Climate Change and Adaptation: Nature-based Solutions for Wildlife and People

Training for CA Dept. of Fish & Game --State Wildlife Action Plan Climate Change Update

Ellie M. Cohen and PRBO Staff

March 7, 2012
PRBO Conservation Science

Applied Bird & Ecosystem Studies to Improve Conservation Outcomes - using birds and other indicator species

- Founded in 1965
- 140+ staff and seasonal biologists
- 2011 Budget: ~$9m
PRBO Conservation Science

PRIORITY: Reduce Impacts of Environmental Change on Ecosystems & Enhance Capacity to Adapt

CLIMATE CHANGE
Biodiversity Hotspot: California vital globally!

http://gis.tnc.org/data/MapbookWebsite/map_page.php?map_id=53
California Wildlife Action Plan Update 2013

http://www.dfg.ca.gov/Climate_and_Energy/Climate_Change/
1. Climate Change – Latest Findings
2. Impacts on Wildlife
3. Adaptive Solutions
4. Climate Smart Conservation
5. Other Considerations
CO₂- higher than anytime in 800,000 years … or 15-20 million years?

By 2050 with “business as usual” - CO₂ at 600 ppm

Today’s CO₂ Concentration ~393 ppm

Last time sustained CO₂ levels this high --15-20 m years ago, SL 25-40 m higher, 3-6°C warmer– Tripati et al, Science, Dec 2009

used ratios of boron to calcium in foraminifera - marine algae ; **atmospheric CO₂ was stable at about 280 ppm for almost 10,000 years until 1750
2000-2009 Warmest Decade on Record (1990-1999 was warmest before that)

- 2010 tied for warmest year (with 2005)
- 2011 9th warmest & warmest La Nina year on record
- Another record breaking year expected soon

[http://www.nasa.gov/topics/earth/features/2010-warmest-year.html](http://www.nasa.gov/topics/earth/features/2010-warmest-year.html) -- differed by less than 0.018 degrees F

Since 1950, almost all of warming that actually heated Earth went into the ocean.

Ocean Acidification Rate - Fastest in 300m yrs .......... too fast for many species to adapt?


  - lower pH in past = mass extinctions; tipping point is pH of 7.8 - calcified organisms begin to disappear, jellies, algae take over; [http://www.eoearth.org/article/Ocean_acidification](http://www.eoearth.org/article/Ocean_acidification)
Puget Sound: measured **7.7 pH already** in 2010; impacts on estuaries? (current global average is 8.1 pH; IPCC projected 7.8 pH globally by 2100)

Pteropods dissolve in pH ~7.7

Size of a small pea- eaten by krill, whales, juvenile salmon…. **pH of ~7.8 projected global avg by 2100 under IPCC “business as usual” scenario**


NOAA: [http://www.pmel.noaa.gov/co2/story/What+is+Ocean+Acidification%3F](http://www.pmel.noaa.gov/co2/story/What+is+Ocean+Acidification%3F)

Arctic Sea Ice Extent 1953-2011
Lowest Volume on Record--Sept 2010-Feb 2011

“...the Arctic summer sea ice cover is in a death spiral. It’s not going to recover.”

Mark Serreze, Director, Natl. Snow & Ice Data Center (NSIDC)
Ice Sheets Melting Faster—both polar regions

Pine Island Glacier (bigger than NYC):

melting into sea at rate of 2.5 miles per year or 35 ft per day

World Meteorological Organization (WMO) and Intl. Council for Science (ICSU ) ;
*Observations beneath Pine Island Glacier in West Antarctica and implications for its retreat*
- Rate of global SLR already >2x faster than IPCC 2007 predictions
  (www.climateinstitute.org.au)

Vermeer, M., Rahmstorf, S. *Global sea level linked to global temperature*. Proceedings of the National Academy of Sciences, December 2009


www.energybulletin.net/stories/2012-01-03/hansen-still-argues-5m-21st-csea-level-rise-possible
17 ft SLR with

- 3 ft. sea level rise (slr)
- 4 ft. + high tide
- 10 ft. wave surges

www.climatechange.ca.gov
Extreme Drought - Permanent Dust Bowls Predicted in Southwest over Decades Ahead

2000-09 2030-39 2060-69

Palmer Drought Severity Index of -4 or lower considered extreme drought; UCAR graphics; not forecasts

Drought under global warming: a review, Aiguo Dai, National Center for Atmospheric Research, 19 Oct 2010
Extreme, Unpredictable, Deadly Weather Events

“It’s not the right question to ask if this storm or that storm is due to global warming, or is it natural variability. Nowadays, there’s always an element of both.”
- Kevin Trenberth, National Center for Atmospheric Research, Aug 15, 2010

Record-breaking: flooding in Pakistan; heat/fire in Russia summer 2010; mud slides in China NY Times, Aug 15, 2010; Australian flooding Dec-Jan 2011; rain, snow and flooding in Midwest spring 2011; tornadoes in April 2011; drought and fire in AZ, TX and NM spring 2011
2011 - record number of extreme events; 2012 - 4th warmest winter on record, 80 tornadoes March 2nd

..a record 14 weather and climate disasters in 2011 each caused $1 billion or more in damages &….loss of human lives --NOAA [http://www.noaa.gov/extreme2011/drought.html]; January was USA's 4th-warmest on record – USATODAY.com [http://www.torontosun.com/2012/03/05/scientists-see-rise-in-tornado-creating-conditions;]
Climate change isn't real.

It won't come soon.

It won't be that bad.

Let's dig a hole!

And keep digging!
Intensity of extreme winter precipitation in West projected over next 50 yrs


...but a decrease in mean precipitation in Southwest
Climate Change Increases Threat of Fire to US West  June 2011 [http://www.scientificamerican.com/article.cfm?id=up-in-flames](http://www.scientificamerican.com/article.cfm?id=up-in-flames);
Marlon et al. **PNAS Plus: Long-term perspective on wildfires in the western USA.**
*Proceedings of the National Academy of Sciences*, 2012; DOI: [10.1073/pnas.1112839109](http://10.1073/pnas.1112839109); Photo by Bill Clayton map.sdsu.edu
Snowpack over western US; project 70%-90% loss in Sierra by 2075

Last 50 yrs--so. Sierra snowpack larger, no. Sierra pack has shrunk; snowpack has declined over ¾ of western US--
Feb 15, 2012 Mike Dettinger, USGS Hydologist, Scripps
CA Climate Change Center, www.climatechange.ca.gov
Water Shortages        Water Storage

CA Climate Change Portal  www.climatechange.ca.gov
Fog on West Coast past 100 yrs; impact on entire Redwood ecosystem?


National Park Service
Wave Height Extremes—increased by ~30% last 2-3 decades; project up to 46 ft.+ next 100 years

Impacts potentially greater than sea level rise
~25% of all species extinct by 2050;
Thomas et al Nature 2004

- underestimate?

Edith’s Bay Checkerspot- Jasper Ridge population extinct; mismatch in timing between emergence of plantain, caterpillar
Alpine species have nowhere to go

Pika or rock rabbit

Elevation at Yosemite (Grinnell):

- 1900- 7,800 ft
- 2004- 9,500 ft
- 500ft higher elevation just in last 10 years

So CA/ Sonoran Desert Record Drought 
2006, 2007 = Reduced or No Songbird Breeding

Crissal Thrasher

Phainopepla

Chris McCreedy  www.prbo.org
Changes in Songbird Arrival Dates

- ~50% have changes in arrival & departure dates
- Mismatch in timing between birds and food?

MacMynowski et al., Global Change Biology, 2007
Grant Ballard [www.prbo.org]
Dramatic decline in SF Estuary copepods with non-native spp invasion during saltwater intrusions

-due to drought & freshwater diversion

-synergistic effects of climate extremes & environmental perturbation facilitated invasives

Cassin’s auklets are expected to decline by >62% over next 20 yrs if 2005-2006 anomaly repeats.

SE Farallon Island- mean productivity = 0.72
Future of Salmon in CA?

San Francisco Chronicle:
“Salmon season called off in bid to save chinook”
April 11, 2008
“Smallest fall run of chinook salmon reported”
February 19, 2009
“Feds: Calif. returning chinook salmon a record low”
February 11, 2010
Common murres:
- breeding 20 days earlier
- likely tracking changes in upwelling
- impact on population?

[Graph showing the timing of breeding for common murres from 1972 to 2010]
Extreme Heat Events… *Nest Abandonment, Chick Mortality on Alcatraz, Farallon Refuge*

Brandt’s Cormorant

Record Heat in SF Bay Area- May 15-16, 2008
PRBO Conservation Science

Acorn Woodpecker: negative response to projected future climate (precipitation)
Oak Titmouse: positive response (vegetation)

Two oak woodland associated bird species but different responses to changing conditions....

Variables in order of Importance:
1. Vegetation
By 2070: Over 50% of CA with very different “no-analog” bird communities

Red= Very Different
Blue= Less Different

www.prbo.org/data

- Data from 60 land bird focal species; from multiple partners including KBO, CDFG, others
- Assumes all exist 60 years from now
- Combined with temperature, precipitation and vegetation variables
- From IPCC moderate climate scenarios A1B, A2

Source: PRBO, Stralberg et al., PLoS One, 2009
RUNNING ON EMPTY...

POPULATION

6982374193

FOSSIL FUELS

WILDERNESS

FISHERIES

WATER
Humans Rely on Healthy Ecosystems!

**Ecosystem Services**

- Food
- Freshwater
- Wood and Fiber
- Fuel
- Climate
- Flood
- Disease
- Water quality
- Recreational
- Educational
- Spiritual

www.millenniumassessment.org/en/index.aspx
How Might We Provide Time for Wildlife and People to Adapt?  (*adaptive capacity*)
Must Manage for Multiple Benefits Simultaneously—move from single species to whole ecosystem approach
To Prevent Extreme Climate Disruption—Engage in Mitigation and Adaptation

- **Mitigation**: reduce greenhouse gas emissions and enhance carbon sinks

- **Adaptation**: actions to reduce the risks of and to adapt to climate change impacts on the human and natural environment
1. Identify/reassess assumptions, targets & outcomes
   - Focal (indicator) species
   - Functioning habitats
   - Ecosystem Benefits (e.g., groundwater recharge, flood control)

2. Identify threats & opportunities
   - Climate Change w/ other Stressors
   - ID Vulnerable Habitats, Populations
   - Policy Changes

3. Identify & prioritize conservation & management options
   - Increase Adaptive Capacity
   - Protect/Restore
   - Modify Management

4. Implement conservation & management options
   - Monitor, research, evaluate, adapt; Scientists, managers, policymakers & community
   - Restore/design habitat
   - Change harvest rates (e.g., fisheries)
   - Revise Policies
A Vulnerability Assessment seeks to determine how susceptible—how at risk—a species or a system is to the negative impacts of climate change.


Assessed 156 rare plant species
Found most species vulnerable

Example: *Brodiaea orcuttii*

Preliminary result: highly vulnerable

- Prefers vernaly moist grasslands and is dependent on a seasonal flood regime.
- Predicted climate change exposure is +2.2-2.4°C for half of the *B. orcuttii* occurrences and +2.5-2.7°C for the other half of the *B. orcuttii* occurrences (Figure 2).
- Anthropogenic barriers: Development and construction are major threats; the majority of its range is surrounded by high density urban interface.
- Renewable energy production within the species range also threatens the species, decreasing its ability to shift range and, therefore, increasing its susceptibility to climate change.

Figure 2: Maxent’s predicted historical (1951-2006) and future (2080) climate suitability

Anacker et al, CDFG, Biogeographic Data Branch
Ranked 358 at-risk bird species

Found 128 (38%) vulnerable to climate change (on top of other threats—e.g., development, invasives)

Most vulnerable in wetlands (e.g., tidal marshes, beaches and rocky shorelines); also marine, arid lands

Helps guide allocation of scarce conservation dollars

Climate Smart: Incorporate development; Climate alone underestimates impacts - e.g., Climate, housing density & oak woodland birds

Red = high conservation value & threat from future urbanization

Brown = high conservation value & threat from future urbanizations, by county

Source: PRBO, Veloz, et al., manuscript, 2012
Renewable Energy Siting: Assess ecological impact, ensure science-based decisions & as eco-friendly as possible

State renewable energy goal -- 33 % of all retail electricity by 2020
Climate Smart: Ranked top 10% of landscape to avoid disturbance from solar siting

*For CA DRECP Planning Area based on breeding land bird focal species*

Finding: Every CA desert region (Colorado, Mojave and Sonoran) contains high priority portions valuable to birds (not including future climate impacts);
Degraded areas recommended for solar siting, other development

http://www.prbo.org/cms/574
and to the website with the data layers available for download:
http://data.prbo.org/apps/drecp/
~80% of highest priority conservation areas fall outside of today’s existing protected areas…

How protect them?

• PRBO statewide **Zonation** analysis of 199 bird species, vegetation, and climate models; includes current and future distributions

• Data from PRBO, KBO, CDFG, Natural Diversity Database, USGS, eBird, Forest Service and more

Source: PRBO, Veloz, et al., manuscript, 2012
Climate Smart: include major private lands efforts to address climate impacts on wildlife—landscape scale.
Climate Smart: Work w/ private landowners to “re-water” foothills through eco-friendly grazing practices

• Leverage Farm Bill funds

• Hire, train 21 partner biologists with NRCS

• Enhance 1 million+ acres on grazing lands in Sac and SJ Valley foothills, and Coastal Watersheds over next 5 years

• Restore water storage & flow = double Hetch-Hetchy

• Ecological, economic benefits
Combined Current/Future Zonation prioritizes riparian areas—mostly “potential” — must be restored.

Source: PRBO, Veloz, et al., manuscript, 2012
• Reduces drought and flood impacts
• Recharges groundwater
• Provides habitat connectivity
• Creates thermal refugia for wildlife
• Supports fish, birds, other wildlife

www.PRBO.org Seavy et al., Why climate change makes riparian restoration more important than ever. 2009. Ecological Restoration Ecol. Rest. v27
Climate Smart: plan for extremes, wider range of variability to increase adaptive capacity

-- Design restorations to succeed under multiple scenarios

-- Reduce stressors and (e.g., non-native predators, noxious invasives,

-- Protect refugia (e.g., marine food web reserves)

-- Manage for habitat and ‘climate space’ heterogeneity

E.g. plan for mega-drought, 1000+ yr flood, increased coastal salinity, etc.
Climate Smart: Test New Restoration Designs

planting more species tolerant of extremes

Shrubs in restoration design

- Sun tolerant
- Clay tolerant
- Wet tolerant
- Dry tolerant
- Fire adapted

Number of species

- Climate Design
- Current Design

Source: Tom Gardali, Nat Seavy [www.prbo.org](http://www.prbo.org)
Climate Smart: Test Restoration Designs—provide more food resources over longer period for disrupted phenologies

Shrubs in restoration design

Source: Tom Gardali, Nat Seavy [www.prbo.org]
Climate Smart: connect Sierra meadows to foothills to valley floor to SF Bay to ocean— for water function, wildlife, people
Design to maximize benefits for wildlife and people
Multi-partner approach: SCC, USFWS, CDFG, SFBayJV, NOAA, USGS, SLT…

Ecosystem “services”:
- Reduce flood impacts
- Reduce sea level rise impacts
- Sustain biodiversity
- Filter out pollutants
- Replenish ground water
- Sequester carbon
- Protect Human Infrastructure—"living shorelines"

North SF Bay ~50k Acres of Wetland Restoration
Napa Sonoma Marsh Restoration, Ponds 2, 2a, 3, Larry Wyckoff, CDFG
Climate Smart: Project where future tidal marsh might be e.g., Petaluma Tidal Marsh, 1.65 m SLR, Low Sediment by 2090

www.prbo.org/sfbayslr
Climate Smart: Prioritize tidal marsh restoration to guide where invest today for best future outcome

Based on tidal marsh birds, sediment availability, sea level rise scenarios; see [www.prbo.org/sfbayslr](http://www.prbo.org/sfbayslr)
Climate Smart- Designed Tidal System: reduce sea level rise, storm surge impact on infrastructure and create new habitat

ESA PWA tidal marsh restoration design
Hayward Area Shoreline Planning Agency, Hayward, CA (SF Bay)

Phase I:

- existing damaged parking lot removed; materials recycled
- Beach widened by 60 ft
- Multi-use bike path relocated inland
- New parking area built north

Partners include: City of Ventura, Ventura County Fairgrounds (Seaside Park), California Coastal Conservancy, California State parks, the State Coastal Commission and the Surfrider Foundation

http://www.surferspoint.org/
Climate Smart: Sonoma Bayland Restoration, San Pablo Bay

- Installing marsh plants, constructing hundreds of small islands to create wind breaks and filter out sediment from the incoming tides
- Breaching levees to allow tidal waters into marsh area
- Building a new levee to protect the railroad, Highway 37 and adjacent private property

http://www.sonomalandtrust.org/
John Burgess / Santa Rosa Press Democrat: Sears Point Ranch Restoration Site
http://www.pressdemocrat.com/article/20120216/ARTICLES/120219645/1042/opinion?p=2&tc=pg&tc=ar
• Identified food web “hotspots” in the California Current

• Identified gaps in protection

• Providing science to policy makers to decide:
  • where to establish marine protected zones
  • what types of protection and when
Climate Smart: Give Time to Sensitive Species to Adapt

Cassin’s Auklets:
• protect from extreme heat
• control invasive predators to help with adaptation
Climate Smart: Reduce Human Impacts—Change shipping lanes, speed; employ near-real time assessments
**Climate Smart: Collaborate across traditional barriers**

*Example: Bay Area Ecosystems Climate Change Consortium*  
or BAECCC  [www.baeccc.org](http://www.baeccc.org)

Bringing together scientists, natural resource managers and planners to sustain nature’s benefits in the face of accelerating climate change

- NOAA Gulf of the Farallones and Cordell Bank National Marine Sanctuaries
- NOAA Coastal Services Center  
  - US Fish & Wildlife Service  
  - PRBO Conservation Science  
  - US Geological Survey  
  - CA Coastal Conservancy  
  - CA Dept of Fish and Game  
  - National Park Service  
  - Bay Conservation and Development Commission  
  - SF Bay Joint Venture  
  - SF Estuary Partnership  
  - Upland Goals Project  
  - Bay Area Open Space Council
**Project Example:** Preparing for SLR & Extreme Storms Along SF Bay Area’s Outer Coast & SF Bay

*Funded by NOAA SARP and NPS*

### Project Objectives
- Assess vulnerabilities to SLR & increased storm intensity and stakeholder information needs from Point San Pedro to Point Reyes.
- Map vulnerabilities at the scale necessary for management.
- Conduct workshops and communicate the findings in accessible, user-friendly formats to apply to local adaptation and response strategies.

### Project Leads
- USGS constructing seamless digital elevation model
- PRBO developing web-based tool and interactive maps
- GFNMS managing team and leading stakeholder participation
**Project Example: Climate Change Technical Update of 1999 Baylands Ecosystem Habitat Goals**

*Funded by State Coastal Conservancy*

**Project Partners include:**

- State of California Coastal Conservancy
- U.S. Fish & Wildlife Service
- San Francisco Bay Joint Venture
- BCDC
- Bay Area Open Space Council

**Project Objectives include:**

- Provide updated habitat restoration and protection goals for next decade- including sites that can accommodate wetland transgression upslope.
- Identify management strategies for more resilient marshes (e.g., improve sedimentation dynamics).
- Identify long term science gaps and management needs to implement recommendations.
- Develop recommendations for “living shorelines”- using habitats to reduce shoreline erosion.
“a management-science partnership informing and promoting integrated science and natural resource mgmt to address impacts of climate change and other stressors”
How address the economic & ecological challenges of accelerating climate change on top of other stressors?
Employ **Climate Smart** Conservation Principles

- Landscape-scale approach, think & link beyond current protected areas
- Focus on future possible conditions- not past
- Requires flexible & informed management
- Takes into account range of possibilities—extremes
- Benefits wildlife & people
- Avoids maladaptation
- Promotes collaboration, open sharing of information
- Minimizes carbon footprint

*Adapted from National Wildlife Federation: Climate Smart Conservation Principles*

• **Inspire**: I think I can, I think I can

• **Solution oriented**: confident, hopeful, belief in human ingenuity – people more likely to accept the science than if focus is only on dire consequences, inevitable, catastrophic

• **We have CHOICES** --talk about choices we have!

Susan Joy Hassol- AGU talk- December 2011
http://www.climatechangecommunication.org/index.cfm
**Climate Smart: Communicate science terms in ways that have appropriate meaning to public**

<table>
<thead>
<tr>
<th>Scientific term</th>
<th>Public meaning</th>
<th>Better choice</th>
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<tbody>
<tr>
<td>enhance</td>
<td>improve</td>
<td>intensify, increase</td>
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<tr>
<td>aerosol</td>
<td>spray can</td>
<td>tiny atmospheric particle</td>
</tr>
<tr>
<td>positive trend</td>
<td>good trend</td>
<td>upward trend</td>
</tr>
<tr>
<td>positive feedback</td>
<td>good response, praise</td>
<td>vicious cycle, self-reinforcing cycle</td>
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<tr>
<td>theory</td>
<td>hunch, speculation</td>
<td>scientific understanding</td>
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<tr>
<td>uncertainty</td>
<td>ignorance</td>
<td>range</td>
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<tr>
<td>error</td>
<td>mistake, wrong, incorrect</td>
<td>difference from exact true number</td>
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<td>bias</td>
<td>distortion, political motive</td>
<td>offset from an observation</td>
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<td>sign</td>
<td>indication, astrological sign</td>
<td>plus or minus sign</td>
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<td>values</td>
<td>ethics, monetary value</td>
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<tr>
<td>manipulation</td>
<td>illicit tampering</td>
<td>scientific data processing</td>
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<td>scheme</td>
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<td>systematic plan</td>
</tr>
<tr>
<td>anomaly</td>
<td>abnormal occurrence</td>
<td>change from long-term average</td>
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</tbody>
</table>

Climate Smart: Apply the 10% Rule Every Day

Allocate 10% of your time to

T = Test &

E = Experiment

N = Now

www.prbo.org
Stop greenhouse gas emissions and make ecosystem conservation an equal priority now
CO2 Target:

< 350 ppm

“To preserve creation, the planet on which civilization developed” – Jim Hansen

Director, NASA Goddard Institute for Space Studies
Human-made Climate Change: A Moral, Political and Legal Issue, Blue Planet Lecture, Tokyo, Japan, October 2010

Ppm = parts per million of CO2 in the atmosphere
350 ppm is possible

1. Phase out Coal by 2030
   All coal emissions halted in 20 years; no unconventional fossil fuels -
   tar sands, oil shale, methane hydrates

2. Price Carbon Immediately: Fee and Dividend


   Enriching soil carbon, farming with perennials, climate-friendly livestock
   production, protecting natural habitats, restoring watersheds and rangelands,
   protecting ocean biodiversity hotspots

From: Jim Hansen, Human-made Climate Change: A Moral, Political and Legal Issue, Blue Planet Lecture, Tokyo, Japan, October 2010
and Worldwatch Report #179: Mitigating Climate Change Through Food and Land Use
Climate Smart: prohibit new building at sea level, flood plains; include future costs to society
Climate Smart: capture roof rainwater, greywater; require permeable streets/surfaces, white roofs/surfaces


www.oaec.org/water-institute/
www.greywateralliance.org
www.watersprout.org
Climate Smart: link back yards, plant more and plant natives, promote open space

- Link and scale up habitats
- Cool micro-climate
- Strengthen water cycle
- Provide habitat for birds, butterflies, other wildlife

Monkey Flower

www.prbo.org/cms/183
Climate Smart: Engage youth & community in local, hands-on restoration efforts!

PRBO STRAW Project- Students & Teachers Restoring a Watershed  www.prbo.org/straw
1. Climate change impacts are here and accelerating; exacerbates other stressors

2. Make ecosystem conservation an equal priority: water, carbon, biodiversity

3. Plan for extremes: drought, fires, floods, heat, variability

4. Actively apply climate smart adaptive management, including monitoring

5. Be climate-smart!

6. Test, experiment now!

www.prbo.org/climatechange
Our future?

Courtesy Tom Suchanek, USGS
OR...restored watersheds to sustain wildlife and our communities....
…. healthy tidal habitats to protect wildlife and people from sea level rise & extremes….
And healthy populations of fish, wildlife in the ocean.

Murres on Farallones

Juvenile rockfish on Cordell Bank National Marine Sanctuary

Salmon in CA

Photo © Annie Schmidt

Photo © Greg McFall / NOAA / CBNMS
Each of us can make a difference!
Because of our work, in 100 years California’s diverse habitats will still support resilient ecosystems, thriving wildlife populations and vital ecosystem services for California’s residents.

California will still be a premier center for nature on Earth—providing unparalleled economic, cultural, and conservation values.
Additional Resources

- www.nwf.org/Global-Warming/Climate-Smart-Conservation.aspx  Climate Smart Conservation
- www.skepticalscience.com  Explaining climate change science & rebutting global warming misinformation
- www.realclimate.org  Climate science from climate scientists
- www.climatechangecommunication.org  Center for Climate Communication
- www.merchantsofdoubt.org/  how handful of scientists obscured truth from tobacco smoke to global warming
- http://blogs.kqed.org/climatewatch/  climate-related science and policy issues, with a specific focus on California
- www.baeccc.org  list serve- receive weekly biodiversity and climate change news updates
THANK YOU!

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California Department of Water Resources
California Bay Delta Authority
California Landscape Conservation Cooperative
Central Valley Joint Venture
Faucett Family Foundation
Richard Grand Foundation
Marin Community Foundation
Giles Mead Foundation
Moore Family Foundation
David and Lucile Packard Foundation
National Park Service
National Science Foundation
NOAA National Marine Sanctuaries
Natural Resource Conservation Service
Resources Legacy Fund Foundation
San Francisco Foundation
San Francisco Bay Joint Venture
The Nature Conservancy
U.S. Fish and Wildlife Service
USDA Forest Service
USDA Natural Resources Conservation Service
US Geological Survey
and PRBO Board, Members and Staff