California Drought: Current Conditions and Future Possibilities in a Changing Climate

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Talk Overview

• Current Conditions
• 20th Century California Drought
• Paleodroughts
• Expected Impacts from Climate Change
• Future Drought Characteristics
## Daily Drought Information Summary (02/24/2014)

Report generated: 02/24/2014 12:05

### Reservoir Storage as of 02/23/2014 at midnight

<table>
<thead>
<tr>
<th>Reservoir</th>
<th>River</th>
<th>Storage (in Acre Feet)</th>
<th>% of Capacity</th>
<th>Storage Year Ago This Date</th>
<th>% of Capacity Year Ago This Date</th>
<th>% Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trinity Lake</td>
<td>Trinity</td>
<td>1,180,196</td>
<td>48</td>
<td>1,981,350</td>
<td>81</td>
<td>110</td>
</tr>
<tr>
<td>Shasta Lake</td>
<td>Sacramento</td>
<td>1,730,766</td>
<td>38</td>
<td>3,589,145</td>
<td>79</td>
<td>109</td>
</tr>
<tr>
<td>Lake Oroville</td>
<td>Feather</td>
<td>1,388,506</td>
<td>39</td>
<td>2,826,095</td>
<td>80</td>
<td>116</td>
</tr>
<tr>
<td>New Bullards Bar Res</td>
<td>Yuba</td>
<td>471,479</td>
<td>49</td>
<td>779,282</td>
<td>81</td>
<td>126</td>
</tr>
<tr>
<td>Folsom Lake</td>
<td>American</td>
<td>290,077</td>
<td>30</td>
<td>559,077</td>
<td>57</td>
<td>104</td>
</tr>
<tr>
<td>New Melones Res</td>
<td>Stanislaus</td>
<td>1,057,926</td>
<td>44</td>
<td>1,607,279</td>
<td>66</td>
<td>110</td>
</tr>
<tr>
<td>Don Pedro Res</td>
<td>Tuolumne</td>
<td>1,055,208</td>
<td>52</td>
<td>1,398,696</td>
<td>69</td>
<td>98</td>
</tr>
<tr>
<td>Lake McClure</td>
<td>Merced</td>
<td>213,924</td>
<td>21</td>
<td>452,793</td>
<td>44</td>
<td>86</td>
</tr>
<tr>
<td>Millerton Lake</td>
<td>San Joaquin</td>
<td>172,068</td>
<td>33</td>
<td>325,694</td>
<td>63</td>
<td>96</td>
</tr>
<tr>
<td>Pine Flat Res</td>
<td>Kings</td>
<td>185,805</td>
<td>19</td>
<td>319,540</td>
<td>32</td>
<td>62</td>
</tr>
<tr>
<td>Isabella</td>
<td>Kern</td>
<td>59,340</td>
<td>10</td>
<td>82,482</td>
<td>15</td>
<td>45</td>
</tr>
<tr>
<td>San Luis Res (Offstream)</td>
<td>678,066</td>
<td>33</td>
<td>40</td>
<td>1,201,459</td>
<td>59</td>
<td>70</td>
</tr>
</tbody>
</table>

### Snowpack Water Content as of 02/24/2014

<table>
<thead>
<tr>
<th>Region</th>
<th>Water Content (in inches)</th>
<th>% Average to Date</th>
<th>% of Apr 1 Average</th>
<th>Water Content (in inches) Last Year This Date</th>
<th>% Average Last Year This Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northern Sierra</td>
<td>3.20</td>
<td>13</td>
<td>11</td>
<td>17.50</td>
<td>72</td>
</tr>
<tr>
<td>Central Sierra</td>
<td>7.60</td>
<td>30</td>
<td>25</td>
<td>17.30</td>
<td>67</td>
</tr>
<tr>
<td>Southern Sierra</td>
<td>4.40</td>
<td>21</td>
<td>17</td>
<td>12.10</td>
<td>59</td>
</tr>
<tr>
<td>Statewide</td>
<td>5.50</td>
<td>23</td>
<td>19</td>
<td>15.80</td>
<td>67</td>
</tr>
</tbody>
</table>

### Precipitation Index Accumulation as of 02/24/2014

<table>
<thead>
<tr>
<th>Index</th>
<th>Season to Date</th>
<th>% of Average</th>
<th>Season to Date Last Year</th>
<th>% of Average Last Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northern Sierra</td>
<td>12.90</td>
<td>38</td>
<td>34.10</td>
<td>101</td>
</tr>
<tr>
<td>Southern Sierra</td>
<td>8.51</td>
<td>32</td>
<td>21.04</td>
<td>79</td>
</tr>
</tbody>
</table>

Provisional Data, Subject to Change
CONDITIONS FOR MAJOR RESERVOIRS: 23-FEB-2014

Data as of Midnight: 23-Feb-2014

- **Trinity Lake**: 48% (Total Cap), 66% (Hist. Av)
- **Lake Shasta**: 38% (Total Cap), 53% (Hist. Av)
- **Lake Oroville**: 39% (Total Cap), 57% (Hist. Av)
- **Folsom Lake**: 44% (Total Cap), 72% (Hist. Av)
- **New Melones**: 44% (Total Cap), 72% (Hist. Av)
- **San Luis**: 33% (Total Cap), 40% (Hist. Av)
- **Millerton Lake**: 33% (Total Cap), 51% (Hist. Av)
- **Pyramid Lake**: 98% (Total Cap), 103% (Hist. Av)
- **Castaic Lake**: 84% (Total Cap), 97% (Hist. Av)

**Legend**
- Blue Bar: Storage level for date
- Gold Bar: Total reservoir capacity
- Red Line: Historic level for date

% of Capacity | % Historical Avg
---|---
Trinity Lake: 48% | 66%
Lake Shasta: 38% | 53%
Lake Oroville: 39% | 57%
Folsom Lake: 44% | 72%
New Melones: 44% | 72%
San Luis: 33% | 40%
Millerton Lake: 33% | 51%
Pyramid Lake: 98% | 103%
Castaic Lake: 84% | 97%

Click for printable version of current data. Report Generated: 24-Feb-2014 12:57 PM
Northern Sierra
8 Station Index

WRCC
WestMap

Annual Average: 50 inches
Maximum Year (1983): 88.5 inches
Minimum Year (1924): 17.1 inches
Period of Record 1921- Present
*WY2014 assumes no further precipitation this year
What will California drought look like in the next century as climate warms?
Location Matters
Precipitation Characteristics
The Northern CA 8-Station Index

Eight Stations: Mt. Shasta City, Shasta Dam, Mineral, Quincy, Brush Creek, Sierraville, Blue Canyon, and Pacific House
Monthly 8 Station Distribution

Average : 50 Inches
Drought Average: 38 Inches
Snowpack
Drought Average April 1st: 60%

Snowpack Characteristics
Runoff Characteristics
Drought Runoff Characteristics – Sacramento Basin

The graph shows the percentage of Drought Years and Period of Record for different periods:
- **Oct Mar**: 60% Drought Years and 40% Period of Record
- **Apr-Jul**: 70% Drought Years and 30% Period of Record
- **Water Year**: 65% Drought Years and 35% Period of Record

The chart indicates a higher proportion of drought years compared to the period of record across all three timeframes.
Paleodroughts

Woodhouse et al., 2006: Upper Colorado River Basin Streamflow Reconstruction

Palaeo droughts
100+yr. Droughts in California?

“Here I present a study of relict tree stumps rooted in present-day lakes, marshes and streams, which suggests that California’s Sierra Nevada experienced extremely severe drought conditions for more than 2 centuries before AD~1112 and for more than 140 years before AD~1350.”

“Future natural or anthropogenically induced warming may cause a recurrence of the extreme drought conditions”

“California's mediaeval precipitation regime, if it recurred with today's burgeoning human population, would be highly disruptive environmentally and economically.”

1921-1940 Sacramento Basin

- Only 6 years with above average rainfall in 8 Station Index (1921, 1925, 1927, 1936, 1938, 1940)
- Average annual precipitation 44 inches during this time
- Water year runoff average 14.9 MAF
- WSI Class Distribution: 2W, 4AN, 4BN, 5D, 5C
Climate Change Impacts

- Less Precipitation Falling as Snow
- Drier Springs
- Increased Variability
Signs of Change?

- Driest Precipitation Year Southern CA 2007
- Driest Spring Northern Sierra 2008
- Water Year 2009 Precipitation Distribution
Future Drought Characteristics

- Decrease in Spring Precipitation decreases odds of “March Miracles”

- Dry springs and smaller snowpacks will yield lower base flow values earlier in year

- Ability to manage water increasingly constrained by hydrologic conditions and regulatory decisions
What If Drought Year – 8 Station Index

- Blend elements of past drought years to represent climate change drought year

- Low 10 Monthly Average: 6.91 inches

- Low 10 Seasonal Total Average: 17.10 inches

- 1977/1991/1924 Seasonal Mix: 11.07 inches
What If Drought Year - Runoff

- No snowpack for spring runoff
- Fall runoff increase requires more precipitation
- Winter flows harder to maintain
- Average of 10 Lowest Drought Flows:
  Oct-Mar: 3.8 MAF (10.4 MAF)
  Apr-Jul: 2.6 MAF (6.8 MAF)
  Water Year: 7.5 MAF (18 MAF)
Multi-Year Sequencing

- **20th Century** shows 2, 3, 4, and 6 Yr droughts
- 20-year dry period 1921-1940 in observed record for 8 Station Index & Sacramento Basin Runoff
- Paleorecord shows multiple 10+ year droughts as well as 2 century-long dry periods (climate shifts)
Conclusions

• 20\textsuperscript{th} century drought characteristics show wintertime precip/runoff deficits sometimes offset by wetter than average springs

• Climate change is expected to have fewer wet springs potentially increasing drought occurrence and severity risk.
Conclusions

• The expectation of increased variability means future conditions can change quickly with 2013 serving as an example.

• Planning for future droughts can take advantage of information in the historical record including paleoreconstructions. The trick will be to increase our understanding of causal mechanisms and watershed response.
Questions?

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