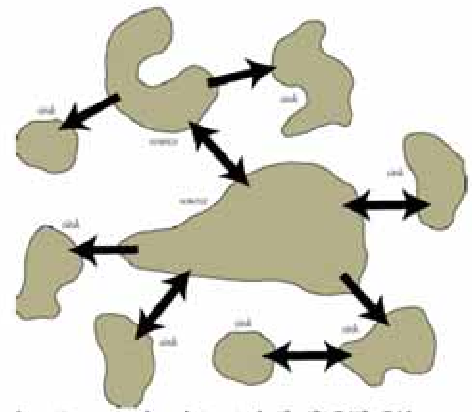
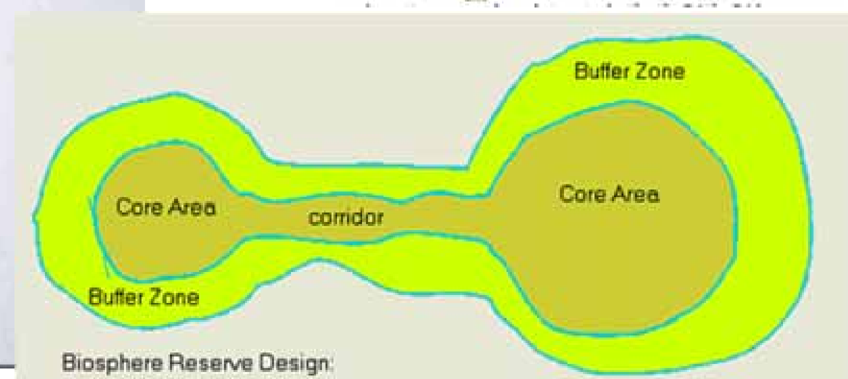
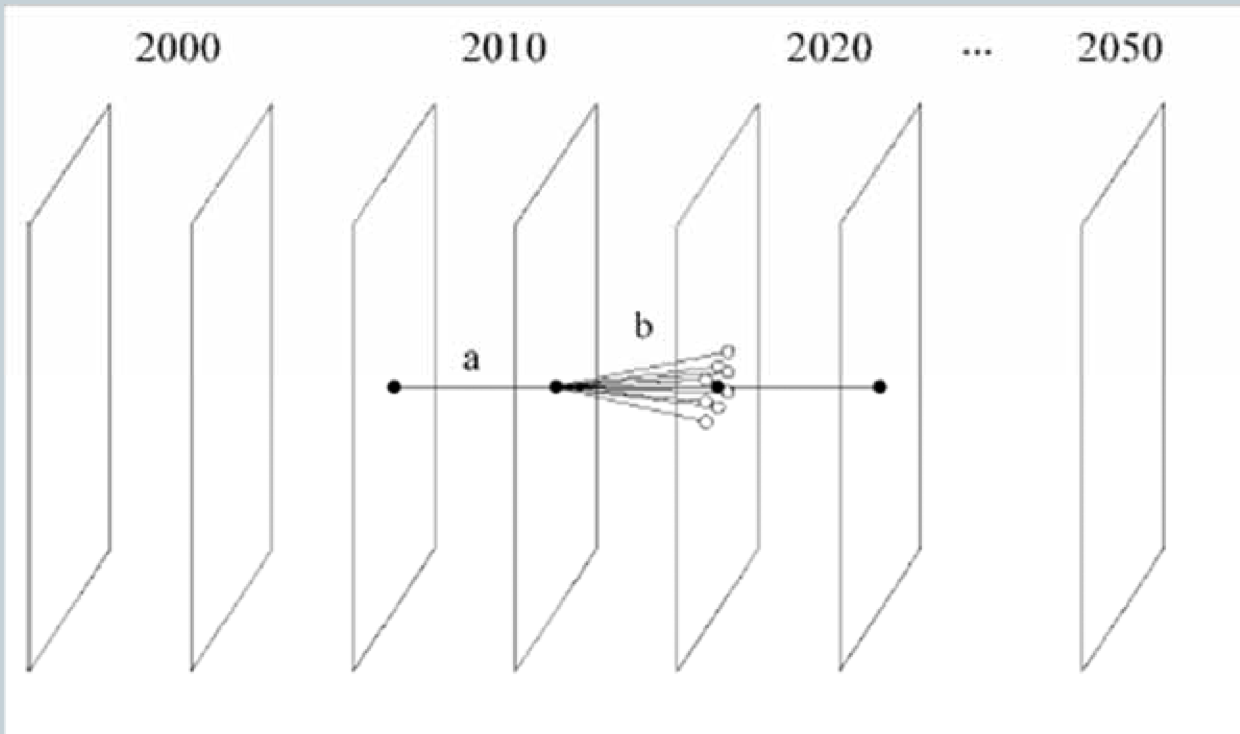
The Connectivity Analysis Toolkit (CAT): New methods to enhance effectiveness of conservation planning in dynamic ecosystems





Carlos Carroll, Klamath Center for Conservation Research
Brad McRae, The Nature Conservancy, Seattle, WA
Allen Brookes, University of Washington

Climate change adaptation planning - How to use the CAT to map habitat connectivity across time



How is connectivity relevant to "climate change aware" conservation planning?

"Climate change aware" planning forms part of the broader question of planning for biodiversity in dynamic systems.

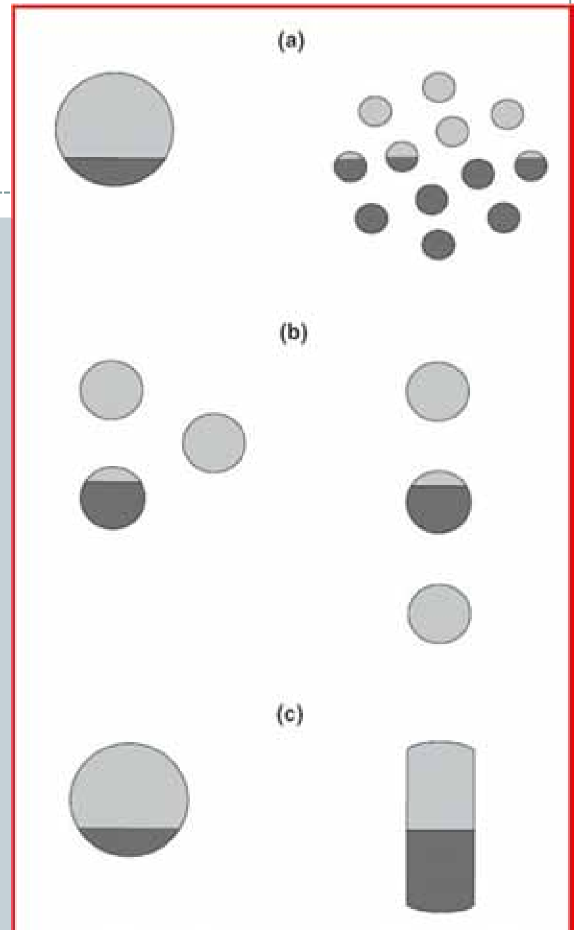
Planning to enhance resilience to climate change should build on insights from previous conservation planning efforts.

For example, Reed Noss's 3-track approach, which combines a focus on coarse and fine-filter conservation targets, is still relevant in dynamic systems.

Climate change and connectivity

Climate change challenges traditional rules of thumb for conservation planning:

- Bigger is better
- Closer is better than distant
- Less edge is better then more edge



Araújo 2009

Complementary approaches to climate-aware connectivity planning

Coarse-filter- based on land classes, e.g., areas of high climatic and topographic heterogeneity are priorities

Fine-filter- based on species, identifies priority areas from overlap of species habitat over time, locates optimal ‘climate corridors’ that allow dispersal to new habitat as climate shifts

Three approaches to climate-aware connectivity planning

1) Enduring features/coarse-filter: areas of high climatic and topographic heterogeneity are priorities
2) Zonation – identifies priority areas from overlap of species habitat over time
3) Network flow – locates optimal ‘climate corridors’ that allow dispersal to new habitat as climate shifts

Three approaches to climate-aware connectivity planning

1) Enduring features/coarse-filter:

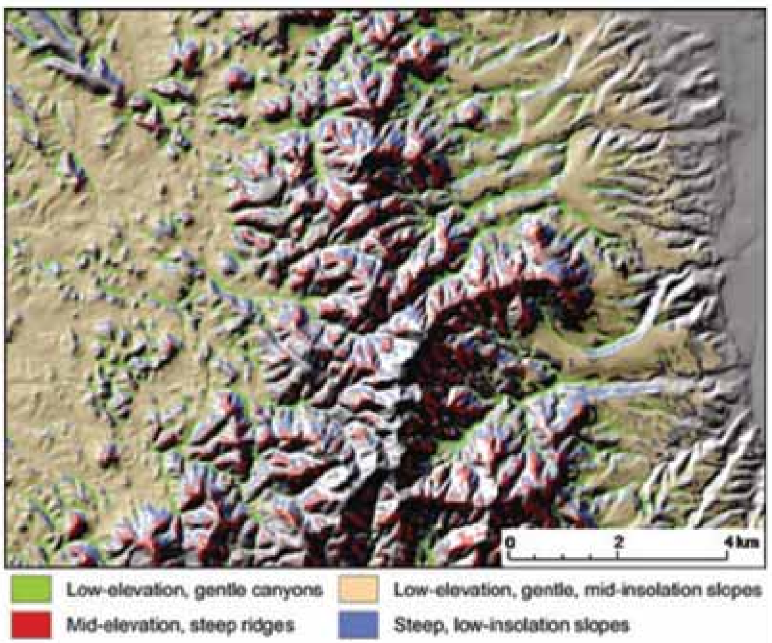


Figure 2. Illustration of the geographic distribution of land facets, defined on the basis of elevation, slope, insolation, and topographic position, draped over a hillshade map. For clarity, not all land facets in the landscape are shown.

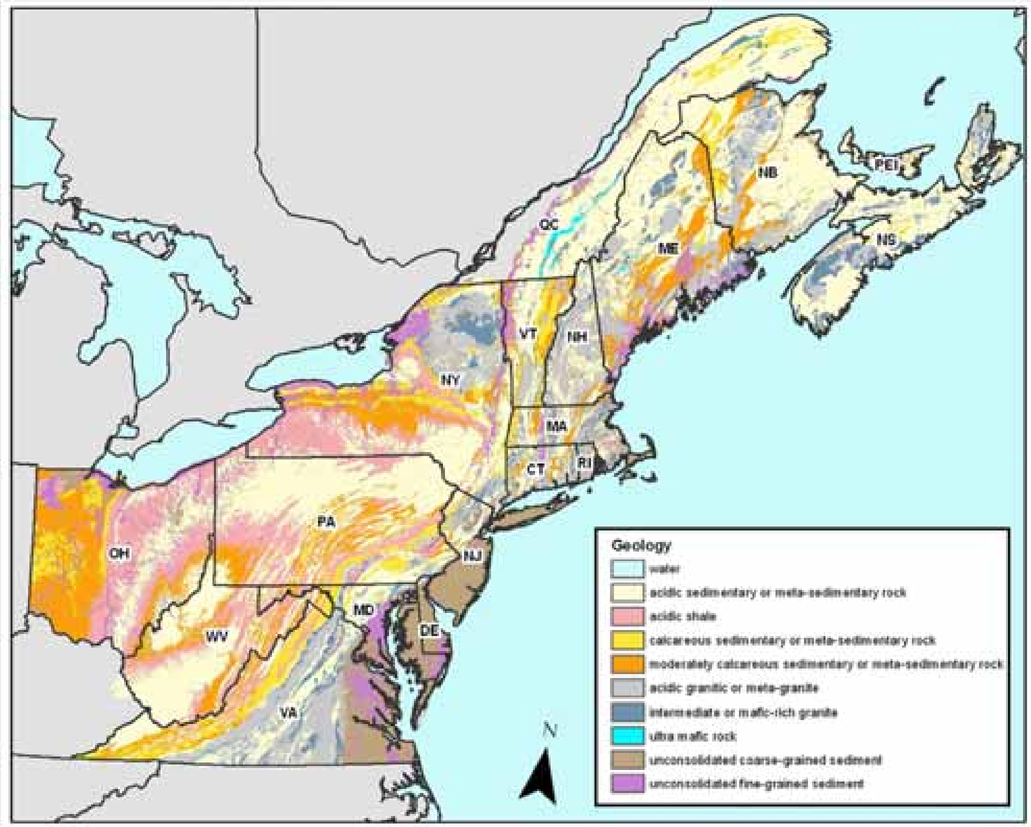
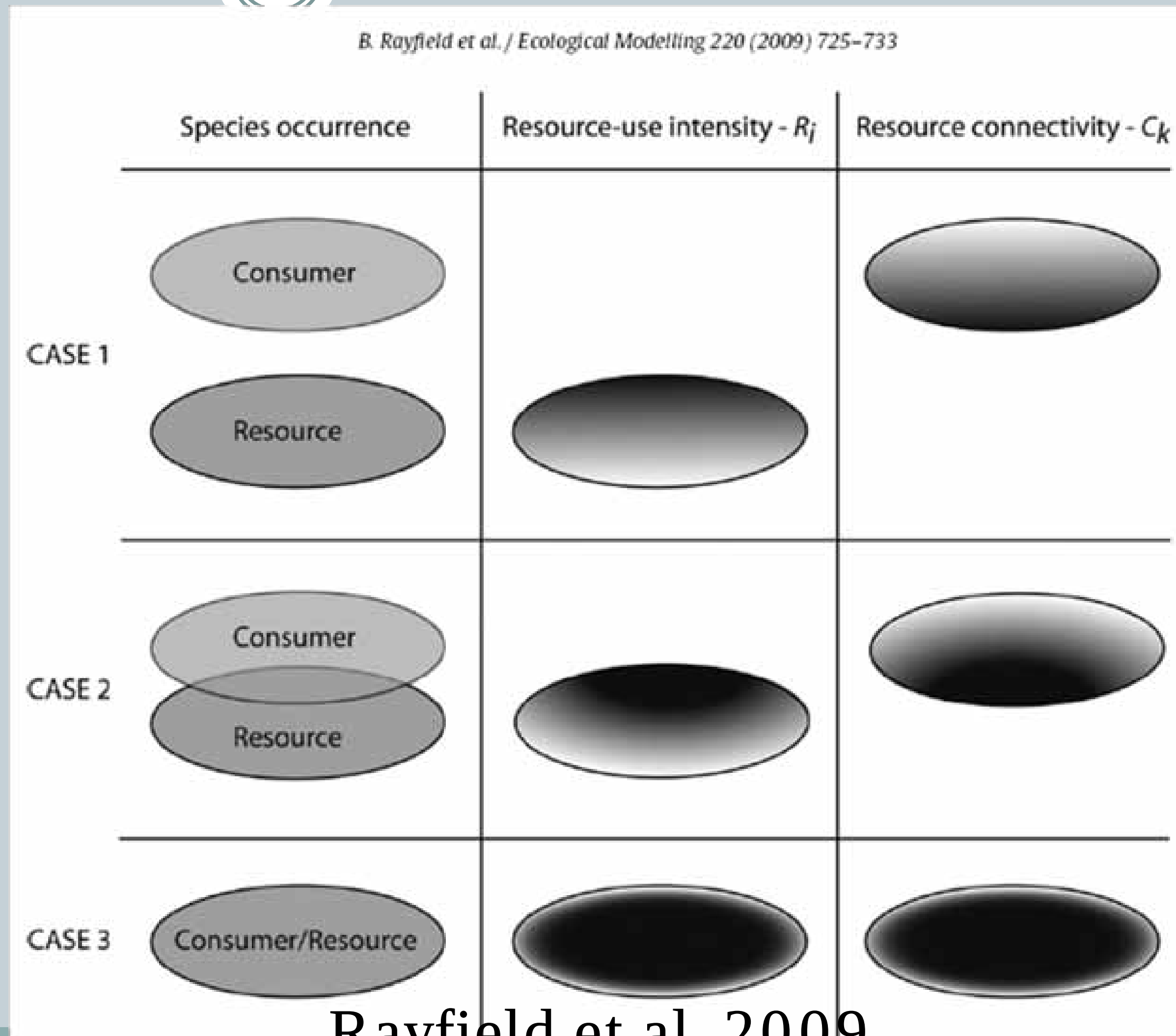


Figure 1. Map of the study region showing the geologic classes and state/province boundaries. Key to abbreviations: Maine (ME), New Hampshire (NH), Vermont (VT), New York (NY), Massachusetts (MA), Rhode Island (RI), Connecticut (CT), Pennsylvania (PA), Delaware (DE), New Jersey (NJ), Maryland (MD), Ohio (OH), West Virginia (WV), Virginia (VA), New Brunswick (NB), Nova Scotia (NS) and Prince Edward Island (PE). doi:10.1371/journal.pone.0011554.g001

Goal: Prioritize refugia in planning

Zonation's interaction feature prioritizes areas based on current and future habitat value and proximity



Rayfield et al. 2009

Case study of Zonation approach: Climate adaptation for the Northwest Forest Plan

- Evaluate the ability of reserves designed for the Northern Spotted Owl to protect rare and endemic species
- Identify priority areas for enhancing resilience of reserve network to climate change: where current habitat is connected or in proximity to future habitat

Carroll et al. 2009 *Global Change Biology*

Do umbrellas protect against climate change?

As species' ranges shift,
does a focal species-based reserve network protect a broad range of taxa?

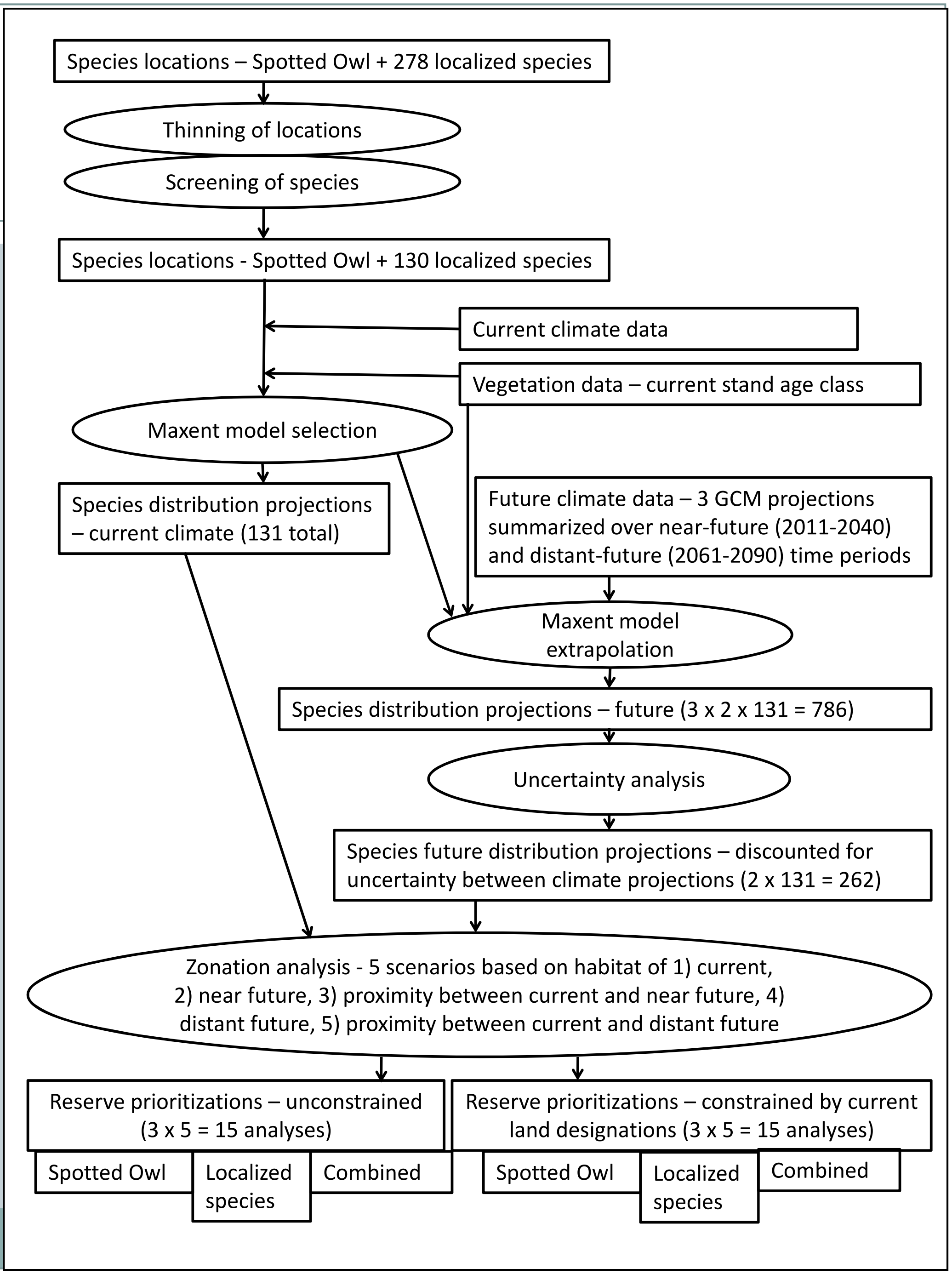
Key analysis steps

Pre-process survey records

Develop habitat models using MAXENT

Variables considered:

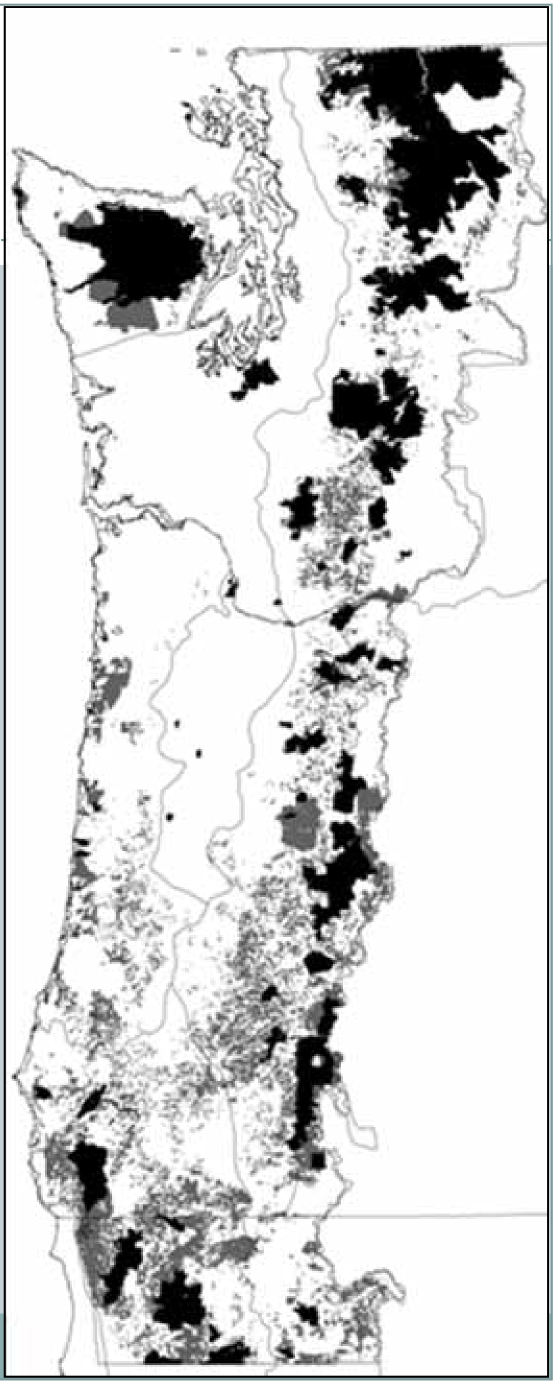
- Forest age class
- Climatic variables (seasonal temperature and precipitation)



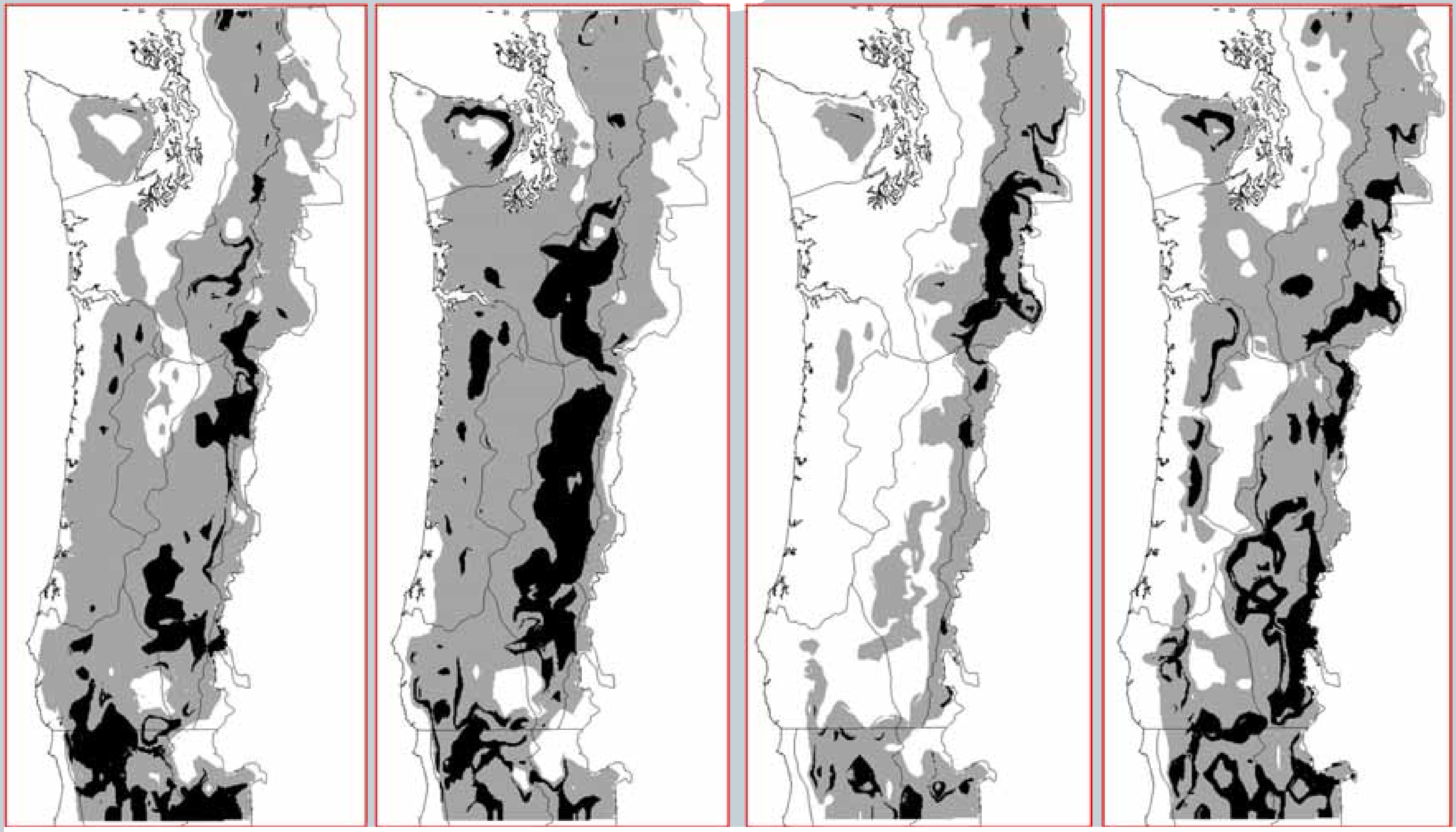
A multi-species analysis

130 Survey and Manage species had more than 10 locations after "thinning":

- 75 fungi
- 21 lichen
- 10 bryophytes
- 8 vascular plants
- 12 mollusks
- 2 amphibians
- 1 mammal
- 1 bird



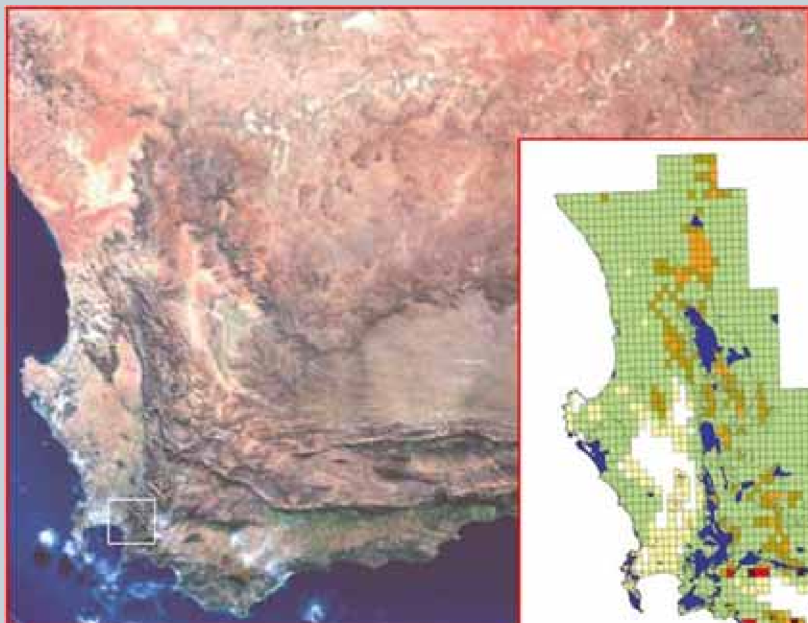
Need to account for uncertainty in climate models, especially due to precipitation projections

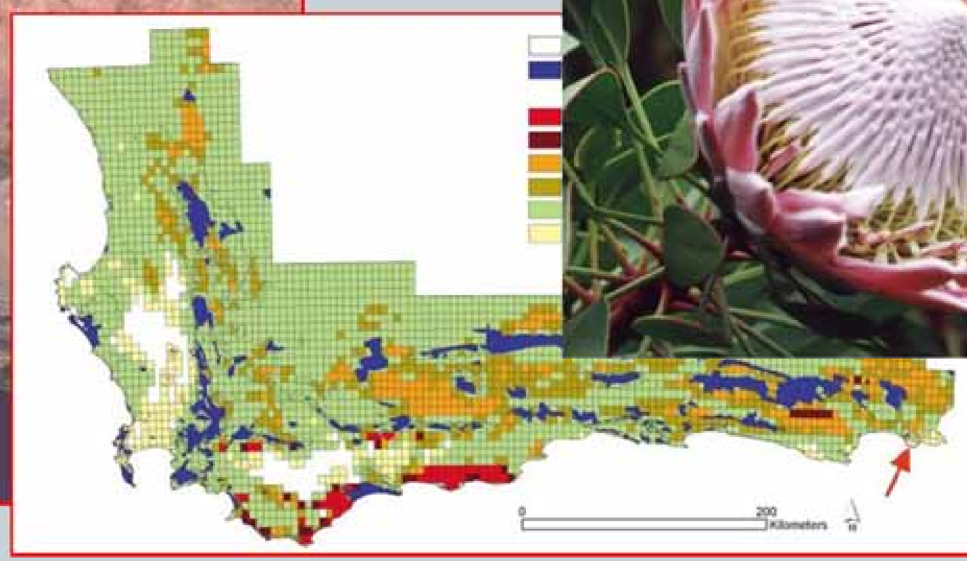


CLIMATE-ONLY MODEL:
CURRENT CLIMATE

Spotted Owl climate-only niche models

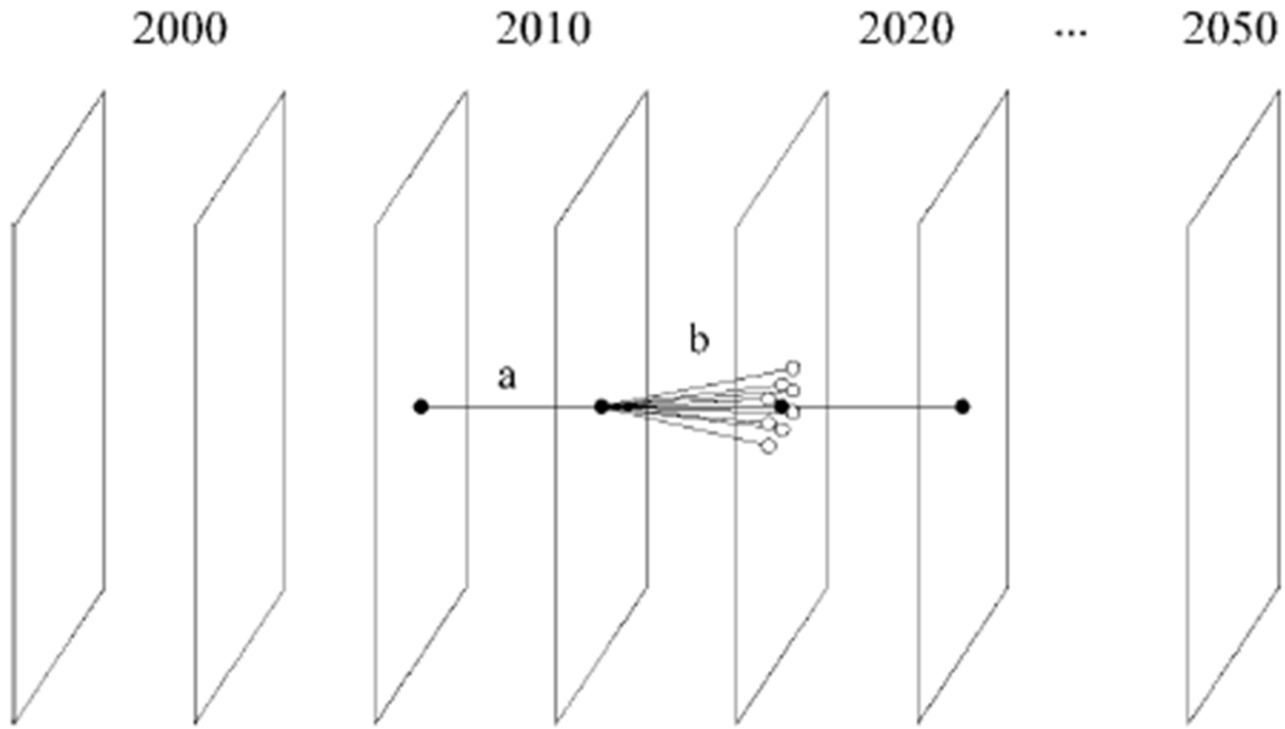
Network-flow based approach: identify ‘climate corridors’ in South Africa’s Cape Province





Phillips et al. 2008 *Ecological Applications*

Habitat linkages across time identified by network flow

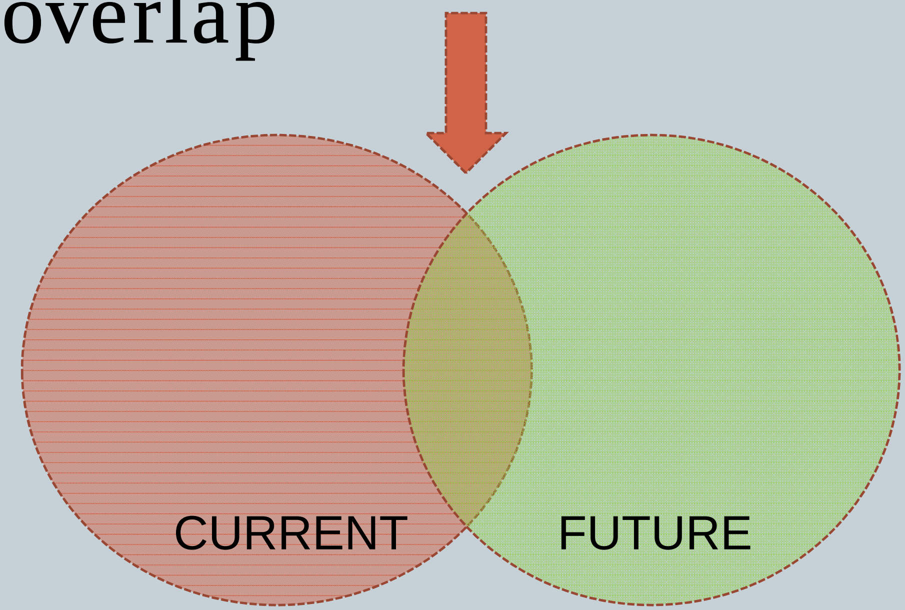


Phillips et al. 2008 *Ecological Applications*

Assumptions about dispersal influence climate change adaptation planning

Assumption of no dispersal:

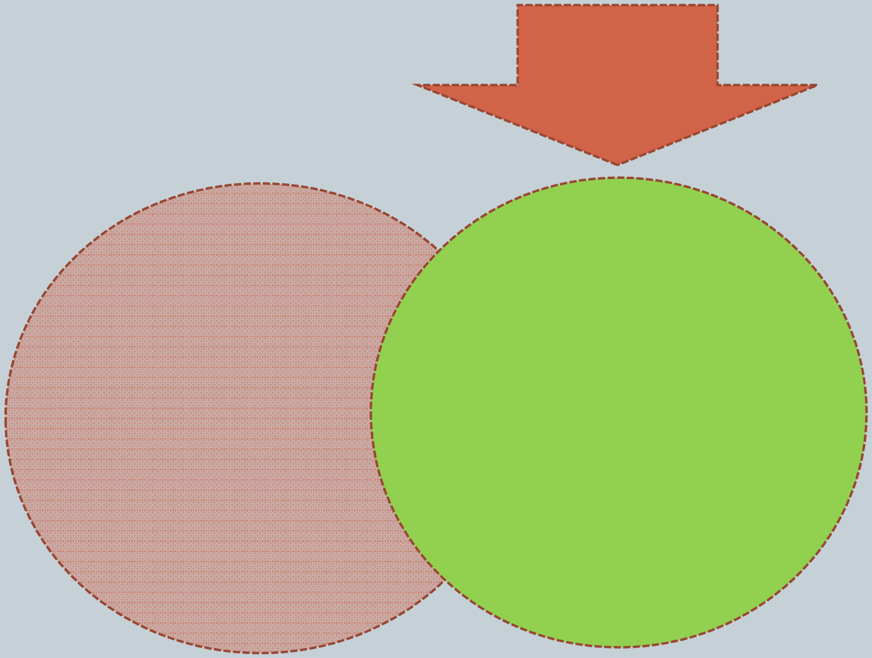
Species persists only where current and future habitat overlap



Assumptions about dispersal influence climate change adaptation planning

Assumption of unconstrained dispersal:

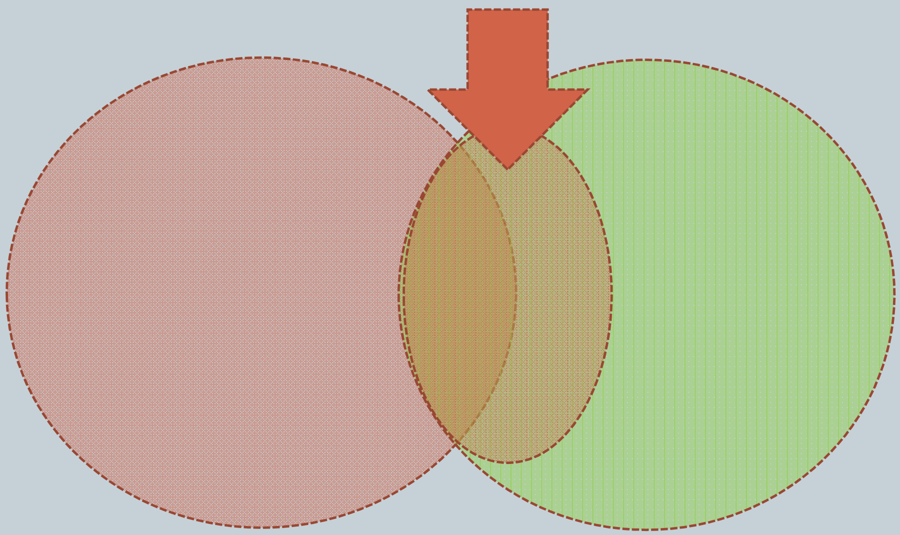
Species persists wherever future habitat is present



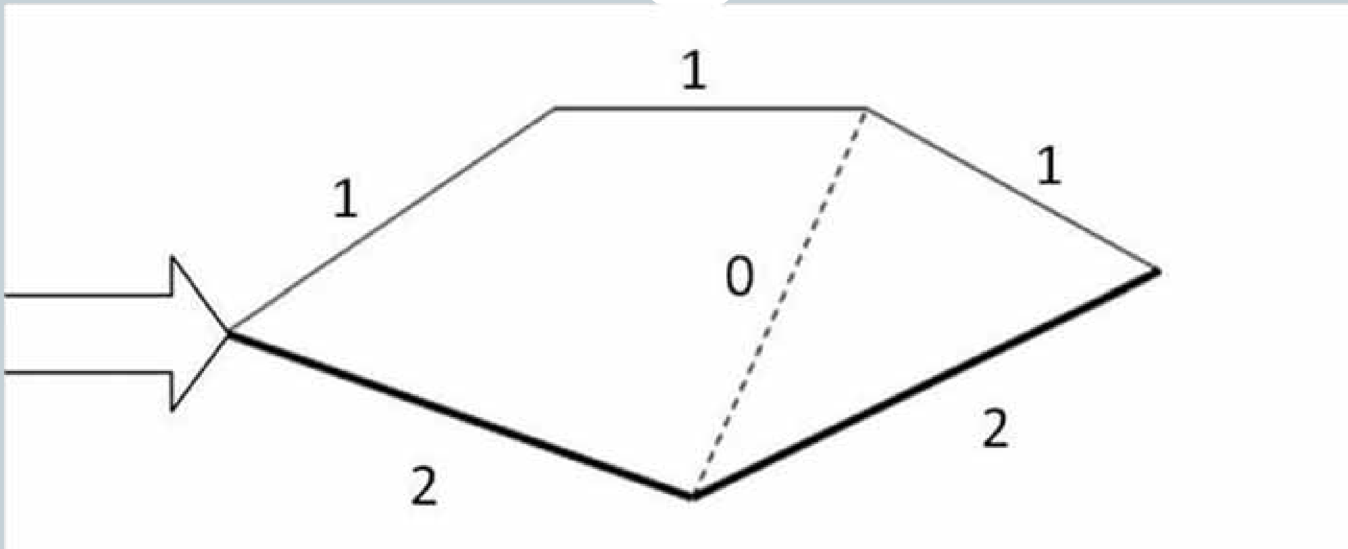
Assumptions about dispersal influence climate change adaptation planning

Network flow analysis allows assumption of constrained dispersal:

Species persists wherever future habitat is within dispersal distance of current habitat



Network flow allows unified analysis of time series



Adds two major factors that increase realism:

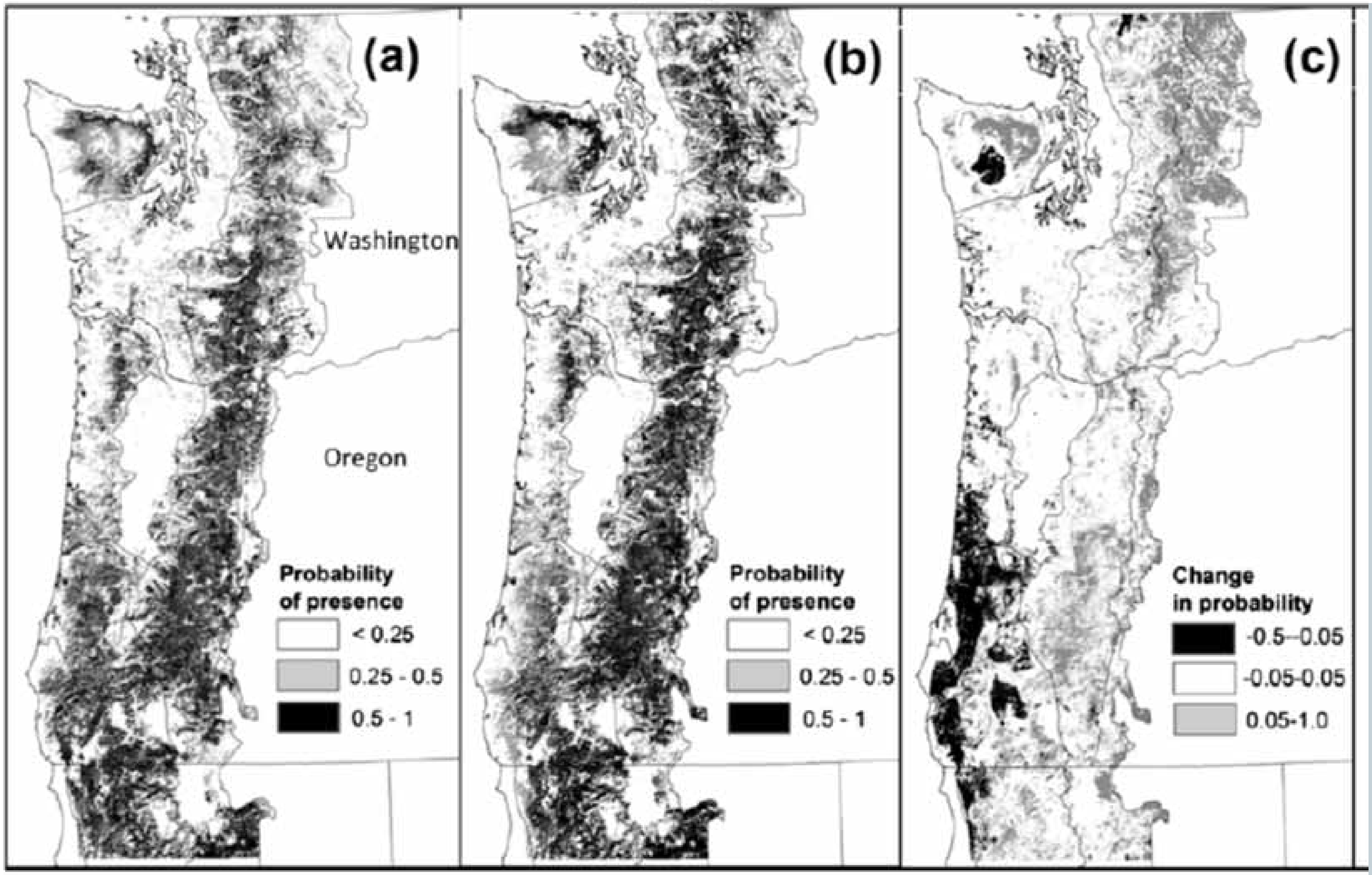
- Flow conservation – current habitat originates flow
- Capacity constraints – any time step can create a bottleneck to flow

Network flow allows unified analysis of time series

Adds two major factors that increase realism of analysis:

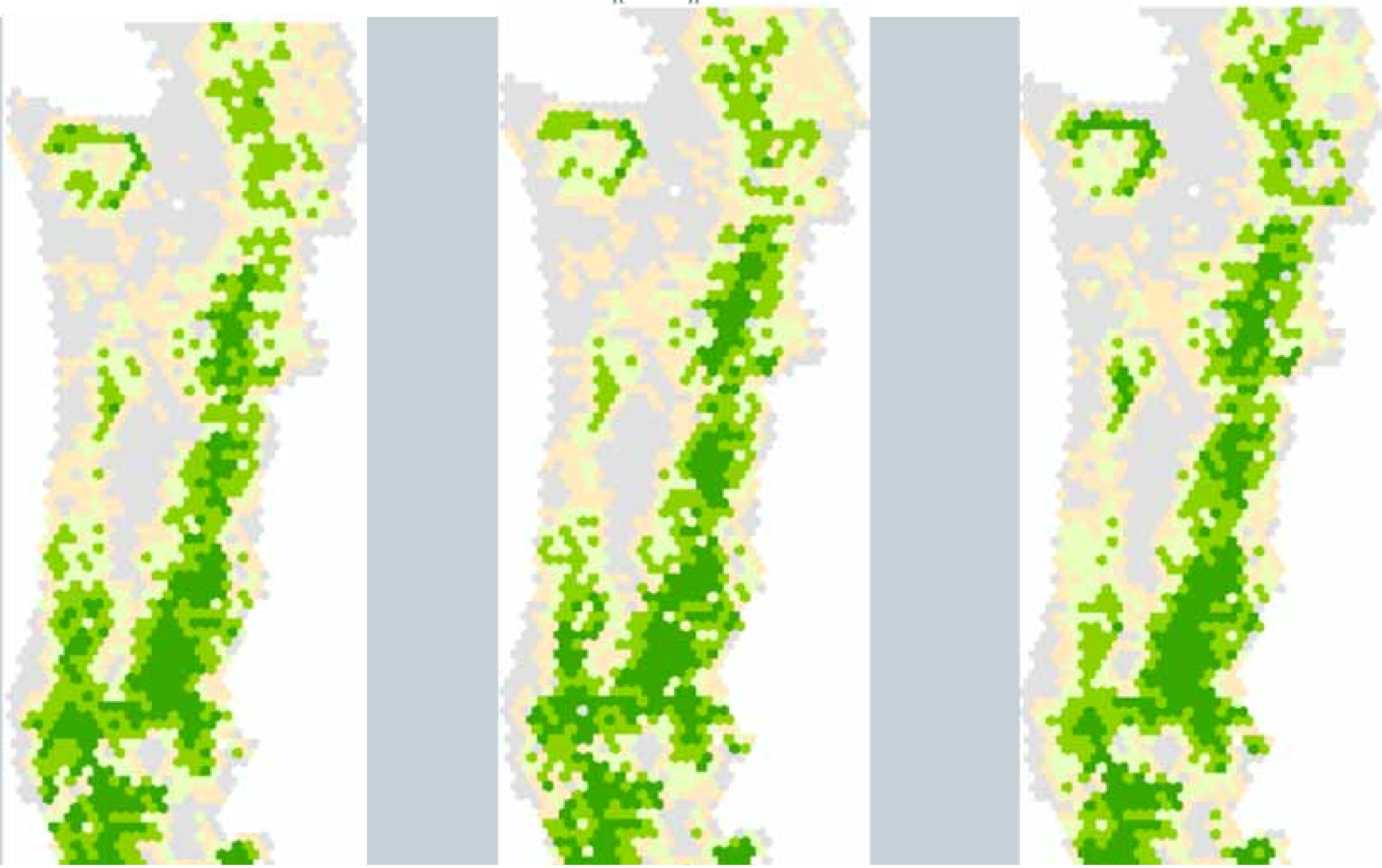
- Flow conservation – current habitat originates flow
- Capacity constraints – any time step can create a bottleneck to flow

Case study: Northern Spotted Owl



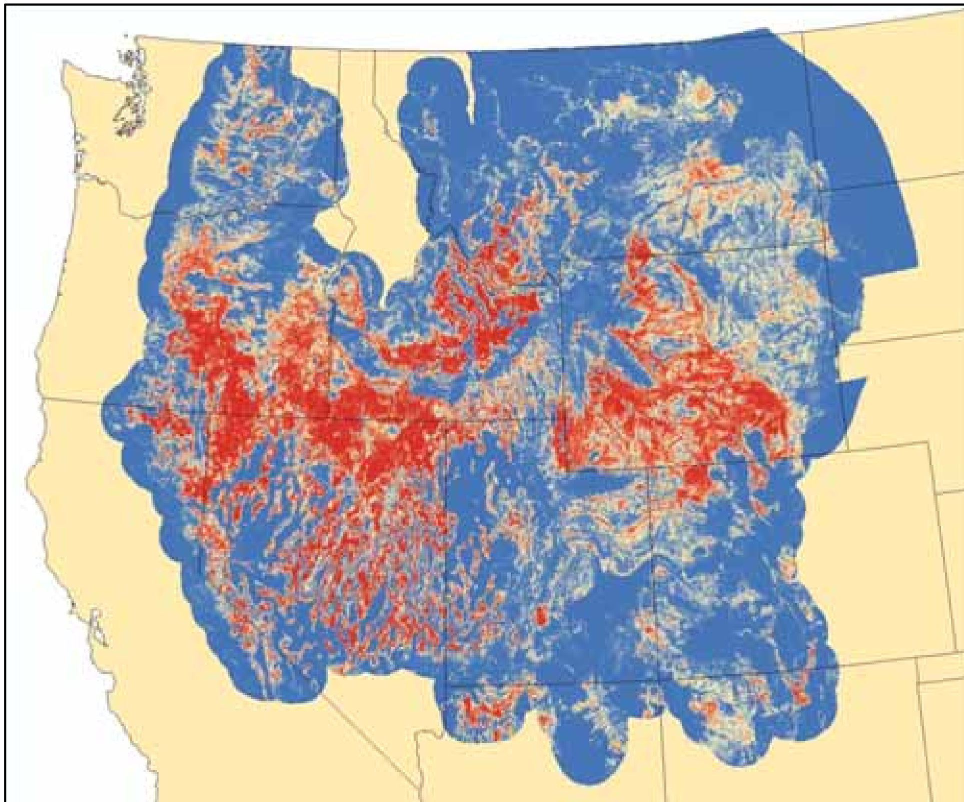
CURRENT FUTURE CHANGE

Results of CAT min-cost flow: Northern Spotted Owl

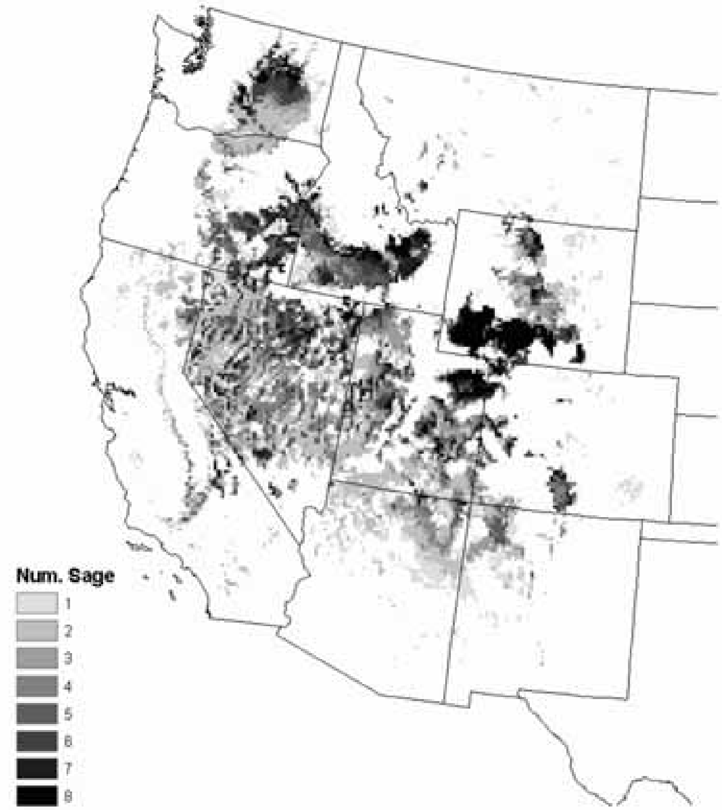


TIMESTEP 1 TIMESTEP 2 TIMESTEP 3

Assumption: maximum 34 km dispersal between steps



Future distribution of sagebrush under climate change -
Neilson et al. 2005



Analysis of sage grouse habitat connectivity

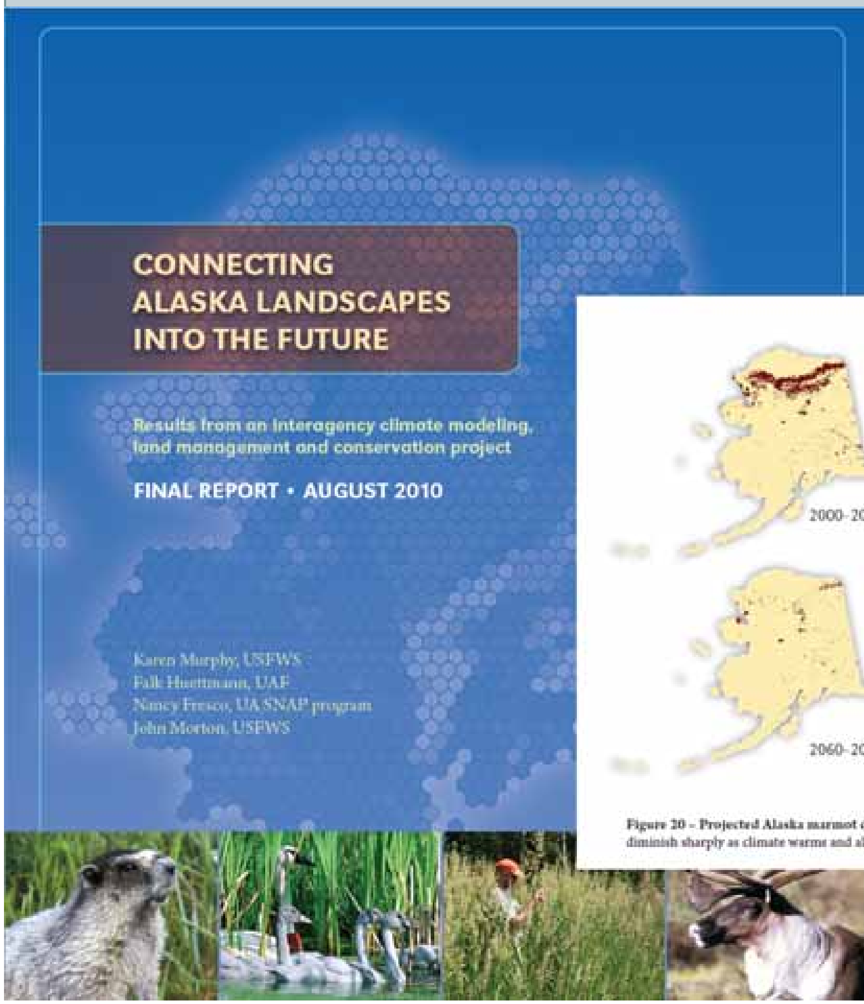
A multi-faceted strategy for climate change adaptation planning

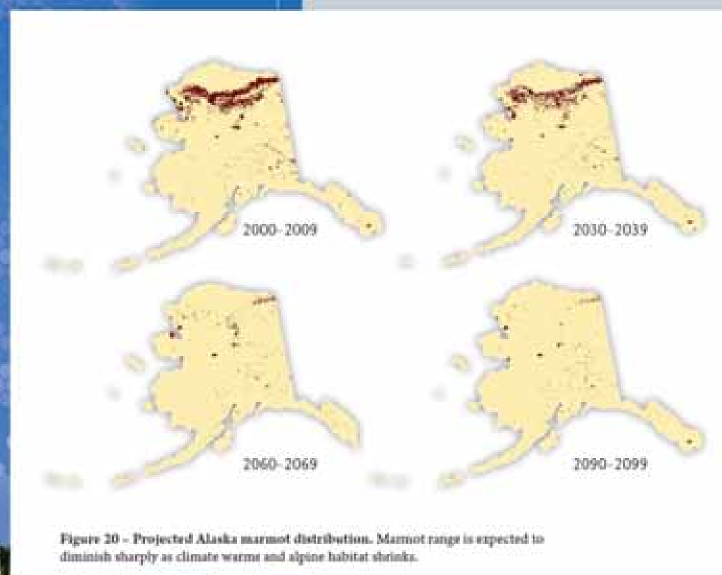
Coarse-filter refugia – Areas of stable climate

Fine-filter refugia – Areas with stable habitat

Fine-filter ‘climate corridors’ – Areas that allow dispersal to new habitat as climate shifts

Linkage mapping results can be applied to assist climate change adaptation planning





Example of inter-agency regional adaptation plan from Alaska

THE END