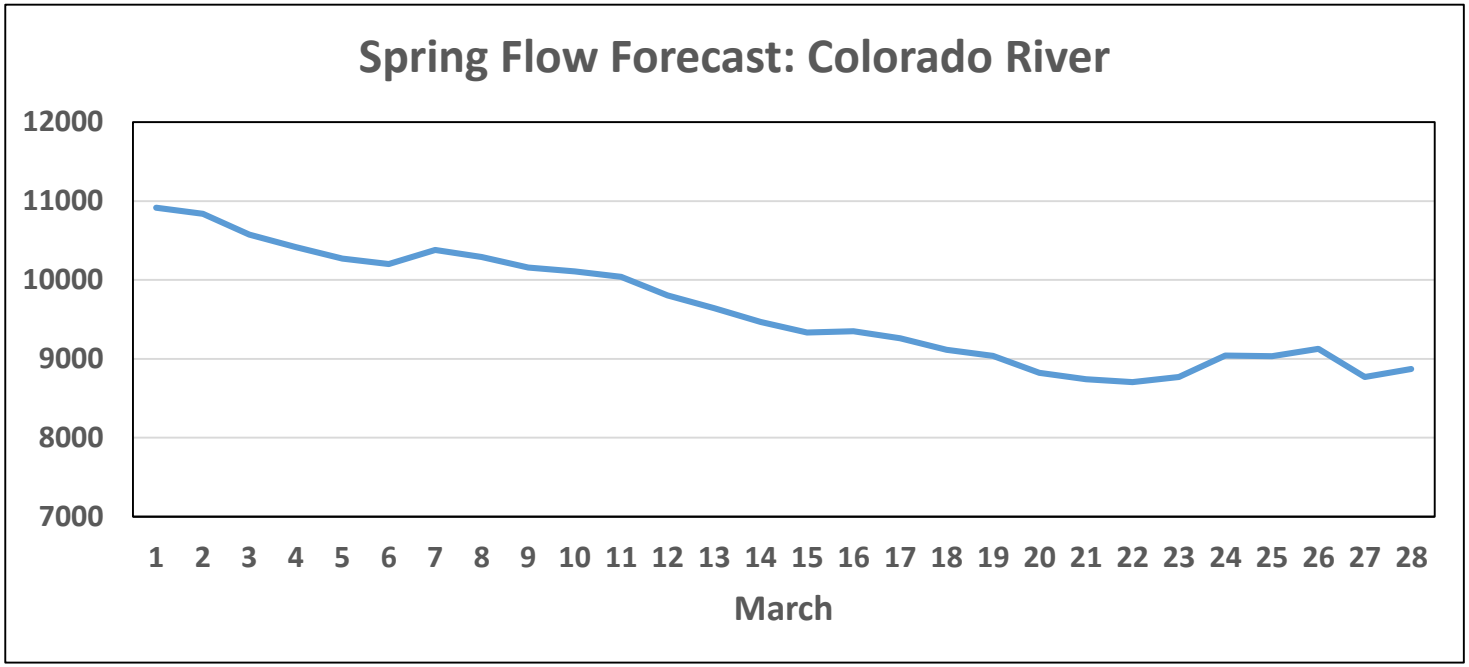
Equalization is Just Projection

Decision Made in April

The operating tier for water year 2017, established in August 2016, is the Upper Elevation Balancing Tier, with an initial water year release volume of 8.23 maf and the potential for an April 2017 adjustment to equalization or balancing releases. Based on the March 1 forecast, an April adjustment to equalization releases is projected to occur and Lake Powell is currently projected to release 11.1 maf in water year 2017. This is only a projection, the actual April forecast and 24 Month Study will determine the final 2017 volume release from Glen Canyon Dam.

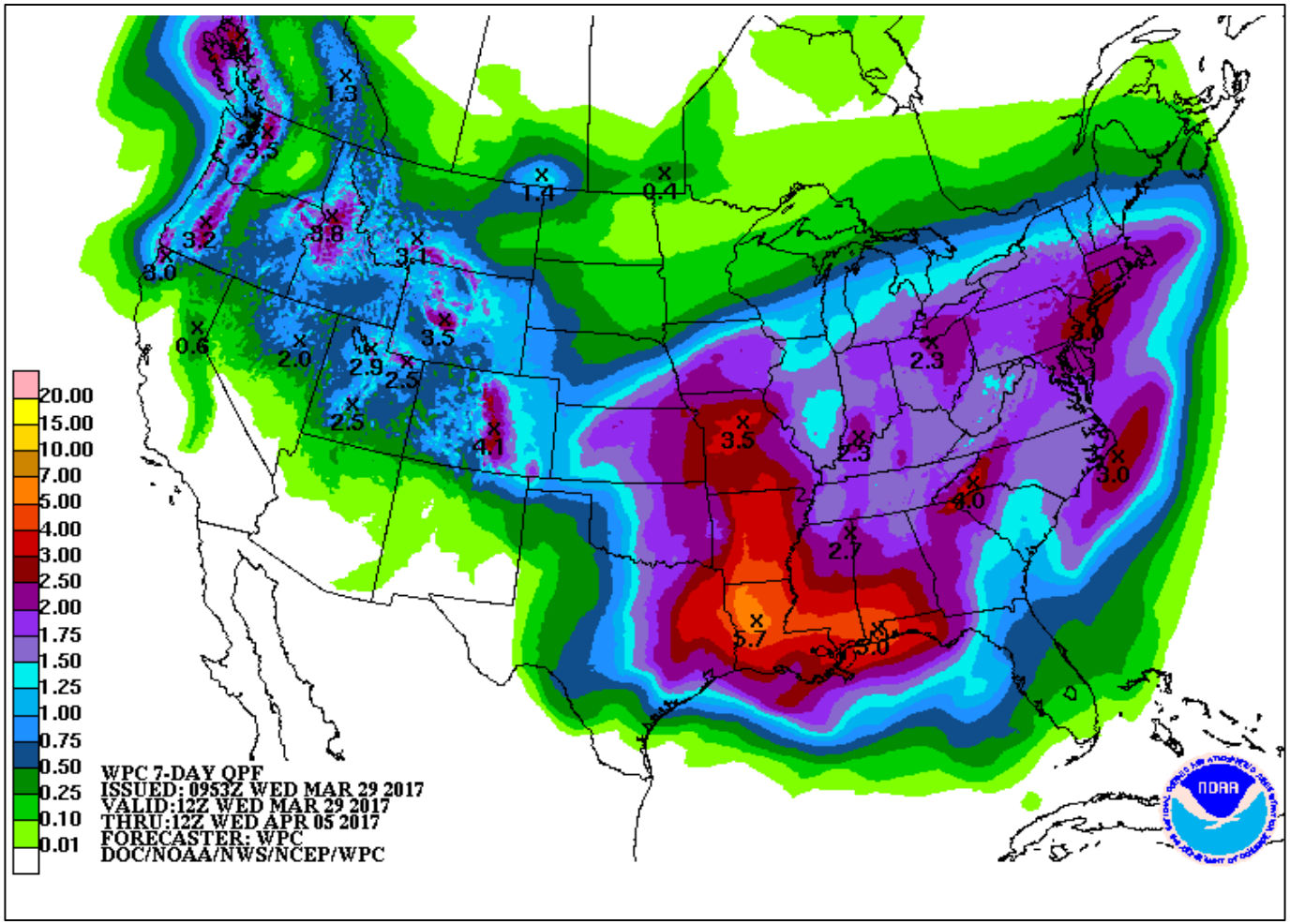


March Decline in Flow Forecast



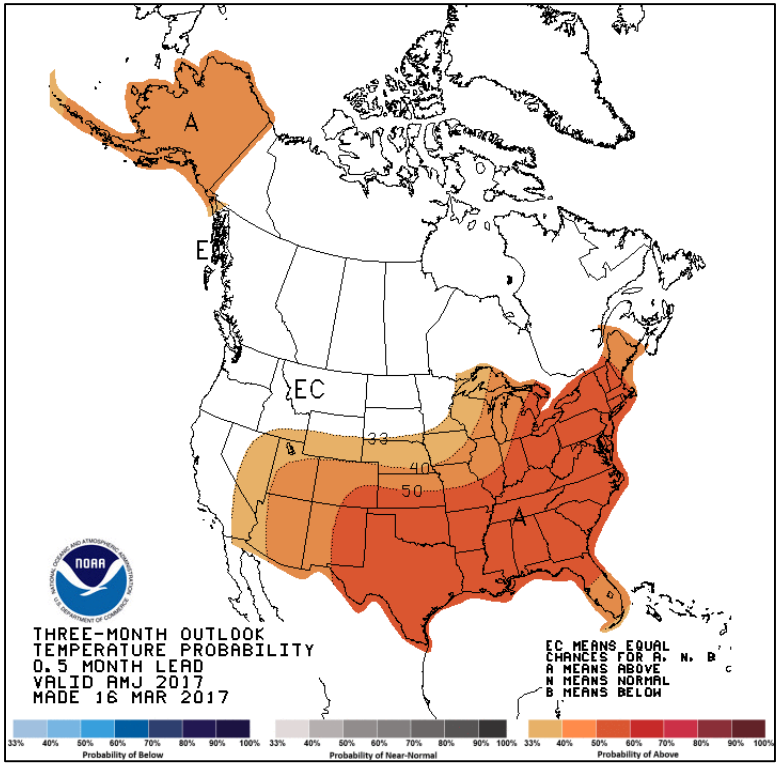
It should be noted that since the March final forecast was issued on March 2, 2017, the Colorado Basin River Forecast Center Ensemble Streamflow Prediction indicates a decrease in the forecasted inflow. It is unlikely that the March final forecasted inflow will be sustained in the April final forecast. The April 24-Month Study projections are used to determine whether there is an adjustment to equalization or balancing under the Interim Guidelines governing Lake Powell releases for the remainder of water year 2017.

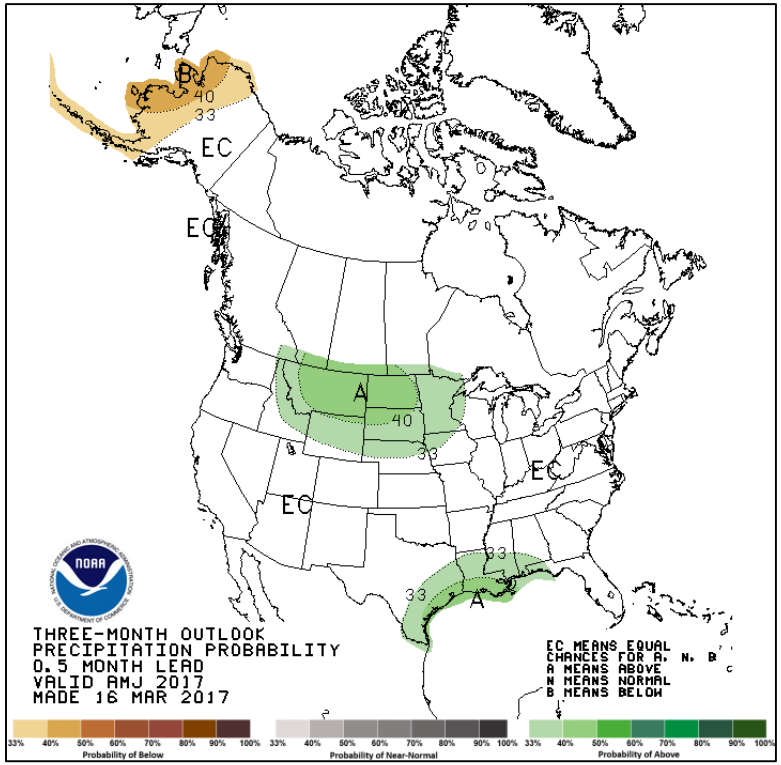
Hope This Comes True & In Time



Flow Projection w/o Precipitation: 8.87 MAF
Flow Projection with Precipitation: 9.47 MAF

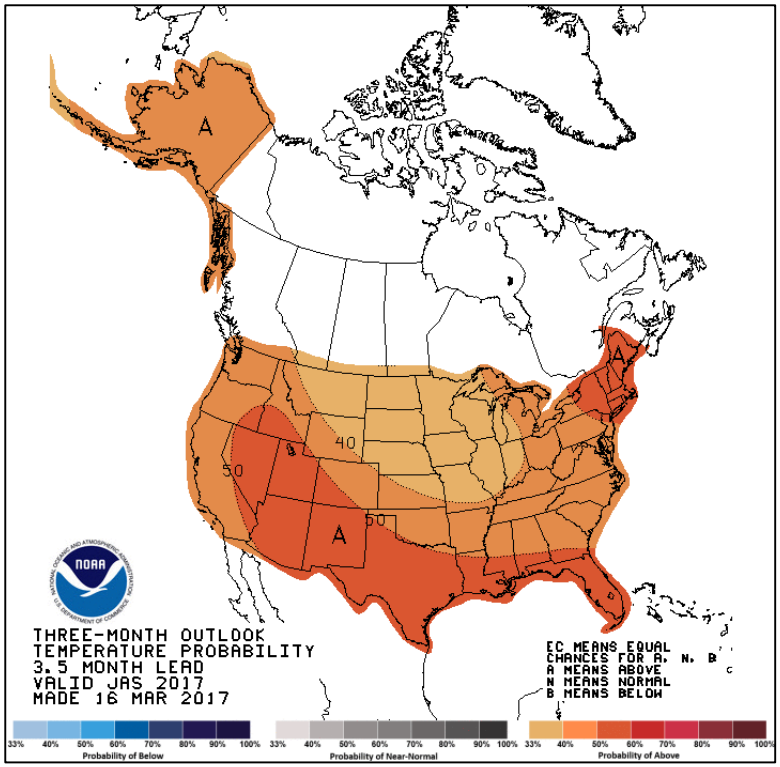
Forecast: April-June 2017

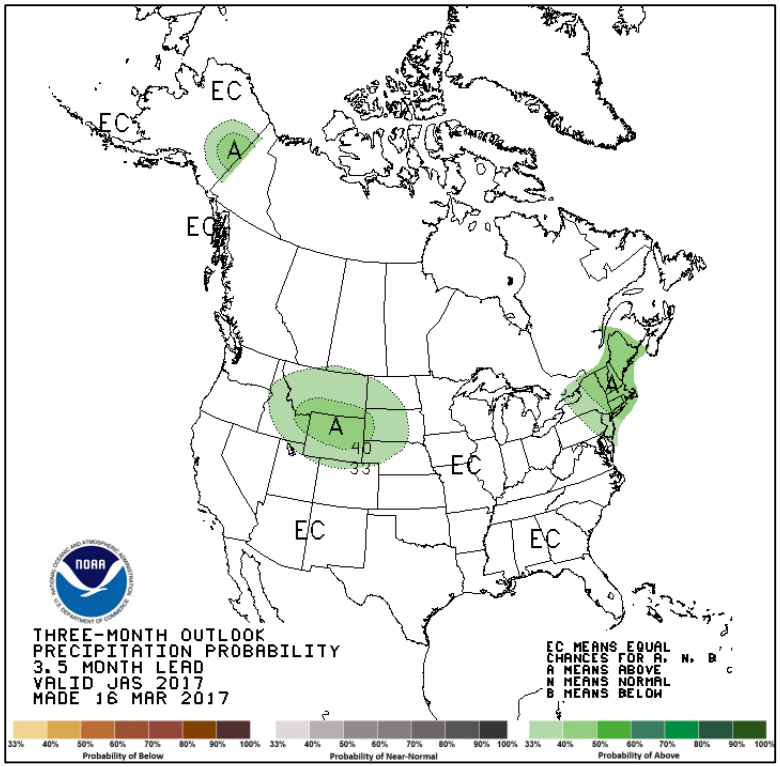




--Weak to moderate warm bias in Arizona; no bias for precipitation

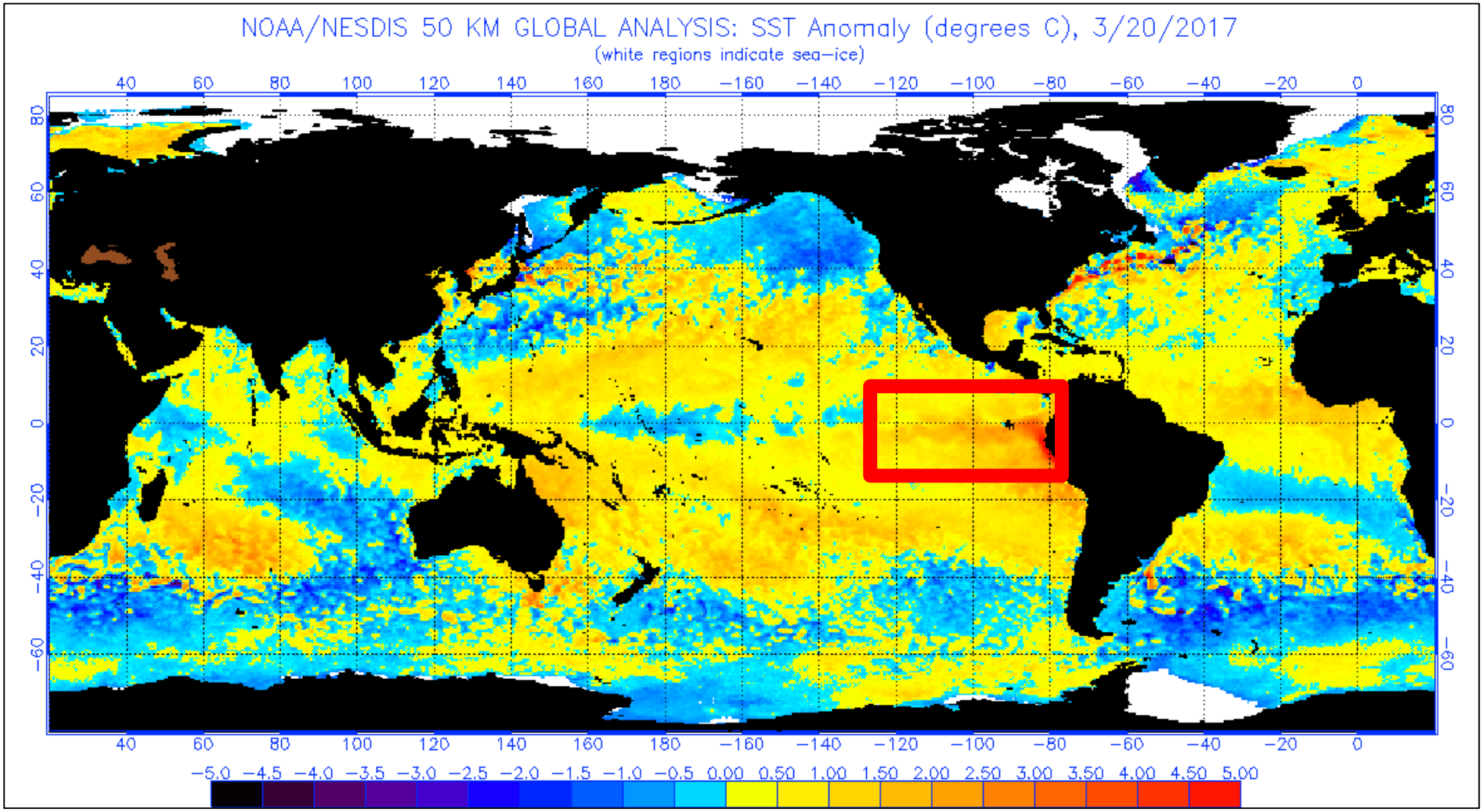
Forecast: July-September 2017





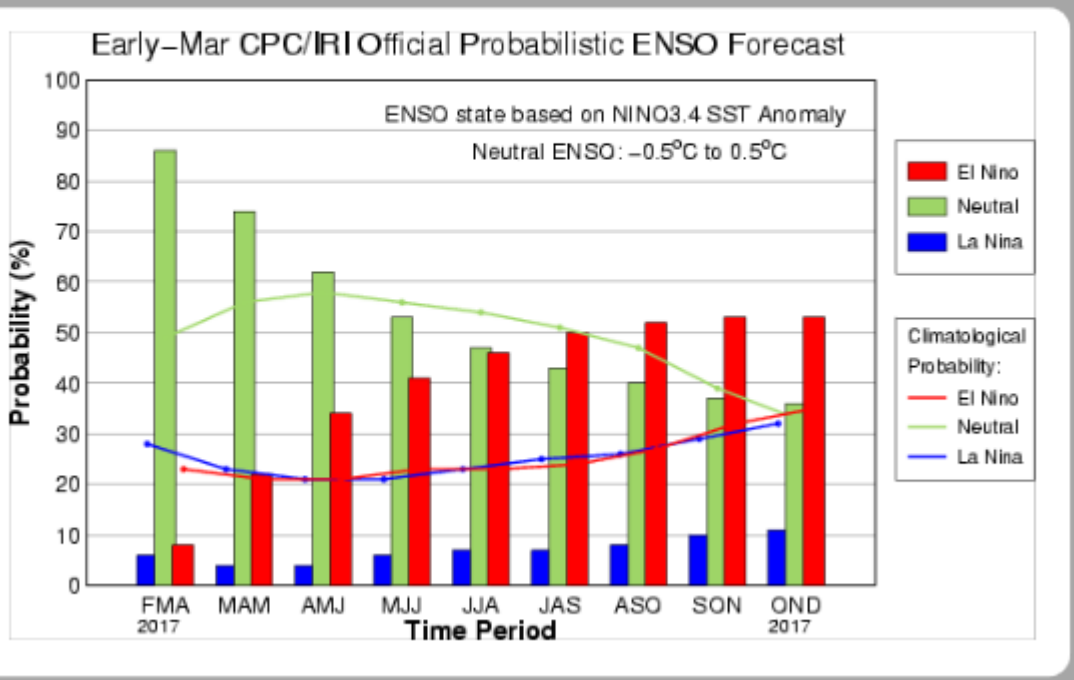
--Strong warm bias for AZ; no bias for monsoon precipitation

Return of El Niño???



Return of El Niño???

ENSO-neutral is favored through mid-2017, with a slight tilt toward El Niño (~50%) during the late summer through fall 2017.



Proposed New Drought Contingency Plan