Climate Change in the North Pacific LCC Region

Terrestrial Ecosystems

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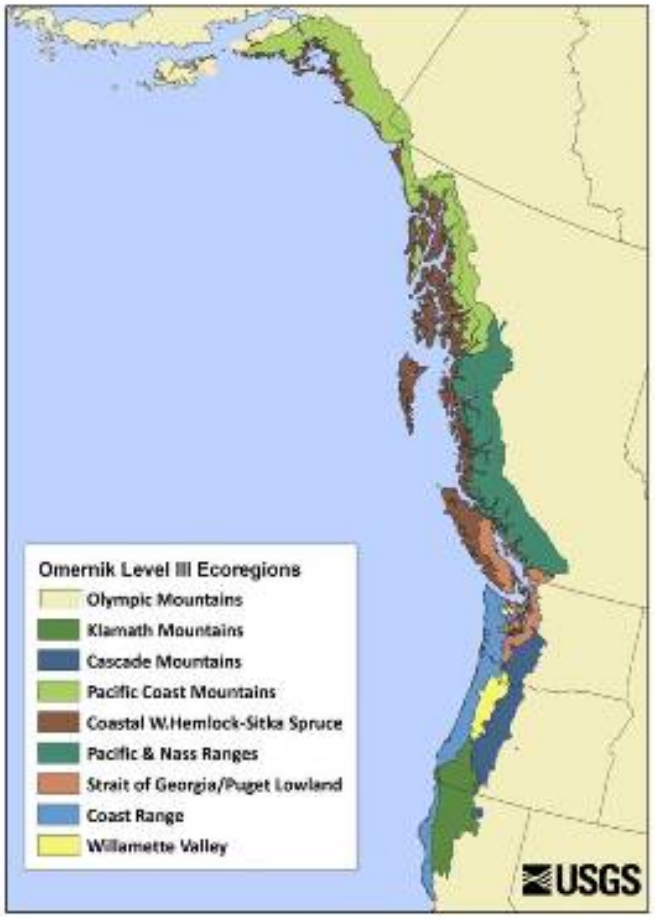
Purpose & Methodology

- Inform NPLCC priorities and operations
- Literature review of ~250 documents
  - Published through Oct. 2013
  - Peer-reviewed science, government reports, NGO publications
  - Historical baselines, observed trends, future projections, adaptation options



CO_2, temperature, and precipitation

- Continued increase in carbon dioxide (CO_2)
  - 394 ppm → 400 to 1000+ ppm by 2100
- Continued increase in temperature
  - Region-wide, 2100: +2.7 to +13°F
  - Winter increase may exceed summer in AK and north BC coast
- Enhanced precipitation variability
  - Annual PNW, 2080s: -10% to +20%
  - Annual BC Coast, 2050: + 6%
  - Annual CA, 2050: -12% to +35%
  - Summer AK, 2099: +5.7%
  - Elsewhere: Winter ↑ | Summer ↓

❖ **Novel climates may develop**

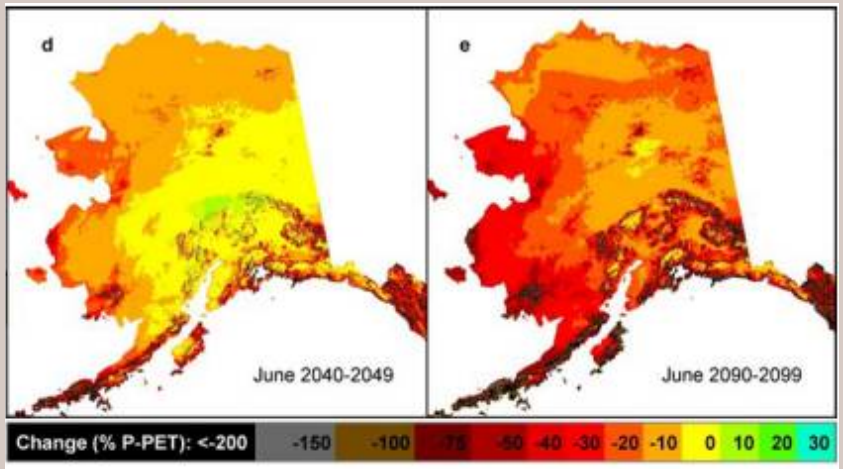
More Climate Change Impacts

- Reduced snowpack, earlier snowmelt, more intense rain, increased drought; altered fog patterns in northwest CA
- Longer growing seasons & frost-free periods. By 2100:
  - AK: +20 to +40 days longer
  - Winter freeze events cease in parts of southern OR, northern CA
- Altered patterns of landslides, windstorms, and avalanches

June Water Availability

vs. 1961-1990

0% to -50% -10% to -75%



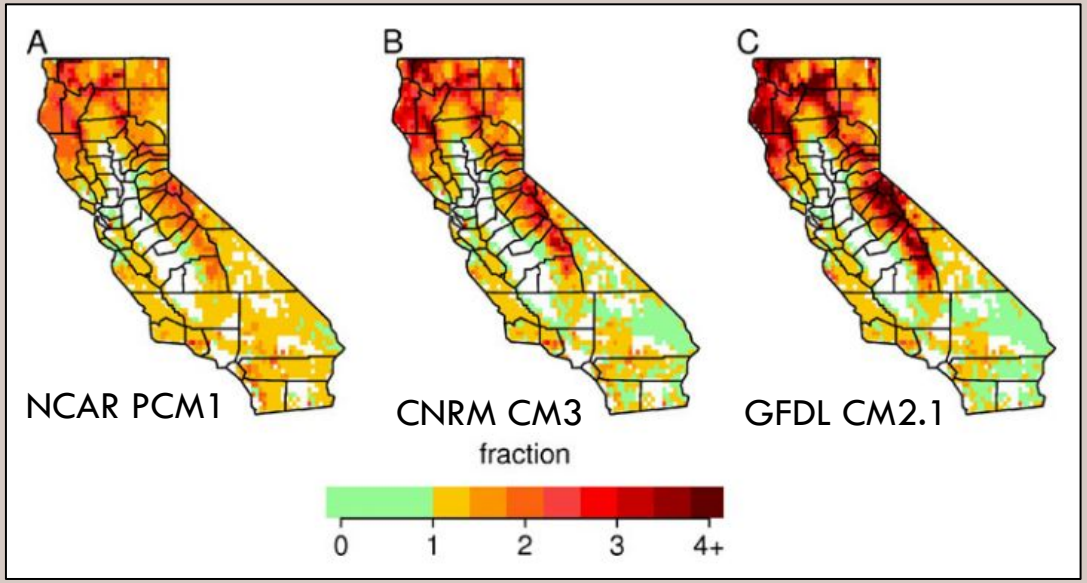
Modified from O'Brien & Loya (n.d., Figure 1)

Increased fire frequency and severity

- Pacific Northwest
  - +78% area burned by 2050
  - Larger (+76% to +310%) and more severe (+29% to +41%) fires in western WA and OR by 2100

2085 Predicted Burned Area

Value of 1: No change
Value of 4: 300% increase



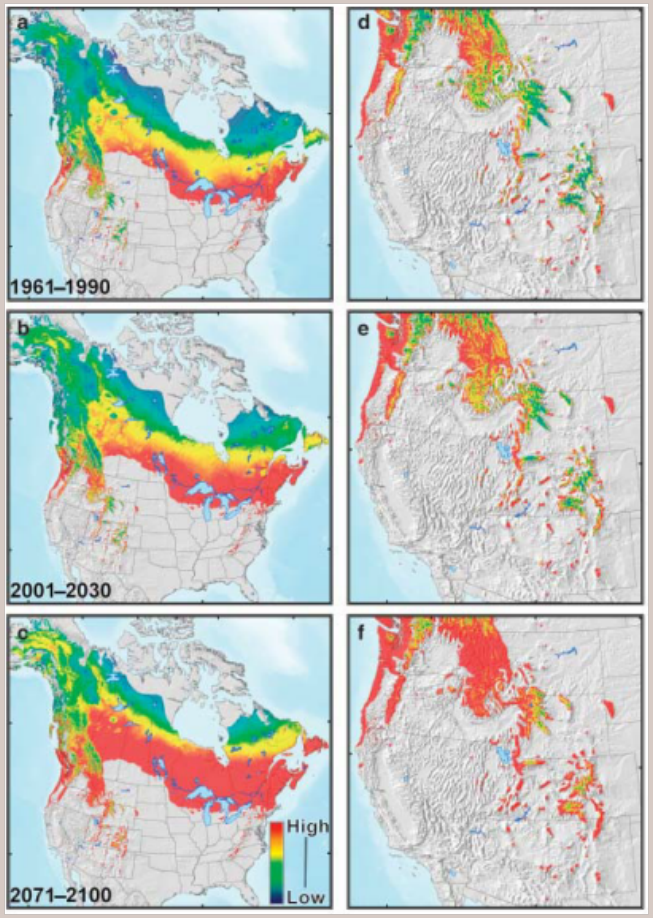
Modified from Westerling et al. (2011, Figure 5)

Spruce bark beetle, the dominant disturbance in southcentral AK, may increase in population

Current range, spruce bark beetle

Holsten et al. (1999, Figure 2)

Predicted probability of spruce beetle offspring developing in 1-yr



Bentz et al. (2010, Figure 1)

Yellow-cedar decline expanding in AK, BC

- 70% mortality across 617,763 acres since 1900
- Snow accumulation threshold: 9.84 inches
- Future Possibilities
  - Migrate northeast
  - Persist in current range under suitable conditions
  - Outcompeted by western redcedar; western hemlock, mountain hemlock, shore pine may enter assemblage

Yellow-cedar deteriorating (USFS)

Altered insect, pathogen, & disease regimes

- Swiss needle cast incidence & severity may increase
  - Reduces growth and needle retention in Douglas-fir, especially under warm, wet conditions
  - Number of infected needles: +9.2%/+1.8°F (average)
  - Expected to expand north from central Oregon and inland
  - Expected to decrease from California to southern Oregon
- Sudden oak death linked to wet springs in CA and OR
  - Optimal pathogen growth: 64-72°F
  - Infected trees more susceptible to mortality during drought
- Mountain pine beetle impacts decline by 2100

Climate Change Impacts

- Reduced snowpack, earlier snowmelt, more intense rain, increased drought, altered fog patterns
- Longer growing seasons & frost-free periods
- Altered patterns of landslides, windstorms, & avalanches
- Increased fire frequency & severity
- Altered insect, disease, & pathogen regimes

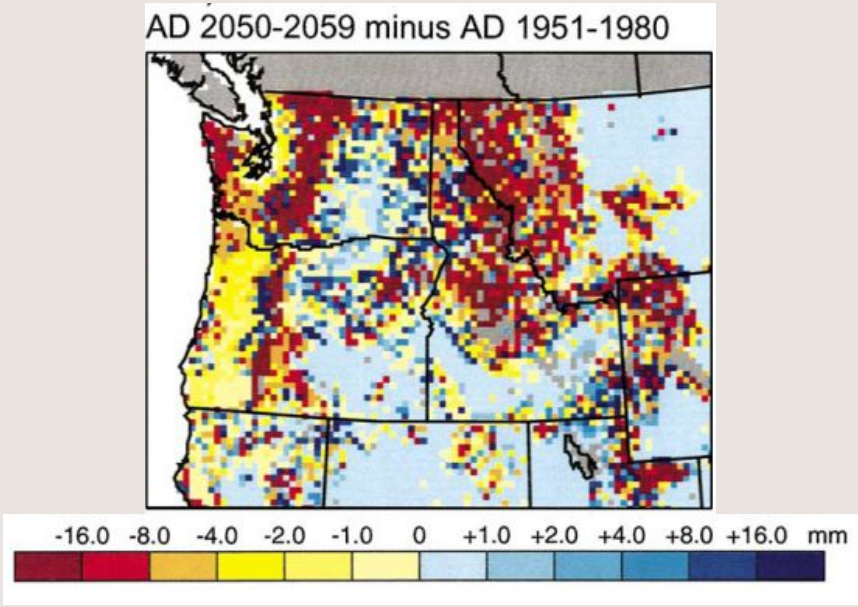
Implications

- Altered soil attributes and carbon sequestration
- Habitat loss and transition
- Phenology, range shifts, and community composition

Altered soil attributes & carbon sequestration

- Increased soil moisture stress in spring and summer
- Warmer winter soils
- Carbon storage is among world's highest

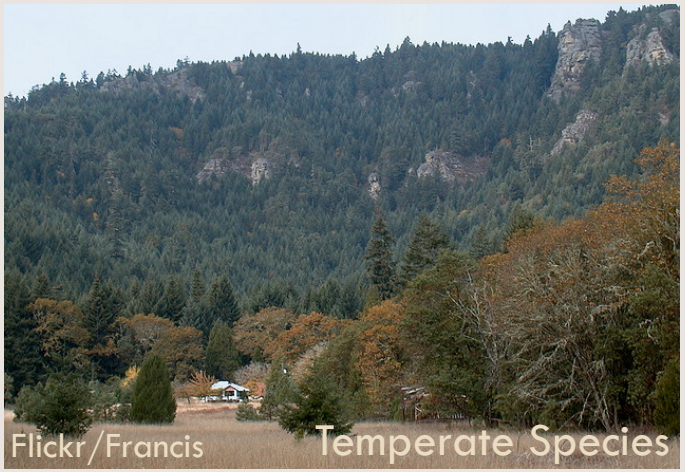
Soil Moisture Anomalies
(July-Sept.)



Modified from Whitlock et al. (2003, Figure 3)

Changes in forest composition

Northwest California

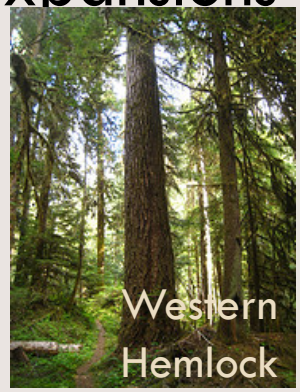


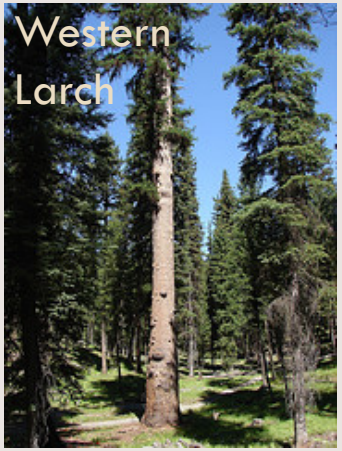
Oregon Coast Range

Subtropical species

Projected range shifts, expansions, & contractions

- Shifts
  - WA: Pacific silver fir replaces mountain hemlock & subalpine meadow
- Expansions





*A 4% decline and shifts inland are also projected

- Contractions
  - High-elevation habitat, especially alpine and tundra
  - Southern AK: Trees and shrubs expected to replace alpine/tundra

Images (L to R): Chris M Morris, Eric Hunt, Jami Dwyer, Flickr/born1945

Changes in non-forested habitats

- Shifts to shrub and grass habitats may occur where heat stress induces tree mortality
- Garry-oak woodlands
  - 20th century losses may be recovered in Oregon, BC, and especially WA
  - Habitat loss could increase due to competition

Native range of Oregon white oak
Little (1971)

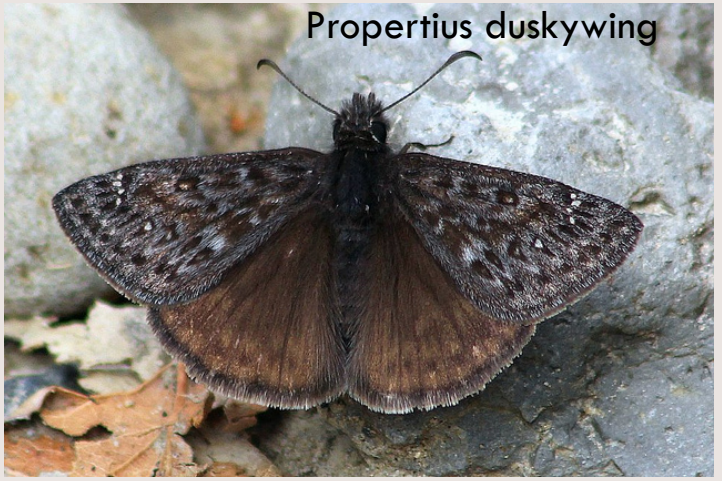
Phenology, range shifts, & community composition: Oak woodlands

- Propertius duskywing unable to colonize less preferable oak species under simulated climate change
- Grass and oak woodland birds in CA least vulnerable
- Northward expansion of prairie-oak habitat may support range expansion for:
  - Ash-throated flycatcher
  - Blue-gray gnatcatcher
  - White-tailed kite
  - Western scrub jay
  - Slender-billed white-breasted nuthatch
  - Lark sparrow
  - Western meadowlark

Western meadowlark

Western scrub jay

Propertius duskywing



Images (L to R): matt knoth, eugene beckes, David A. Hoffmann

57% of western U.S. forest birds have medium to high vulnerability to climate change (single habitat)

May benefit from increased forest fire intensity

Black-backed woodpecker

Olive-sided flycatcher

At high risk from changing fire, temperature, and precipitation regimes

Flammulated owl

Western grebe

Also: Clark's grebe, black-necked stilt, American avocet, long-billed curlew, black tern

May move north

Grey-crowned rosy-finch

American pipit

May decline

White-tailed ptarmigan

May move upslope

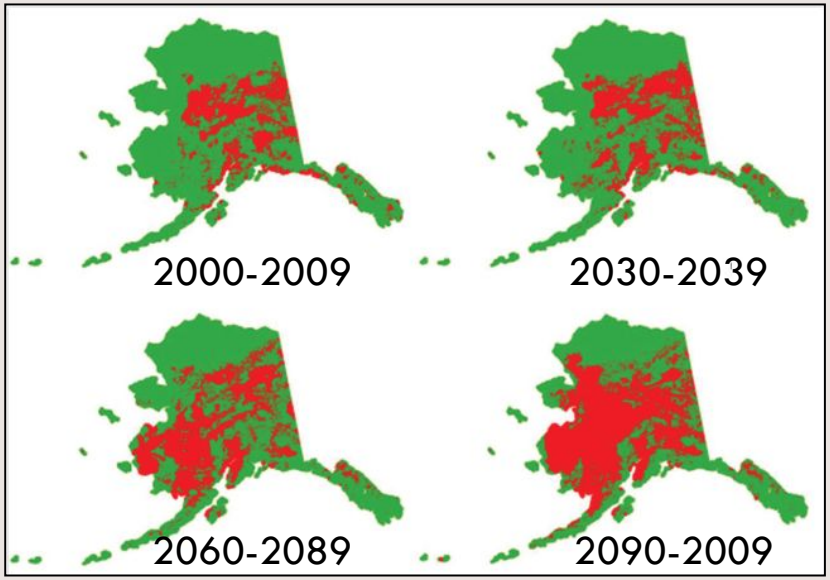
Blue grouse

Images (L to R, T to B): Mike Laycock (NPS), ODFW, Coconino National Forest, Doug Greenberg, Tony Morris, Jamie Chavez, Peter Plage (USFWS), Tom Talbott

Altered migratory & breeding patterns in birds

Alaska

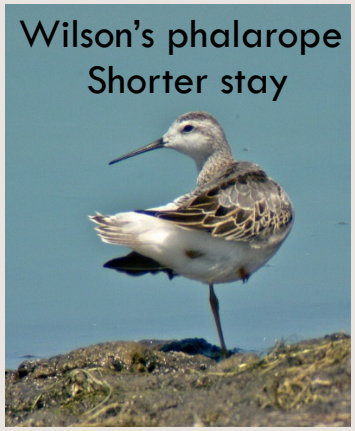
- Trumpeter swans are breeding longer



Potential expansion of trumpeter swan habitat.

Swans Present | Swans Absent

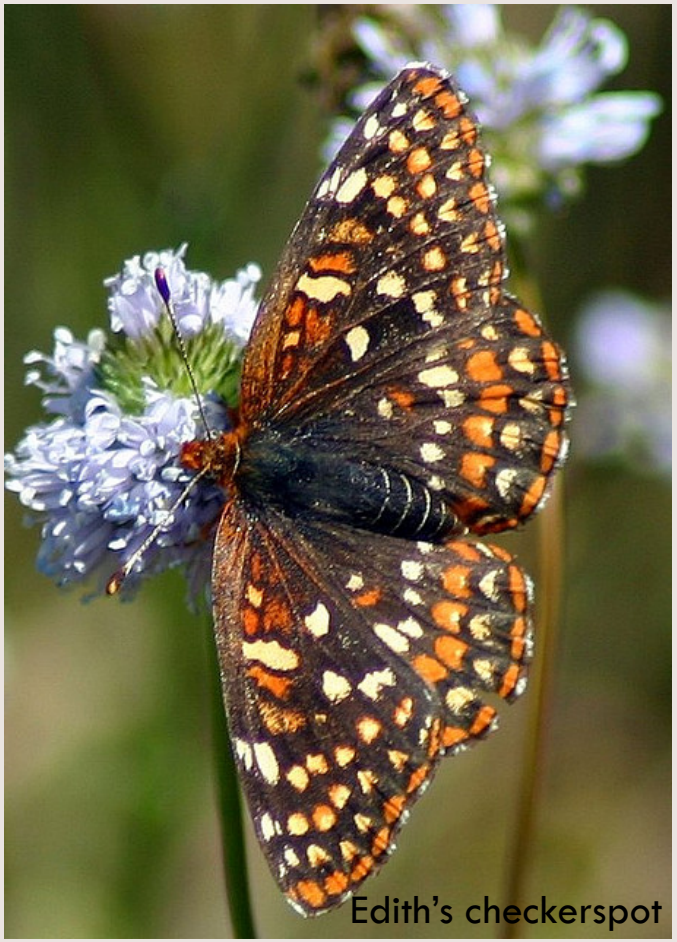
British Columbia & Pacific Northwest



Yellow warbler
Longer stay

Images (L-R): Len Blumin, Kaaren Perry, Kristine Sowl (USFWS)

Invertebrates: Butterflies



Shifting range northward and upward

- Shifting range northward and east across Cascade Mtns
- Warmer, rainier conditions expected to enhance persistence

Images (L to R): David A. Hoffmann, Victor Slade

Mammals

- Milder, less snowy winters are projected to
  - Further isolate habitat for snow-dependent **wolverine**
  - Potentially benefit **moose, mountain goat,** and **deer** populations due to increases in forage
  - May benefit or strain **Canada lynx**


Wolverine


Moose


Canada lynx

Images (L to R): Josh More, Ryan Hagerty (USFWS), Eric Kilby

Mammals

- Yukon: Red squirrels bred18 days earlier
  - 6 days per generation
    - 3.7 days was due to more abundant food
  - Spring temperatures also increased
  - Study period: 1989-2001

- Masked shrew may benefit from more available prey
- Wrangell Island red-backed vole may lose habitat
  - High moisture requirements may not be met

Novel assemblages and interactive effects

- Species combinations new to an area may develop
  - Species turnover projected in U.S. national parks
  - Interactions with invasive and non-native species

Impacts & Implications

- Changes in hydrology
- Altered patterns of landslides, windstorms, & avalanches
- Increased fire frequency & severity
- Longer growing seasons & frost-free periods
- Altered insect, disease, & pathogen regimes
- Altered soil attributes and carbon sequestration
- Habitat loss and transition
- Phenology, range shifts, and community composition

Adaptation Options

- Support science-mgmt partnerships
- Modify forest water mgmt
- Modify infrastructure
- Reduce fuel loads
- Restore, create, or maintain:
  - Climate-resilient habitats
  - Terrestrial connectivity
  - Non-forested habitat
  - Habitat for vulnerable species
- Address invasive/non-native species & insects/pathogens/ disease
- Increase carbon storage
- Preserve/restore genetic diversity

Conclusion

- Climate change impacts are already occurring and are projected to continue
- Some species and ecosystems may benefit
  - Others are highly vulnerable
- Both mitigation and adaptation are needed

Acknowledgements

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Questions?

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