# A climate change vulnerability assessment for Sierra Nevada birds

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www.birdpop.org

**Rodney Siegel, Peter Pyle, James Thorne, Andrew Holguin, Sarah Stock, and Chrissy Howell**

# Project partners

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***The Institute for Bird Populations***

**Jim Thorne and Andy Holguin**
***UC Davis***

**Sarah Stock**
***Yosemite National Park***

**Chrissy Howell and Diana Craig**
***USDA Forest Service***

**Partnering unde**
**auspices of CA**
**LCC**

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# Objectives

1) Identify bird species whose Sierra Nevada breeding populations are most vulnerable to climate change during the next 50 years

2) Assess patterns in habitat associations and distributions that may predispose species to being vulnerable to climate change in the region

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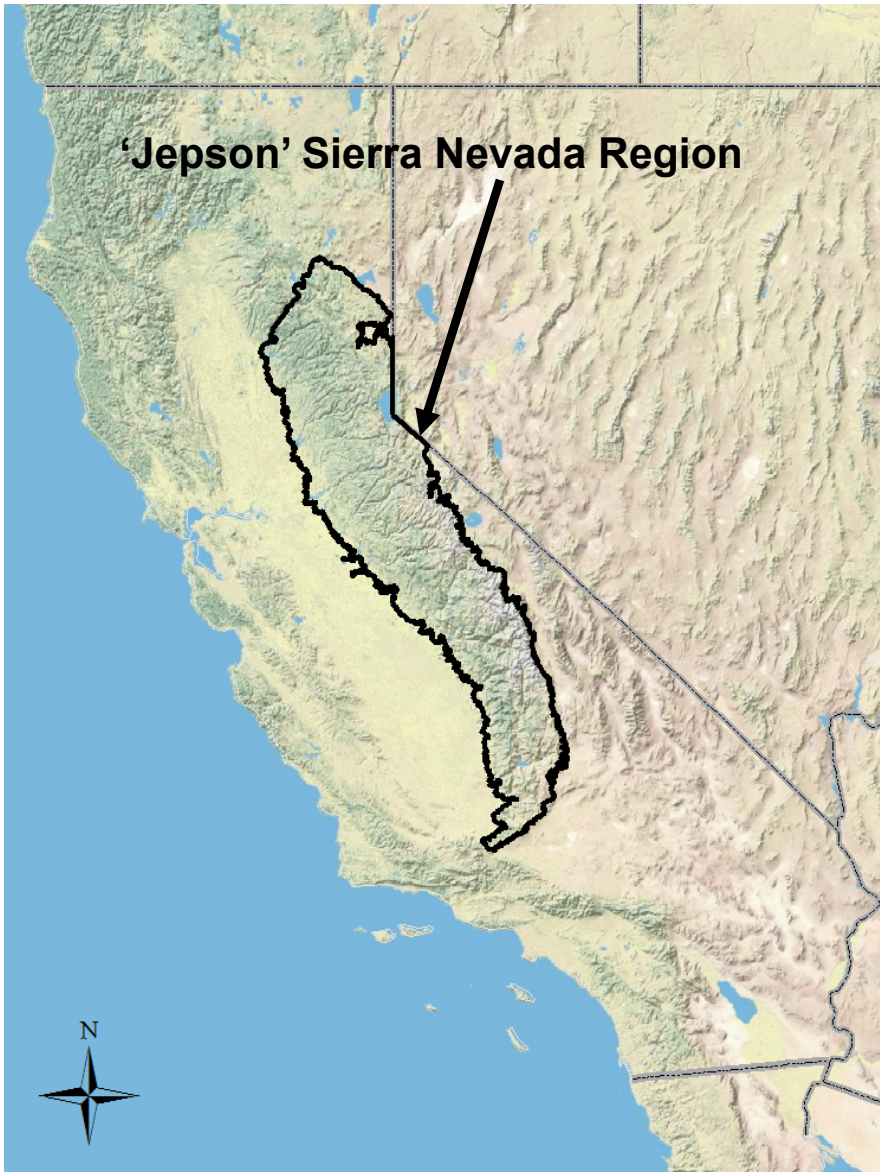
# Study area

## "Jepson" Sierra Nevada Region boundaries

**Extends from North Fork of Feather River south to Tejon Pass**

**Includes Sierra foothills and highlands; also Tehachapis**

- **37% - privately owned**
- **47% - National Forest**
- **10% - National Park**
- **5% - BLM**
- **2% - tribal and misc.**



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# Species selection

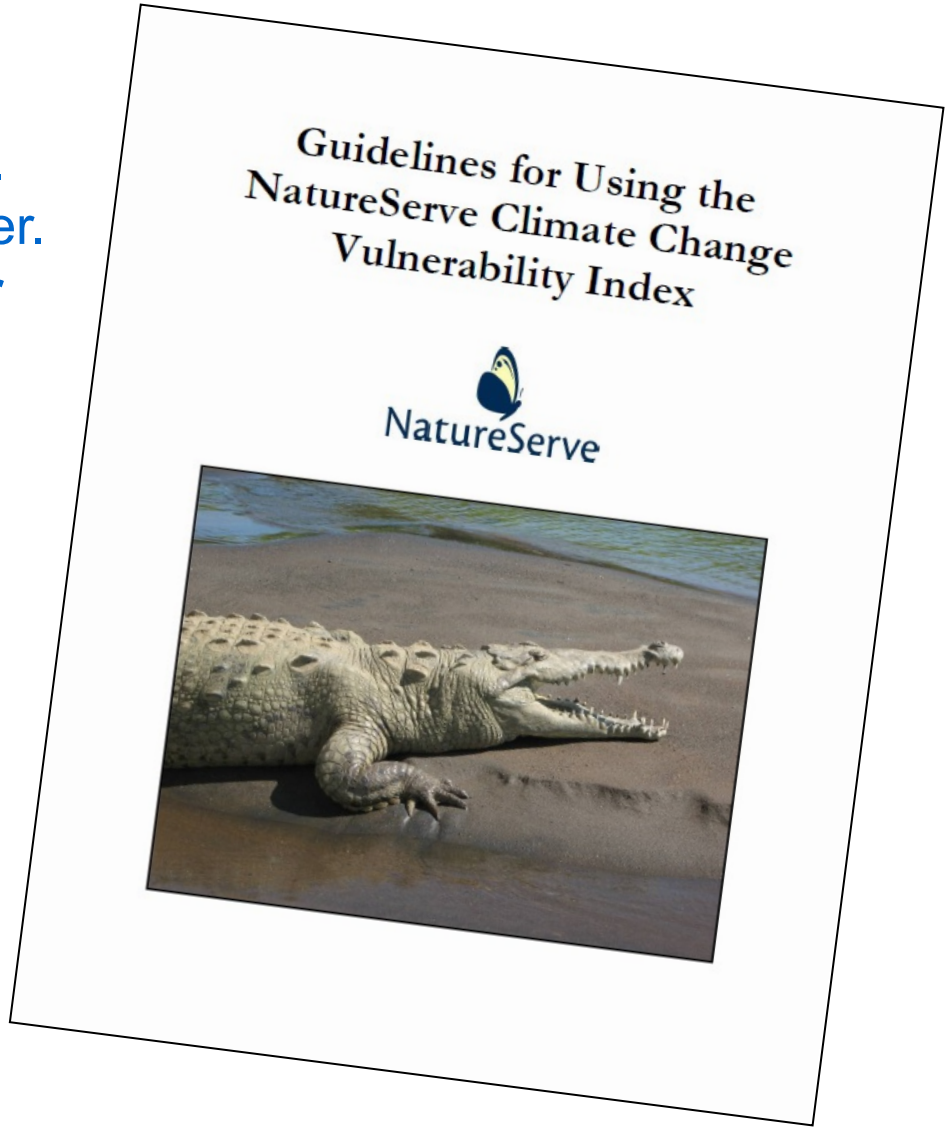
**>300 bird species occur in region, many as wintering birds, passage migrants, or occasional vagrants.**

**We focused more narrowly on REGULAR BREEDERS in the region, with mapped breeding ranges:**

## Result = 168 SPECIES

# NatureServe's Climate Change Vulnerability Index (CCVI)

Young, B., E. Byers, K. Gravuer, K. Hall, G. Hammerson, and A. Redder. 2011. **NatureServe guidelines for Using the NatureServe Climate Change Vulnerability Index (Release 2.1, 7 April 2011)**. NatureServe, Arlington, VA.



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# Other studies using NatureServe's Climate Change Vulnerability Index (CCVI)

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# NatureServe's Climate Change Vulnerability Index (CCVI)

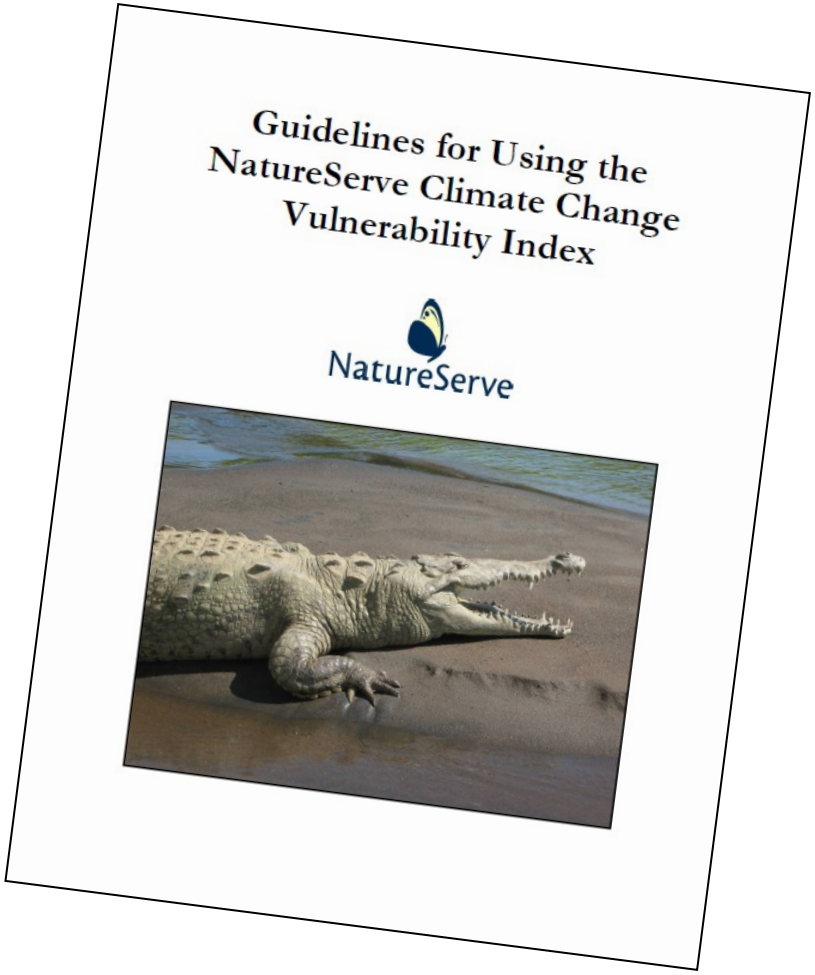
## Inputs for each species:

**Digital range map within area of interest**

**Information on natural history and ecological relationships**

**Historic and current climate data**

**Spatially explicit, quantitative climate projections for area of interest**



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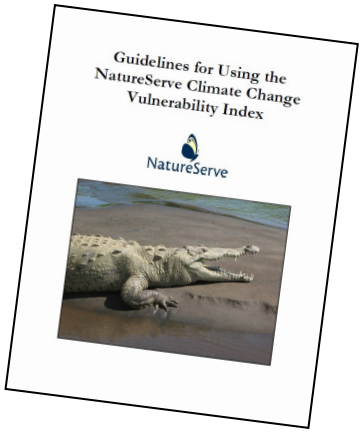
# NatureServe's Climate Change Vulnerability Index (CCVI)




**<u>Output:</u> Assessment of species-specific vulnerability to climate change in the region of interest.**

Non-climate factors like habitat destruction, small population size, or population trend are not considered

CCVI outputs should be considered in concert with current conservation status rankings for conservation planning and priority-making

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# Direct exposure to climate change

## CCVI Section A: Direct Exposure to Climate Change

Index exposure to climate change as:

proportion of each species' current summer range in the Sierra Nevada forecast to undergo different magnitudes of temperature and moisture change during next 50 years.

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# Direct exposure to climate change

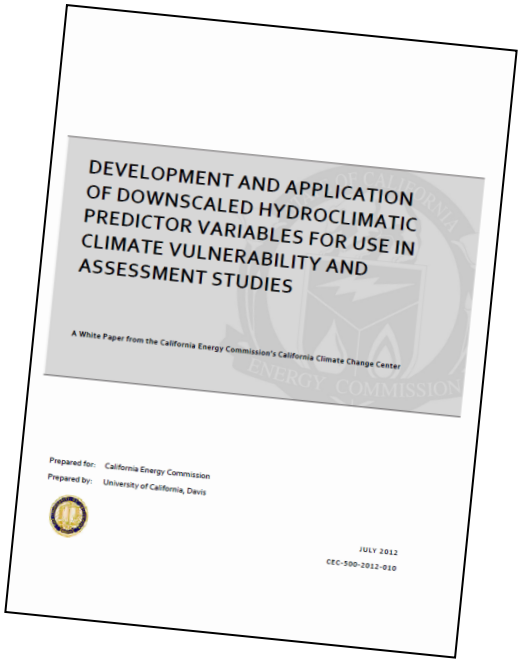
## CCVI Section A: Direct Exposure to Climate Change

**We obtained 270-meter grid-scale maps of historical and projected temperature and climatic water deficit (CWD) in the Sierra Nevada from:**

Thorne, J.H., R. Boynton, T.N. Le, A. Flint, and L. Flint. 2012. **Development and application of downscaled hydroclimatic predictor variables for use in cross-sector climate vulnerability and assessment studies**. California Energy Commission.

**Monthly data were summarized for**

- **historic period (1971-2000) and**
- **future period (2040-2069)**



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# Direct exposure to climate change

## CCVI Section A: Direct Exposure to Climate Change

We used a 'precision-based' rather than 'ensemble' approach:

Selected a medium-high (A2) emissions scenario and 2 climate models:

1) Geophysical Fluid Dynamics Laboratory (GFDL)

2) Parallel Climate Model (PCM)

GFDL model projects >change, including slightly more warming, and much more drying.

# Climate projections - temperature

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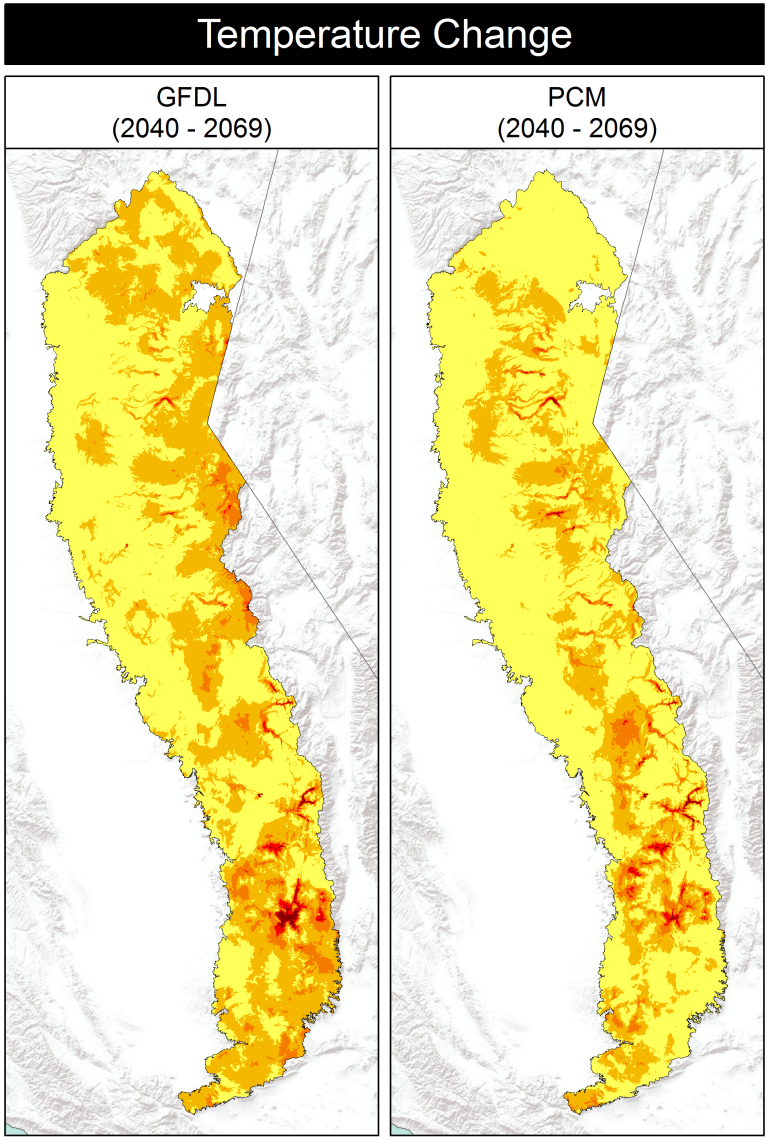
Projected Change in Temperature (°C)

| | | |
|---|---|---|
| < 2.2 | 2.5 - 2.8 | ≥ 3.1 |
| 2.2 - 2.5 | 2.8 - 3.1 | |

**Projected TEMPERATURE change between the periods 1971-2000 and 2040-2069.**



# Climate projections - moisture

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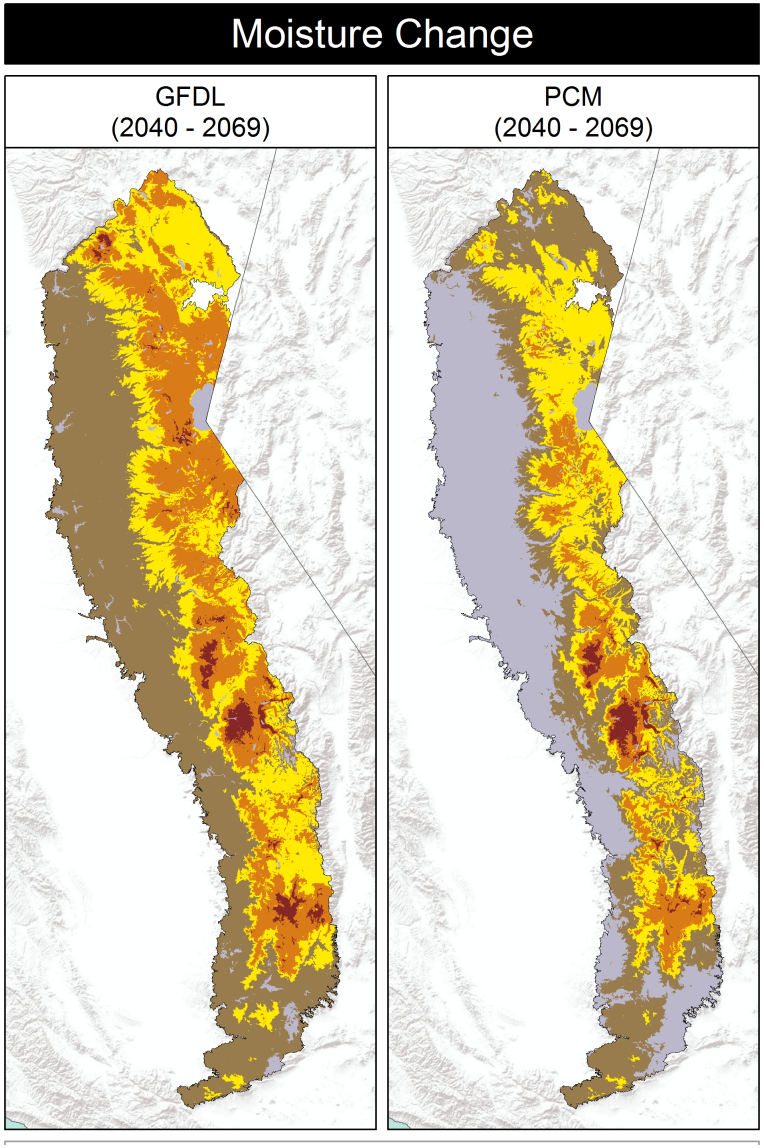
Projected Change in CWD (mm)

| | | |
|---|---|---|
| < -13.1 | 40.5 - 94.1 | 147.7 - 201.3 |
| -13.1 - 40.5 | 94.1 - 147.7 | ≥ 201.3 |

**Projected CLIMATIC WATER DEFICIT change between the periods 1971-2000 and 2040-2069.**



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# Species range maps

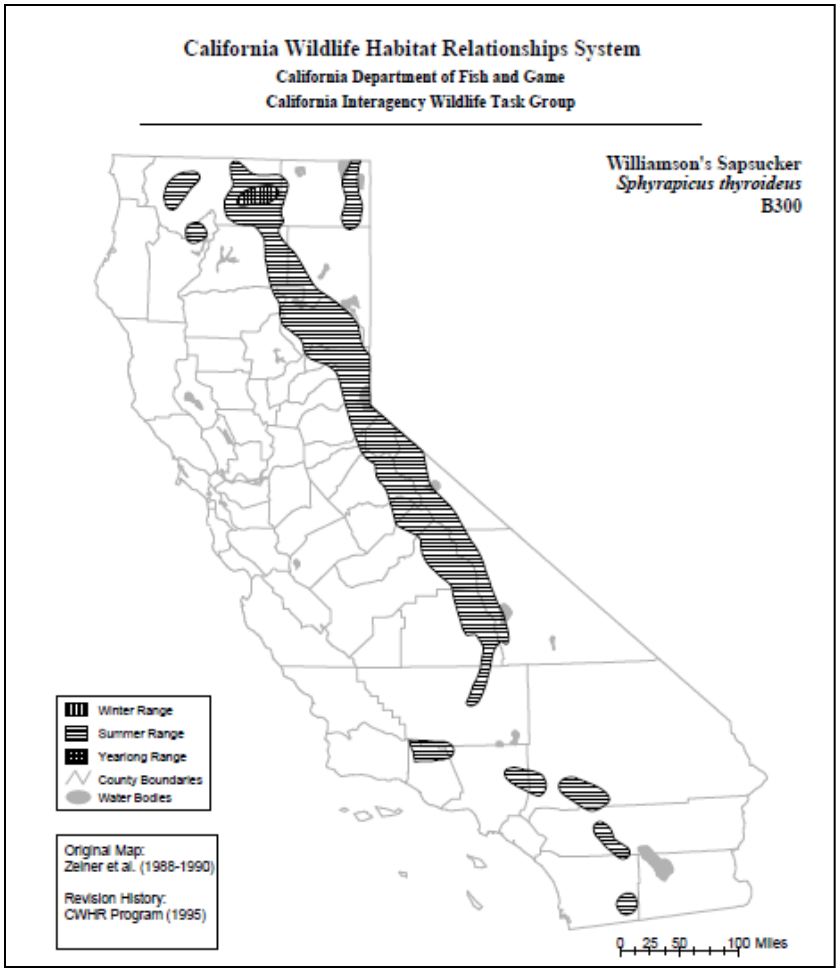
## CCVI Section A: Direct Exposure to Climate Change

### Delineating summer ranges of Sierra Nevada birds

We used digital range maps for CA developed by CDFW for the California Wildlife Habitat Relationships GIS system.

- Maps are good but not perfect:
  - varying levels of detail between spp.
  - lack recent data for some rare spp.

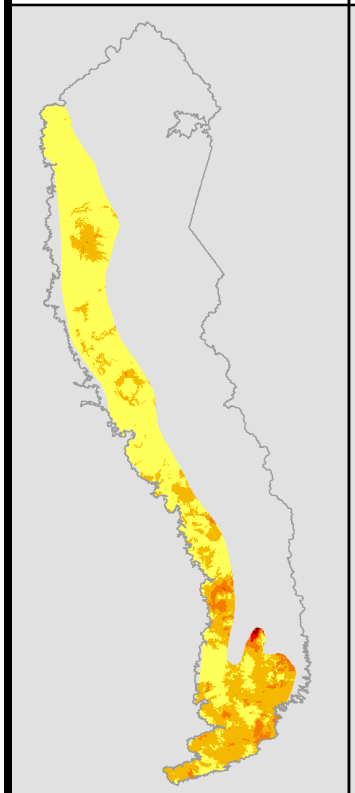
Nevertheless, they are the **best published range maps for Sierra birds.**



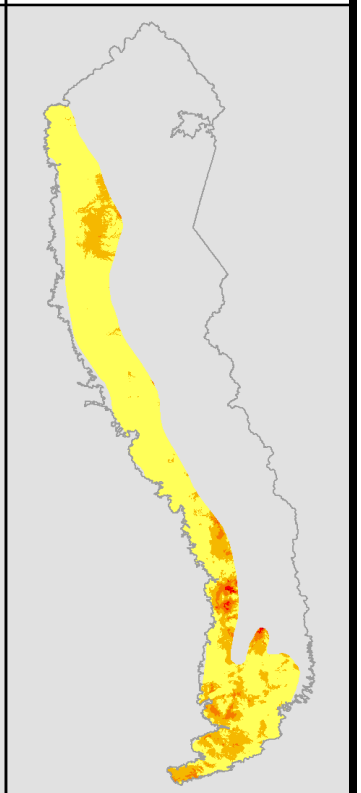
# Projected climate change exposure for California Thrasher

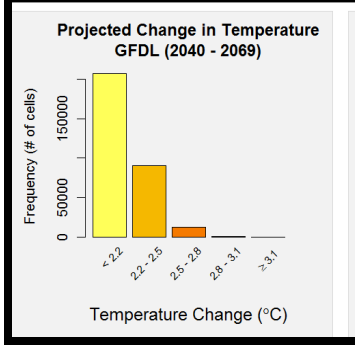
## Temperature

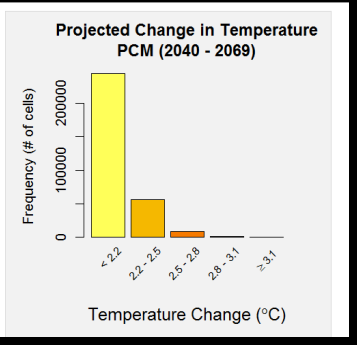
GFDL (2040 - 2069)



PCM (2040 - 2069)

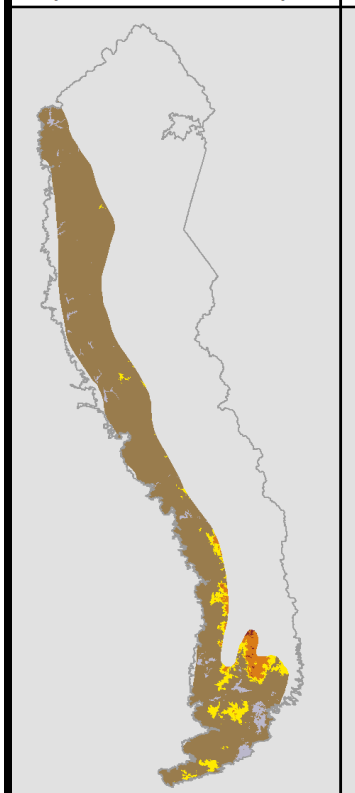




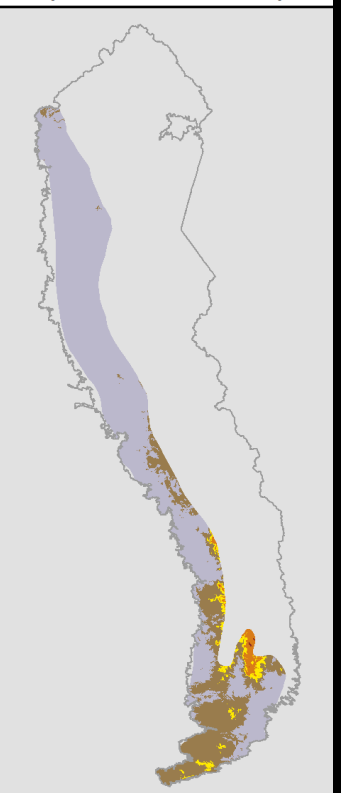



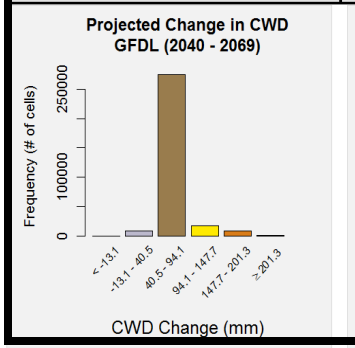

## Moisture

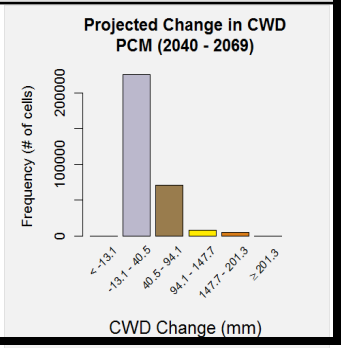
GFDL (2040 - 2069)



PCM (2040 - 2069)



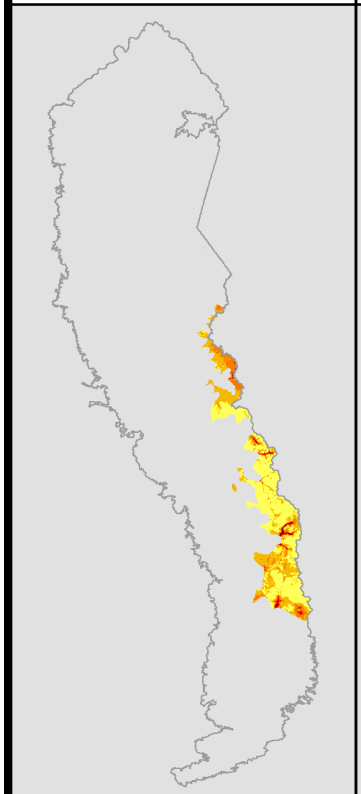


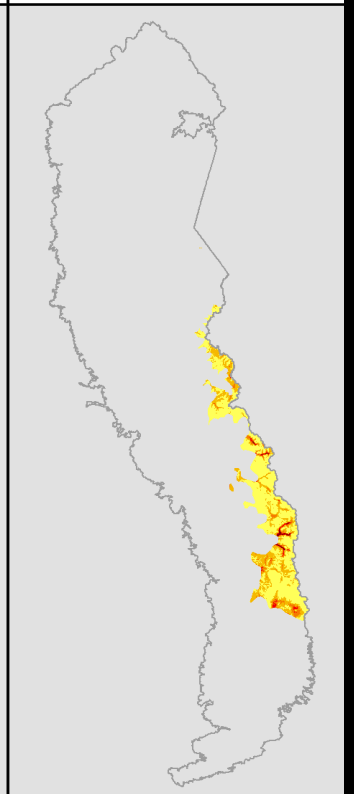
# Projected climate change exposure for Gray-crowned Rosy-Finch

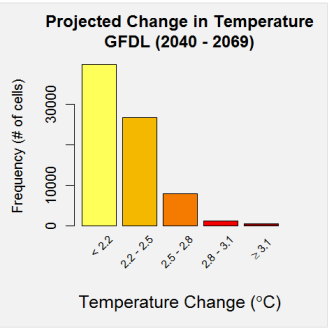
## Temperature

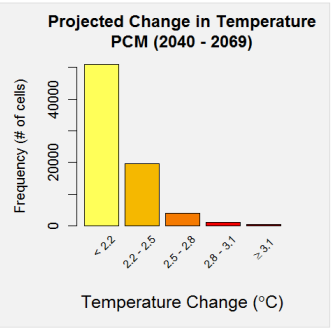
GFDL (2040 - 2069)



PCM (2040 - 2069)

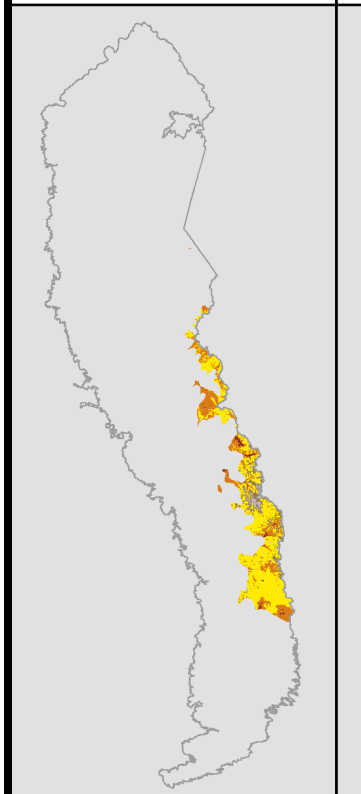




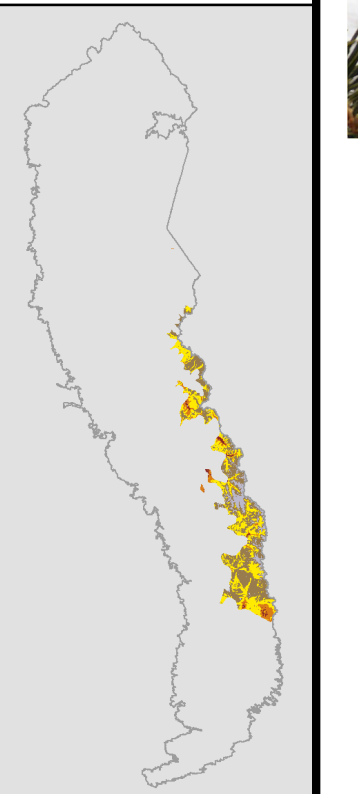



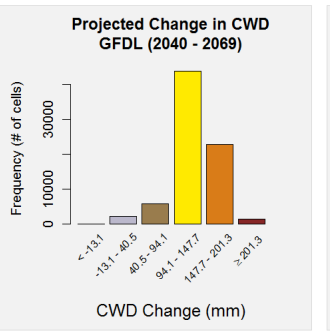

## Moisture

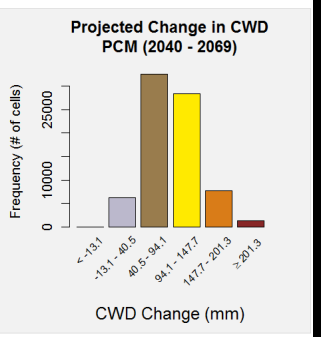
GFDL (2040 - 2069)

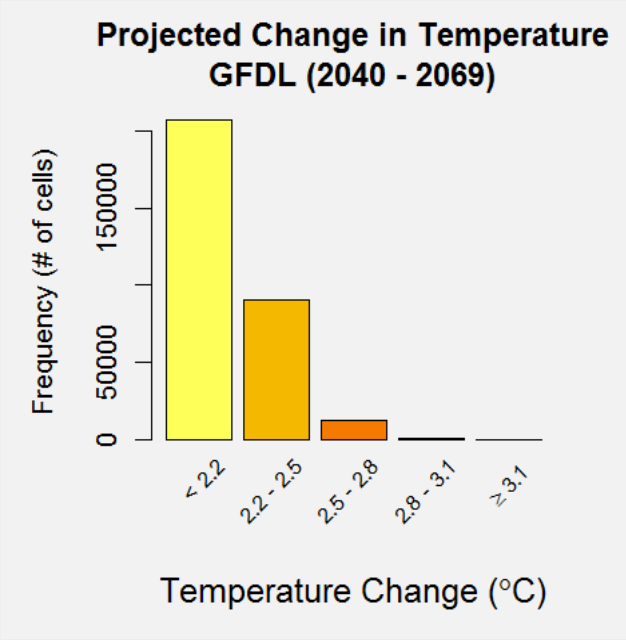


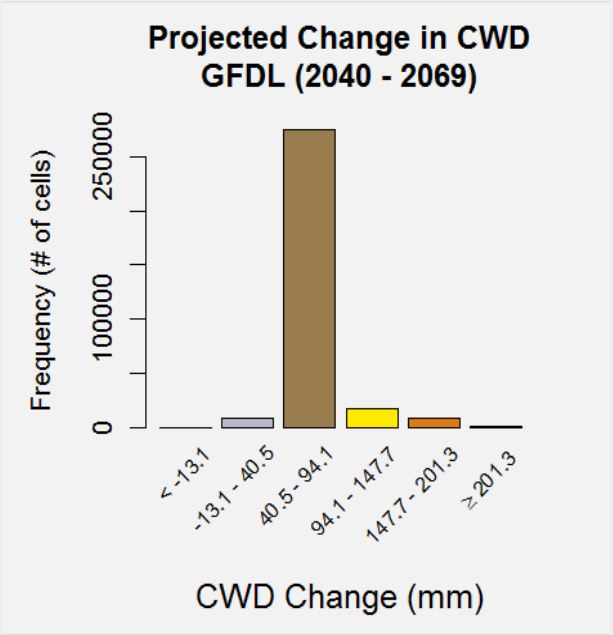
PCM (2040 - 2069)



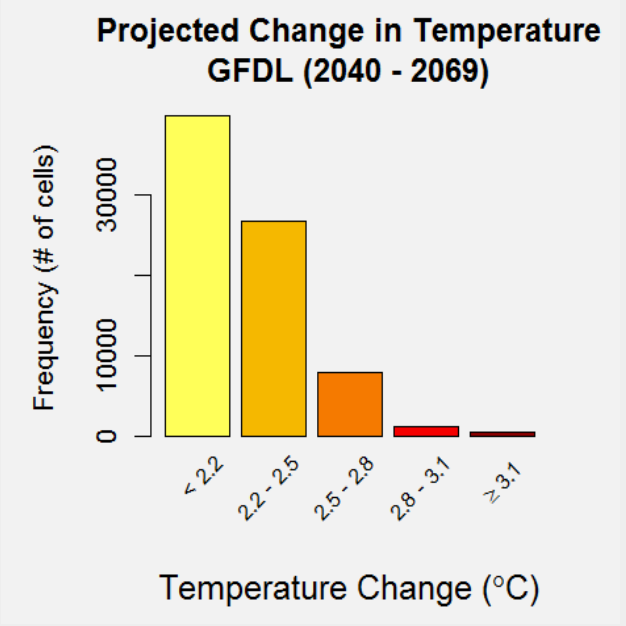


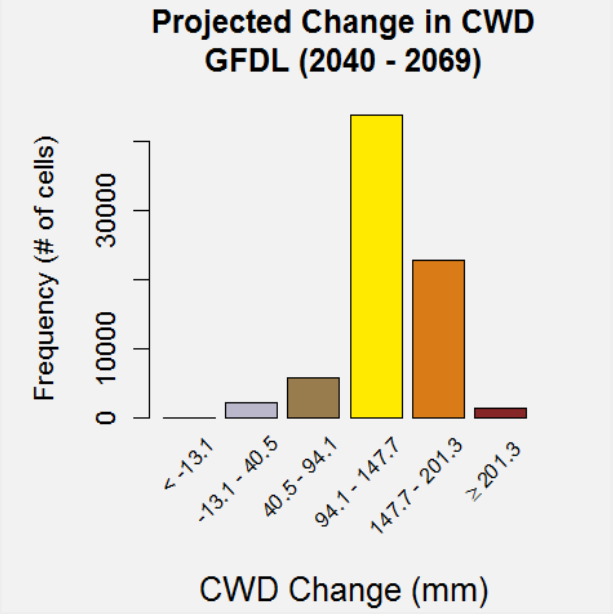





# California Thrasher



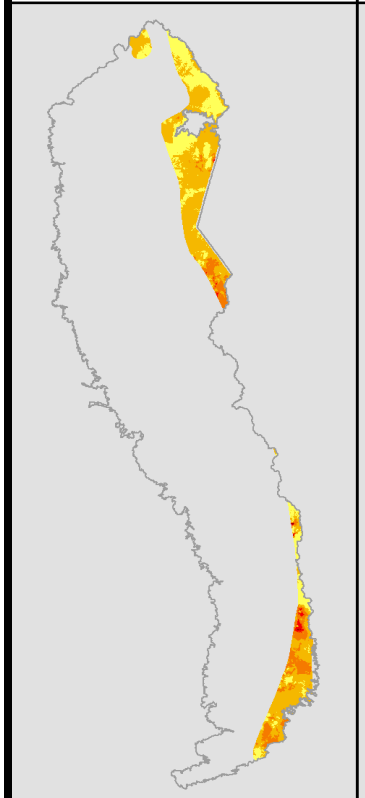



# Gray-crowned Rosy-Finch

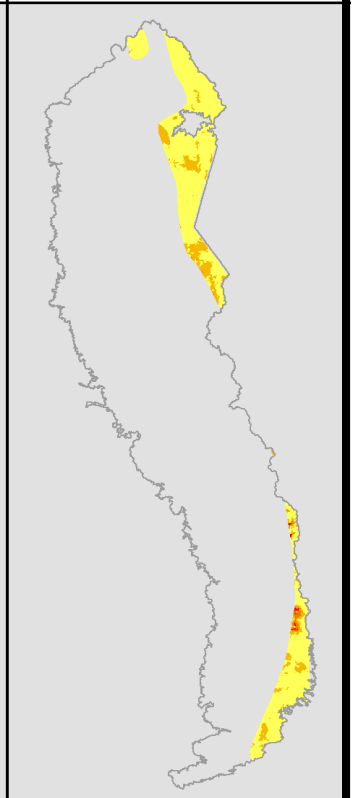
# Projected climate change exposure for Brewer's Sparrow

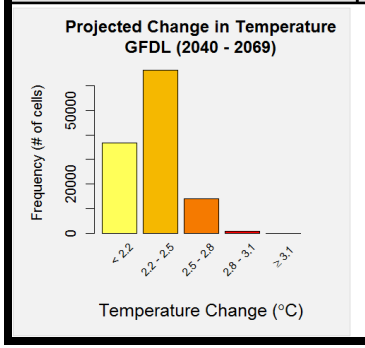
## Temperature

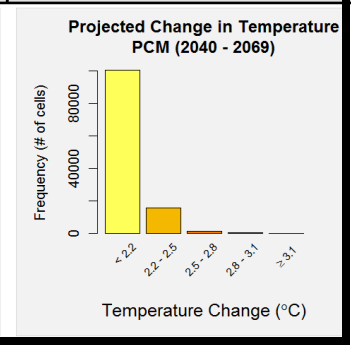
GFDL (2040 - 2069)



PCM (2040 - 2069)

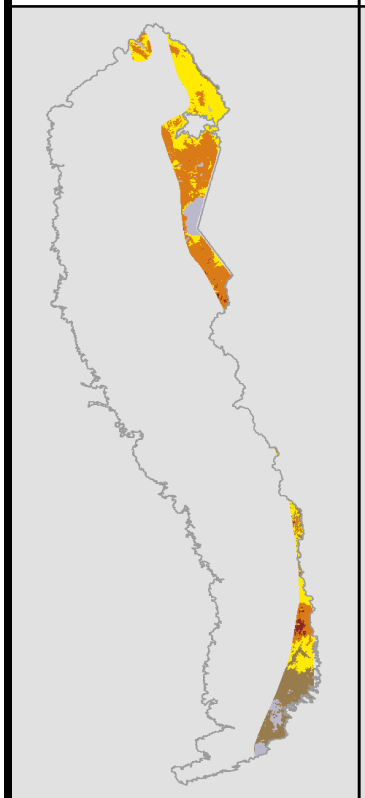





## Moisture

GFDL (2040 - 2069)



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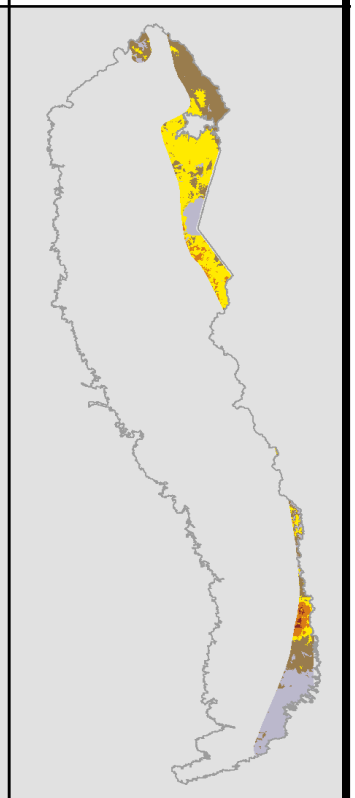
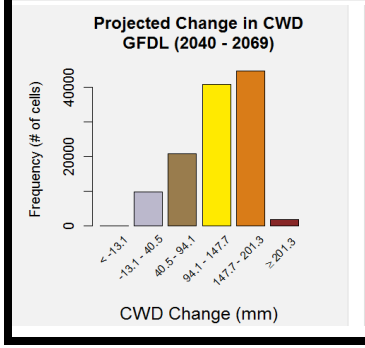
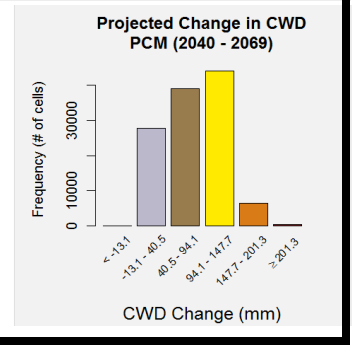


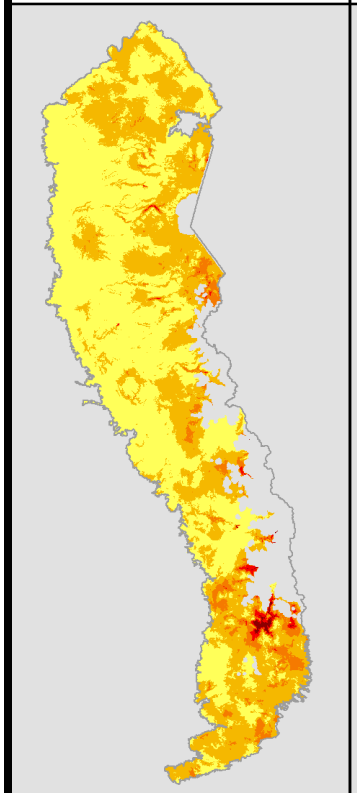


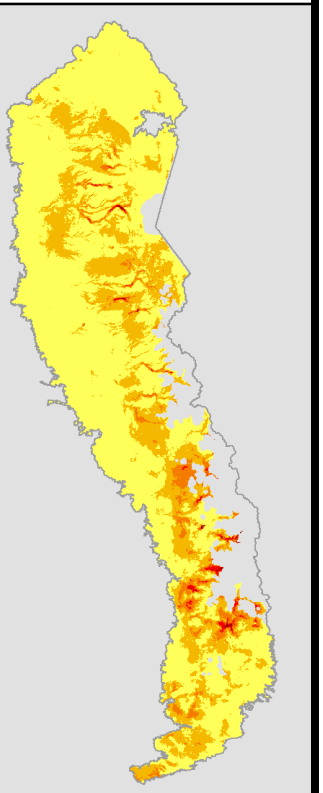
# Projected climate change exposure for Song Sparrow

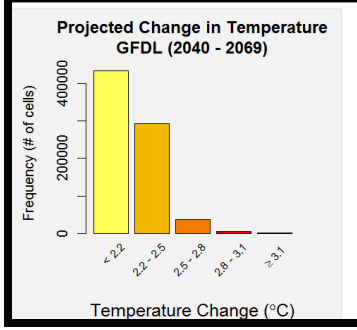
## Temperature

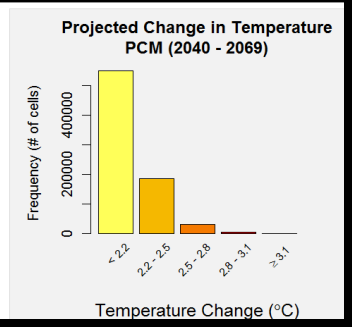
GFDL (2040 - 2069)



PCM (2040 - 2069)

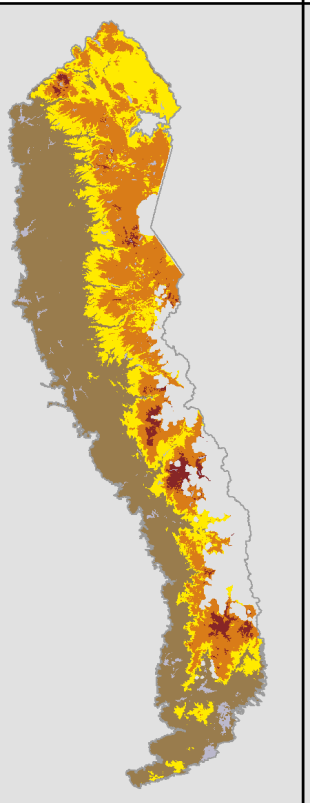




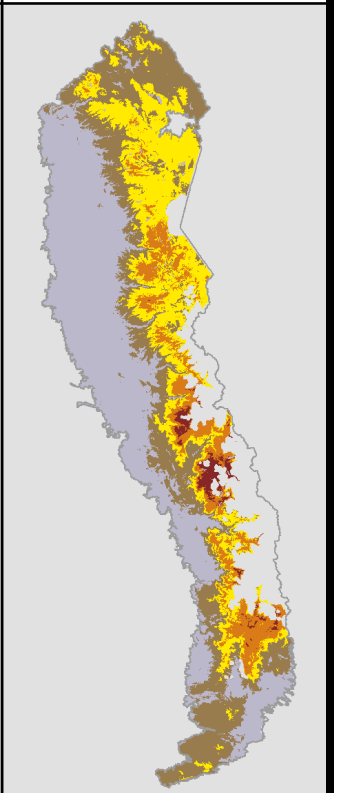



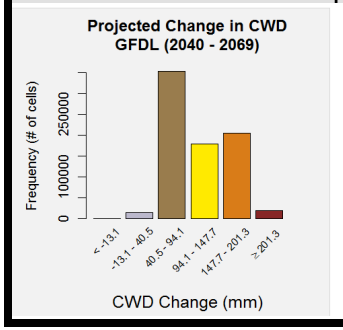

## Moisture

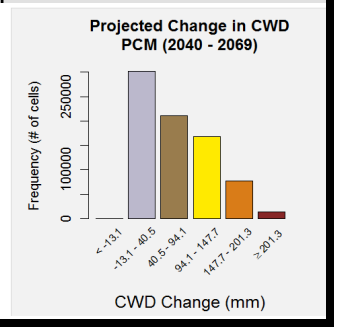
GFDL (2040 - 2069)



PCM (2040 - 2069)





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# Indirect exposure to climate change

| Section B Vulnerability Factors – Indirect Exposure to Climate Change |
| --- |
| B1 - Exposure to sea-level rise |
| B2a - Ability to disperse through foreign habitats or barriers |
| B2b - Ability to disperse across anthropogenic barriers |
| B3 - Impact of climate-related human activities (e.g., wind farms, dams) |

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# Sensitivity to climate change

| Section C Vulnerability Factors – Sensitivity to Climate Change |
| --- |
| C1 - Ability to disperse in response to climate change |
| C2ai - Historic temperature variation |
| C2aii - Physiological need for cool temperatures |
| C2bi - Past precipitation variation |
| C2bii - Physiological need for moist habitats |
| C2c - Response to increased disturbance regimes (e.g., fires, floods) |
| C2d - Response to decreased ice and snow |
| C3 - Dependence on uncommon geologic features |
| C4a - Dependence on particular plant or animal species |
| C4b - Dietary versatility; reliance on one or two species for food |
| C4d - Dependence on other species to disperse |
| C4e - Reliance on interspecific interactions |
| C5a - Degree of measured genetic variation |
| C5b - Indication of bottlenecks in recent genetic history |
| C6 - Vulnerability based on phenotypic inability to respond |

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# Documented or modeled response to climate change

| Section D Vulnerability Factors – Documented or Modeled Response to Climate Change |
| --- |
| D1 - Documented range changes due to recent climate change |
| D2 - Modeled predictions for range contraction or expansion |
| D3 - Overlap of modeled future range with current range |
| D4 - Overlap of predicted future range with protected areas |

***Some key information sources for these vulnerability factors***


***Stralberg D, D. Jongsomjit, C. A. Howell, M. A. Snyder, J. D. Alexander, et al. 2009. Re-shuffling of species with climate disruption: A no-analog future for California birds? PLoS ONE 4: e6825.***

***Tingley, M. W., W. B. Monahan, S. R. Beissinger, C. Moritz. 2009. Birds track their Grinnellian niche through a century of climate change. Proceedings of the National Academy of Sciences of the United States of America 106:19637-19643.***

***Tingley, M. W., M. S. Koo, C. Moritz, A. C. Rush, and S. R. Beissinger. 2012. The push and pull of climate change causes heterogeneous shifts in avian elevational ranges. Global Change Biology. doi: 10.1111/j.1365-2486.2012.02784.x***

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# CCVI vulnerability rankings

| Vulnerability Ranking | Interpretation |
|---|---|
| Extremely Vulnerable | Abundance and/or range extent within geographical area assessed extremely likely to substantially decrease or disappear by 2050. |
| Highly Vulnerable | Abundance and/or range extent within geographical area assessed likely to decrease significantly by 2050. |
| Moderately Vulnerable | Abundance and/or range extent within geographical area assessed likely to decrease by 2050. |
| Not Vulnerable/ Presumed Stable | Available evidence does not suggest that abundance and/or range extent within the geographical area assessed will change (increase/decrease) substantially by 2050. Actual range boundaries may change. |
| Not Vulnerable/ Increase Likely | Available evidence suggests that abundance and/or range extent within geographical area assessed is likely to increase by 2050. |

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# Vulnerability rankings – all species

| Ranking | GFDL model | PCM model |
|---|---|---|
| Extremely Vulnerable | 1 | 1 |
| Highly Vulnerable | 0 | 0 |
| Moderately Vulnerable | 15 | 13 |
| Potentially Stable | 110 | 125 |
| Increase Likely | 42 | 29 |

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# Rankings – Extremely Vulnerable species

| Species | GFDL model | PCM model |
|---|---|---|
| ***Extremely Vulnerable**** | | |
| **White-tailed Ptarmigan** | **X** | **X** |

***Extremely vulnerable:** Abundance and/or range extent within geographical area assessed extremely likely to substantially decrease or disappear by 2050.*

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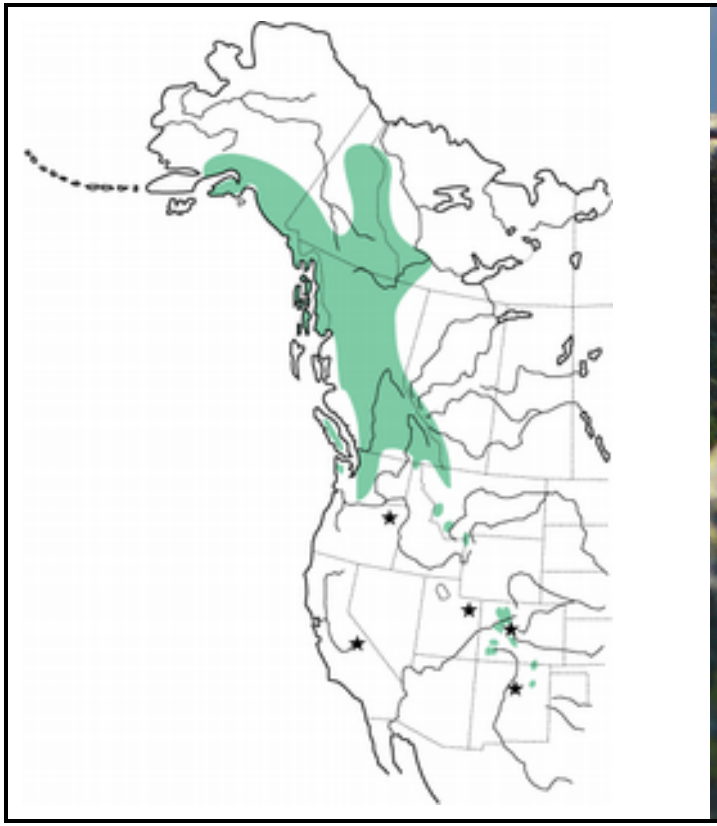
# Rankings – Extremely Vulnerable species

## White-tailed Ptarmigan = non-native species in CA

**Deliberately introduced to the Sierra in 1970s**

**Conservation may not be a high priority for most managers**



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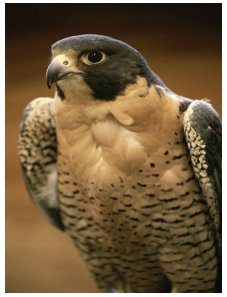
# Rankings – Moderately Vulnerable species, part 1

| Species | GFDL model | PCM model |
|---|---|---|
| ***Moderately Vulnerable**** | | |
| Common Merganser | X | X |
| Osprey | X | |
| Bald Eagle | X | X |
| Northern Goshawk | X | X |
| Peregrine Falcon | X | X |
| Prairie Falcon | X | |
| Spotted Sandpiper | X | X |
| Great Gray Owl | X | X |

***Moderately vulnerable:***
**Abundance and/or range extent within geographical area assessed likely to decrease by 2050.**



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# Rankings – Moderately Vulnerable species, part 2

| Species | GFDL model | PCM model |
|---|---|---|
| ***Moderately Vulnerable**** | | |
| Black Swift | X | X |
| Clark's Nutcracker | | X |
| American Dipper | X | |
| Swainson's Thrush | X | X |
| American Pipit | X | X |
| Gray-crowned Rosy-Finch | X | X |
| Pine Grosbeak | X | X |
| Evening Grosbeak | X | X |

***Moderately vulnerable:***
**Abundance and/or range extent within geographical area assessed likely to decrease by 2050.**

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# Rankings – Increase Likely species

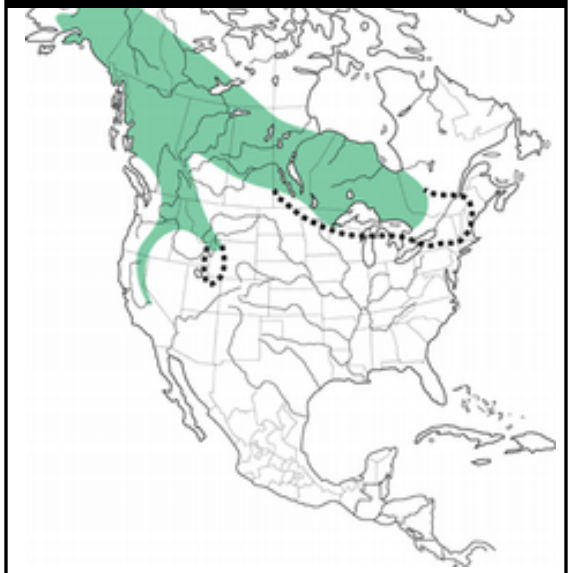
| Species Ranked as Increase Likely* Under *Both* the GFDL and PCM Climate Models | |
|---|---|
| Red-tailed Hawk | American Robin |
| Mourning Dove | California Thrasher |
| Common Nighthawk | European Starling |
| Common Poorwill | Spotted Towhee |
| Hairy Woodpecker | California Towhee |
| Northern Flicker | Chipping Sparrow |
| Western Wood-Pewee | Black-chinned Sparrow |
| Gray Flycatcher | Savannah Sparrow |
| Ash-throated Flycatcher | Fox Sparrow |
| Western Kingbird | Song Sparrow |
| Steller's Jay | Lazuli Bunting |
| Western Scrub-Jay | Brewer's Sparrow |
| Brown Creeper | Brown-headed Cowbird |
| House Wren | House Finch |
| Western Bluebird | |

*_Increase Likely:_ Available evidence suggests that abundance and/or range extent within geographical area assessed is likely to increase by 2050.

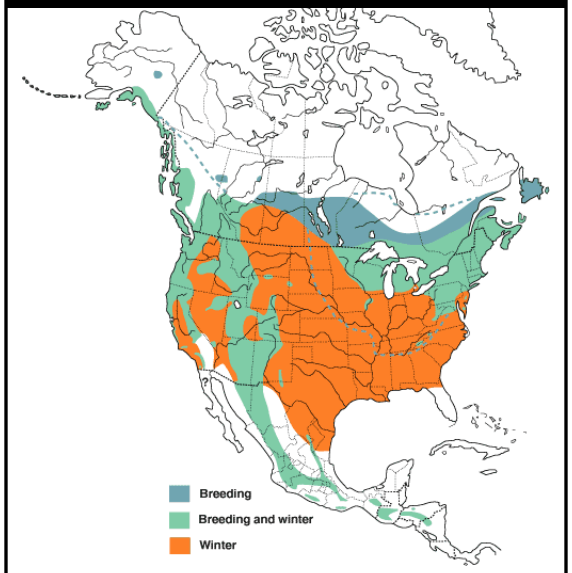
# Patterns in vulnerability – overall breeding range

**We classified each species' overall breeding range relative to the Sierra Nevada:**

## 'Northern' / Southern
*e.g., Great Gray Owl*



## 'Central'
*e.g., Brown Creeper*



## *e.g., Black Phoebe*

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# Patterns in vulnerability – overall breeding range

| Species Group | N | No. of Species with Ranking | | | | Mean Score |
|---|---|---|---|---|---|---|
| | | Increase Likely | Potentially Stable | Moderately Vulnerable | Extremely Vulnerable | |
| *GFDL climate model* | | | | | | |
| All species | 168 | 42 | 110 | 15 | 1 | 1.86 |
| Northern | 33 | 1 | 24 | 7 | 1 | 2.27* |
| Central | 125 | 34 | 83 | 8 | 0 | 1.79 |
| Southern | 10 | 6 | 4 | 0 | 0 | 1.40 |
| *PCM climate model* | | | | | | |
| All species | 168 | 29 | 125 | 13 | 1 | 1.92 |
| Northern | 33 | 0 | 25 | 7 | 1 | 2.30** |
| Central | 125 | 25 | 94 | 6 | 0 | 1.85 |
| Southern | 10 | 4 | 6 | 0 | 0 | 1.60 |

# Patterns in vulnerability – overall breeding range

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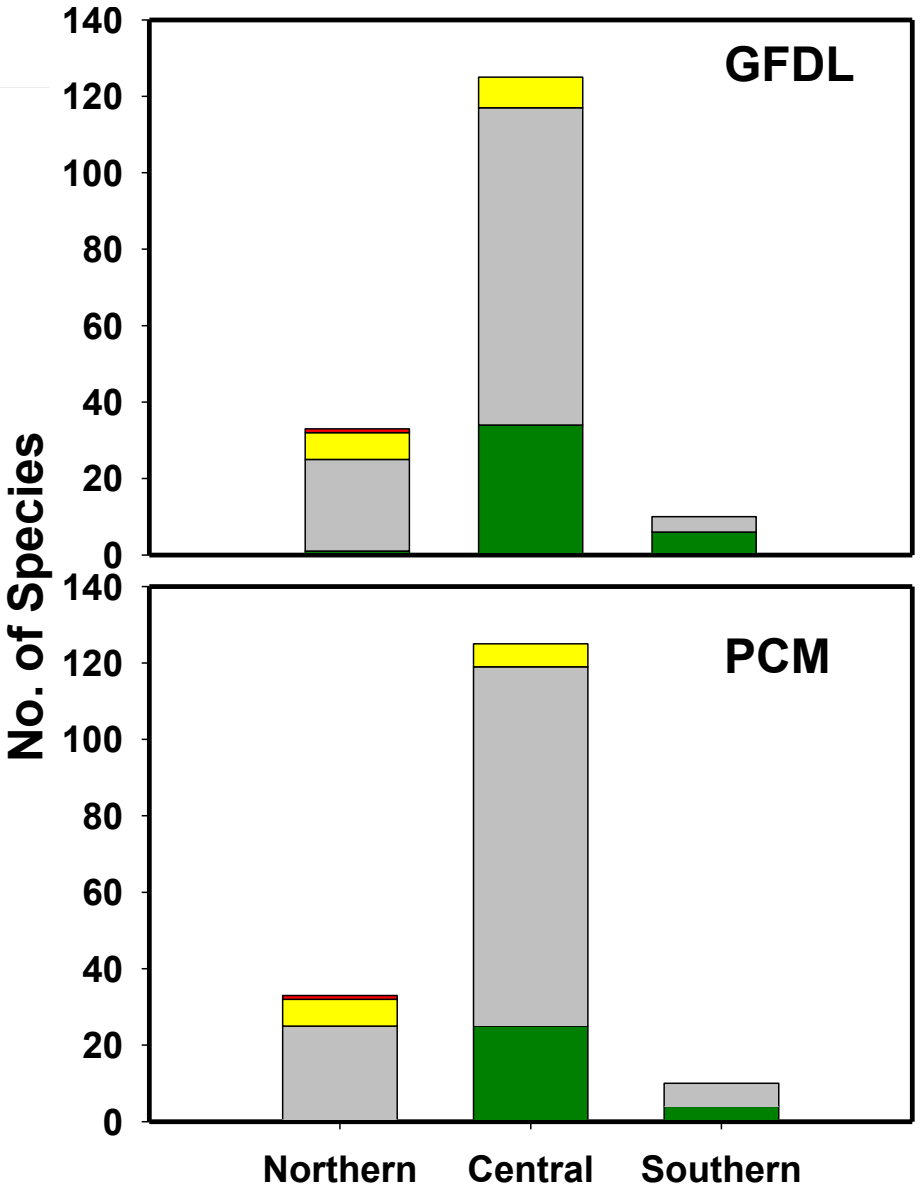
- Extremely Vulnerable
- Moderately Vulnerable
- Potentially Stable
- Increase Likely



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# Patterns in vulnerability – habitat associations

| Species Group | N | No. of Species with Ranking | | | | Mean Score |
|---|---|---|---|---|---|---|
| | | Increase Likely | Potentially Stable | Moderately Vulnerable | Extremely Vulnerable | |
| *GFDL climate model* | | | | | | |
| All species | 168 | 42 | 110 | 15 | 1 | 1.86 |
| Foothill Woodland and Chaparral | 67 | 31 | 36 | 0 | 0 | 1.54*** |
| Montane Conifer Forest | 62 | 9 | 47 | 6 | 0 | 1.95 |
| Montane Chaparral & Sagebrush | 28 | 12 | 15 | 1 | 0 | 1.61* |
| Aquatic | 15 | 0 | 10 | 5 | 0 | 2.33* |
| Meadow, Marsh, and Riparian | 52 | 13 | 36 | 3 | 0 | 1.81 |
| Subalpine and Alpine | 13 | 0 | 10 | 2 | 1 | 2.38* |
| *PCM climate model* | | | | | | |
| All species | 168 | 29 | 125 | 13 | 1 | 1.92 |
| Foothill Woodland and Chaparral | 67 | 20 | 47 | 0 | 0 | 1.70** |
| Montane Conifer Forest | 62 | 9 | 46 | 7 | 0 | 1.95 |
| Montane Chaparral & Sagebrush | 28 | 9 | 19 | 0 | 0 | 1.68** |
| Aquatic | 15 | 0 | 12 | 3 | 0 | 2.20 |
| Meadow, Marsh, and Riparian | 52 | 10 | 39 | 3 | 0 | 1.87* |
| Subalpine and Alpine | 13 | 0 | 9 | 3 | 1 | 2.46* |

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# Limitations of our approach

- Assessment was limited to summer range; migratory species also likely face important climate-related threats on winter ranges and along migration routes.
- Results are difficult to validate – apply to the future, not the past or present, and do not incorporate non-climate factors.

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# Conclusions, part 1

**1. Only 1 (non-native) species ranked as Extremely Vulnerable and no species ranked as Highly Vulnerable; this is good news for Sierra birds**

**2. Portions of the Sierra avifauna nevertheless face risks – 16 native species ranked as Moderately Vulnerable**

**3. Many species (17-25%) were predicted to benefit from climate change in the Sierra Nevada, especially species associated with lower-elevation and/or arid habitats**

**4. Rankings were not terribly sensitive to climate model selection – GFDL and PCM yielded largely similar results, although the GFDL-based rankings included both more vulnerable species AND more species likely to benefit.**

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# Conclusions, part 2

**5. 'Northern' species are generally predicted to be more vulnerable than 'Southern' species**

**6. Birds associated with these habitats are predicted to be particularly vulnerable:**

- **aquatic habitats (under GFDL predictions)**
- **subalpine and alpine habitats**

**7. Birds associated with these habitats are predicted to be less vulnerable:**

- **foothill woodlands and foothill chaparral**
- **montane chaparral and sagebrush**

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# Acknowledgments

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**THANK YOU !**