Northern California Focal Resources & Scenario Planning Workshop

Climate Variable	Trend	Relative Change (by 2100)	Specific Projections (include region/state-wide)	Confidence & Uncertainty (trend direction, magnitude)	Source(s)
Air temperature	↑	High	**Northern CA** Annual temperature (historical temperature 8ºC to 9.3ºC) > By 2005-2034: +0.5ºC to +1.5ºC > By 2035-2064: +0.8ºC to +2.3ºC > By 2070-2099: +1.5ºC to +4.5ºC Summer temperature (historical temperature 17.9ºC to 21.5ºC) > By 2005-2034: +0.6ºC to +2.1ºC > By 2035-2064: +1.1ºC to +3.4ºC > By 2070-2099: +1.6ºC to +10ºC Winter temperature (historical temperature 0.08ºC to -0.46ºC) > By 2005-2034: +0.1ºC to +1.4ºC > By 2035-2064: +0.9ºC to +2.4ºC > By 2070-2099: +1.7ºC to +4ºC **Northern CA - Coastal vs. Inland** (by 2060-2069) Annual temperature: +1.9ºC coastal; +2.2ºC inland Summer temperature: +2.4ºC coastal; +2.9ºC inland Winter temperature: +1.5ºC coastal; +1.7ºC inland	Overall Confidence: HIGH High confidence in trend direction, medium-high confidence in magnitude, although ranges are very wide based on regional factors (e.g., coastal, inland, montane). Climate models and emissions scenarios also have wide projections, with a high-emissions scenario (A1F1) projecting increases twice that of a low-emissions scenario (B1).	Cayan et al. 2008; Hayhoe et al. 2004; Pierce et al. 2013; Thorne et al. 2015
Extreme heat events	↑	High	**California** (by 2070-2099) > +1.5ºC to +9ºC increase in extreme temperatures at the 50th and 95th percentiles > 12-30% of days annually will exceed the current 95th percentile **Northern CA** (by 2100) *Extreme high temperatures compared to historical temperature distribution*: > Days that exceed the 99.9th percentile occur 50-500 times more frequently > Daytime and nighttime heat waves increase, with the greatest increase in humid nighttime heat waves and in coastal areas *Extreme summer temperature compared to future temperature distribution (shifts with general warming trend)*: > Coastal heat waves increase, especially humid nighttime heat waves (due to less extreme warming expected in coastal areas) > No significant increase for inland heat waves	Overall Confidence: HIGH High confidence in trend direction, medium confidence in magnitude. Trends are heavily dependent on the temperature distribution being used; if it is historical temperatures, the frequency and magnitude of future heat waves will be extremely high. If compared to the changing future distribution, trends are less clear.	Cayan et al. 2008; Gershunov and Guirguis 2012; Hayhoe et al. 2004

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Precipitation (amount and timing)	↑↓	Low	**Northern CA** Annual precipitation (historical precip is 750-1,098 mm) > By 2005-2034: -0.4% to +7% > By 2035-2064: -3% to +3.4% > By 2070-2099: -30% to +18% Summer precipitation (historical precip is 14 mm): > By 2005-2034: -29% to +44% > By 2035-2064: -67% to +35% > By 2070-2099: -68% to -4% Winter precipitation (historical precip is 386-649 mm): > By 2005-2034: -5% to +13% > By 2035-2064: -5% to +6% > By 2070-2099: -9% to +4% **Klamath Basin** (by 2085) Annual precipitation: -9% to +2% by 2045, -11% to +24% Summer precipitation: -23% to -15% by 2045, -37% to -3% Winter precipitation: +1% to +10% by 2045, -5% to +27%	Overall Confidence: LOW Low confidence in trend and magnitude; the magnitude of changes are not expected to be large in most cases.	Cayan et al. 2008; Hayhoe et al. 2004; Koopman et al. 2009; Snyder et al. 2004
Drought	↑	Moderate	**California** (by 2100) > Drought years are twice as likely to occur over the next several decades > Increased risk of extensive multi-year drought due to increased probability of consecutive low-precipitation/high-temperature years > By 2030, dry years will coincide with very warm years ~100% of the time > 2012-2014 drought broke multiple records for the most severe drought year (2014) and lowest accumulated soil moisture; additional records were broken in coastal regions of the state > High temperatures have exacerbated the current drought, accounting for 8-27% of the drought during the 2012-2014 period and 5-18% of the 2014 drought year alone	Overall Confidence: MODERATE Moderate confidence in trend; low confidence in magnitude due to highly uncertain projections for precipitation. Drought metrics are inconsistent making comparison of records difficult, and experts disagree on the most accurate way to measure past and future drought (e.g., PDSI, SPEI, BCM characterization of water balance deficit).	Diffenbaugh et al. 2015; Griffin and Anchukaitis 2014; Williams et al. 2015

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Snowpack (amount)	↓	High	**Sacramento, San Joaquin, and Trinity River Drainages** Annual April 1 snow water equivalent (SWE): > By 2005-2034: -29% to +6% > By 2035-2064: -42% to +0.12% > By 2070-2099: -79% to -32% At 1,000-2000 m elevation: > By 2005-2034: -48% to -13% > By 2035-2064: -61% to -26% > By 2070-2099: -93% to -60% At 2,000-3,000 m elevation: > By 2005-2034: -33% to +12% > By 2035-2064: -36% to -8% > By 2070-2099: -79% to -25% At 3,000-4,000 m elevation: > By 2005-2034: -13% to +19% > By 2035-2064: -16% to -2% > By 2070-2099: -55% to -2% > Annual snowpack depth decreases by 2050 compared to the late 1800s: -73.1% in the North Coast region, -61.8% in the Sacramento Valley region > Snowfall still begins in November, but monthly mean depth decreases significantly for all months Nov to May (with the exception of Dec) > The largest monthly loss is in March for both regions, and snow accumulation ceases one month earlier	Overall Confidence: HIGH High confidence in trend and moderate confidence in magnitude of change; some high-elevation areas may see modest increases in snowpack in the first half of the century.	Cayan et al. 2008; Snyder et al. 2004; Thorne et al. 2015

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Timing of snowmelt/runoff	←	High	**Western US** > Observed 10-45 days earlier since 1948, corresponding to snow accumulation ceasing one month earlier > Future snowmelt is expected to continue to shift ~10-30 days earlier timing by 2100 > Temperature plays a greater role in determining the timing of snowmelt than precipitation > Earlier snowmelt is highly correlated with higher mean winter temperatures (DJF) **Northern CA** *Changes in the timing of the center of mass of annual flow (CT)*: > Snowmelt-dominated streams: 10-30 days earlier (0.3 to 1.7 days per decade) > Precipitation-dominated streams: 5-25 days later > No significant change in low-elevation coastal streams *Changes in fractional flow (i.e., percentage of annual flow)*: > April-July: +3% to -20% > March: +3% to +20% > June: +3% to -10%	Overall Confidence: MODERATE High confidence in trend direction; low confidence in magnitude of trend due to lack of downscaled projection data for snowmelt, very low confidence in precipitation projections, and the interaction of multiple contributing factors (e.g., temperature, precipitation, water source).	Barnett et al. 2008; Hamlet et al. 2007; Rauscher et al. 2008; Snyder et al. 2004; Stewart et al. 2005
Streamflow	↑↓	Moderate	**California** > Higher winter flows and lower late-spring/summer flows > Increased flow variability > Overall decrease in annual flow is suggested by some models > Observed decrease in 7-day low flows in some low-elevation coastal streams in northern California since 1948	Overall Confidence: LOW Low confidence in trend direction and magnitude. Projections largely depend on precipitation models, which are very uncertain. Additional interacting factors make projections of streamflow difficult, including temperature, evapotranspiration, soil moisture, snowpack, and timing of snowmelt. Spatial heterogenity (e.g., topography) and natural patterns of climate variability (e.g., PDO) also greatly influence streamflow.	Madej 2011; Pagano and Garen 2005; Vicuna and Dracup 2007; Vicuna et al. 2007

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Water temperature	↑	Moderate	**California** > By 2010-2099: ~ +1ºC to +3ºC increase in water temperature for the Sacramento River **Western US** > Observed temperature increases in rivers and streams since ~1950 **Global** Stream temperature is highly correlated with daily maximum air temperature: > +1.3ºC under air temperature of +2ºC > +2.6ºC under air temperature of +4ºC > +3.8ºC under air temperature of + 6ºC	Overall Confidence: MODERATE High confidence in trend, moderate confidence in magnitude; stream temperature increases linearly with air temperature, making it relatively easy to predict. However, low flow conditions and inputs from precipitation, snowmelt, and groundwater can alter stream temperature as well.	Cloern et al. 2011; Kaushal et al. 2010; van Vliet et al. 2011
Wildfire (frequency, severity, intensity)	↑	Moderate	**California** Increases in total area burne**d:**By 2020: +6% to +23% By 2050: +7% to +41% By 2085: +9% to +74**%** **Northern CA** (by 2085) > +100% to +>400% increase in area burned in northern CA > +11% to +22% increase in area burned in Klamath Basin > -50% decrease in area burned is possible in coastal areas	Overall Confidence: MODERATE High confidence in trend direction for northern CA (and other forested areas of the state). Low-Moderate confidence for magnitude of change, which is very dependent on emissions scenario, as well as other variables such as soil moisture/drought, insect outbreaks, management practices, and anthropogenic use (e.g., recreation).	Koopman et al. 2009; Lenihan et al. 2008; Westerling et al. 2011

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Sea level rise	↑	Low	**California** By 2020-2049: +8.7 cm to +12.7 cm By 2070-2099: +19.2 cm to 140 cm **Northern CA** Compared to 2000 sea levels: By 2030: -4 cm to +23 cm By 2050: -3 cm to +48 cm By 2100: +10 cm to +143 cm > SLR is projected to be less in northern CA due to uplift of land from shifting tectonic plates > An earthquake along the Cascadia fault line could lead to abrupt subsidence and a very large and sudden increase in relative sea level rise	Overall Confidence: MODERATE High confidence in trend direction; low-moderate confidence in magnitude. Tidal influences and geologic influences make regional projections of SLR difficult; land subsidence and uplift due to shifting tectonic plates may alter the magnitude of SLR. Historic tide gauges were compared to stationary gauges on land, which do not account for subsidence or uplift.	Cayan et al. 2009; Hayhoe et al. 2004; Kadir et al. 2013
Storms	↑	Moderate	**Northern CA** Extreme precipitation (during the period of 1961-1990, a total of 111 daily precipitation totals fell into the 99th percentile and 12 days fell into the 99.9 percentile): > By 2005-2034: 117-129 days in the 99th percentile (8-19 days in the 99.9th percentile) > By 2035-2064: 129-130 days in the 99th percentile (14-40 days in the 99.9th percentile) > By 2070-2099: 127-161 days in the 99th percentile (25-30 days in the 99.9th percentile) Coastal storms (defined as days with sea level pressure below 1005 mb): > By 2099: +0.57 days to -4.99 days > Possible increase in frequency, severity, and duration of high sea level, wave, and storm surge events > Possible increase in the frequency and severity of El Niño events > Possible increase in the severity and duration of atmospheric river events > North Pacific storm tracks may shift northwards	Overall Confidence: LOW Low confidence in both trend direction and magnitude. Models do not agree on likely changes in future storms, and studies draw varying conclusions which include both increases and decreases in storm frequency/severity. Large-scale atmospheric patterns (e.g., ENSO, atmospheric rivers), sea level rise, and precipitation play a large part in storm projections, and these are all uncertain for northern CA.	Cai et al. 2014; Cayan et al. 2008, 2009; Dettinger 2011; Neelin et al. 2013