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EcoAdapt™

Meeting the challenges of climate change

Vulnerability Assessment, Mapping, & Adaptation Strategies

FOR NORTHERN CALIFORNIA

Project Findings

Photo by Redwood National and State Forests via Flickr (Public Domain)

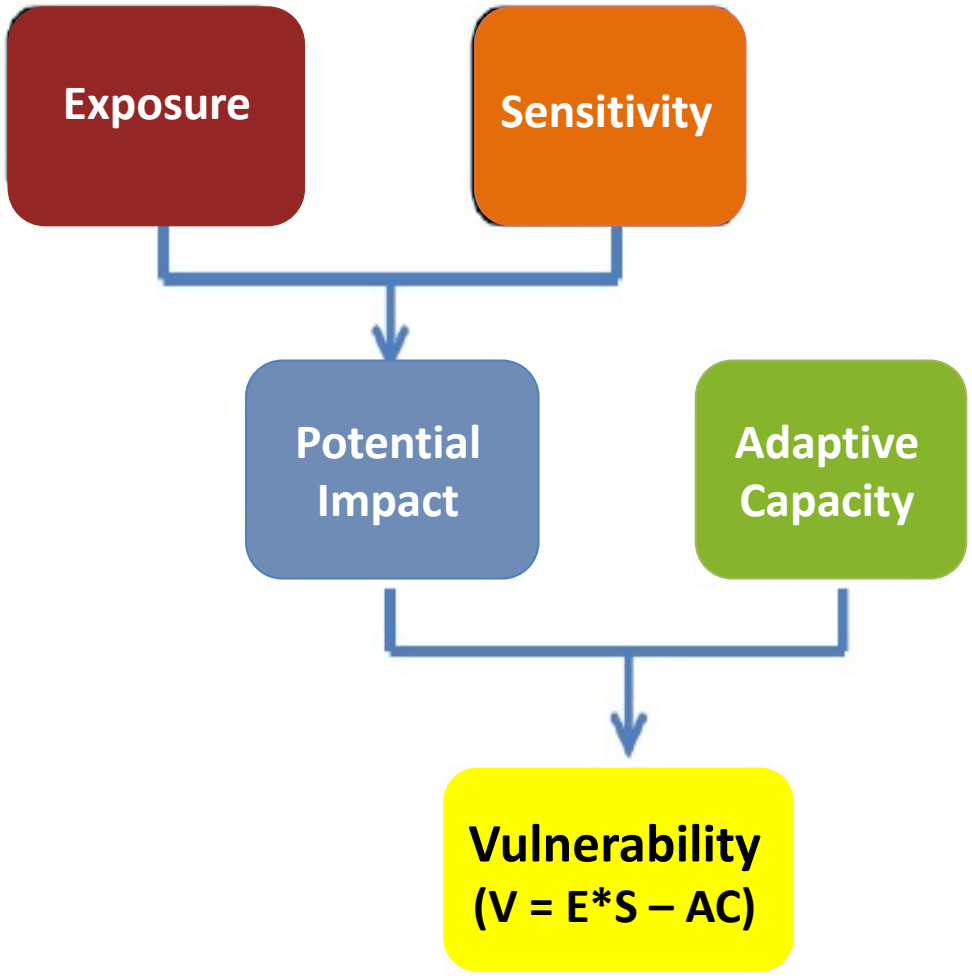
- **Vulnerability Assessments**
- **Regional Climate Impacts**
- **Climatic Water Deficit Maps**
- **Adaptation Strategies & Actions** *(linked to vulnerability)*

Vulnerability Assessment

Purpose of a vulnerability assessment:

Identify ***which*** resources are most vulnerable and ***why***

- **Exposure**
- **Sensitivity**
- **Adaptive Capacity**



Vulnerability Assessment

EXPOSURE is a measure of ***how much change*** in climate that a resource is likely to experience

Factors considered:

- Direction and magnitude of change in climate stressors and disturbance regimes
- Degree of uncertainty associated with projected changes

Vulnerability Assessment

Photo by USFS/Mike McMillan (Public Domain)

SENSITIVITY is a measure of whether and how a resource is likely to be affected by a given change in climate factors

Factors affecting sensitivity:

- Climate drivers
- Disturbance regimes
- Non-climate stressors

Vulnerability Assessment

ADAPTIVE CAPACITY is a measure of a resource's ability to accommodate or cope with climate change impacts with minimal disruption

Factors affecting adaptive capacity:

- Extent & integrity
- Connectivity
- Resistance & recovery
- Diversity
- Public, societal, and cultural value
- Management potential

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Climate Change Vulnerability:
Late-Successional-Dependent Species

Moderate-High Vulnerability

Moderate Confidence

Exposure

Moderate Exposure

Low Confidence

- ↑ Air temperature
- ↑ Heat waves
- ↑↓ Precipitation amount/timing
- ↑ Drought
- ↓ Snowpack
- ← Timing of snowmelt/runoff
- ↑ Storms
- ↑ Wildfire

Sensitivity

Moderate-High Sensitivity

High Confidence

- Decreased survival and recruitment
- Altered prey availability and interspecific competition for food/habitat resources
- Changes in habitat structure and availability of critical habitat features
- Reduced habitat extent and connectivity
- Shifts in species distribution
- *Non-climate stressors:* Fire exclusion, timber harvest, roads, poisons

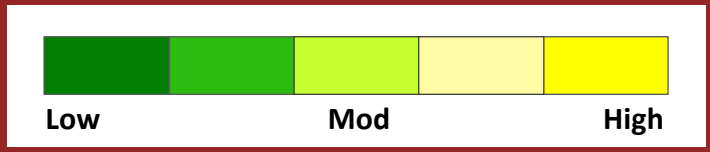
Adaptive Capacity

Low-Moderate Adaptive Capacity

High Confidence

- ▲ Behavioral plasticity
- ▲ Some regulatory and legislative support for species management
- ▼ Declining regional populations
- ▼ Small, isolated populations vulnerable to extirpation or genetic bottlenecks
- ▼ Recovery limited by low reproductive potential & reliance on late-seral stand conditions

Vulnerability Results: *Habitats*



Low Vulnerability

Coastal redwood forest

Mixed conifer/ponderosa forest

Freshwater marshes

Mixed grasslands

Seeps & springs

Lakes

Chaparral shrublands

Wet meadows/fens

Ponds

Black oak & tanoak woodlands

Oak savannas & open woodlands

Rivers, streams, & floodplains

Vernal pools

Coastal conifer/hardwood forest

Mixed evergreen forest

Alpine grassland/shrubland

Rock outcrops/ cliffs/talus slopes

Coastal bluffs/scrub

Coastal dune systems

Caves, karst, & lava tubes

True fir forest

Subalpine forest

High Vulnerability

Adaptive Capacity

High

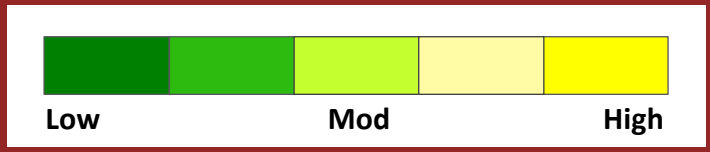
Low

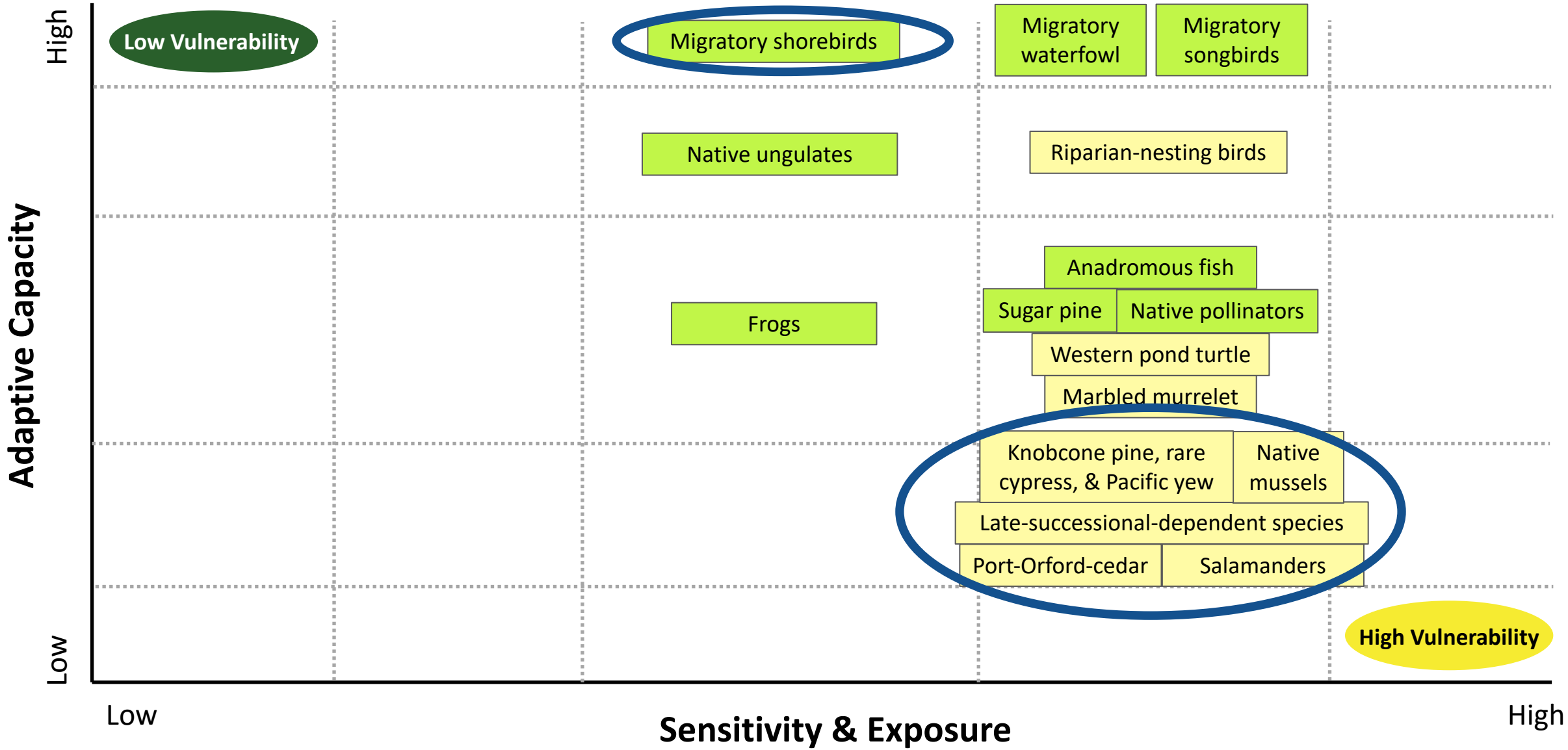
Low

High

Sensitivity & Exposure

Vulnerability Results: *Species*





Vulnerability Assessment Trends

Climate Stressors
- Precip/soil moisture
- Drought

Disturbance Regimes
- Wildfire
- Disease

Non-Climate Stressors
- Fire suppression
- Timber harvest
- Pollutions & poisons
- Dams & water diversions
- Roads, highways, & trails


Photo by BLM/Greg Shine (CC BY 2.0)

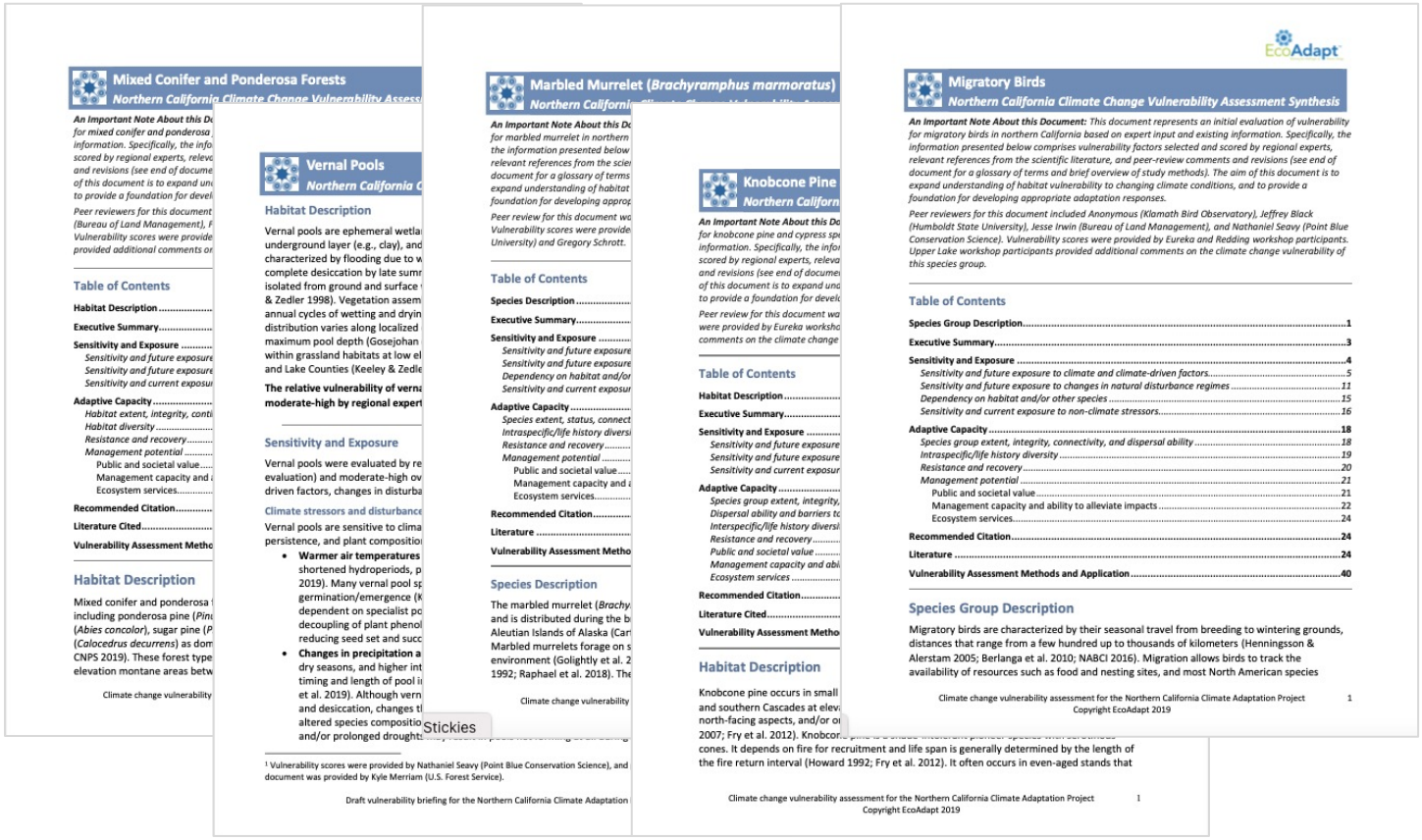

Photo by USFWS/Tom Kogutus (CC BY 2.0)

Adaptive Capacity Factors
- ▲ High physical and topographical diversity
- ▲ Large areas of undeveloped/roadless land increase connectivity
- ▼ Many habitats & populations degraded
- ▼ Past management activities
- ▼ Low to mod management capacity & ability

Vulnerability Assessment Products

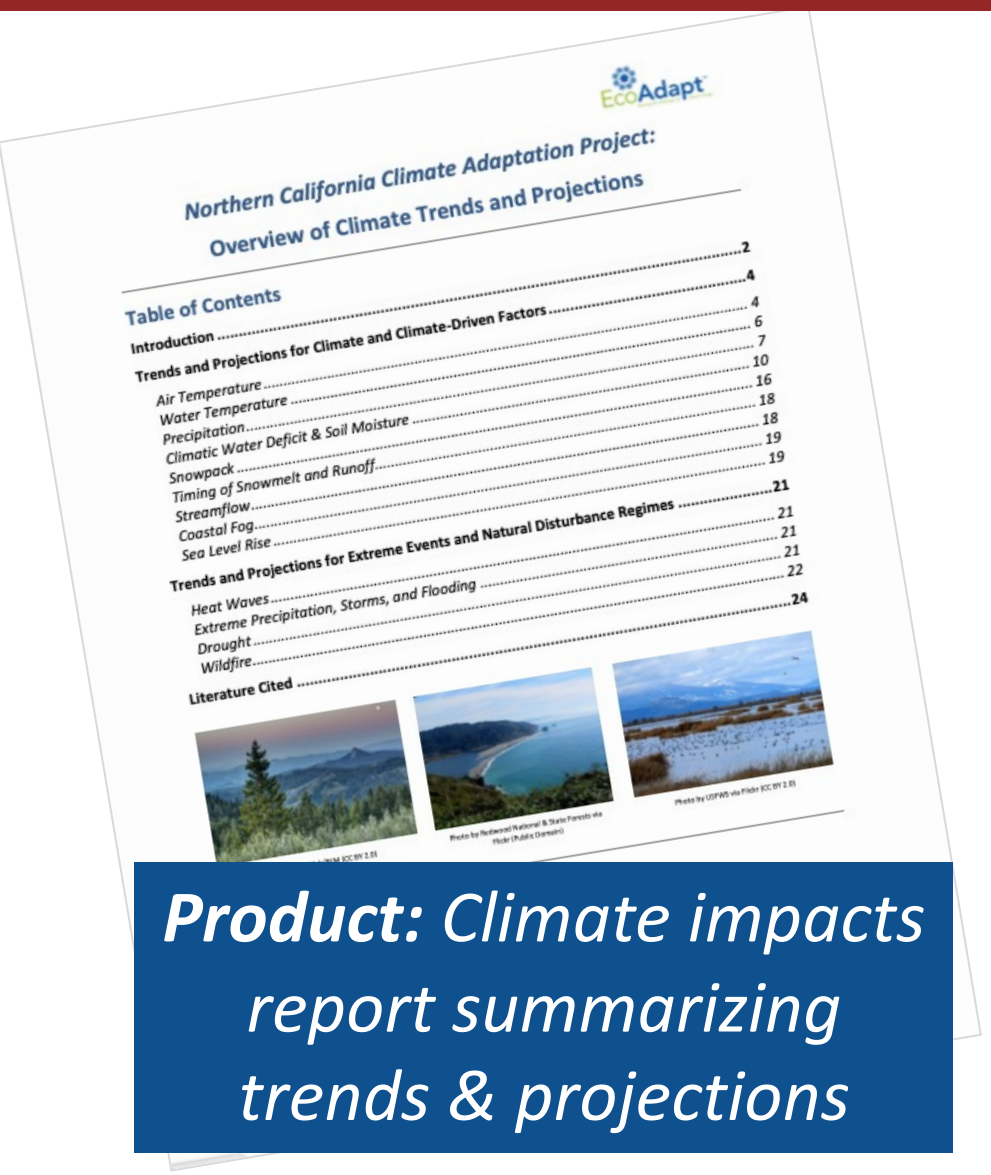

Photo by USFWS via Flickr (Public Domain)

- Expert assessment
- Downscaled climate projections
- Review of scientific literature
- Peer review and evaluation of results



Product: *Vulnerability assessment syntheses for 33 focal resources*

Regional Climate Impacts



EcoAdapt

Northern California Climate Adaptation Project:
Overview of Climate Trends and Projections

Table of Contents

Product: *Climate impacts report summarizing trends & projections*

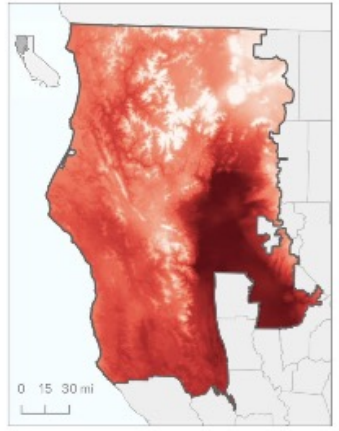
Table 1. Summary of trend direction and projected future changes for climate and climate-driven factors, extreme events, and major natural disturbance regimes within the Northern California Climate Adaptation Project study area.

Variable	Trend	Projected Future Changes
Climate and climate-driven factors		
Air temperature	⬆	• 2.2–6.1°C (4.0–11.0°F) increase in annual mean
Water temperature	⬆	• 0.4–0.8°C (0.8–1.4°F) increase in August stream 2080s
Precipitation	⬆⬇	• -23% to +38% change in mean annual precipitat • Shorter, wetter winters and longer, drier summe interannual variability
CWD & Soil moisture	⬆ ⬇	• 4–43% increase in mean annual climatic water d • Reduced soil moisture due to enhanced evapotr
Snowpack & Snowmelt	⬆ ⬅	• 61–100% decrease in April 1 snow water equiva • 5–15-day shift towards earlier timing of snowme
Streamflow	⬆⬇	• General increase in wet season flows and decre with overall increase in flow variability • 30–40% decline in the lowest streamflow per de
Coastal fog	⬇	• Weak decline in the frequency of days with coas
Sea level rise	⬆	• High likelihood of 0.03–1.24 m (0.1–4.1 ft) sea l
Extreme events and natural disturbance regimes		
Heat waves	⬆	• Significant increase in heat wave frequency and humid nighttime events and in coastal areas
Storms & Flooding	⬆	• Increased storm intensity and duration, resultin frequent/intense extreme precipitation events a • 300–400% increase in the frequency of 200-yea
Drought	⬆	• Drought years twice as likely to occur, with signi of prolonged and/or severe drought
Wildfire	⬆	• 77% increase in mean annual area burned state increase in montane forested areas of northern • 50% increase in the frequency of extremely larg • Significant increases in fire severity are likely du behavior combined with human activity and fue

Trends and Projections for Climate and Climate-Driven Factors

Air Temperature

Annual, minimum, and maximum temperatures have increased state-wide over the past century (LaDochy et al. 2007; Cordero et al. 2011; Pierce et al. 2018), with accelerated rates of warming since the 1970s (Cordero et al. 2011). Minimum temperatures (representing nighttime lows) have warmed faster than mean and maximum temperatures in most regions, including northern California (LaDochy et al. 2007; Cordero et al. 2011; Pierce et al. 2018). However, mean annual temperatures have increased less in northern California (+0.6°C [1.0°F]) compared to the state-wide average (+0.8°C [1.5°F]; Grantham 2018; Pierce et al. 2018), and maximum temperatures in the region have exhibited very slight decreases (Rapacciuolo et al. 2014). Within the study area, increases in annual and minimum temperatures over the past century have been greatest in the Great Valley ecoregion; decreases in maximum temperatures are also greatest in this ecoregion (Rapacciuolo et al. 2014).



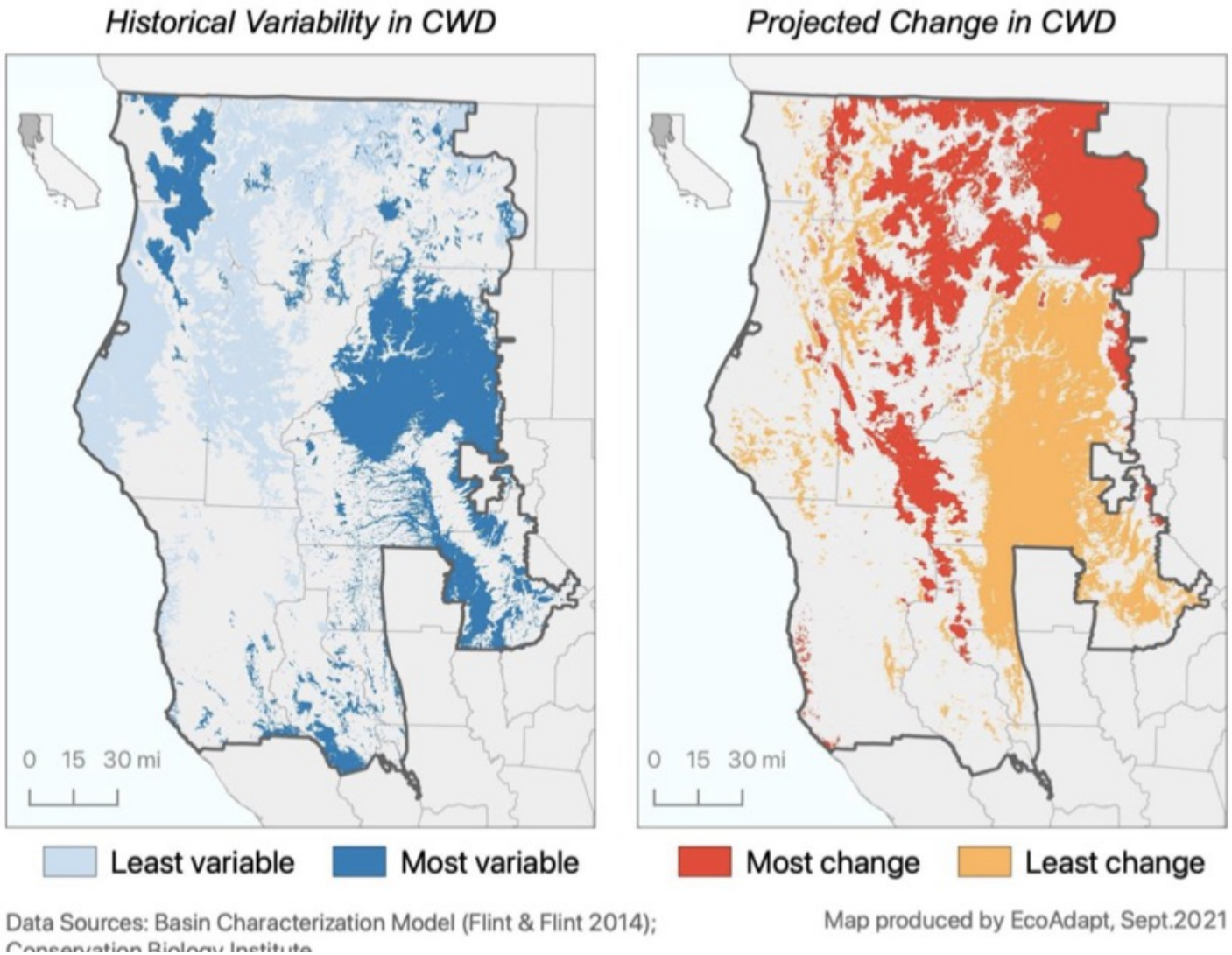
Data Sources: Basin Characterization Model (Flint & Flint 2014); Conservation Biology Institute. Map produced by EcoAdapt. Sept. 2021

Figure 2. Annual mean temperature in degrees Celsius (°C) for the Northern California Climate Adaptation Project study area between 1951 and 1980.

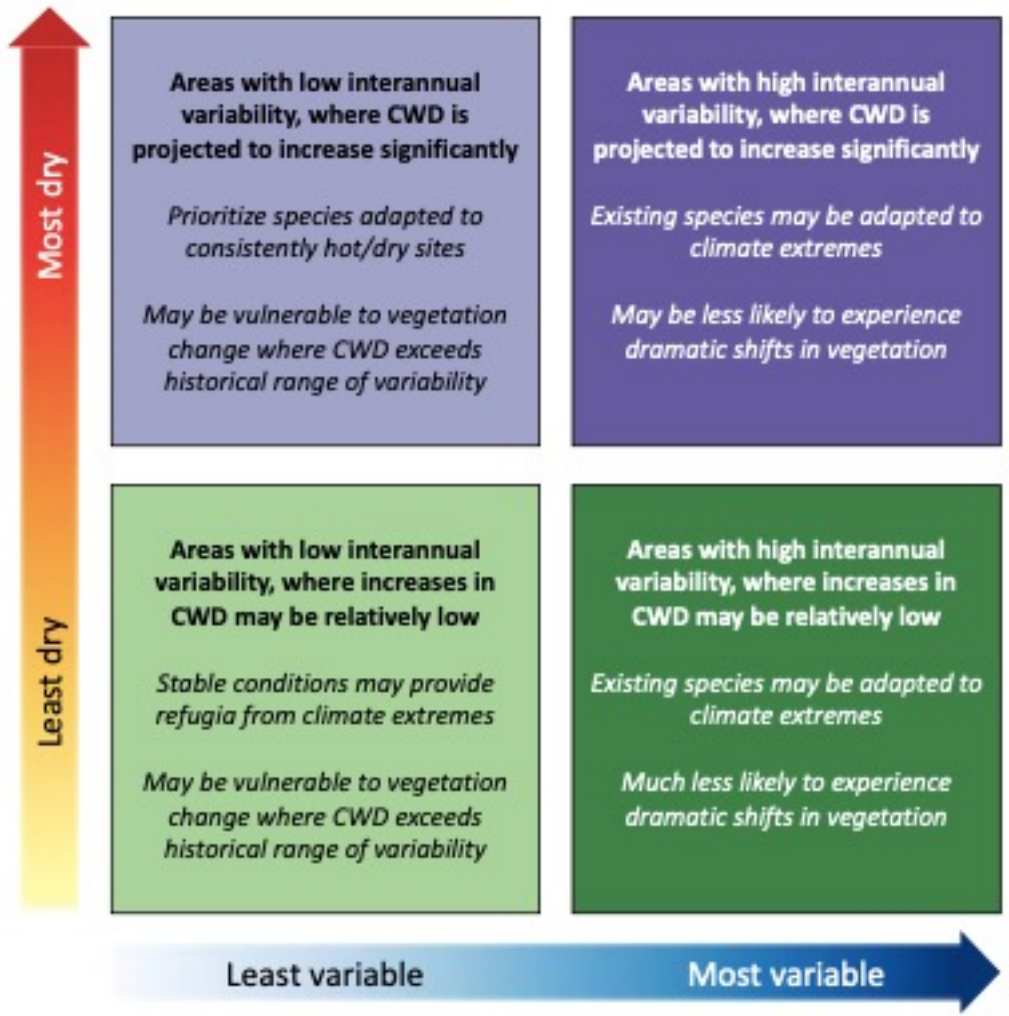
By the end of the century (2070–2099), annual mean temperatures within the Northern California study area are projected to rise by 2.2–6.1°C (4.0–11.0°F) compared to historical temperatures (1951–1980; Figure 2 and Figure 3), with slightly greater warming projected in summer maximum temperatures (2.0–6.8°C [3.6–12.2°F]) compared to winter minimums (1.9–5.8°C [3.4–10.4°F]; Flint et al. 2013; Flint & Flint 2014; Table 2). Because oceans warm more slowly than land, interior zones are generally projected to experience greater temperature increases than coastal areas ventilated by ocean breezes (Pierce et al. 2018). Other factors associated with landscape-scale temperature variability include elevation and urbanization (LaDochy et al. 2007).

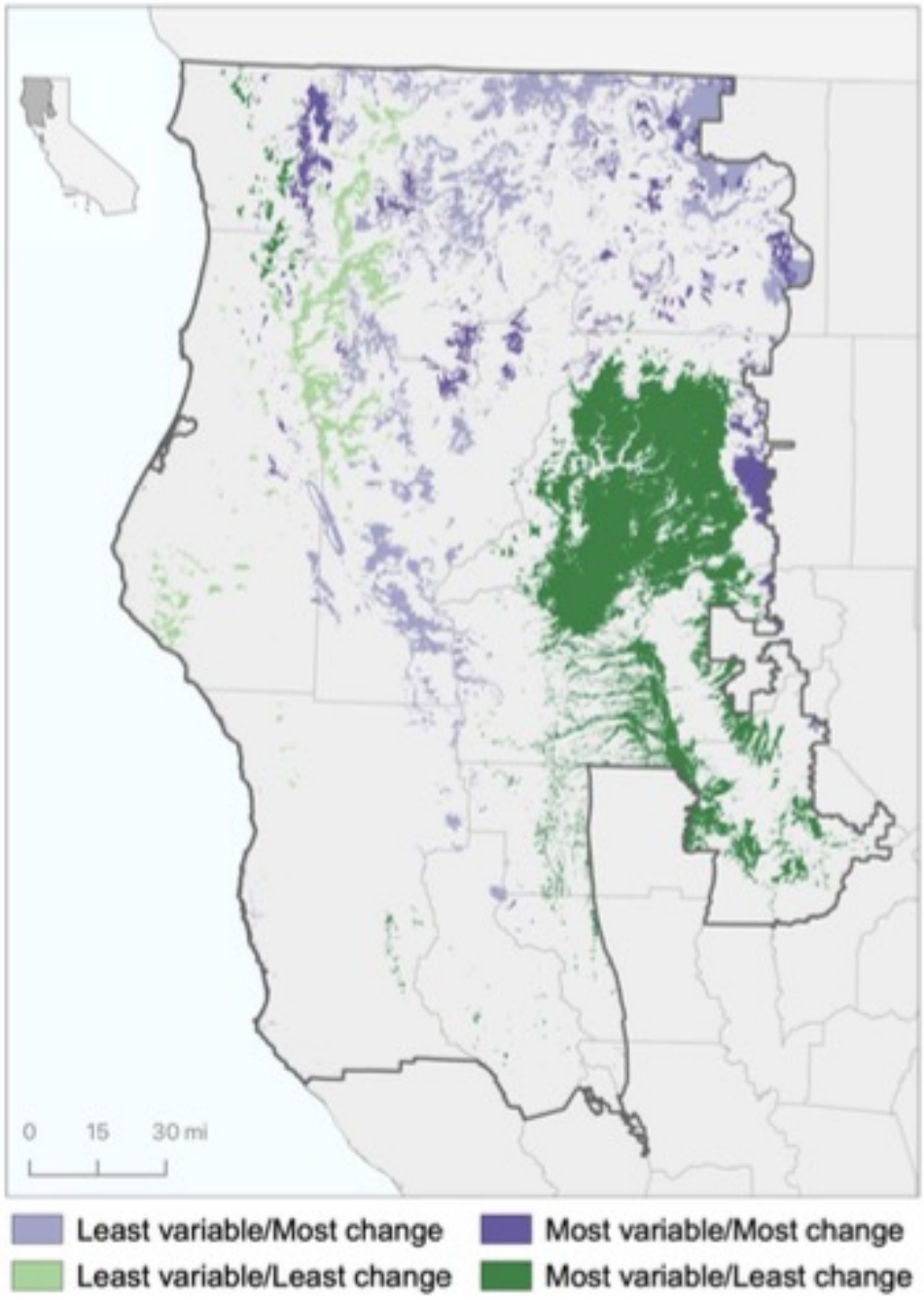
Climatic Water Deficit Maps

Some areas of the landscape may be more vulnerable to significant ecosystem changes



Climatic Water Deficit Maps



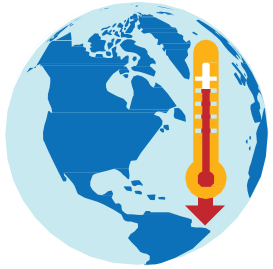


Data Sources: Basin Characterization Model (Flint & Flint 2014); Conservation Biology Institute
Map produced by EcoAdapt, Sept.2021

Adaptation Strategies & Actions

Climate change adaptation refers to adjustments in natural or human systems in response to changing climate conditions

ADAPTATION STRATEGIES:



Reduce climate impacts
(sensitivity & exposure)

Increase climate resilience
(adaptive capacity)

Reduce climate change vulnerability

Adaptation Approaches

Resistance/Resilience

Focused on managing for persistence of existing ecosystems

Example: Use exclusion fencing in upland areas to prevent herbivory of oak seedlings

Acceptance

Focused on accommodating change in response to novel conditions

Example: Identify areas where post-fire type conversion should be allowed to occur without management intervention

Direct/Response

Focused on actively facilitating change/ transformation in response to novel conditions

Example: Experiment with seeds from climate analog zones for restoration projects

Knowledge

Focused on gathering information about climate impacts and/or management effectiveness

Example: Expand research on hardwood silviculture techniques, esp. for drought- and heat-tolerant species

Collaboration

Focused on coordinating management efforts and/or capacity across organizations

Example: Develop and/or strengthen new and existing collaborative networks in order to leverage resources

Adaptation Products

Product: *Vulnerability-adaptation summaries linking suite of adaptation strategies & actions to identified vulnerabilities*

- Summary of key habitat and species vulnerabilities
- Table linking suite of adaptation strategies & actions to identified vulnerabilities

COASTAL HABITATS
Climate Change Vulnerability and Adaptation Strategies for Northwestern California

Coastal Habitat Descriptions

This summary includes information about coastal habitats considered within the project area of the Northern California Climate Adaptation Project, which includes the Klamath, Six Rivers, Mendocino, and Shasta-Trinity National Forests as well as public lands managed by the Bureau of Land Management, including Arcata, Redding, and portions of the Ukiah field offices.

The following coastal habitat types are considered in this summary:

Coastal Dune Systems

Coastal Bluffs & Scrub

FOREST AND WOODLAND HABITATS
Climate Change Vulnerability and Adaptation Strategies for Northwestern California

Forest and Woodland Habitat Descriptions

This summary includes information about forest and woodland habitats considered within the project area of the Northern California Climate Adaptation Project, which includes the Klamath, Six Rivers, Mendocino, and Shasta-Trinity National Forests as well as public lands managed by the Bureau of Land Management, including Arcata, Redding, and portions of the Ukiah field offices.

The following forest and woodland habitat types are considered in this summary:

Coastal Conifer-Hardwood Forest

Oak Savannas & Open Woodlands

SHRUBLAND AND GRASSLAND HABITATS
Climate Change Vulnerability and Adaptation Strategies for Northwestern California

Shrubland and Grassland Habitat Descriptions

This summary includes information about shrubland and grassland habitats considered within the project area of the Northern California Climate Adaptation Project, which includes the Klamath, Six Rivers, Mendocino, and Shasta-Trinity National Forests as well as public lands managed by the Bureau of Land Management, including Arcata, Redding, and portions of the Ukiah field offices.

The following shrubland and grassland habitat types are considered in this summary:

Mixed Grasslands

Mixed grasslands are generally dominated by herbaceous vegetation comprised of both annual and perennial grasses and forbs. Grassland types considered in this assessment include interior or valley grasslands (found in the northern Central Valley and up to 2,300 ft on coastal hills and foothills), coastal prairie grasslands (found on coastal terraces influenced by summer fog), and serpentine grasslands (occur as habitat islands on ultramafic soils).

Photo by Jim Eaton/Tuleyome (Public Domain)

Chaparral Shrublands

Chaparral habitats are dominated by sclerophyllous ("hard-leaved") evergreen shrubs and small trees that are well-adapted to fire and drought, and can occur on both serpentine (ultramafic) and non-serpentine soils. Both montane chaparral (elevation 3,000–9,000 feet) and mixed chaparral (elevations below 5,000 feet) communities are found in northwestern California, often occupying drier sites and/or areas with shallow soils or recently disturbed areas.

Alpine Grasslands/Shrublands

Alpine grasslands and shrublands occur above the treeline or in scattered openings within subalpine forests of the Klamath Mountains and southern Cascades. Plant communities are typically dominated by perennial herbaceous species (e.g., cushion plants, tufted or rhizomatous graminoids), and in some areas may include dwarf or low prostrate shrubs. Vegetation composition is strongly influenced by topography, substrate, and the harsh conditions typical of high-elevation sites.

Shrubland and grassland habitats in northwestern California have already experienced habitat loss and degradation due to land-use conversion, habitat fragmentation, and shifts in species composition following the spread of invasive plants and loss of historical disturbance regimes.

CLIMATE CHANGE VULNERABILITY AND ADAPTATION STRATEGIES FOR GRASSLAND AND SHRUBLAND HABITATS OF NORTHWESTERN CALIFORNIA

FRESHWATER HABITATS
Climate Change Vulnerability and Adaptation Strategies for Northwestern California

Freshwater Habitat Descriptions

This summary includes information about freshwater habitats considered within the project area of the Northern California Climate Adaptation Project, which includes the Klamath, Six Rivers, Mendocino, and Shasta-Trinity National Forests as well as public lands managed by the Bureau of Land Management, including Arcata, Redding, and portions of the Ukiah field offices.

The following freshwater habitat types are considered in this summary:

Rivers, Streams, & Floodplains

Rivers and streams in northwestern California receive precipitation input from both snowmelt and rainwater, with rain-dominated basins primarily occurring in coastal areas. They are typically characterized by high winter and low summer flows as well as biota adapted to high inter-annual flow variability and frequent disturbances. Low-lying floodplains adjacent to river and stream channels experience periodic flooding, and often include riparian vegetation such as bigleaf maple (*Acer macrophyllum*), Port-Orford-cedar (*Camaecyparis lawsoniana*), Oregon ash (*Fraxinus latifolia*), cottonwood (*Populus fremontii*), valley oak (*Quercus lobata*), alder (*Alnus* spp.), and willows (*Salix* spp.).

Photo by Bob Wick/BLM (Public Domain)

Wet Meadows & Fens

In northwestern California, wet meadows and fens primarily occur in montane and subalpine areas (3,950–6,400 ft), although they can also be found in lower-elevation montane valleys and depressions. Wet meadows are located in areas that confine or slow the release of groundwater over the landscape, and can range from open, herbaceous-dominated areas to densely packed riparian shrubfields. Fens, which may occur within wet meadows or adjacent to lakes or ponds, are usually small (less than 2.5 acres) and contain surface water for a significant portion of the year. Fens are characterized by a thick peat substrate that supports many distinctive plant species, including mosses and the insectivorous California pitcher plant (*Darlingtonia californica*).

Seeps & Springs

Seeps and springs are the physical locations where groundwater is discharged from aquifers to the Earth's surface, with discharge rates varying seasonally depending on the depth and size of the supporting aquifers. Seeps and springs support unique, biologically rich ecosystems, and can include aquatic, wetland, and terrestrial species that are dependent on or benefit from groundwater for persistence.

CLIMATE CHANGE VULNERABILITY AND ADAPTATION STRATEGIES FOR FRESHWATER HABITATS OF NORTHWESTERN CALIFORNIA

Adaptation Strategies & Actions

GOAL 1. REDUCE THE IMPACT OF NON-CLIMATE STRESSORS

1.1 Prevent the introduction and establishment of invasive species and remove existing populations

1.2 M

1.3 Re

1.4 Re

GOAL

2.1 U

2.2 Er

GOAL

3.1 Re

3.2 Re

3.3 Re

GOAL

4.1 In

GOAL 8. MAINTAIN AND PROTECT REFUGIA

8.1 Prioritize and maintain sites that may be more resistant to changes in climate (e.g., cooler, wetter sites), harbor high biodiversity, and/or provide habitat for rare species

Example adaptation actions:

- Identify forest areas of least/slower change to support the protection and management of potential climate change refugia **(R/K)**
- Protect mature and late-successional forests **(R)**
- Expand reserve boundaries to include mid-seral and complex early-seral forests that have high structural diversity and the potential to develop old-growth characteristics over time **(R)**

Vulnerabilities addressed:

Land-use conversion and human land uses that result in habitat loss and fragmentation

Air temperature, precipitation, soil moisture, drought, wildfire *(loss of cool, moist refugia in mature and late-successional forests)*

Habitat diversity *(loss of structural complexity and range of successional stages)*

Questions?

EcoAdapt™
Meeting the challenges of climate change

FOREST SERVICE
U.S. DEPARTMENT OF AGRICULTURE

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

CONSERVATION BIOLOGY INSTITUTE