The Nature Conservancy

Protecting nature. Preserving life.™

Adapting to Global Climate Change

Rebecca Shaw, Kirk Klausmeyer and Jason MacKenzie

Climate Change, Natural Resources and Coastal Management: A workshop on the coastal ecosystems of California, Oregon and Washington

January 30, 2009

Photo credits: (Top) Richard Herrmann; (Bottom) Donna McCoy, Macduff Everton

Framing Adaptation Approach

If humanity wishes to preserve a planet similar to that on which civilization developed and to which life on Earth is adapted, paleoclimate evidence and ongoing climate change suggest that CO2 will need to be reduced from its current 385 ppm to at most 350 ppm...If the present overshoot of this target CO2 is not brief, there is a possibility of seeding irreversible catastrophic effects.

James Hansen, Goddard Space Institute, 2008

Current Temperature and Ecosystem Impacts

At the current 0.7°C *(*1.3°F, *385 ppm$_v$ CO_2e), impacts are measureable, significant and comprehensive*:

- *glacier and polar ice cap loss*
- *sea level rise*
- *species movement*
- *increase in growing season length*
- *increased frequency and magnitude of extreme events (drought and storms)*

Temperature Thresholds and Ecosystem Impacts

At 2°C *(*3.6°F *, 450ppmv CO_2e)*

- *Retreat of Greenland and Antarctic ice*
- *Increased damage from floods and storms*
- *Most corals bleached*

At 3°C *(*5.4°F *, 550ppmv CO_2e)*

- *Several meters of sea level rise*
- *Widespread coral mortality*
- *50% of permafrost thaws*

At 4°C *(*7.2°F *, 650ppmv CO_2e)*

- *Mid-latitude glaciers disappear*
- *Major extinctions around the globe*
- *Terrestrial biosphere becomes net carbon source*

• IPCC. 2007. Working Group II: Impacts, adaptation and Vulnerability,
• Anderson & Bows. 2008. Phil Trans. Royal Society A Based on the range of cumulative emissions within IPCC AR4 (for 450 ppmv) and the Stern report (for 550 and 650 ppmv),13 with the accompanying rates of reduction representing the mid-values of the ranges

Current Policy Efforts
To Achieve Temperature Thresholds

CA Global Warming Solutions Act (AB32) - passed

- ***Goal: Temperature Increase 0f 3 – 5.5 F (1.6 – 3 C)***
  - *1990 Emissions by 2020*
  - *80% below 1990 emissions by 2050*

US Climate Action Partnership (USCAP) - proposed

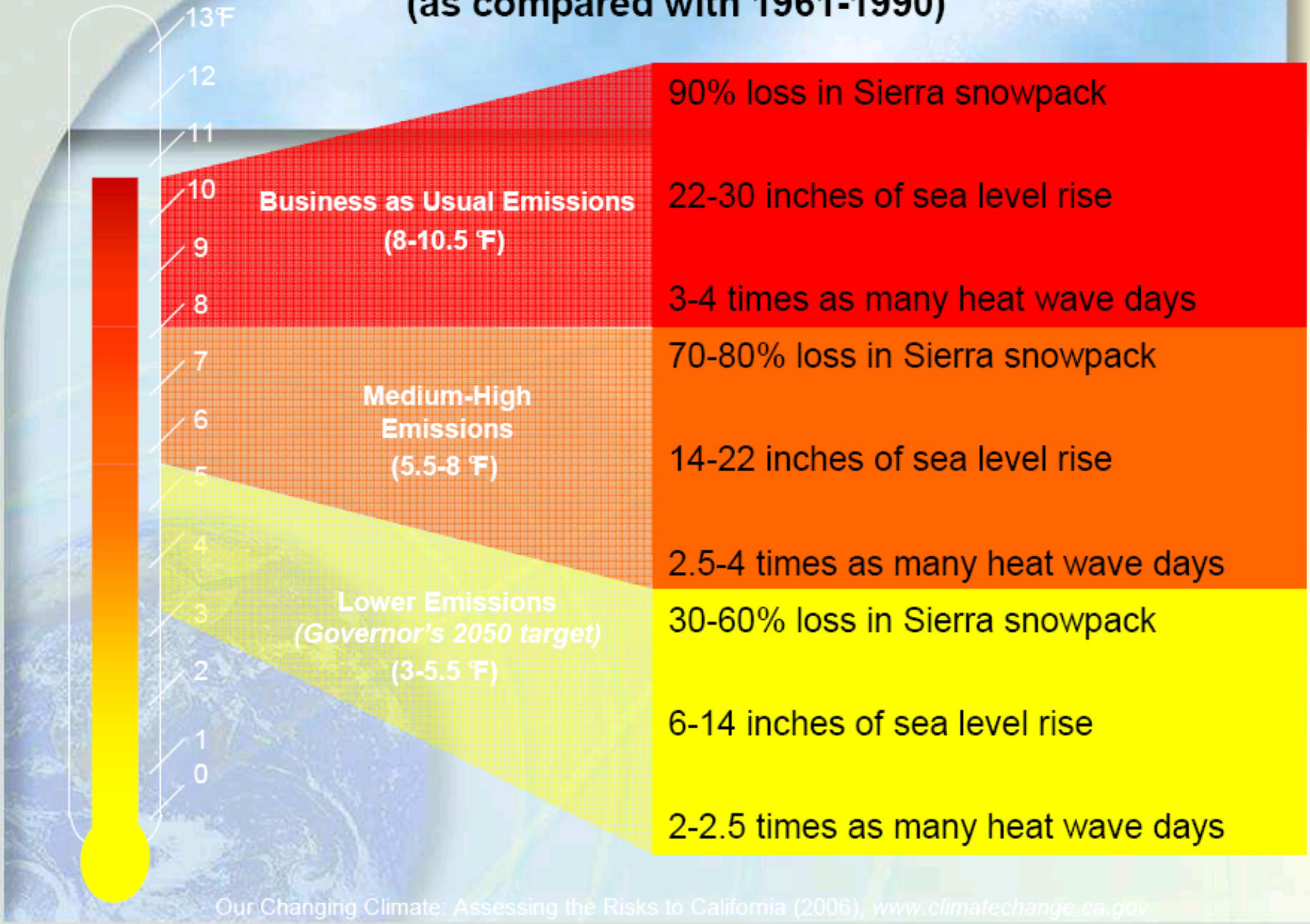
- ***Goal: Stabilize at 450-550 ppm CO2e***
  - *97%-102% of 2005 levels by 2012*
  - *80%-86% of 2005 levels by 2020*
  - *58% of 2005 levels by 2030*

Lieberman-Warner Climate Security Act of 2008 - not passed

- ***Goal: Stabilize at 450-550 ppm CO2e***
  - *4% of 2005 levels by 2012*
  - *19% of 2005 levels by 2020*
  - *71% of 2005 level in 2050*

Projected Global Warming Impact on California, 2070-2099

(as compared with 1961-1990)



Our Changing Climate: Assessing the Risks to California (2006), *www.climatechange.ca.gov*

Trajectory of Global CO_2 Emissions

“ Get off 20% below by 2020. It’s not going to happen.”

-Prof. Steve Schneider, San Francisco, CA January 30, 2009

Framing Adaptation Potential

- For climate mitigation

  2°C (3.6 ° F) should remain the driver of policy

- For climate change adaptation

  4°C (7.2 ° F) should become the driver of policy

  science, and management

What do we need to know to adapt to 4°C?

Resource management

Adaptation best practices

Key strategies

- Protect key ecosystem features
- Reduce anthropogenic stresses
- Ensure representation
- Ensure replication
- Increase connectivity
- Consider restoration
- Identify and protect refugia
- Consider relocation
- Enhance resilience
- Manage adaptively

What do we need to know to adapt to 4°C?

- *Focus on management goals at the outset*
- *Data inputs to meet goals*
- *Vulnerability (targets, goals)*
- *Adaptive capacity including costs*
- *Changes in trends*
- *You can reassess goals*

"No single metric can adequately capture the diversity of key vulnerabilities, nor determine their ranking"

- Prof. Schneider, January 30, 2009

Adaptation Models

Theoretical (IPCC)

Assess impacts

Evaluate adaptive capacity

Assess vulnerability

Evaluate adaptation options

Develop adaptation activity

Practical (Resource Managers)

Assess climate impacts

Assess vulnerability of targets

Evaluate management options

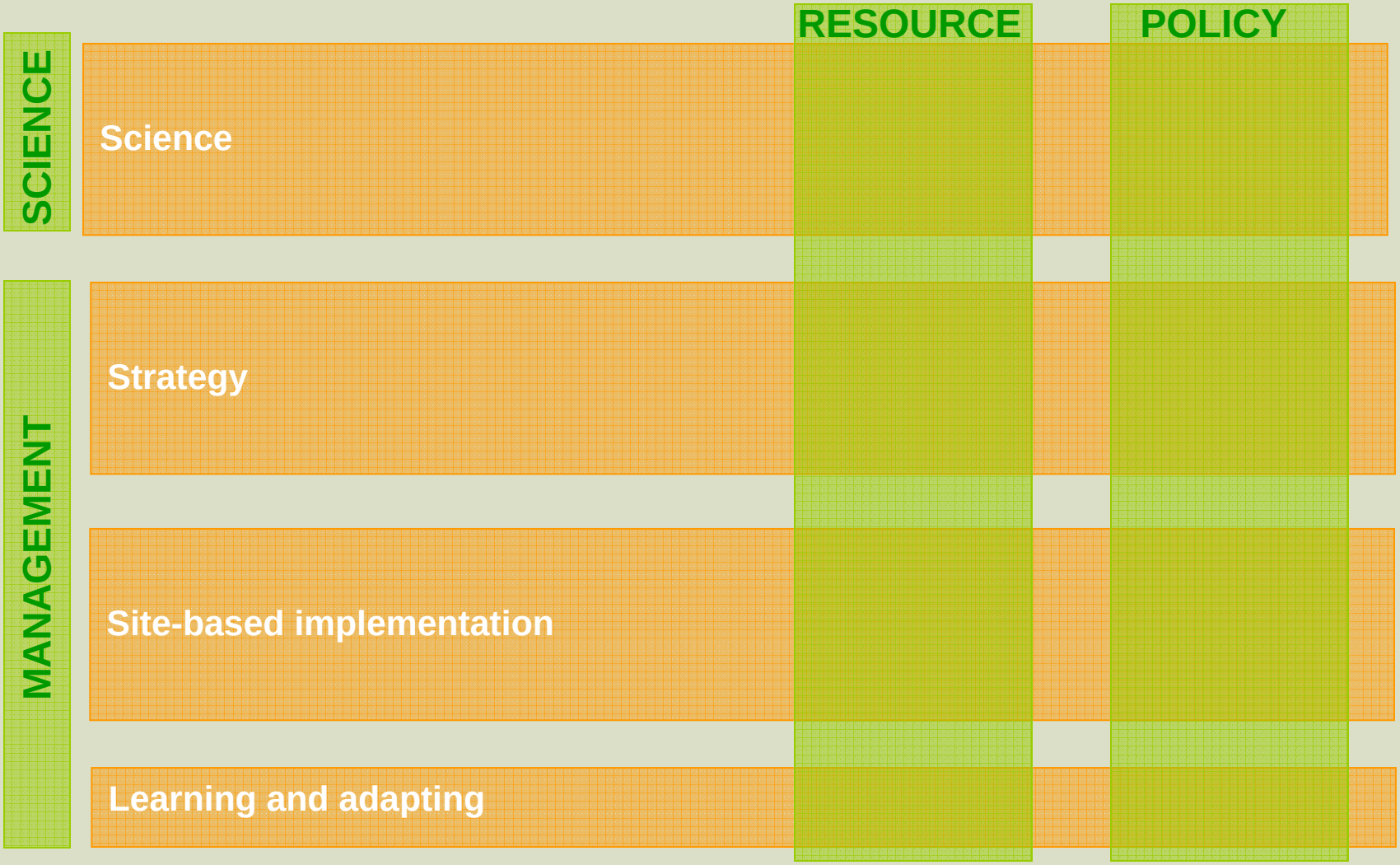
Evaluate capacity to respond

Develop management response

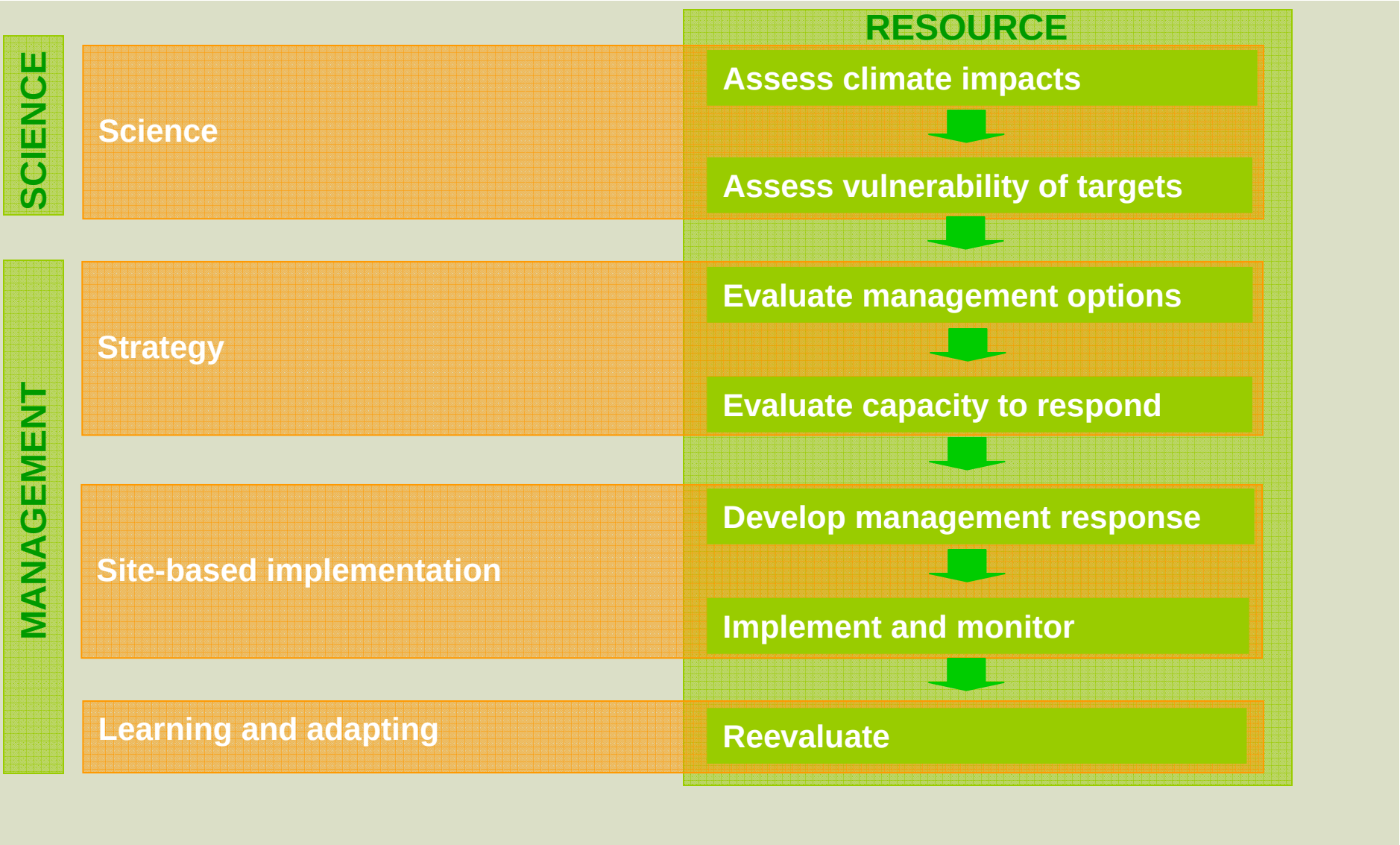
Monitor

Reevaluate

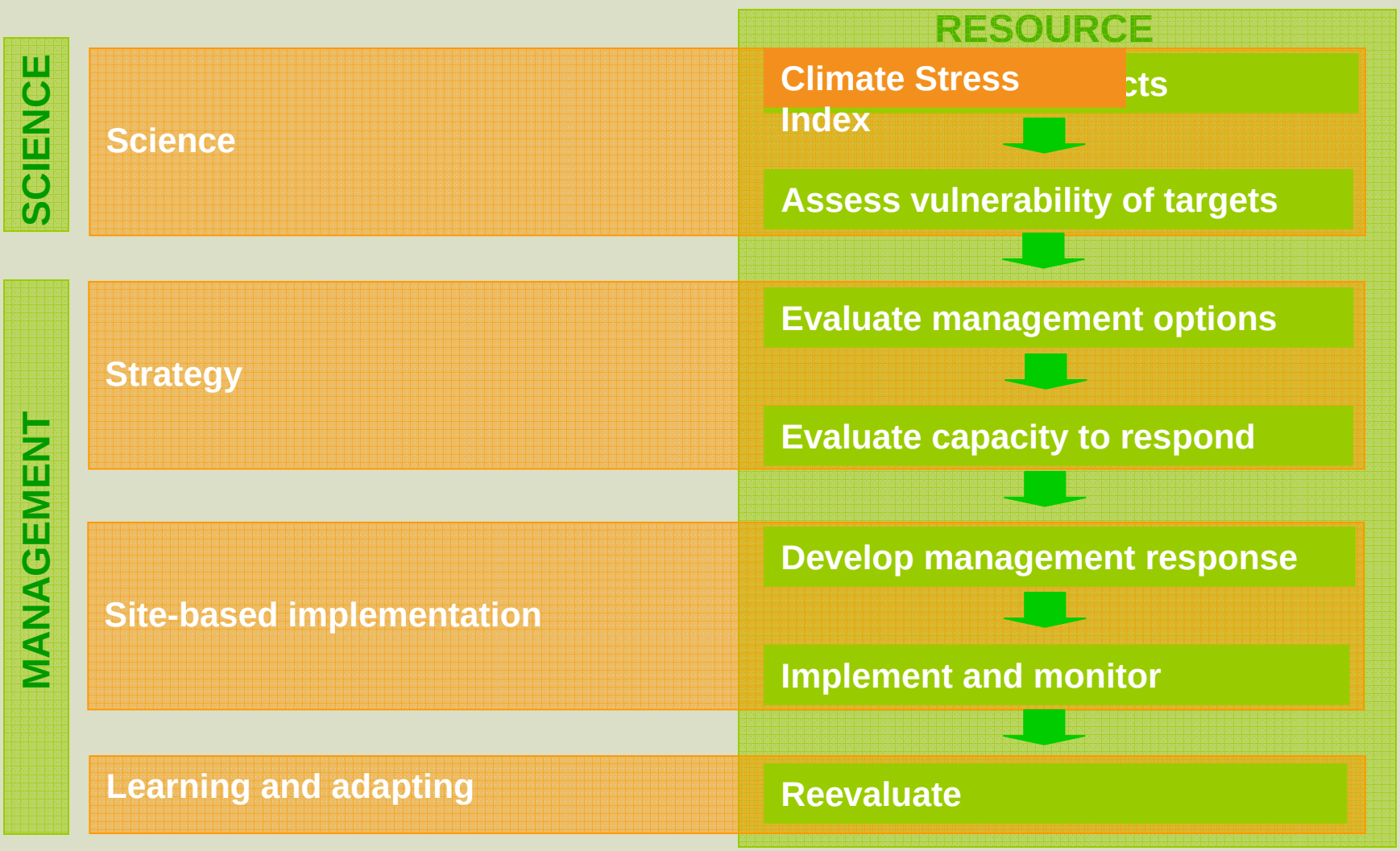
Linking Resource, Science, Policy & Management

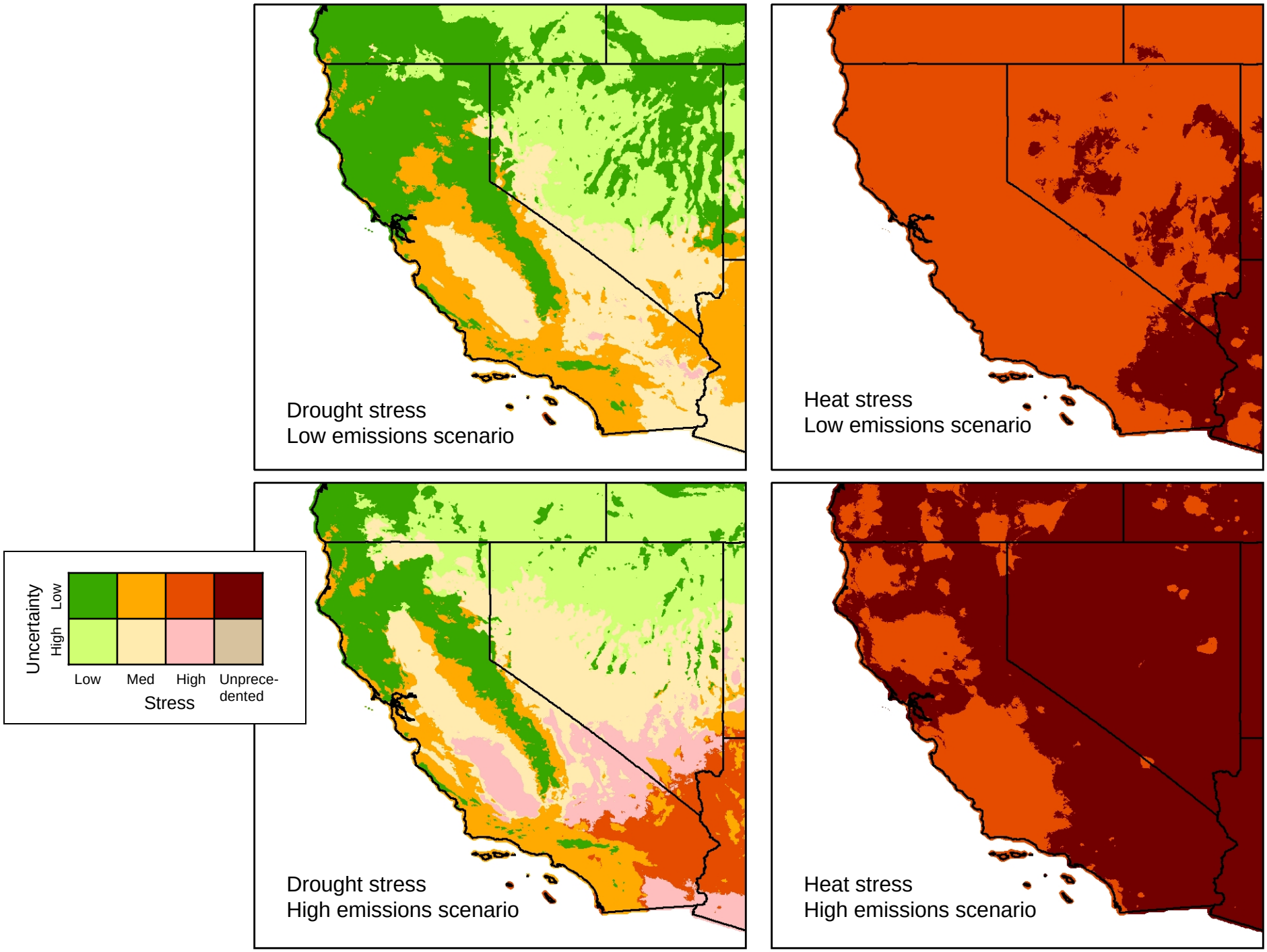


Developing tools for managers



Developing tools for managers




Drought stress
Low emissions scenario
Heat stress
Low emissions scenario
Drought stress
High emissions scenario
Heat stress
High emissions scenario
Uncertainty
Low
High
Low
Med
High
Unprece-
dented
Stress

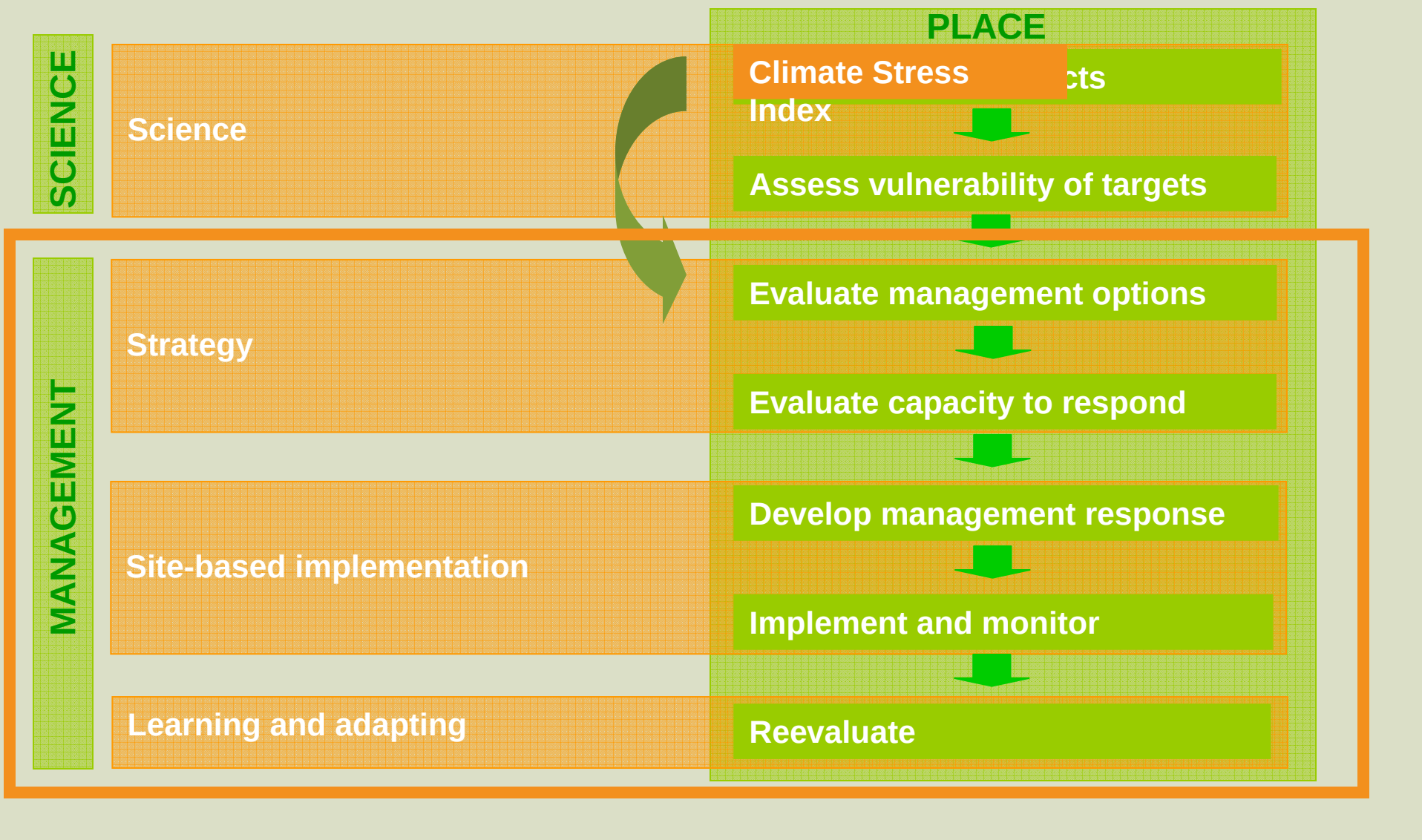
Drought Stress Index – High Emissions, 4°C

Uncertainty	Low Stress	Medium Stress	High Stress	Unprecedented Stress
Low	Lassen Foothills Napa - Sonoma Northern Sierra Valleys Pit River Sequoia Foothills Smith River Watershed Sonoma Coastal Forests	Carmel River Watershed Coachella Valley and Mountains Cosumnes River Gabilan Range - San Benito River Humboldt Bay Kern River and Southern Sierra Mount Hamilton Northern Channel Islands Salinas River San Diego Coast & Mountains San Francisco Bay San Luis Obispo Coast & Interior Santa Ana Mountains and Coast Santa Barbara Coast & Interior Santa Clara River and Coast Southern Santa Cruz Mountains Tehachapi Mountains	Colorado River Eastern Mojave	
High	Eagle Lake Goose Lake Klamath Basin Yolla Bolly Woodlands	Carrizo Plain Merced Grasslands Mono Basin Panoche and Ciervo Hills Sacramento - San Joaquin Delta Sacramento River San Joaquin River Sierra East Side Rivers	Amargosa River Mojave Desert Corridors Salton Sea Tulare Basin	

Heat Stress Index – High Emissions, 4°C

Uncertainty	Low Stress	Medium Stress	High Stress	Unprecedented Stress
Low			Carmel River Watershed Carrizo Plain Gabilan Range - San Benito River Humboldt Bay Merced Grasslands Mount Hamilton Napa - Sonoma Northern Channel Islands Panoche and Ciervo Hills Sacramento River Salinas River San Joaquin River San Luis Obispo Coast & Interior Santa Barbara Coast & Interior Smith River Watershed Southern Santa Cruz Mountains Tehachapi Mountains Tulare Basin	Amargosa River Coachella Valley and Mountains Colorado River Cosumnes River Eagle Lake Eastern Mojave Goose Lake Kern River and Southern Sierra Klamath Basin Lassen Foothills Mojave Desert Corridors Mono Basin Northern Sierra Valleys Pit River Sacramento - San Joaquin Delta Salton Sea San Diego Coast & Mountains San Francisco Bay Santa Ana Mountains and Coast Santa Clara River and Coast Sequoia Foothills Sierra East Side Rivers Sonoma Coastal Forests Yolla Bolly Woodlands
High				

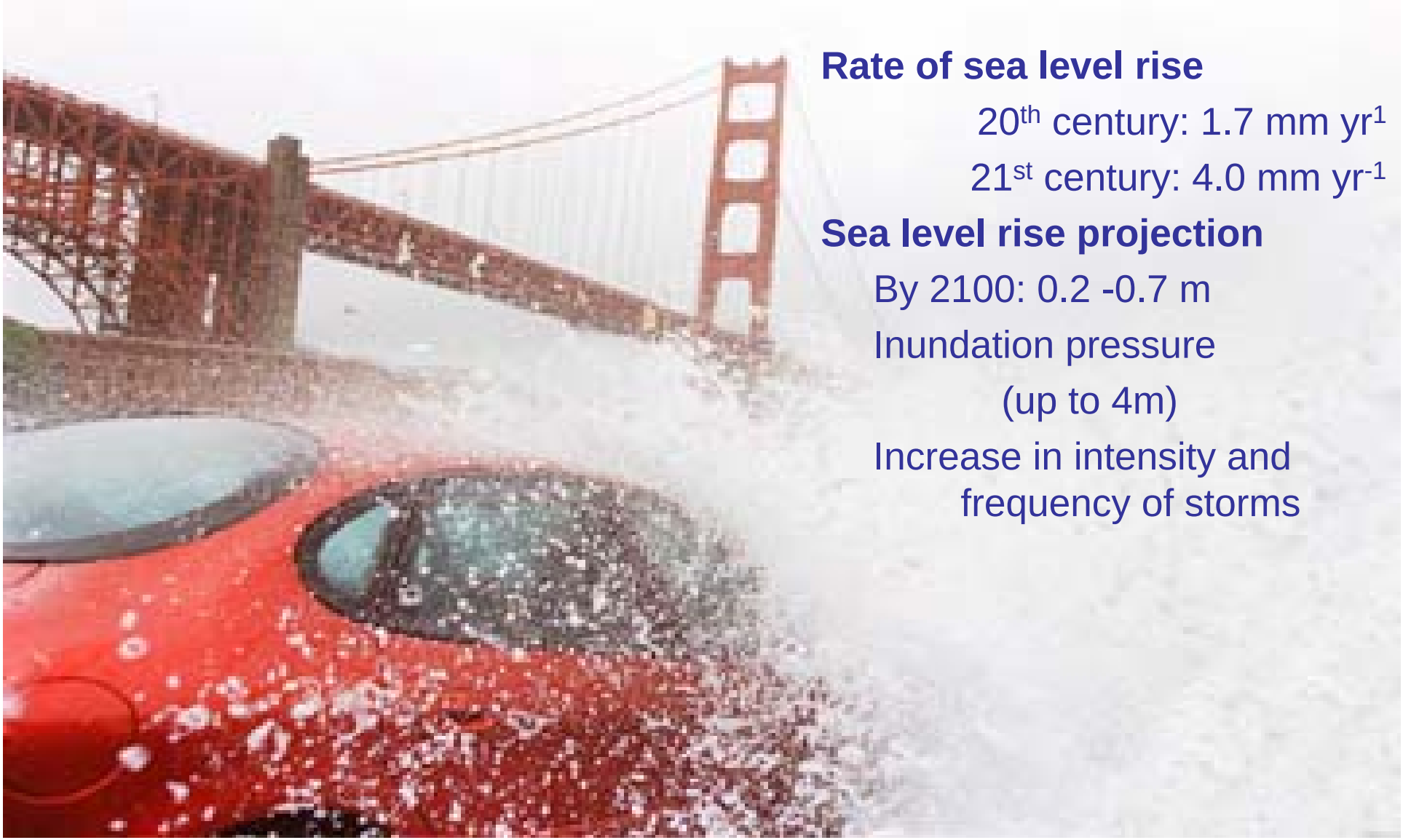
Developing tools for Managers



Climate Stress Index Strategy Matrix

Uncertainty \ Stress	Low	Medium	High	Unprecedented
Low	• Implement current strategies • Monitor climate for change	• ID Key Stressor • Assess microclimate • Assess microclimate • Consider target analysis •Develop strategies to counteract stressor • Calculate cost •Monitor climate	• ID Key Stressor • Reassess goals to determine if achievable • Develop strategies to counteract stressor, new goals or consider triage	• Reassess goals • Consider reprioritization or divesting
High	Implement current strategies • Monitor for climate and target change	• ID key stressor • Assess microclimate • Consider target analysis • Calculate cost • Develop strategies to counteract stressor • Monitor for climate and target change	• ID Key Stressor • Reassess goals to determine if achievable • Monitor for climate and target change • Consider triage	• Consider reprioritization or divesting

Climate Stress Index: Mean sea level rise High emissions, 4°C



Rate of sea level rise

20th century: 1.7 mm yr^{1}

21st century: 4.0 mm yr^{-1}

Sea level rise projection

By 2100: 0.2 -0.7 m

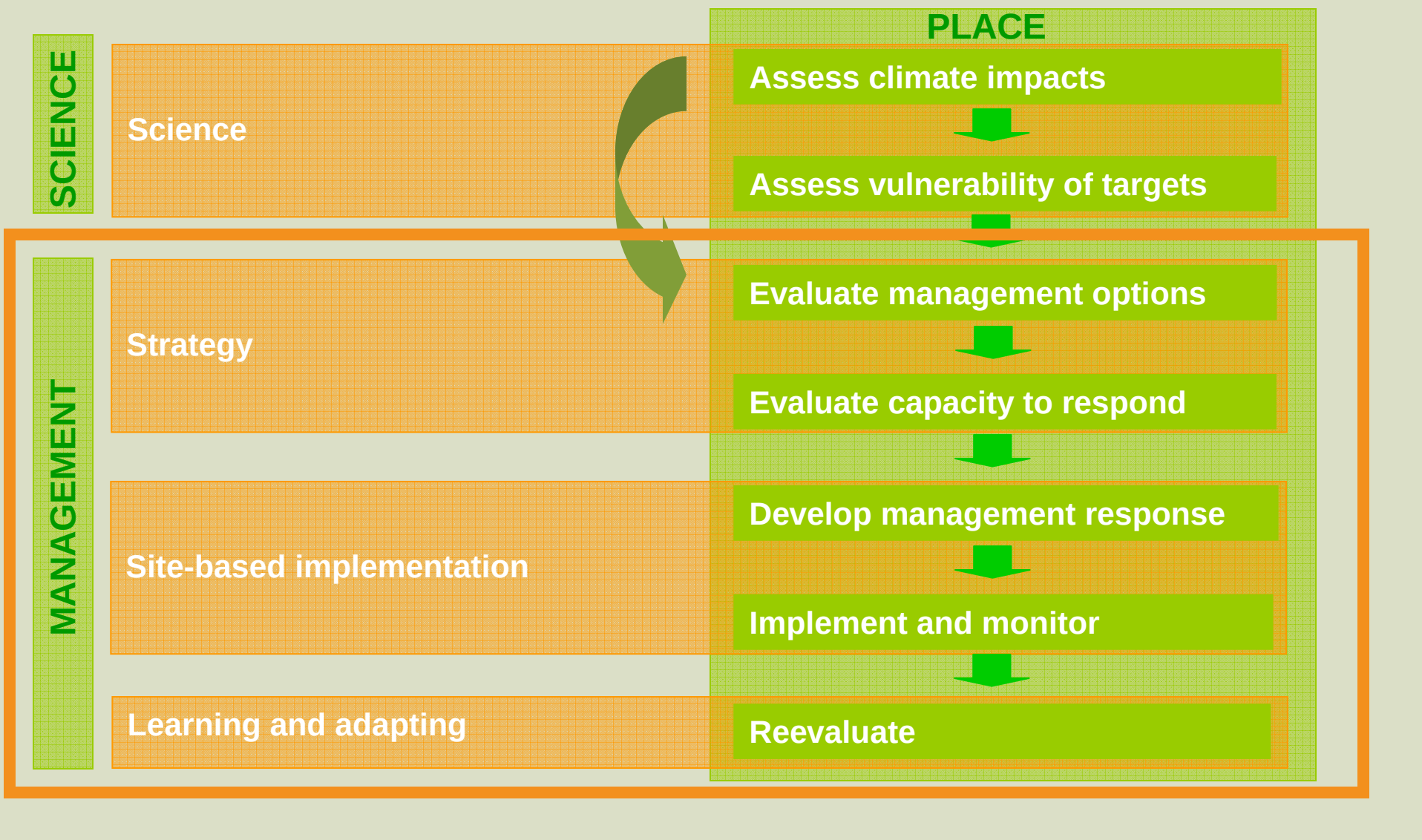
Inundation pressure (up to 4m)

Increase in intensity and frequency of storms

Climate Stress Index: Mean sea level rise
High emissions, 4°C

Climate Stress Index: Mean sea level rise with storm surge, High emissions, 4°C

Developing tools for managers



Mount Hamilton Range

Drought Stress Index:

Medium Change, Low Uncertainty

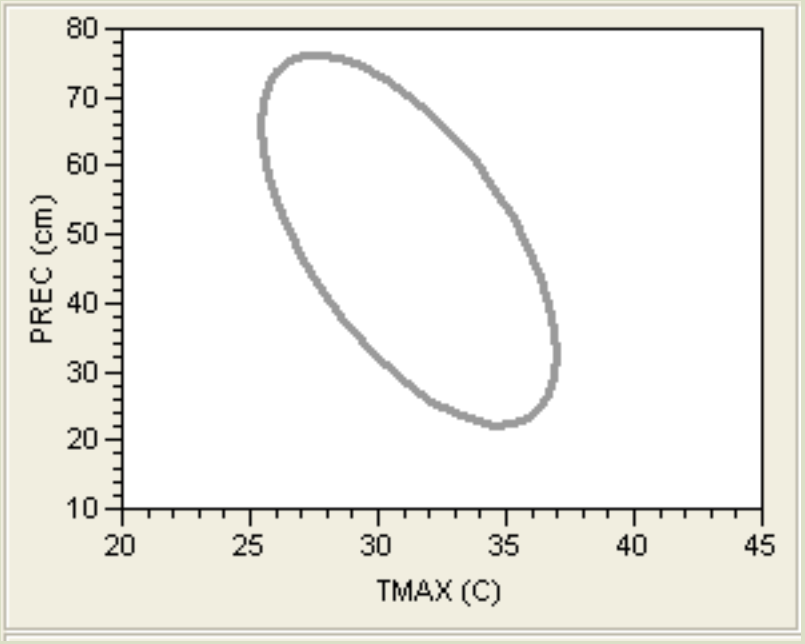
Heat Stress Index:

High Change, Low Uncertainty

- **ID Key Stresso**
- **Assess microclimate for refugia in future**
- **Consider targe analysis**
- **Develop strateg to counteract stressor**
- **Calculate costs**
- **Reassess strategies, goals**
- **Monitor for cha**

Project-Specific Climate Change Projections

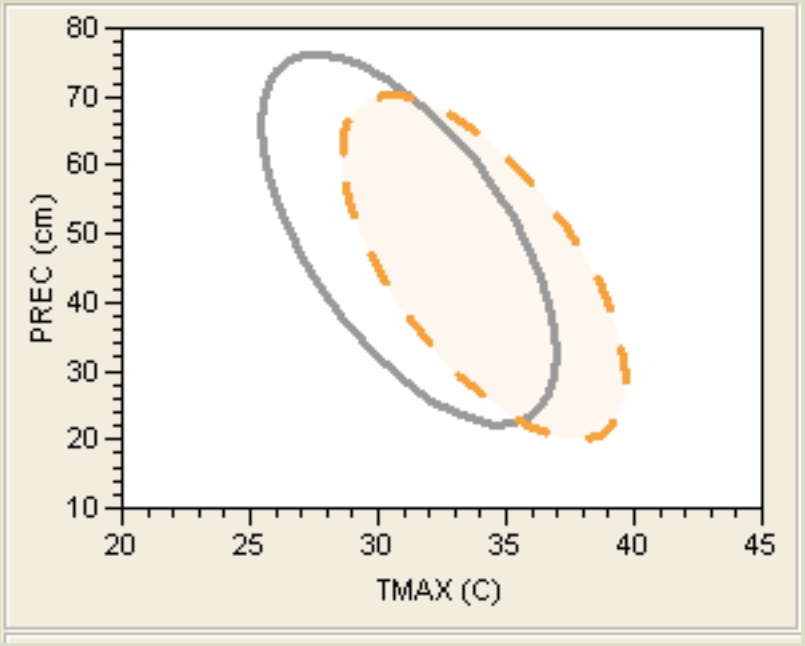
Mount Hamilton



1900-1999 Observations

Project-Specific Climate Change Projections

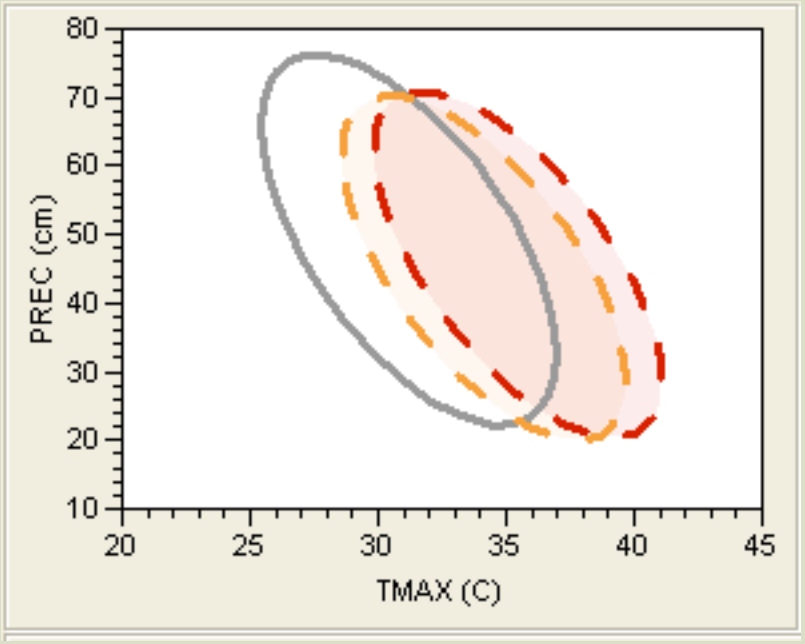
Mount Hamilton



1900-1999 Observations
2070-2099 B1 Scenario Projections

Project-Specific Climate Change Projections

Mount Hamilton



1900-1999 Observations
2070-2099 B1 Scenario Projections
2070-2099 A2 Scenario Projections

High

CLIMATE SPECIALIZATION

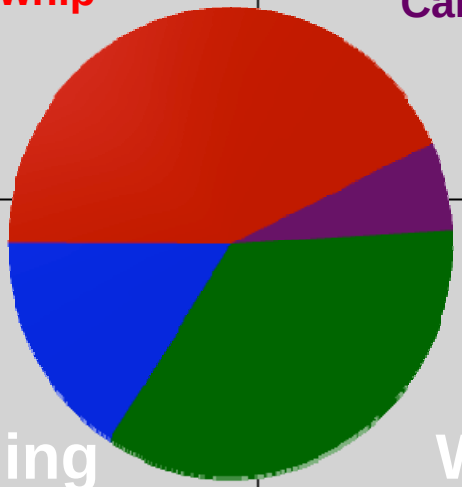
Low

Narrow-ranging specialist

Sharsmith's onion
Bay checkerspot butterfly
San Joaquin coachwhip

Wide-ranging specialist

San Joaquin kit fox
Grasshopper sparrow
California horned lark



Narrow-ranging generalist

California legless lizard
Coast (California) horned lizard

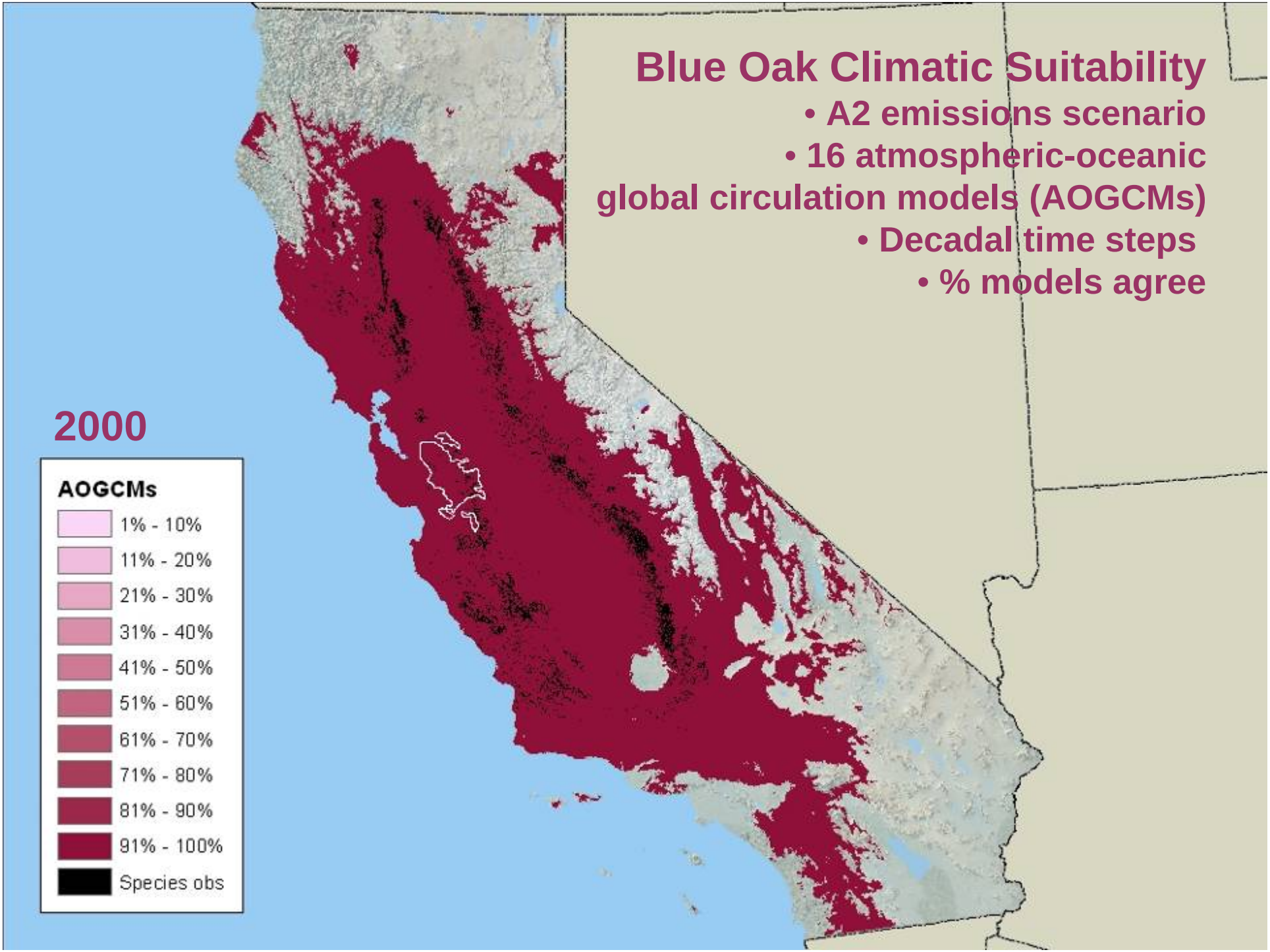
Wide-ranging generalist

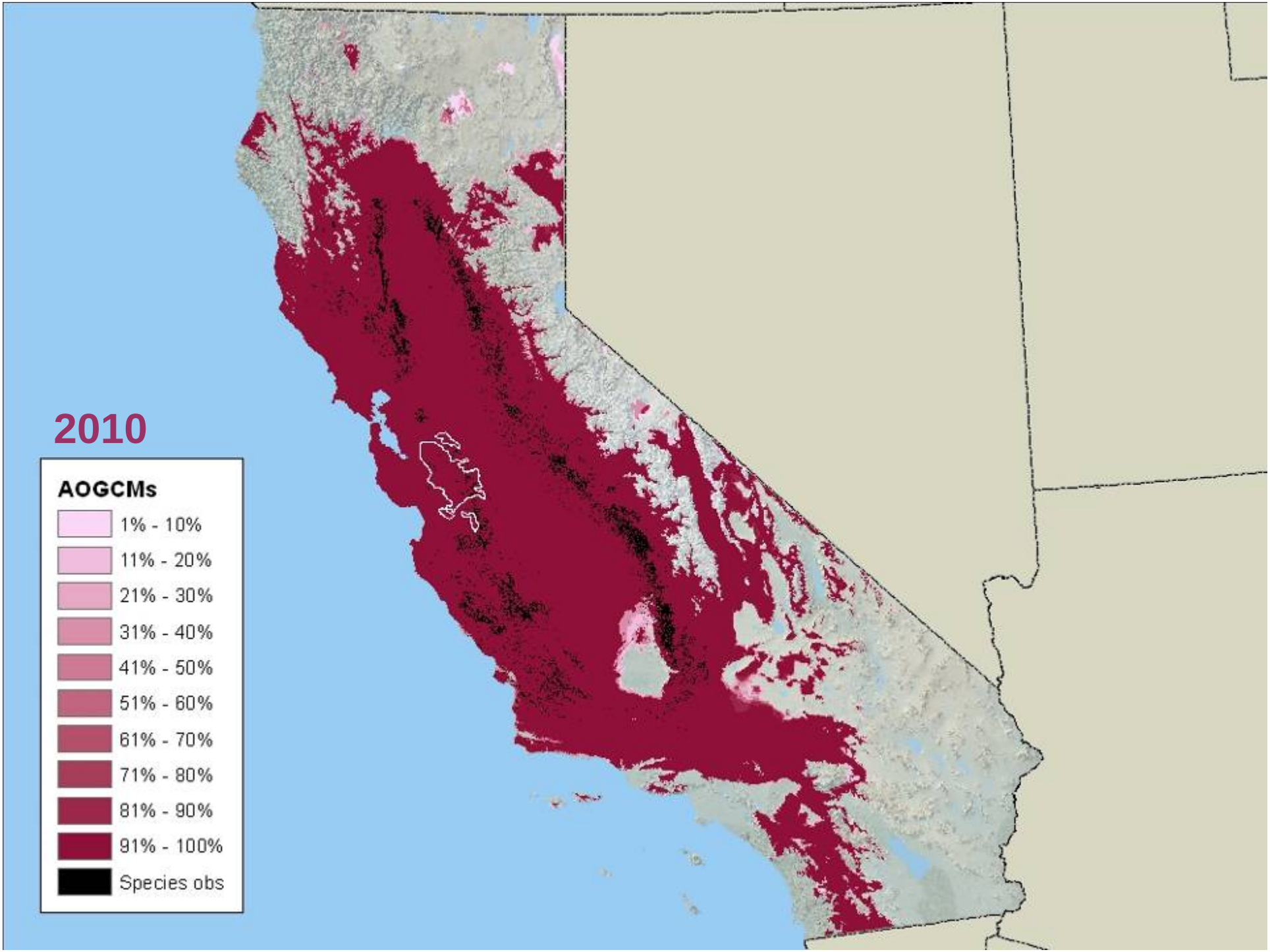
California red-legged frog
Valley Oak
Blue Oak

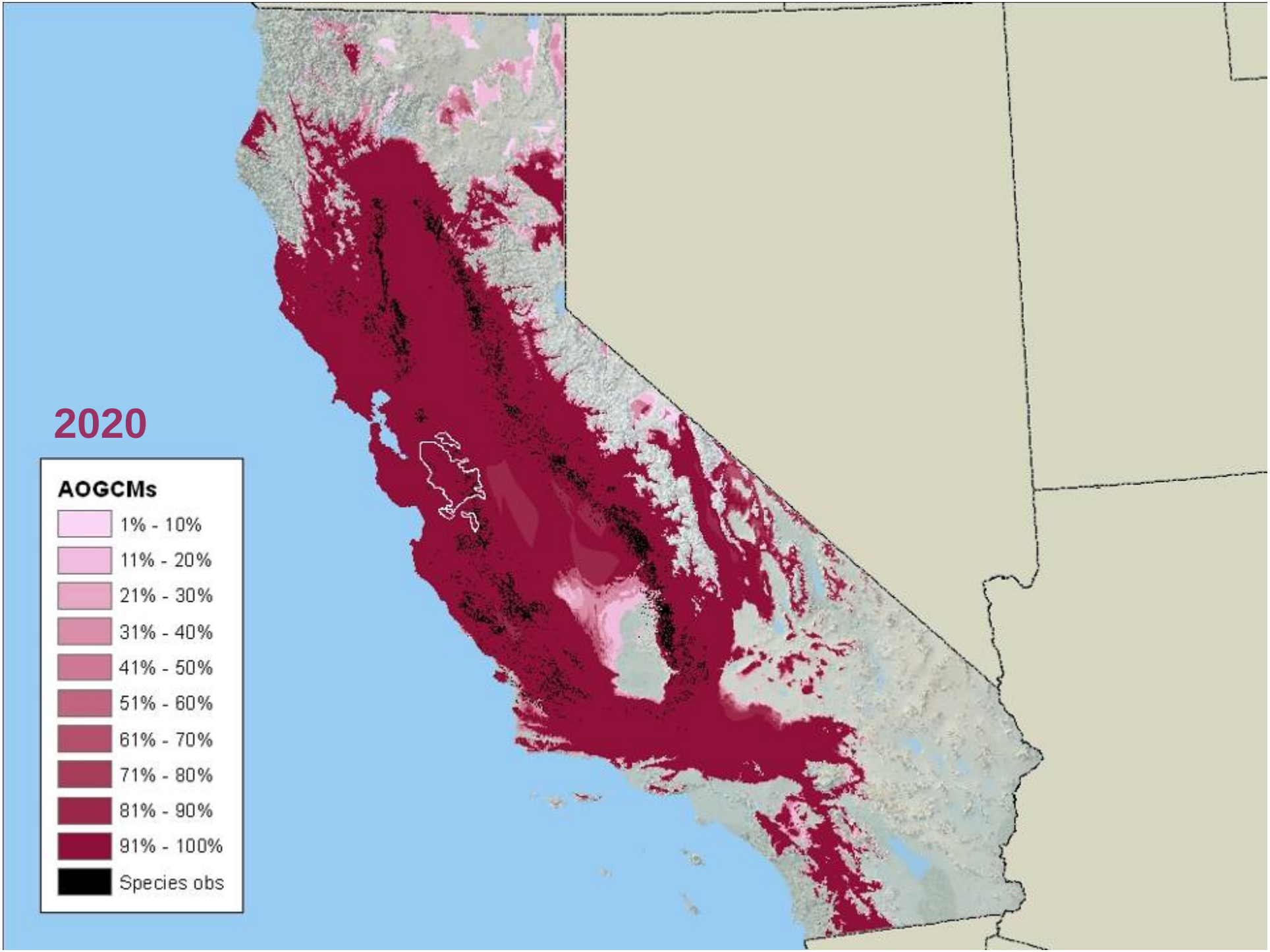
Low

DISPERSAL ABILITY

High


Blue Oak Climatic Suitability
• A2 emissions scenario
• 16 atmospheric-oceanic global circulation models (AOGCMs)
• Decadal time steps
• % models agree
2000
AOGCMs
1% - 10%
11% - 20%
21% - 30%
31% - 40%
41% - 50%
51% - 60%
61% - 70%
71% - 80%
81% - 90%
91% - 100%
Species obs


2010
AOGCMs
1% - 10%
11% - 20%
21% - 30%
31% - 40%
41% - 50%
51% - 60%
61% - 70%
71% - 80%
81% - 90%
91% - 100%
Species obs


2020
AOGCMs
1% - 10%
11% - 20%
21% - 30%
31% - 40%
41% - 50%
51% - 60%
61% - 70%
71% - 80%
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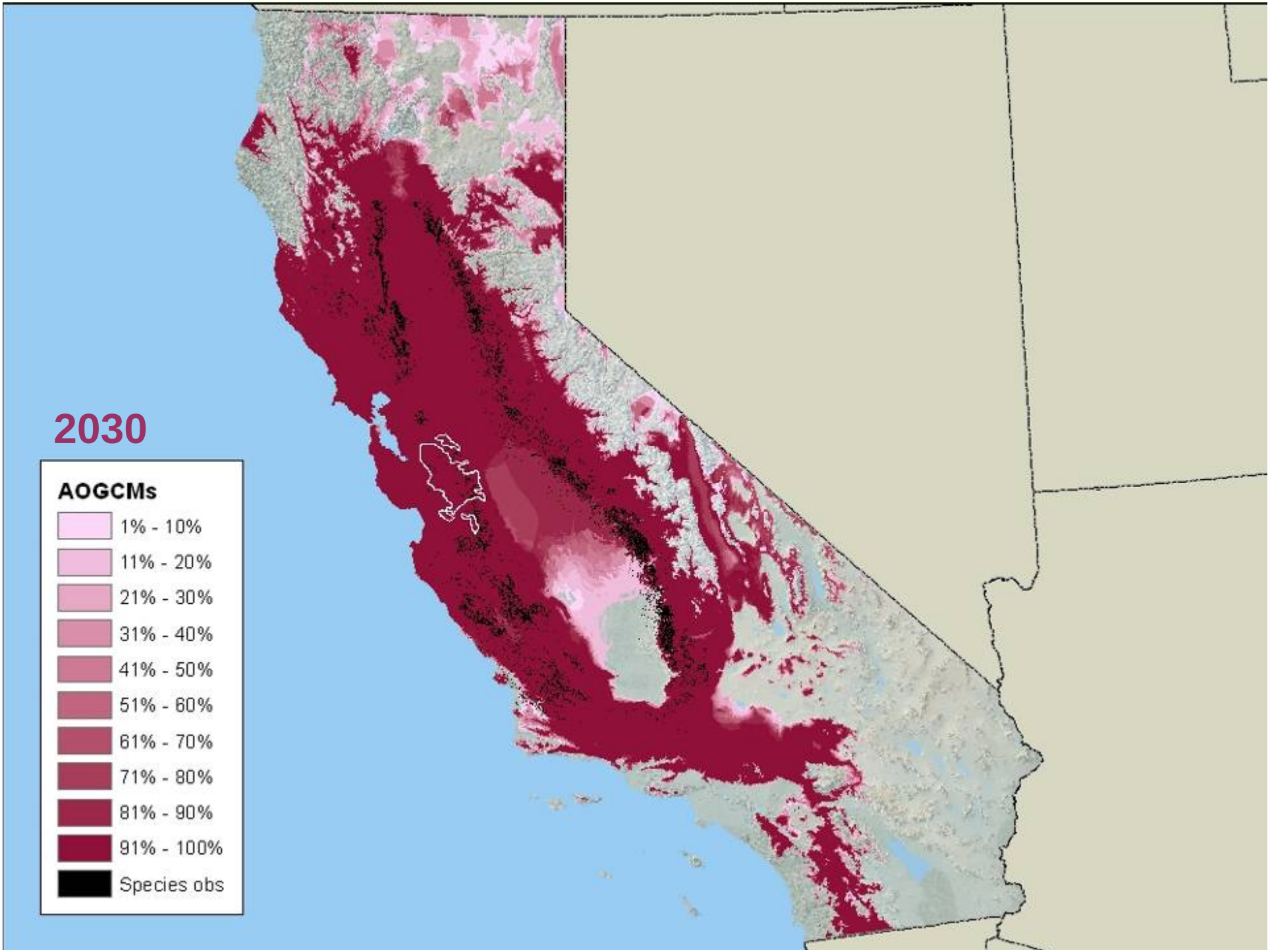
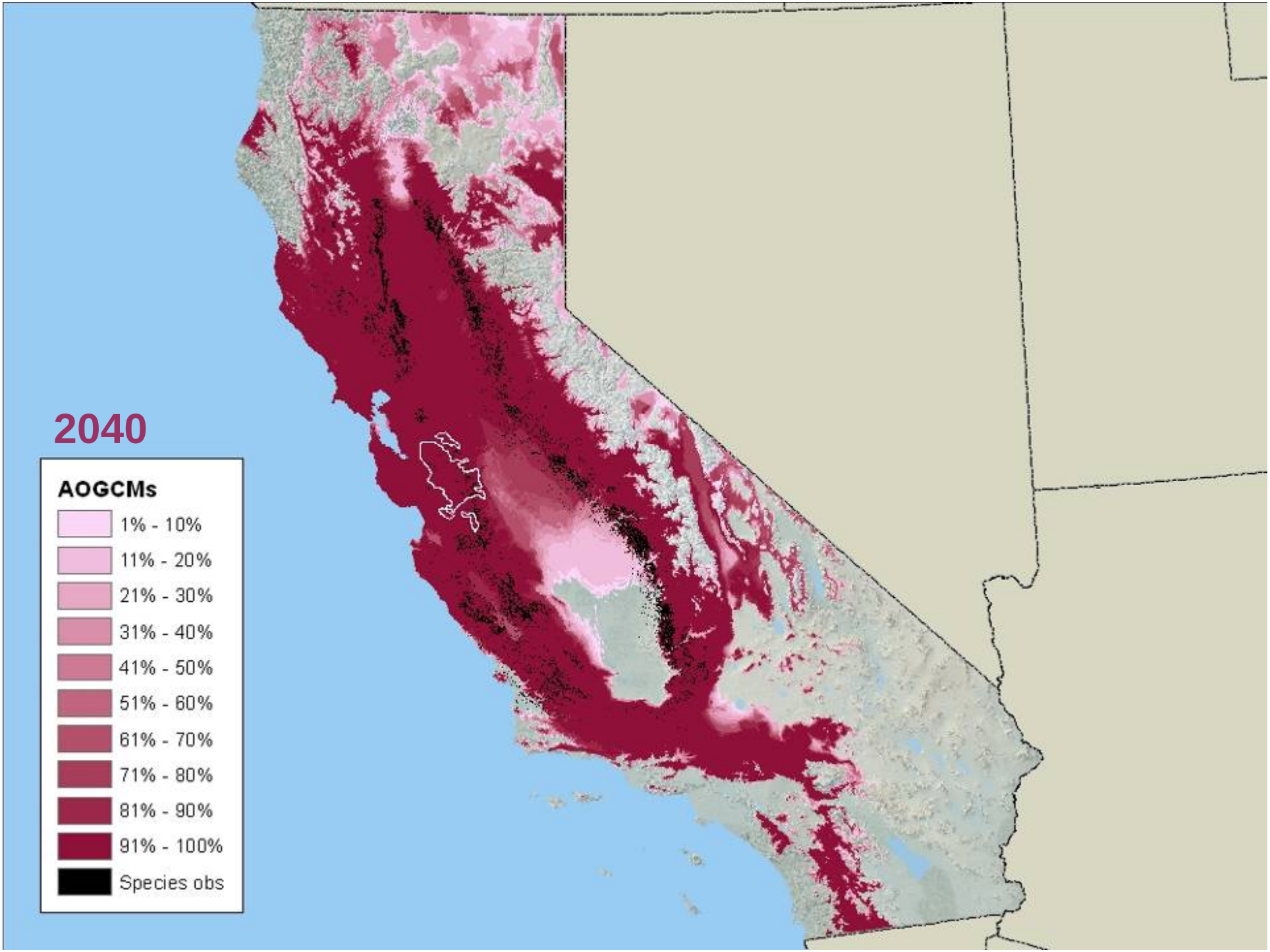
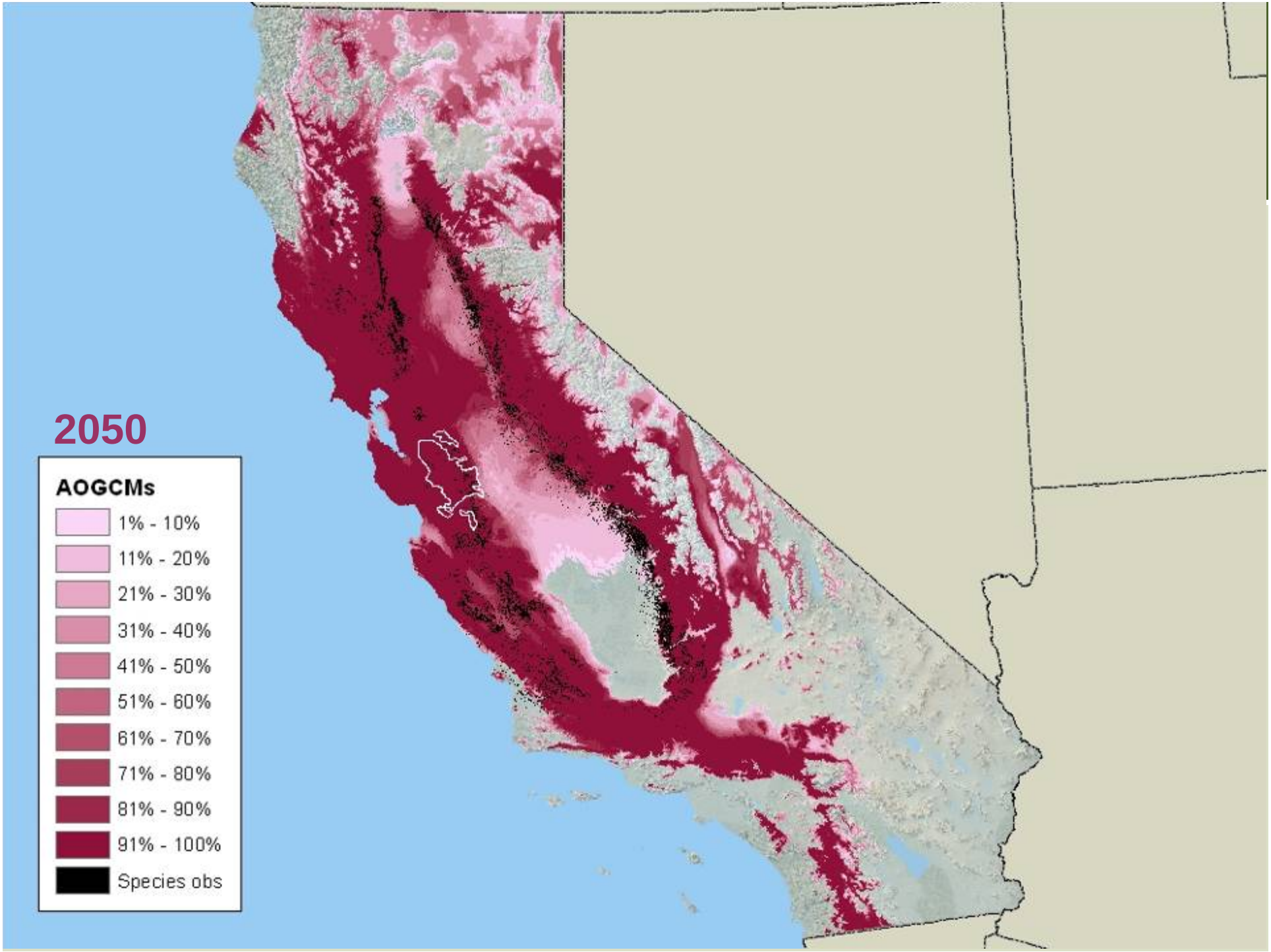
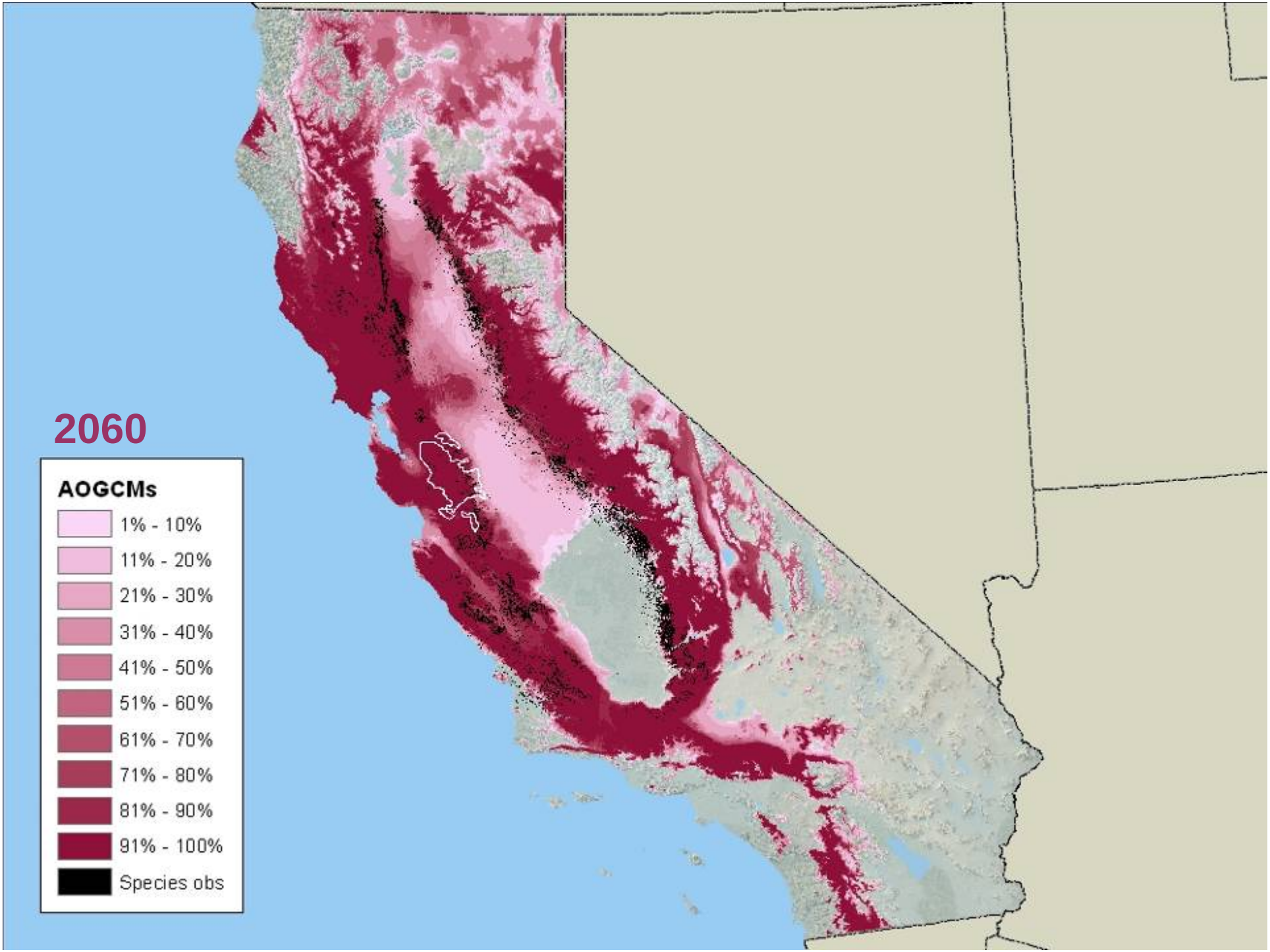
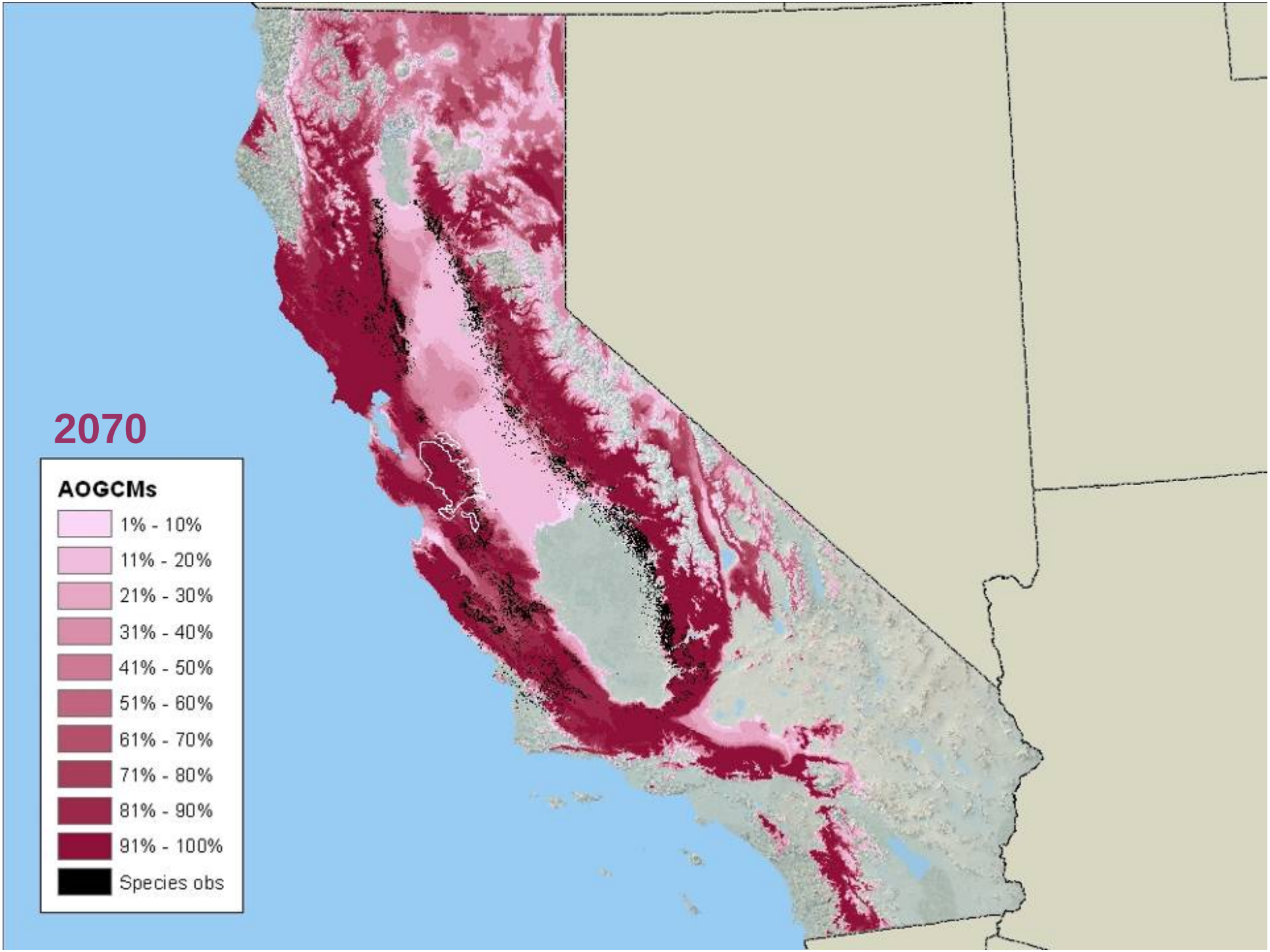
91% - 100%
Species obs

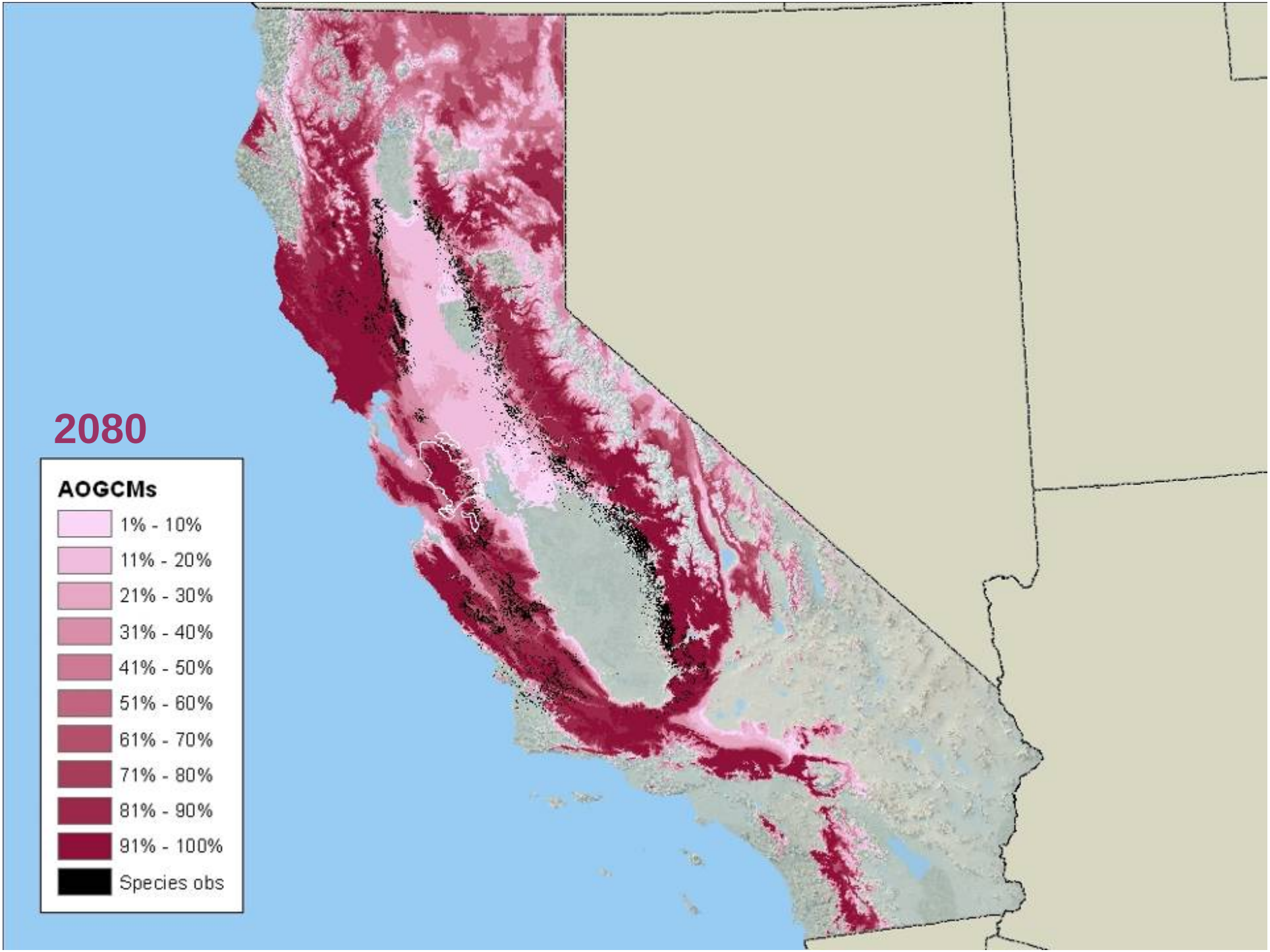

2030
AOGCMs
1% - 10%
11% - 20%
21% - 30%
31% - 40%
41% - 50%
51% - 60%
61% - 70%
71% - 80%
81% - 90%
91% - 100%
Species obs


2040
AOGCMs
1% - 10%
11% - 20%
21% - 30%
31% - 40%
41% - 50%
51% - 60%
61% - 70%
71% - 80%
81% - 90%
91% - 100%
Species obs


2050
AOGCMs
1% - 10%
11% - 20%
21% - 30%
31% - 40%
41% - 50%
51% - 60%
61% - 70%
71% - 80%
81% - 90%
91% - 100%
Species obs


2060
AOGCMs
1% - 10%
11% - 20%
21% - 30%
31% - 40%
41% - 50%
51% - 60%
61% - 70%
71% - 80%
81% - 90%
91% - 100%
Species obs


2070
AOGCMs
1% - 10%
11% - 20%
21% - 30%
31% - 40%
41% - 50%
51% - 60%
61% - 70%
71% - 80%
81% - 90%
91% - 100%
Species obs


2080
AOGCMs
1% - 10%
11% - 20%
21% - 30%
31% - 40%
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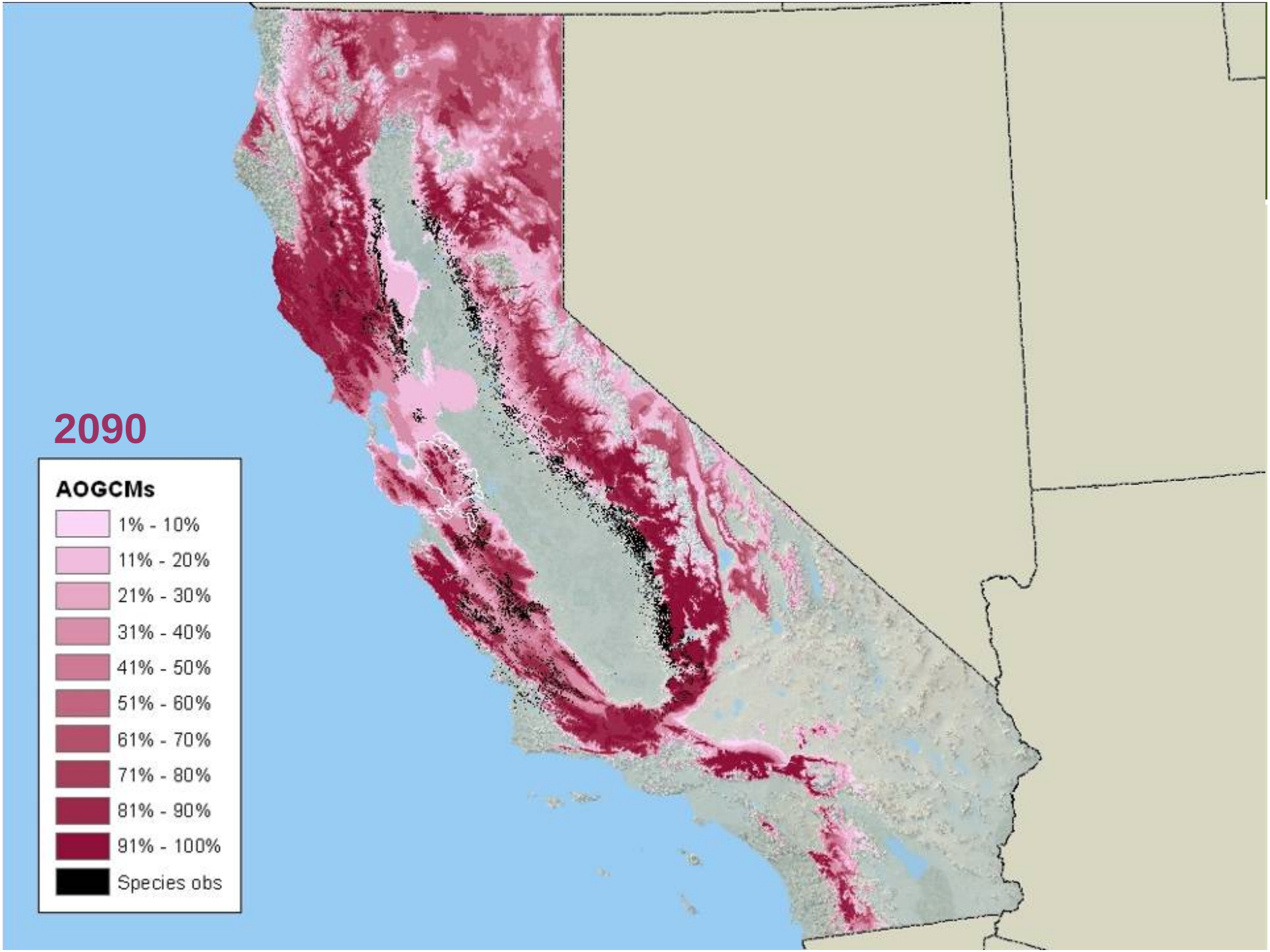
51% - 60%
61% - 70%
71% - 80%
81% - 90%
91% - 100%
Species obs


2090
AOGCMs
1% - 10%
11% - 20%
21% - 30%
31% - 40%
41% - 50%
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61% - 70%
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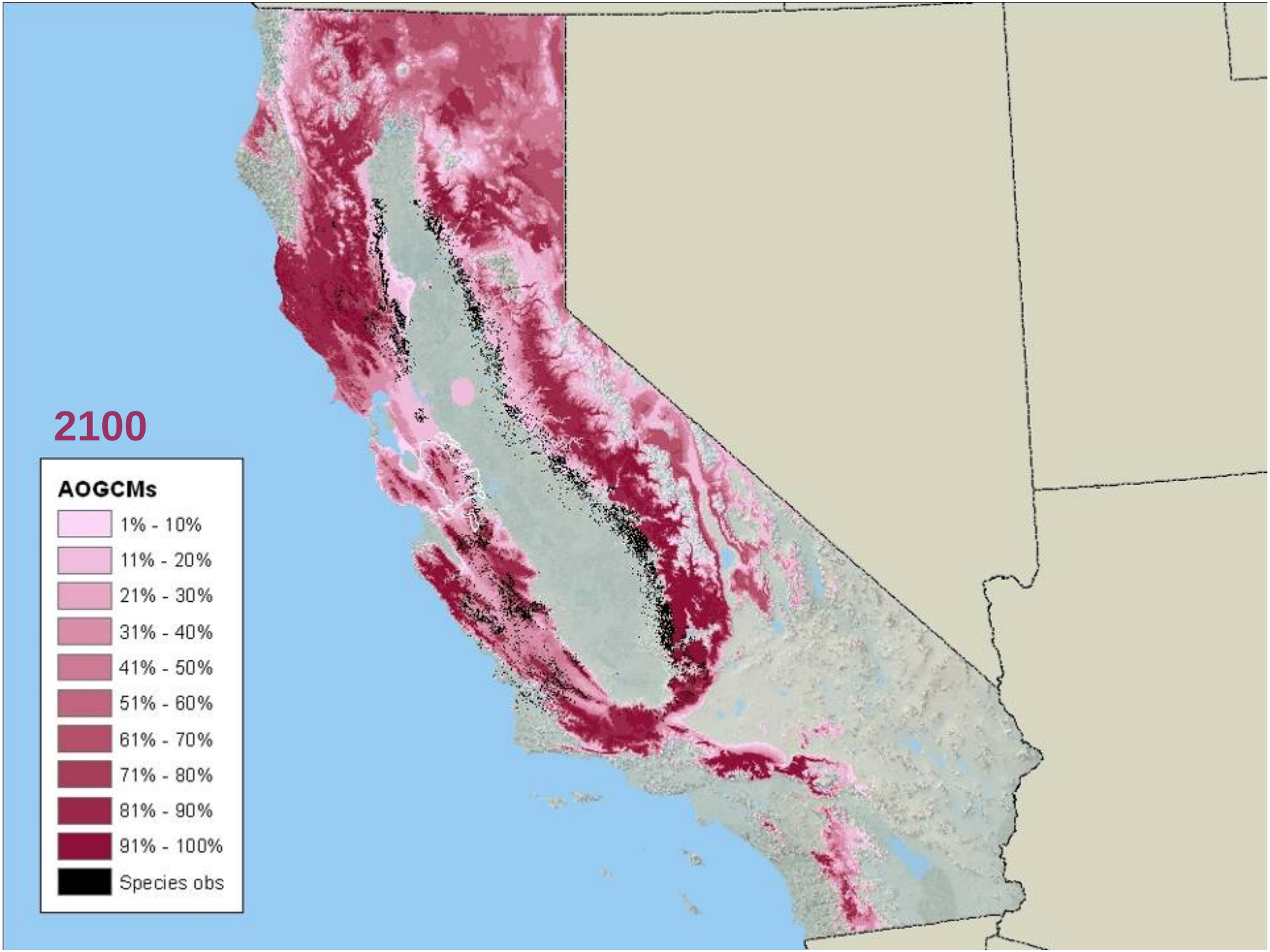
Species obs


2100
AOGCMs
1% - 10%
11% - 20%
21% - 30%
31% - 40%
41% - 50%
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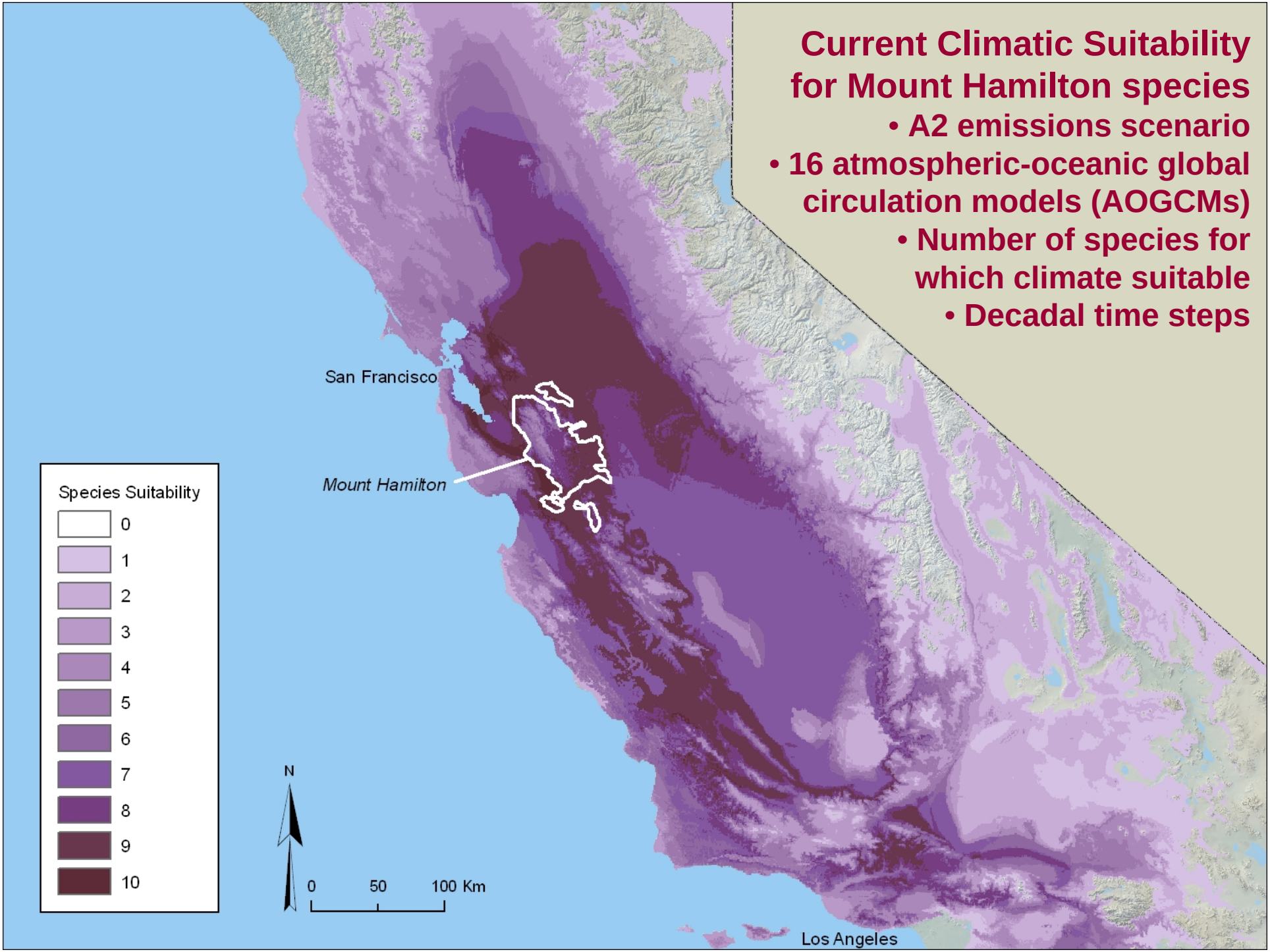
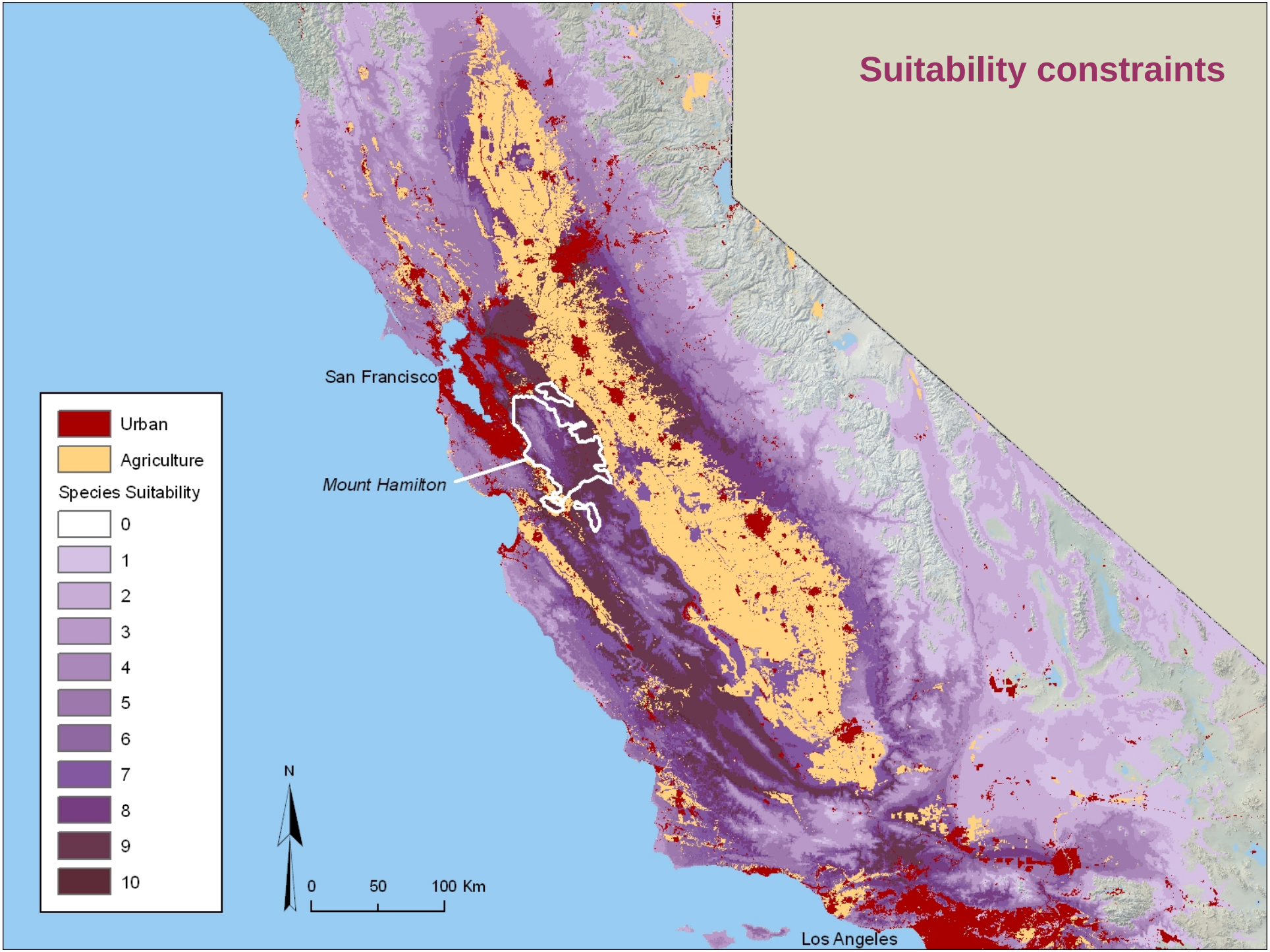
61% - 70%
71% - 80%
81% - 90%
91% - 100%
Species obs


Current Climatic Suitability for Mount Hamilton species
• A2 emissions scenario
• 16 atmospheric-oceanic global circulation models (AOGCMs)
• Number of species for which climate suitable
• Decadal time steps
San Francisco
Mount Hamilton
Los Angeles
Species Suitability
0
1
2
3
4
5
6
7
8
9
10
N
0
50
100 Km


Suitability constraints
San Francisco
Mount Hamilton
Los Angeles
Urban
Agriculture
Species Suitability
0
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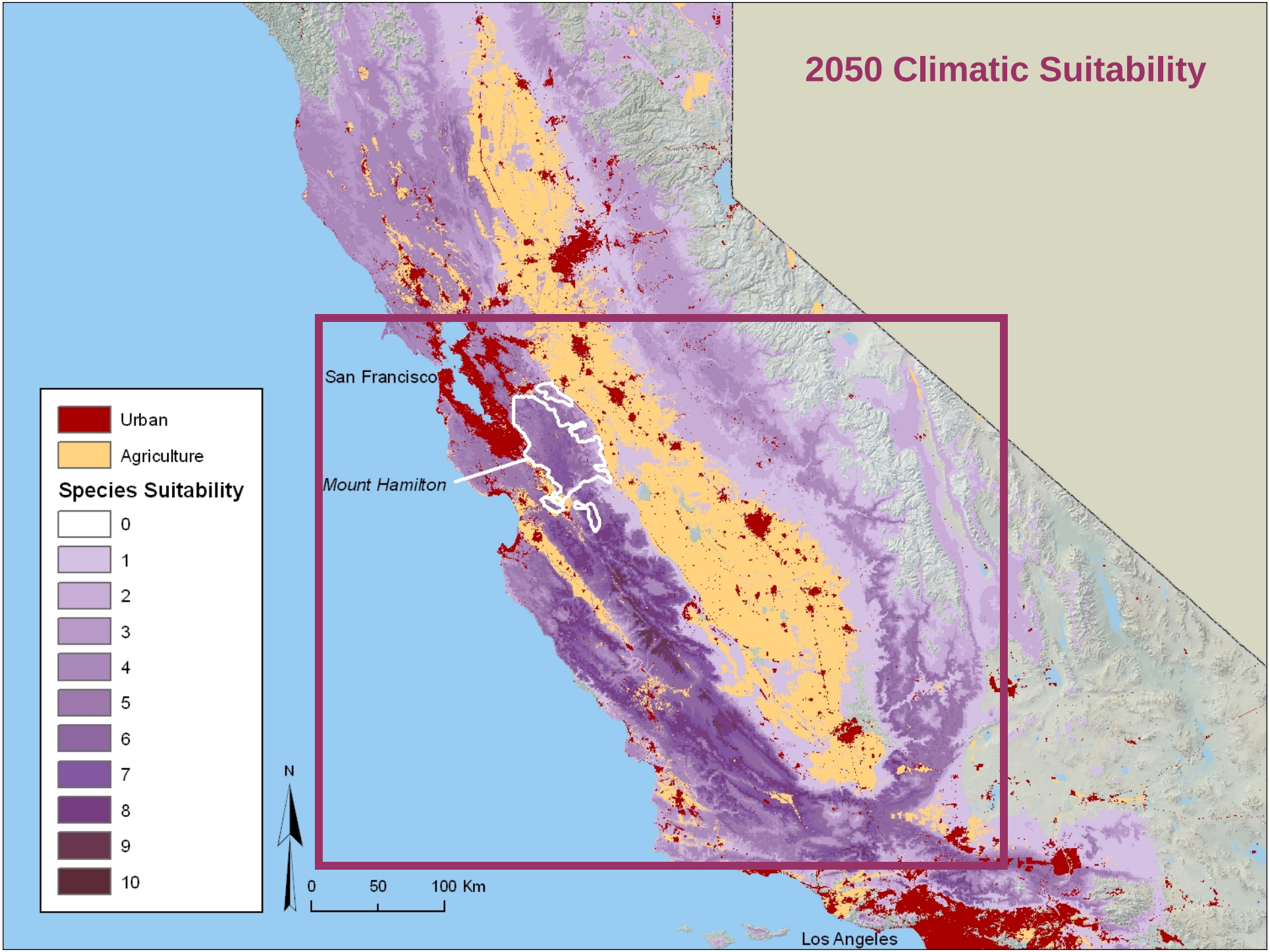
50
100 Km


2050 Climatic Suitability
San Francisco
Mount Hamilton
Los Angeles
Urban
Agriculture
Species Suitability
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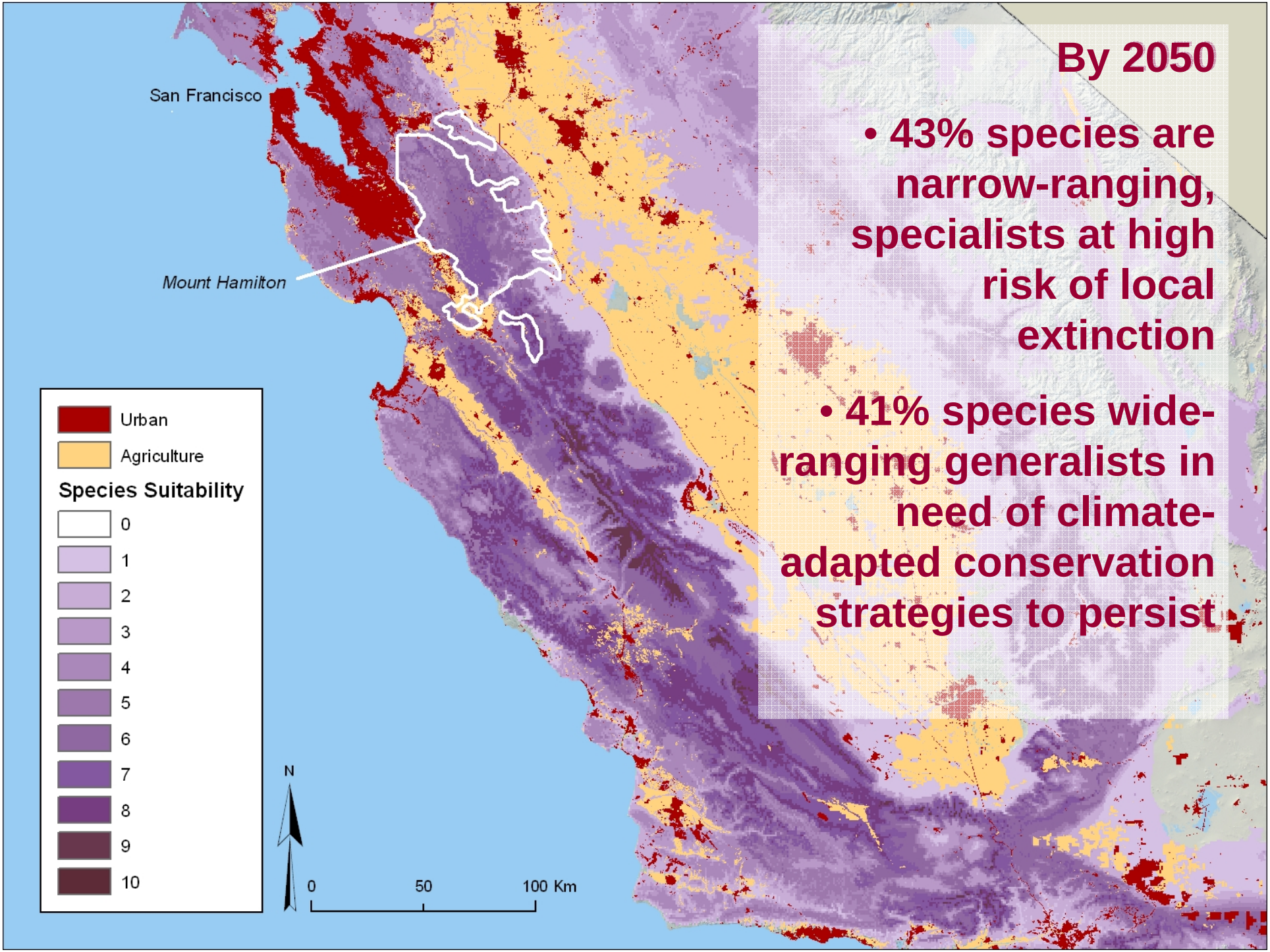
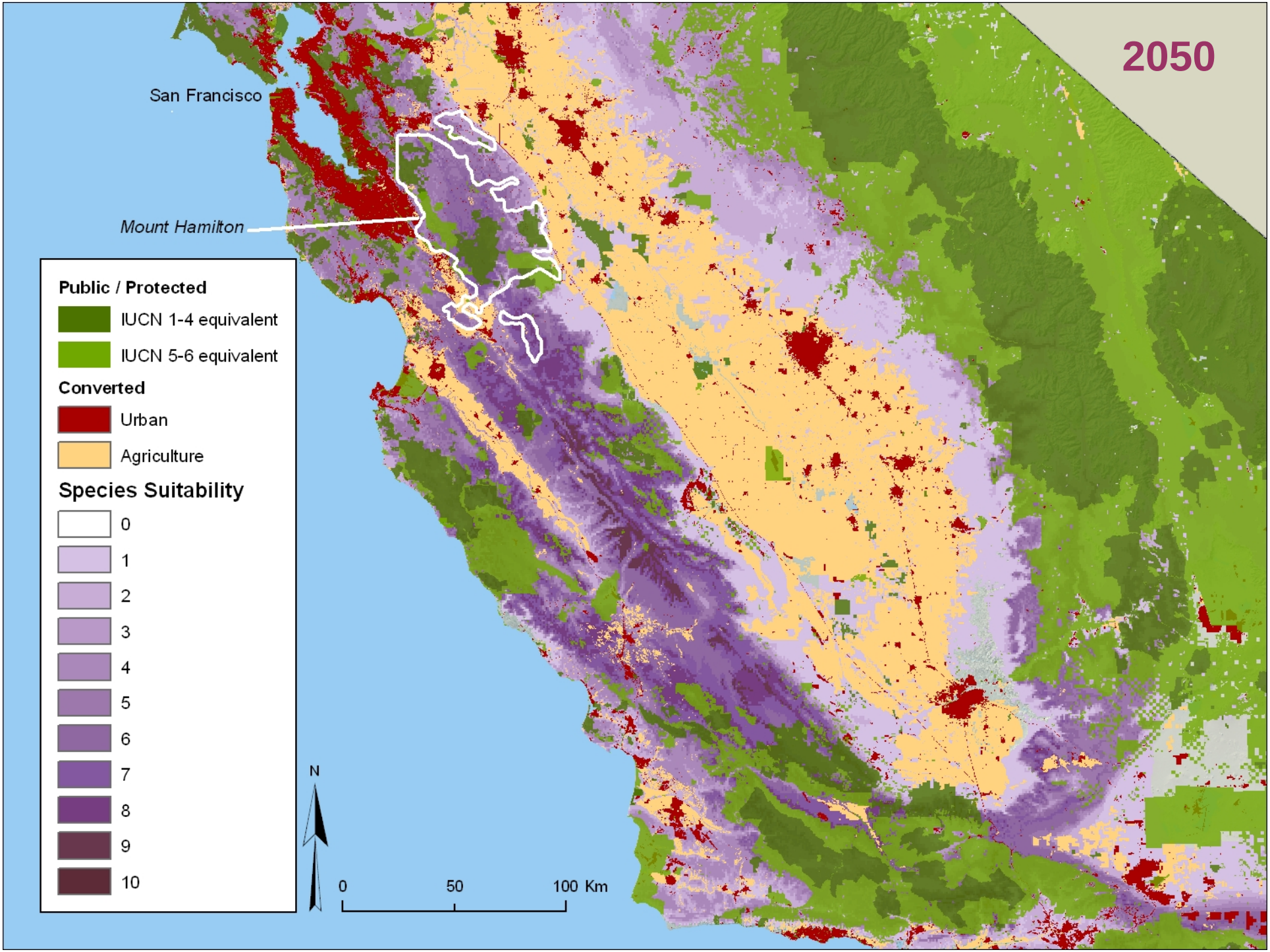
100 Km



By 2050

- 43% species are narrow-ranging, specialists at high risk of local extinction
- 41% species wide-ranging generalists in need of climate-adapted conservation strategies to persist


2050
San Francisco
Mount Hamilton
Public / Protected
IUCN 1-4 equivalent
IUCN 5-6 equivalent
Converted
Urban
Agriculture
Species Suitability
0
1
2
3
4
5
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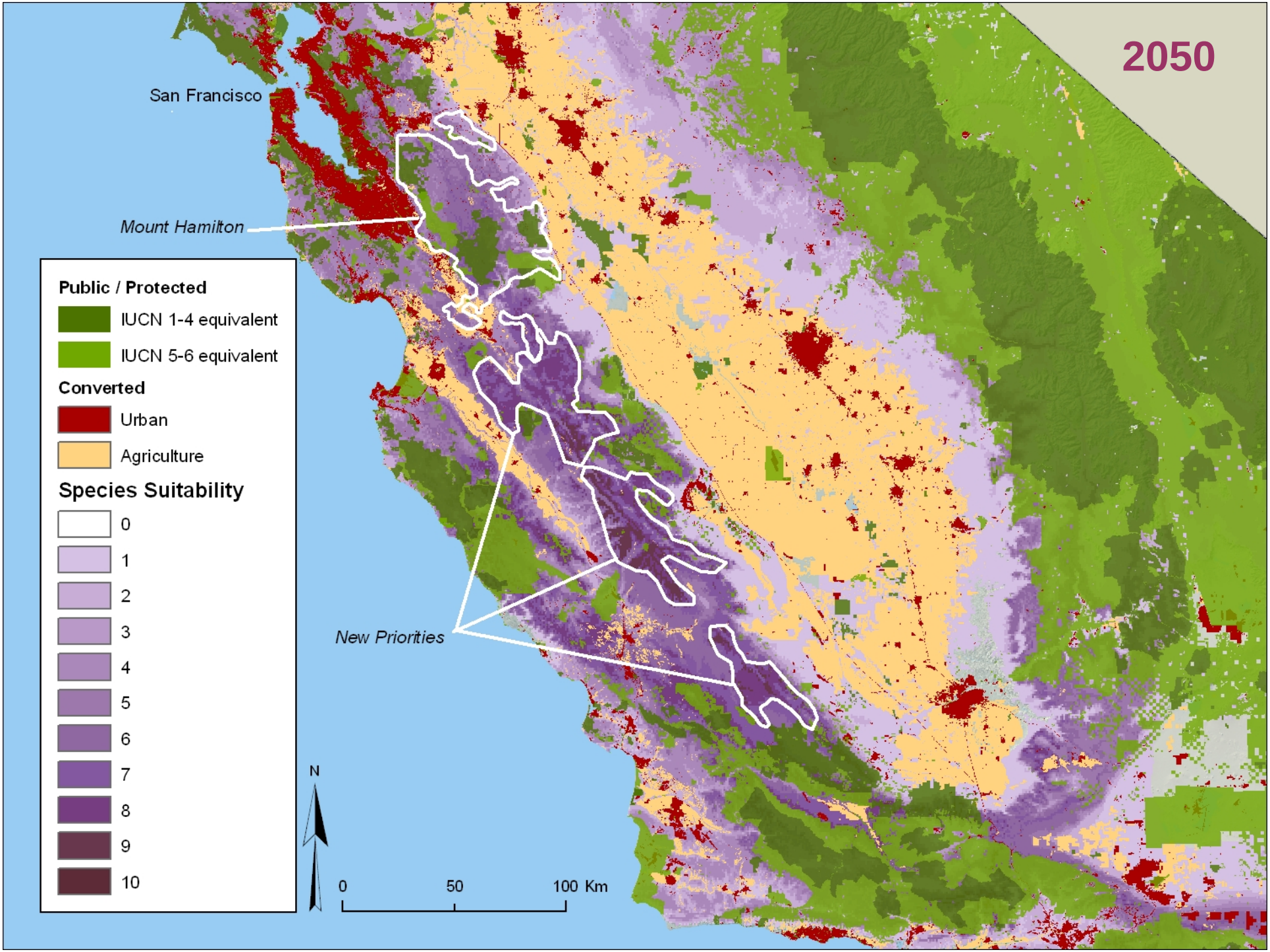
7
8
9
10
N
0
50
100 Km


2050
San Francisco
Mount Hamilton
New Priorities
Public / Protected
IUCN 1-4 equivalent
IUCN 5-6 equivalent
Converted
Urban
Agriculture
Species Suitability
0
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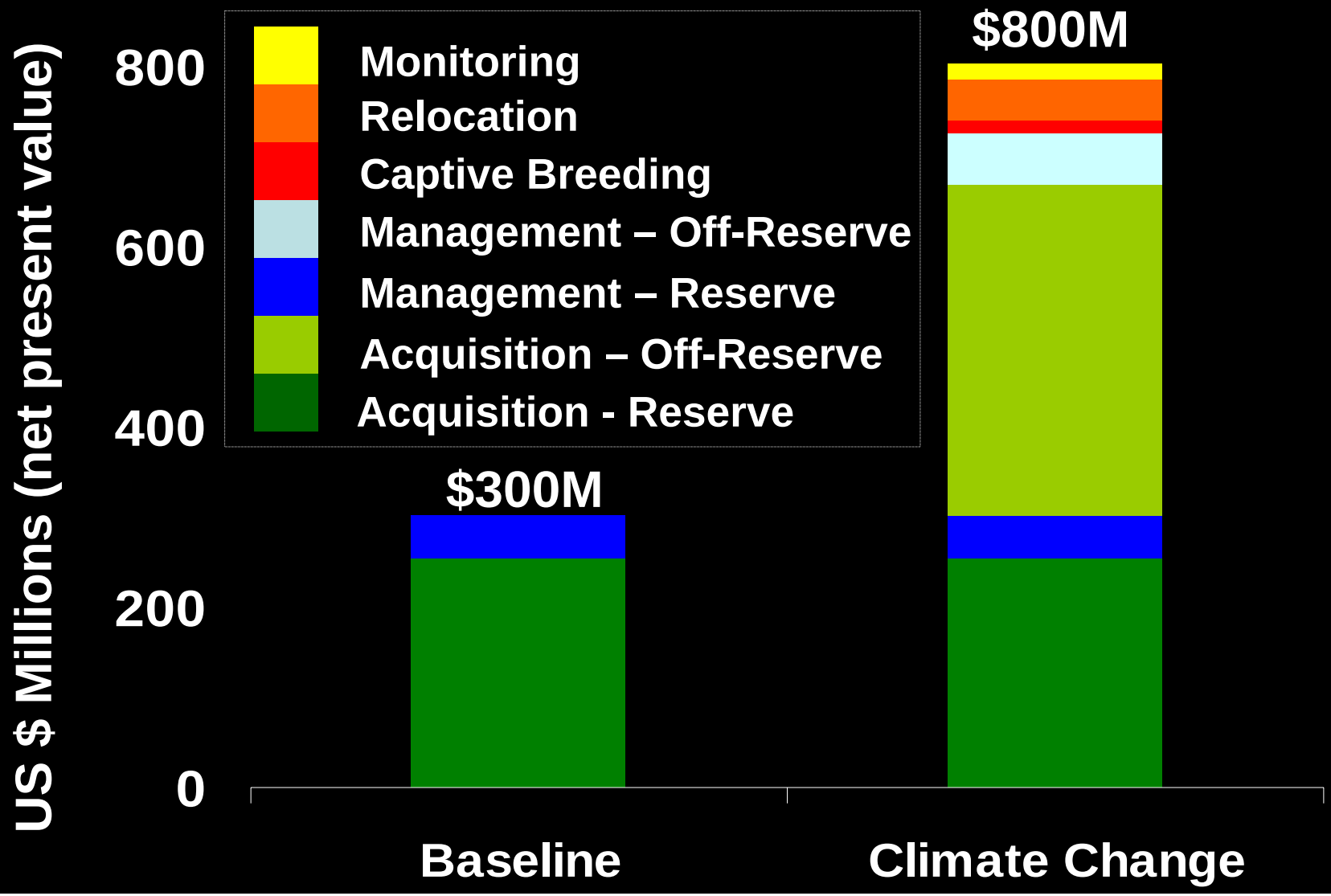
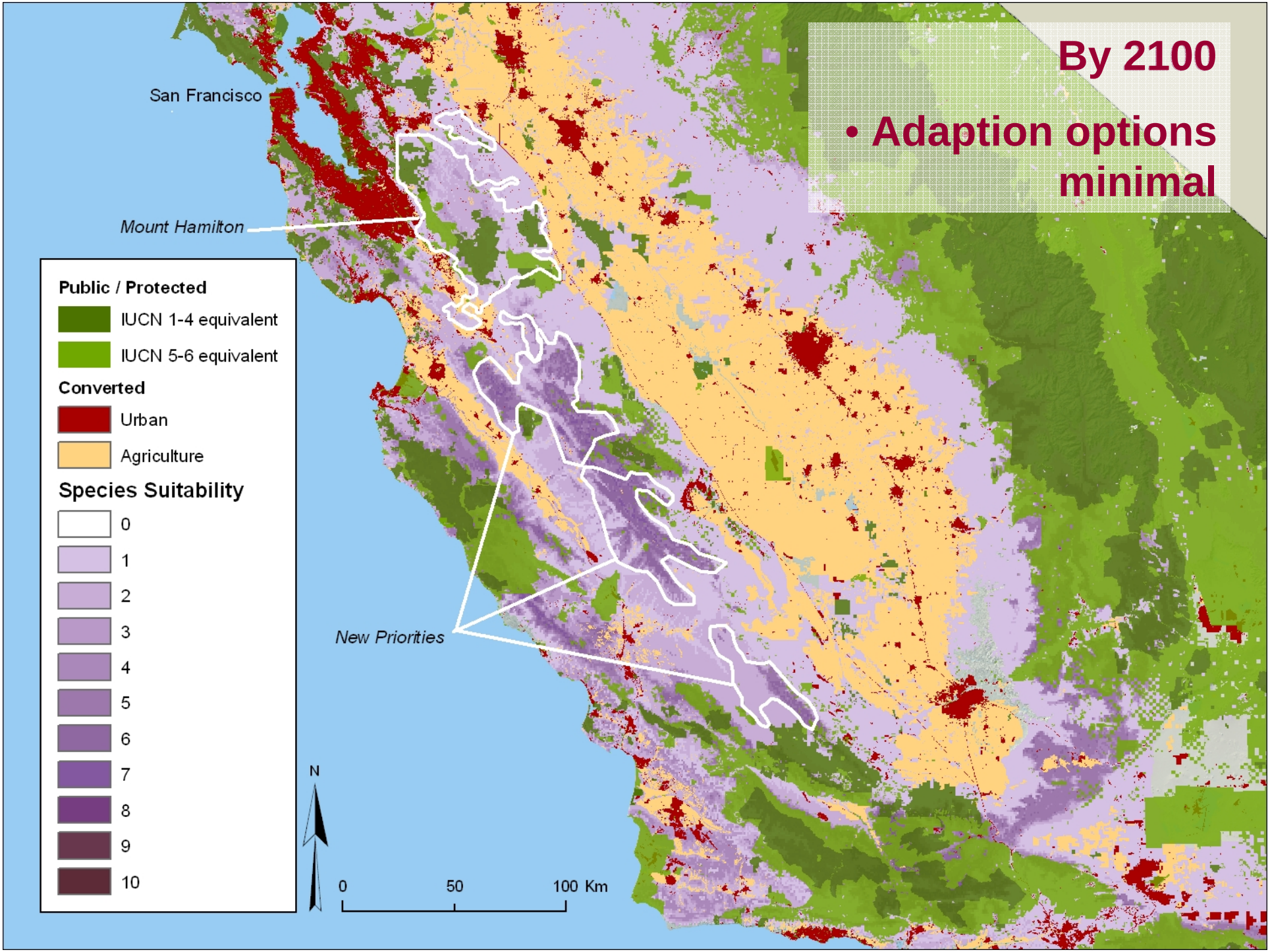
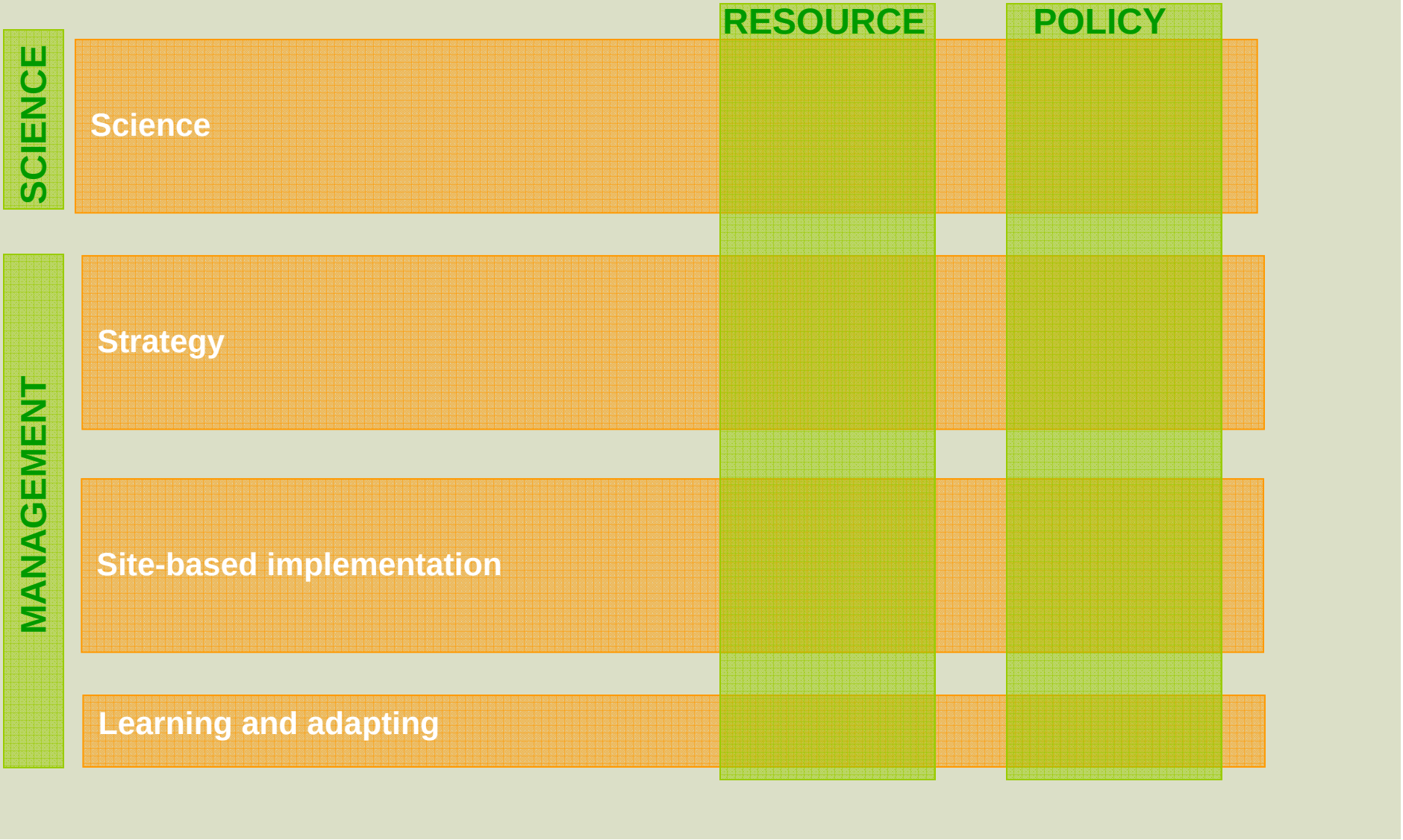
N
0
50
100 Km

ADAPTATION COSTS TO 2050




By 2100
• Adaption options minimal
San Francisco
Mount Hamilton
New Priorities
Public / Protected
IUCN 1-4 equivalent
IUCN 5-6 equivalent
Converted
Urban
Agriculture
Species Suitability
0
1
2
3
4
5
6
7
8
9
10
N
0
50
100 Km

Linking Resource, Science, Policy & Management



Conclusion

- Adaptation needs to be reframed in context of +4°C (7.2 ° F)
- Managers need to carefully address institutional goals and data needs to assess goal and strategy viability – *managing for change*
- Achieving ***current goals*** using current strategies to *may not be* ***possible***
- Costs will constrain options,
- ***Options*** for adaptation ***diminish*** rapidly after 2050
- *Policy changes* must keep pace with adaptive learning