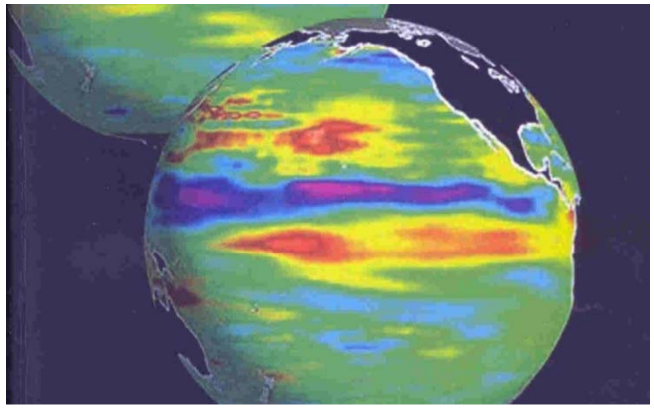
Conserving the arenas, not the actors: wildlife linkages for a changing climate



Brian Brost, Paul Beier, Jeff Jenness

NORTHERN ARIZONA UNIVERSITY

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RMRS
ROCKY MOUNTAIN RESEARCH STATION

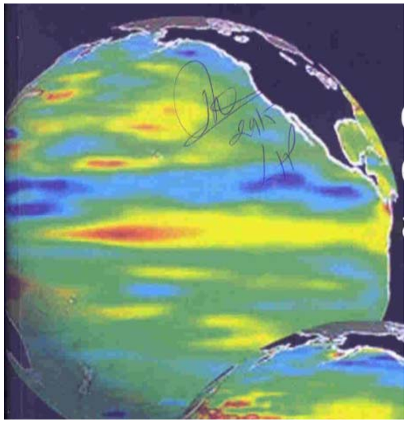
USDA McIntire-Stennis Cooperative Forestry Research Program

Arizona Board of Forest Research

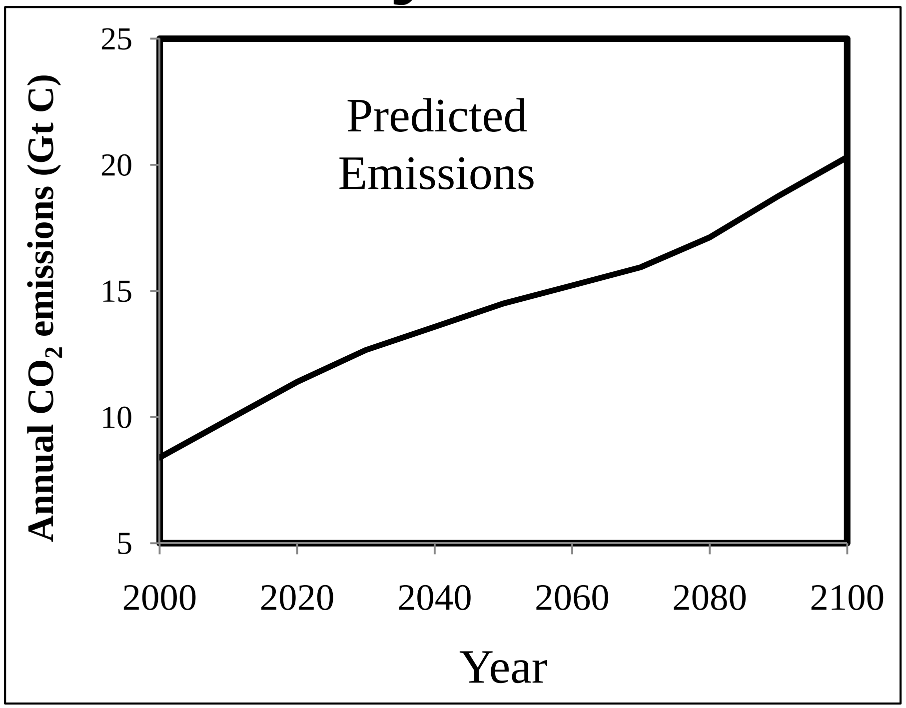
Two ways to design linkages for climate change

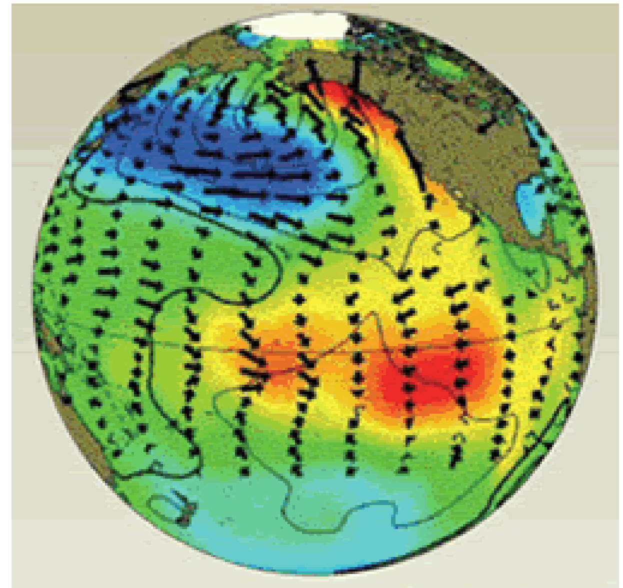
Linked dynamic models

Corridors with high continuity & diversity of land facets



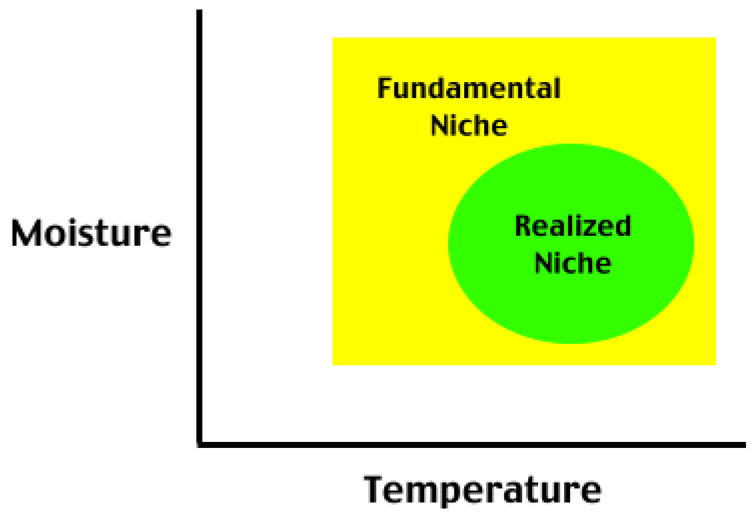
Linked dynamic models





Air-Ocean Global
Circulation Model

Climate
envelope
model for
each species

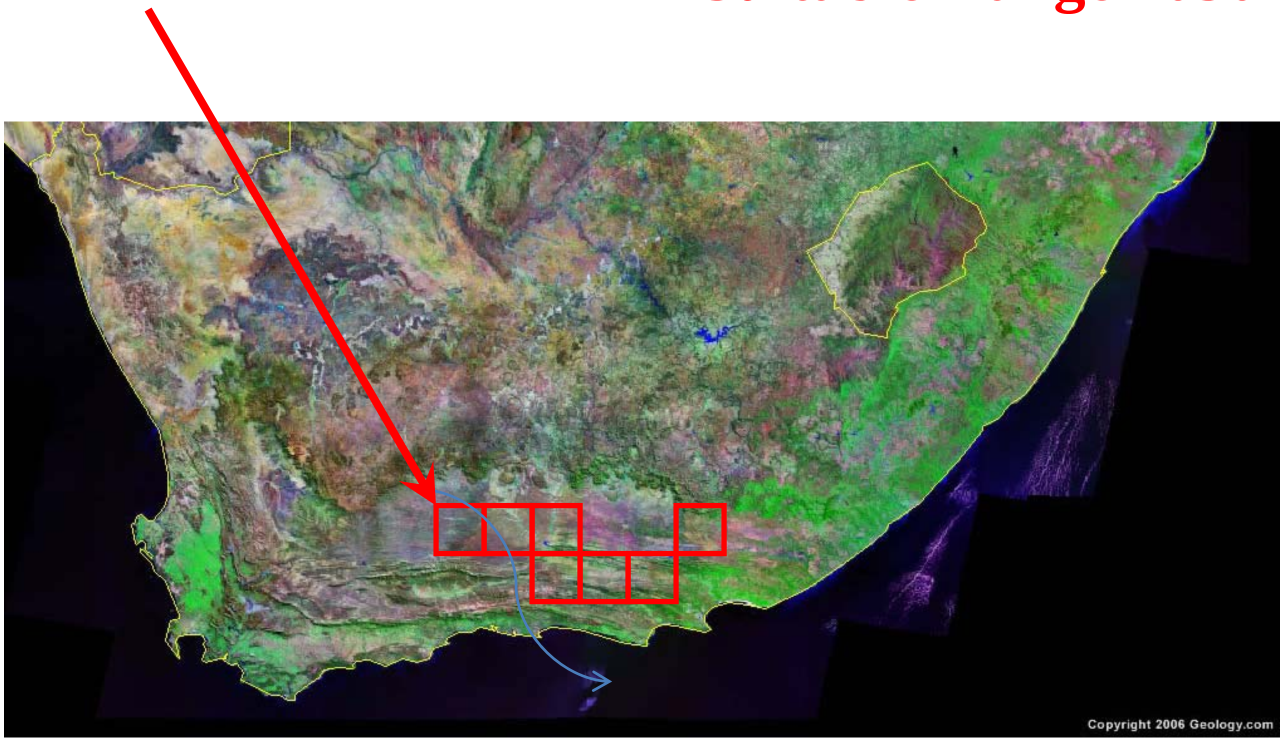


Linked dynamic models

Bioclimatic envelopes will shift with climate change, 2010-2050.

Cape Protaceae

Suitable Range 2050



Williams et al. (2005); Phillips et al. (2008)

Linked dynamic models

Bioclimatic envelopes will shift with climate change, 2010-2050.

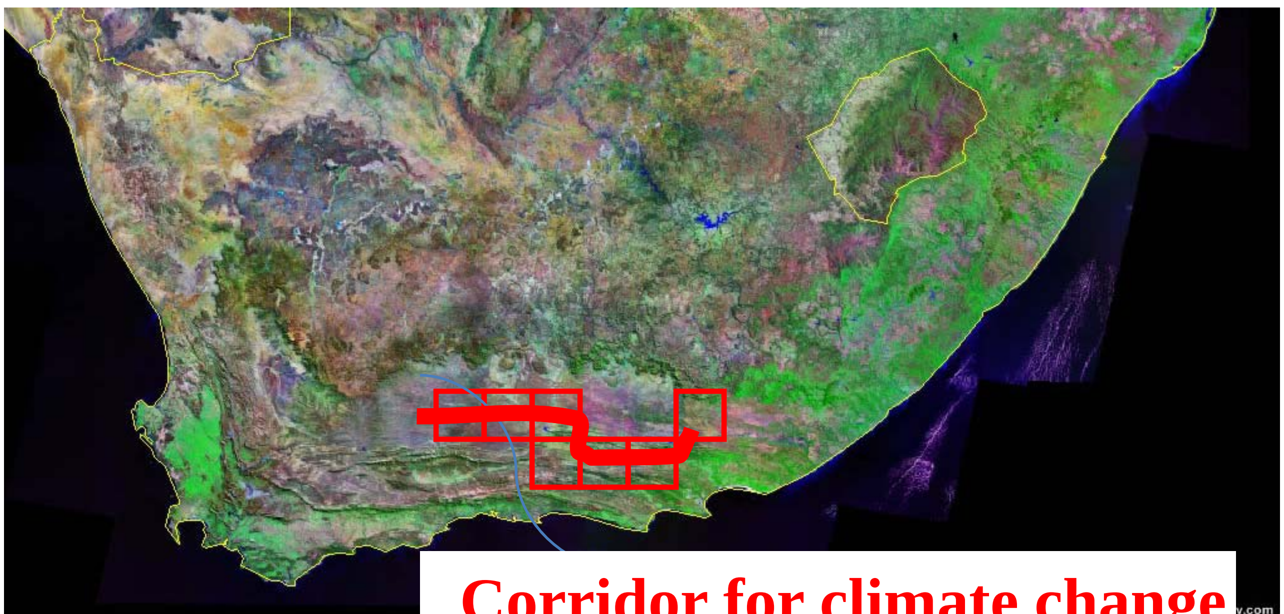
Cape Protaceae

Williams et al. (2005); Phillips et al. (2008)

Linked dynamic models

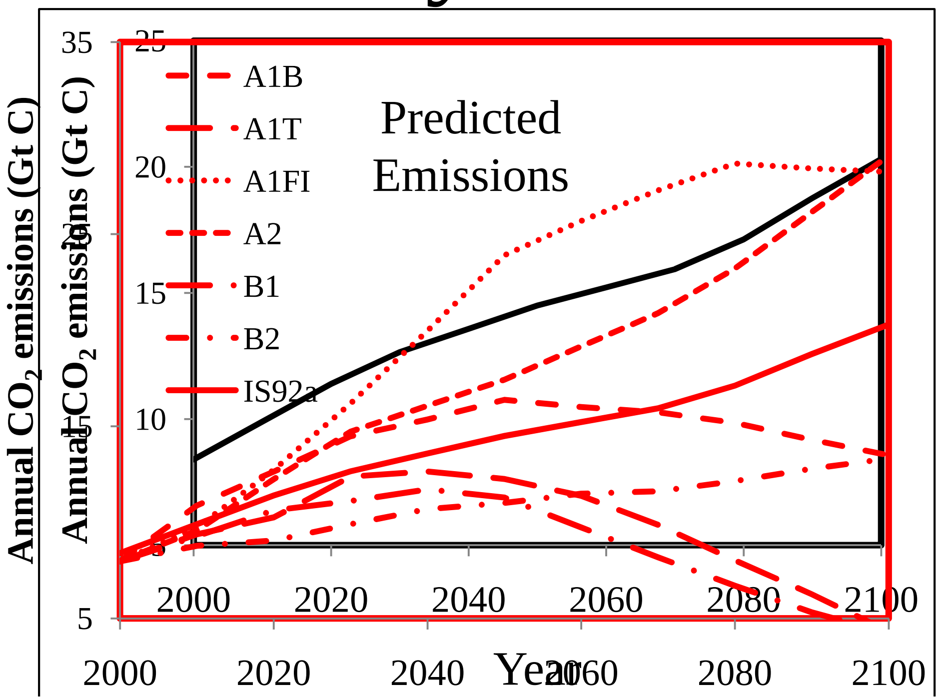
That is really cool!

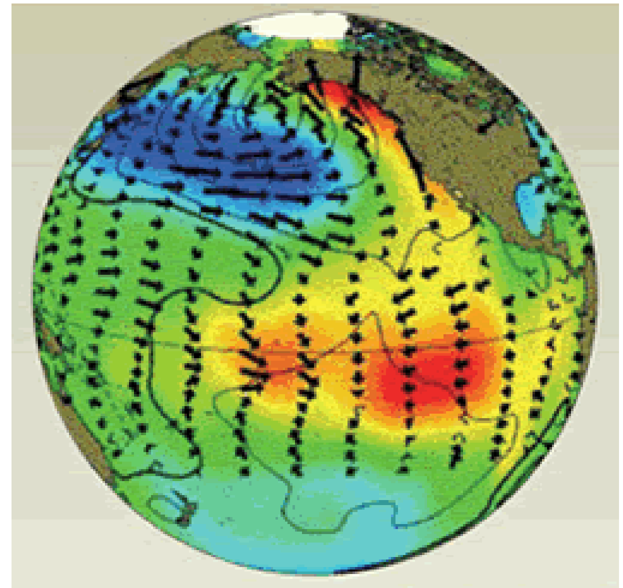
Why *don't* we like it?



Williams et al. (2005);
Phillips et al. (2008)

Linked dynamic models





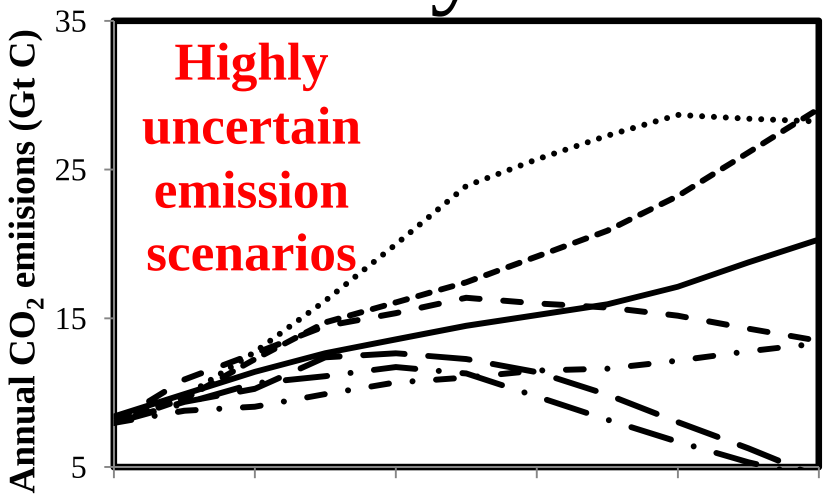
Air-Ocean Global
Circulation Model

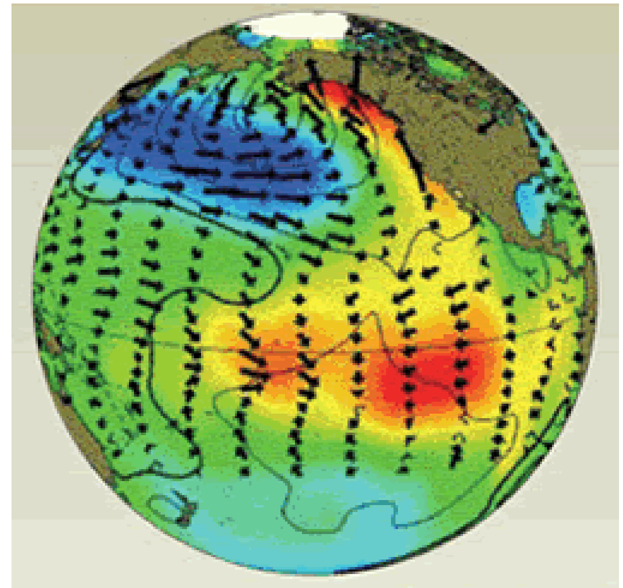
The IPCC has 7 scenarios.

They differ by a factor of 6.

… and actual emissions during 2000-2004 exceeded all scenarios.

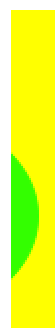
Linked dynamic models



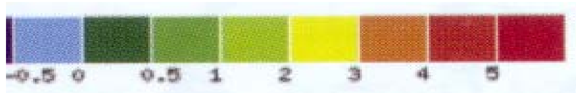


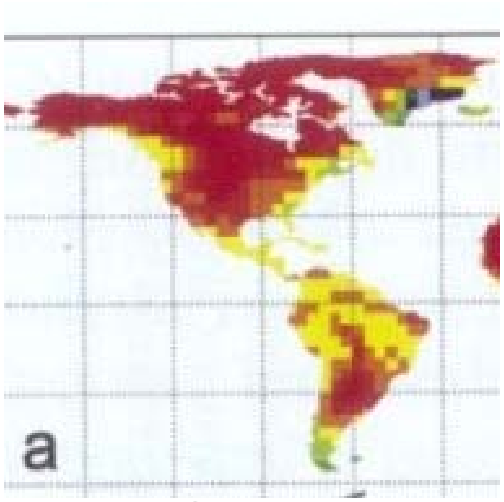
Air-Ocean Global Circulation Model

There are 7 major AOGCMs.

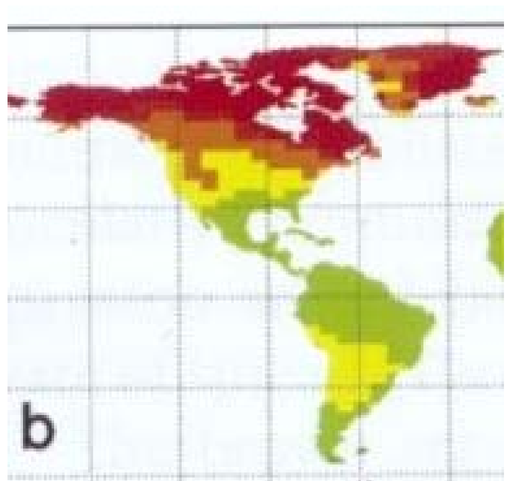


Temperature

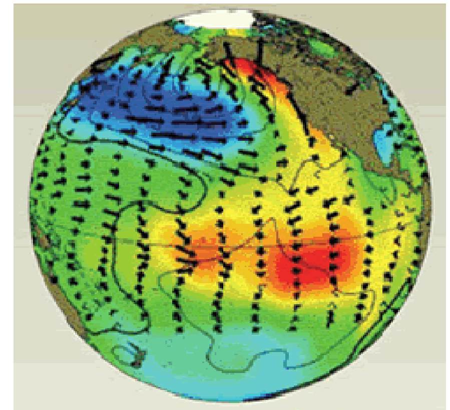
-1 C  +6 C



ECHAM4



CSIRO

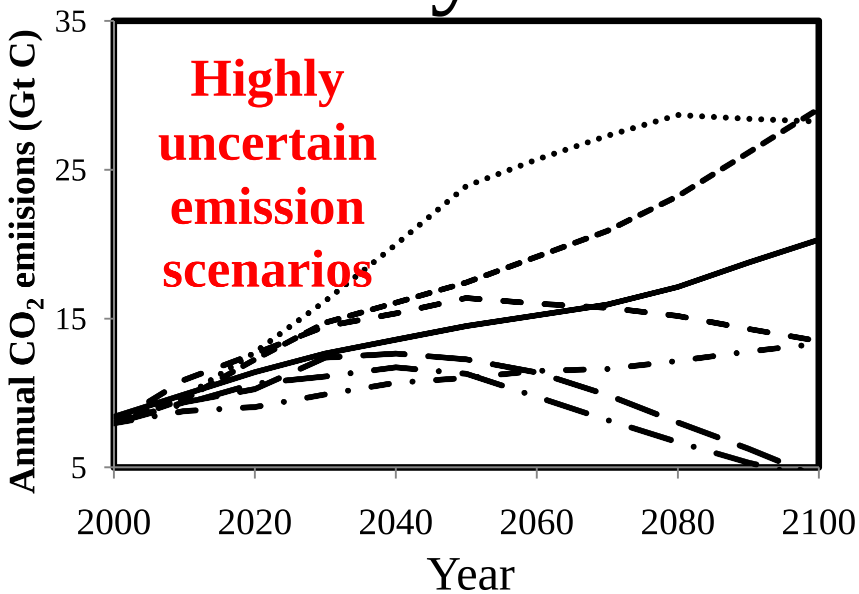


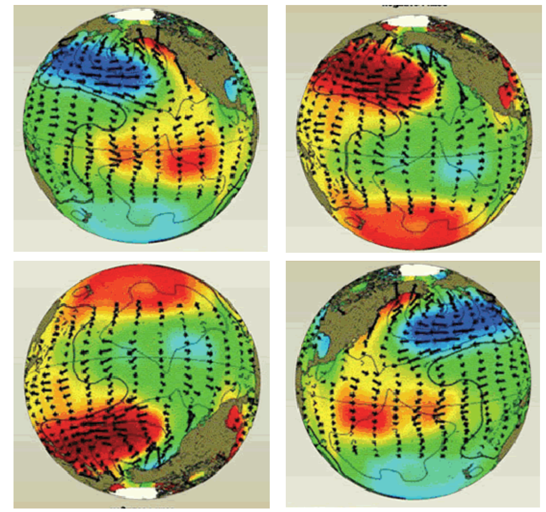
Air-Ocean Global
Circulation Model

Predicted change in temperature over 20 years <u>using one emission scenario</u>.

GCMs also differ greatly in predicted precipitation.

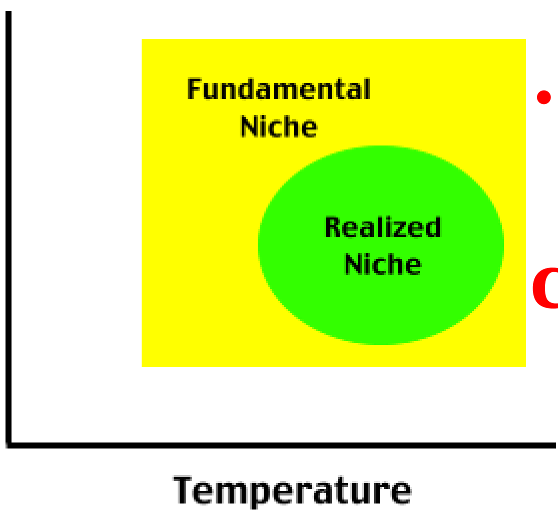
Linked dynamic models





Highly uncertain Air-Ocean Global Circulation Models

Climate envelope models



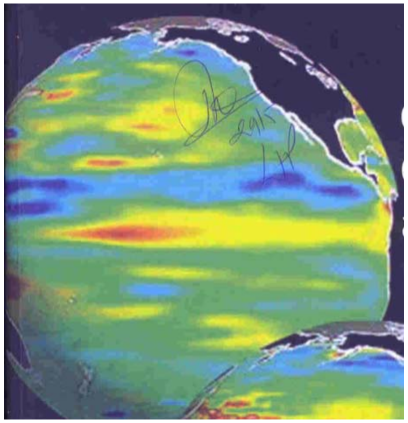
…perform no better than chance (Beale et al. 2008. *PNAS* 104:14908)

Two ways to design linkages for climate change

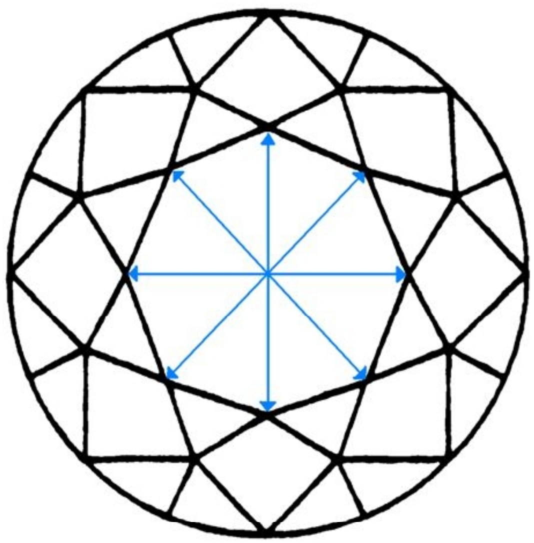
Linked dynamic models

UNCERTAINTY

Corridors with high continuity & diversity of land facets

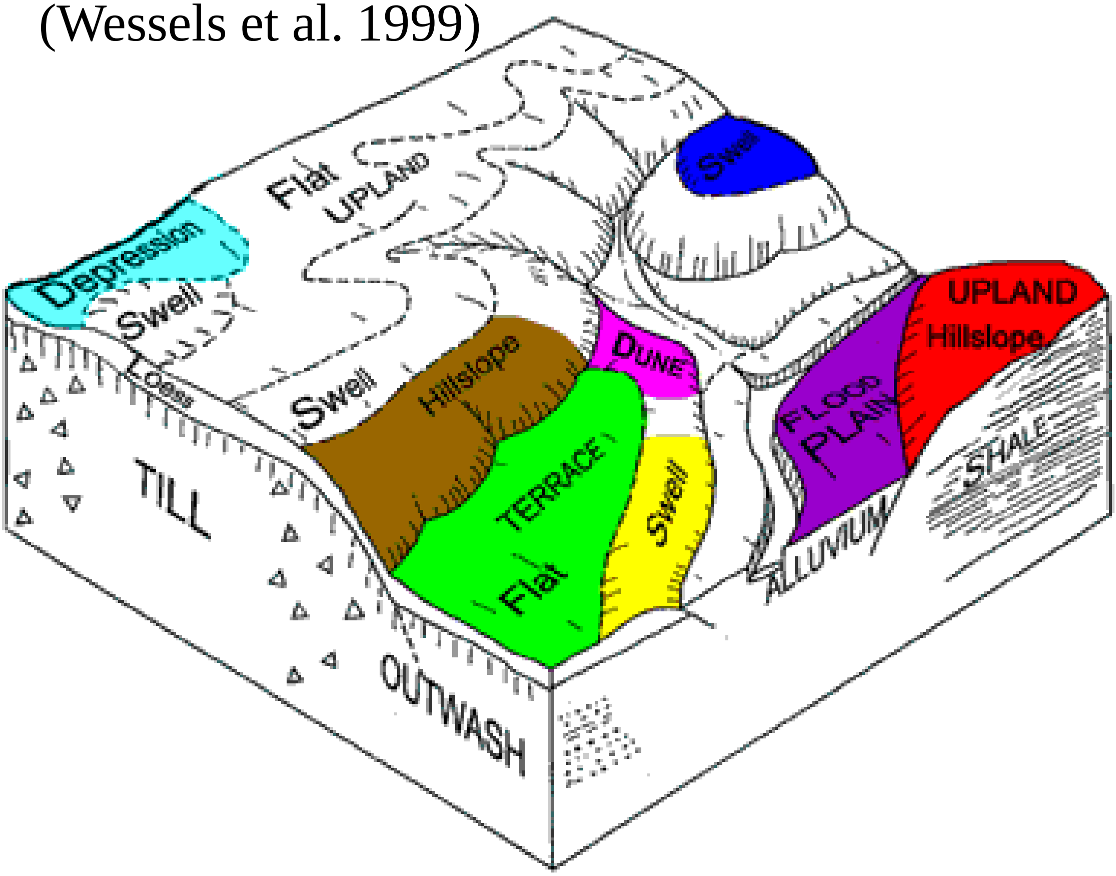


Facet: a flat polished surface cut or naturally occurring on a crystal



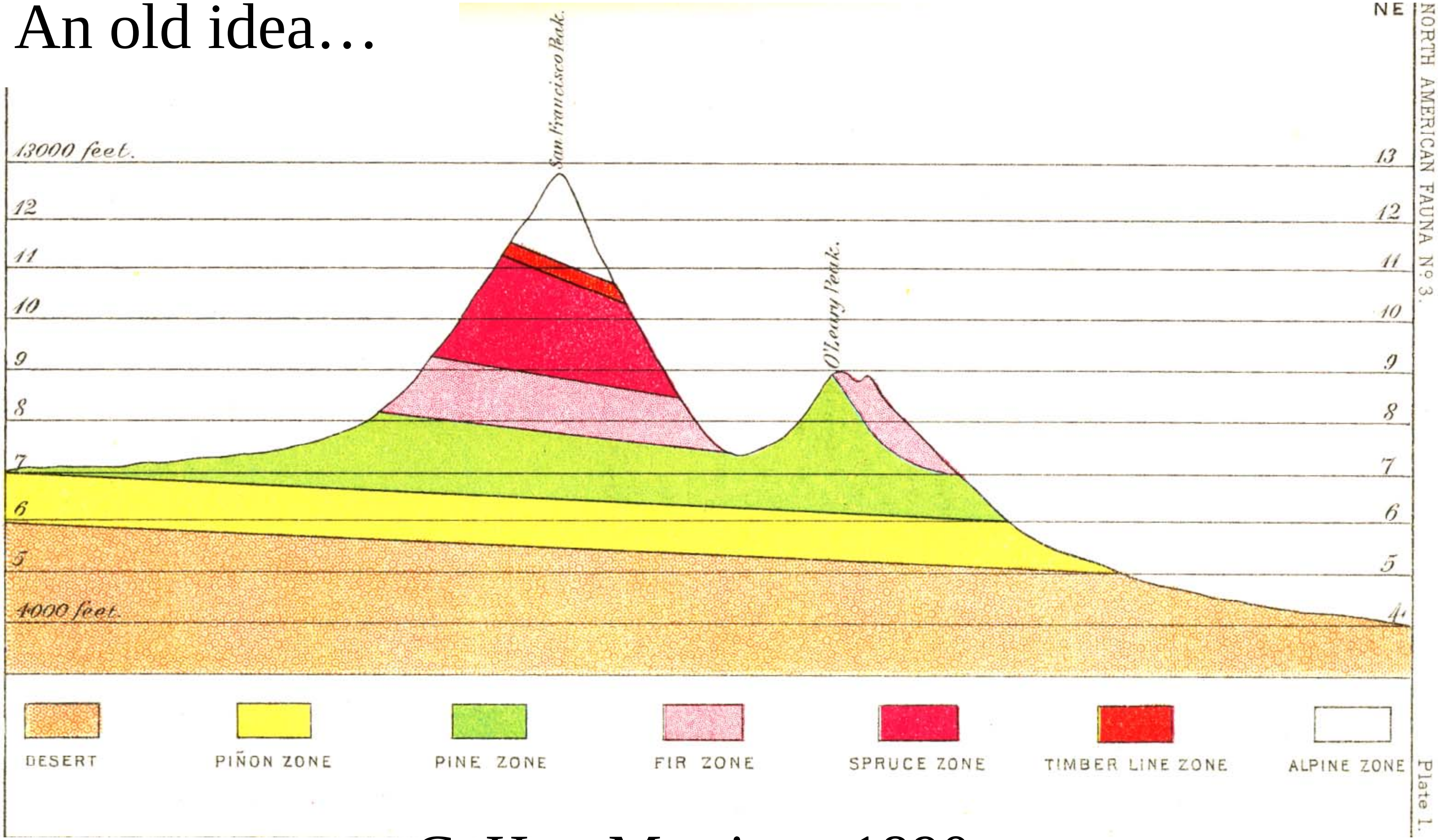
Land facet: a recurring landscape polygon with uniform topography & soil

(Wessels et al. 1999)



Tehama County, California

An old idea…

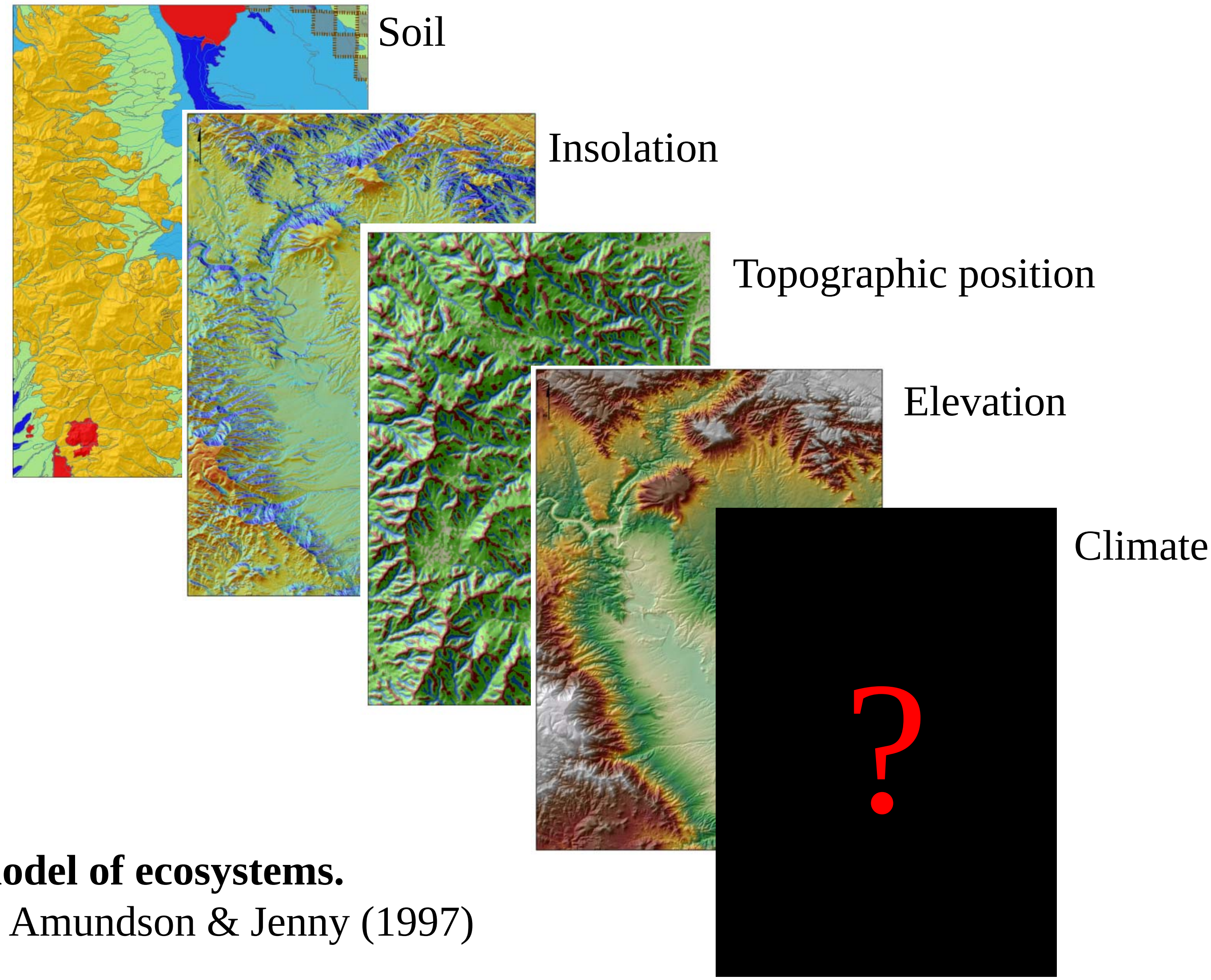


C. Hart Merriam, 1890:

life zones based on elevation & aspect

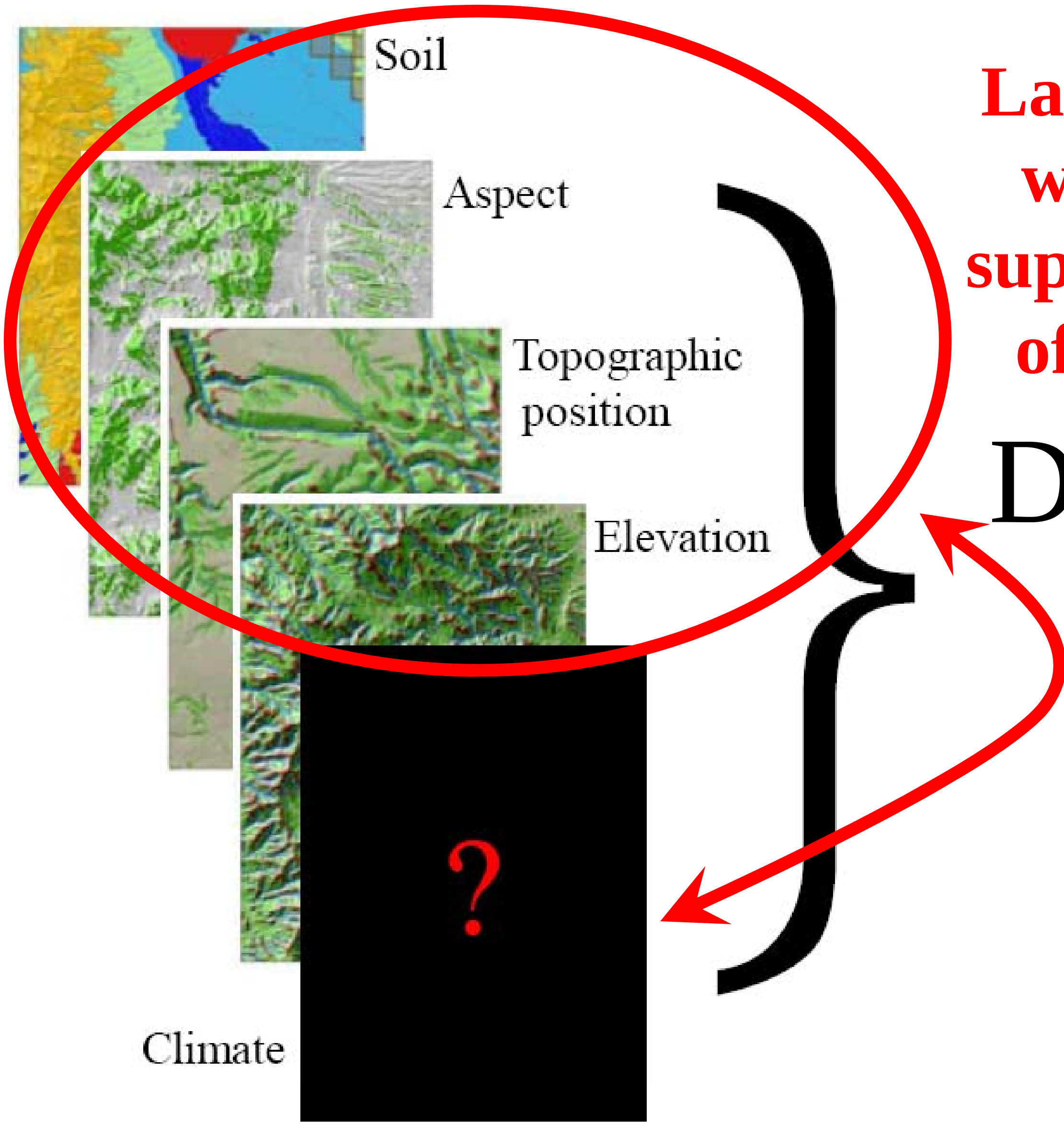
Land facets as drivers of biodiversity

Plants & animals are (and will be) a function of:



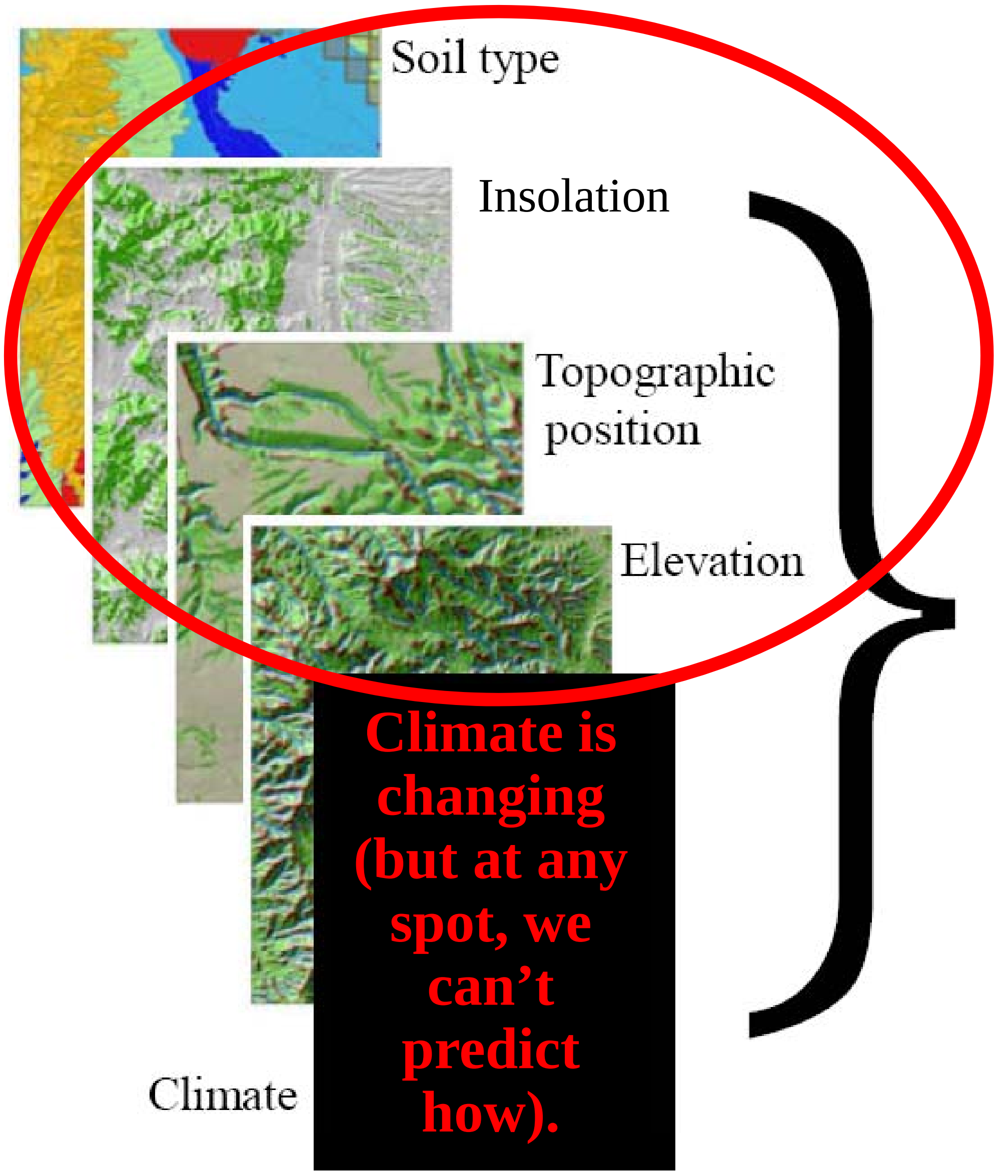
The state-factor model of ecosystems.
Hans Jenny (1941); Amundson & Jenny (1997)

These variables are stable. They define land facets.

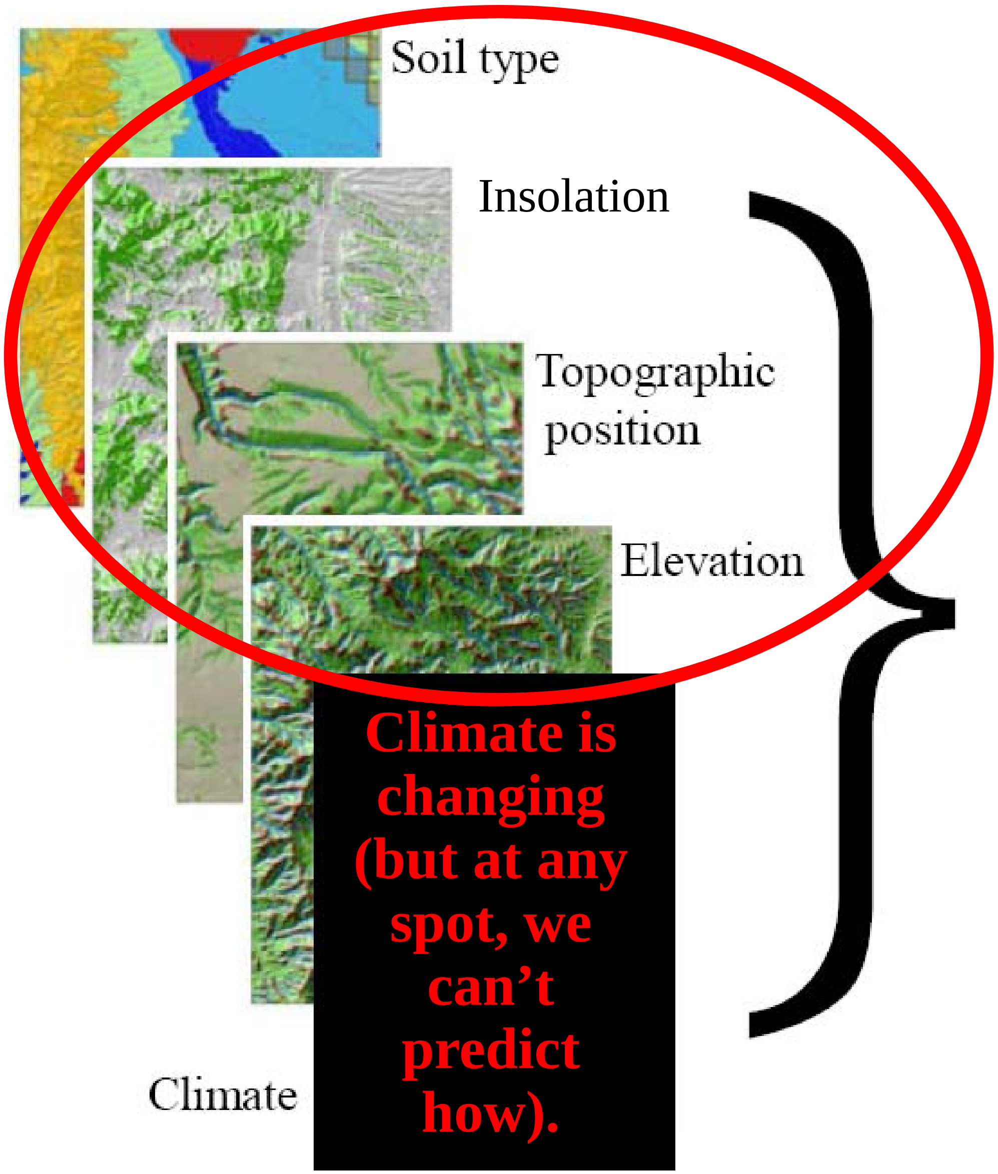


Land facets will interact with future climate to support new assemblages of plants and animals.

Distribution of plants & animals

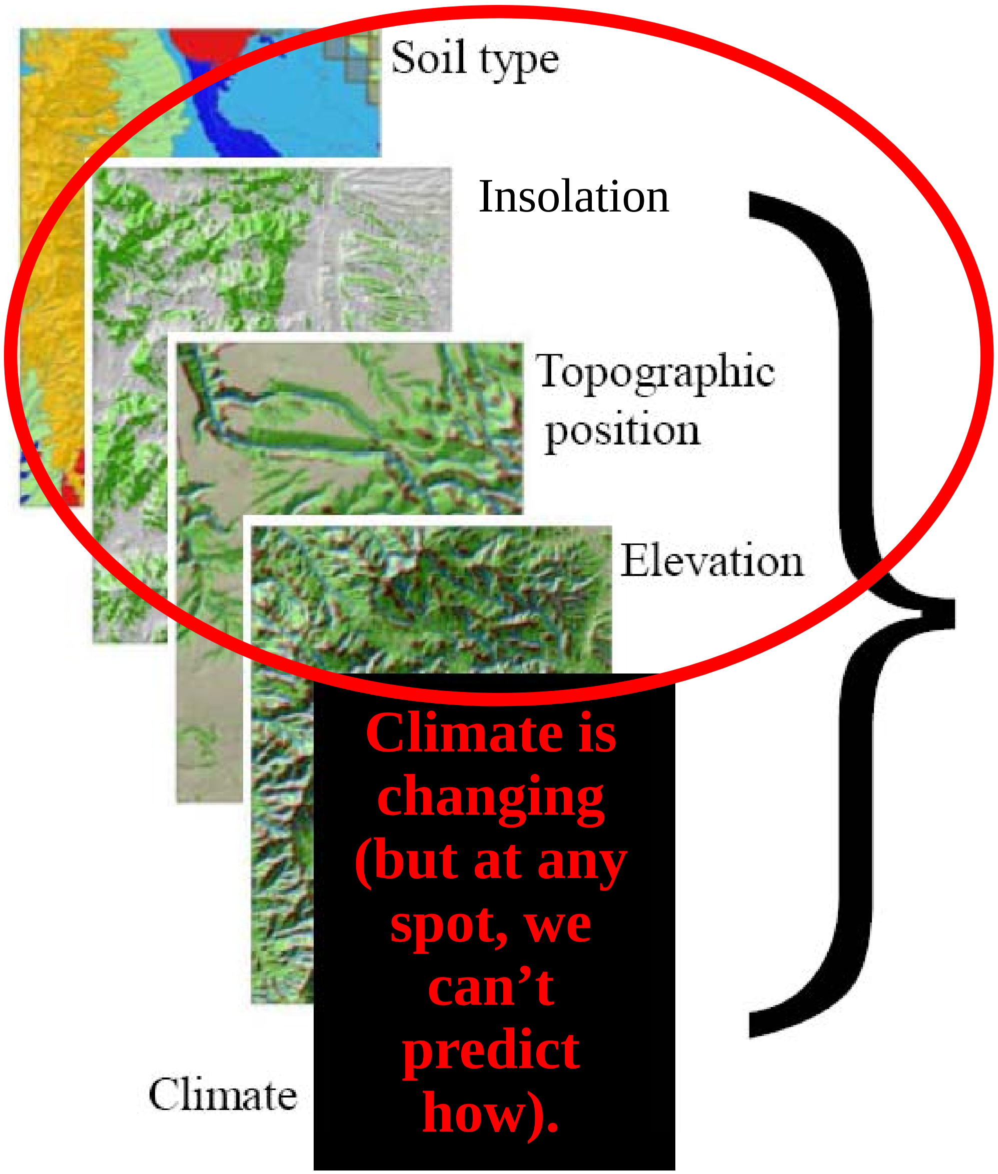


"Conserve
the arenas of biological activity rather than the temporary occupants of those arenas."
(Hunter et al. 1988)



<u>Using land facets as a coarse-filter approach to conservation planning:</u>

See Beier & Brost (2010. Conservation Biology 24:701)



Using land facets as a coarse-filter approach for linkage design:

Identify a continuous strand of each land facet, and a strand with high diversity of facets.

These should provide linkages under future climate, and should support range shift as climate changes.

Using land facets to design a linkage

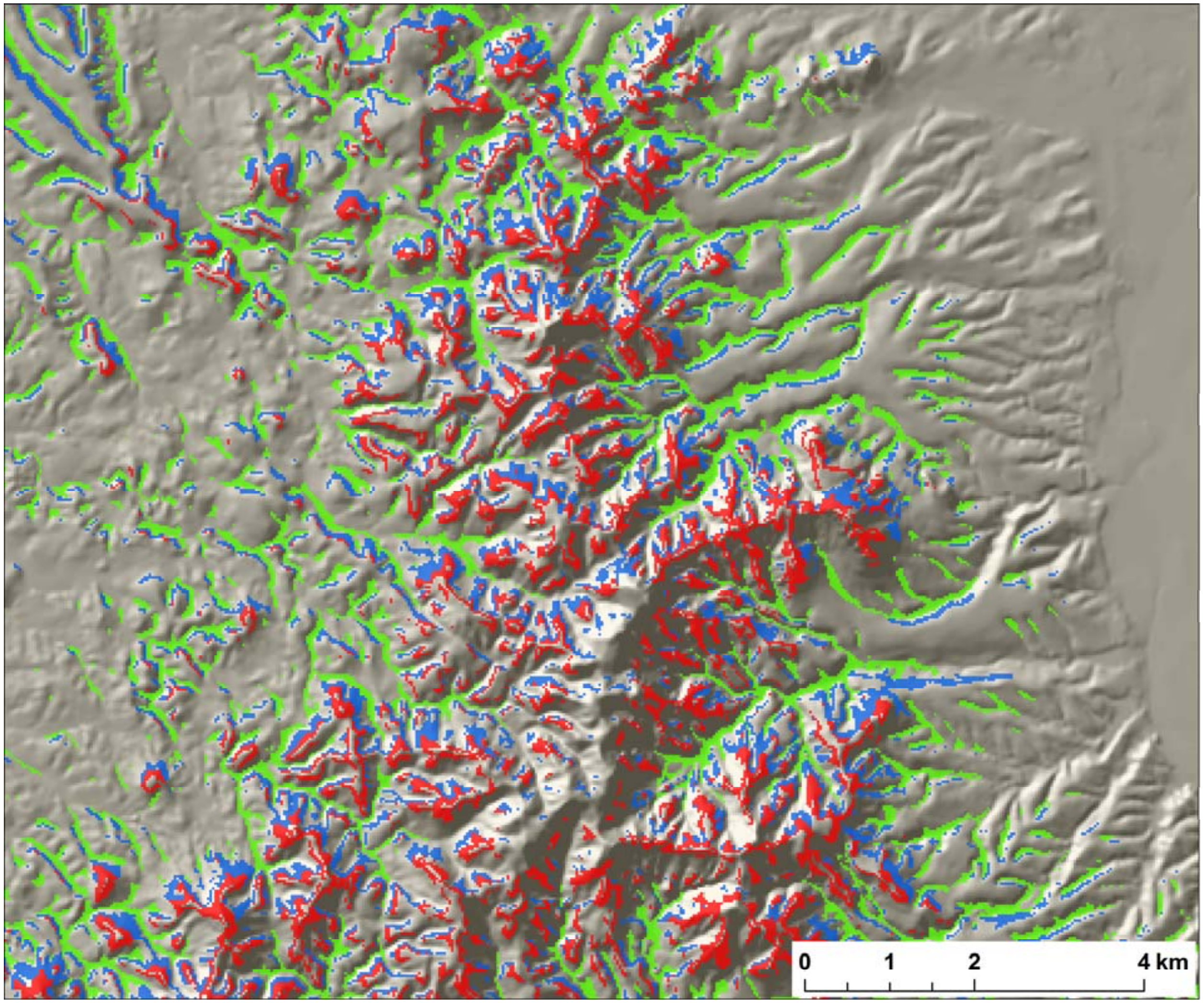
1. Define land facets based on soil & topography.
2. Design a corridor for each land facet:
    - Define corridor start & end points.
    - Define a resistance surface for each facet type.
    - Identify a least-cost corridor for that facet.
3. Design an additional corridor for high diversity of facet types.
4. Add a riverine/riparian corridor.
5. Join the corridors.

Beier & Brost. 2010. *Conservation Biology* 24:701

1. Define land facets: fuzzy clustering

Examples of land facets

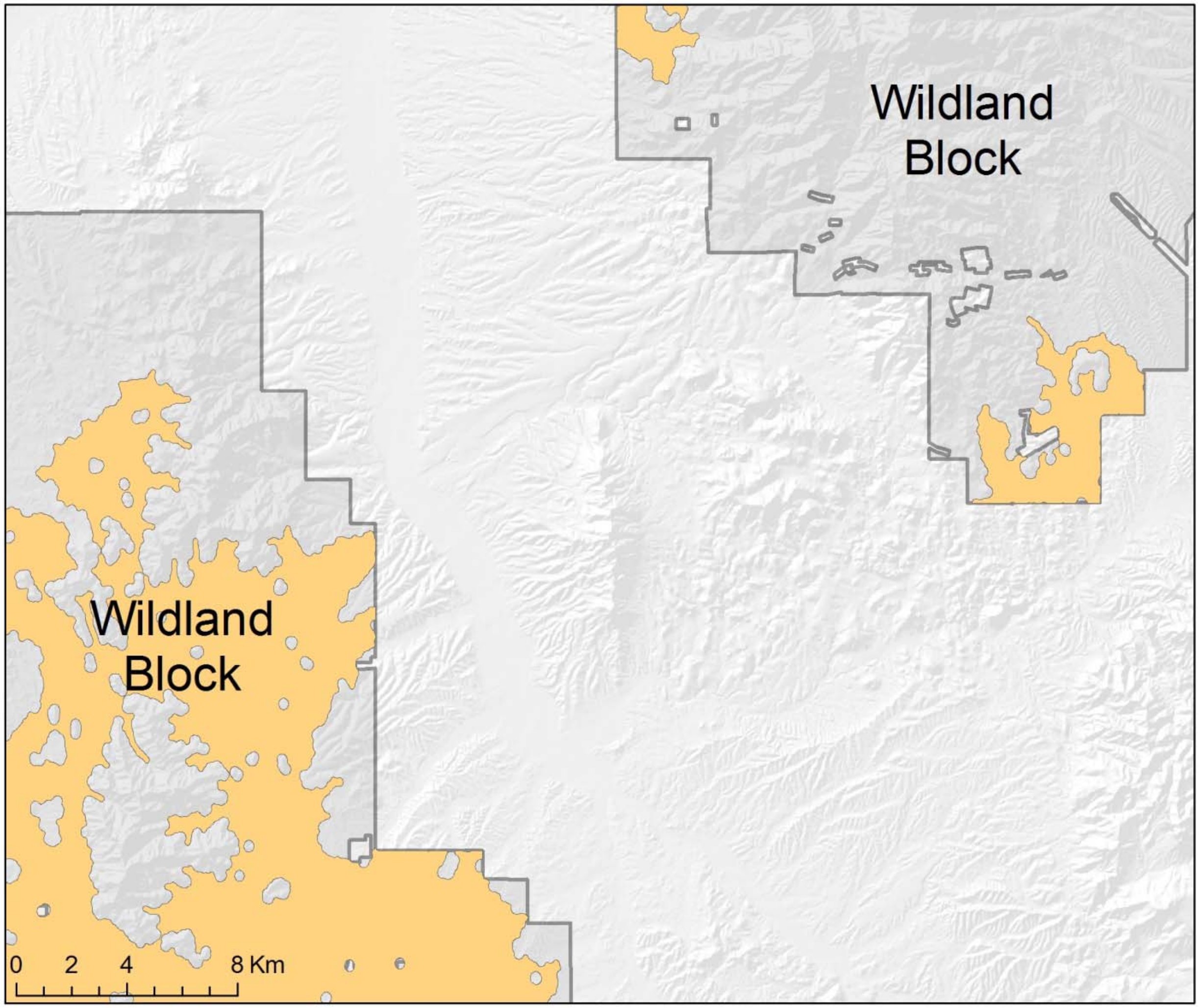
- low-elevation, gentle canyons with thick soils
- mid-elevation, steep ridges with rocky soils
- steep, low-insolation (shaded) slopes with shallow soils



2a. Define start & end points for each facet type.

Each terminus is:

- an area dominated by the focal facet type
- within one of the wildlands to be connected
- larger than a size threshold

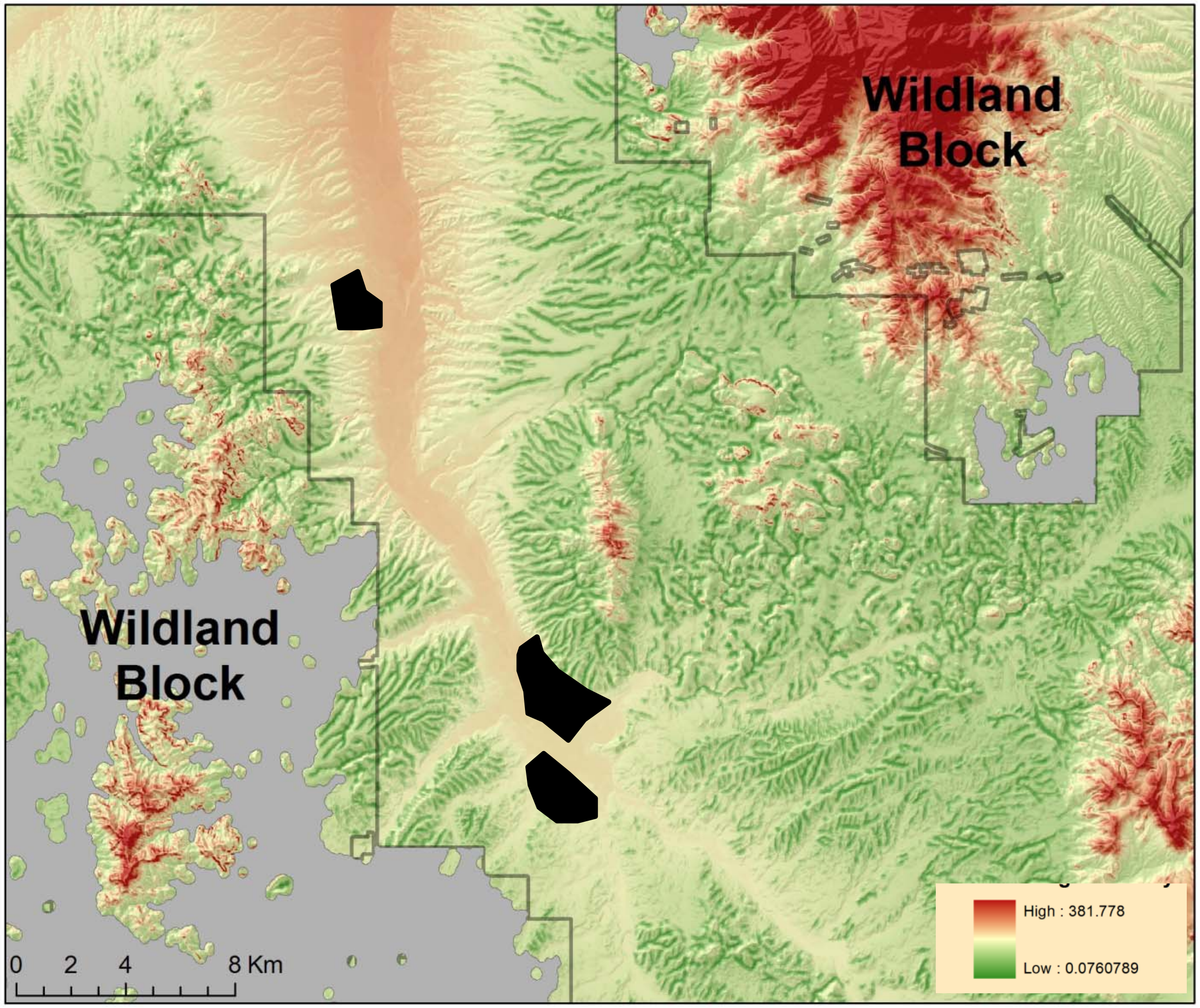


2b. Define “resistance” for each facet type.

Each pixel’s resistance is its Mahalanobis distance (multivariate dissimilarity) from the focal facet type’s average:

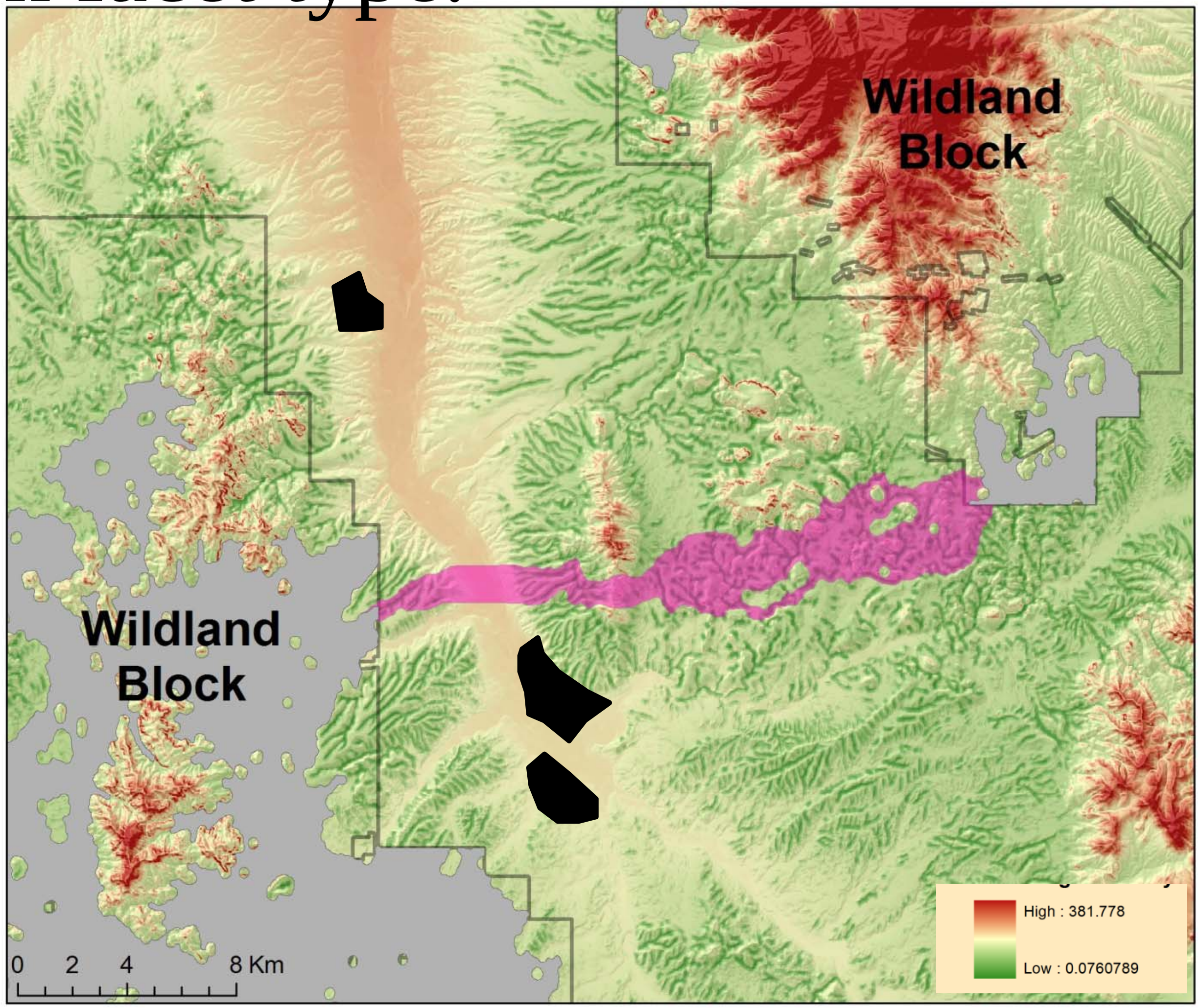
- o elevation
- o slope
- o insolation
- o % of nearby pixels of the facet type

Unrestorable areas (e.g., urban) are removed from the resistance surface



2c. Use least-cost modeling to identify a corridor for each facet type.

Each corridor should support movement by species associated with that facet (today or in the future).

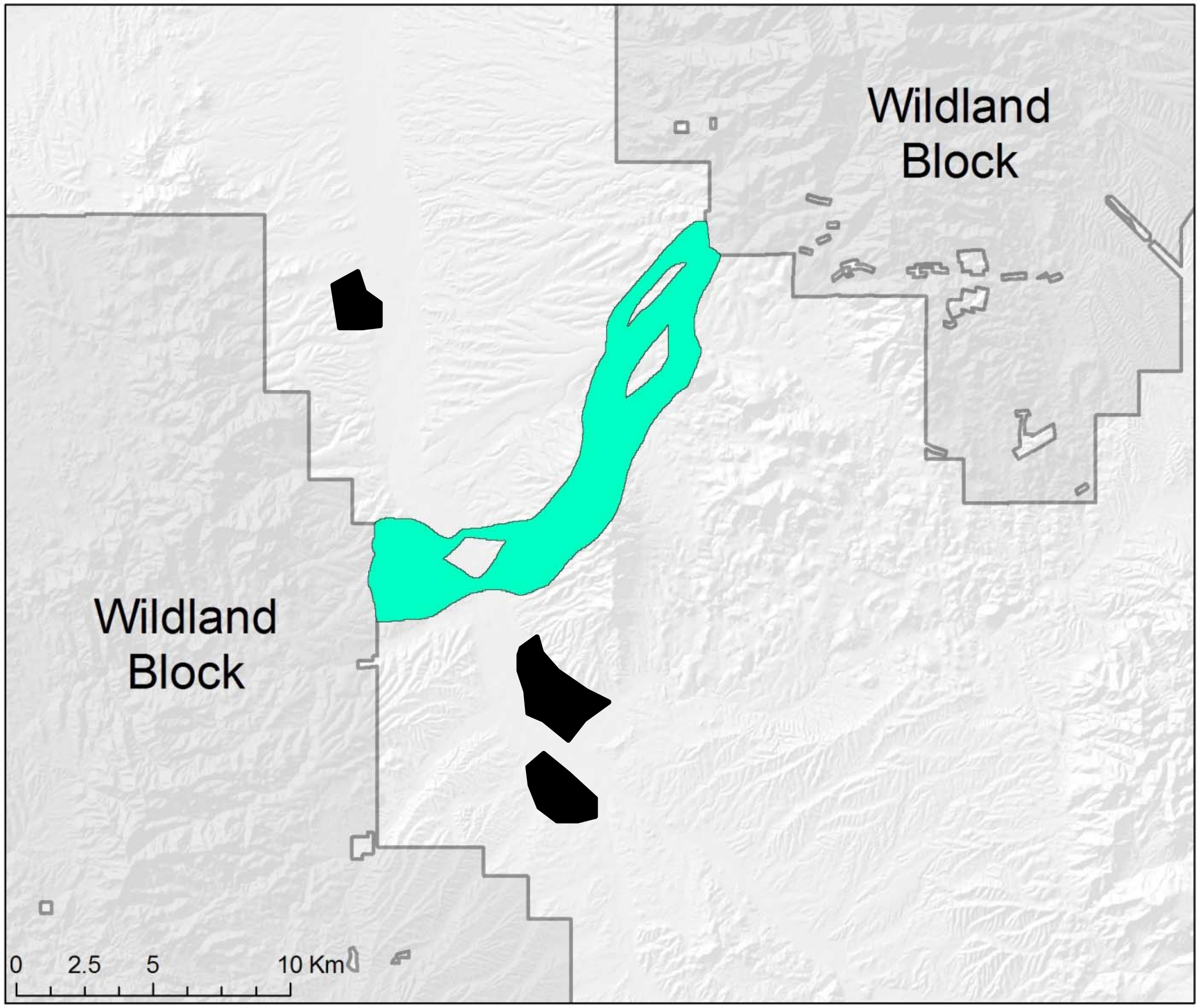


Least-cost modeling procedures are described by Adriaensen et al. (2003), Beier et al. (2006, 2008).

3. Map one corridor with high interspersion of facet types.

This corridor should support rapid, short-distance range shifts during periods of climate instability.

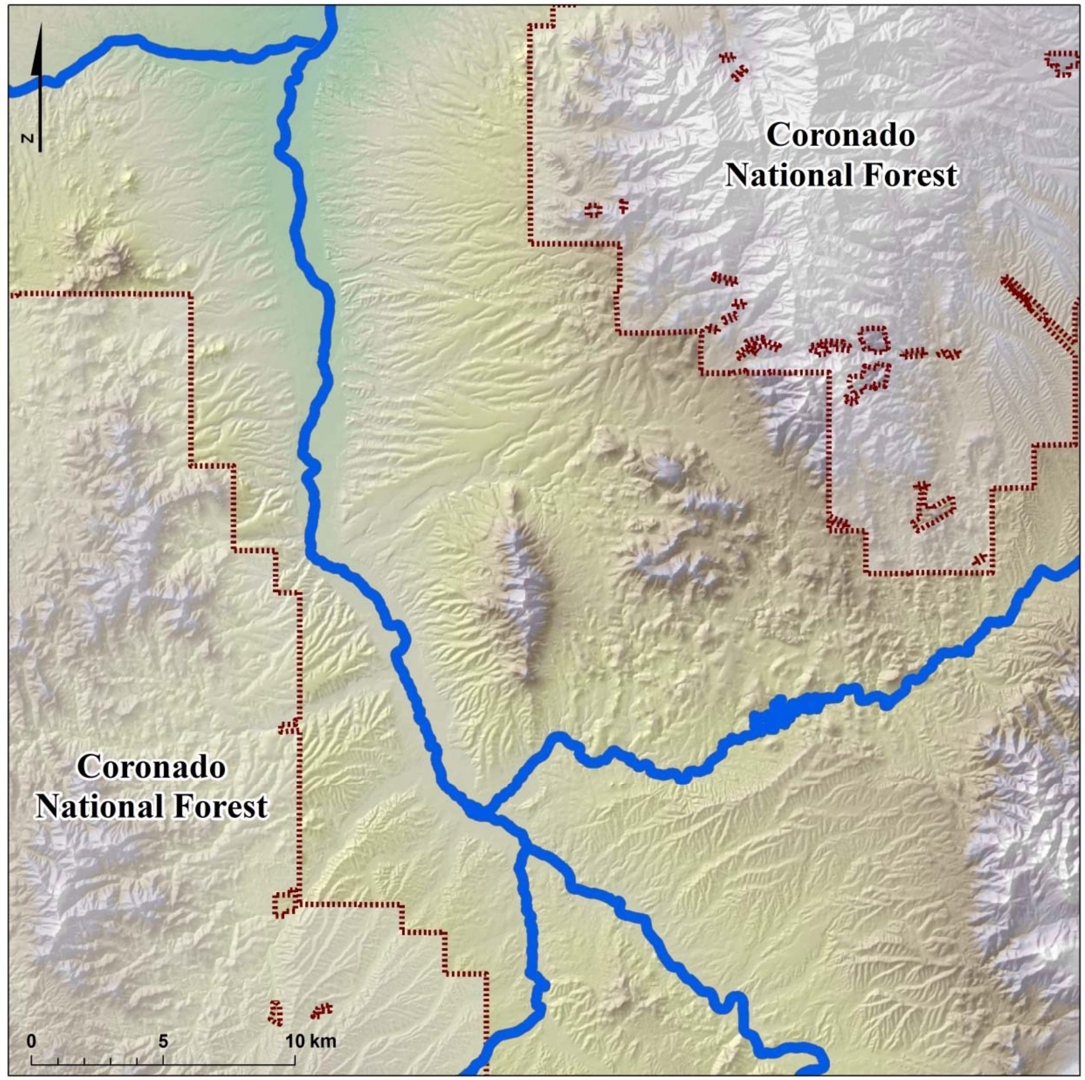
It should also support interaction between species, and ecological processes that depend on juxtaposition.



4. Add a riparian or riverine corridor.

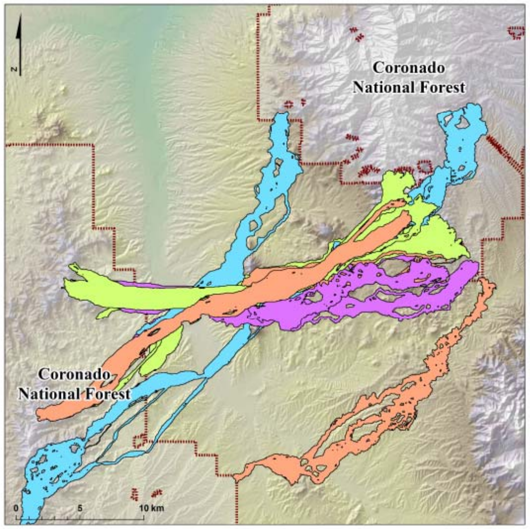
Promotes the movement of animals, sediment, water, and nutrients.

Can be mapped without no stinkin' GIS.

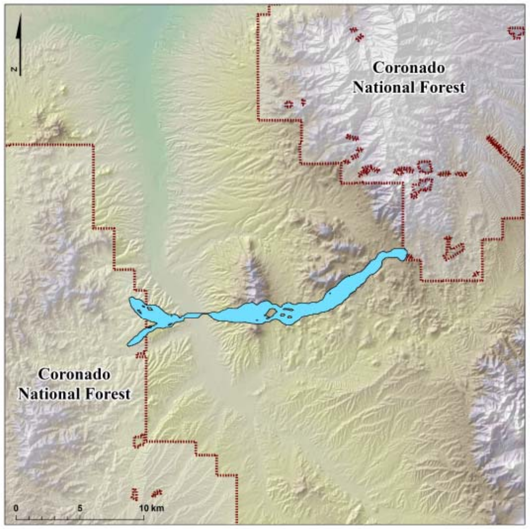


5. Join the corridors.

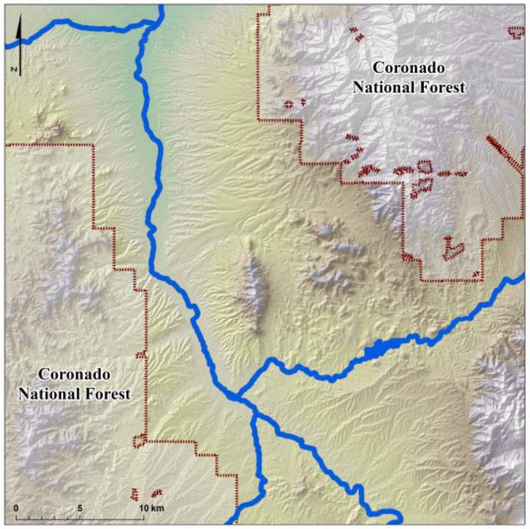
Corridors for land facets



Corridor for high diversity of land facets

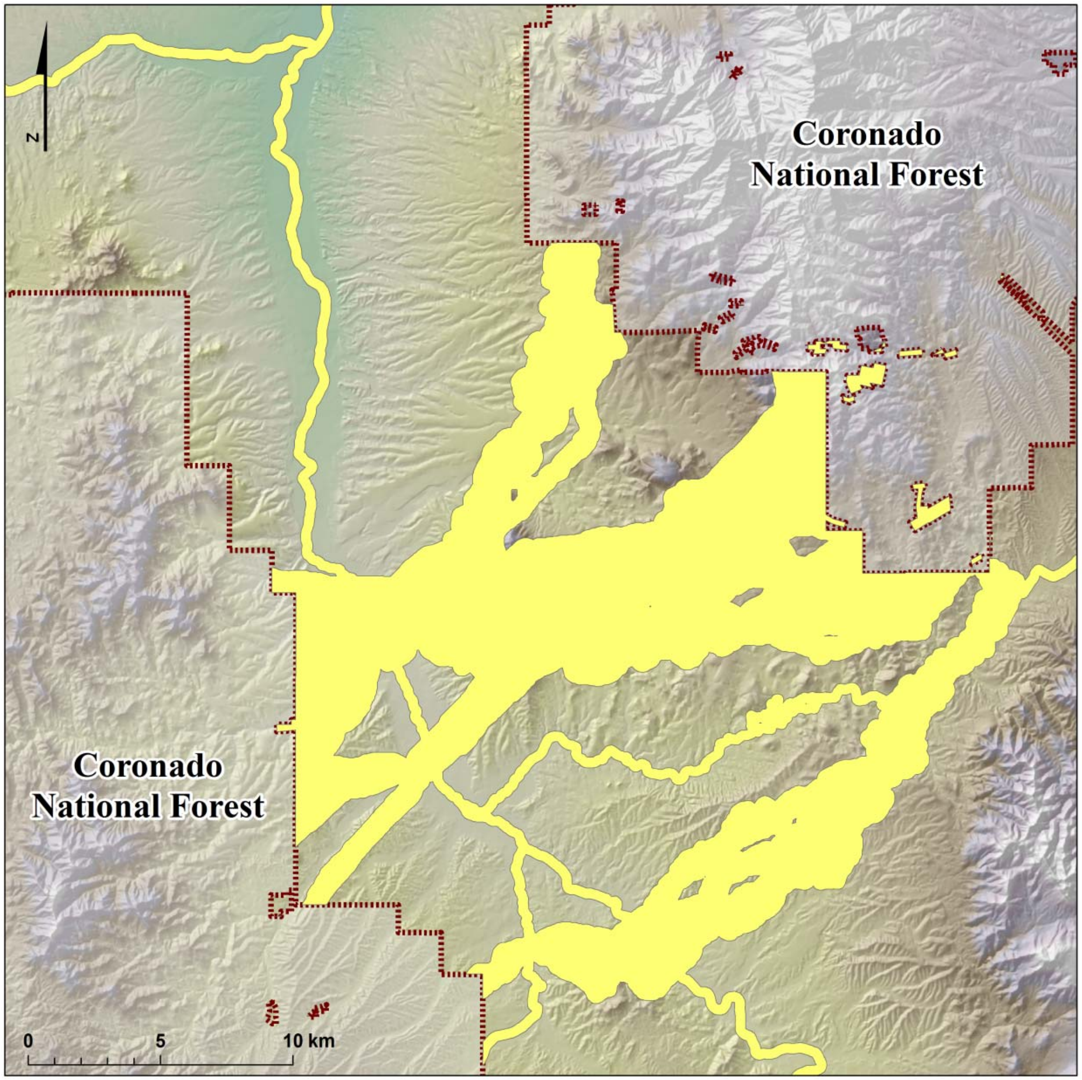


Riparian corridor



The ***Linkage Design***: the union of corridors

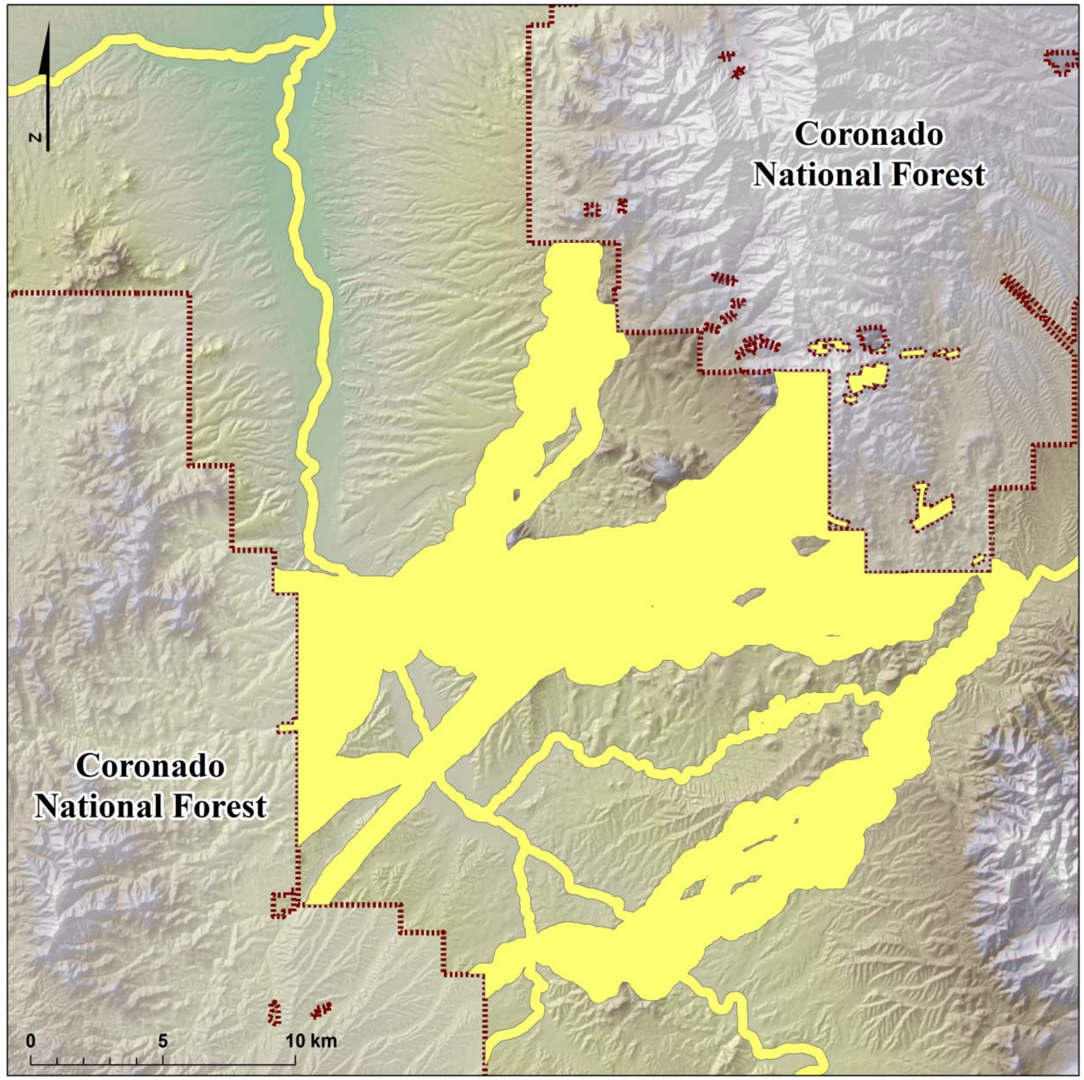
Wildlife
Linkage
for a
changing
climate



Corridor Design

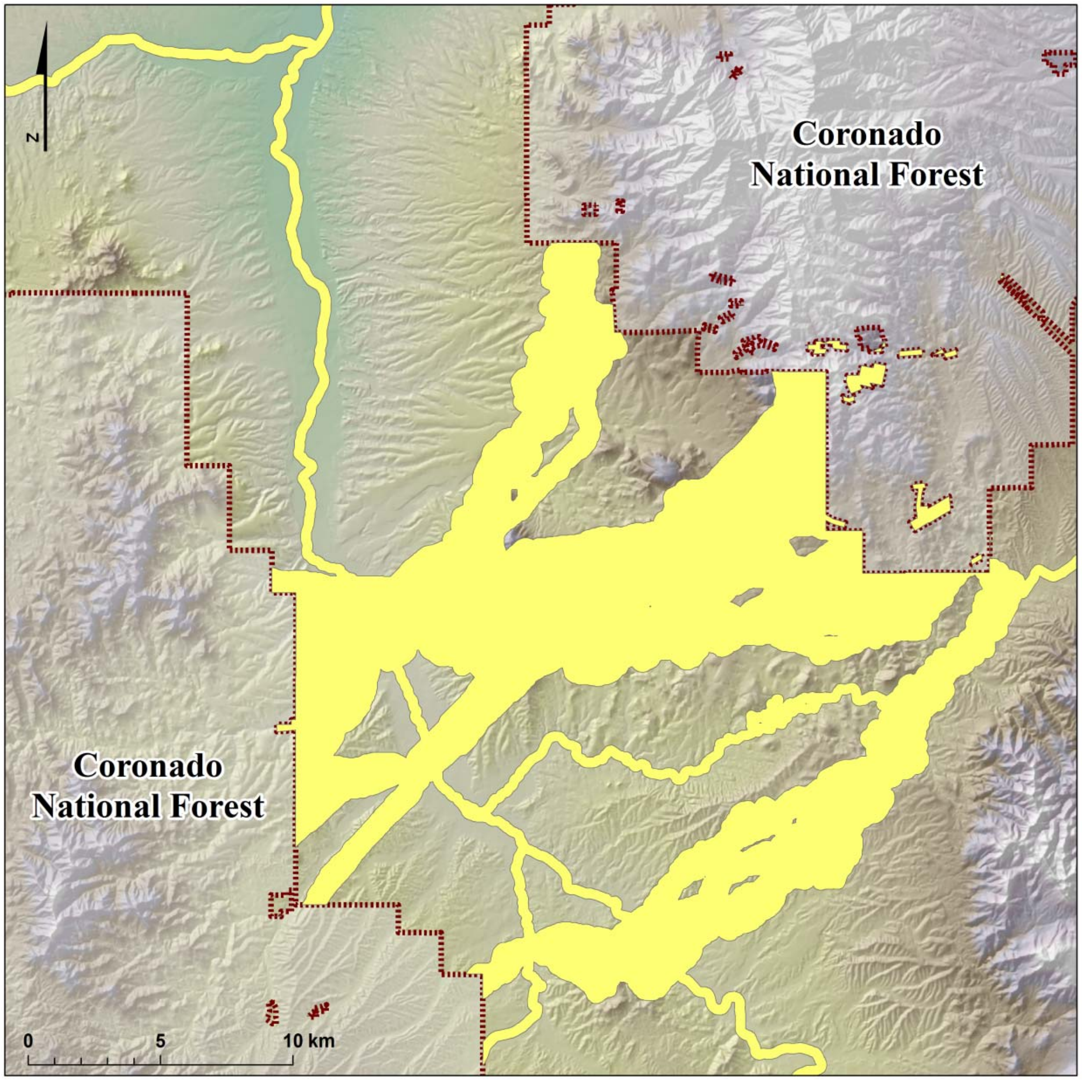
Advantages of using land facets to define corridors

- Useful where no vegetation maps exist.
- No bias to include "data-rich" areas.
- Not subject to error propagation from linked, highly uncertain models.
- Not subject to error compounding from projecting 50-100 years into the future.
- 30-m resolution matches grain of conservation decisions.



Limitations of using land facets to define corridors

- Should be used to complement, not replace, other approaches to conservation planning.
- Not an excuse to avoid reversing CO_2 emissions.



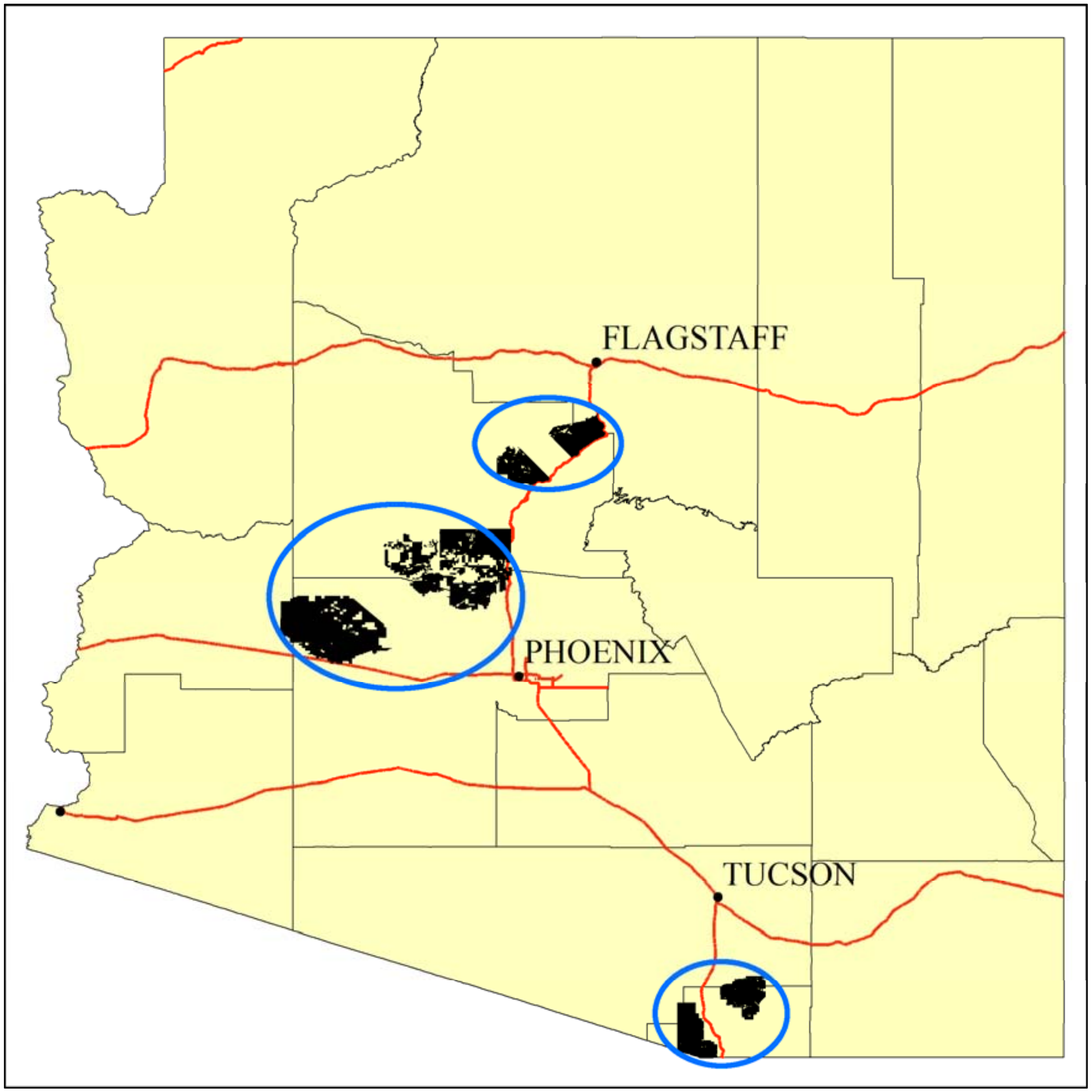
(end slide show)

Evaluation

3 landscapes in Arizona

<u>In each landscape</u>:

- Beier et al. (2007) had previously developed a linkage design based on 5-16 focal species.
- We developed a land facet linkage design based on 9-12 land facets plus a corridor with high diversity of facets.



Evaluation

We mapped patches of modeled breeding habitat for each focal species.

We draped each linkage design over the map of breeding patches.

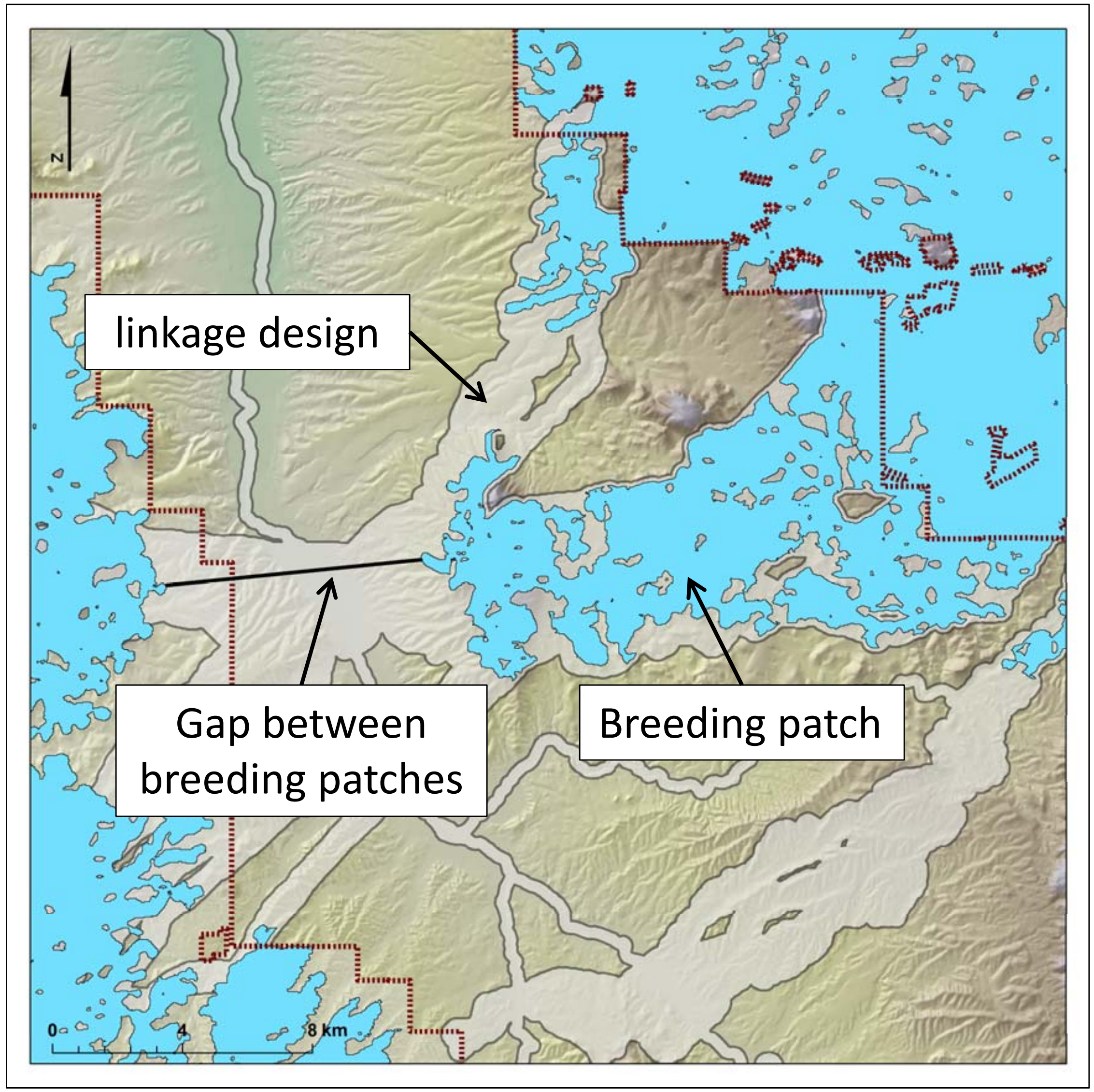
We used 2 metrics to evaluate how well each type of linkage design served each focal species in each landscape.





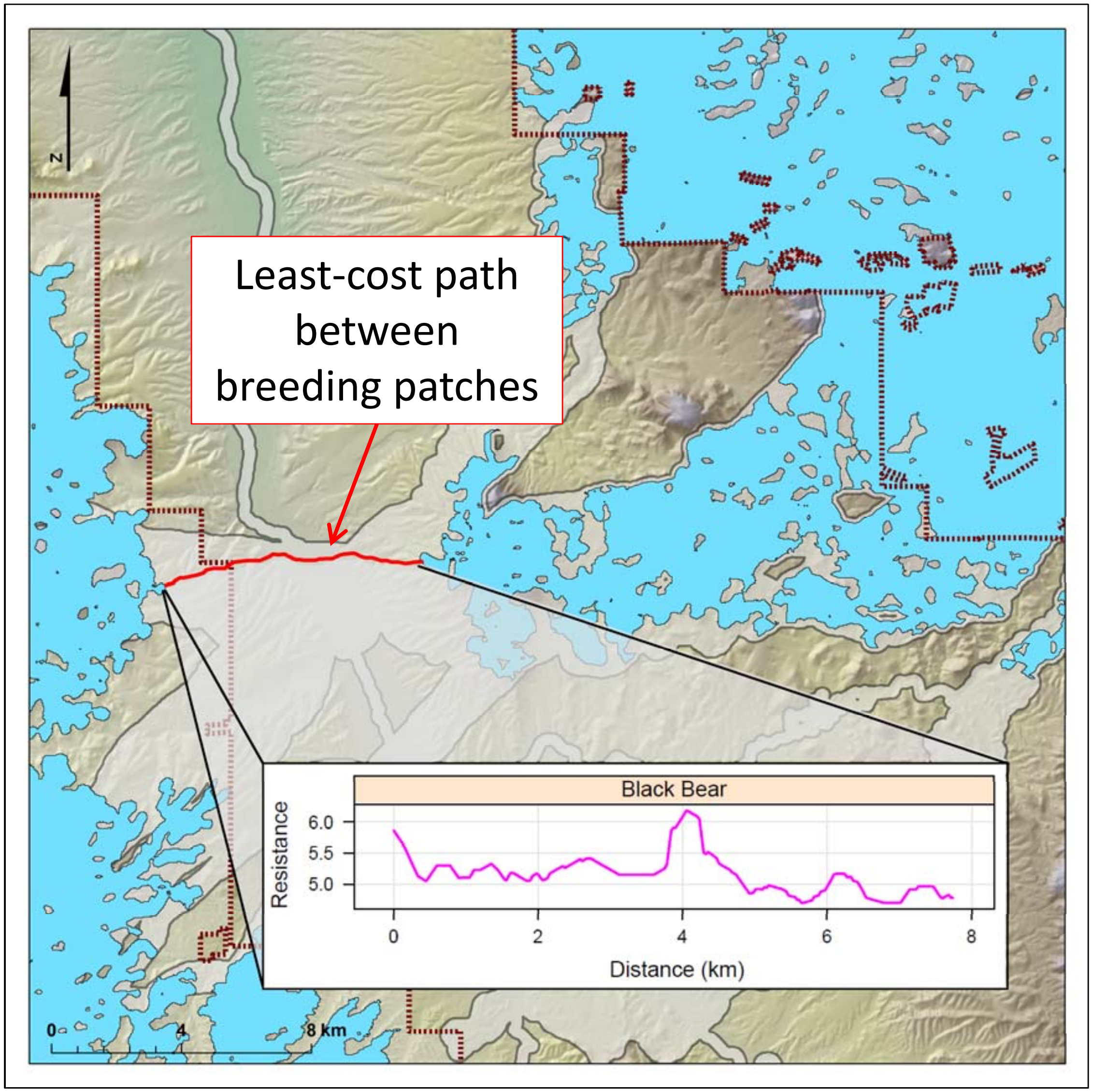
Evaluation metric #1

Distance between patches of modeled breeding habitat.



Evaluation metric #2

Resistance profile of the least-cost paths between breeding patches



Evaluation Results

- Breeding patches for 16 of 28 focal species in the 3 landscapes were locally widespread. Both designs performed equally well for these species.
- 12 species had more sparsely distributed patches.
  - 4 were served equally well by both designs.
  - 5 were served better by the land facets linkage designs.
  - 3 (the 3 with the least habitat extent in the landscape) were served better by the focal species linkage designs.