Research Home
Current Publications
All Publications
WWA Reports
WWA Annual Reports
Intermountain West Climate Summary
Stakeholder Climate Needs

WWA Home È Research È Publications È Intermountain West Climate Summary

INTERMOUNTAIN WEST CLIMATE SUMMARY

A product of the Western Water Assessment

Issued May 24, 2012, Vol. 8, Issue 4

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May 2012 Summary

Temperature — *April temperatures were well above average across the entire region, with most of the region 4Ð8iF warmer than average.*

Precipitation — *While April was wetter than March, precipitation was still below average across most of the region, with southern Utah, western Colorado, and west-central and southeastern Wyoming being especially dry.*

Hydrological Conditions — *Snowpacks across the region continued their rapid and early melt during April, with May 1 snowpacks near or at record-low levels for many basins. Accordingly, the May 1 forecasts call for much-below-average spring-summer runoff for nearly all basins the region.*

ENSO — *ENSO-neutral conditions have returned to the tropical Pacific Ocean. More than half of the ENSO forecast models indicate that El Ni–o conditions will develop by fall 2012, with the rest calling for persisting ENSO-neutral conditions through the fall.*

Climate Forecasts — *The temperature outlooks from the NOAA CPC indicate an enhanced chance of warmer-than-average temperatures in nearly all of the region in June and in subsequent seasons. An slightly enhanced chance of dry conditions is indicated only for northern Utah and western Wyoming.*

RETURN TO TOP

Announcements & News

New review paper on water yield effects of bark beetle infestations

WWA's Eric Gordon, along with Evan Pugh from the University of Colorado-Boulder, recently published a paper entitled "A conceptual model of water yield effects from beetle-induced tree death in snow-dominated lodgepole pine forests" in the journal *Hydrological Processes*. The article reviews and synthesizes previous research on the effects of bark beetle infestations on a number of hydrologic processes in lodgepole pine forests. By combining this review with the results of new field measurements, Pugh and Gordon developed a conceptual model of the hydrologic effects of beetle-induced tree death during different stages of mortality. The paper describes differences in ecohydrologic processes as they operate in living forest stands, stands in multiple stages of death, and long-dead stands undergoing regeneration, and estimates the overall directions of change in a number of water yield variables. It is intended to provide a useful summary of existing knowledge for decision makers. The abstract is available at http://onlinelibrary.wiley.com/doi/10.1002/hyp.9312/abstract; for a copy of the full article please email esgordon@colorado.edu.

For more information on WWA's efforts to aid decision makers in understanding the water-related impacts of bark

beetle infestations, visit our "Beetles, Water, and Climate" web resource at http://wwa.colorado.edu/ecology/beetle/.

IWCS reader survey coming soon, followed by changes to the IWCS

WWA has been producing the Intermountain West Climate Summary since 2005. As a research program that has been chartered by NOAA to *prototype* regional climate services, we need to clearly justify activities that become "semi-operational", such as the IWCS. Since 2008, several other climate-digest products covering different portions of our three-state region have been initiated, and there are many new climate-data portals available to users. Thus, we are reconsidering the future of the IWCS in the context of this expanding portfolio of climate information for the region. We will be sending out a reader survey in the next few months to help us to (1) better understand what our readers find useful about IWCS relative to other climate products, and (2) make appropriate changes to the IWCS. In the meantime, you are always welcome to send us feedback at wwa@noaa.gov.

Southwest Climate Science Summit, June 11-14, Tucson

The Southwest Climate Science CenterÑa DOI-funded applied research entity in which the University of Colorado and WWA are partnersÑis hosting a summit to help structure future climate research in the Southwest. Join resource managers, scientists, and federal, tribal, state, and local stakeholders to discuss the state of climate science in the Southwest (which does include Utah and Colorado) and to identify climate-related research needed to inform better societal and management decisions. Results from the Southwest Climate Assessment Report will also be shared. The summit will be convened June 11-14 in Tucson, Arizona. Registration is required. Learn more at http://www.swcsc.arizona.edu.

RETURN TO TOP

Feature Article

There is no Feature Article in this issue.

Focus Article

There is no Focus Article in this issue.

Recent Climate Conditions

April temperatures were generally much warmer than average across the entire three-state region (Figures RC-1 and RC-2). **Colorado** was unseasonably warm, with temperatures averaging over 40iF throughout the mountains and 55-60iF across the plains and western desert areas. Almost all of **ColoradoÕs** mountains and portions of the plains were 6-10iF above normal for the month. **Wyoming** saw temperatures averaging 35-40iF in the mountains and around 50iF on the high plains, with the Yellowstone-Teton region and sections of the northeast and southeast parts of the state 6-8iF above normal. **UtahÕs** temperatures were overall a few degrees closer to seasonal averages, with most of the state 2-4iF above normal for the month, with averages ranging from the mid-30s in the mountains to the mid-60s in the far southern portions of the state.

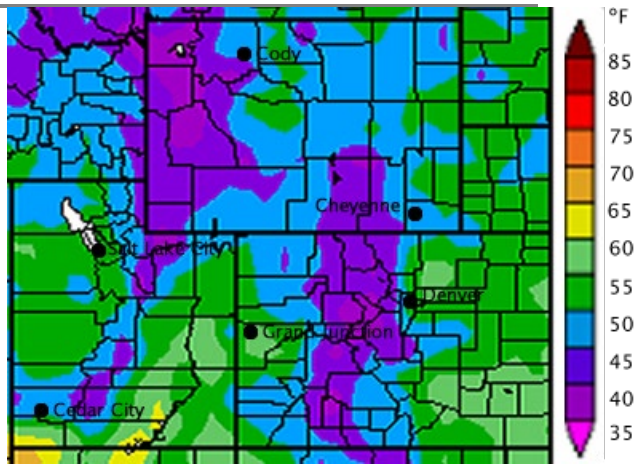

Figure RC-1. Average temperature for the month of April 2012 in iF. (Source: High Plains Regional Climate Center)

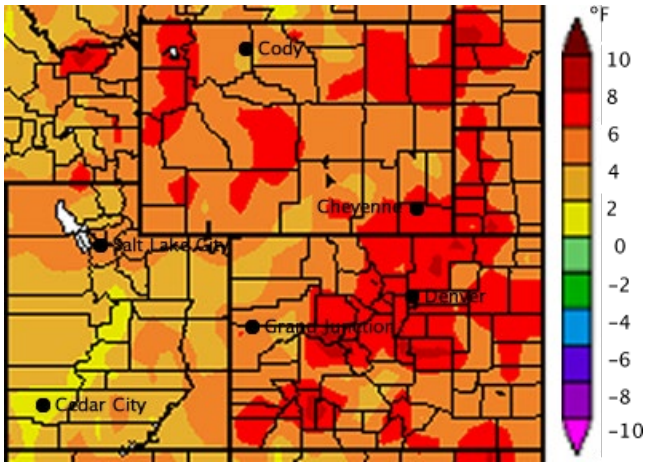

Figure RC-2. Departure from average temperature for the month of April 2012 in iF. (Source: High Plains Regional Climate Center)

Precipitation for April was above-average in only a few small areas in the three-state region (Figure RC-3 and RC-4a). Far eastern **Colorado**, northeastern **Wyoming** and the Yellowstone area, and **UtahÕs** Wasatch Front received the most precipitation, with over 3" of precipitation. Much of southern **Utah** received virtually no precipitation. Compared with average April precipitation, almost all of **Utah** was less than 40% of average, with large portions of **Colorado** and **Wyoming** also receiving much less than average for the month (Figure RC-4a). Only far northeastern **Wyoming,** portions of northern **Utah,** and eastern **Colorado** were above average. For the water-year-to-date, precipitation has been below average across most of the region (Figure RC-4b), especially in, **Utah,** western **Colorado**, and portions of eastern **Wyoming**. Southwestern and far northern **Wyoming** have fared better, receiving over 150% of average precipitation since October 1.

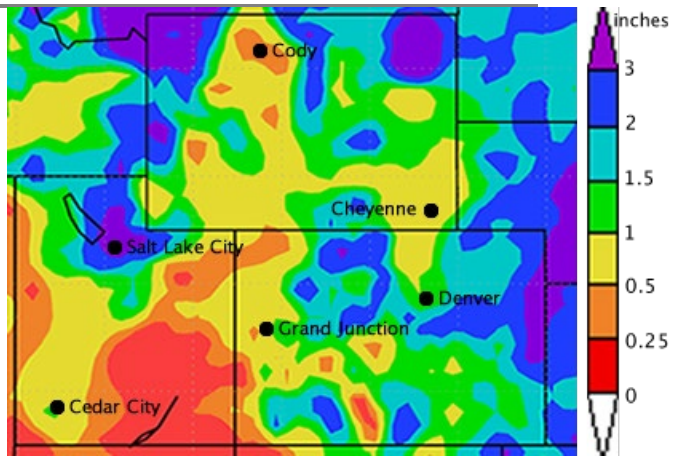

Figure RC-3. Total precipitation for the month of April 2012 (inches). (Source: Gary Bates, NOAA ESRL Physical Science Division)

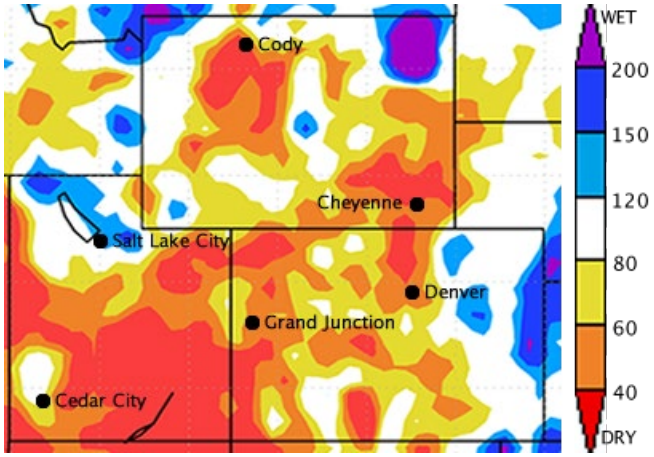

Figure RC-4a. Percent of average precipitation for the month of April 2012. (Source:Gary Bates, NOAA ESRL Physical Science Division)

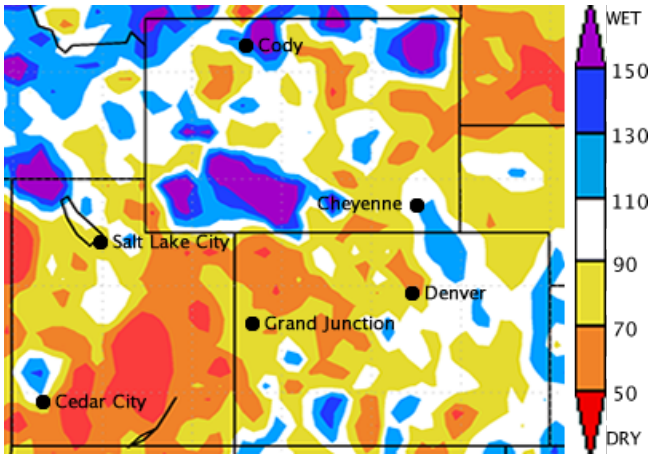

Figure RC-4b. Percent of average precipitation for October 2011ÐApril 2012. (Source: Gary Bates, NOAA ESRL Physical Science Division)

The 3-month Standardized Precipitation Index (SPI) shows that April continued a short-term drying trend across much of the Intermountain West (Figure RC-5). Western **Colorado**, southeastern **Wyoming**, and part of east-central **Utah** are extremely dry for the February-April period, with large portions of **Wyoming** and western **Utah** considered very dry. Only far northeastern **Colorado** and northwestern **Wyoming** are considered moderately wet in the 3-month SPI. In the 36-month SPI, conditions are much closer to normal for most of the three-state region, reflecting wet conditions during the 2010-2011 water year balanced by dry conditions so far during the 2011-2012 water year (Figure RC-6). Northeastern **Colorado**, northern **Utah**, and portions of northern **Wyoming** all appear moderately wet in the 36-month SPI, with east-central **Wyoming** categorized as very wet. South-central **Colorado** is the only area showing very dry conditions over the past three years.

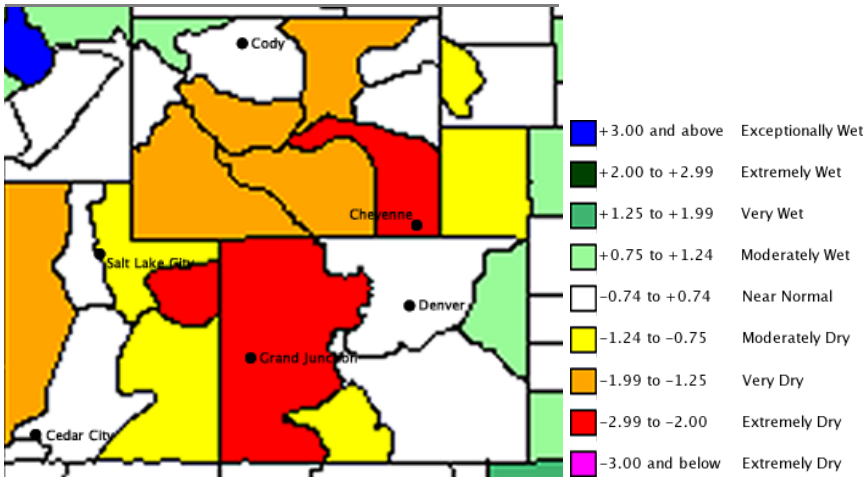

Figure RC-5. 3-month Intermountain West regional Standardized Precipitation Index as of the end of April 2012 (data from 2/01/12Ð 4/30/12). (Source: Western Regional Climate Center)

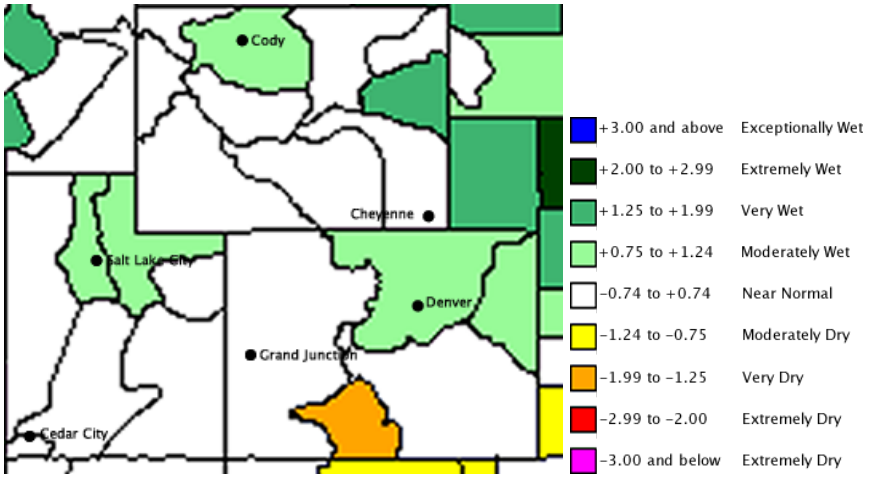

Figure RC-6. 36-month Intermountain West regional Standardized Precipitation Index as of the end of April 2012 (data from 05/01/10Ð4/30/12). (Source: Western Regional Climate Center)

The US Drought Monitor for May 15 shows dry conditions and drought continuing to expand and intensify across the three-state region compared to conditions one month earlier (Figure RC-7). Most of **Utah** and **Colorado** are at least experiencing D1 (moderate) drought conditions, with D2 (severe) across northeastern **Utah** and northwestern **Colorado**. Much of **Wyoming** is now categorized as D0 (abnormally dry).

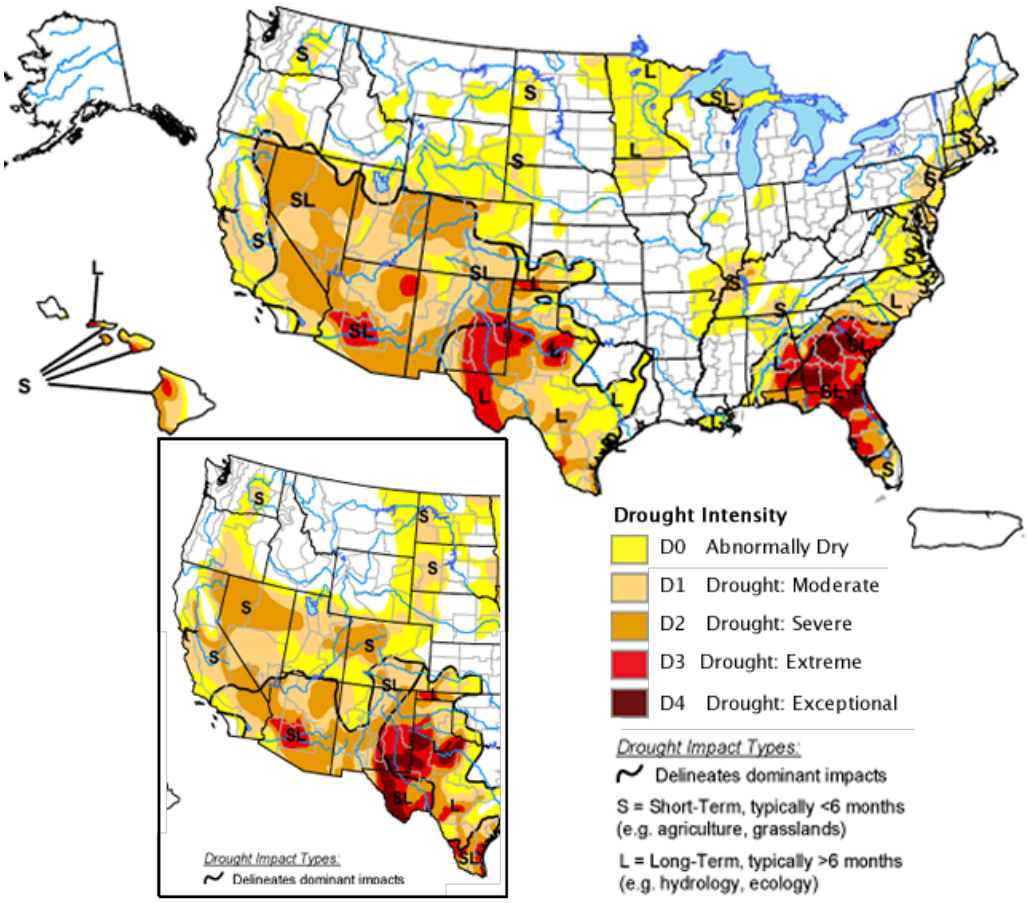

Figure RC-7. Drought Monitor from May 15, 2012 (full size) and April 17, 2012 (inset, lower left) for comparison. (Source: National Drought Mitigation Center)

Notes & Weblinks
(provides explanations of graphics and additional information sources)

RETURN TO TOP

Intermountain West Snowpack

May 1 snowpacks in the three-state region were very low, following the very early and rapid retreat driven by much-above-average March and April temperatures and low precipitation. Nearly all basins in the region reported below- to much-below-average snowpack conditions, with only the northwestern corner of **Wyoming** reporting near-average conditions. While by May 1st one would expect significant melt in an average year, this year was exceptional, with little lower and mid-elevation snow remaining. Many SNOTEL sites have set records for earliest melt-out dates, mostly in **Colorado** and **Utah**, with some Colorado sites melting out more than a full month ahead of previous records.

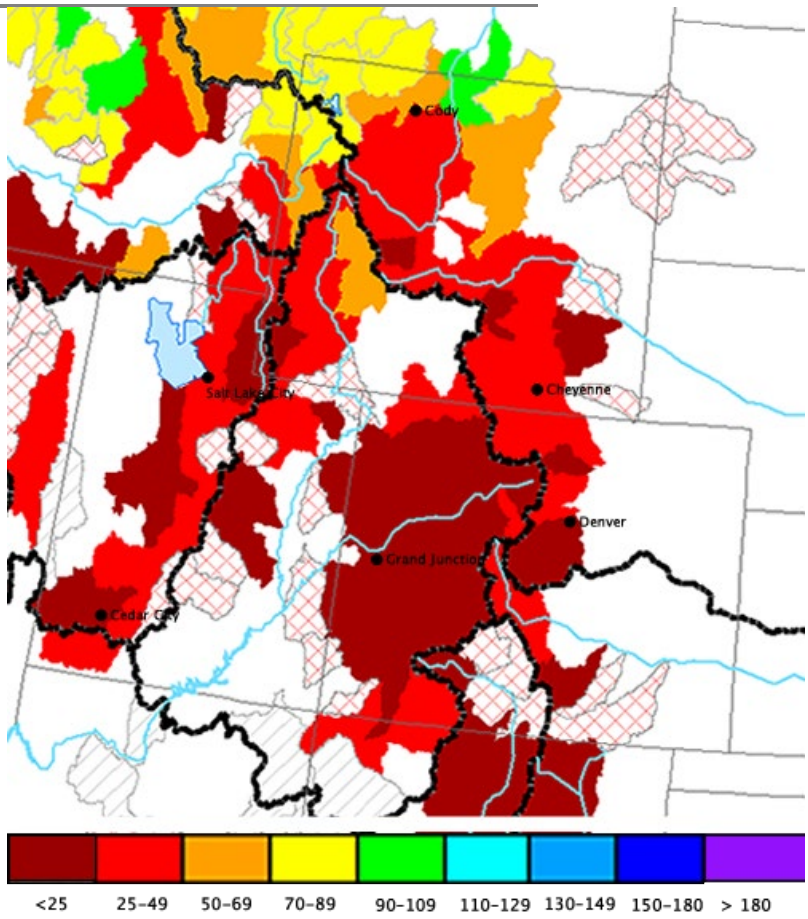

Figure SP-1. Snow water equivalent (SWE) as a percent of average for available SNOTEL and snow course sites, calculated for each basin in the Intermountain West as of May 1, 2012. Note: The red cross-hatching indicates basins in which there was zero observed SWE on May 1. (Source: Natural Resource Conservation Service)

In **Colorado**, May 1 snowpacks were near record lows in most basins, and set new record lows in the Upper Colorado, Yampa and White basins. A warm and dry April, with a statewide precipitation of 60% of average, continued the rapid melt initiated in March and reduced snowpacks from 52% of average on April 1 to 19% on May 1st, tying the record statewide record low set in 2002. Individual basins ranged from a high of 27% on the North Platte to a low of 15% on the Upper Rio Grande.

Utah statewide snowpacks on May 1 were just 13% of last year and 24% of average. Individual basins ranged from a low of 3% in southeast Utah to a high of 32% on the Bear River. April conditions were more favorable than March, but still saw above-average temperatures and below-average precipitation. April precipitation was 77% of average and ranged from 59% in the Uintas to 92% in the Weber basin. While many individual SNOTEL sites set new record lows, or early melt out dates, at the basin scale, only the southeast Utah drainages tied record low basin conditions for May 1st.

Wyoming snowpacks as of May 1 were below average in all basins, resulting in a statewide snowpack of 45% of average. Conditions were somewhat more favorable in northern basins, but still below average. April precipitation was much below average in most basins, with the exception of the Yellowstone and Madison basins in the northwest corner of the state, and near-average precipitation in the northeast. Low precipitation and warm temperatures resulted in more rapid snowmelt than is typical.

Snowpack Update, May 22nd: The rapid meltout of snowpacks around the region continued during May, with the mountain areas continuing to experience below-average precipitation except for some areas in north-central and south-central Colorado. By May 22, most SNOTEL sites around the region had experienced complete meltout, with nearly all of the remaining sites below 25% of average SWE for the date (Figure SP-2). Some of the sites which have melted out normally have more than 20" SWE remaining on May 22. A handful of sites in northwest and north-central Wyoming were reporting near-average SWE.

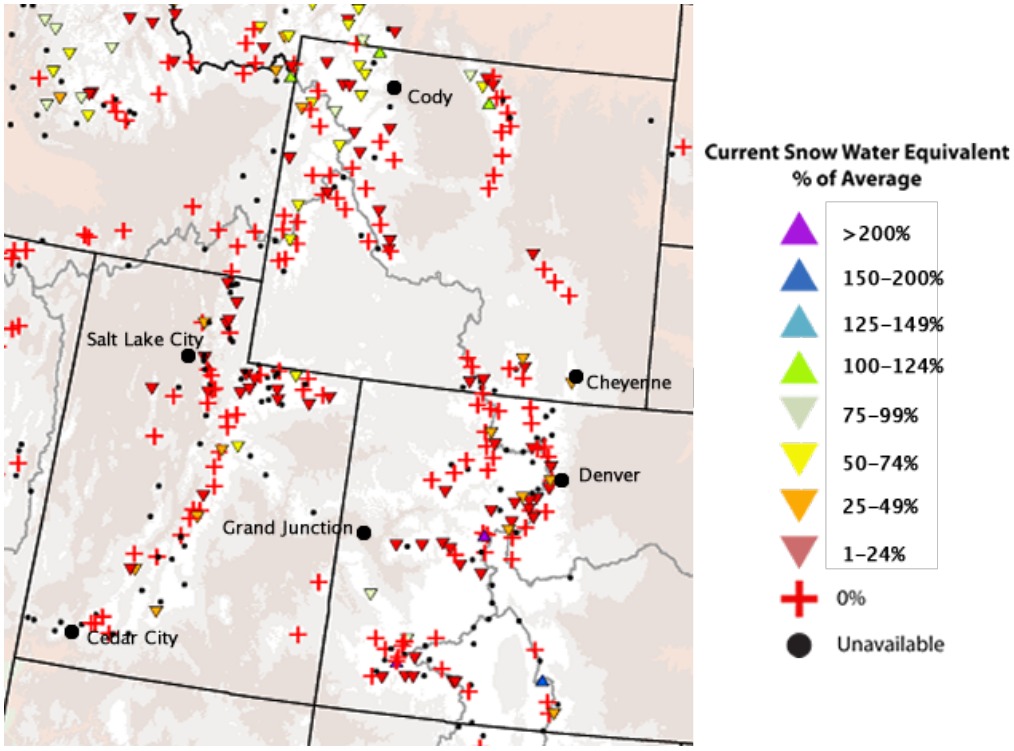

Figure SP-2. Current snow water equivalent (SWE) for individual SNOTEL sites as a percent of average as of May 22, 2012 (Source: Natural Resources Conservation Service).

Notes & Weblinks
(provides explanations of graphics and additional information sources)

RETURN TO TOP

Spring and Summer Streamflow Forecasts for the 2012 Runoff Season

The spring and summer streamflow forecasts issued on May 1 call for much-below-average runoff for most of the region. Runoff conditions are slightly more favorable, but still near average to below average in northwestern **Wyoming**. Forecasted runoff values declined steeply for most basins for the second consecutive month due to unfavorable weather conditions, and in many cases, early snowpack meltout. The projected April to July inflows to Lake Powell, for example, dropped from 44% of average in the April 1 forecast to 30% of average in the May 1 forecast (based on 1971-2000; see below).

Important note about "percent of average": The coordinated streamflow forecasts provided in the IWCS are taken from NRCS State Basin Outlook Reports and use the 1971Ð2000 period for calculating the percent of average, while the NOAA NWS Colorado Basin River Forecast Center (CBRFC) this year has switched to the 1981Ð2010 period for calculating the percent of average for the same coordinated forecasts. Since the 1970s were wetter than the 2000s, the NRCS baseline is generally higher than CBRFCÕs for a given gage, and thus the NRCS-reported % of average will generally be *lower* than the CBRFC-reported % of average for the same volume forecast. For example, the coordinated May 1 forecast for AprilÐJuly Lake Powell inflow is for 2360 KAF, which NRCS calculates as 30% of average (1971Ð2000), while CBRFC calculates it as 33% of average (1981Ð2010).

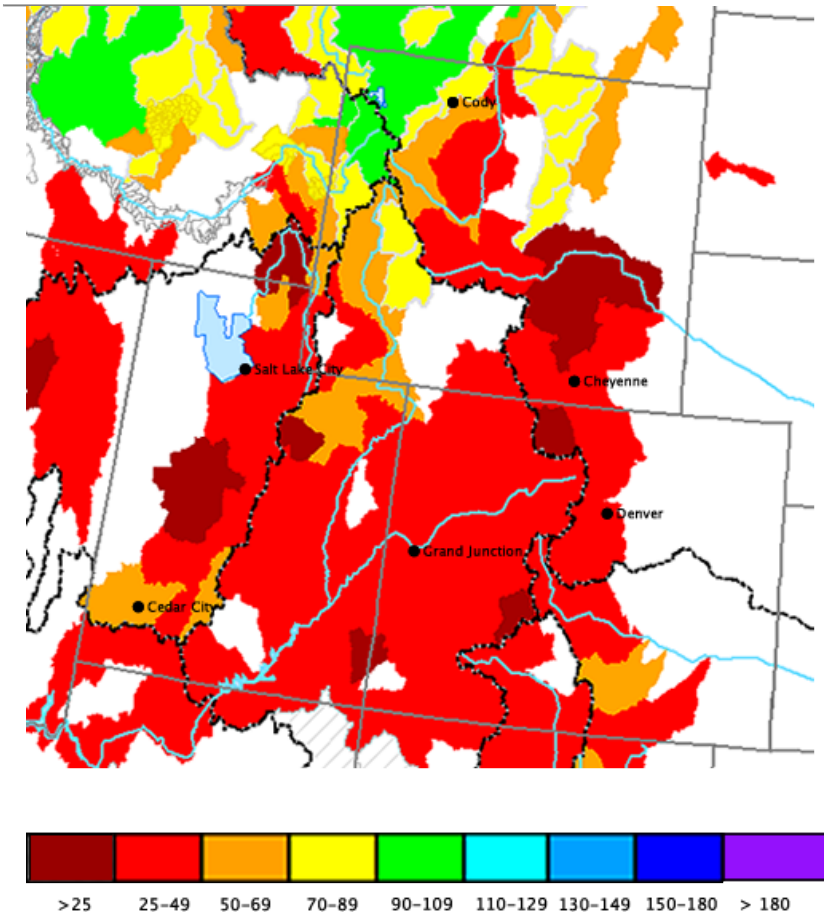

Figure STRM-1. NRCS outlook for natural streamflows for spring and summer in the Intermountain West region as a percent of average streamflows as of May 1, 2012. (Source: Natural Resource Conservation Service)

In **Colorado**, May 1 streamflow forecasts are for much-below-average runoff conditions throughout the state. Most forecasts fall in the range of 20% to 40% of average. The highest forecasts in the state are near 50% of average for the Upper Rio Grande. The lowest forecasts in the state are for 15% to 30% for much of northern Colorado. Forecasted runoff volumes decreased significantly in most areas from the March 1st and April 1st forecasts due to extremely poor March and April conditions. Runoff in some areas may approach record-low spring and summer volumes.

In **Utah**, May 1st streamflow forecasts are for much below average runoff conditions statewide. Most forecasts are in the range of 25% to 50% of average. Forecasts range from a high of 59% of average for the Lakefork in the Uinta Basin to a low of 11% for the White River in the Price Drainage. As in Colorado, most forecasts have decreased significantly since March 1st due to poor March and April conditions.

In **Wyoming**, May 1st streamflow forecasts are mostly below average, but considerably higher than Colorado and Utah. The statewide average forecasted flows dropped 13% from the April 1st forecast, to 62% of average. Runoff conditions are generally near to below average in the north and western regions of the state, and far drier to the south and east.

Projected Water-year Lake Powell inflows and Lees Ferry natural flows: In early May, the Bureau of Reclamation projected, based on the coordinated May 1 forecast for April-July inflows to Lake Powell (2.4 MAF), that the most-probable unregulated (non-naturalized) inflow to Powell for the 2012 water year is 5.7 MAF, 51% of average, with a range from 4.9 MAF to 6.5 MAF. Based on the relationship between unregulated and natural streamflows since 1999, this projection translates to a water-year natural flow at Lees Ferry of about 9.7 MAF, and a range from about 9.0 MAF to 10.9 MAF. (For comparison, the 2002 water year natural flow at Lees Ferry was only 6.2 MAF.)

Streamflow Update, May 21st: The well-below-average precipitation thus far in May in most of the regionÕs mountains means that total spring and summer runoff may be yet lower (if possible) than forecasted on May 1, and June 1 forecasts will likely reflect the continued dry conditions. Instantaneous streamflows on large streams around the region recorded on May 21st were generally "below normal" (10th-24th percentile) or "much below normal" (<10th percentile) at gages in **Utah** and **Colorado**, and generally "below normal" or "normal" (25th-75th

percentile) across gages in **Wyoming**. Daily inflows to Lake Powell since May 1 have varied between 5,000 and 17,000 cfs, roughly one-third to one-half the daily inflows during the same period last year.

[The majority of the text on this page comes from the NRCS State Basin Outlook Reports: http://www.wcc.nrcs.usda.gov/cgibin/bor.pl.]

Notes & Weblinks
(provides explanations of graphics and additional information sources)

RETURN TO TOP

Reservoir Supply

Reservoir storage throughout the Intermountain West is typically lowest at the beginning of May in preparation for inflows from spring runoff. But this year, with much-below-average runoff forecasted in most basins, many reservoir managers are trying to conserve as much storage of last year's above-average runoff as possible. Thus, the generally above-average storage conditions across the region as of May 1 (Figure RES-1) may actually decline, in percent of average terms, by the end of the runoff season. The very large reservoirs in the region, such as Lake Powell and Bear Lake, that saw a huge gain in storage last year, are likely to lose storage volume by the end of the water year.

	reservoir	current storage (af)	capacity (af)	% full	average	% of average
COLORADO	Dillon Reservoir	242,827	257,304	96%	212,800	114%
	Turquoise Lake	70,225	129,390	54%	70,665	99%
	Lake Granby	420,502	539,750	78%	296,104	142%
	Blue Mesa	532,109	829,500	64%	404,700	131%
	Pueblo	232,592	354,000	66%	163,500	142%
UTAH	Strawberry	993,300	1,106,500	90%	663,700	150%
	Utah Lake	866,600	870,900	102%	872,600	102%
	Bear Lake	1,187,300	1,302,000	91%	971,000	122%
	Lake Powell	15,507,966	24,322,000	64%	17,551,000	88%
WYOMING	Fontenelle	160,149	344,800	46%	143,500	112%
	Flaming Gorge	3,205,000	3,749,000	86%	2,952,000	109%
	Seminoe	826,472	1,017,273	81%	463,140	178%
	Boysen	627,548	741,594	85%	485,068	129%
	Buffalo Bill	480,648	644,126	75%	374,462	128%

Figure RES-1. All reservoir content data is from the end of April 2012. Percent of average ranges are color coded as follows: green: >80%; light green: 60Ð79%; yellow: 40Ð59%; orange: 20Ð39%; red: 0Ð19%.

CORRECTION: The values for "% full" in this table were incorrect when this issue of the IWCS was released on 5/24, but have been corrected as of 5/30. All other values were and are correct.

Notes & Weblinks
(provides explanations of graphics and additional information sources)

RETURN TO TOP

ENSO Status and Forecast

The NOAA Climate Prediction Center has announced that the La Ni–a of last fall through early spring has transitioned to ENSO-neutral conditions, with sea-surface temperatures (SSTs) having warmed to near average in the key regions of the tropical Pacific Ocean (Figures EN-1 and EN-2).

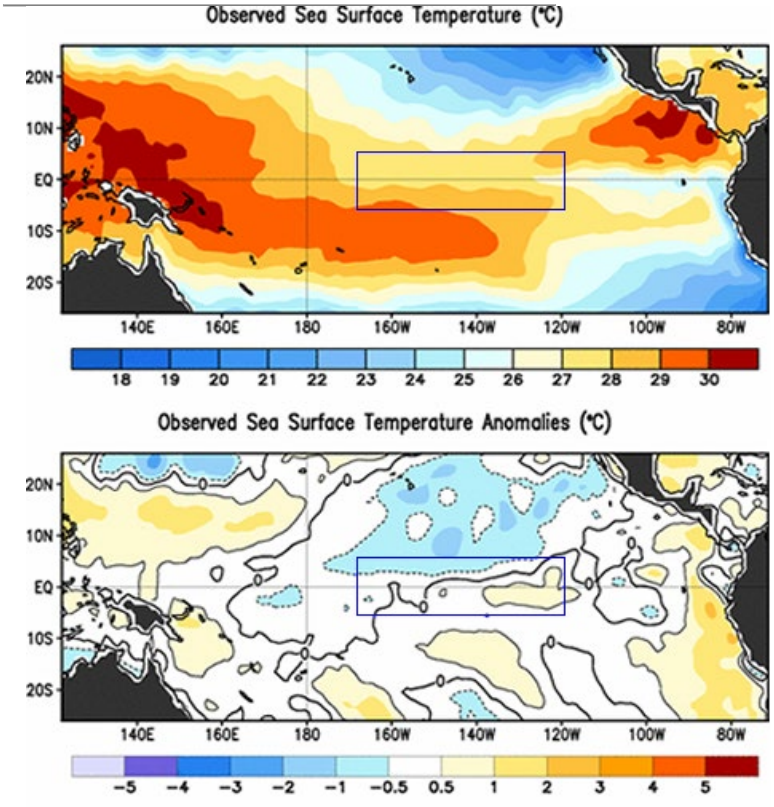

Figure EN-1. Observed SSTs (upper) and Observed SST anomalies (lower) in the Pacific Ocean. The Ni–o 3.4 region (blue rectangles) encompasses the area between 120iWÐ170iW and 5iNÐ5iS. The graphics represent the 7-day average centered on May 9, 2012. (Source: NOAA Climate Prediction Center)

Across a broad set of dynamical and statistical ENSO forecast models, nearly all models indicate a continuation of the warming trend in tropical eastern Pacific SSTs (Figure EN-2), with over half of the models indicate that the warming will reach the level for El Ni–o conditions (+0.5*i*C) by late summer or fall, and remainder indicating that ENSO-neutral conditions will still persist through fall. The vast majority of the dynamical models (average: thick yellow line) are forecasting El Ni–o conditions by fall, while none of the statistical models are calling El Ni–o (average: thick green-gray line).

The NOAA ENSO Diagnostic Discussion will be updated on the first Thursday of June 2012.

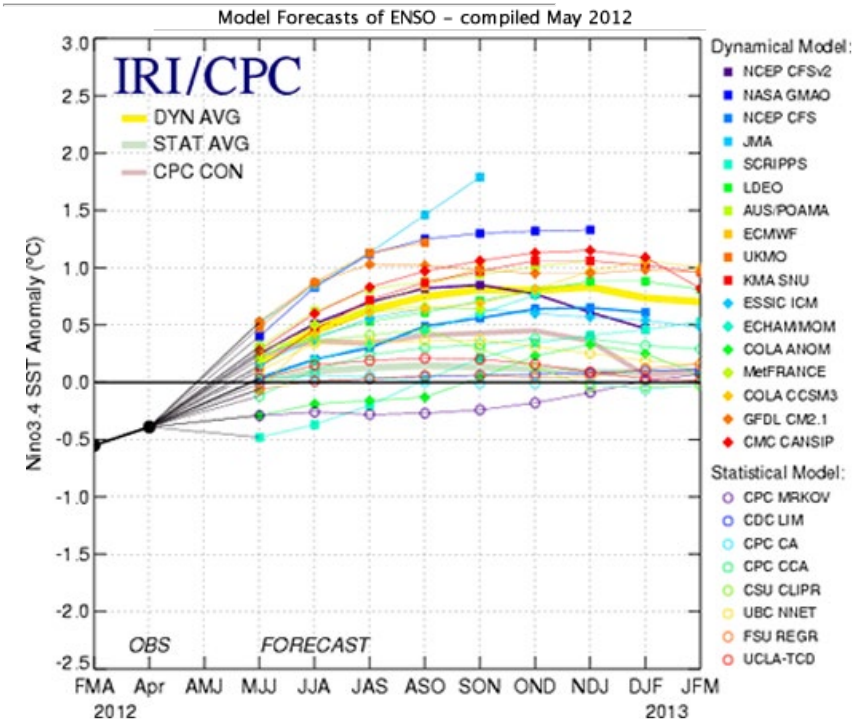

Figure EN-2. Forecasts made by dynamical and statistical models for sea surface temperatures (SST) in the Ni–o 3.4 region for nine overlapping 3-month periods from MayÐJuly 2012 to JanuaryÐMarch 2013 (released May 17, 2012). (Source: International Research Institute (IRI) for Climate and Society)

Notes & Weblinks
(provides explanations of graphics and additional information sources)

RETURN TO TOP

Temperature Outlook
June–October 2012 (Released May 17, 2012)

The latest temperature outlooks from the NOAA Climate Prediction Center indicate an enhanced chance of warmer-than-average temperatures for nearly all of the Intermountain region in June and subsequent seasons, with the greatest chance of warm temperatures in southern **Utah** and southern **Colorado** throughout this period (Figures TEMP-1 through TEMP-4).

Note: These climate outlooks are intended for use prior to the start of their valid period (in this case, prior to the beginning of June). Within any given valid period, observations and NWS short- and medium-range forecasts should be consulted. The June 2012 temperature forecast will be updated on May 31st on the CPC web page. This Òzero-leadÓ monthly update will incorporate information from the short range numerical weather prediction models and the latest monthly predictions from the Climate Forecast System models. The Seasonal Outlooks are updated on the third Thursday of the month, and the next one will be issued on June 21st.

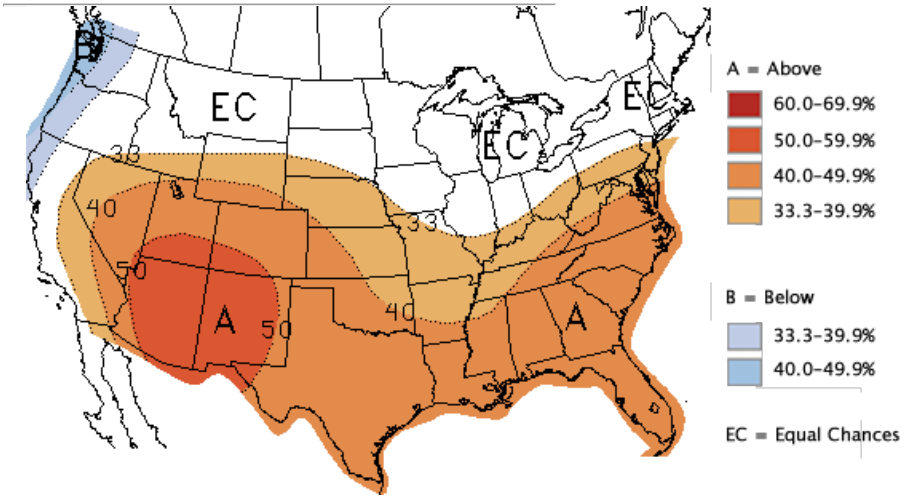

Figure TEMP-1. Long-lead national temperature forecast for June 2012. (Source: NOAA Climate Prediction Center)

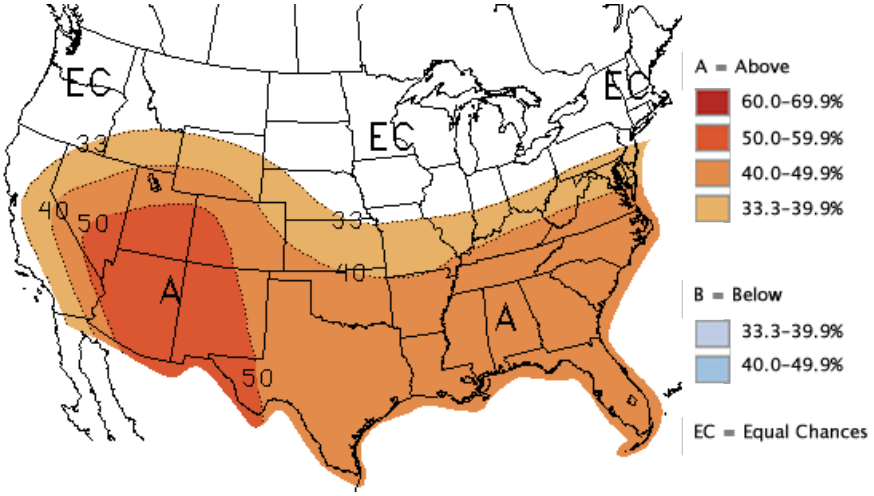

Figure TEMP-2. Long-lead national temperature forecast for JuneÐAugust 2012. (Source: NOAA Climate Prediction Center)

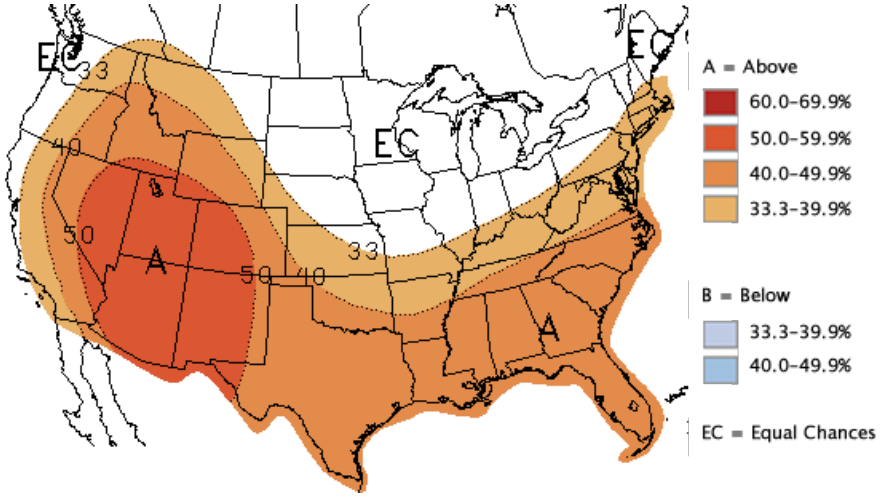

Figure TEMP-3. Long-lead national temperature forecast for JulyÐSeptember 2012. (Source: NOAA Climate Prediction Center)

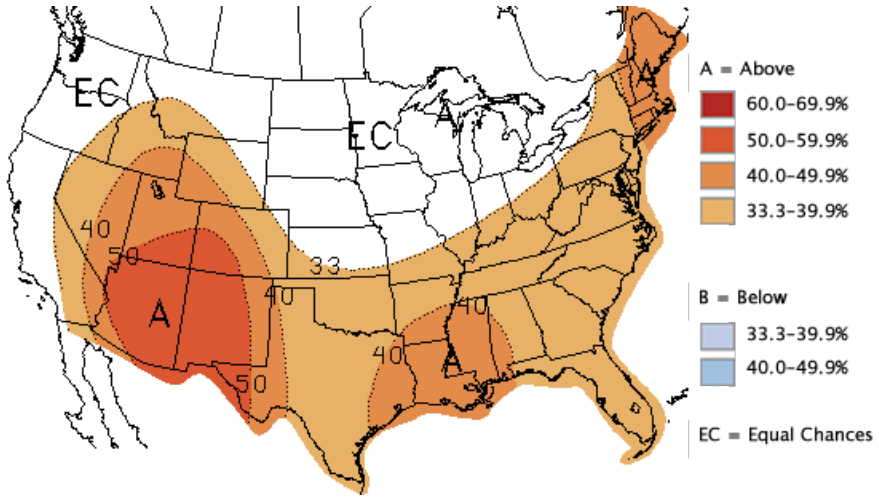

Figure TEMP-4. Long-lead national temperature forecast for AugustÐOctober 2012. (Source: NOAA Climate Prediction Center)

Notes & Weblinks

(provides explanations of graphics and additional information sources)

RETURN TO TOP

Precipitation Outlook
June–October 2012 (Released May 17, 2012)

The NOAA CPC precipitation outlook for June (Figure PPT-1) shows an area of enhanced chances of drier-than-average conditions extending into western Wyoming and northern Utah. For the JuneÐAugust and JulyÐ September seasons, this area is shifted to the north (Figure PPT-2 and PPT-3). For the AugustÐOctober season, all of the region has equal chances (ÒECÓ) for above- and below-average precipitation (Figure PPT-4).

Note: these climate outlooks are intended for use prior to the start of their valid period (in this case, prior to the beginning of June). Within any given valid period, observations and NWS short- and medium-range forecasts should be consulted. The June 2012 precipitation forecast will be updated on May 31st on the CPC web page. This Òzero-leadÓ monthly update will incorporate information from the short range numerical weather prediction models and the latest monthly predictions from the Climate Forecast System models. The Seasonal Outlooks are updated on the third Thursday of the month, and the next one will be issued on June 21st.

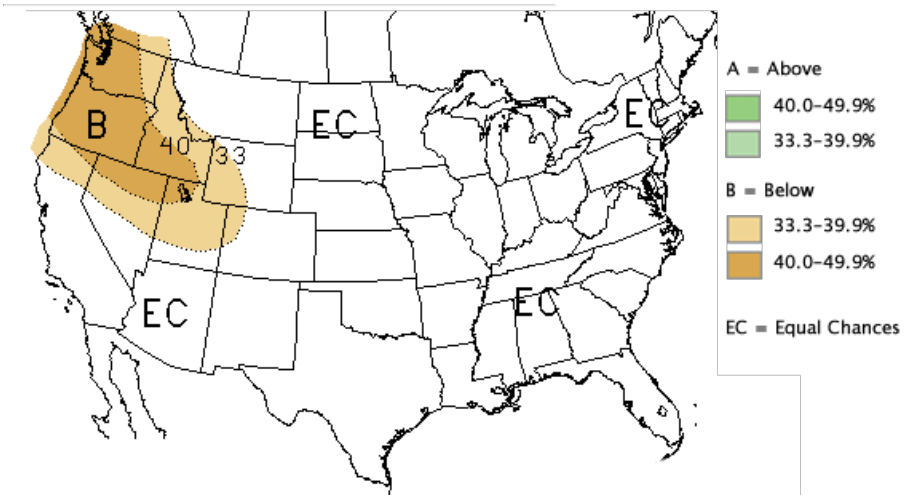

Figure PPT-1. Long-lead national precipitation forecast for June 2012. (Source: NOAA Climate Prediction Center)

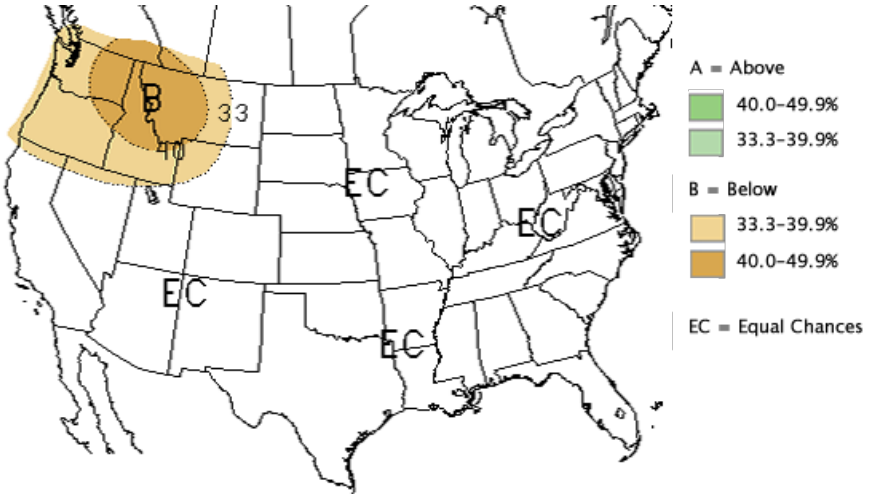

Figure PPT-2. Long-lead national precipitation forecast for JuneÐAugust 2012. (Source: NOAA Climate Prediction Center)

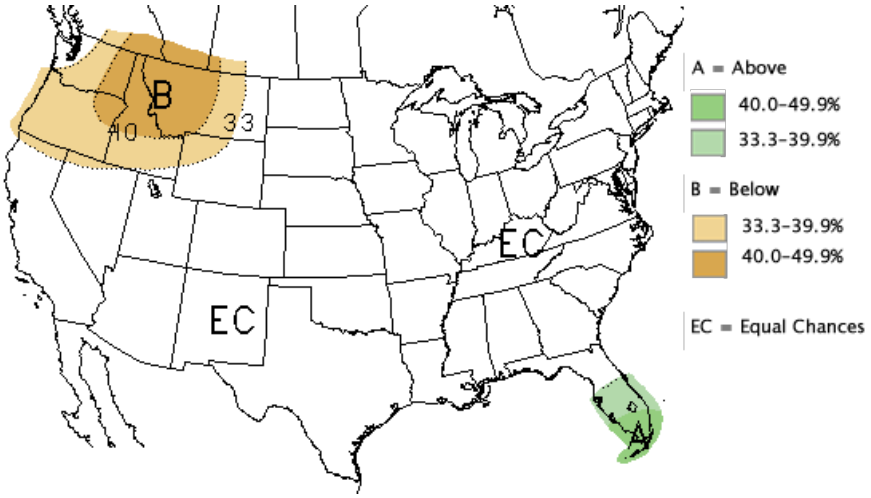

Figure PPT-3. Long-lead national precipitation forecast for JulyÐSeptember 2012. (Source: NOAA Climate Prediction Center)

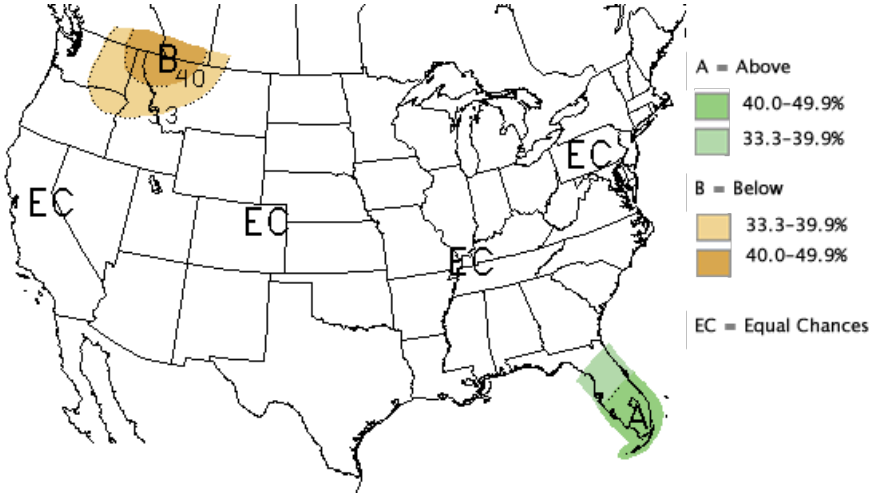

Figure PPT-4. Long-lead national precipitation forecast for AugustÐOctober 2012. (Source: NOAA Climate Prediction Center)

According to the experimental PSD Precipitation Forecast Guidance released in mid-May, there is a slight tilt ("-") towards dryness for the JulyÐSeptember period for northern **Utah**, a tilt towards wet conditions covering most of southern **Colorado**, and a slight tilt ("+") towards wetness in northeastern **Colorado** (Figure PPT-5). The outlook is neutral ("N") for eastern **Utah** (i.e., enhanced chances for the middle tercile of precipitation), more uncertain ("?"; enhanced chances of both the wet and dry terciles) in north-central **Colorado**, and equal chances of wet or dry conditions for the rest of **Colorado** and **Utah**.

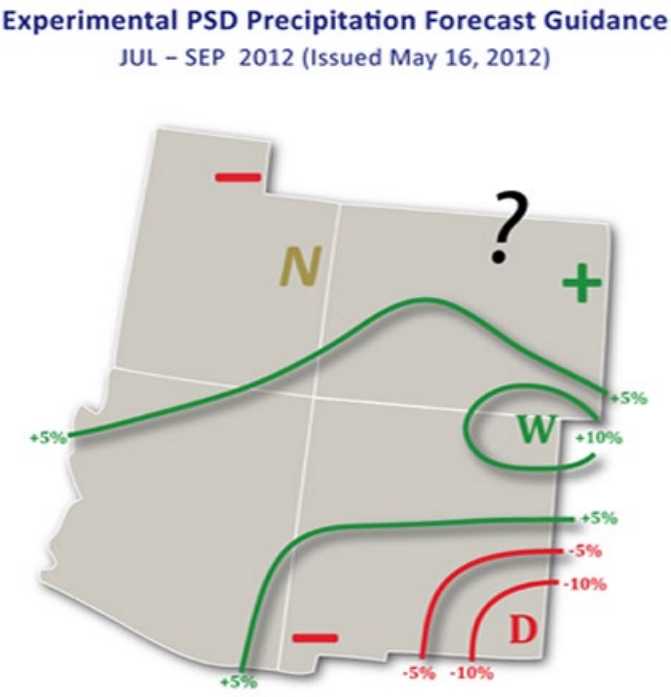

Figure PPT-5. Experimental precipitation forecast guidance. Forecasted shifts in tercile probabilities for JulyÐ September 2012. (Source: Klaus Wolter, NOAA ESRL Physical Science Division)

Notes & Weblinks

(provides explanations of graphics and additional information sources)

RETURN TO TOP

Seasonal Drought Outlook
through August 2012 (Released May 17, 2012)

The U.S. Seasonal Drought Outlook projects how drought areas categorized in the U.S. Drought Monitor might change and where new drought areas might develop. The areas in **Utah** and most of **Colorado** currently experiencing moderate to severe drought (D1 and D2) are projected to have drought conditions persist over the next three months (Figure DO-1). Drought conditions are also expected to develop in small areas of southwestern **Utah** and southwestern **Colorado** during that period.

Readers interested in the next 5 and 6Ð10 days can consult the ÒLooking AheadÓ section of each weekÕs Drought Monitor for near-term drought outlook conditions. The next Seasonal Drought Outlook will be issued June 1st.

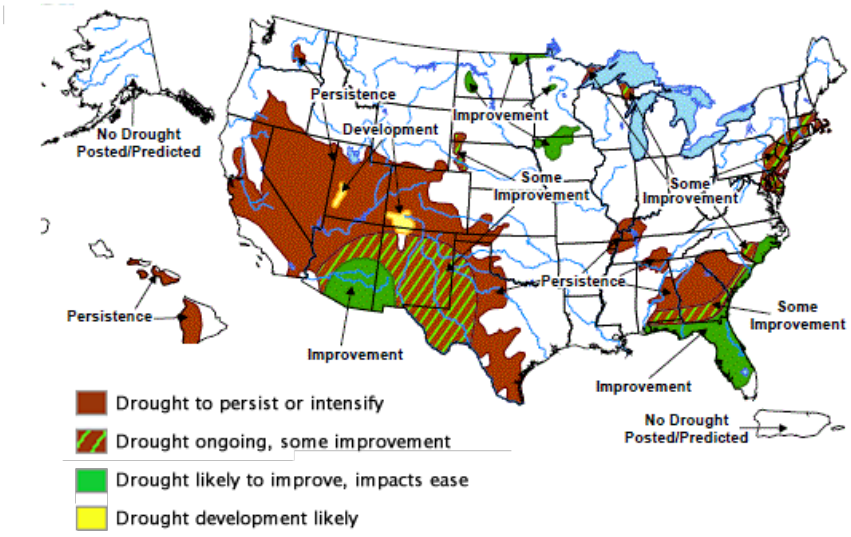

Figure DO-1. Seasonal Drought Outlook for May 17, 2012ÐAugust 2012. (Source: NOAA Climate Prediction Center)

Notes & Weblinks

(provides explanations of graphics and additional information sources)

RETURN TO TOP

The Intermountain West Climate Summary is published periodically by Western Water Assessment (WWA), a joint project of the UNiversity of Colorado Cooperative Institute for Research in Environmental Sciences (CIRES) and the National Oceanic and Atmospheric Administration (NOAA) Earth System Research Laboratory (ESRL) researching water, climate, and societal interaction.

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