POTENTIAL IMPACTS OF CLIMATE CHANGE TO CALIFORNIA’S WILDLIFE AND HABITATS

MARC HOSHOVSKY
CALIFORNIA DEPARTMENT OF FISH AND GAME
WITH SUPPORT FROM CALIFORNIA ENERGY COMMISSION PIER PROGRAM
Key Points

- California’s climate is already rapidly changing
- Expect greater stress on species and habitats
- Species/habitats will respond in different, perhaps surprising, ways
- We can take action now to help them adapt and survive
CALIFORNIA IS ALREADY WARMING
1950-2000

Los Angeles Temperature Trend
1880-2007
NORTHERN HEMISPHERE IS WARMER THAN PAST 1300 YEARS

1961-1990 mean

NORTHERN HEMISPHERE TEMPERATURE RECONSTRUCTIONS

IPCC (2007)
WARMING IS DUE TO INCREASED GREENHOUSE GASES

Sources of California’s 2002 Greenhouse Gas Emissions

- Transportation: 41%
  Mostly motor gasoline burned in light duty vehicles.
- Electric Power: 20%
- Industrial: 23%
- Ag & Forestry: 8%
- Others: 8%

CEC 2005
How will temperature change in the future?

Depends on our choices

- **High emissions**
  - Rapid, fossil-fuel intensive growth

- **Moderate emissions**
  - Primarily fossil-fuel dependent growth
  - Some green technology

- **Lowest emissions**
  - Shift to service & information economy
  - Lots of green technology
How will temperature change in the future?

High Emissions
+8.1 to 10.4 °F

Medium Emissions
+5.6 to 7.0 °F

Lowest Emissions
+3.0 to 4.7 °F

Cayan et al. 2006a
LITTLE CHANGE IN ANNUAL PRECIPITATION

PROJECTED CHANGES IN ANNUAL PRECIPITATION, NORTHERN CALIFORNIA

Percentage of 1951–80 norm

Dettinger 2004
EXPECTED PHYSICAL IMPACTS
EXPECT THREE KEY PHYSICAL IMPACTS

• Greater seasonality in precipitation
  – Less winter snow in mountains
  – More summer drought
• Risk of large wildfires
• Sea level rise
<table>
<thead>
<tr>
<th></th>
<th>Temp Change</th>
<th>Sierra snowpack</th>
<th>Critically dry years</th>
<th>Large fire risk</th>
<th>Sea level rise</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>High Emissions</strong></td>
<td>8-10.4°F</td>
<td>90% loss</td>
<td>2.5x</td>
<td><em>not evaluated</em></td>
<td>22-33&quot;</td>
</tr>
<tr>
<td><strong>Medium Emissions</strong></td>
<td>5.5-7.9°F</td>
<td>78-80% loss</td>
<td>2-2.5x</td>
<td>55% increase</td>
<td>14-22&quot;</td>
</tr>
<tr>
<td><strong>Lower Emissions</strong></td>
<td>3.0-5.4°F</td>
<td>30-60% loss</td>
<td>1-1.5x</td>
<td>10-35% increase</td>
<td>6-14&quot;</td>
</tr>
</tbody>
</table>
Most of California’s water depends on snow.
<table>
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<tr>
<th>Snowpack Already Reducing in Sierra</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dana Glacier</strong></td>
</tr>
<tr>
<td><img src="1883_I.C._Russell.png" alt="Image 1" /></td>
</tr>
<tr>
<td><img src="September_5_2004_H._Basagic.png" alt="Image 2" /></td>
</tr>
<tr>
<td><strong>Darwin Glacier</strong></td>
</tr>
<tr>
<td><img src="August_14_1908_G.K._Gilbert.png" alt="Image 3" /></td>
</tr>
<tr>
<td><img src="August_14_2004_H._Basagic.png" alt="Image 4" /></td>
</tr>
</tbody>
</table>
SNOWPACK WILL CONTINUE TO SHRINK

- Historical Average (1961–1990)
  - 100% remaining

- 2070–2099
  - Lower Warming Range
    - Drier Climate
    - 40% remaining
  - Medium Warming Range
    - Drier Climate
    - 20% remaining

April 1 snow water equivalent (inches)
Much less water storage as snow.
MORE WINTER RUNOFF AND FLOODING

![Graph showing the relationship between hours after a storm event and scaled runoff for different temperature increases.]

- Base Case
- 1 degree increase
- 3 degree increase
- 5 degree increase

Scaled Runoff

Hours after storm event
SNOWPACK – ECOLOGICAL LINKS

• Expect
  – More violent winter flooding
  – Increased riparian erosion
  – Calls for more water storage and flood control
  – Less water for species and water-dependent habitats (rivers, wetlands)

• Consider
  – Wider floodplains, meander belts
  – Creative water storage ideas
Fire risk is already increasing

As temperatures increase, wildfire frequency increases.
FIRE WILL CONTINUE TO INCREASE

Historical Average (1961–1990)

2070–2099

Lower Warming Range
Wetter Climate

11% increase

Medium Warming Range
Drier Climate

55% increase

Probability of a large wildfire (more than 200 hectares)
FIRE RISK – ECOLOGICAL LINKS

• Expect:
  – More frequent, large wildfires
  – Longer wildfire seasons
  – Changes in vegetation types and distribution
    • More shrublands, less forest

• Consider:
  – Reducing fuel loads
    • Limits on prescribed burning, though
Sea level is already rising

More than 8” rise at Golden Gate in last 100 years

Roos 2005
SEA LEVEL WILL CONTINUE TO RISE

12” to 36” rise expected by 2100

Emission levels
High
Medium
Lowest
Lands less than 3 feet above sea level

Source: DEM 100m 3ArcSec and 90m NED
Sea level rise
Where do coastal wetlands go?

Newport Bay
Sea Level Rise – Ecological Links

• Expect:
  – Permanent marine flooding of low-lying areas
  – Calls for alternative Delta water transfer
  – Much less freshwater in Delta area
  – Upslope migration of coastal urban areas

• Consider:
  – Protect upslope areas around coastal habitats (wetlands)
  – Rely less on terrestrial reserves in low-lying areas
ECOLOGICAL RESPONSES
EXPECT ECOLOGICAL RESPONSES

- Earlier spring events (phenology)
- Species shifting to cooler areas
- Habitat type shifts
  - Changes in amount and distribution
- Different responses by different species
Spring events already occurring earlier

Average for 130 bird, plant, insect species

3.2 days earlier each decade

- Flowering
- Insect emergence
- Arrival of migratory birds

- Averages for 130 bird, plant, insect species

Root et al. (2005)
EARLIER SPRING EVENTS – CALIFORNIA EXAMPLES

• 12 of 22 bird species (55%) show change

• Different responses by species
  – 7 arrived earlier
  – 2 arrived later

• Four species with strong link to temp
  – Wilson’s Warbler
  – Swainson’s Thrush
  – Black-headed Grosbeak
  – Warbling Vireo

MacMynowski & Root (2006)
Species shifts to cooler areas

Sierra small mammals
Early 1900’s and today

2000 feet
5 high-elev species

1700 feet
4 low-elev species

3800 feet
2 high-elev species
Species shifts – Pinon mouse

**Piñon mouse**
*Peromyscus truei*

habitat expansion associated with elevational increase in distribution

lodgepole - whitebark pine, upper Lyell Canyon, 10,200 ft

piñon-juniper woodland, sage and rabbitbrush understory, east slope
Sierra Nevada, 8000 ft
Habitat shifts in amount and location

Projected changes in biomes by 2100.

- More grass, less shrub
- More shrub, less subalpine

Lenihan et al. 2006
HABITAT SHIFTS - BLUE OAK EXAMPLE

Hannah et al. 2006
CHANGES IN AMOUNT OF HABITAT TYPES

-100% to 100% change

Higher, Medium, Lowest

Alpine & Subalpine

Evergreen conifer forest

Mixed evergreen woodland

Shrubland

Grassland

Desert

Mixed evergreen forest

Emission levels

% change

-100
-50
0
50
100
150
DIVERSE SPECIES, DIVERSE RESPONSES

- More habitat generalists
  - invasive plants, insects and pathogens
- Greater survival of heat-tolerant species
- Mismatches in timing or distribution among species
  - Pollinators and flowers
  - Insectivores and hatching of insect prey
  - Migrating birds and mammals
- Changes in ecosystem functioning?
Moving will be difficult or impossible

- No room upslope (hilltop or mountaintop)
- Impassable migration routes
- Climate warming faster than trees can relocate
- New areas unsuitable for other reasons
  - Wrong soil type
  - No symbiotic species (fungi) for establishment
  - High competition from more hardy exotic species
WHAT DO WE NEED TO DO?

• Most important action
  – Reduce greenhouse gas emissions

• Biological conservation actions
  – Reduce existing stressors on species
  – Buy time for species to adapt
REDUCE EXISTING STRESSORS

Growth and Development

Invasive Species

Water Conflicts

Altered Fire Regimes

Excessive grazing
Plan for climate-sensitive species

- **Species with:**
  - Limited dispersal ability
  - Slow reproductive rate
  - Very specific habitat or soil requirements

- **Populations located:**
  - On isolated habitat “islands”
    - mountain tops, highly urbanized areas, etc
  - Near limits of physiological tolerance
  - At range extremes
    - southernmost, lowest, driest
BUYING MORE TIME TO ADAPT

- Large reserves with topography
  - Provide room for northward and upslope movement
  - Maintain high species and functional group diversity
  - Represent habitat types across environmental gradients
- Maintain/restore habitat linkages
- Reduce fragmentation
BUYING MORE TIME TO ADAPT

• Restore habitats
  – Use species or genotypes that are more resistant or resilient to climate extremes
  – Focus on northern edge of range, higher ground

• Control invasive species

• Assisted migration (?)
Key Points to Remember

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