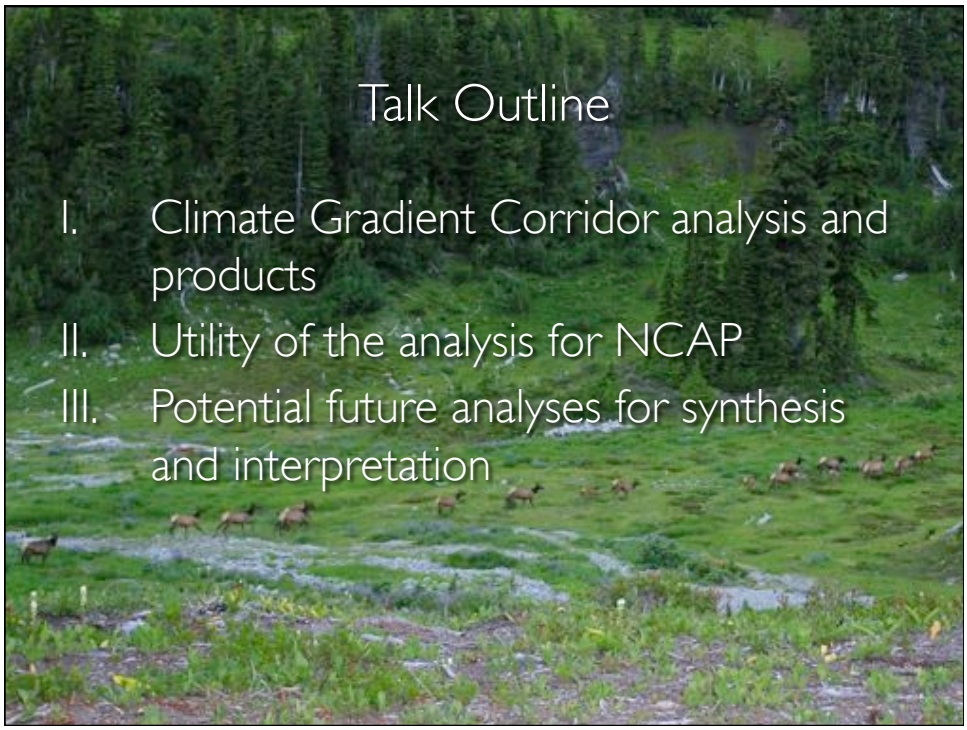
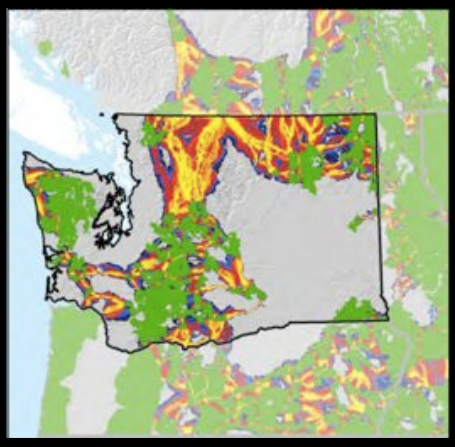

Washington Connected Landscapes Project:
Climate-Gradient Corridor Analysis
Meade Krosby, Tristan Nuñez, Lynn Helbrecht,
Darren Kavanagh, Joshua Lawler, Brad McRae,
John Pierce, Peter Singleton, Joshua Tewksbury

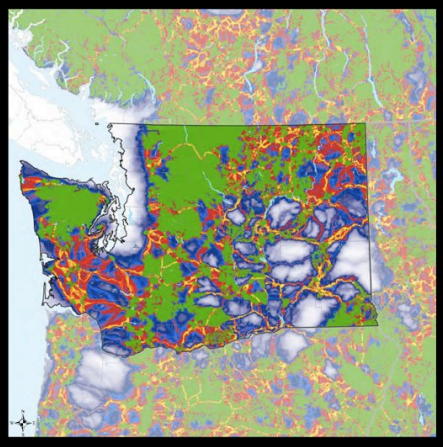

Talk Outline
I. Climate Gradient Corridor analysis and products
II. Utility of the analysis for NCAP
III. Potential future analyses for synthesis and interpretation

Washington Connected Landscapes Project

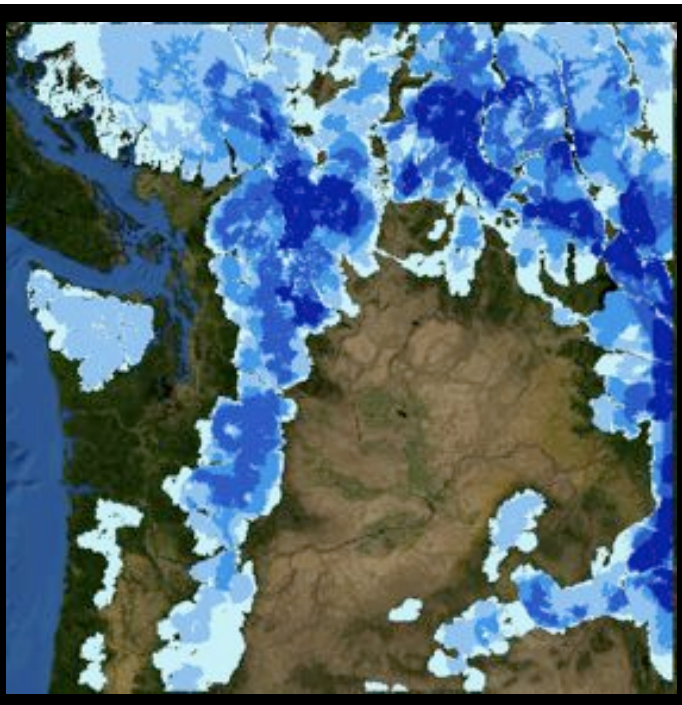
- www. waconnected. org



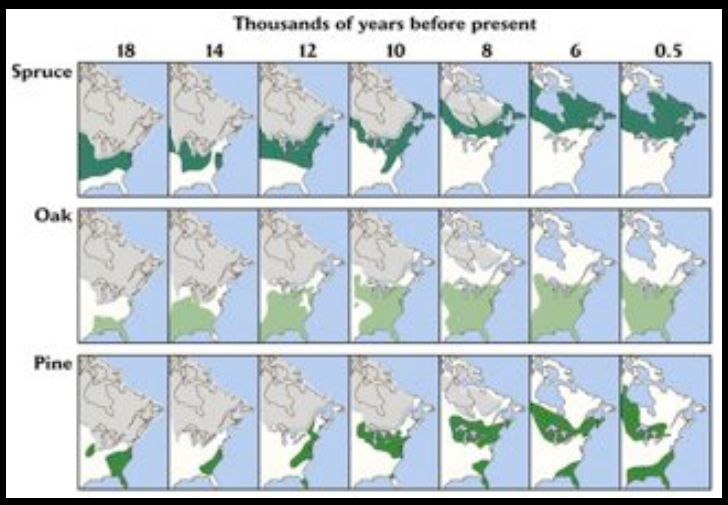
- 16 focal species (ex: elk)



- Landscape integrity



Range shifts have been the most important adaptive response to past climate change



Species are already moving….

- Upward (~6m / decade) and poleward (~6km / decade)

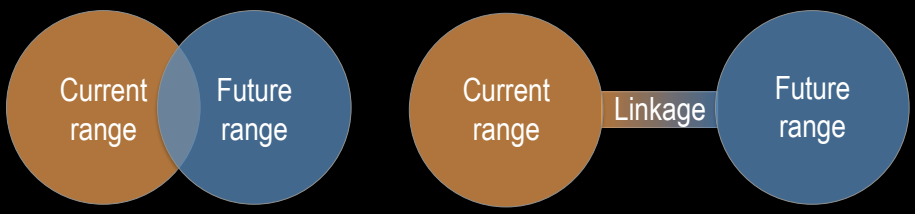
(Parmesan & Yohe 2003)

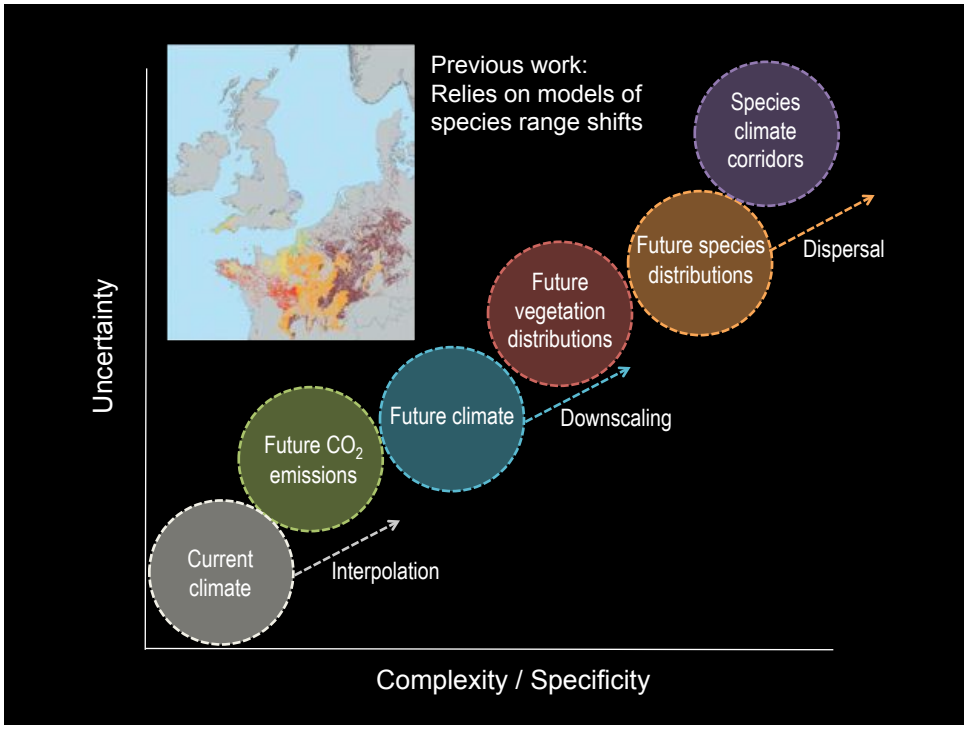
….and will need to move farther and faster as climate change accelerates

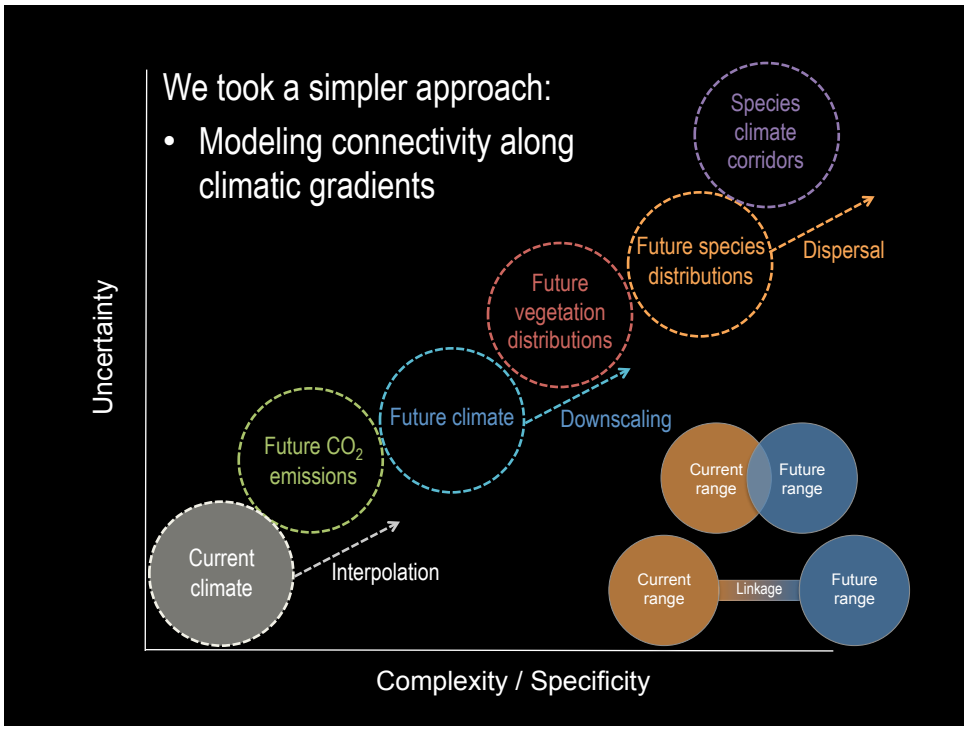
Movement will be impeded by human land use

Conserving connectivity is:

- The most oft-cited recommendation for climate adaptation (Heller and Zavaleta 2009)
- The first near-term goal of Washington State's Integrated Climate Change Response Strategy
- Not easy

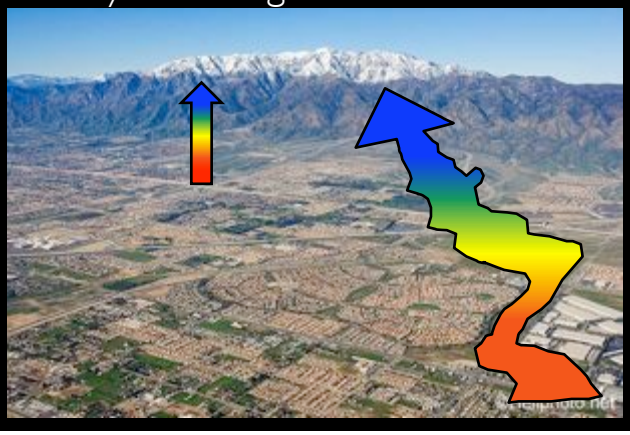



Previous work:
Relies on models of species range shifts
Species climate corridors
Future species distributions
Dispersal
Future vegetation distributions
Future climate
Downscaling
Future CO_2 emissions
Current climate
Interpolation
Uncertainty
Complexity / Specificity


We took a simpler approach:
• Modeling connectivity along climatic gradients
Species climate corridors
Future species distributions
Dispersal
Future vegetation distributions
Future climate
Downscaling
Future CO_2 emissions
Current range
Future range
Current climate
Interpolation
Current range
Linkage
Future range
Uncertainty
Complexity / Specificity

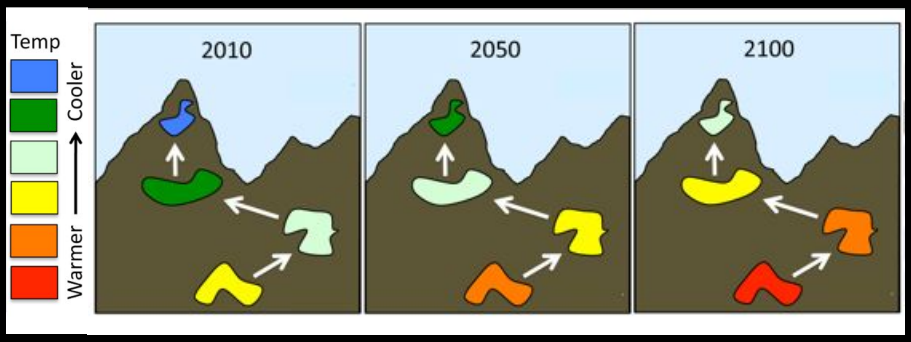
Assumptions

- Species will need to cross climatic gradients
- …and avoid developed areas
- Present-day climate gradients will be conserved



A pathway through a changing climate

-Connect warm areas to cool



A pathway through a changing climate

-Connect warm areas to cool

-Avoid areas of heavy land use

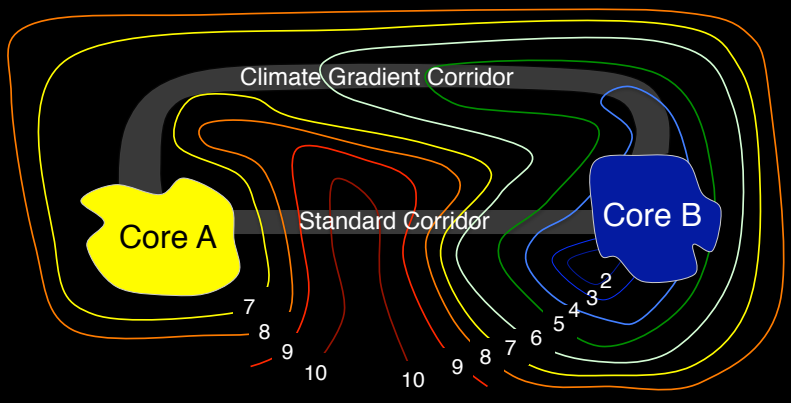


A pathway through a changing climate

-Connect warm areas to cool

-Avoid areas of heavy land use

-Minimize changes in temperature

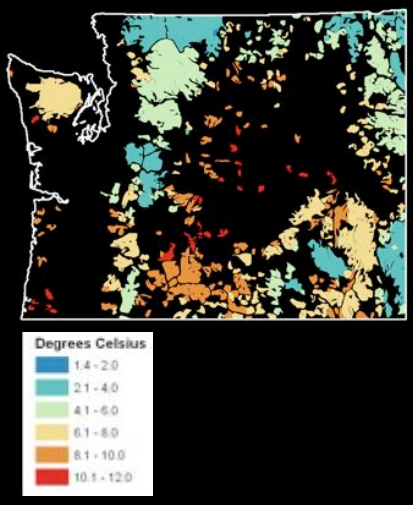


Link large, natural patches of land

- Patches in "natural" land cover
- Patches larger than 10,000 acres in size

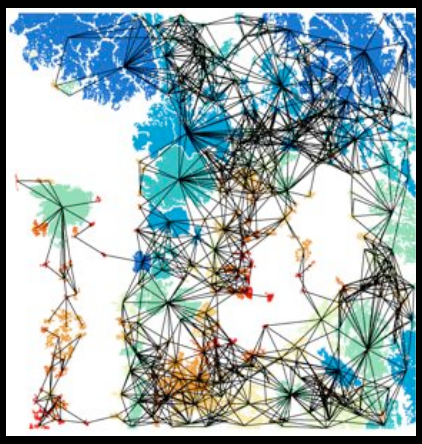
Link patches that differ in temperature

- Patches that differ by more than >1°C
- Temperature data:
  - 30-year average of Mean Annual Temperature (1971-2000)



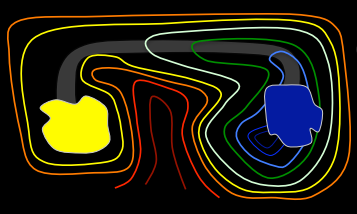
Link patches that are relatively nearby

- Patches that are < 50 km apart from each other



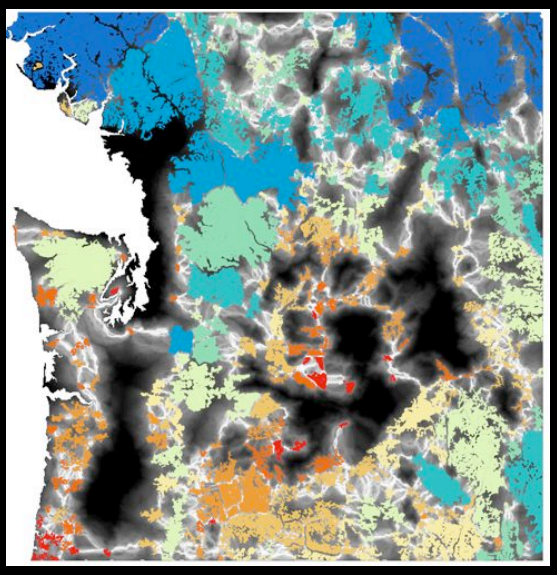
Map corridors that:

- Follow gentlest temperature gradients
- Avoid barriers

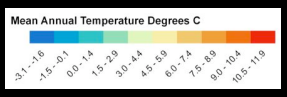


Linkage Mapper for ArcGIS
+
GRASS GIS

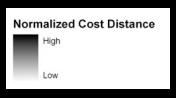
Climate Gradient Corridor Network



Patch Temperature

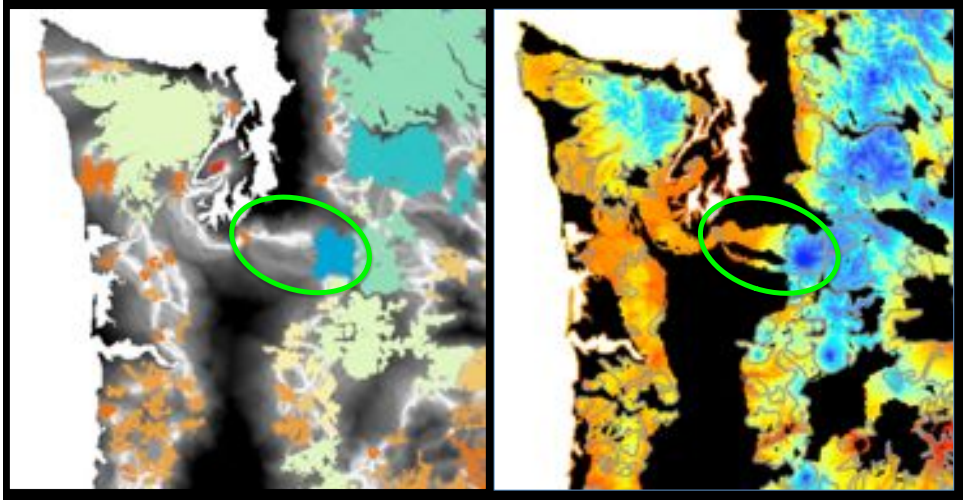


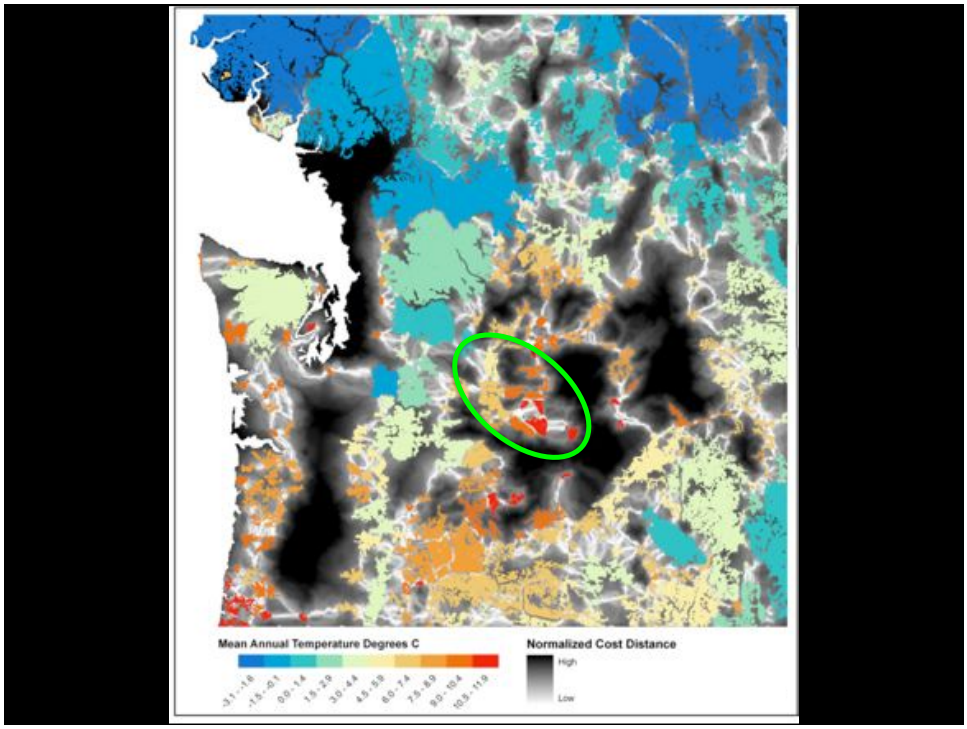
Corridors

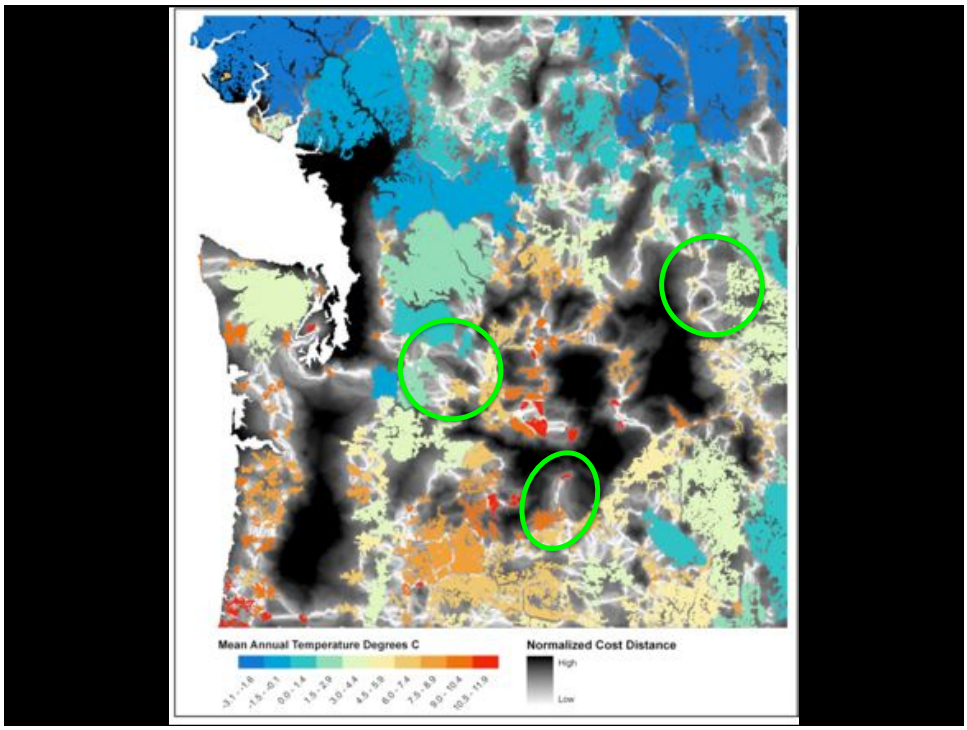


Nuñez 2011,
Nuñez et al. in prep

Climate Gradient Corridor Network




Mean Annual Temperature Degrees C
-3.1 - -1.6
-1.5 - -0.1
0.0 - 1.4
1.5 - 2.9
3.0 - 4.4
4.5 - 5.9
6.0 - 7.4
7.5 - 8.9
9.0 - 10.4
10.5 - 11.9
Normalized Cost Distance
High
Low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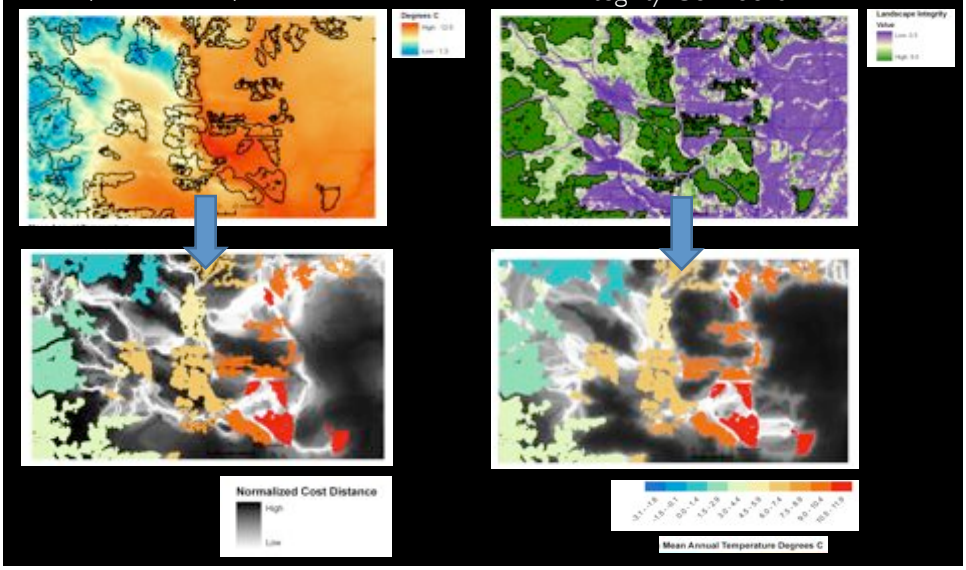
Normalized Cost Distance
High
Low

Influence of Topography and Landuse

Temperature-only Corridors

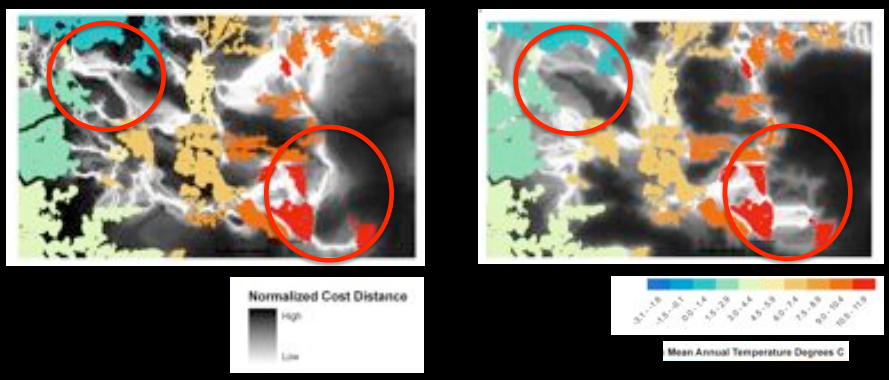
Temperature-plus-Landscape Integrity Corridors



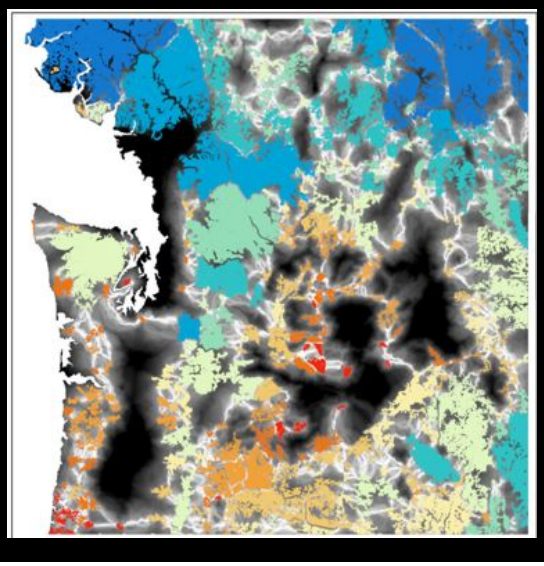
Using the two models together

Temperature-only Corridors

Temperature-plus-Landscape Integrity Corridors

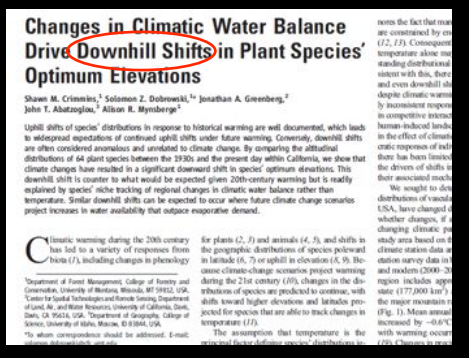


It is best to think of Climate Gradient Corridors as representing "Connectivity Zones"



Take-home points:

- Connectivity will be critical for range shifts, but where & how individual species will move is highly uncertain
- Gradient approach requires relatively few assumptions
- Gradients can work in either direction (and can be modeled for precip, moisture deficit, other variables)

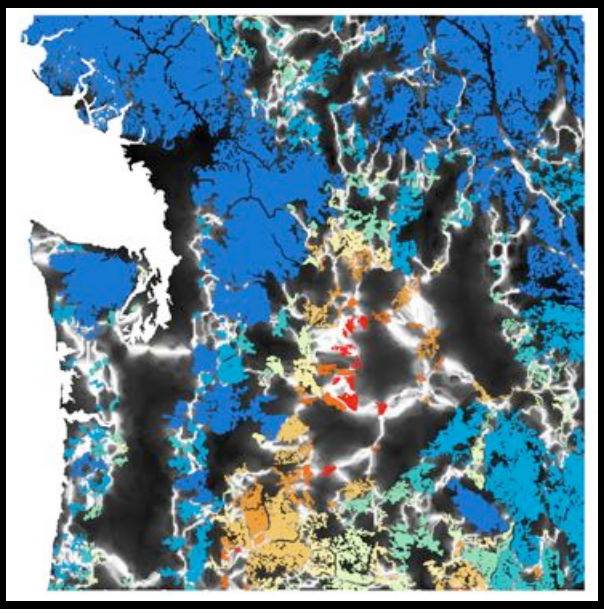


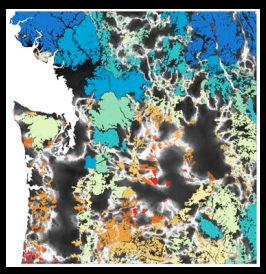
Changes in Climatic Water Balance Drive Downhill Shifts in Plant Species' Optimum Elevations

Shawn M. Crimmins,[1] Solomon Z. Dobrowski,[1]* Jonathan A. Greenberg,[2] John T. Abatzoglou,[3] Alison R. Mynsberge[1]

Uphill shifts of species' distributions in response to historical warming are well documented, which leads to widespread expectations of continued uphill shifts under future warming. Conversely, downhill shifts are often considered anomalous and unrelated to climate change. By comparing the altitudinal distributions of 64 plant species between the 1930s and the present day within California, we show that climate changes have resulted in a significant downward shift in species' optimum elevations. This downhill shift is counter to what would be expected given 20th-century warming but is readily explained by species' niche tracking of regional changes in climatic water balance rather than temperature. Similar downhill shifts can be expected to occur where future climate change scenarios project increases in water availability that outpace evaporative demand.

Climate Moisture Deficit Gradient Corridors

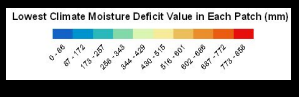




Temperature Gradient Corridors

Corridors

Patch Moisture Deficit



Take-home points:

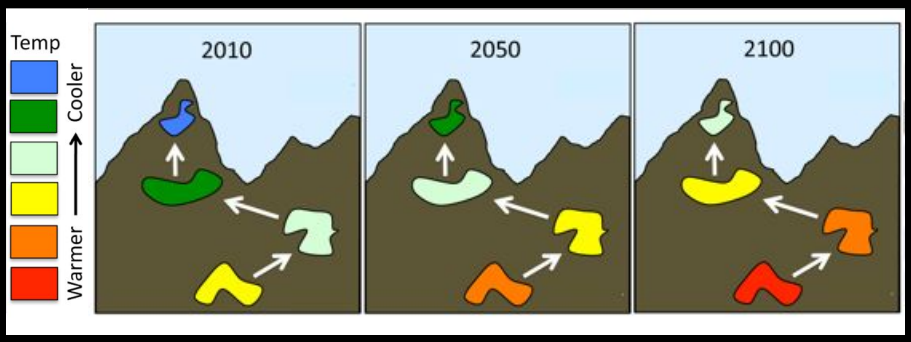
- Connectivity will be critical for range shifts, but where & how individual species will move is highly uncertain
- Gradient approach requires relatively few assumptions
- Gradients can work in either direction (and can be modeled for precip, moisture deficit, other variables)
- Best used for coarse-scale, landscape-level planning
- Automated GIS tools on the way

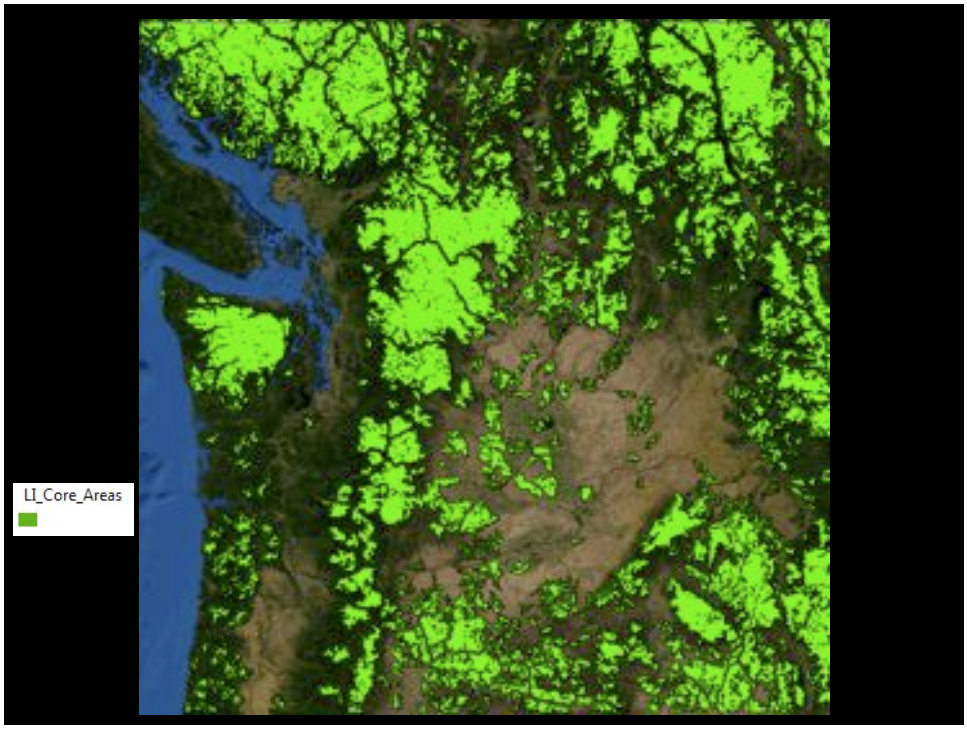
Utility of the Analysis for NCAP

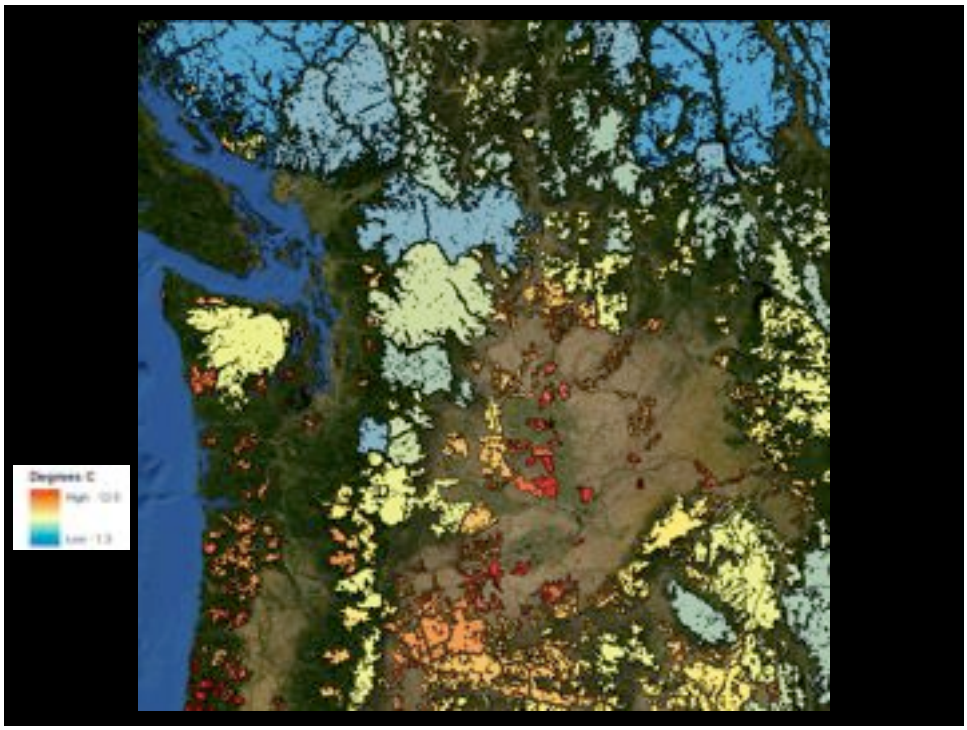
- Implications for species distributions
- Using the model within NCAP parks and forests

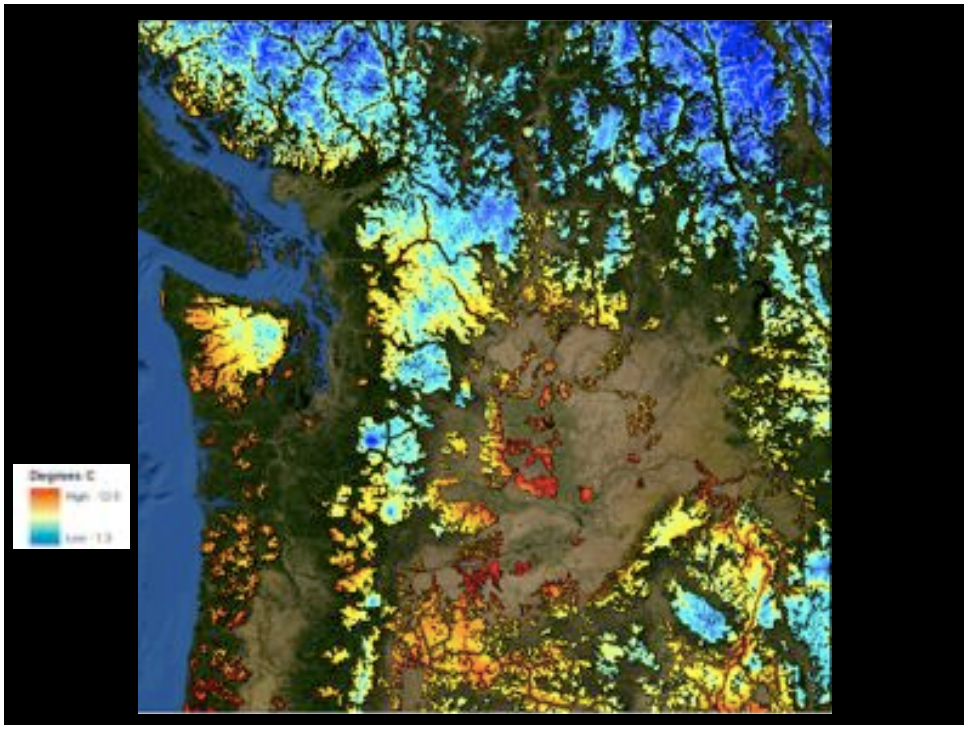
Implications for species distributions

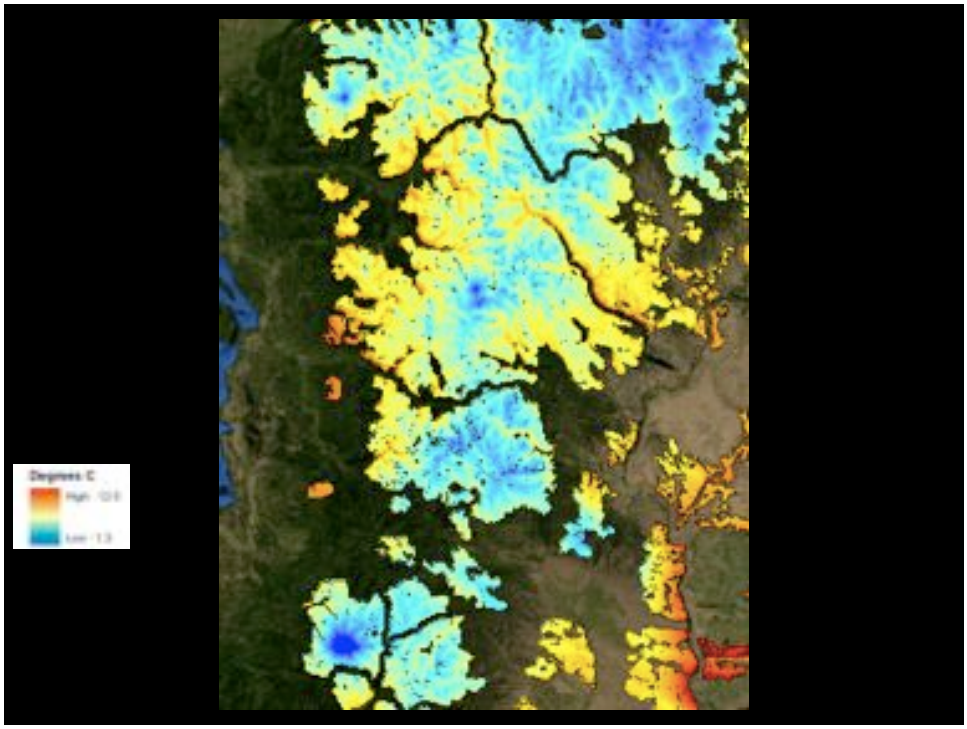
- New species moving in
- Alpine species moving out

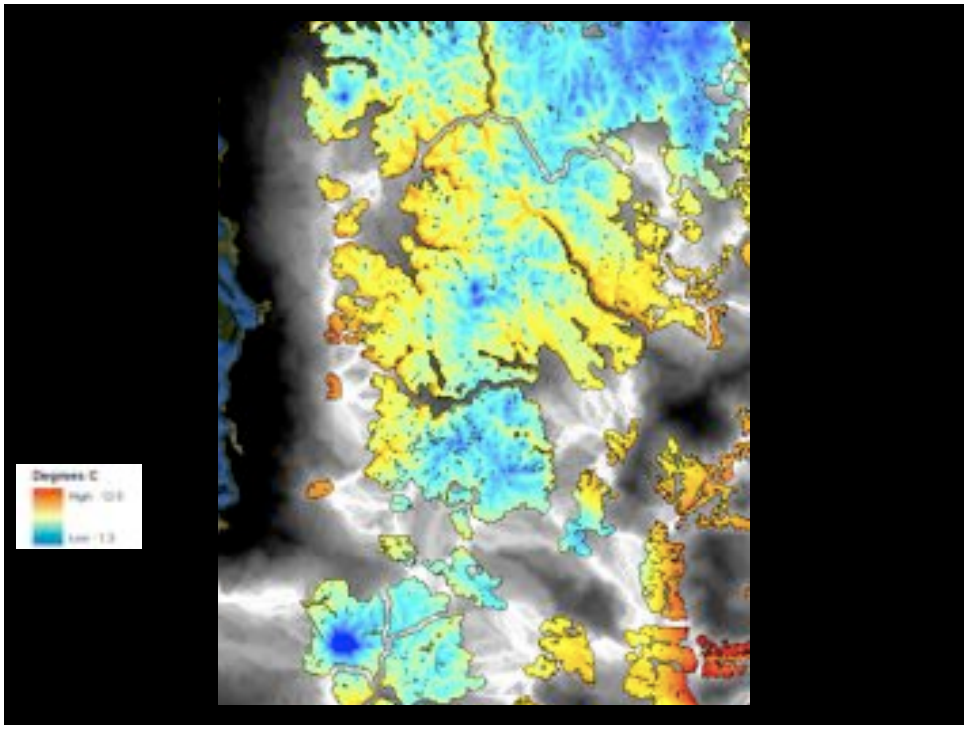


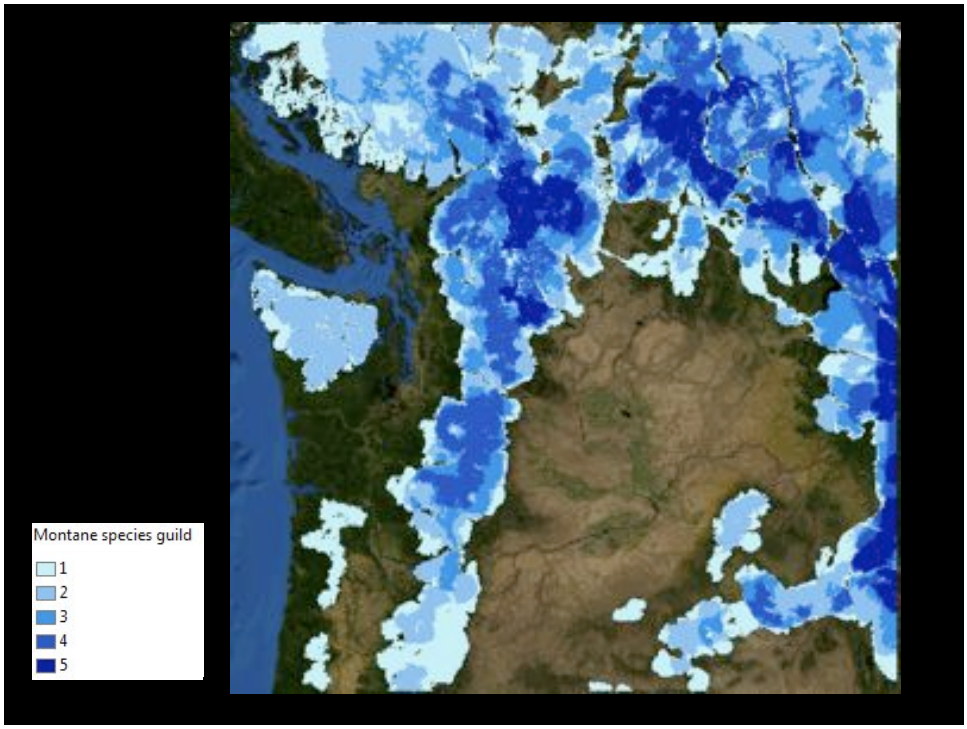

LI_Core_Areas




Degrees C


Degrees C


Degrees C


Montane species guild
1
2
3
4
5

Potential Additional Analyses for Synthesis and Interpretation

- Re-running the model
  - With finer scale LI layers
  - Within large cores
- Overlaying with focal species layers
  - Guilds
  - Single species
- Overlaying with other relevant map layers
  - Land ownership/conservation status
  - Riparian or other landcover layers

Acknowledgements

Washington Wildlife Habitat Connectivity Working Group

- Climate Change Subgroup:
  - Tristan Nuñez, Lynn Helbrecht, Joshua Lawler, Brad McRae, John Pierce, Peter Singleton, Joshua Tewksbury, Darren Kavanagh

Funding

- Wilburforce Foundation
- DOI Great Northern and North Pacific Landscape Conservation Cooperatives
- Wildlife Conservation Society's Wildlife Action Opportunities Fund

Check out:

- Online tools, reports, and thesis at www.waconnected.org
- Online maps at Databasin.org