A climate change vulnerability assessment for Sierra Nevada birds

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www.birdpop.org

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Project partners

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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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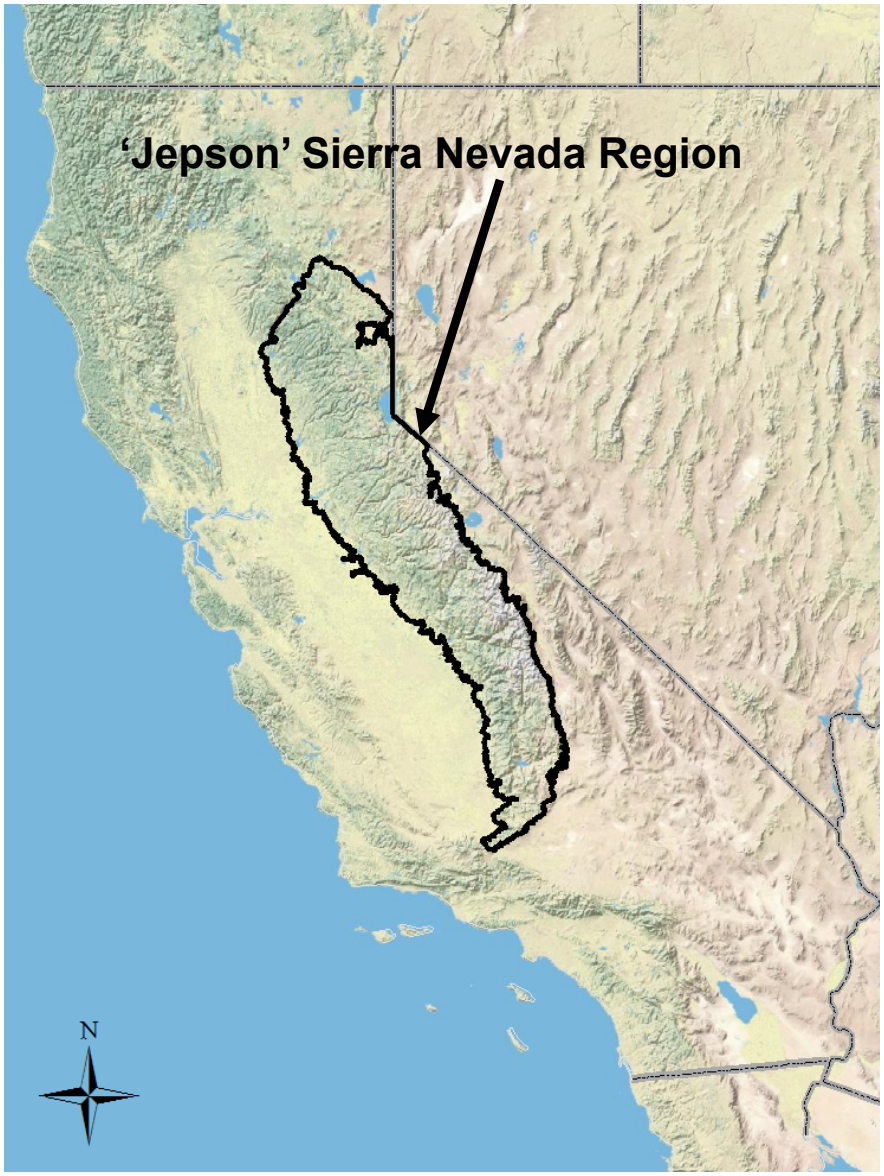
Study area

"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

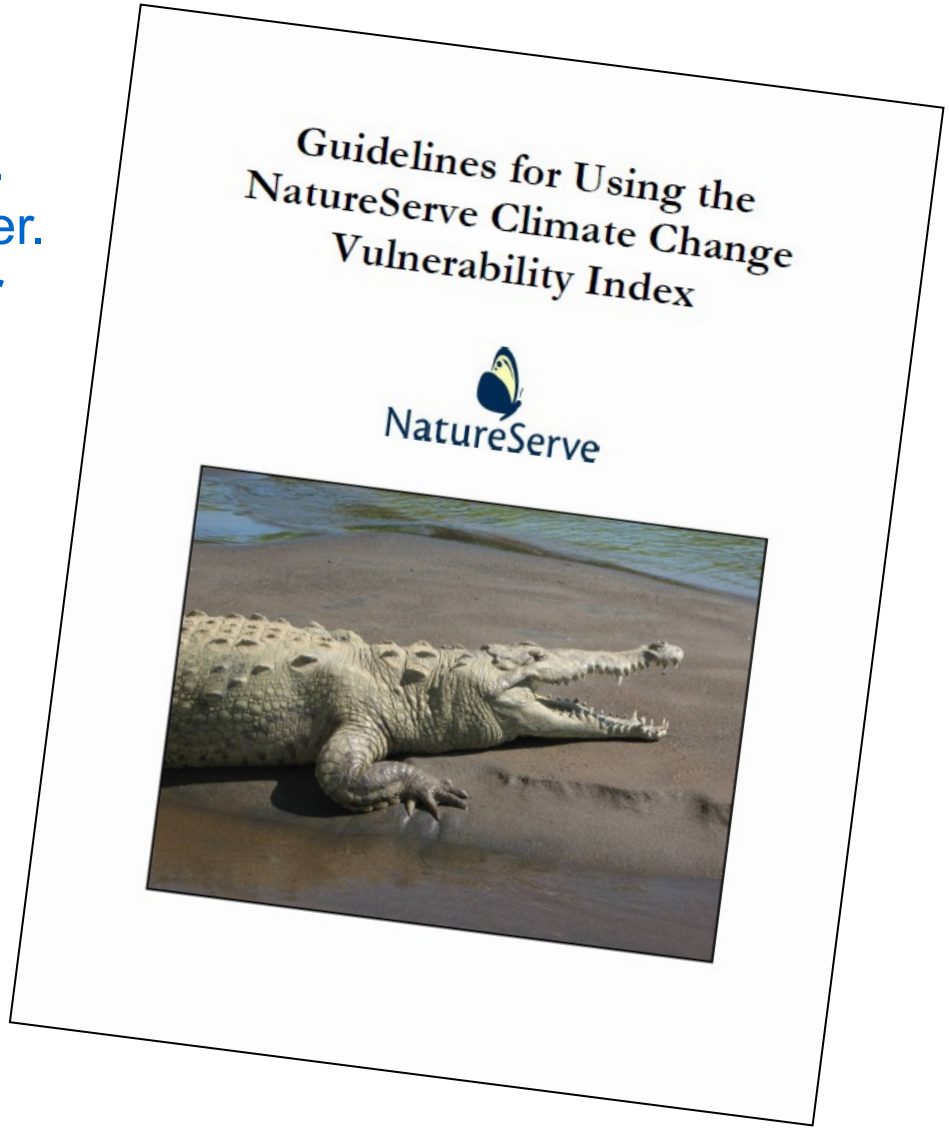
>300 bird species occur in region, many as wintering birds, passage migrants, or occasional vagrants.

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)

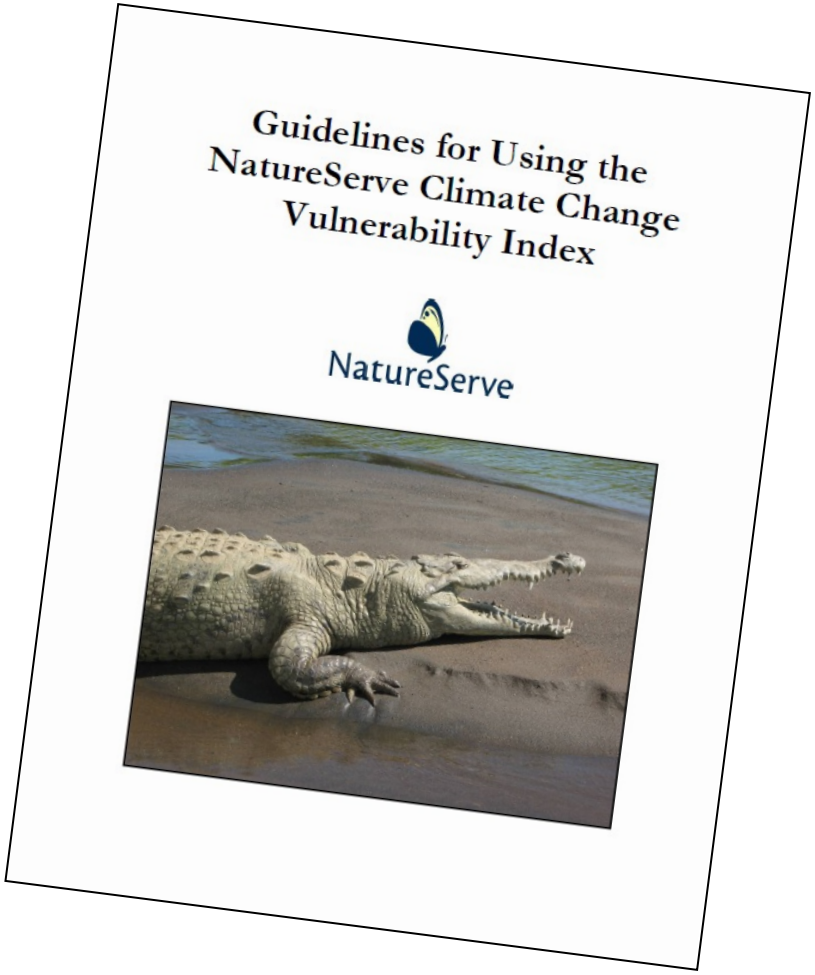
Inputs for each species:

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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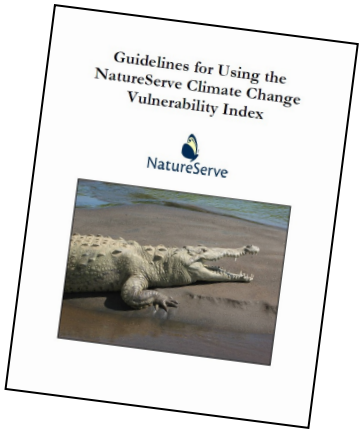
NatureServe's Climate Change Vulnerability Index (CCVI)



<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

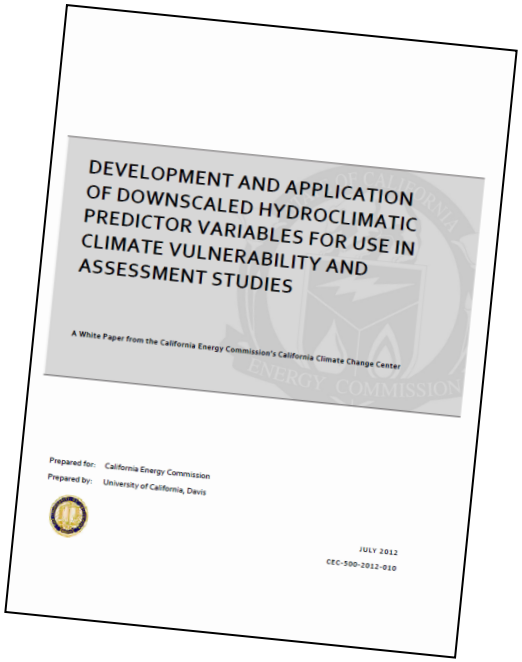
CCVI Section A: Direct Exposure to Climate Change

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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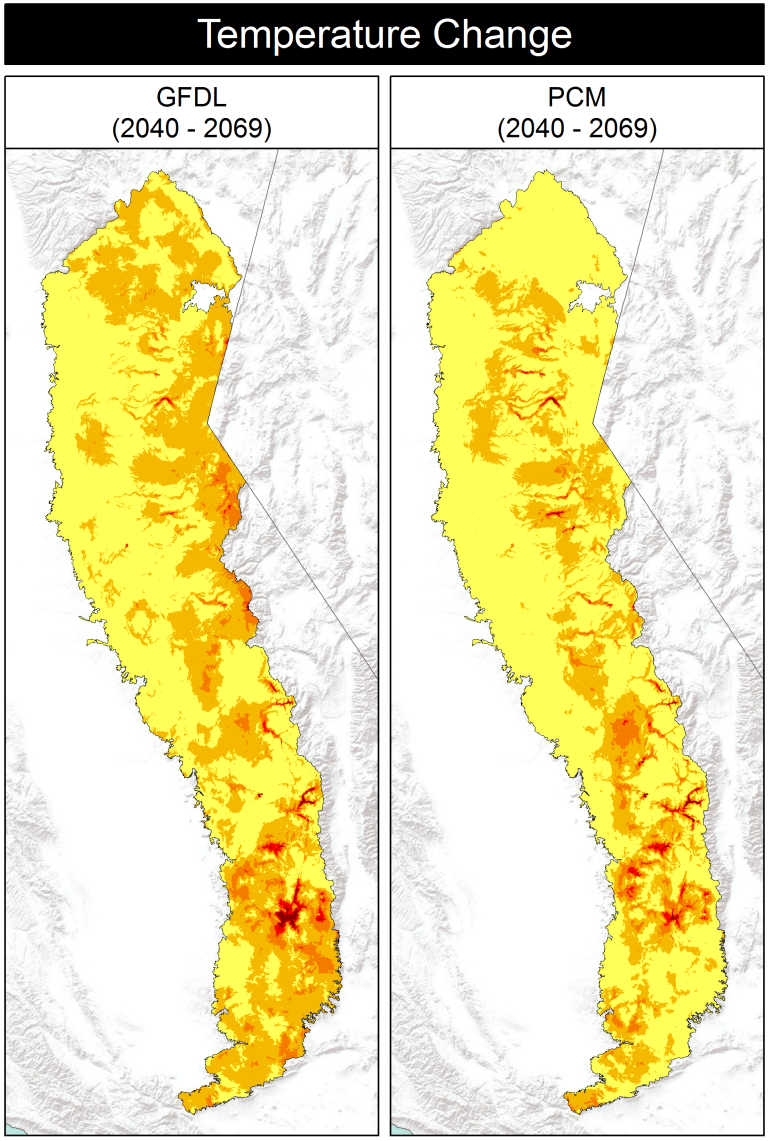
Projected Change in Temperature (°C)

< 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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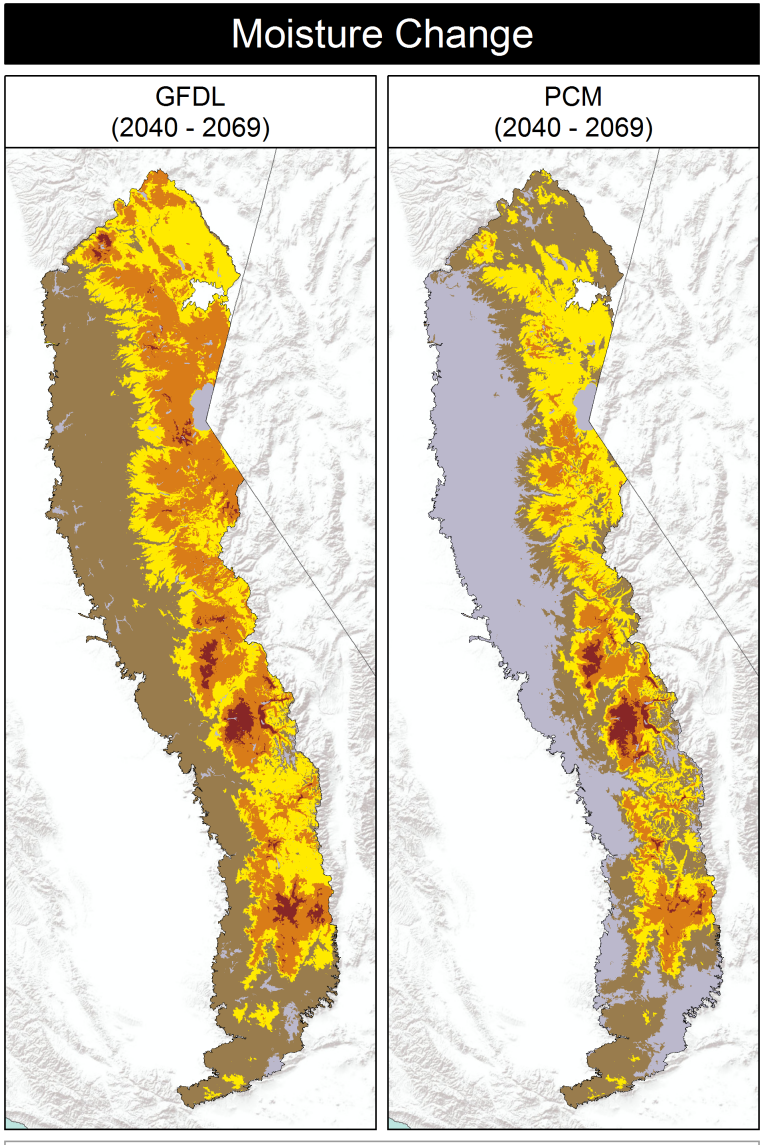
Projected Change in CWD (mm)

< -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

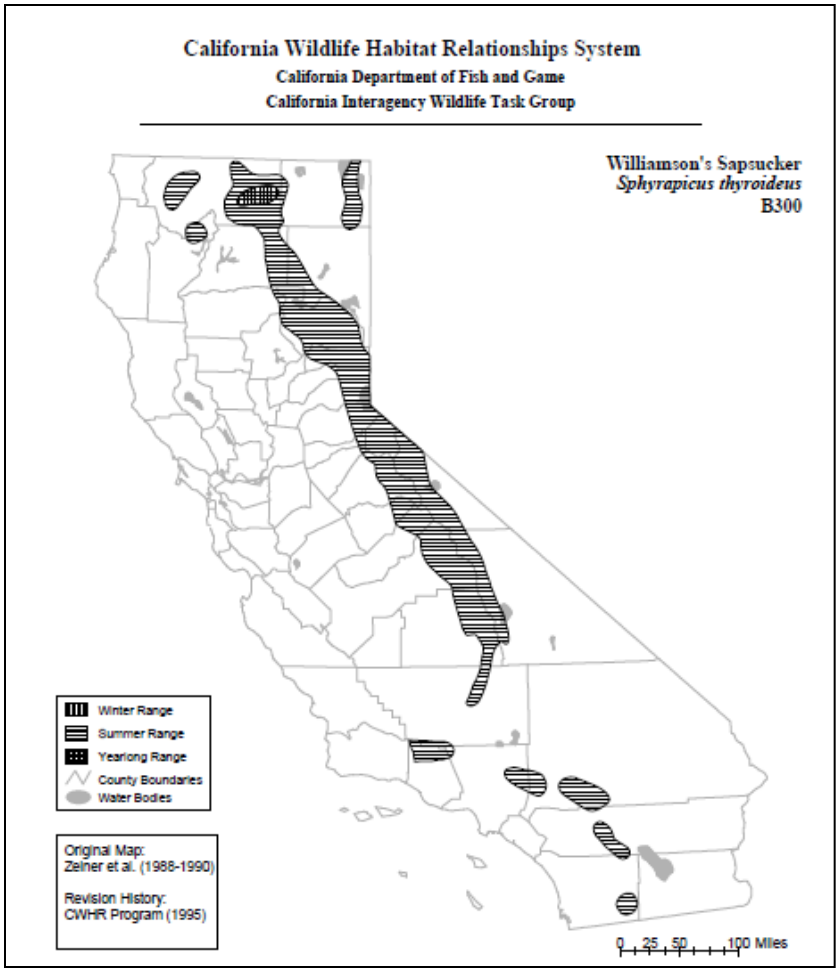
CCVI Section A: Direct Exposure to Climate Change

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.

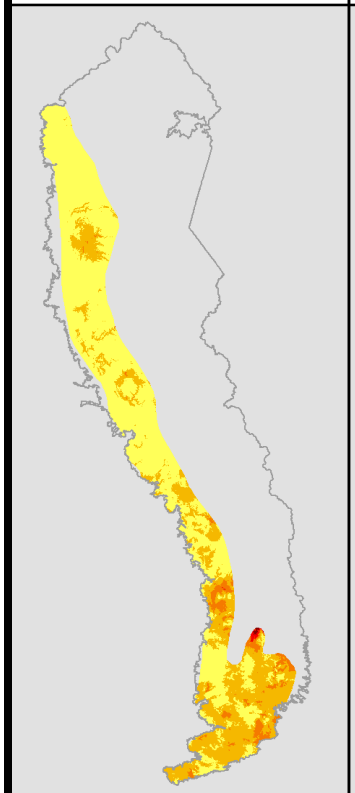
Nevertheless, they are the **best published range maps for Sierra birds.**



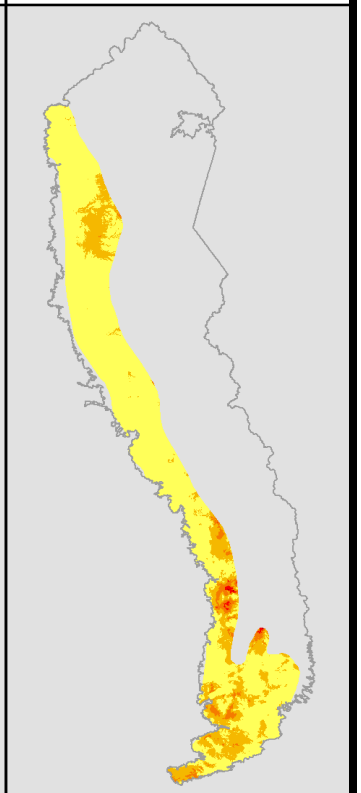
Projected climate change exposure for California Thrasher

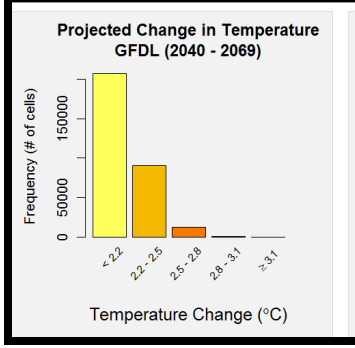
Temperature

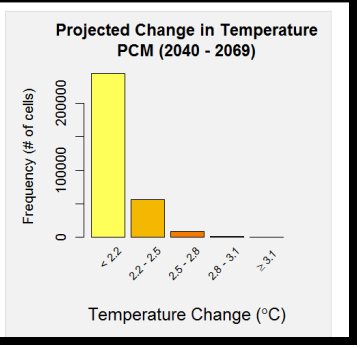
GFDL (2040 - 2069)



PCM (2040 - 2069)

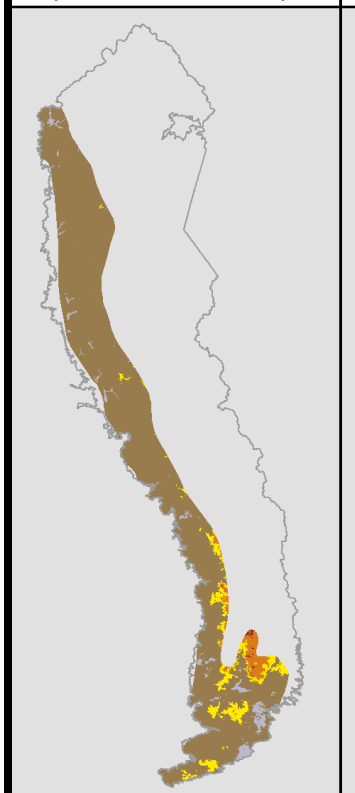




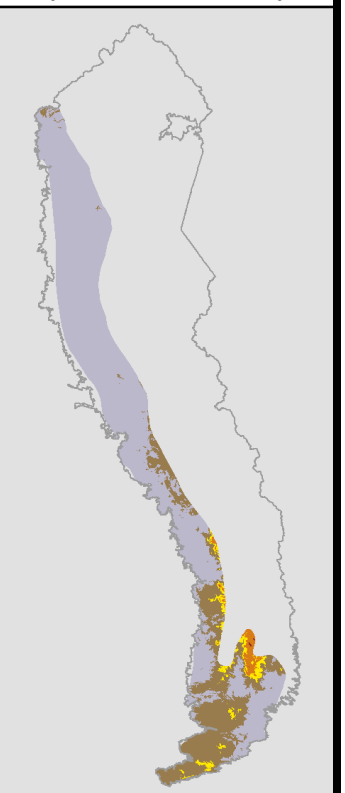


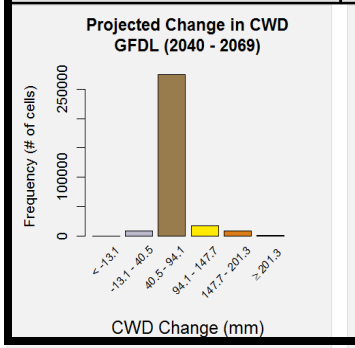
Moisture

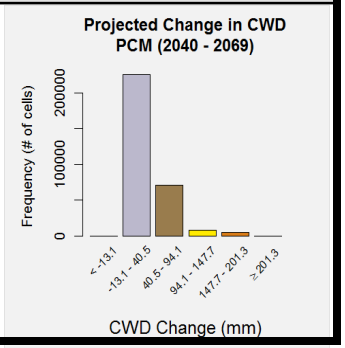
GFDL (2040 - 2069)



PCM (2040 - 2069)



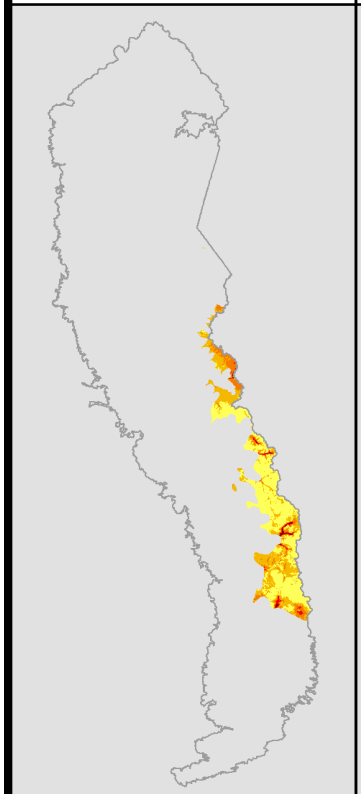




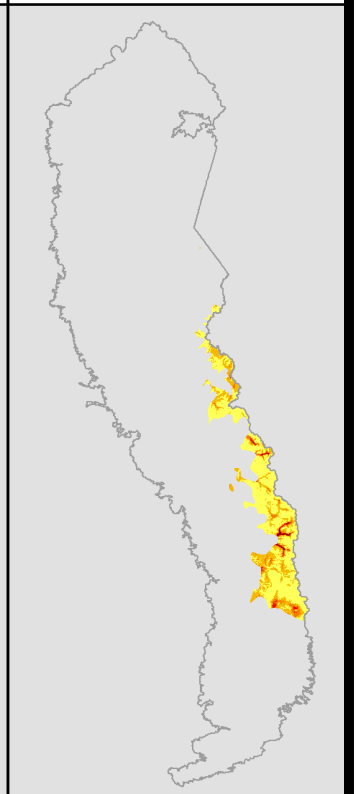
Projected climate change exposure for Gray-crowned Rosy-Finch

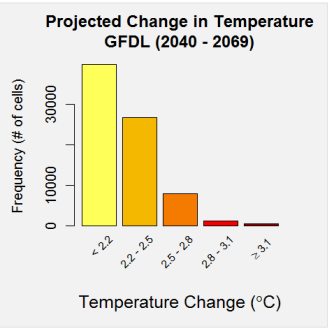
Temperature

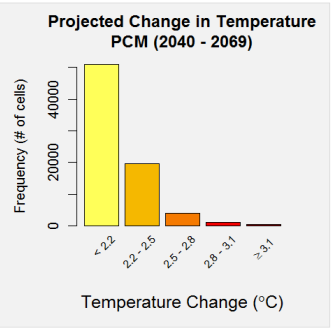
GFDL (2040 - 2069)



PCM (2040 - 2069)

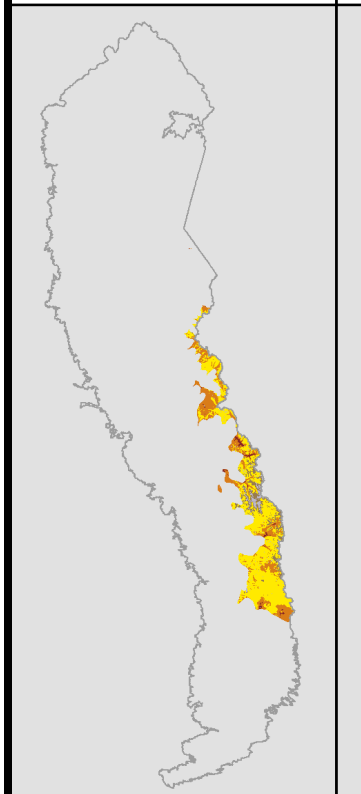




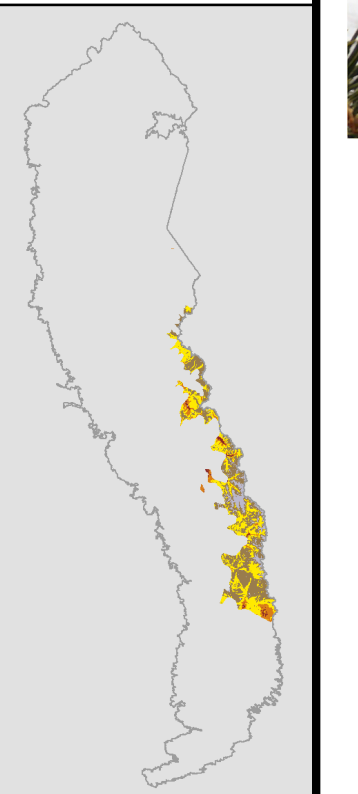


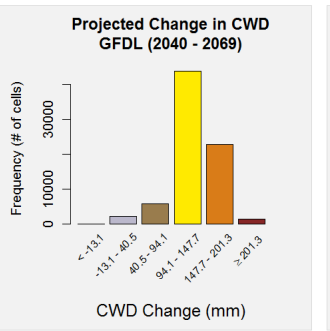
Moisture

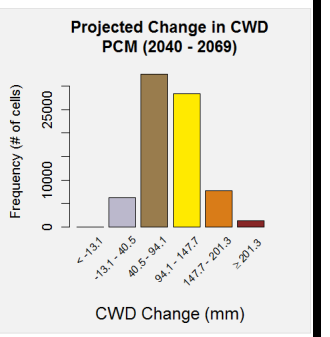
GFDL (2040 - 2069)

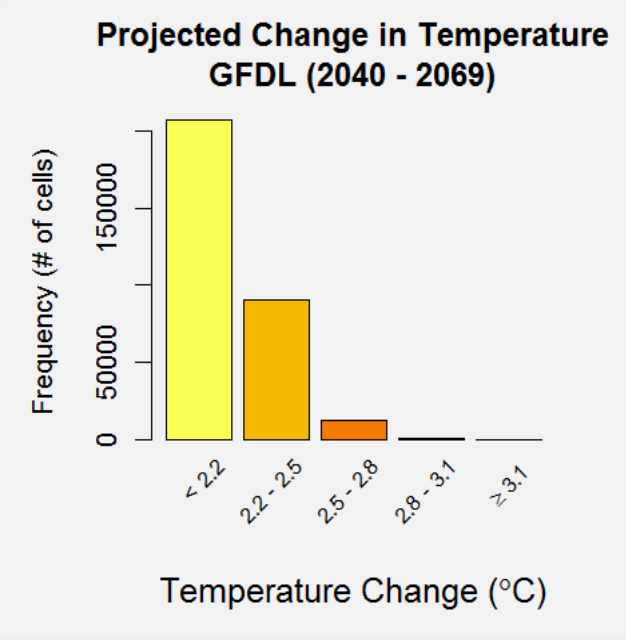


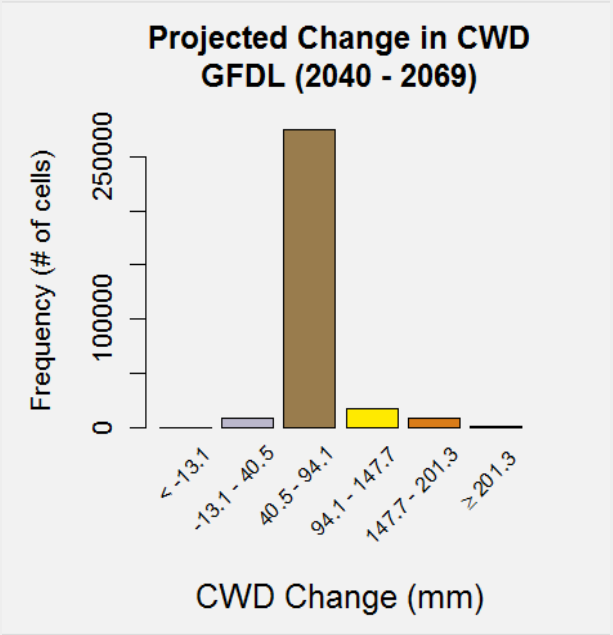
PCM (2040 - 2069)



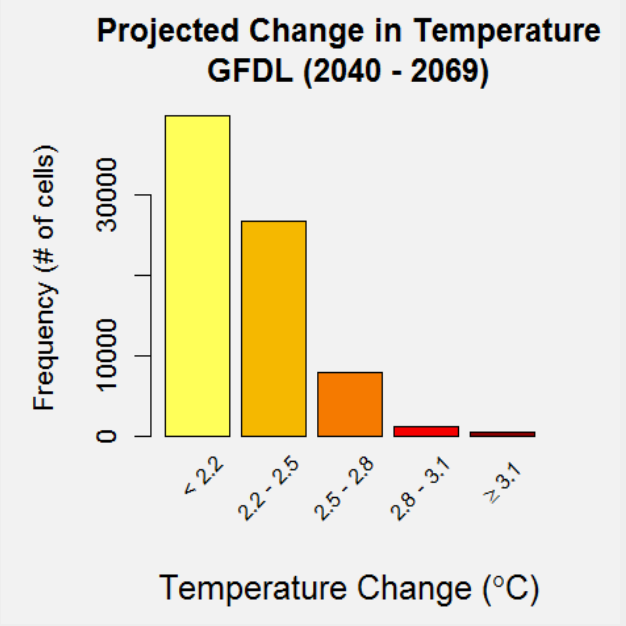


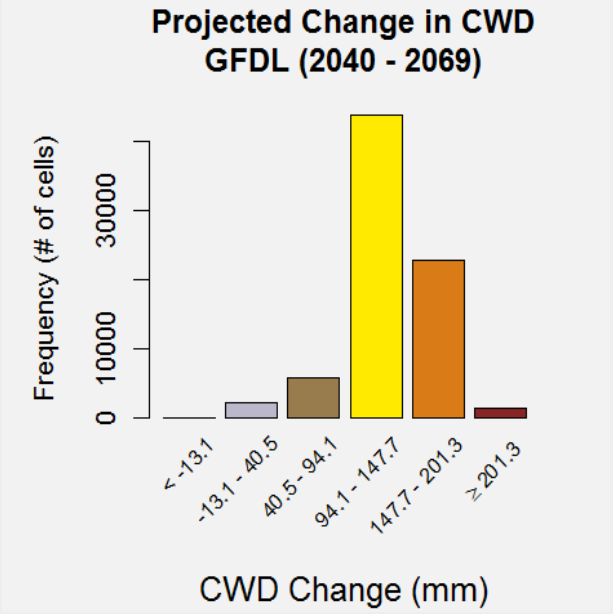






California Thrasher



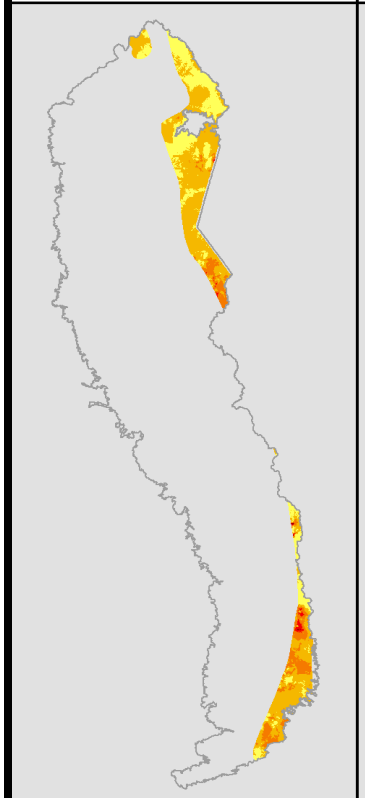


Gray-crowned Rosy-Finch

Projected climate change exposure for Brewer's Sparrow

Temperature

GFDL (2040 - 2069)



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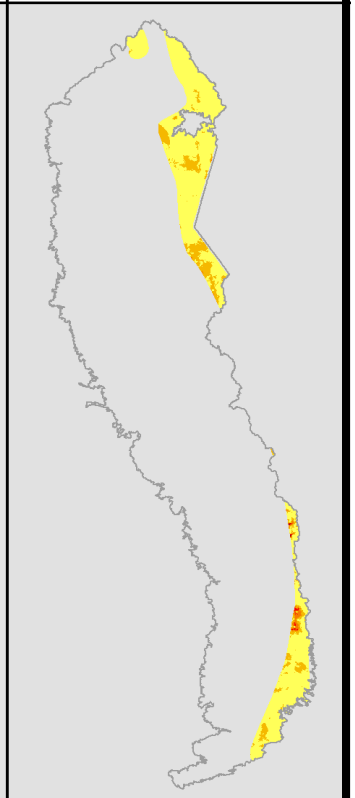
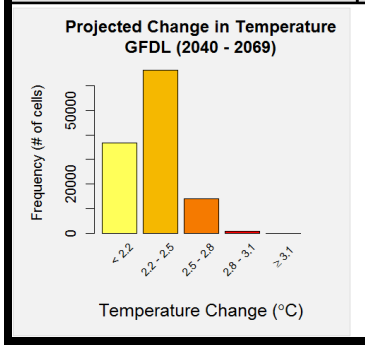
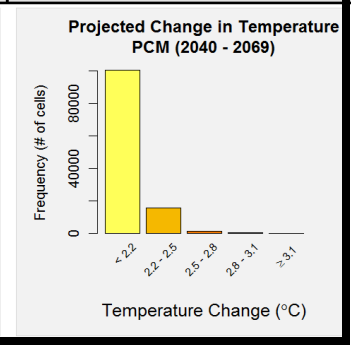
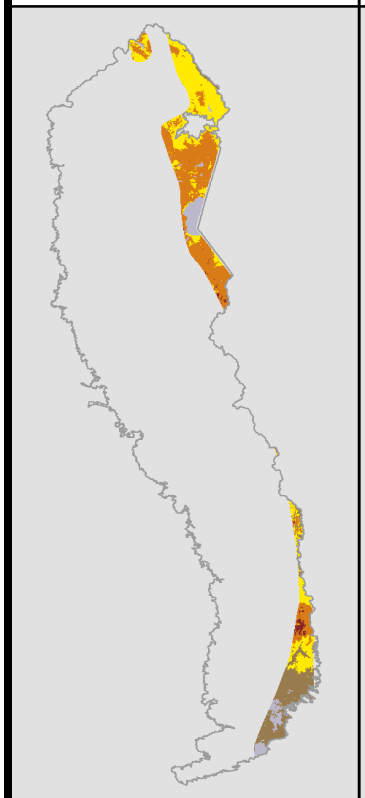






Moisture

GFDL (2040 - 2069)



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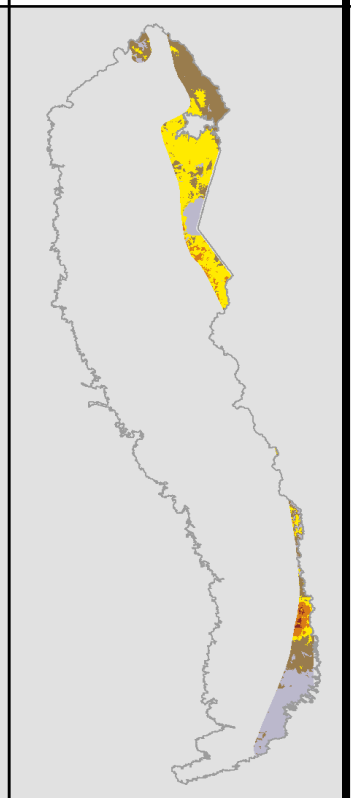
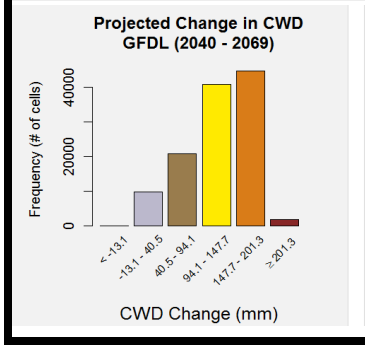
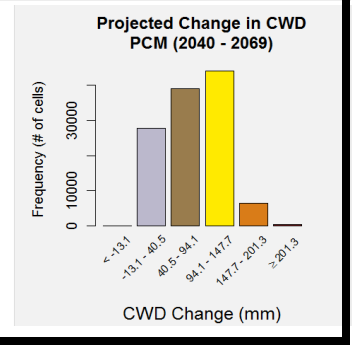


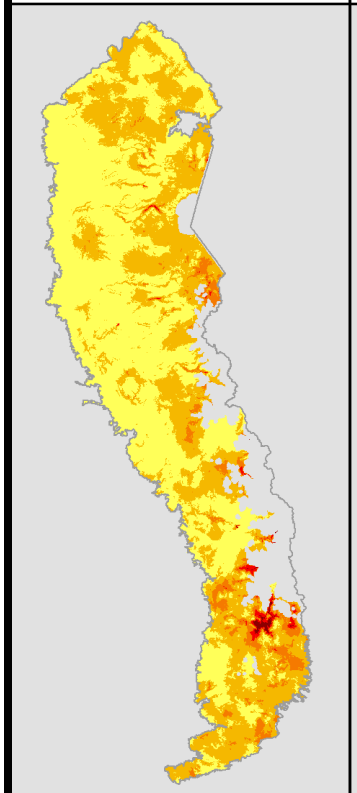




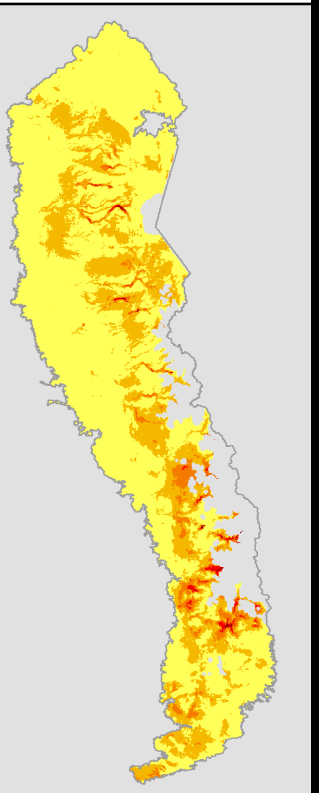
Projected climate change exposure for Song Sparrow

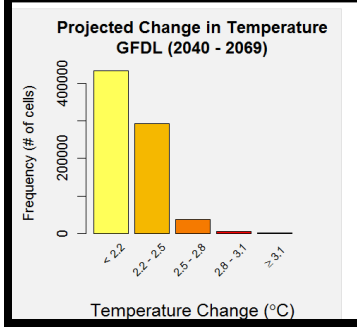
Temperature

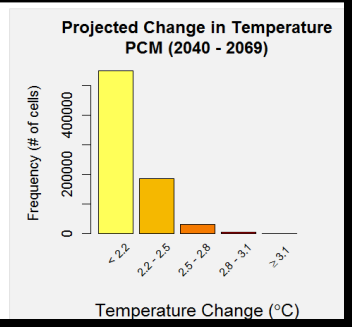
GFDL (2040 - 2069)



PCM (2040 - 2069)

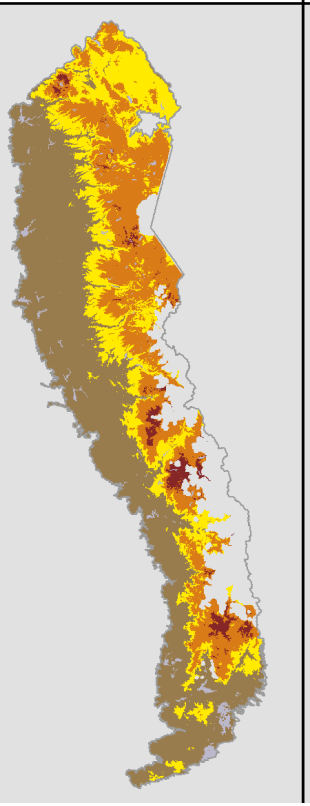




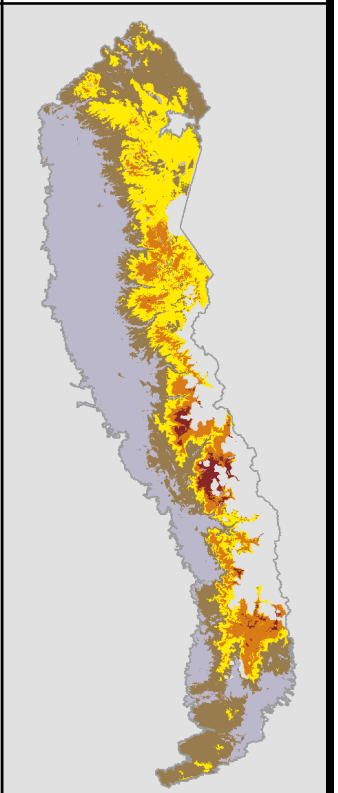


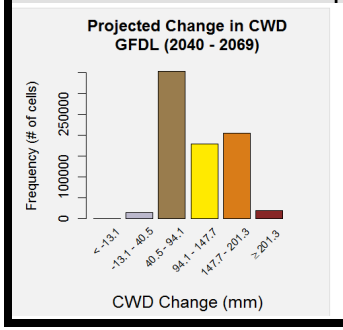
Moisture

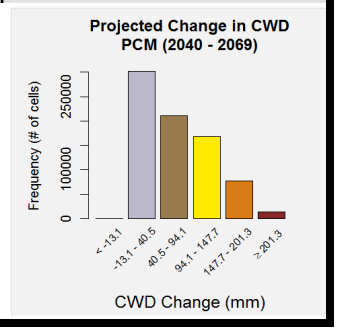
GFDL (2040 - 2069)



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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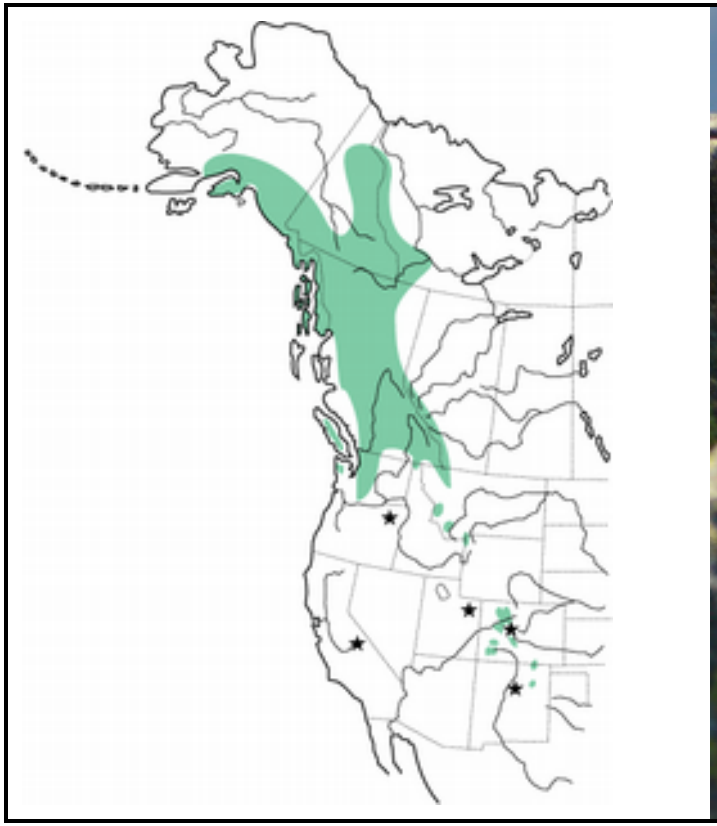
Rankings – Extremely Vulnerable species

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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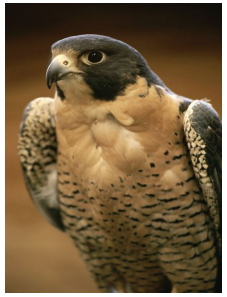
Rankings – Moderately Vulnerable species, part 1

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

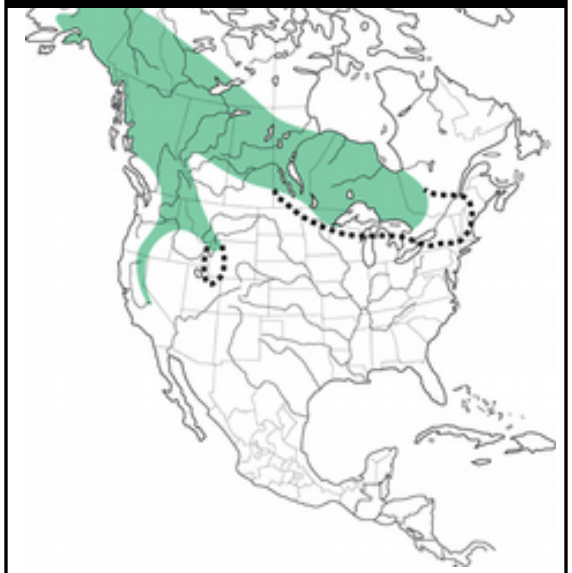
Species Ranked as Increase Likely* Under *Both* the GFDL and PCM Climate Models	
Red-tailed Hawk	American Robin
Mourning Dove	California Thrasher
Common Nighthawk	European Starling
Common Poorwill	Spotted Towhee
Hairy Woodpecker	California Towhee
Northern Flicker	Chipping Sparrow
Western Wood-Pewee	Black-chinned 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.

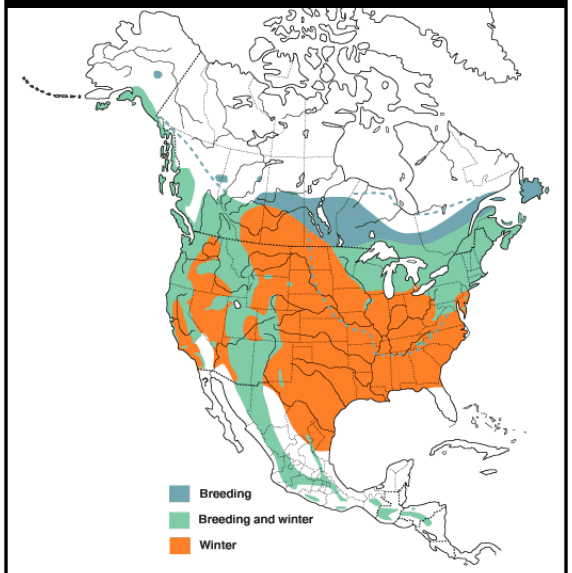
Patterns in vulnerability – overall breeding range

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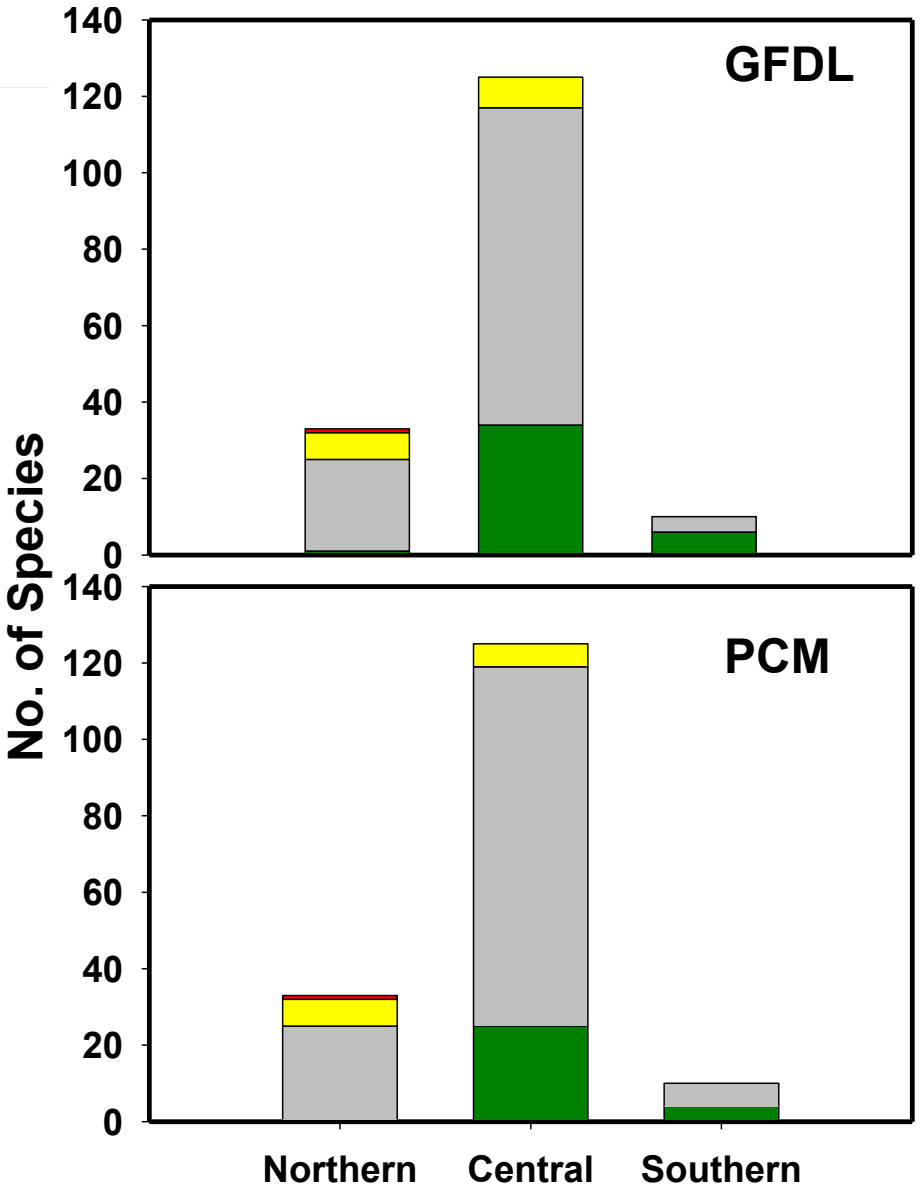
- Extremely Vulnerable
- Moderately Vulnerable
- Potentially Stable
- Increase Likely



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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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THANK YOU !