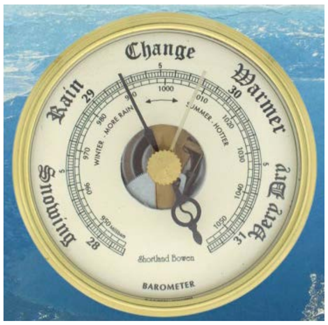
Climate Change Vulnerability Assessment

for the North Coast Integrated Regional Water Management Plan



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1 VUNERABILITY ASSESSMENT APPROACH

The assessment process used borrows from the ICLEI (2007) Climate Change Guide for Local Governments to provide managers with a clearer understanding of the combined relative sensitivity and adaptability North Coast sectors to potential future climate impacts. Detail and precision of this assessment is designed to match the information available as well as the likely resources available for these types of assessments (ICLEI 2007). Vulnerability is determined by considering a set of qualitative questions for which both quantitative and qualitative information may be available (sensitivity and adaptive capacity sections below). The questions considered incorporate current conditions and stressors as well as likely extent and magnitude of impacts in the region and closely reflect the concepts proposed for consideration in IRWM checklist (DWR 2011). Because many climate change impacts involve complex system responses to projected climate changes, detailed studies often involving numeric models of other systems (hydrologic, ecologic, vegetation, fire) which use climate projections as inputs are often used to determine and quantify impacts. These studies combined with regional climate projection data and region-specific information relevant to the sectors defined such as topography, land-use, crop values, water supply source, water quality issues, etc. formed the core of knowledge for identifying impacts and determining sensitivity and adaptive capacity which combine to specify vulnerability. Determinations of sensitivity, adaptive capacity, and vulnerability necessarily contain a degree of subjectivity based on the availability of relevant literature, understanding of cause and effect processes relating future climatic conditions to the current and future state of the systems involved. However, a relative scale from high to low along with a consistently applied process should provide reasonable scoring precision and accuracy. The steps taken to complete the vulnerability assessment are described briefly and in general terms in the sections below.

DEFINING SECTORS

A regional characterization had been created in the form of the Phase 1 IRMWP (NCIRWMP, 2007) which provides the physical and water resource context for defining sectors and assessing impacts to specific components of each sector. The IRWMP includes descriptions of the physical and biological characteristics, sensitive habitats and special designations, and current water management issues which were considered in the impact vulnerability assessment, some of which are reflected in Table 1.1 below.

Sectors are defined as groupings of physical or human systems that provide important services to the community and provide an effective organizational structure to evaluate specific impacts of expected climatic trends related to water resources. Systems are composed of the essential attributes, structures, networks, or regimes that define the status of the sector, how it changes over time, what drives those changes. Sectors have been defined in this assessment to readily align with resource management organization so that the information can be most efficiently integrated to planning processes or documents as necessary. Sectors used for this assessment are sometimes closely related or may feedback on one another. As defined in Table 1.1, they can be grouped into two basic types: Natural and Human/Built/Economic.

Table 1.1 Sector definitions

Sector Type	Sector	Definition
Natural	Forest	Forests are areas of the region with high densities of trees, which make up the largest type of land cover of the region by area. This sector includes consideration of the natural ecosystems that compose the forest environment.
	Rangeland	Rangelands are natural landscapes in the form of grasslands, shrublands, woodland, and wetlands, and in this context also include pasture lands (which grow plants established by humans). This sector includes consideration of the natural ecosystems that compose the different rangeland types.
	Riparian	The riparian zone or riparian area is the interface between land and a river or stream. They are important natural biofilters, protecting aquatic environments from excessive sedimentation, pollutants, and erosion and provide shelter for aquatic animals and they shade the stream which regulates water temperatures. This sector includes consideration of the ecosystems that compose the riparian zone, with special consideration to cold water fish species. Several of the streams and rivers throughout region are federally designated 'Wild and Scenic' rivers.
	Coastal	The coastal zone can be defined by the area of interaction of land and sea processes. This sector includes systems such as coastal lagoons, the intertidal zone, near shore currents, sea cliffs, and developed areas along the coast. It includes 21 critical coastal areas spread across the North Coast region.
Human/Built /Economic	Forestry	Forestry includes the management, use, and conservation of forest for human benefit. This sector includes natural resource management and economic activities related to the forest environment.
	Urban	Urban areas of the region are characterized by higher population and structure density and extensive impervious surface coverage. This sector includes consideration of impacts on property, infrastructure, and development.
	Fisheries	Fish harvesting from the ocean and rivers is an important economic activity on the region. This sector includes consideration how ecological impacts may affect the activities or economics of fish harvesting in the region.
	Water supply/demand	Water supply is physical and programmatic infrastructure that exists in the region to meet residential, industrial, and agricultural water demands. This sector includes consideration of impacts on water supply sources, storage, and conveyance; and changes in patterns of needs based on seasonal temperatures and land-use.
	Energy capacity/demand	Energy capacity refers to the amount of energy that power plants are able to generate to meet the needs of customers. This sector includes consideration of climate change impacts on energy sources such as hydropower and changes to overall demands and timing.
	Recreation	Abundant natural landscapes and waterways in the region provide excellent aquatic recreation opportunities. This sector includes consideration of how impacts may limit those opportunities for direct experience in the regions coastal ocean, rivers, and wetlands as well as appreciation of wildlife that depend on these resources.

CLIMATE CHANGE PROJECTIONS AND EMISSIONS SCENARIOS

Climate science and associated models have historically been focused on large spatial scales, but have been more recently been applied to estimating future climatic conditions and expected responses at regional scales. There are numerous widely-accepted global climate models, each with variations in the representation of the physical and chemical processes and interactions that drive climate patterns. Therefore, climate scientists often use multiple models to evaluate potential future climate patterns and trends, since there is a large amount of uncertainty in our ability to model complex and dynamic systems. In this assessment, projections of climate and hydrologic changes derive from a number of different sources that have been published in the scientific literature (cited in Table 2.1) and usually are the result of a using a suite of different climate models including the Parallel Climate Model (PCM) and the Geophysical Fluid Dynamics Laboratory (GDFL) Model. Climate projections have been regionally downscaled by independent studies to better represent future conditions in California and specific regions within the state including the North Coast using bias correction and special downscaling (BCSD) for a suite of several models and emissions scenarios made available by the California Energy Commission were downloaded for this assessment (available at www.caladapt.org) which are reported in Maurer et al., 2002.

All projections of future climate, hydrology, and sea level by global climate models are very sensitive to future carbon and/or greenhouse gas emissions scenarios, which produce a range of projected change. Emissions scenarios are plausible descriptions, without likelihoods, of the future states of the world and are used to estimate future greenhouse gas emissions. They vary based on assumptions about the nature of population growth and economic development in the future and the resultant estimated rates of fossil fuel and greenhouse gas (GHG) emissions. The two most commonly used emissions scenarios are the A2 and B1 scenarios, which provide a reasonable range of potential future emissions. A2 assumes a continued exponential increase in GHG emissions over the next 100-yrs, with some reduction relative to current rates. B1 assumes a significant global reduction in GHG emissions from industrialized and developing nations with the peak in global carbon emission reached in the middle of 21st century and then declining back to carbon emission rates of the 1970s. For the majority of references cited in this synthesis, the B1 and A2 emissions scenarios are used to bracket the high and low projections.

Climatic model outputs are expressed in summary metrics that represent an overall shift in certain climate variables over decadal time scales (e.g., mean annual precipitation), changes in spatial patterns (e.g., temperature gradients), or 'extreme event' changes (e.g., magnitude, frequency, and return intervals). Changes in climate elements are related to properties of their probability distributions, such as the mean and the variance, several of which are reported in Tables 2.1 and 2.2. Typically, estimation of hydrologic responses in the future results from coupling a hydrologic model with the GCMs which are reported in Table 2.2. Because climate model outputs have a range of uncertainty and agreement amongst individual studies, we provide a measure of confidence associated with each of the projections considered in Table 1.2. Figure 1 shows calculated degrees of change between the future projections and a historic reference period to illustrate changes in the region for a suite of climate models using the A2 and B1 scenarios.

Table 1.2. Climate change projections confidence ranking definitions

Confidence Ranking	Description
High	General agreement of modeling studies has created consensus in the scientific literature. Available information is directly relevant and applicable to local systems.
Moderate	Scientifically supported but consensus is not present due to lack of information, moderate differences between studies, or limitations for drawing general conclusions from limited scientific information. Accessibility or application of information to local systems may be somewhat limited.
Low	Limited information or conflicting results between studies, model outputs, or research findings. Accessibility or application of information to local systems is very limited.

IDENTIFYING IMPACTS

A series of expected climate change impacts by sector were identified using a breadth of available local and regional scientific literature in response to the projected climate and hydrologic changes in North Coast Region which are listed in Table 3.1. Impacts manifest as changes to the state, function, or structure of natural and human systems in the North Coast IRWM Region resulting from warming temperatures. Such changes have already been detected at global to local scales and are expected to continue (Moser et al., 2009). The expected impacts listed in Table 3.1 are not comprehensive, but instead focus on responses related to the health of watershed and aquatic systems in the North Coast IRWM Region for which there is a developed body of scientific information. Assessment of the relevance of a potential impact to the North Coast IRWM Region is done by searching the scientific literature for evidence of impacts that are applicable to the sectors and systems therein. Potential impacts are then either included or discarded based on their relevance to the region. Studies that provide evidence of impacts often use the same data sets that have been cited in the reporting of climate change projections in Table 3.1. Whenever possible, supporting information has been collated specific to the North Coast IRWM Region, and in other cases inference is drawn from anticipated impacts throughout the state and for neighboring regions. Figures 2-4 illustrate three key impacts on the region: wildfire regime shifts, sea level rise, and snowpack reduction.

SENSITIVITY

For each impact identified, the sensitivity was determined with an examination of the scientific literature, climate change projection data, and other information that provided evidence of the impact either in California or within the North Coast IRWM Region. Sensitivity is the degree to which system components within each sector (e.g., wildfire regimes, salmonid populations, or stormwater conveyance) respond to climate conditions (e.g., temperature and precipitation) or system impacts (e.g., stream temperature increases or snowmelt timing changes). If the system or system component is likely to be significantly affected by future climatic conditions then it is considered sensitive. Table 1.3 presents the definitions of the relative sensitivity scale. Factors considered when determining the relative degree of sensitivity include:

- What is the degree of exposure of the impact to climate change? For example, coastal areas are more exposed to sea level rise related impacts compared to inland areas.

- Would the existing stressors in the system and whether future climatic conditions would exacerbate these stressors? For example, the degree of urban encroachment on forests may be a stressor that promotes greater frequency of wildfire ignitions.
- Is the existing balance of resource demand and supply such that climate may increase demand and/or reduce supply?

Table 1.3. Scoring definitions for sensitivity to climate change impacts.

Sensitivity	Definition
High	System components are expected to respond measurably to an impact based on historical observations or modeling studies.
Moderate	The response of system components to an impact has not necessarily been measured, but based on our understanding system function there are likely to be direct or indirect responses.
Low	System components do not respond measurably to impacts and based on understanding of system function there are not likely to be direct or indirect responses.

ADAPTIVE CAPACITY

For each impact identified, the adaptive capacity was determined with an examination of the scientific literature, climate change projection data, and other information that provided evidence of the impact either in California or within the North Coast IRWM Region. Adaptive capacity is the inherent natural ability of a system or system component to accommodate an impact that results from projected climate or hydrologic changes. For natural systems, we assess the intrinsic ability of system components to adapt without any human intervention such as policy or management action changes. For assessment of human/built/economic systems, adaptive capacity assessment may include consideration of the timeframe and level of effort or cost associated with management actions to increase resiliency to a climate change impact. In determining how adaptive a system is to climate change the following questions are considered:

- What are current level of stressors and flexibility to respond to future stressors? Can or has the system adapted to historic climatic changes or inclement conditions?
- Are there limiting factors that restrict the system's ability to adapt? For example, sub-alpine species' ability to adjust to future climate can be limited by elevation if they currently exist at the top of the existing elevations.
- Are there any barriers to the system's abilities to accommodate adjustments (legal, physical, biological) in response to future climate?
- How do timescales of adaptation rate compare to the rate of climate changes?
- Are there efforts currently underway that would increase adaptability form human/built/economic sectors?

Table 1.4. Scoring definitions for adaptive capacity to climate change impacts.

Adaptability	Definition
High	System components are expected to accommodate climate changes and expected impacts in ways that avoid negative consequences.
Moderate	The system has some capacity to adjust, and the degree of negative consequences will depend on the magnitude of individual and cumulative impacts.
Low	The system has little or no capacity to accommodate expected impacts so that negative impacts cannot be avoided.

VULNERABILITY

Vulnerability is the susceptibility of a system component to harmful impacts due to climate change. The vulnerability of systems to specific climate change impacts is determined by combining sensitivity and adaptive capacity scores in the manner outlined in Table 1.5. System components that have high sensitivity to climate changes and a low capacity to adapt are considered to be highly vulnerable to climate change impacts. As sensitivity decreases the weighting of the adaptive capability is preserved, such that even a system component that is considered not sensitive to climate change but has a low ability to adapt is considered moderately vulnerable. The column labeled 'Vulnerability Comments' in Table 3.1 briefly describes elements of sensitivity and adaptive capacity that lead to the vulnerability determination such as exposure to the impact, existing stressors, observed or modeled responses and barriers to adaptation.

Table 1.5. Vulnerability ranking matrix

		Sensitivity		
		High	Moderate	Low
Adaptive Capacity	High	Moderate	Low	Low
	Moderate	High	Moderate	Low
	Low	High	High	Moderate

Our confidence in the vulnerability scores is limited by the available science and body of information used to score sensitivity and adaptive capacity. It must be noted that these determinations for both sensitivity and adaptive capacity are somewhat subjective and depend upon the perspective and information considered. Therefore, our confidence in the vulnerability of each impact is also provided to put bounds on the strength of the conclusions as defined in Table 1.6.

Table 1.6. Vulnerability confidence scoring definitions

Confidence Ranking	Description
High	General scientific agreement of conclusion that is supported by a number of monitoring data, modeling results, research, or best available scientific information. Available information is directly relevant and applicable to local systems.
Moderate	Scientifically supported but consensus or agreement is not present due to lack of information, moderate differences between studies, or limitations for drawing general conclusions from limited scientific information. Accessibility or application of information to local systems may be somewhat limited.
Low	Limited information or conflicting results between studies, model outputs, expert opinions, and/or research findings. Accessibility or application of information to local systems is very limited.

2 REGIONAL CLIMATE AND HYDROLOGIC CHANGE PROJECTIONS

Table 2.1. Projected changes for selected climate variables. Projected changes in climate and hydrologic variables are presented in Tables 2.1 and 2.2 below, respectively, along with a relative confidence rank, supporting evidence, and descriptions of seasonal and spatial patterns as applicable.

Climate Variable (30 yr. intervals)	Projected change by 2100	Confidence Ranking	Supporting evidence	Seasonal and Spatial Patterns
Annual average maximum air temperature* (AMT)	Expected to increase 1-4°C in the winter (Jan –Mar) and 1.5 -6°C in the summer (Jul –Sep) above a historic reference period (1971-2000)	High	North Coast model projections are in agreement and are consistent with statewide projections (Cayan et al., 2009, data downloaded from Caladapt April, 2013).	Warming is relatively moderate near the coast and greater for the inland portions of the region. Statewide projections indicate longer summers with increases of 1.5-6°C. Winter temperature increases are projected to be slightly lower at 1-4°C (Cayan et al., 2009). Onset of typically summer temperatures will occur earlier in the year (Flint and Flint 2012).
Air temperature variability (ATV)	Expected 20-30% larger standard deviation than a historic reference period (1971-2000)	High	North Coast model projections are in agreement (Caladapt 2011) and are consistent with statewide projections (Cayan et al., 2009, data downloaded from Caladapt April, 2013).	Increases are projected in the frequency, magnitude and duration of heat waves (temperature that exceeds 95th percentile of region's historic record). Typically heat waves occur in July and August, but as temperatures increase over time, heat waves are expected to occur in fall and spring months with greater frequency (Cayan et al., 2009).
Annual Precipitation totals (APT)	Direction of change undetermined	Low	Climate models disagree on the directional impact of climate change on precipitation (Caladapt 2011). PCM climate models generally suggest higher annual precipitation while GFCL models indicate less rainfall, with disagreement on which months are responsible for annual precipitation increases (Cayan et al., 2009; Thorne et al. 2012). Higher temperatures will result in more precipitation delivered at rain rather than snow (Hayhoe et al., 2004; Knowles et al., 2006)	Total annual precipitation changes cannot be determined; however, both models project less precipitation in the fall and spring, meaning a majority of the precipitation will be delivered over a shortened winter season (Cayan et al., 2009; Thorne et al., 2012). Summers are predicted to be longer and drier and peak annual precipitation appears to shift from January to February (Flint and Flint 2012). Higher elevations will receive a greater proportion of precipitation as rain rather than snow compared to present conditions (Hayhoe et al., 2004; Knowles et al., 2006)
Precipitation variability (PV)	Direction of change undetermined	Low	Climate models disagree on the direction of change. Models indicate a high degree of inter seasonal variability, not significantly different than historical record and without a consistent trend for the next 100 years.	Models agree the wet season where the predominant amount of rainfall occurs will be shortened. Some models indicate a decrease in the annual storm count but an increase with the amount of precipitation delivered per event (Cayan et al. 2009). A case study of climate change simulation in the Russian River Valley verified projections of an increase in the number of storms with above average rainfall (Flint and Flint 2012).

Climate Variable (30 yr. intervals)	Projected change by 2100	Confidence Ranking	Supporting evidence	Seasonal and Spatial Patterns
Sea level (SL)	Expected to rise 1-1.4m above a historic reference period (1971-2000)	High	Climate models agree sea levels will rise with an increase in temperature (Laird 2013; Caladapt 2011 - data downloaded from Caladapt April 2013 with contributing SLR data from Pacific Institute 2012 and USGS 2012).	The highest increase of SLR in California is predicted at 4.73 mm/year at Humboldt Bay (Russell and Griggs, 2012).Coastal communities, estuaries, wetlands and all other low lying areas adjacent to the ocean and streams are will be affected. Humboldt, Arcata and Eureka Bays are all examples low lying coastal areas vulnerable to SLR (Laird 2013). Times of extreme high tides, winter storm events and large ocean swells will exacerbate sea level rise impacts on these low lying areas (Cayan et al., 2009; Laird 2013).

* Annual high temperatures for the period of 1961-1990 were compared to predicted temperatures for the period of 2070-2099 to calculate degrees of change.

Table 2.2. Projected changes for selected hydrologic variables

Hydrologic Variable (30 yr. intervals)	Projected change by 2100	Confidence Ranking	Supporting evidence	Seasonal and Spatial Patterns
Droughts (D)	Approximately 50% increase in frequency of occurrence	High	Models agree in that precipitation will demonstrate a high degree of variability and drying trend is anticipated mid-century resulting in vulnerability to drought (Cayan et al., 2012).	In 90 years of historic tracking in the Russian River Valley in Sonoma County, 5 droughts occurred. Future projections indicate an increase in frequency of drought; GFDL-A2 models simulate 6 droughts in the next 70 years followed by a multi-decadal drought at the end of the 21st century. PCM-A2 models suggest 8 droughts over the next 90 years (Flint and Flint 2012).
Groundwater recharge (GWR)	Decrease (6-140 mm) below historic reference period of 1971-2000	High	Statewide models agree that there will be a decrease in groundwater recharge, despite predictions in an increase or decrease in future runoff (Thorne et al., 2012).	Shorter wet seasons and earlier onset of snowmelt coupled with longer drier summers and increased PET will produce unfavorable conditions for recharge. The largest recharge reductions are expected in Del Norte and Humboldt county areas (Thorne et al., 2012) and peak recharge shifts from January to February with the largest recharge decrease anticipated to occur in the fall (Flint and Flint 2012).
Potential evapotranspiration (PET)	Increase (25-70 mm) above historic reference period of 1971-2000	High	Warming average temperatures suggest increases in annual PET. Statewide agree in the increasing change of direction in PET (Thorne et al., 2012).	The largest changes are projected during summer months (Thorne et al., 2012).

Hydrologic Variable (30 yr. intervals)	Projected change by 2100	Confidence Ranking	Supporting evidence	Seasonal and Spatial Patterns
Annual runoff (AR)	Undetermined	Low	PCM models predict and increase in precipitation and GFDL model forecast a drying trend. Runoff predictions are tied to conflicting precipitation models; as a result, PCM models predict a large increase in runoff volumes in the North Coast region while GFDL predict a decrease (Thorne et al., 2012).	Peak runoff has traditionally been observed during snowmelt, typically between April – July in California. As temperatures increase and snowmelt and peak streamflow will shift to earlier months (Thorne et al., 2012). Changes in precipitation patterns will lead to a greater proportion of runoff during winter months and less during the rest of the year (Cayan et al., 2009; Thorne et al., 2012).
Runoff variability (RV)	Increase	Low	Simulations of Maacama Creek and Russian River within Sonoma County project high flows under GFDL-A2 models to be lower than historical flows. PCM-A2 models predict the lower flows to be similar to slightly higher than historical conditions, whereas the top 10% of flows far exceed the historical period (Flint and Flint 2012).	Some Mendocino, Trinity and Humboldt county watersheds show increases from 0.6-10 standard deviation above the historic period indicating increased variability under the PCM-B1 model, but no change or reductions under GDFL-A2 and GDFL B1 (Thorne et al., 2012).
Snow Pack (SP)	Decrease	High	California climate models project as temperatures warm snow accumulation persistence and volume will decrease. Models and emission scenarios predict reductions of 25-90% of snow water equivalent (SWE) in the Sierras by the end of the twenty first century (Hayhoe et. al, 2004). Increased mean temperatures predicted in January – March will impact precipitation as snow deposition will transition to rainfall (Knowles et. al, 2006).	Reductions in snowpack are predicted to be most pronounced at elevations less than 3000 m where 80% of snowpack storage occurs (Hayhoe et. al, 2004). Snowpack will be affected in the Siskiyou, Humboldt, Modoc, Trinity, and Mendocino counties with an estimated decline of water stored as snowpack of 20 -70% by the end of the century (Caladapt 2011). Increased precipitation as rain versus snow paired with warmer temperatures from April to June will shift peak snowmelt to earlier in the season (Knowles et. al, 2006).
Flooding (F)	Increase	Low	Projected changes in mean air temperature suggested by climate models will impact the fraction of precipitation falling as rain versus snow (Knowles et. al, 2006). Climate models suggest the precipitation season will be shorter and events will be more intense (Flint and Flint 2012). Winter rain storms on snow can accelerate snowmelt and increase the risk of flooding (Knowles et. al, 2006). Additionally, SLR is predicted to be driver for flooding as large winter storms will bring heightened tides, freshwater runoff from the upstream watershed and low lying coastal areas will be vulnerable to floods (Cayan et al., 2008).	While some uncertainty among precipitation model projections exists, there is agreement that precipitation events are expected to occur over a shortened period in December and January (Flint and Flint 2012). The largest risk of flooding coincides in the winter or early spring when rain on snow events could occur (Knowles et. al, 2006). In the North Coast Region, low lying coastal areas such as sloughs, wetland and surrounding Bay areas are at risk for flooding (Laird 2013).

3 REGIONAL VULNERABILITY ASSESSMENT

Table 3.1. Climate change impacts vulnerability assessment

Sector	Climate/ Hydrologic Change Drivers	Expected Impacts	Impacts Supporting Evidence	Sensitivity	Adaptive Capacity	Vulnerability	Vulnerability Confidence	Comments
Forest	AMT ATV PV D PET	Increased wildfire frequency, extent, and intensity	Fried et al. 2004 FRAP, 2010; Flannigan et al., 2000 Westerling et al. 2006 Westerling and Bryant , 2008 Lenihan et al., 2008	High	Moderate	High	High	Forests are extensive throughout the region indicating high exposure to this impact. Current stressors include encroachment at the urban – wildland interface. Forests will adapt to shifting wildfire regimes over the long term but may not do so quickly enough to avoid harm ecosystems.
		Shift from conifer dominance to mixed evergreen hardwood species	FRAP, 2010 Lenihan et al., 2006 PRBO, 2011 Lenihan et al., 2008 Barr et al. 2010	High	Low	High	High	The majority of forests in the North Coast region are conifer dominated, indicating high exposure. Modeling studies generally show that forest composition will shift to mixed evergreen hardwoods rather than adaptation of the conifers indicating low adaptive capacity to this impact.
		Shift in forest species ranges towards higher elevations, loss of subalpine habitat	Lenihan et al., 2006 PRBO, 2011	Moderate	Low	High	High	Primarily mountainous portions of the region will be affected. Habitat fragmentation may limit adaptation in some areas as will the highest elevations that occur in the region. This impact may affect several rare, threatened, or endangered species that live in the region's forests.
		Increased tree mortality due to combined effects to insects, disease and drought	Hansen and Weltzin, 2000 Shugart, 2003 Barr et al., 2010	High	Moderate	High	High	Forests are extensive throughout the region indicating high exposure. Forests will adapt to changes over the long term but may not do so quickly enough to avoid harm to ecosystems.

Sector	Climate/ Hydrologic Change Drivers	Expected Impacts	Impacts Supporting Evidence	Sensitivity	Adaptive Capacity	Vulnerability	Vulnerability Confidence	Comments
		Reduction of coastal redwood forest habitat	Flint and Flint, 2012	High	Low	High	Moderate	Large portions of the region provide redwood habitat that exists in a very narrow zone of climate tolerance indicating high exposure. Simulation studies indicate dramatic contractions in the geographic envelope that will support redwood forest in simulation studies indicating low adaptive capacity. Severity of the reduction in suitable habitat is dependent on CO2 emissions scenario, which adds uncertainty to this impact.
		Vegetation production increases and timing changes	FRAP, 2010 Shugart, 2003 Hansen and Weltzin, 2000	Moderate	Moderate	Moderate	Low	Forests are extensive throughout the region indicating high exposure. Complex interactions of enhanced CO2, temperature increases, and hydrologic changes contribute to uncertainty of changes.
Rangeland	AMT ATV PV D PET	Conversion of scrublands and woodland to grasslands	FRAP, 2010 Pierson et al., 2008	Moderate	Moderate	Moderate	Low	Scrublands and woodlands are a smaller portion of the region compared to forests indicating moderate exposure. Modeling studies indicate conversion may occur in some areas rather than adaptation. Limited information and contributes to low confidence for this impact. Complex interactions of enhanced CO_2, temperature increases, and hydrologic changes contribute to uncertainty of changes.
		Increased stress on drought intolerant plant species and inundation by invasive grasses	Cayan et al., 2006 Thorne, et al., 2012a	Moderate	Moderate	Moderate	Moderate	Drought tolerant invasive species will have a competitive advantage during summer months in the future. No specific modeling evidence for the region was identified but this impact is directly tied to future temperatures contributing to moderate confidence. Complex interactions of enhanced CO_2, temperature increases, and hydrologic changes contribute to uncertainty of changes.
		Vegetation production increases and timing changes	FRAP, 2010 Shaw et al., 2009 Chaplin- Kramer, 2012 Cornwall et al., 2012 Ekstrom and Moser, 2012	Moderate	Moderate	Moderate	Low	Rangelands are a smaller portion of the region compared to forests indicating moderate exposure. Complex interactions of enhanced CO_2, temperature increases, and hydrologic changes contribute to uncertainty of changes.

Sector	Climate/ Hydrologic Change Drivers	Expected Impacts	Impacts Supporting Evidence	Sensitivity	Adaptive Capacity	Vulnerability	Vulnerability Confidence	Comments
Riparian	AMT ATV D RV SP GWR	Reduced aquatic habitat extent and quality with reduced summer base flows, stream temperature increases, and increased pollutant concentrations.	Moyle et al., 2012a Moyle et al., 2012b Ekstrom and Moser, 2012 PRBO, 2011 NMFS, 2012 Medellín-Azuara et al., 2008 Barr et al., 2010 NCIRWMP, 2007	High	Low	High	High	The North Coast region has the highest amount of high priority riparian zones in the state: locations where high value water supply coincides with other threats which are areas that should be prioritized for restoration. Riparian areas provide habitat for several rare, threatened, or endangered species. Smith River and tributaries, Klamath River and tributaries, Scott River, Salmon River, Trinity River, Eel River, and Van Duzen River are all federally designated Wild and Scenic Rivers. These factors indicate high exposure. Surplus moisture delivered in winter is not expected to provide a sufficient buffer to avoid summer low flow reductions indicating low adaptive capacity. Water bodies that drain approximately fifty-nine percent of the area in the North Coast Region are listed as impaired due to sediment under Section 303(d) of the Clean Water Act.
	AMT ATV	Increased thermal stress on cold water fish, amphibian, and invertebrate species and a shift in thermal spawning conditions to earlier in the year	Porinchu et al., 2010 Melack et al., 1997 Parker et al., 2008 PRBO, 2011 Barr et al., 2010 NCIRWMP, 2007	High	Low	High	High	Salmonids live within a narrow water temperature range directly correlated to air temperatures, outside of which survival is affected. Current stressors include riparian degradation with loss of shade cover and reduced baseflow which will limit adaptive capacity in the future. Several rare, threatened and endangered species may be negatively impacted such as the Northern Red Legged Frog.
	RV F	Increased landslides and sediment loading to streams following wildfires and high intensity rainfall events	FRAP, 2010 NCIRWMP, 2007	High	Low	High	Moderate	Large proportions of the region's watersheds are forested and thus exposed to this impact that results from wildfire regime shifts. Some of the most sensitive beneficial uses are currently impacted by sediment. Those uses are associated with the migration, spawning, reproduction, and early development of coldwater fish such as coho salmon and steelhead trout. Uncertainty in rainfall projections contributes to lack reduced confidence in this impact.

Sector	Climate/ Hydrologic Change Drivers	Expected Impacts	Impacts Supporting Evidence	Sensitivity	Adaptive Capacity	Vulnerability	Vulnerability Confidence	Comments
	AMT ATV D RV SP GWR	Decreased native fish habitat distribution and population declines	Knapp et al., 2001, Pope et al., 2009 Moyle et al., 2012a Moyle et al., 2012b Ekstrom and Moser, 2012 NCIRWMP, 2007	High	Low	High	Moderate	Populations of these fish currently are low and habitat conditions generally are poor; these circumstances are likely to deteriorate further with projected climate change. Coho salmon have experienced a significant decline in the past 40 to 50 years. Coho salmon abundance, including hatchery stocks, has declined at least 70% since the 1960s, and is currently 6 to 15% of its abundance during the 1940s. Current stressors include riparian degradation, sediment delivery from logging roads, dams and other hydro modifications. These stressors can affect the migration, spawning, reproduction, and early development of coldwater fish such as coho salmon and steelhead trout. Dependence of salmonids populations on ocean dynamics adds to uncertainty to this impact.
Coastal	SL	Increased coastal erosion	Cayan et al., 2008a Cayan, et al., 2009 Bromirski et al., 2005 Laird, 2013	High	Low	High	Moderate	A substantial portion of the region lies adjacent to a coastline, indicating exposure to erosion increases with sea level rise. In the absence of coastal armoring, there is very little natural adaptive capacity that can mitigate beach erosion or seacliff retreat. No specific estimates of increased coastal erosion rates were identified for the region.
	SL	Landward migration of intertidal marine species with sea level rise	Cayan et al., 2008a Laird, 2013	High	Moderate	High	High	If the coastal plains are not developed, landward migration of intertidal species with sea level is possible. The regions beaches are rugged and mountains or steep hills often extend to the shoreline. In several areas there are limited low-lying areas where intertidal marine species can migrate. Additionally many of the coastal low lying areas such as Humboldt Bay and Crescent City have been urbanized thus limiting adaptive capacity near these locations.

Sector	Climate/ Hydrologic Change Drivers	Expected Impacts	Impacts Supporting Evidence	Sensitivity	Adaptive Capacity	Vulnerability	Vulnerability Confidence	Comments
	SL	Reduced extent of tidal marshlands and other wetlands	PRBO, 2011 Langley et al., 2009 Stralberg et al., 2011 Ekstrom and Moser, 2012 Laird, 2013	High	Moderate	High	High	Tidal marshlands throughout the region provide essential habitat for fish, amphibians and migratory sea birds in addition to buffering developed areas from flooding indicating exposure to this impact. Where landward migration of tidal marshlands in not possible due to local topography or urbanization, tidal marshlands will disappear.
	AMT RV D SL	Shifts in sea bird species migration patterns	PRBO, 2011	High	Moderate	High	Low	The region is home to several species of seabirds that use coastal wetlands of the region for breeding, foraging and resting indicating exposure to this impact. Earlier onset of summer, habitat and food availability changes will affect migration patterns. Complex interactions of seasonal temperature changes with dynamics of the California current (also subject to climate impacts) contribute uncertainty of the severity of changes.
	SL	Increased frequency and spatial extent of flooding of coastal lowlands	PRBO, 2011 Bromirski et al., 2012	High	Low	High	High	Since a large portion of the region is coastline including several developed areas there is substantial to exposure to the increase of sea level driven flooding risks.
	-	Reduction in shell forming ability of mollusks due to higher ocean pH	Michaelidis et al., 2005 Shirayama & Thornton 2005 Kleypas et al., 1999 Riebesell et al., 2000 Feely et al., 2004 Harley et al., 2006	High	Low	High	High	Shellfish are abundant in the region and there is substantial evidence to indicate that they will not be able to adapt to ocean chemistry changes quickly enough to avoid negative effects on species populations.
	AMT ATV	Changes to the timing and intensity of coastal upwelling	Cayan, et al., 2009 Bromirski et al., 2012 Pisias et al., 2001 Snyder et al., 2003	Moderate	Moderate	Moderate	Low	Proximity of the region to coastal currents indicates exposure to this impact. Increasing temperatures will stratify ocean waters, while the current dynamics and winds will promote upwelling. These two forces work counter to one another contributing uncertainty to the timing and severity of changes to the California Current dynamics.

Sector	Climate/ Hydrologic Change Drivers	Expected Impacts	Impacts Supporting Evidence	Sensitivity	Adaptive Capacity	Vulnerability	Vulnerability Confidence	Comments
Forestry	AMT ATV PV D PET	Increased tree mortality due to combined effects to insects, disease and drought	Hansen and Weltzin, 2000 Shugart, 2003 Barr et al., 2010	High	Moderate	High	Moderate	A large portion of the region's area is subject to forest management indicating exposure to this impact. Timber harvest is a current stressor that may exacerbate consequences of this impact. Complex interactions of enhanced CO2, temperature increases, and hydrologic shifts contribute to uncertainty of changes.
		Reduced conifer timber harvest	Hannah et al., 2011	High	High	Moderate	Moderate	Timber is in the top 2 grossing agricultural industries in 5 of 7 of the North Coast Counties indicating exposure to this impact. Current stressors include wildfires, human encroachment into forests, insects and disease. Timber harvest practices can be altered to mitigate changes indicating high adaptive capacity.
		Increased costs of fuels management and fire suppression	Joyce et al., 2008	High	Moderate	High	Moderate	Increasing wildfire risks and human encroachment to forests exposes the forest management to increased costs to manage ignitions and damage from fires. Enhanced practices resulting from new research may reduce costs and increase adaptive capacity.
Agriculture	AMT ATV PV D PET	Crop type changes and geographic pattern shifts	Moser et al., 2009 Jackson et al., 2012a Thorne, et al., 2012a Ekstrom and Moser, 2012 Jackson et al., 2012b Diffenbaugh et al., 2011 Jones et al., 2010 Barr et al., 2010	High	Moderate	High	High	Climate is likely to become unsuitable for high value crops such as grapes, fruits and nuts indicating exposure to this impact. Zones of suitability for fruits and nuts will be reduced with rising temperatures, especially wine grapes. New or modified farming techniques may mitigate the need to change growing locations to some degree.
	AMT ATV PV D PET	Enhanced forage production but reduced forage reliability during drought years	Shaw et al., 2009; Chaplin- Kramer, 2012 Cornwall et al., 2012 Ekstrom and Moser, 2012	Moderate	Low	High	Low	Cattle ranching are one of the top 5 grossing agriculture industries in 6 of the 7 North Coast counties that depend on reliable forage production indicating exposure to this impact. Complex interactions of enhanced CO_2, temperature increases, and hydrologic changes contribute to uncertainty of changes.
	AMT	Longer growing season with shift towards longer summers	Thorne, et al., 2012	High	High	Moderate	High	While many crops in the region are affected by this impact, growers can adjust to changes simply by planting earlier in the season.

Sector	Climate/ Hydrologic Change Drivers	Expected Impacts	Impacts Supporting Evidence	Sensitivity	Adaptive Capacity	Vulnerability	Vulnerability Confidence	Comments
	AMT ATV PV D PET	Increased wine grape yields but reduced quality	Chaplin-Kramer, 2012 Ekstrom and Moser, 2012 Jones et al., 2010 Diffenbaugh et al., 2011 Jones et al., 2010	High	Moderate	High	High	Climate changes will alter the economics of wine producing regions. Willamette valley in Oregon may become like Napa is today. Exposure to this impact is based on economic importance of these crops. Growers can adapt with grape breeding, but climate that will be as warm as Napa will be in 2050 would be a table grape region today rather than some of the varieties that the Napa region is currently known for.
	AMT PET	Increased irrigation water demand during summer	Jackson et al., 2012a Thorne et al., 2012a Jackson et al., 2012b	High	High	Moderate	High	Hotter, longer summers will mean that that most crops will require more water indicating exposure to this impact. Current water demands for crops and ecosystem services are the key existing stressors that will be exacerbated with projected climate changes. Conservation practices or crop type changes contribute to adaptive capacity.
	SL RV	Increased risk of field damage from flooding in coastal low lying areas	Laird, 2013 Cayan et al., 2008a	Moderate	Moderate	Moderate	Moderate	The greatest increase in the risk of damage due to floods is in coastal low lying areas. Only 2% of land is dedicated to agriculture and urban land uses. Land use maps indicate that much of the agriculture in the region occurs in coastal lowland areas such as Arcata and Crescent City with some degree of exposure to flood damage, but is a small percent of land use in the region. Flooding damage will also be dependent on rainfall pattern changes which are less certain than sea level rise
Urban	SL RV	Increased risk of property and infrastructure damage from flooding	Moritz and Stephens, 2008 Jones and Goodrich, 2008 Laird, 2013	Moderate	Moderate	Moderate	Moderate	Low lying communities in the region are anticipated to suffer an increase in acreage flooded by 2100 by approximately 17-18%. Relative to other California coastal areas this is a moderate increase, when compared to more populous coastal areas of the state which have projected inundation increases of ranging from 30-46%

Sector	Climate/ Hydrologic Change Drivers	Expected Impacts	Impacts Supporting Evidence	Sensitivity	Adaptive Capacity	Vulnerability	Vulnerability Confidence	Comments
	AMT ATV PV D PET	Increased risk of property and infrastructure damage from wildfires	Thorne et al., 2012b Moritz and Stephens, 2008 Jones and Goodrich, 2008	High	Moderate	High	Moderate	Population increase in the future will mean further pressure for development to encroach into forests and greater damage to property with increasing wildfire occurrence and extent risks. Land-use planning policies are a means of increasing adaptive capacity to climate change and altered fire regimes to mitigate risks of property damage.
	SL RV	Increased erosion risk for coastal development	Cayan et al., 2008a Cayan, et al., 2009 Bromirski et al., 2005 Laird, 2013	High	Low	High	Moderate	The region contains about 400 miles of shoreline all of which are at risk to erosion with projected sea level rise. The major developed areas on the coast in the North Coast region include Santa Rosa, Arcata, and Crescent City which are all exposed to this impact. However, much of the coastline is sparsely populated and undeveloped relative to other coastal regions of the state.
	RV	Increased winter stormwater conveyance requirements	Jones and Goodrich, 2008 Cayan et al., 2009	Moderate	Moderate	Moderate	Low	The possibility of more frequent intense rainfall events may require greater capacity requirements for urban infrastructure. Adaptation actions such as retrofitting culverts, bridges, and storm drains would be a high cost endeavor is required. Uncertainty surrounding rainfall projections contributes to low confidence.
	AMT ATV PV D PET SL RV	Greater constraints on land-use and new development	Moritz and Stephens, 2008 Jones and Goodrich, 2008	Moderate	Moderate	Moderate	Low	Increasing population creates greater development pressure on ecosystems at the urban-wildland interface. Increased flooding and wildfire risks may crate the need to place constraints on development to avoid unnecessary risks to life and property.
Water supply/ demand	SP	Reduced spring snowpack water supply storage	Cayan et al., 2009 FRAP, 2010 Anderson, 2008 Mote et al., 2005 Hayhoe et al., 2004	Low	Low	Moderate	High	Reduced snowpack is expected but majority of watersheds in the region are rain fed. While a snowpack loss of 73 to 90% (estimated in the PCM model in the Sierras) may stress aquatic ecosystems with lower base flows in summer months, much water supply in the region is met with groundwater sources and groundwater fed springs.

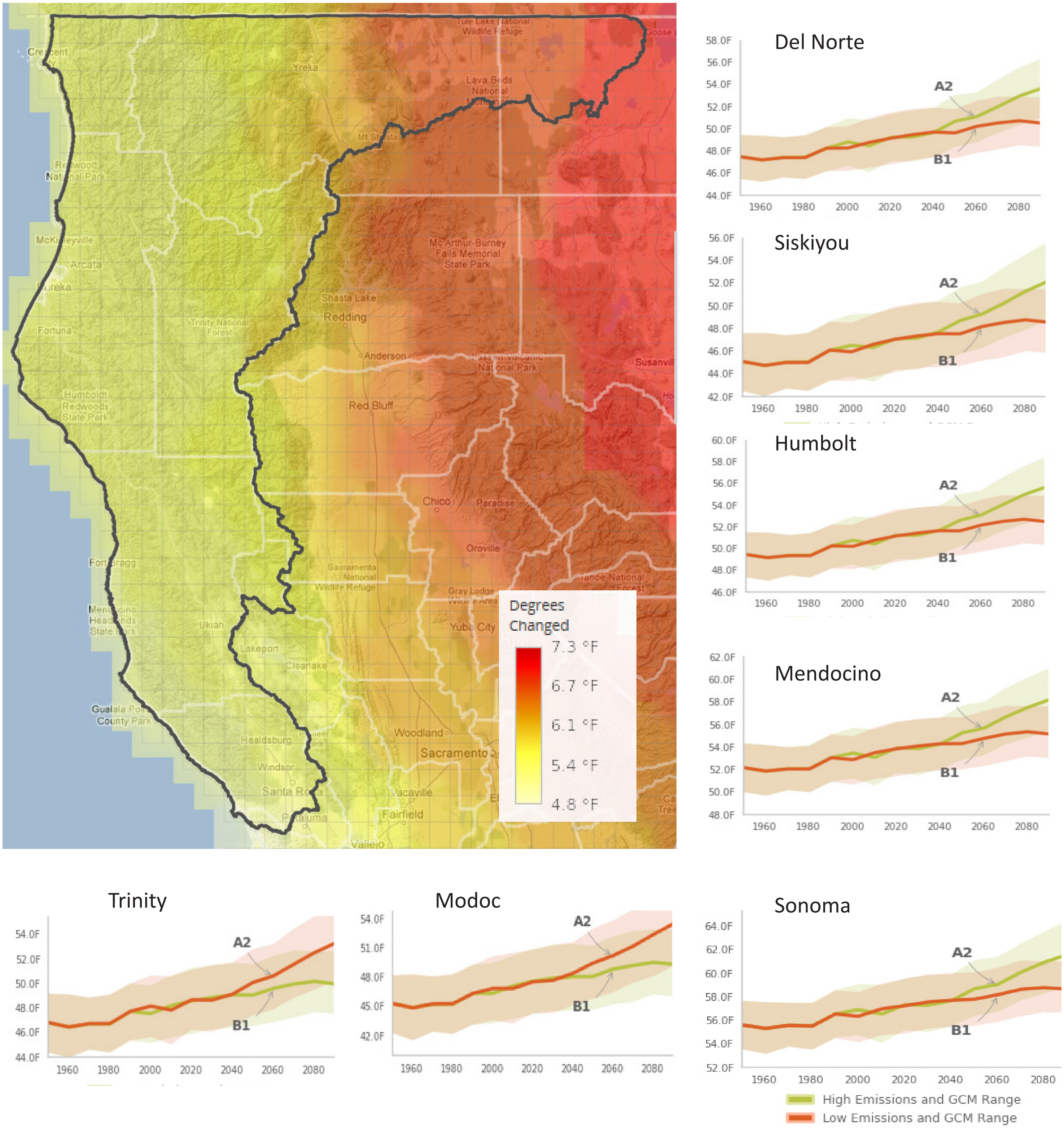
Sector	Climate/ Hydrologic Change Drivers	Expected Impacts	Impacts Supporting Evidence	Sensitivity	Adaptive Capacity	Vulnerability	Vulnerability Confidence	Comments
	GWR RV D AMT SP	Increased risk of water conflicts between urban, agriculture, and ecosystems	Barr et al., 2010 PRBO, 2011 Elkind et al., 2012 NC RWQCB, 2011	High	High	Moderate	High	Major water supply projects in the region include the U.S. Bureau of Reclamation Klamath Project, the U.S. Army Corps of Engineers Russian River Project, the Humboldt Bay Municipal Water District Ruth Reservoir, and the U.S. Bureau of Reclamation Trinity Lake Reservoir. The Klamath Project has been extremely controversial because to maintain adequate instream fishery flow to ensure the survival of endangered salmonid populations, coordination between many jurisdictions is necessary. Water to farms has at times been cut off to prevent harm to the fisheries, resulting in extreme controversy, and in some cases, violence. Currently, surplus surface water is exported out of the region for use elsewhere in the state, but reduced snowpack storage may tax existing resources are require changes to satisfy all existing water supply needs in the region.
	GWR RV D AMT SP	Increased dependence on groundwater supply in summer months	NC RWQCB, 2011 Ekstrom and Moser, 2012	High	High	Moderate	Moderate	Most basins within the region depend on groundwater or groundwater fed springs indicating exposure to this impact. Current resources are adequate to meet current and projected needs indicating resilience to changes and a high adaptive capacity.
	GWR SL	Increased seawater intrusion to coastal groundwater aquifers	PRBO, 2011 NC RWQCB, 2011	Low	Moderate	Low	Moderate	Rising sea level will increase the potential for seawater intrusion indicating exposure to this impact for coastal communities. Given the adequate groundwater basin recharge that occurs, saltwater intrusion is not generally a problem in North Coast groundwater basins.

Sector	Climate/ Hydrologic Change Drivers	Expected Impacts	Impacts Supporting Evidence	Sensitivity	Adaptive Capacity	Vulnerability	Vulnerability Confidence	Comments
Energy demand/ capacity	AMT ATV	Increased summer energy demand during heat waves	Hanuk and Lund 2008 FRAP, 2010 Barr et al., 2010 NCIRWMP, 2007	Low	High	Low	High	The Iron Gate Reservoir in Siskiyou County provides energy for a hydroelectric facility owned by Pacific Power and Light Company. Future electricity demand will rise due to increased population and needs for home cooling, refrigeration, water (which requires energy to transport), and power supplies for an ever-increasing number of small electronics. At the same time, efficiency and reliability of power transmission and delivery is likely to decline as power lines are stressed with higher ambient temperatures and increased risk from wildfires. As a result, more brownouts and blackouts are expected. Much of the region's climate is moderated by its proximity to the ocean, reducing seasonal temperature variation. Energy conservation and energy efficient development will be responses to mitigate increased demand.
	SP	Reduced hydropower energy generation capacity in spring/summer	Madani and Lund, 2010 Vicuna et al., (2008) FRAP, 2010 Ekstrom and Moser, 2012 Spears et al., 2012 NC RWQCB, 2011 Barr et al., 2010	Low	Moderate	Low	Low	While hydropower is used in the region indicating exposure to this impact, it is not generated at high elevation dams. While lake levels may be reduced in summer months, the projected reductions in snowpack would primarily affect hydropower generation at higher altitudes.
Fisheries	AMT ATV	Shift in marine productivity patterns as a result of nutrient upwelling changes	Snyder et al., 2003	High	Low	High	Low	Fishing is an important industry in the region with economic exposure to climate induced changes of ocean dynamics and chemistry. Complex interactions of seasonal temperature changes with dynamics of the California current, and productivity changes that may occur in other fisheries contribute uncertainty of the severity of the economic impacts.

Sector	Climate/ Hydrologic Change Drivers	Expected Impacts	Impacts Supporting Evidence	Sensitivity	Adaptive Capacity	Vulnerability	Vulnerability Confidence	Comments
	AMT ATV D RV SP GWR	Decreased terrestrial cold water fish yields associated with inland habitat degradation	Knapp et al., 2001 Pope et al., 2009 Moyle et al., 2012a Moyle et al., 2012b NMFS, 2012 Barr et al., 2010 Medellín-Azuara et al., 2008	High	Low	High	Low	Increased erosion is likely to impact the spawning of native fish such as lamprey, suckers, salmon, and trout that build their nests in areas of clean rocks and gravels. Greater levels of fine-sediment input will increase nutrient concentrations in aquatic systems and contribute to algae blooms. Current stressors on fish population will limit adaptive capacity in the future.
	SL	Landward migration of salmonid rearing habitats	Cayan et al., 2008a Laird, 2013	High	High	Moderate	High	Rearing habitats will migrate landward with sea level rise. As long as there are not barriers near the coast to migration, rearing habitats should be able to shift upstream from their current locations.
	-	Reduced oyster and clam farm productivity due to ocean chemistry changes	Michaelidis et al., 2005 Shirayama & Thornton 2005 Kleypas et al., 1999 Riebesell et al., 2000 Feely et al., 2004 Harley et al., 2006	High	Moderate	High	Low	Interference with the shell building ability of mollusks will expose oyster and clam farms to greater mortality in the future. Farms will may identify new or modify existing practice to adapt their businesses and remain viable.
Recreation	RV SP GWR D	Shortened river rafting, boating, and sport fishing season and quality	Morris and Walls, 2009 Cayan et al. 2009	High	Moderate	High	Moderate	Recreation activities that depend on summer river flows and good water quality are exposed to impacts as summer low flows are reduced in rivers due to longer, hotter summers and less snowmelt. There is very little opportunity for adjustment of these activities other than altering dam release patterns upstream.
		Shortened backcountry skiing season	Morris and Walls, 2009 Cayan et al., 2009 Goodstein and Matson, 2004	Moderate	Low	High	High	Opportunities for snow-dependent recreation will be reduced along with the snowpack decline. There is very little opportunity for adjustment of these activities with less snow pack available.

Sector	Climate/ Hydrologic Change Drivers	Expected Impacts	Impacts Supporting Evidence	Sensitivity	Adaptive Capacity	Vulnerability	Vulnerability Confidence	Comments
		Reductions in hunting and wildlife viewing opportunities	Morris and Walls, 2009 Cayan et al., 2009	Moderate	Moderate	Moderate	Low	Hunting and wildlife viewing opportunities are dependent on healthy animal populations and associated habitats. Potential habitat degradation in the future exposes this recreation opportunity to impacts from changing climate and hydrologic conditions. New wild areas may become more suitable or made more accessible in response to changing conditions. The extent of limitations is uncertain since they depend on a host of complex system responses to changed climate conditions as well as human behavior patterns.
		Reduced wildland recreation opportunities and viewshed quality	Morris and Walls, 2009 Cayan et al., 2009	Moderate	Moderate	Moderate	Low	Wetland, riparian, and mountain areas that support recreational fisheries and unique bird populations in the region exposed to climate change impacts such as sea level rise and longer, drier summers. New wild areas may become more suitable or made more accessible in response to changing conditions. The extent of limitations is uncertain since they depend on a host of complex system responses to changed climate conditions as well as human behavior patterns.

*Climate drivers are listed for each impact to which they are most directly connected: Average maximum air temperatures (AMT), Air temperature variability (ATV), Annual precipitation totals (APT), Precipitation variability (PV), Sea Level (SL), Droughts (D), Potential evapotranspiration (PET), Groundwater recharge (GWR), Potential evapotranspiration (PET), Annual runoff (AR), Runoff variability (RV), Snow Pack (SP), Flooding (F). Refer to Table 2 for details and references



Annual high temperatures for the period of 1961-1990 were compared to predicted temperatures for the period of 2070-2099. The map displays the predicted degrees of change between these two periods. Annual high temperatures predicted include data for four different models (PCM1, CCSM3, GFDL, CNRM) for the high emissions scenario (A2). Graphs at the right indicate temperature increases in each North Coast county for both scenarios. Note that the historic reference period and degrees of change are slightly different from that cited in Table 2.1 (reported in Cayan et al., 2009) for the entire State of California. Data Source: http://cal-adapt.org/.

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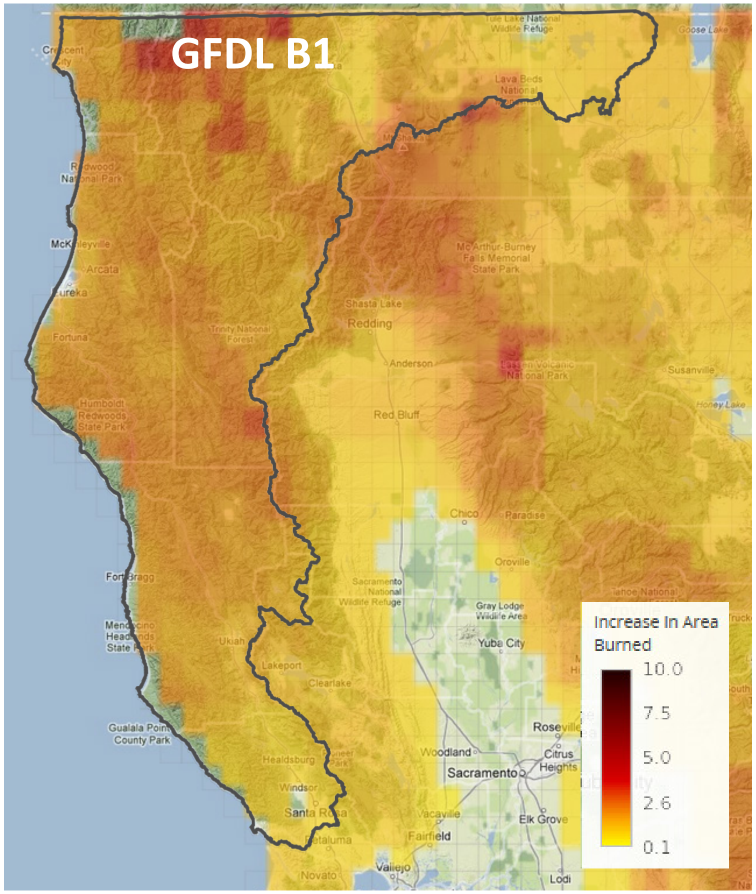
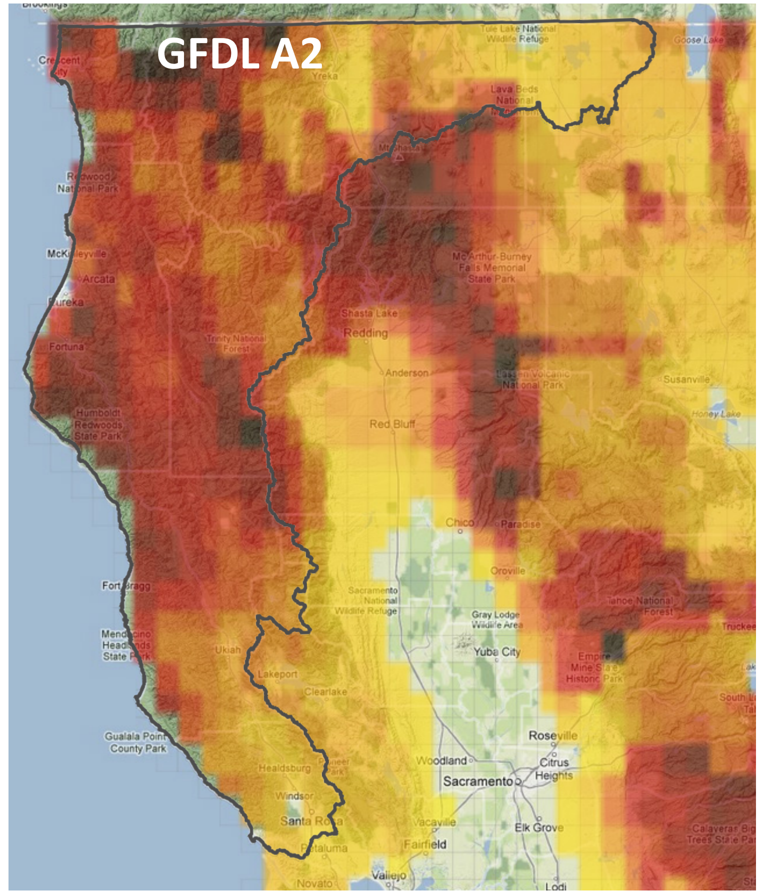
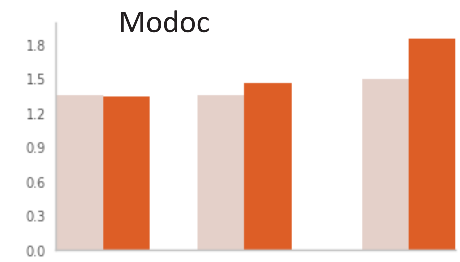
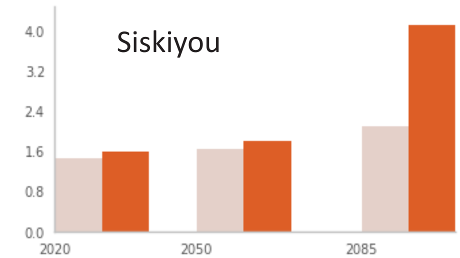
PROJECTED TEMPERATURE CHANGE

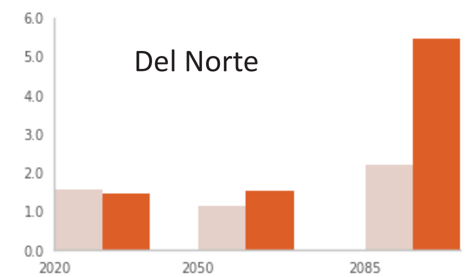
FIGURE 1

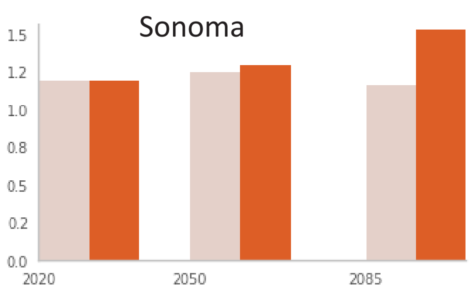


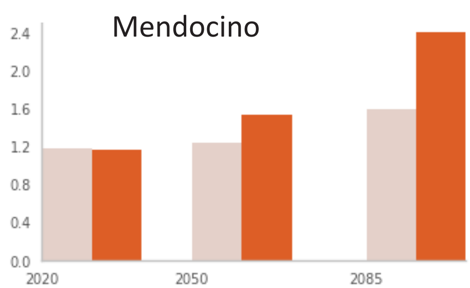


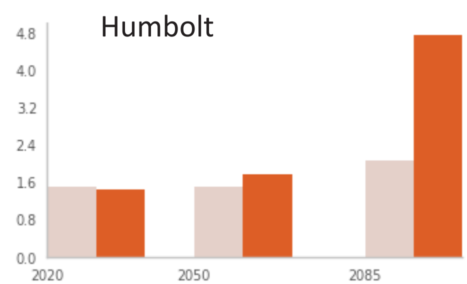


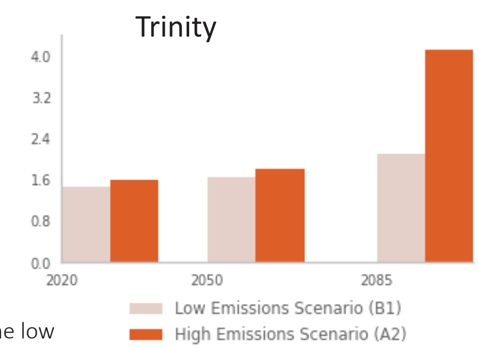












The figures above display the projected increase in potential area burned by wildfire under predictions from climate model GFDL for the low emissions scenario (B1) and the high emissions scenario (A2) for the year 2085. Colors on the maps and the vertical axis on graphs represent a multiplier on the amount of area burned for each grid cell relative to current estimates, so that dark colors suggest a 10 fold increase. The graphs display the projected increase in burned area averaged for three 30 year periods ending in the year displayed on the horizontal axis. Data source: http://cal-adapt.org/.

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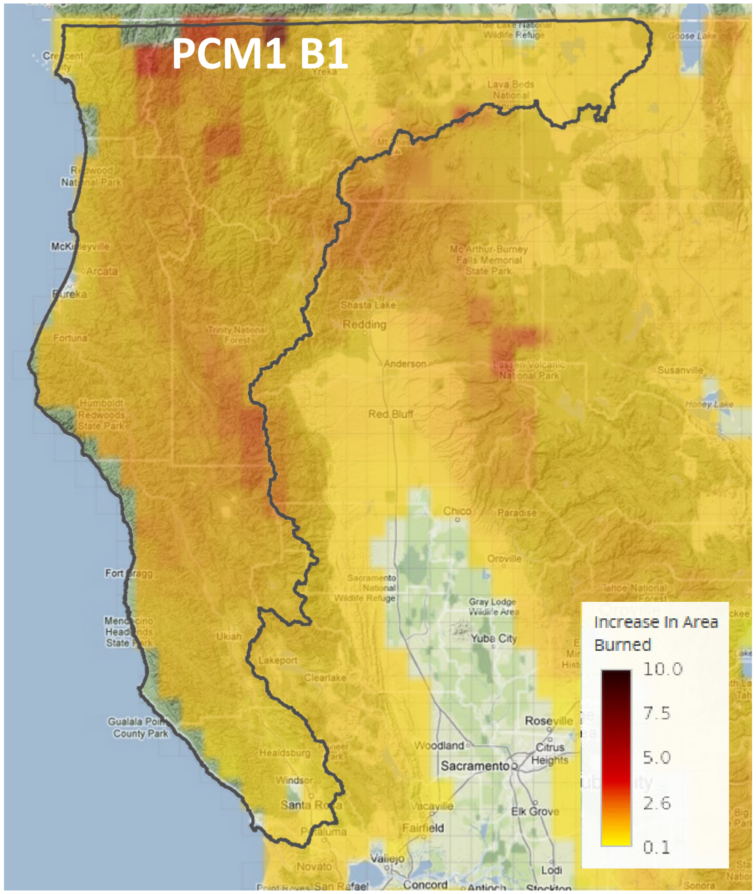
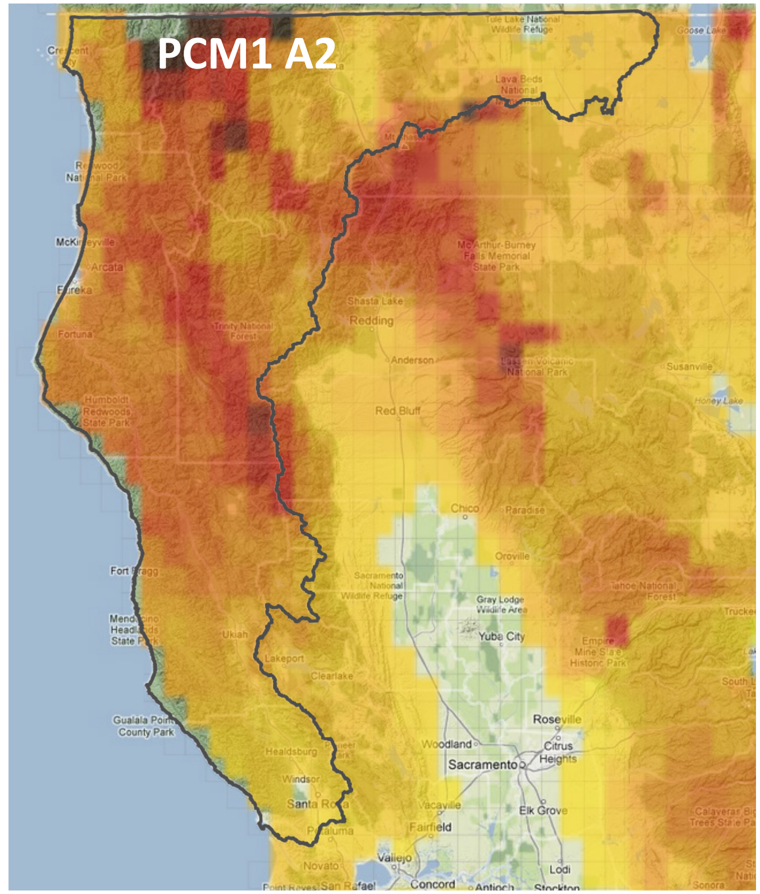
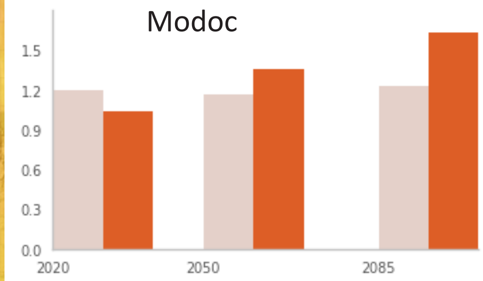
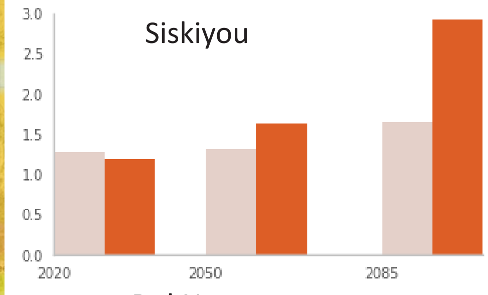
PROJECTED WILDFIRE RISK CHANGE

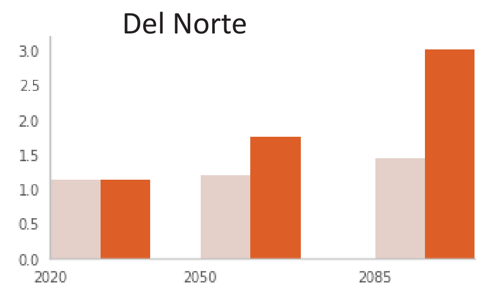
FIGURE 2a

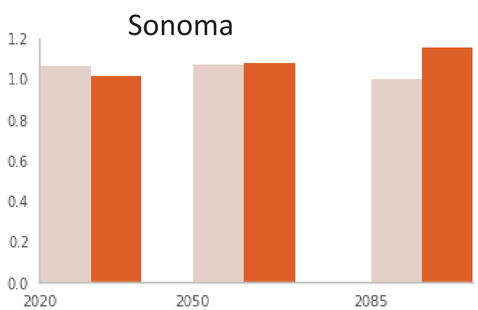


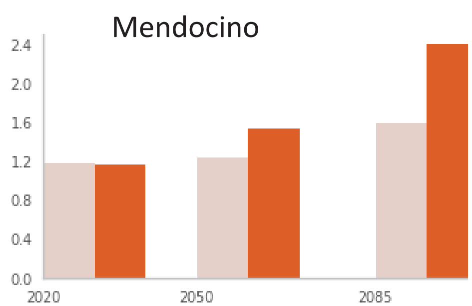


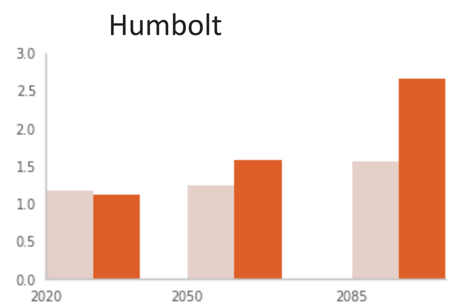


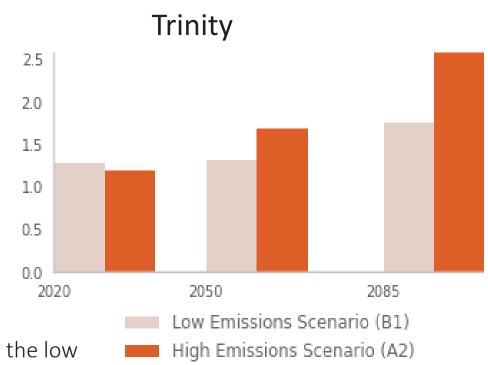












The figures above display the projected increase in potential area burned by wildfire under predictions from climate model PCM1 for the low emissions scenario (B1) and the high emissions scenario (A2) for the year 2085. Colors on the maps and the vertical axis on graphs represent a multiplier on the amount of area burned for each grid cell relative to current estimates, so that dark colors suggest a 10 fold increase. The graphs display the projected increase in burned area averaged for three 30 year periods ending in the year displayed on the horizontal axis. Data source: http://cal-adapt.org/.

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Global models indicate a 55 inch rise in sea level winthin this century. The yellow represents the area that will be inundated during a 100 year flood given a 55 inch sea level rise.
Data source: http://cal-adapt.org/.

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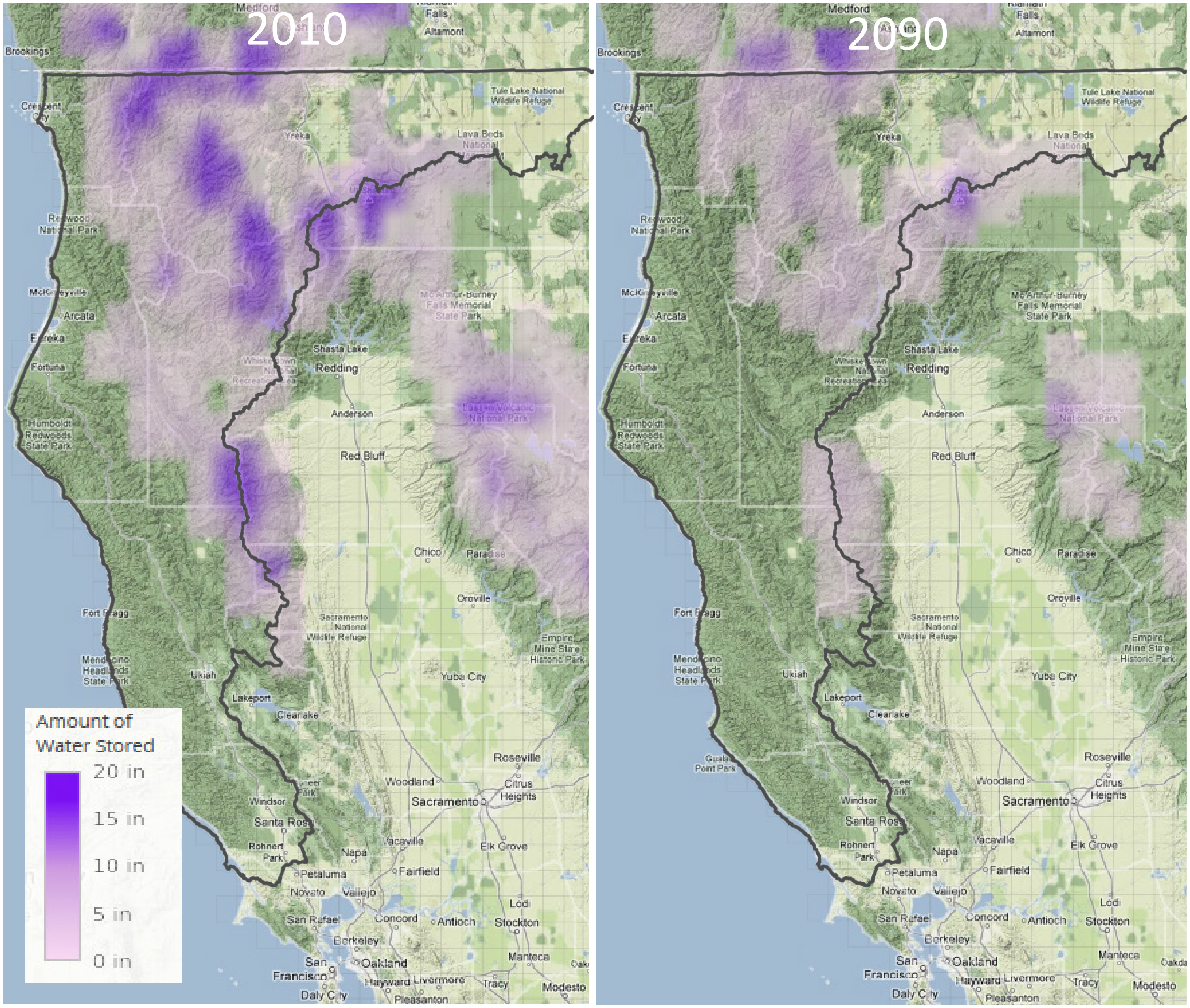
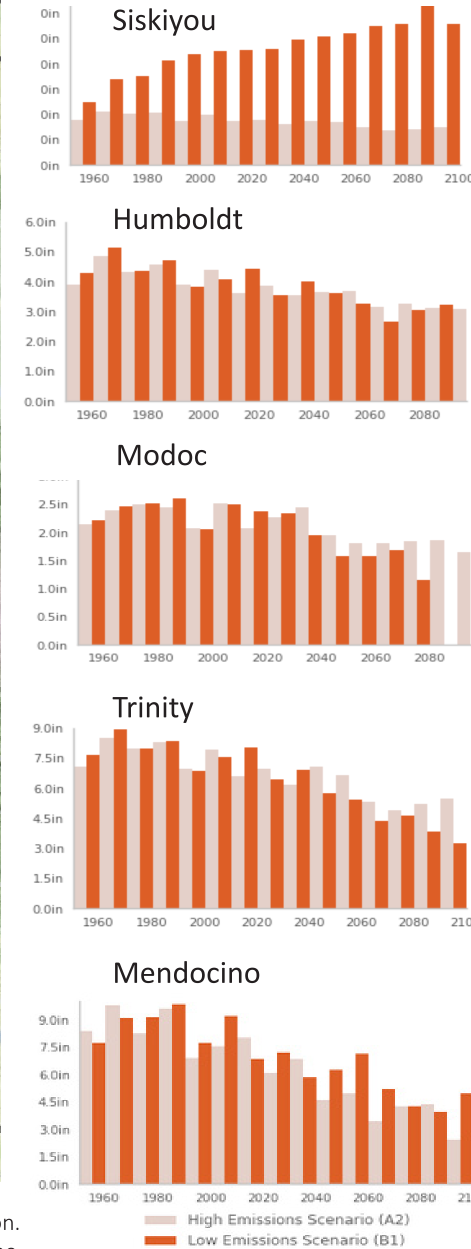
PROJECTED SEA LEVEL RISE

FIGURE 3





Average amount of water stored in snowpack predicted for 2010 and for 2090 are displayed for the North Coast Region. Data is included for four different models (PCM1, CCSM3, GFDL, CNRM) for the High Emissions Scenario (A2) during the month of April. Graphs on right display the average amount of water stored in the snowpack for each county under the low emissions scenario (B1) and the high emissions scenario (A2). Data source did not include snowpack information for Del Norte and Sonoma Counties. Data source: http://cal-adapt.org/.

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PROJECTED SNOWPACK CHANGE

FIGURE 4

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(references highlighted in grey were generally used but not specifically cited)

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