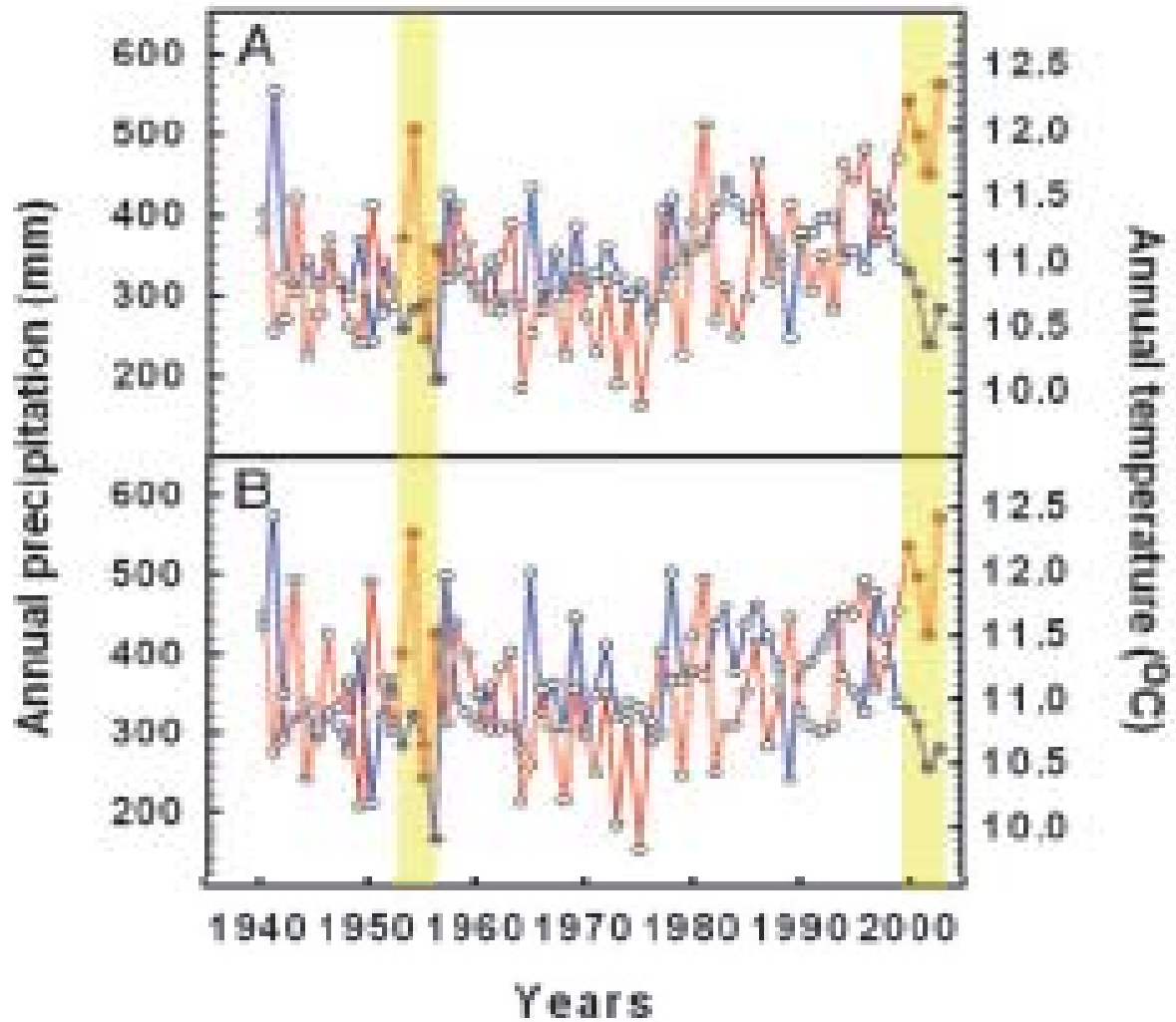


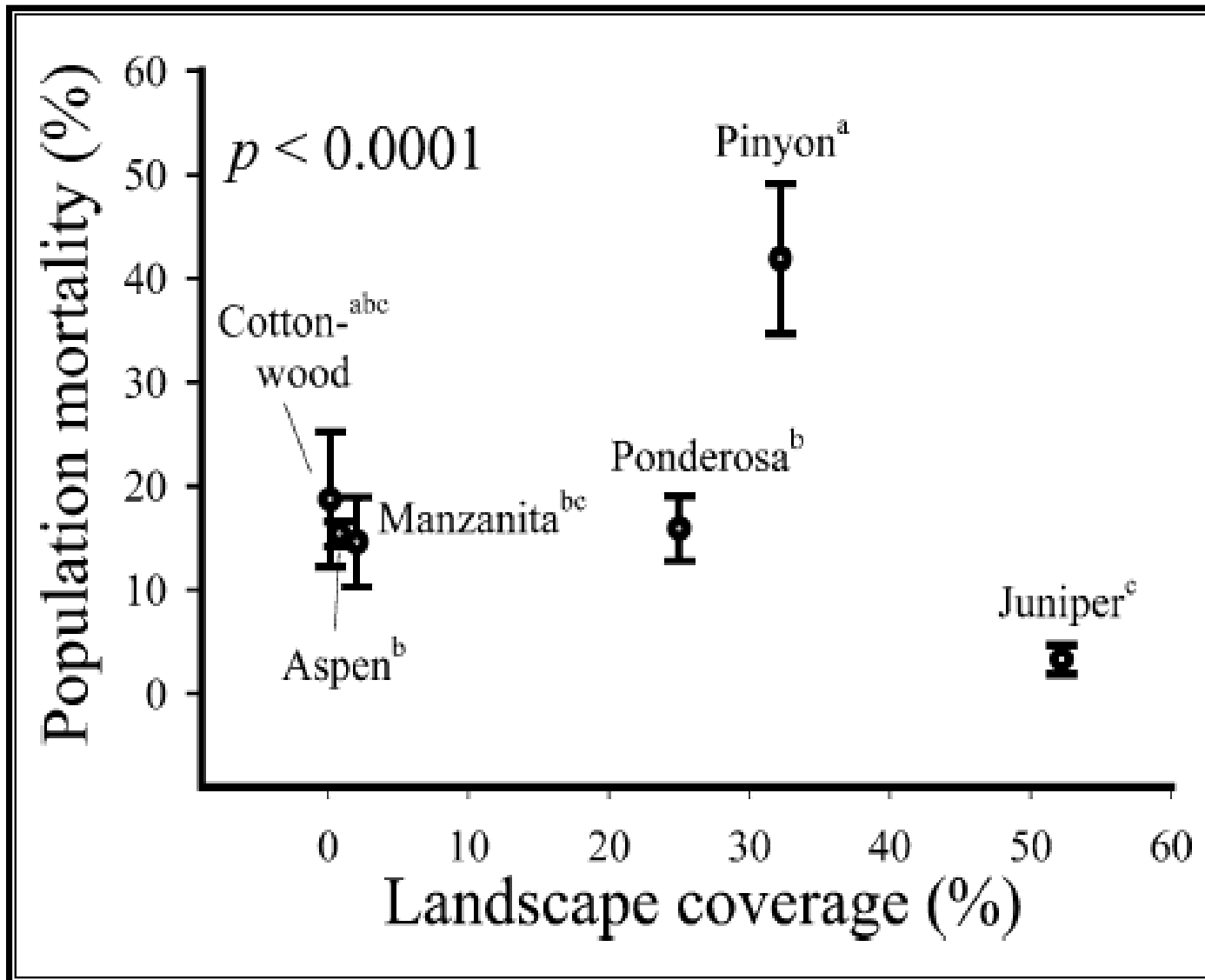
Differential Effects of Climate Perturbations on Pure and Hybrid Cottonwood Species: *implications for management*



Alicyn R.
Gitlin
&
Thomas G.
Whitham



from Brashers et al. (2005)



from Gitlin et al. (2006)

Why should we care??



***A tree is a tree –
how many more
do you need
to look at?***

***--Ronald Reagan,
1966***

Cottonwoods are Foundation Trees:

- create forest structure
 - control ecosystem processes:
 - ~ litter decomposition
 - ~ nutrient fluxes and carbon sequestering
 - support large dependent communities
- (Ellison et al. 2005, Whitham et al. 2006)



Foundation Trees are declining throughout the world because of:

- ~ pests/pathogens
- ~ overharvesting
- ~ land clearing
- ~ climate fluctuations

Cottonwoods are declining, especially lowland species, a situation aggravated by:

- ~ Flow Alteration
- ~ Water Depletion
- ~ Bank Stabilization
- ~ Water Salinization
- ~ Grazing
- ~ Mining
- ~ Pollution
- ~ Exotic Species
- ~ Land Development
- ~ Drought



(Rood and Mahoney 1990,
Howe and Knopf 1991,
Busch and Smith 1995,
Lejeune et al. 1996, Scott et al. 1999,
Scott et al. 2000, Lytle and Merritt 2004,
Rowland et al. 2004, Friedman et al. 2005,
Lite and Stromberg 2005,
Pataki et al. 2005,
Williams and Cooper 2005,
Gitlin et al. 2006)

How will projected droughts influence cottonwood distribution at the landscape and patch level?

Does temperature change increase the effects of drought on cottonwoods?

F₁ hybrid

backcross hybrids

Fremont
(*Sec. Aigeiros*)



narrowleaf
(*Sec. Tacamahaca*)

Hypotheses:

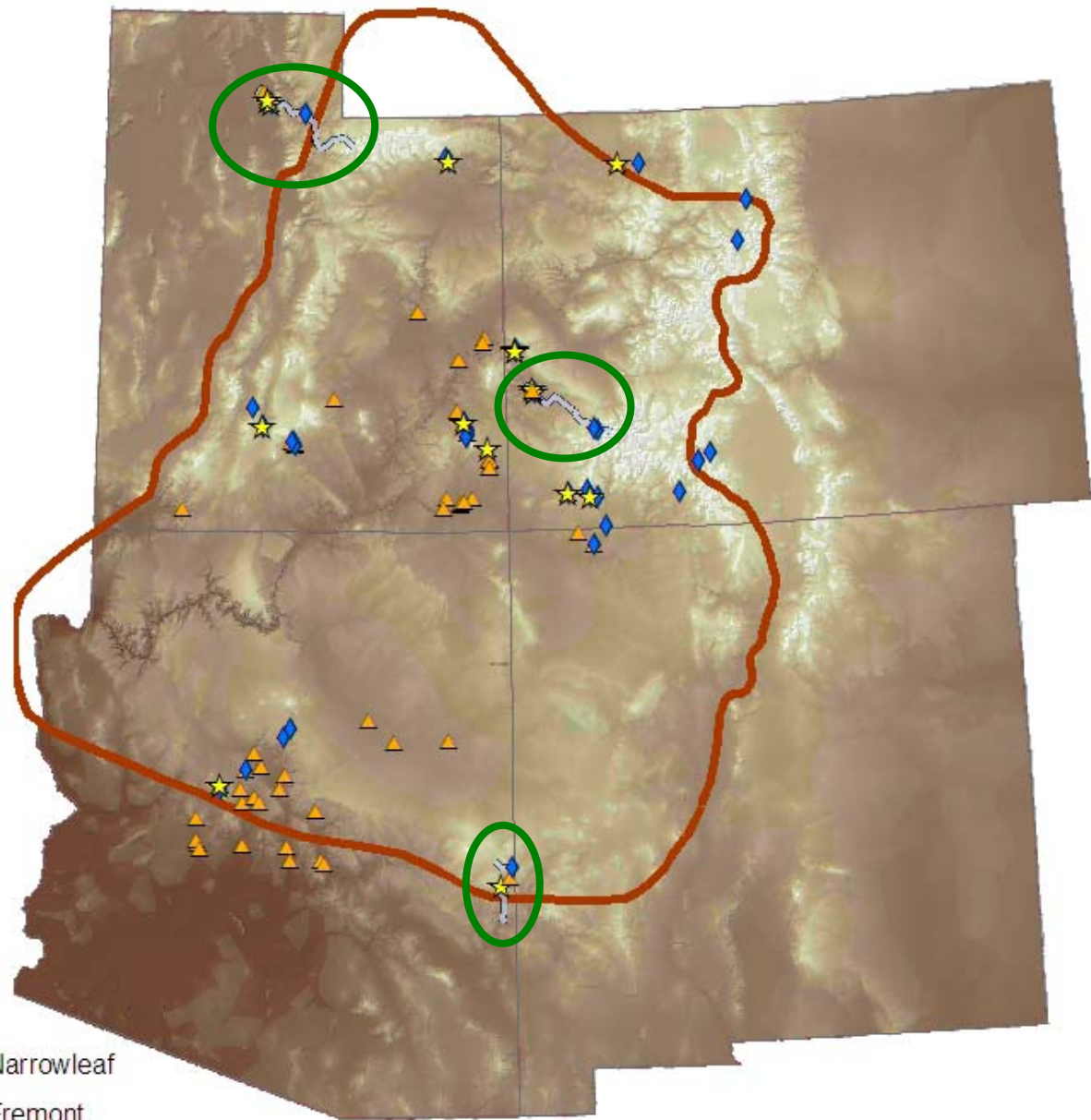
- 1) Levels of **mortality & reproduction** during drought will differ between **parent species & hybrids**

Hypotheses:

- 1) Levels of mortality & reproduction during drought will differ between parent species & hybrids
- 2) **Drought** will **constrict** cottonwood niches, and **higher temperatures** will cause even greater range reductions

Hypothesis 1:

**Levels of
mortality & reproduction
during drought
will differ between parent
species & hybrids**



- ◆ Narrowleaf
- ▲ Fremont
- ★ F1 Hybrids
- Rivers observed in 2004
- Colorado Plateau boundary

0 50 100 200 300 400
Kilometers



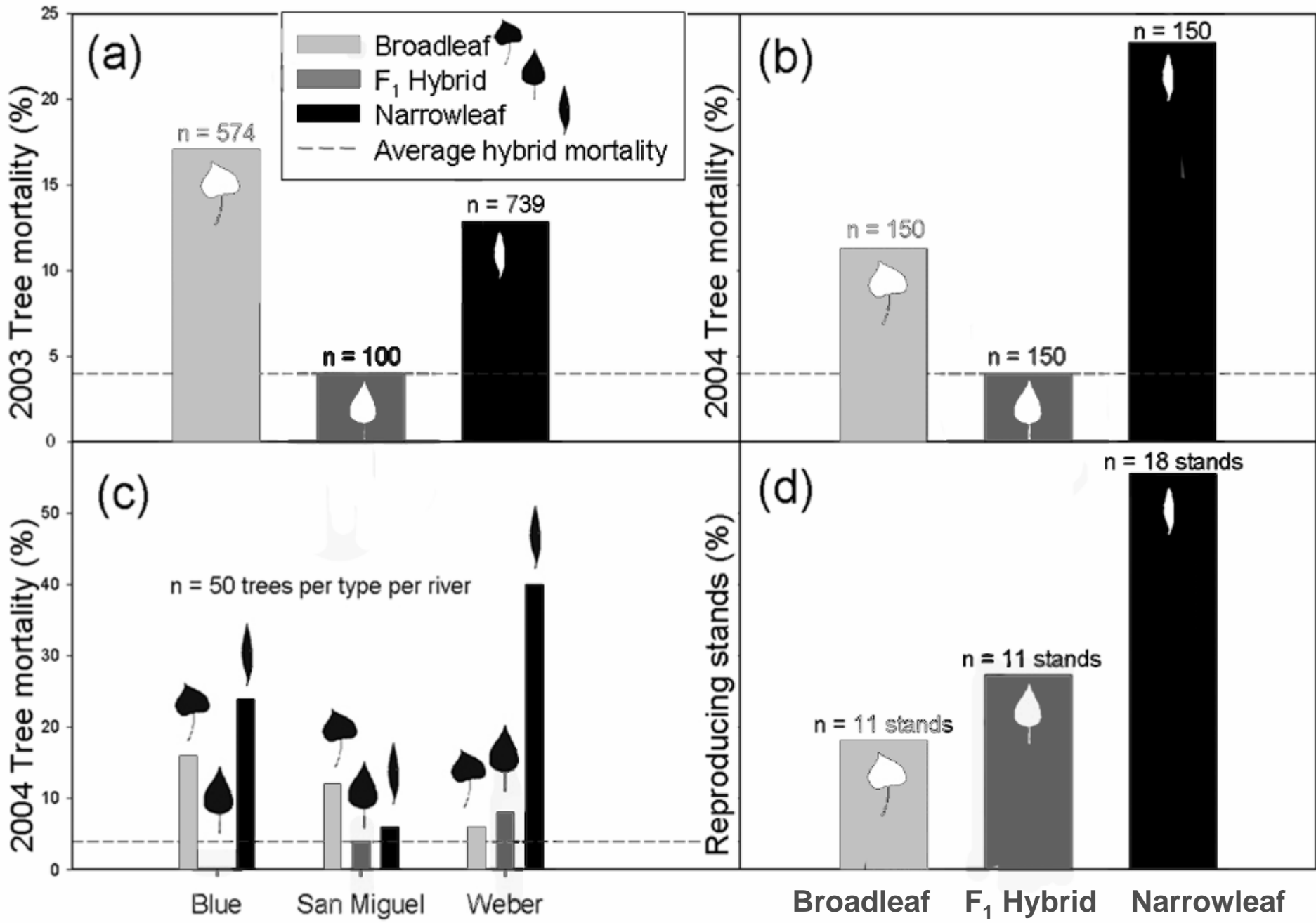
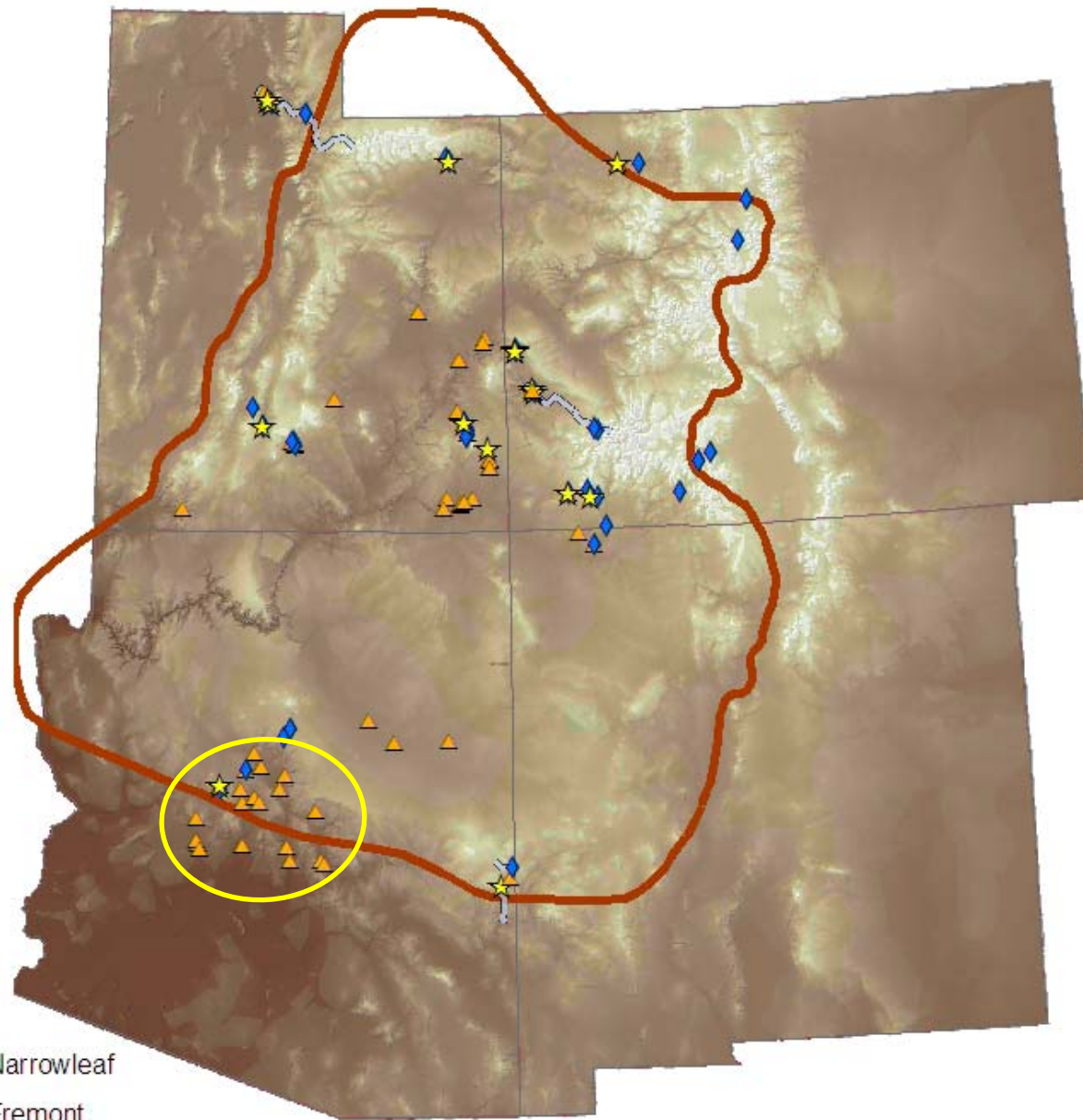






photo by Scott Woolbright





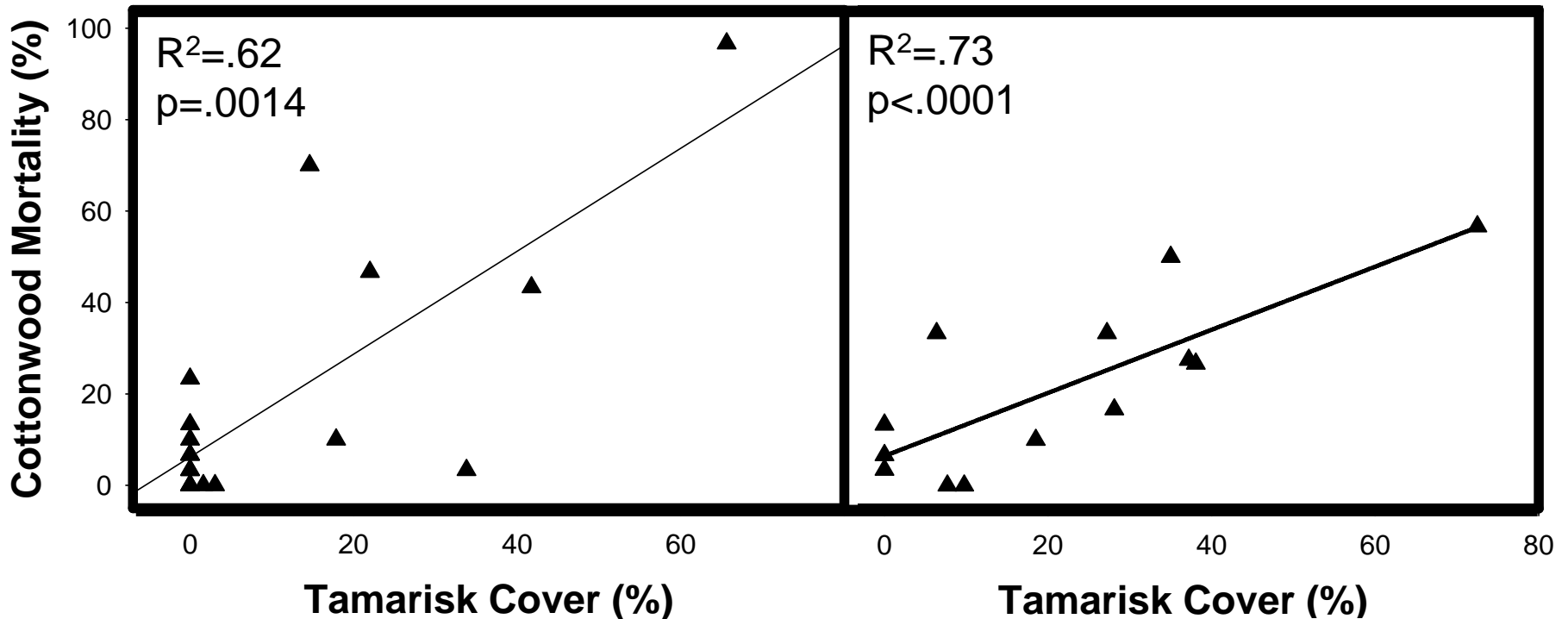
- ◆ Narrowleaf
- ▲ Fremont
- ★ F1 Hybrids
- Rivers observed in 2004
- Colorado Plateau boundary

0 50 100 200 300 400 Kilometers

Tamarisk Cover and Cottonwood Mortality

Central AZ Watersheds

Colorado Plateau



Summary:

- ~ Hybrid trees demonstrated consistently low mortality across years and river systems

Summary:

- ~ Hybrid trees demonstrated consistently low mortality across years and river systems
- ~ Parent species showed high variability in mortality levels between sites

Summary:

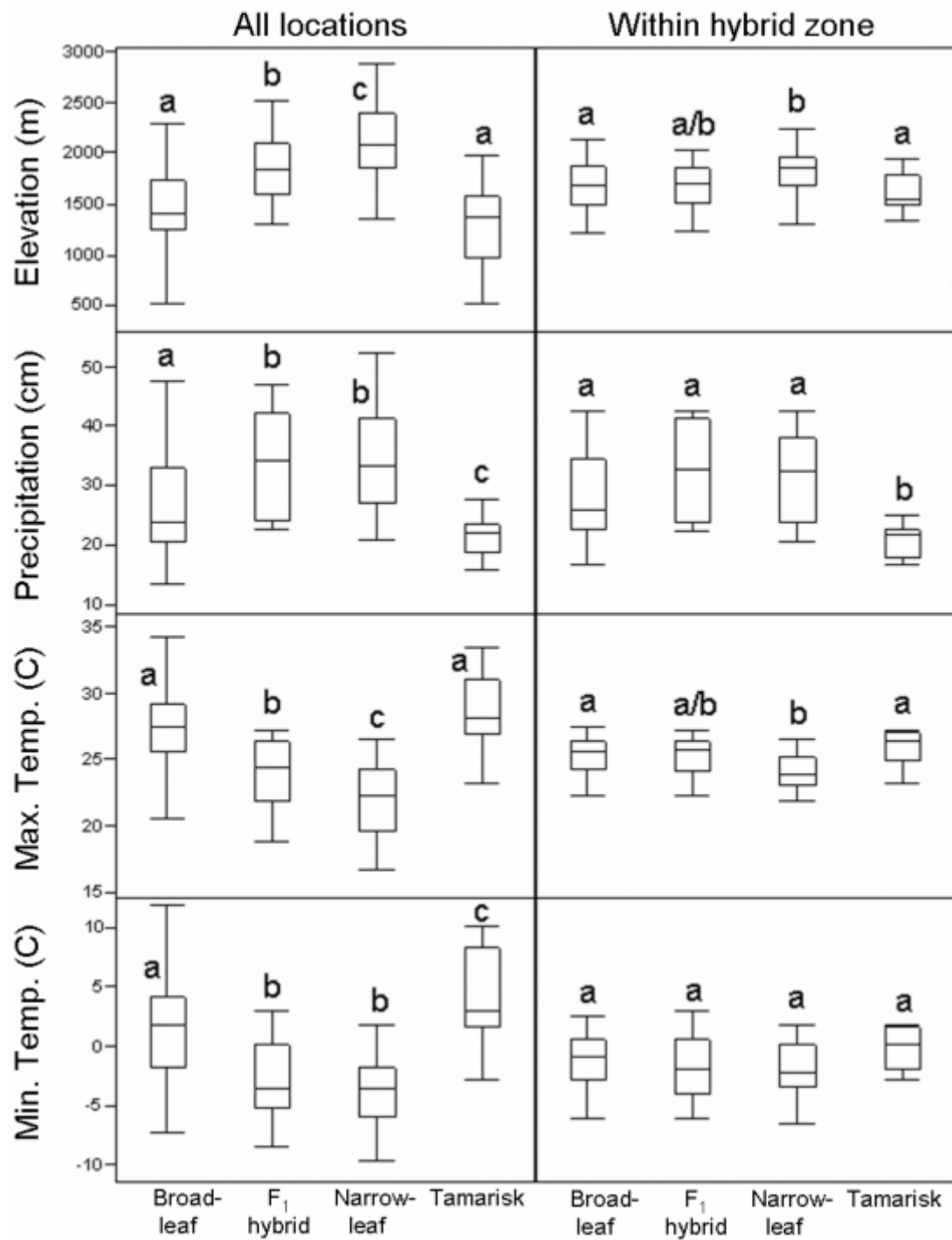
- ~ Hybrid trees demonstrated consistently low mortality across years and river systems
- ~ Parent species showed high variability in mortality levels between sites
- ~ Trees capable of clonal reproduction reproduced at a higher rate during drought

Summary:

- ~ Broadleaf cottonwoods on the Colorado Plateau are dying off in the areas most infested with an exotic dominant tree.

Hypothesis 2:

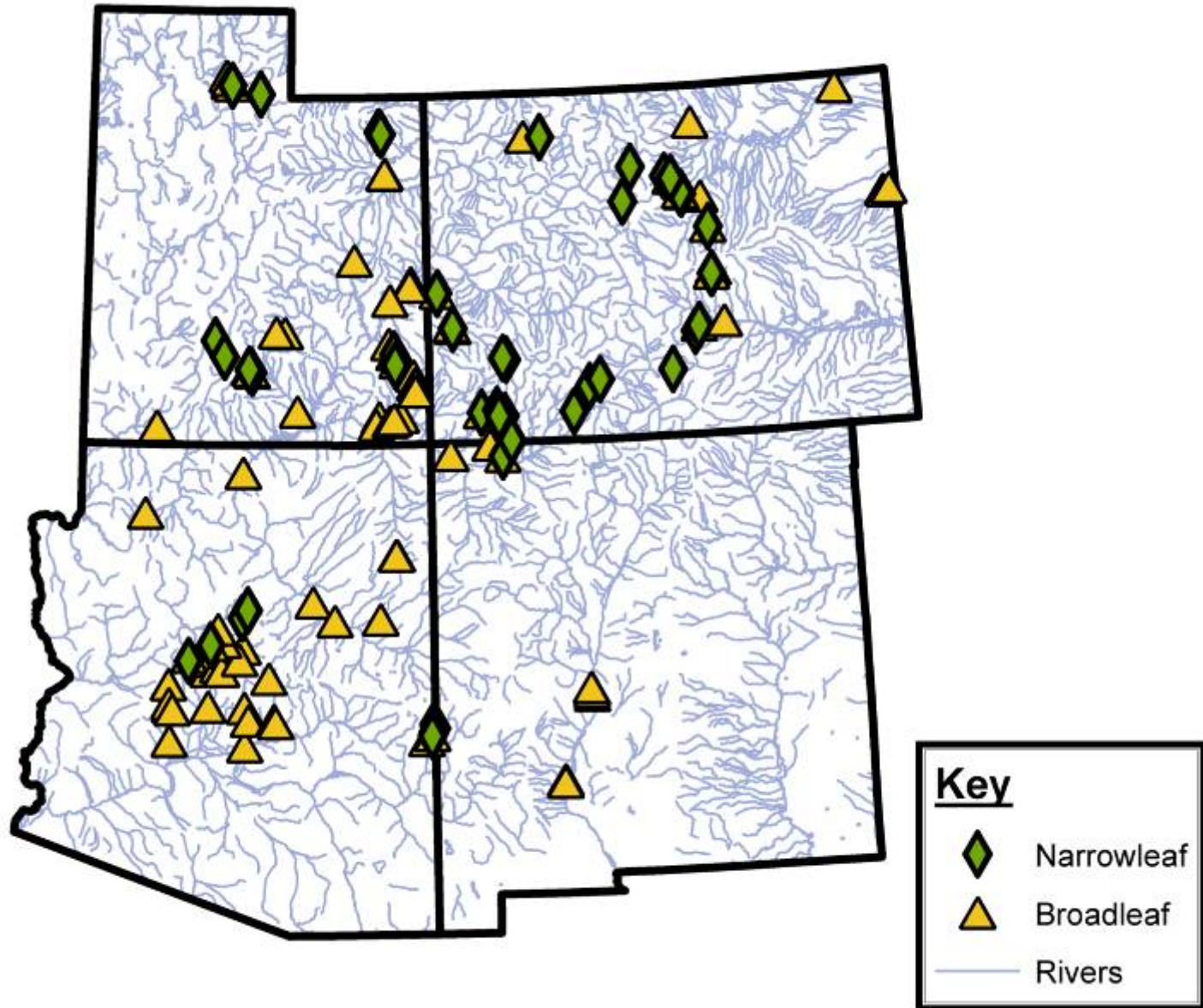
**Drought will constrict
cottonwood niches, and
higher temperatures will
cause even greater range
reductions**





Spatial Modelling

Input to GARP software:



Validations:

1) Large scale:

**F₁ Hybrid locations in
predicted hybrid zone**

2) Regional scale:

Ground truthing in southern Utah

3) River scale:

**Genotyped trees along
Weber River, UT including
complex back cross hybrids**

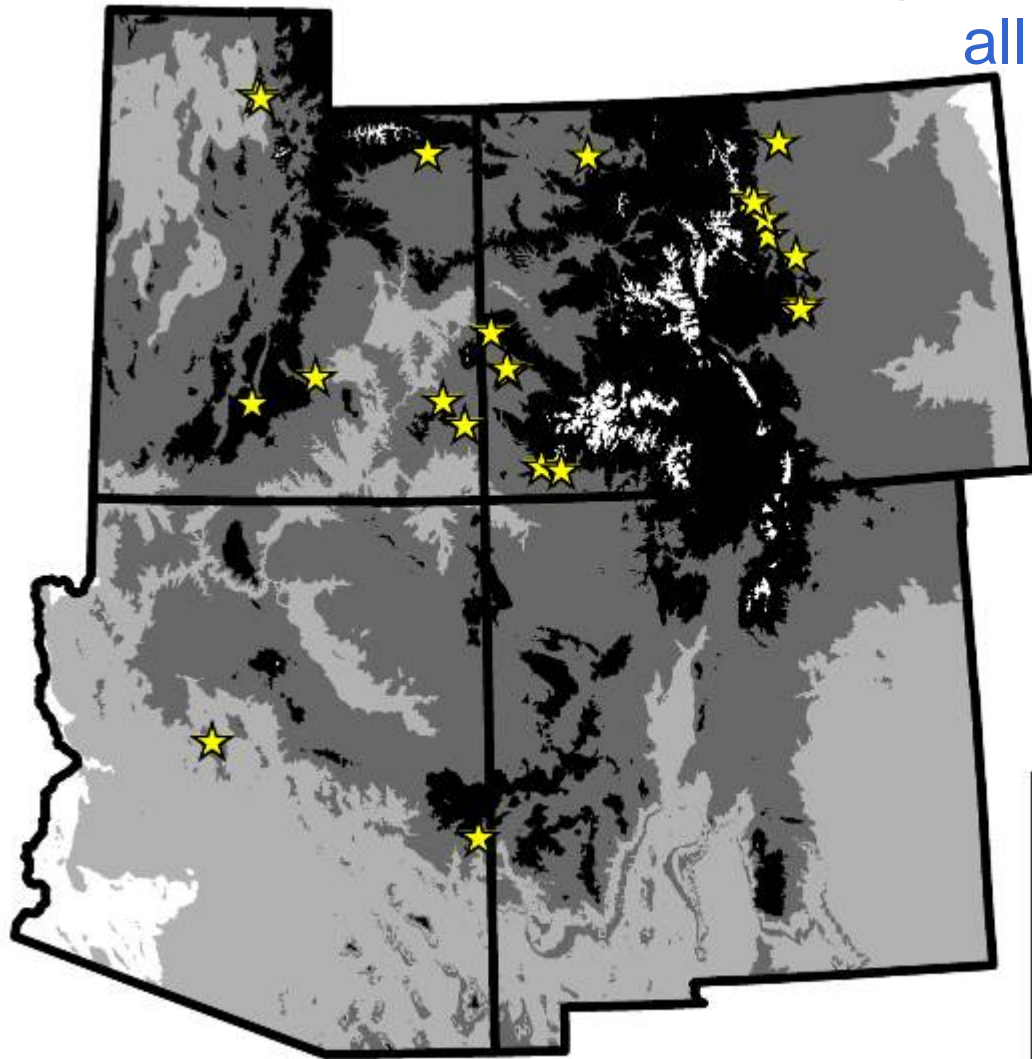
Validation 1:

(n = 25)

19 predicted, $p = 0.001$

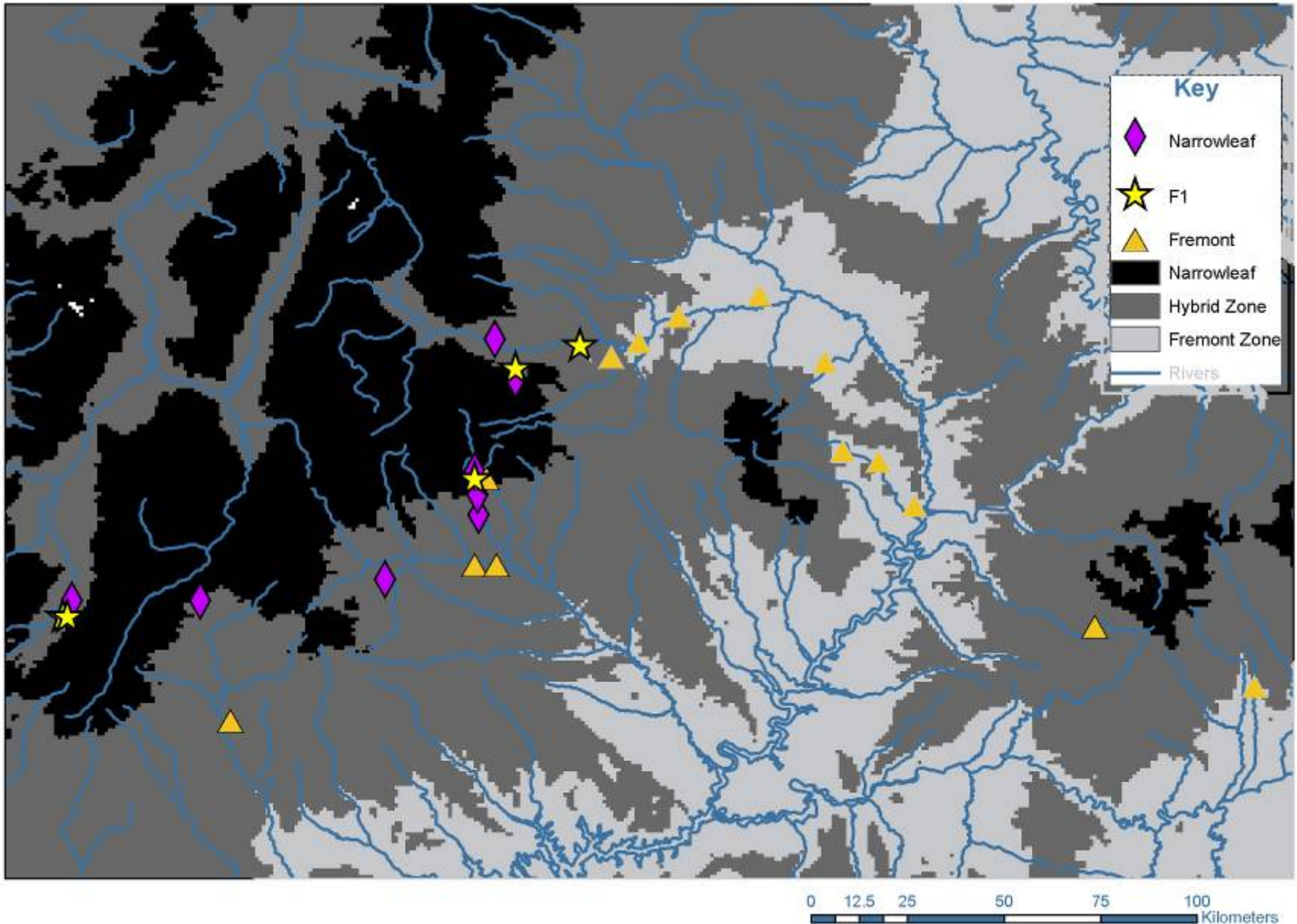
6 unpredicted,

all within 7.5 km (8 pixels)



Validation 2:

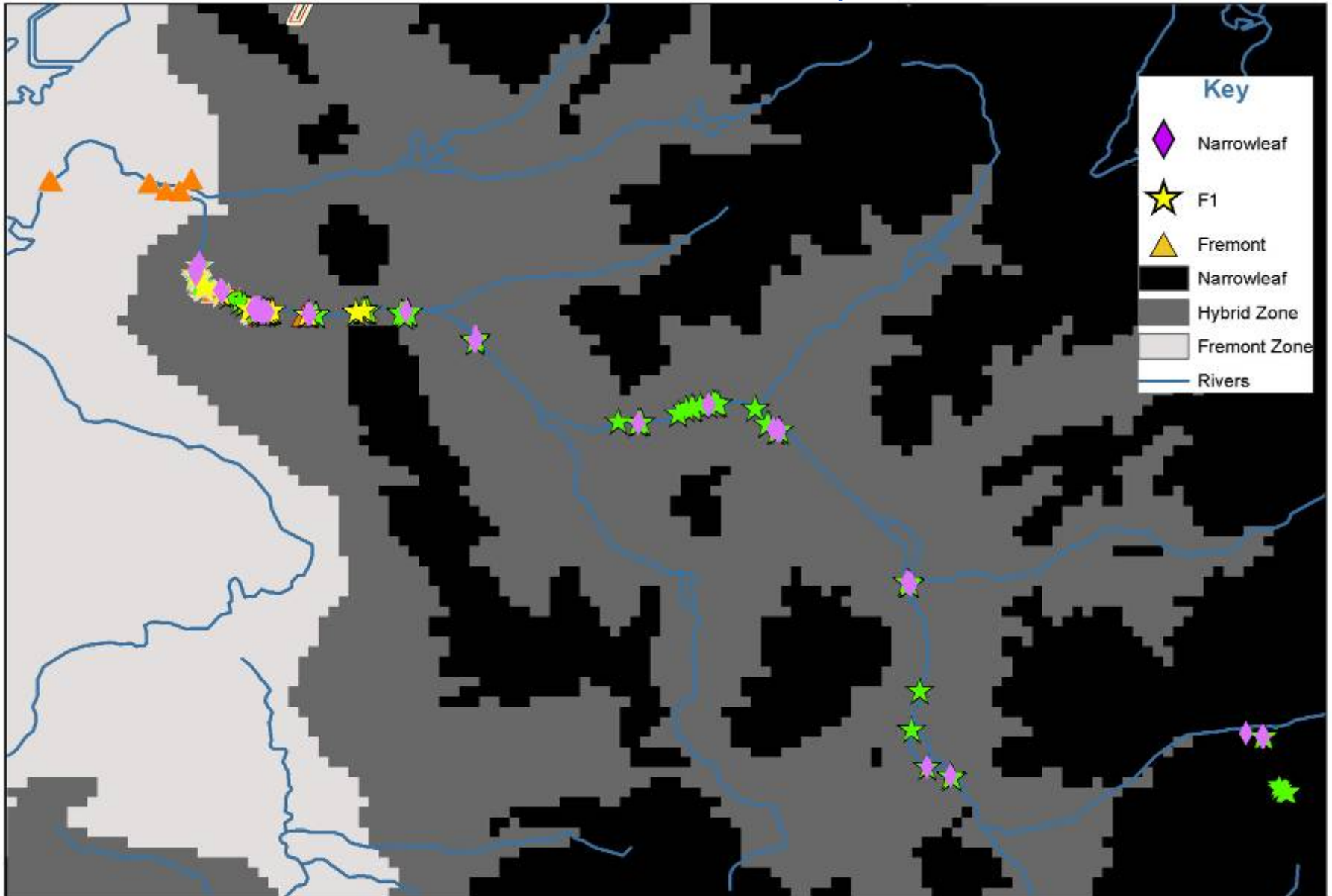
93% accurately predicted (n=27)
2 unpredicted, both within 1.2 km



Validation 3:

(n = 1038)

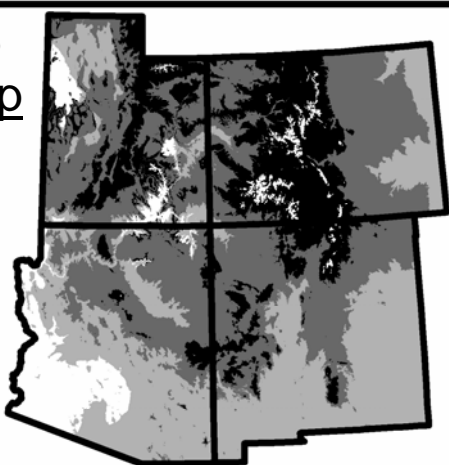
18 unpredicted, all within 8 km



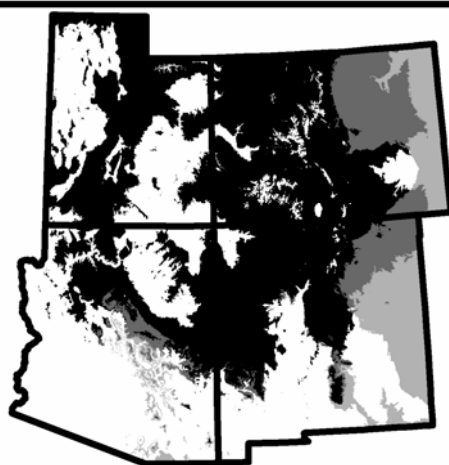
0 3.75 7.5 15 22.5 30
Kilometers

Drought Projections:

50%
precip



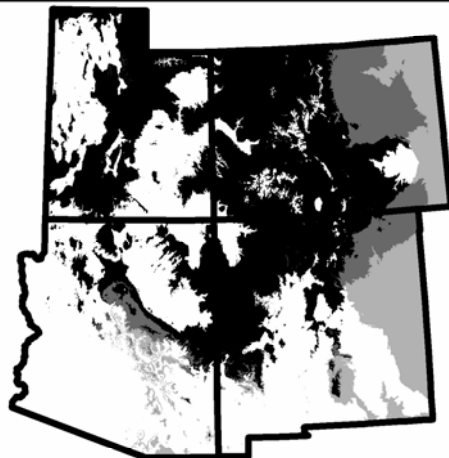
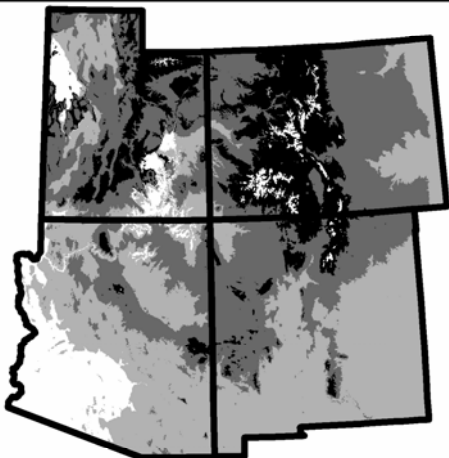
25%
precip



current
average
temp

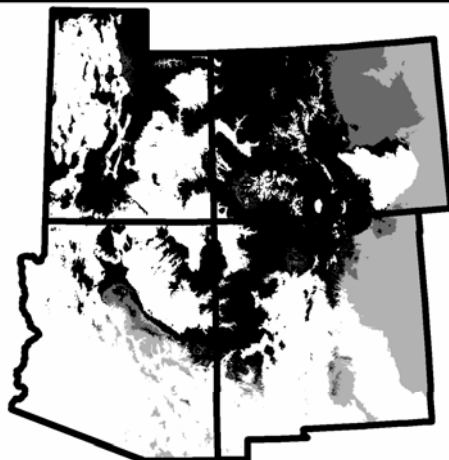
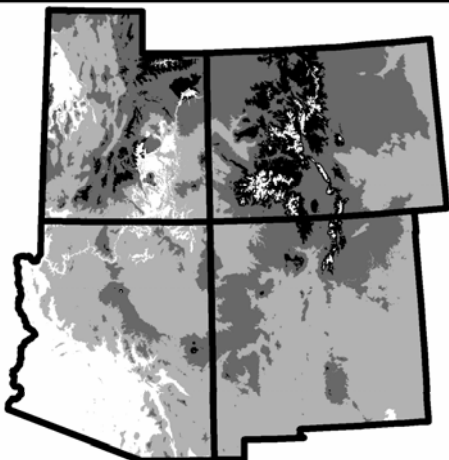
current
average
temp

+ 1.5 C

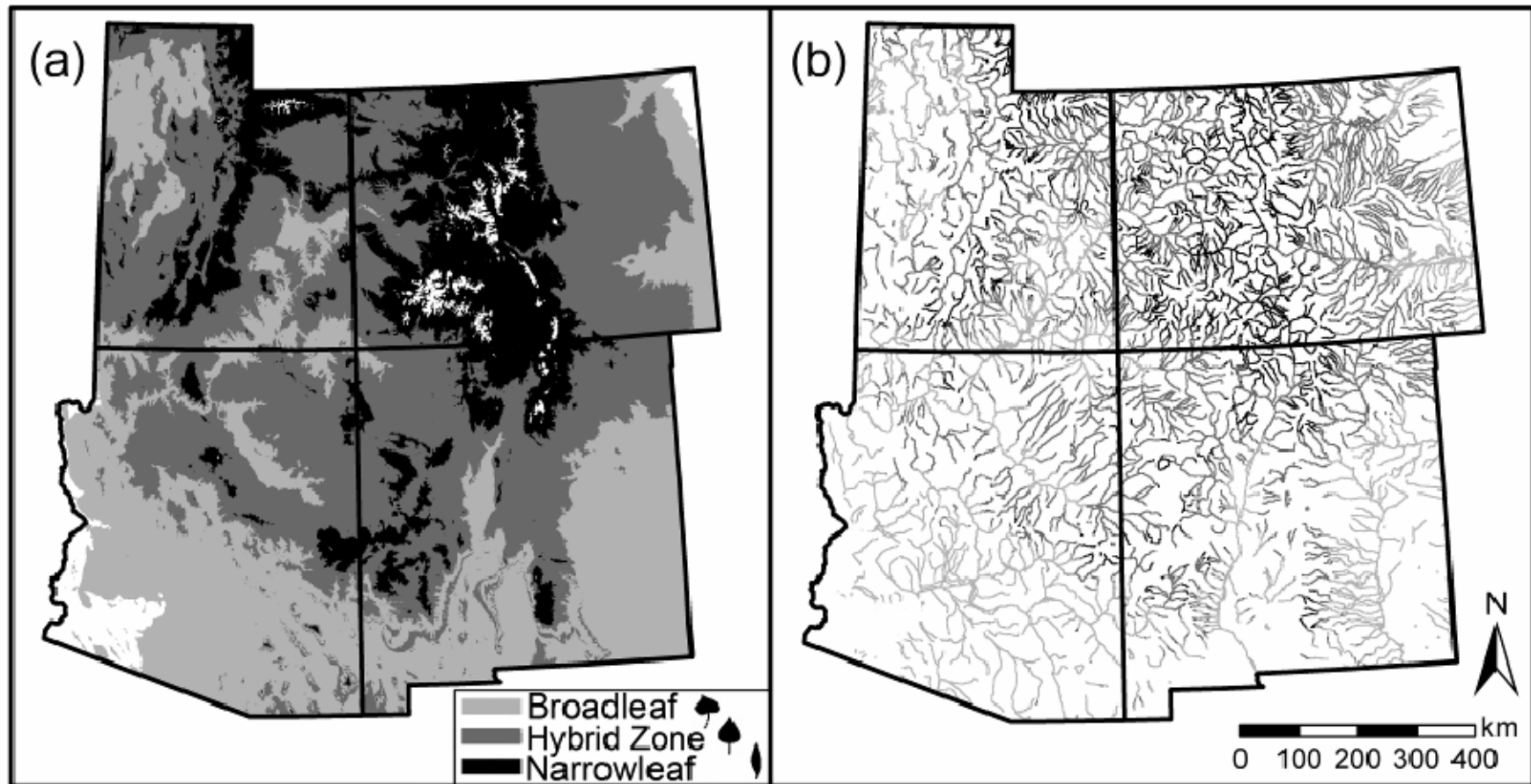


+ 1.5 C

+ 4 C



+ 4 C



Narrowleaf

Potential Niche

Current Precip.

Current Temp.



Narrowleaf

Potential Niche

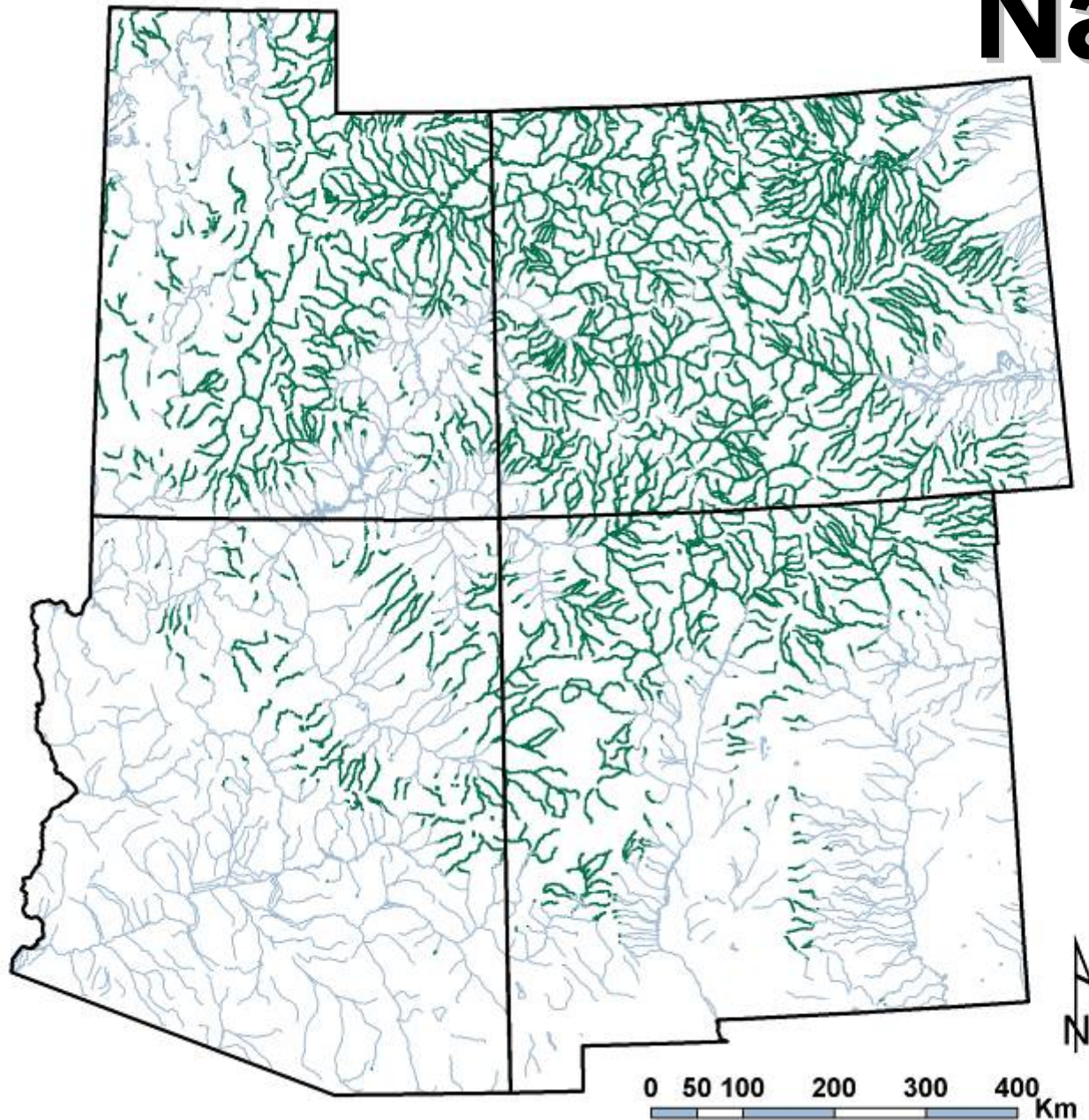


50% Precip.

Current Temp.

Narrowleaf

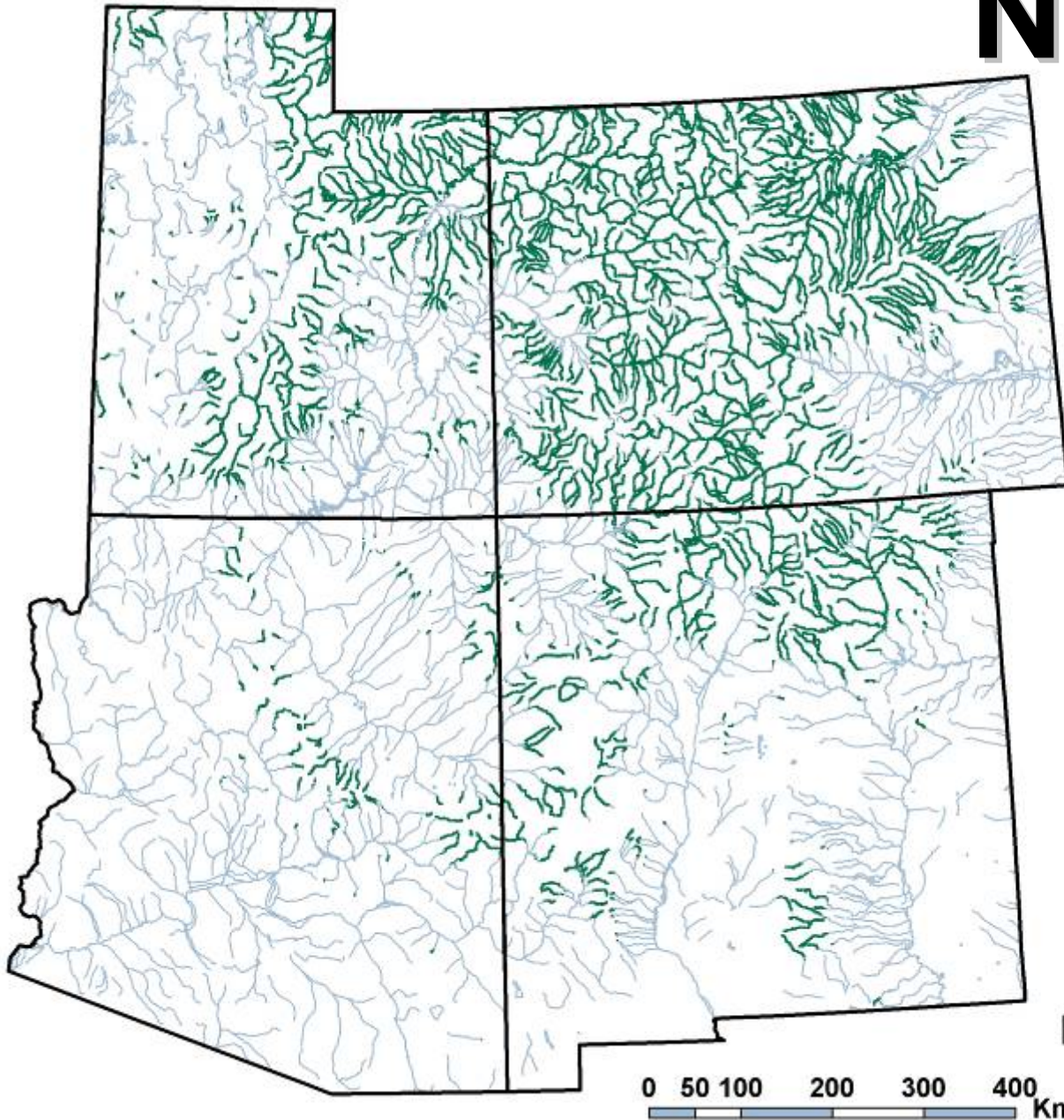
Potential Niche



50% Precip.
+ 1.5° C

Narrowleaf

Potential Niche



50% Precip.

+ 4° C

Narrowleaf

Potential Niche

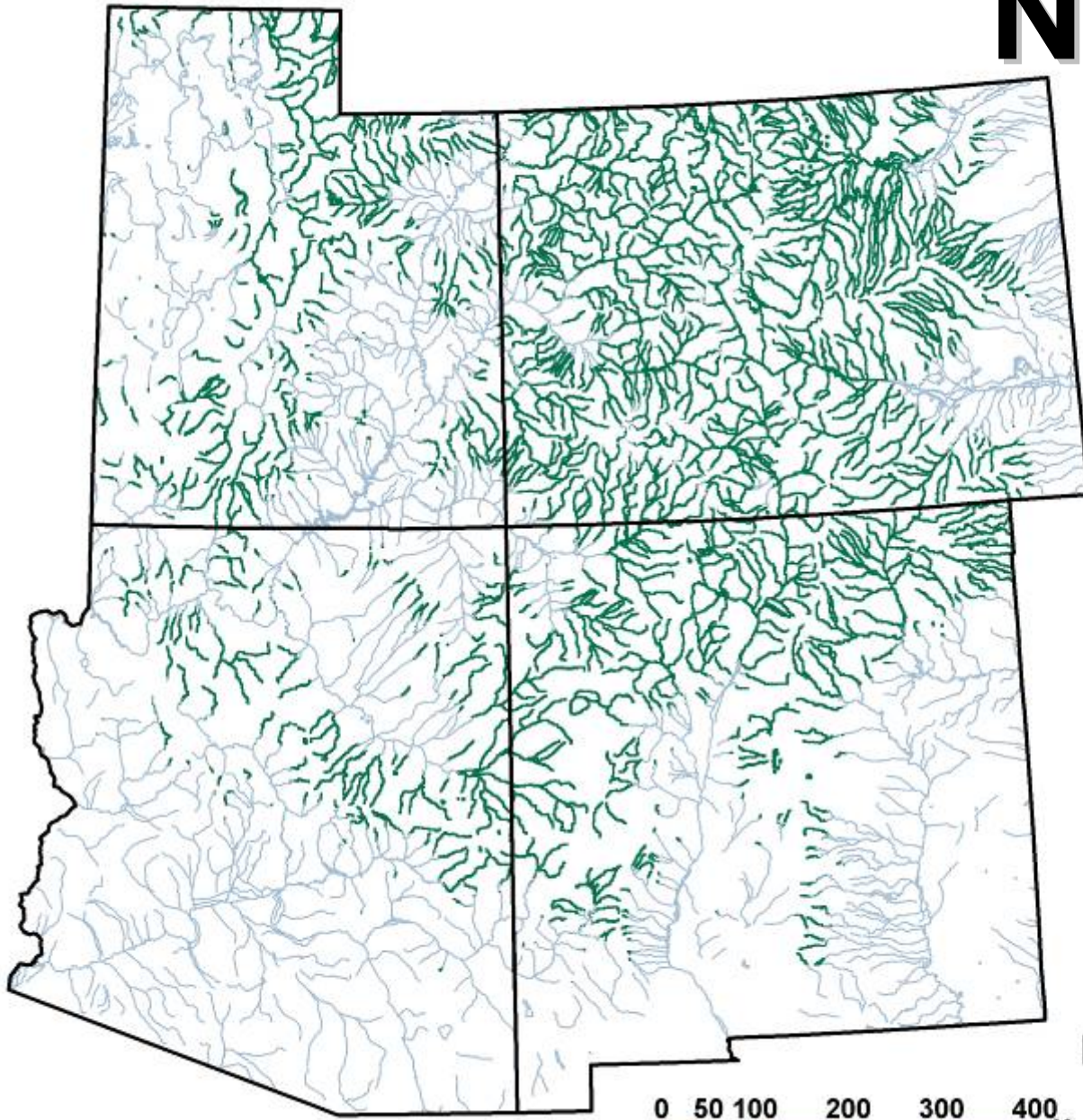
Current Precip.

Current Temp.



Narrowleaf

Potential Niche



25% Precip.

Current Temp.

0 50 100 200 300 400 Km

Narrowleaf

Potential Niche

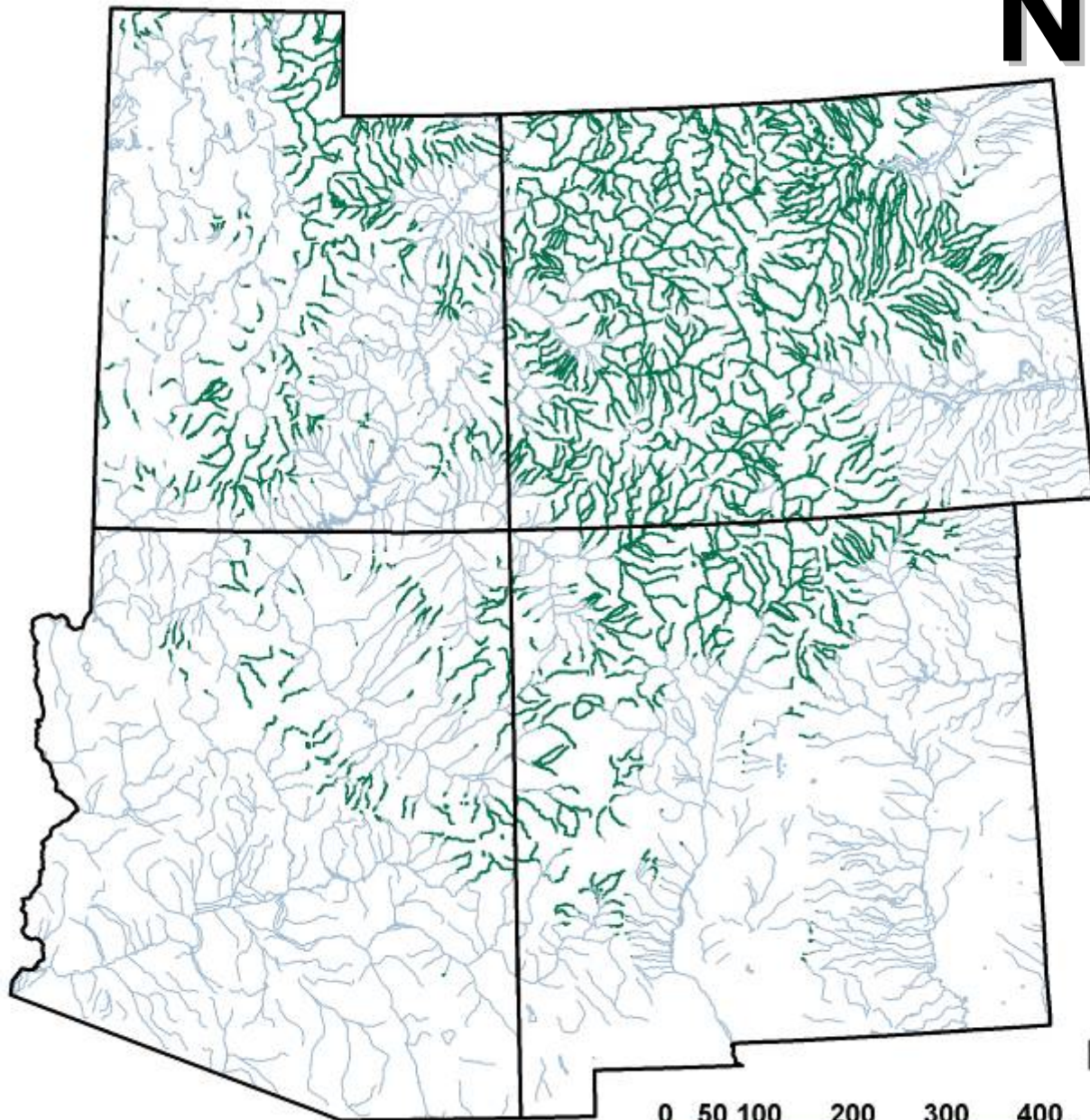


25% Precip.

+ 1.5° C

Narrowleaf

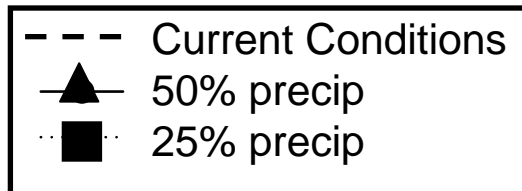
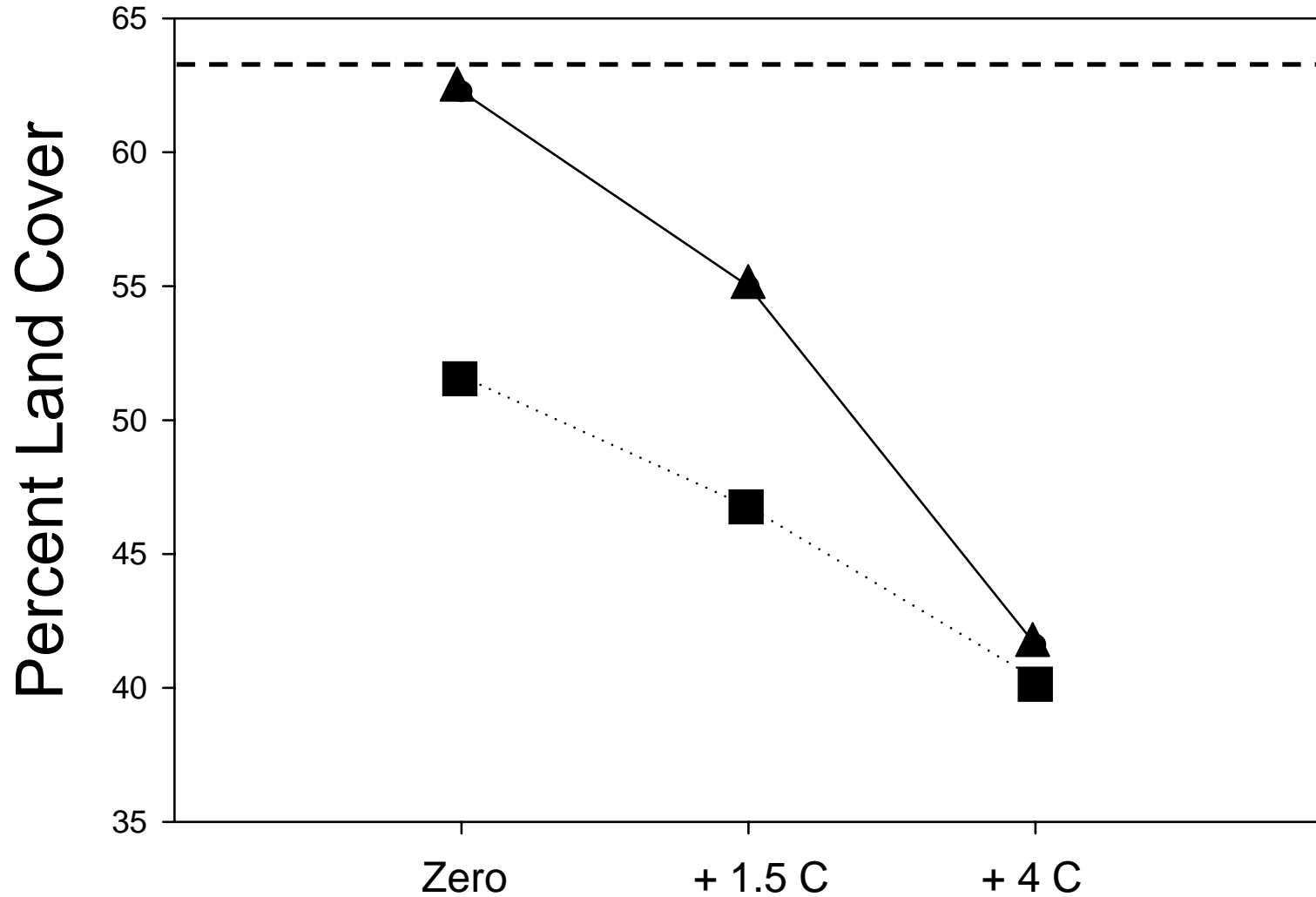
Potential Niche



25% Precip.

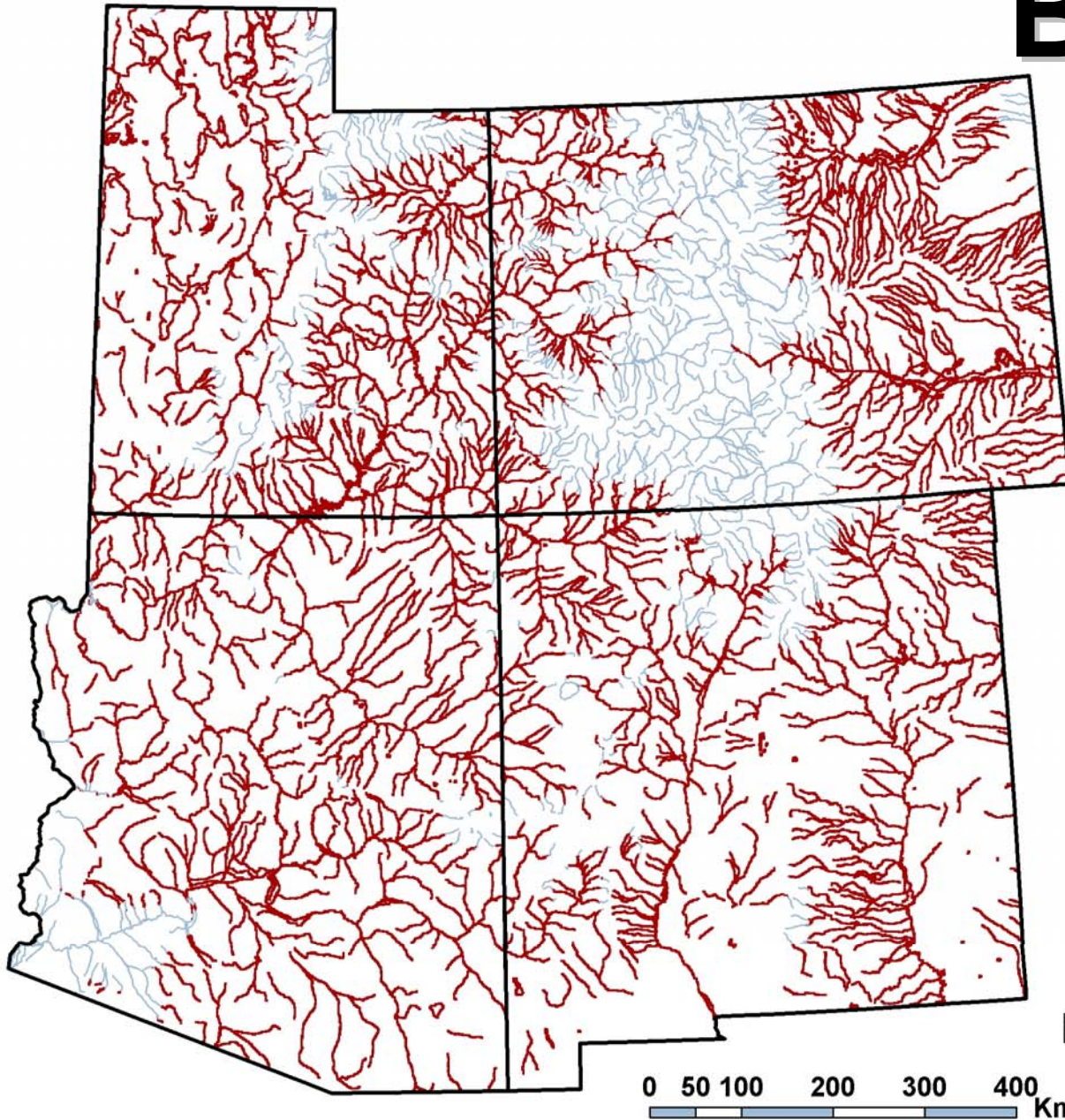
+ 4° C

Narrowleaf: Percent Land Cover



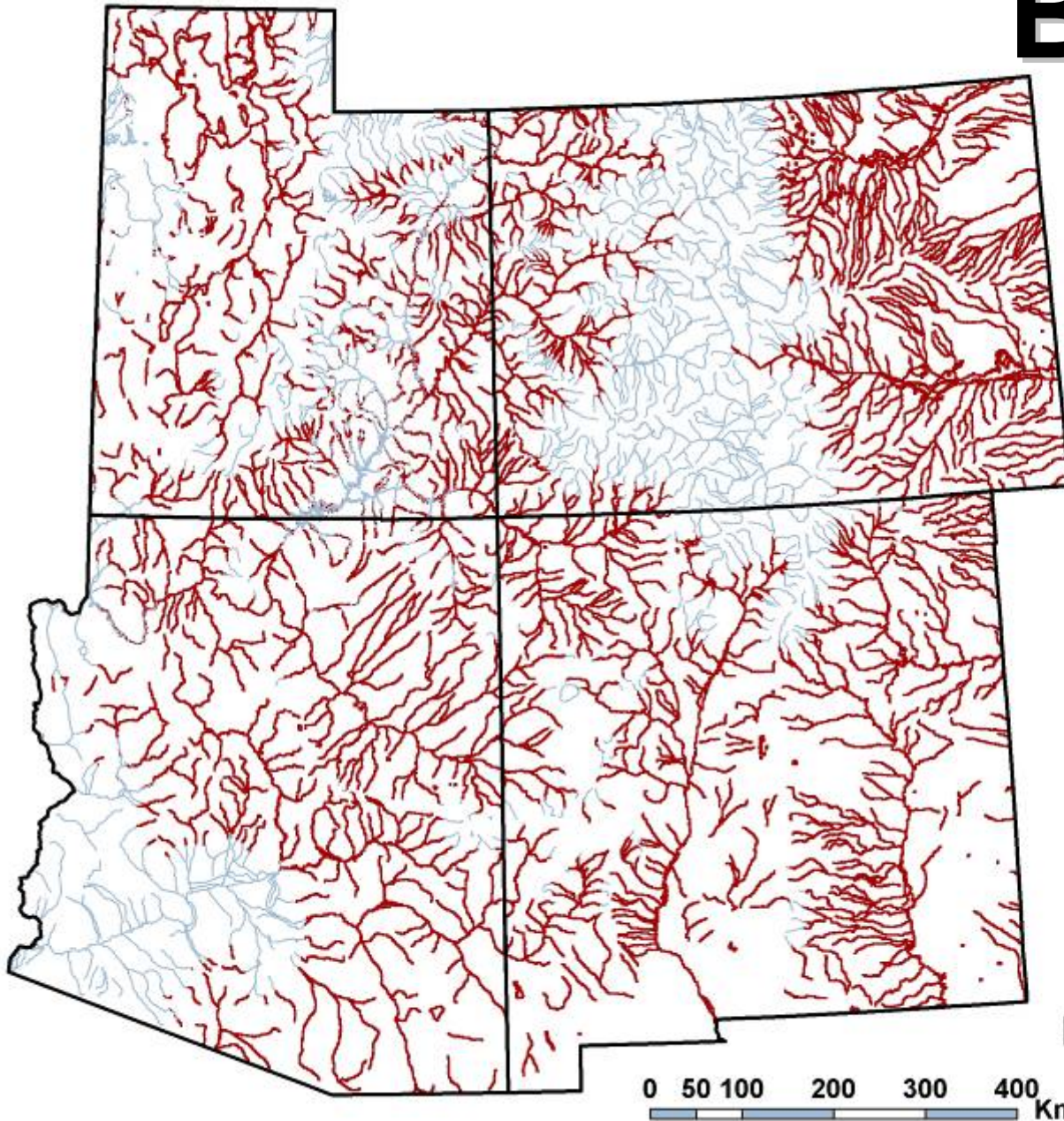
Temperature Increase

Broadleaf Potential Niche



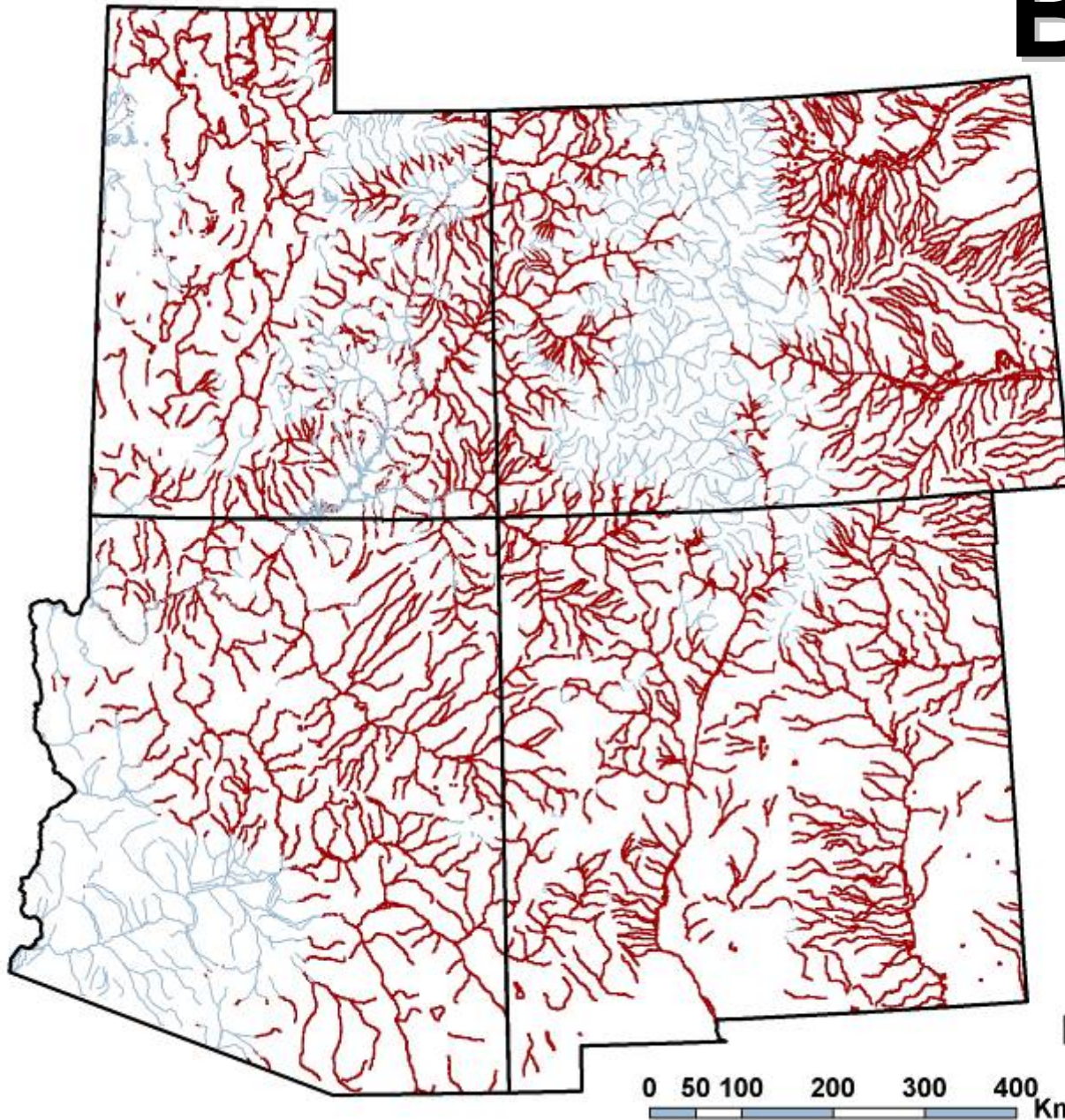
Current Precip.
Current Temp.

Broadleaf Potential Niche



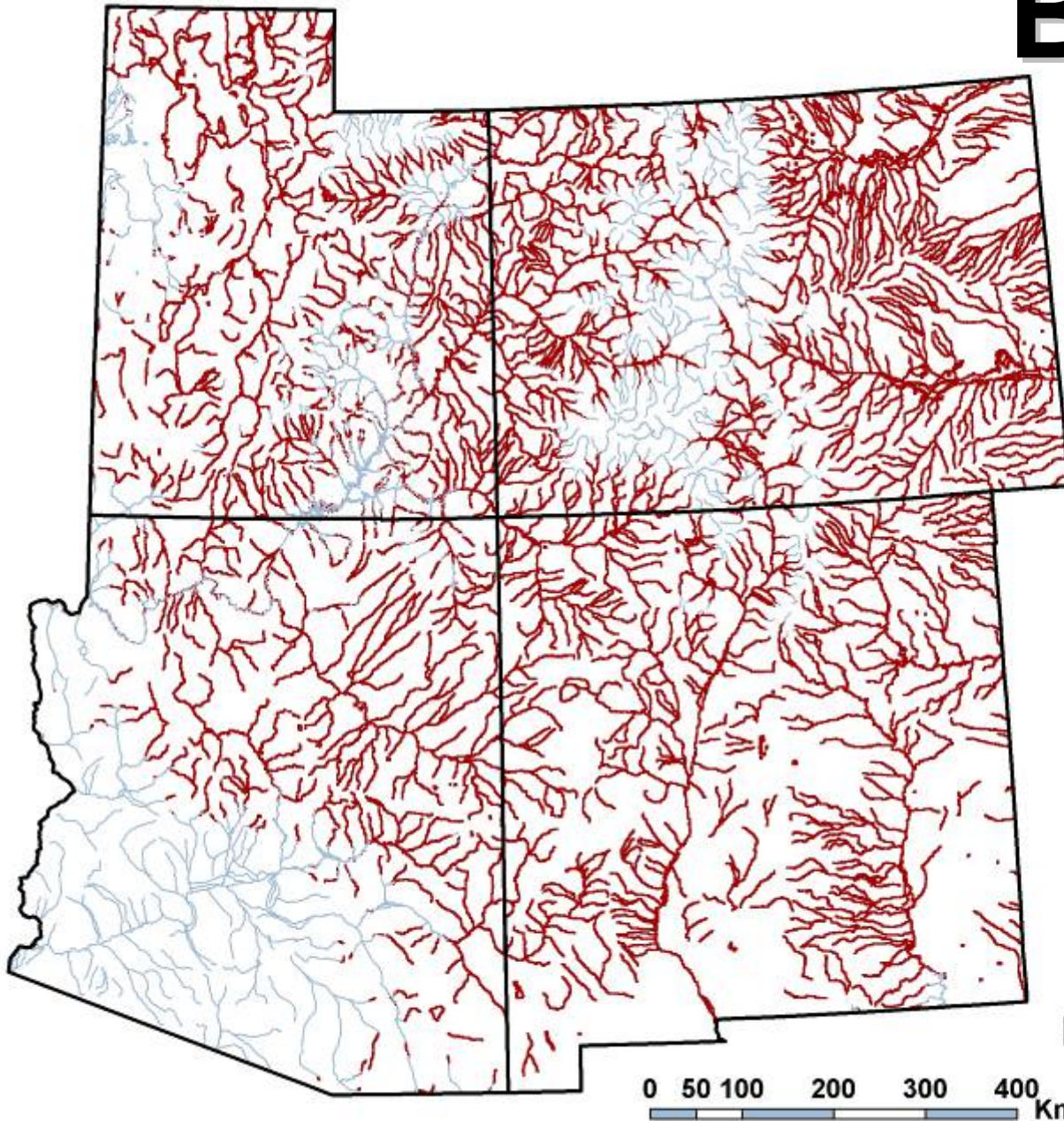
50% Precip.
Current Temp.

Broadleaf Potential Niche



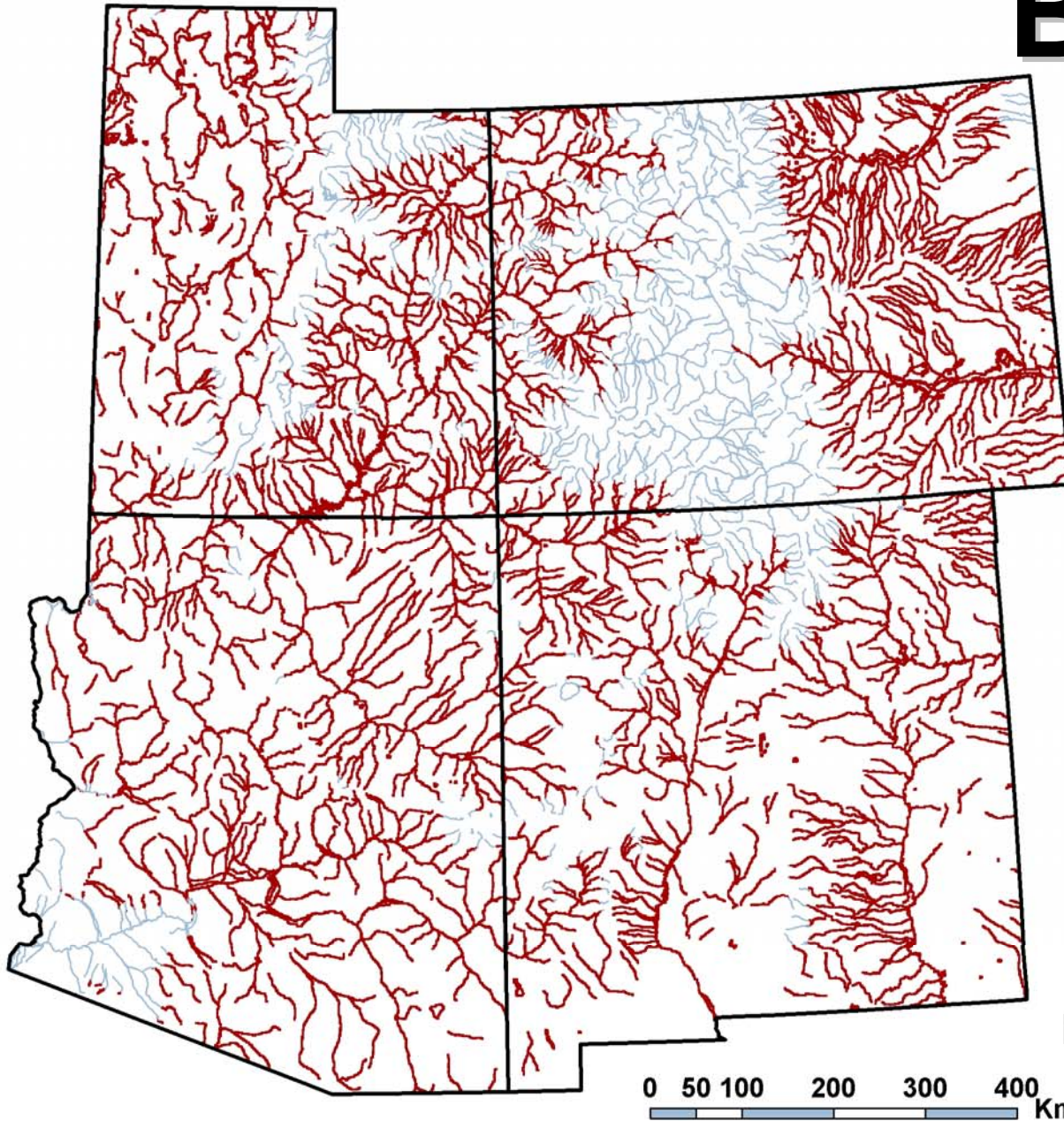
50% Precip.
+ 1.5° C

Broadleaf Potential Niche



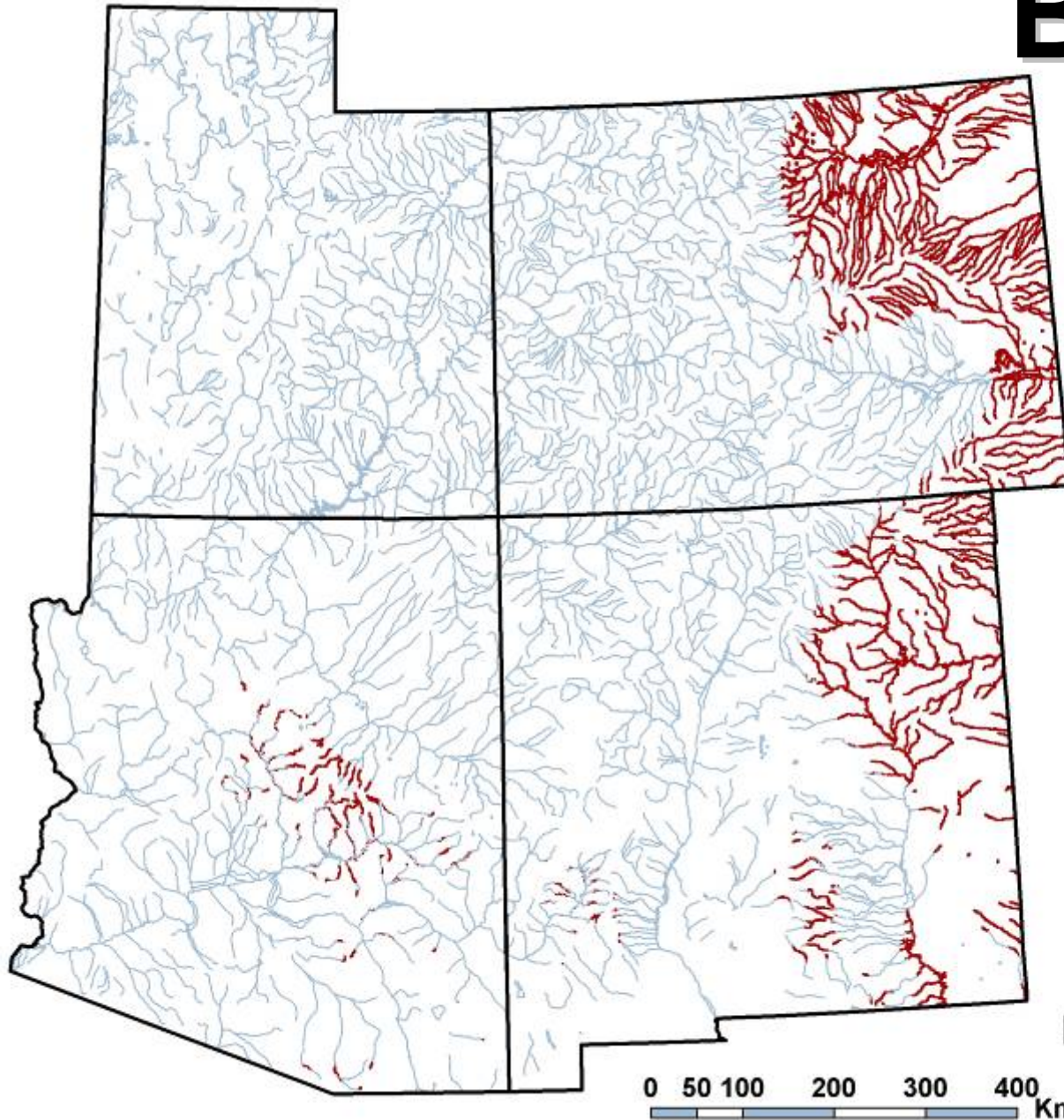
50% Precip.
+ 4° C

Broadleaf Potential Niche



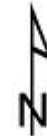
Current Precip.
Current Temp.

Broadleaf Potential Niche

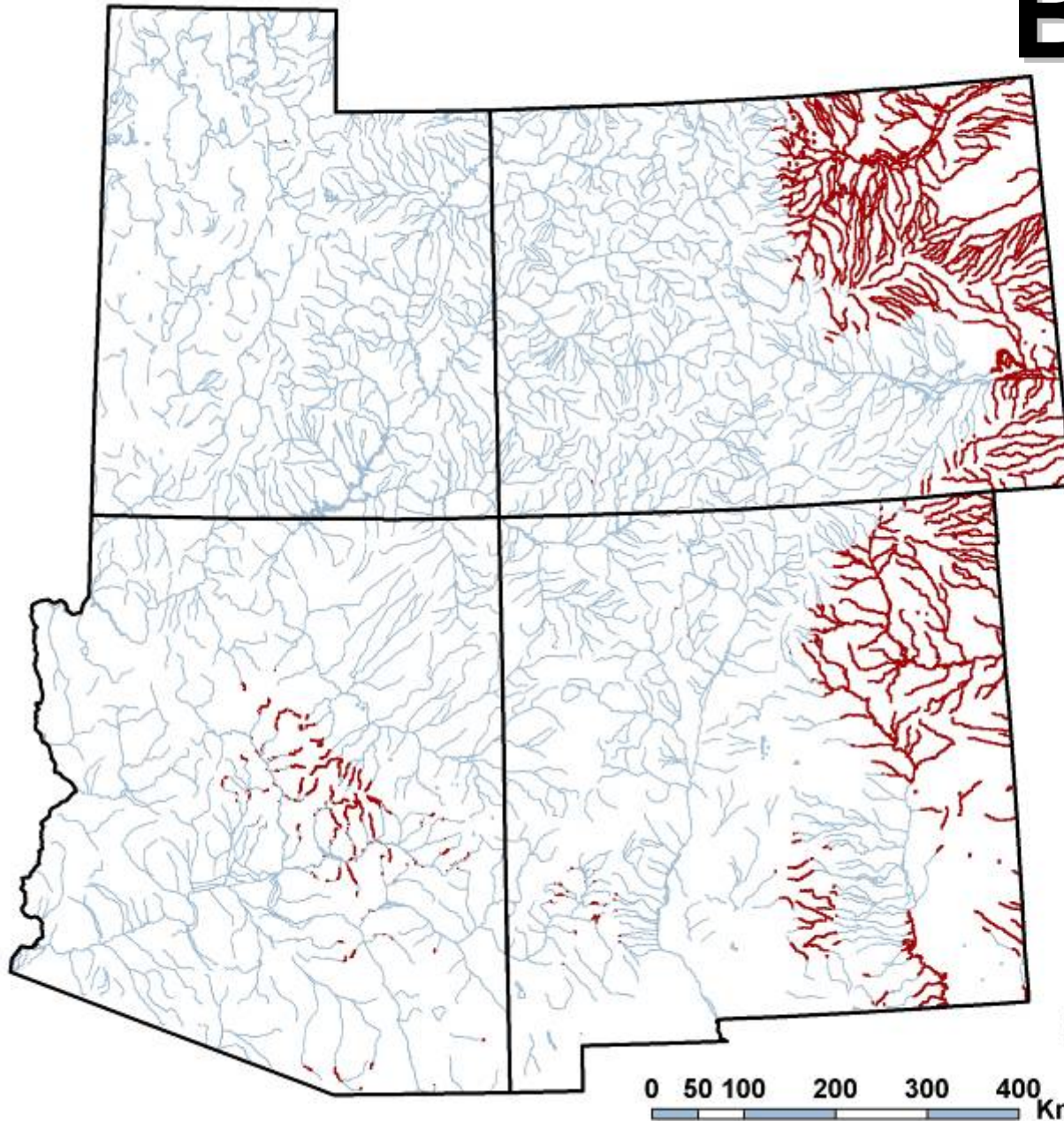


25% Precip.
Current Temp.

0 50 100 200 300 400 Km

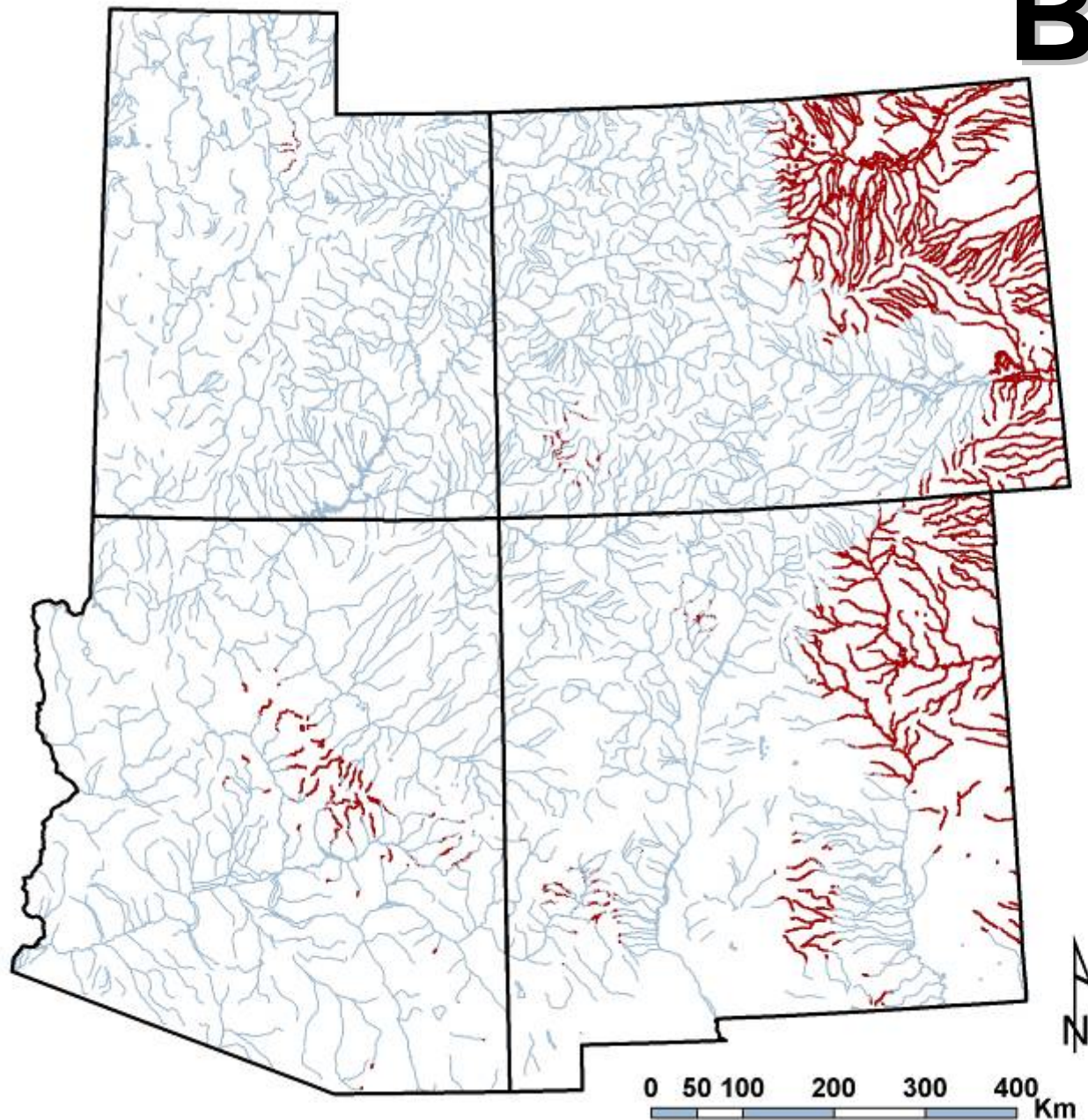


Broadleaf Potential Niche



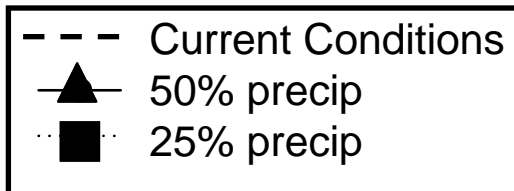
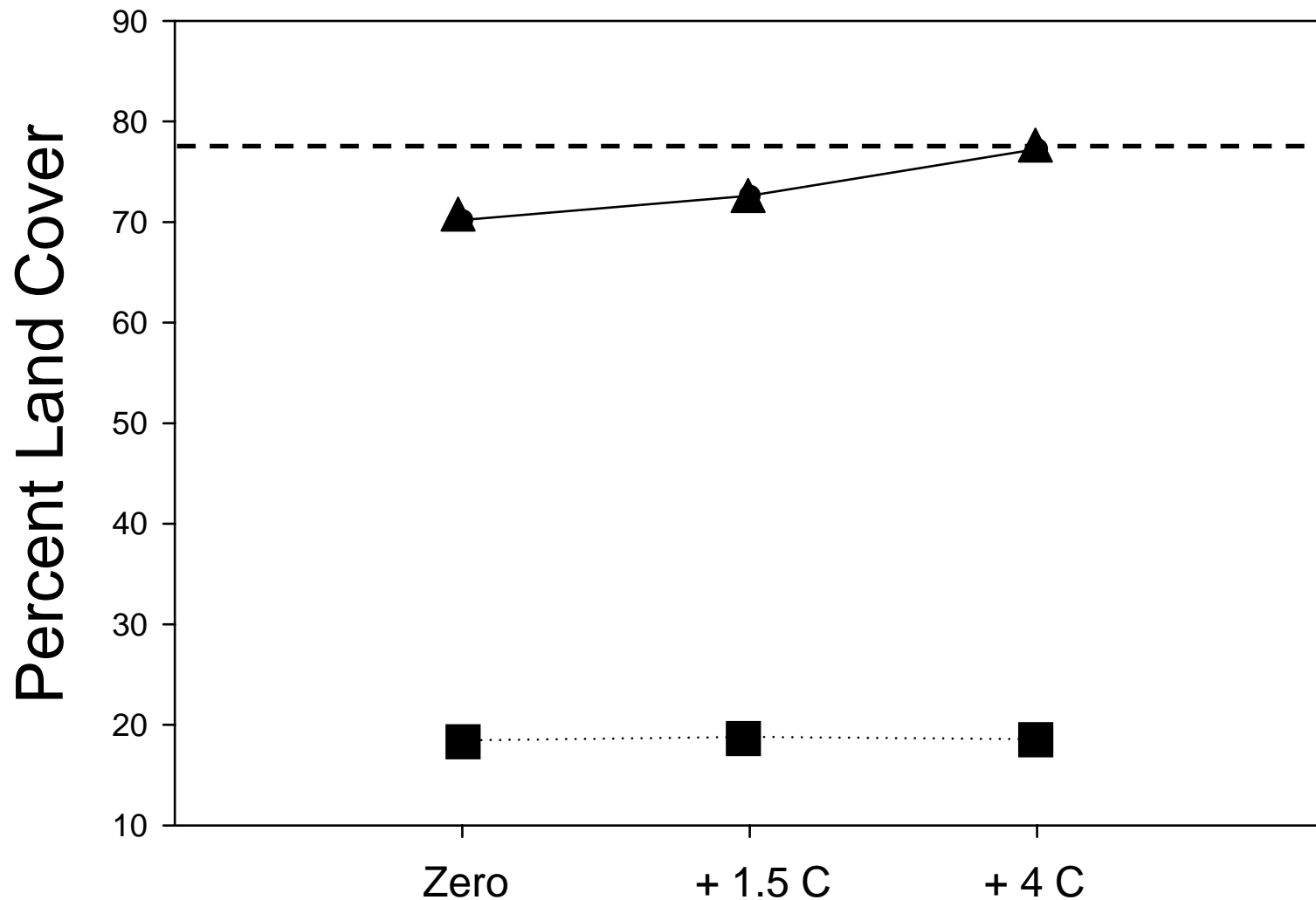
25% Precip.
+ 1.5° C

Broadleaf Potential Niche



25% Precip.
+ 4° C

Broadleaf: Percent Land Cover



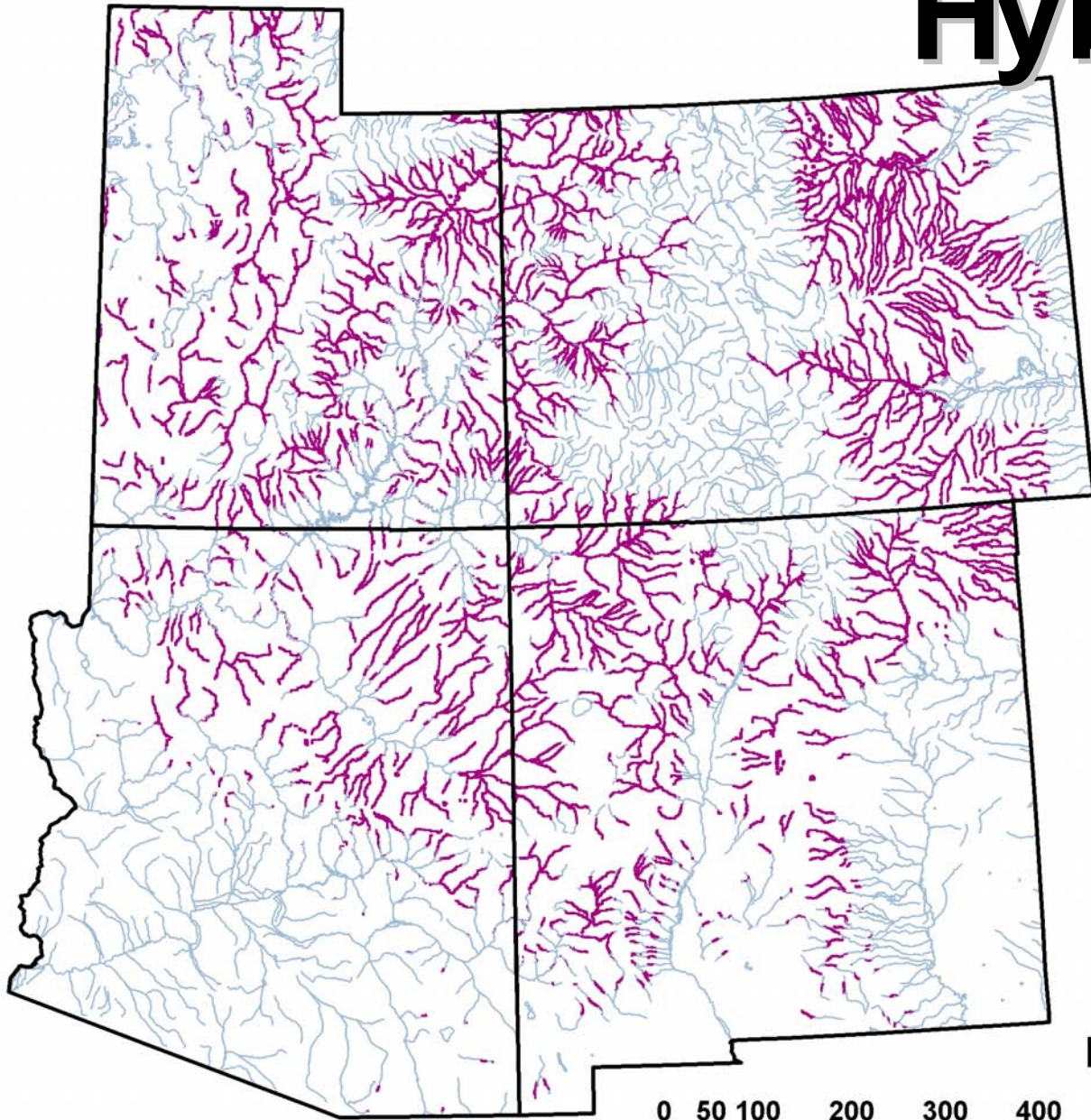
Temperature Increase

Hybrid Zone

Potential Niche

Current Precip.

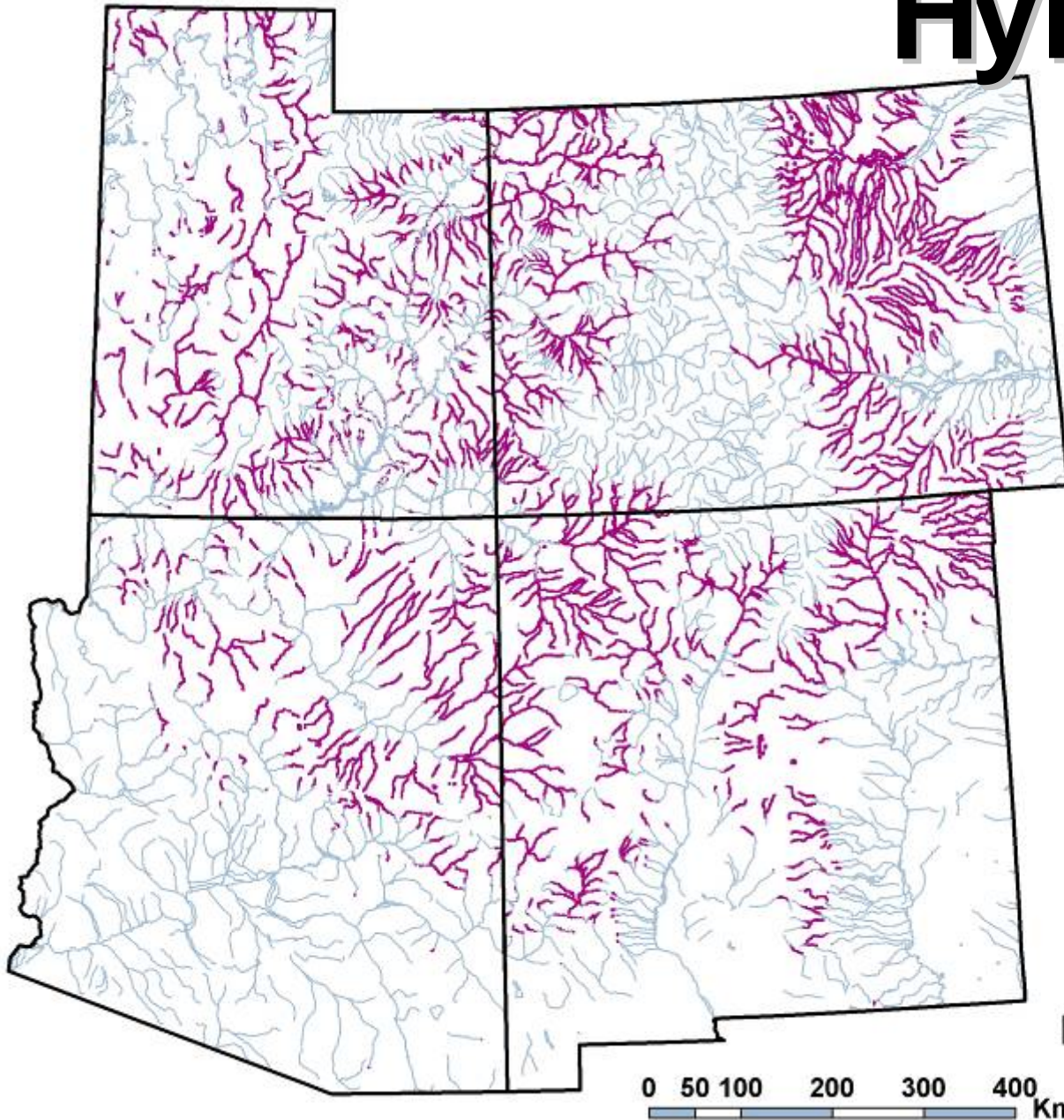
Current Temp.



0 50 100 200 300 400 Km

Hybrid Zone

Potential Niche

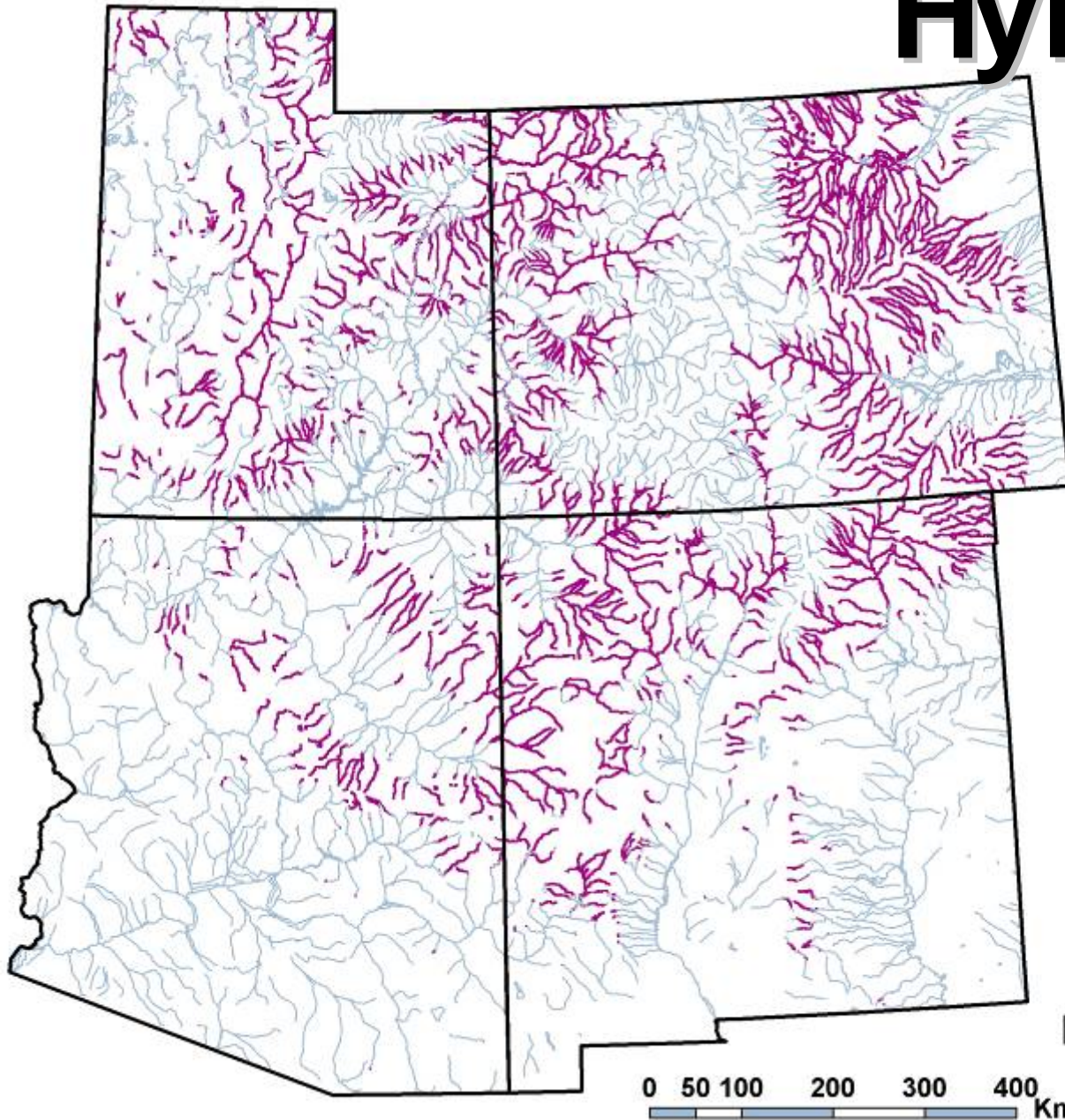


50% Precip.

Current Temp.

Hybrid Zone

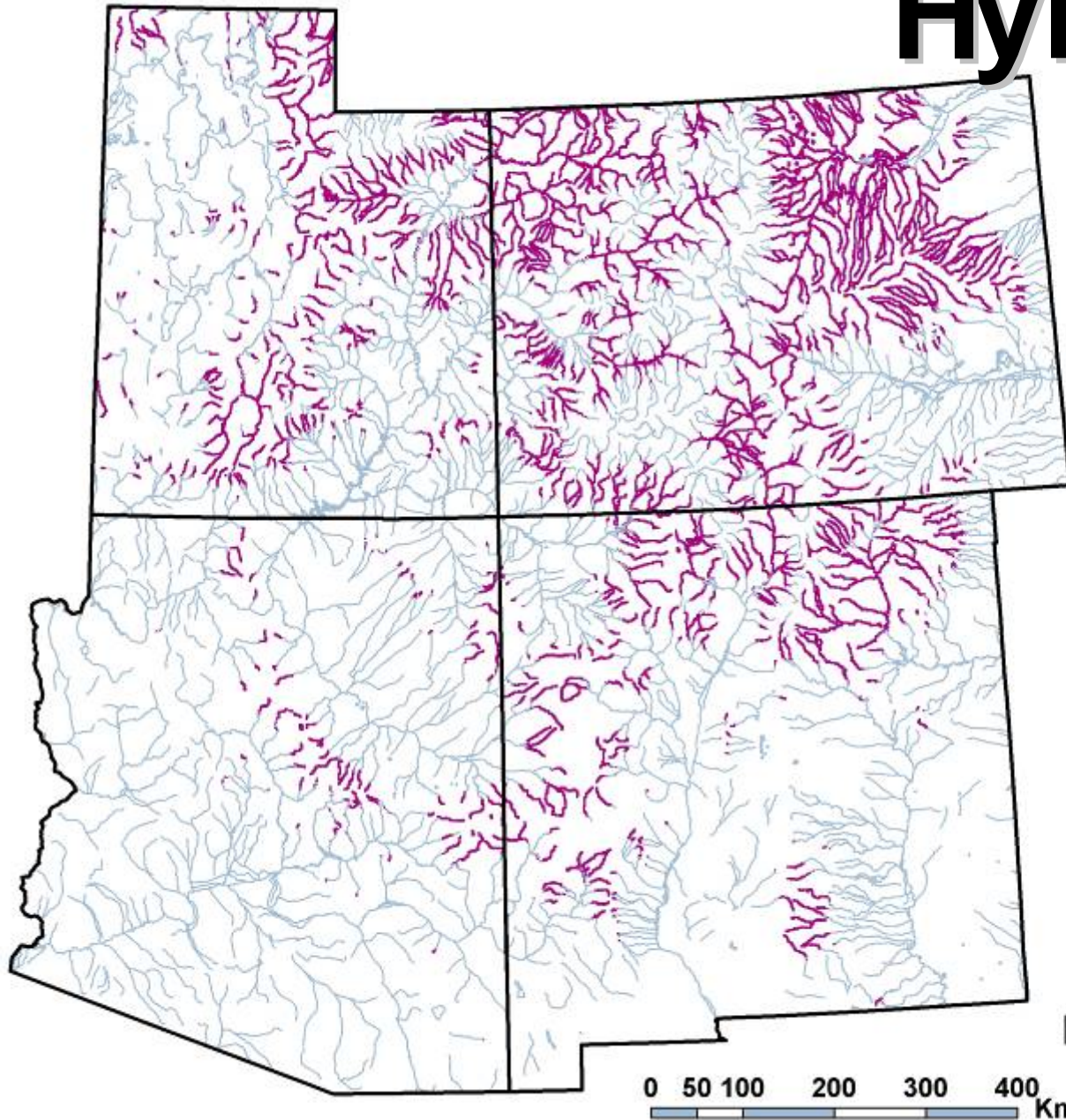
Potential Niche



50% Precip.
+ 1.5° C

Hybrid Zone

Potential Niche



50% Precip.

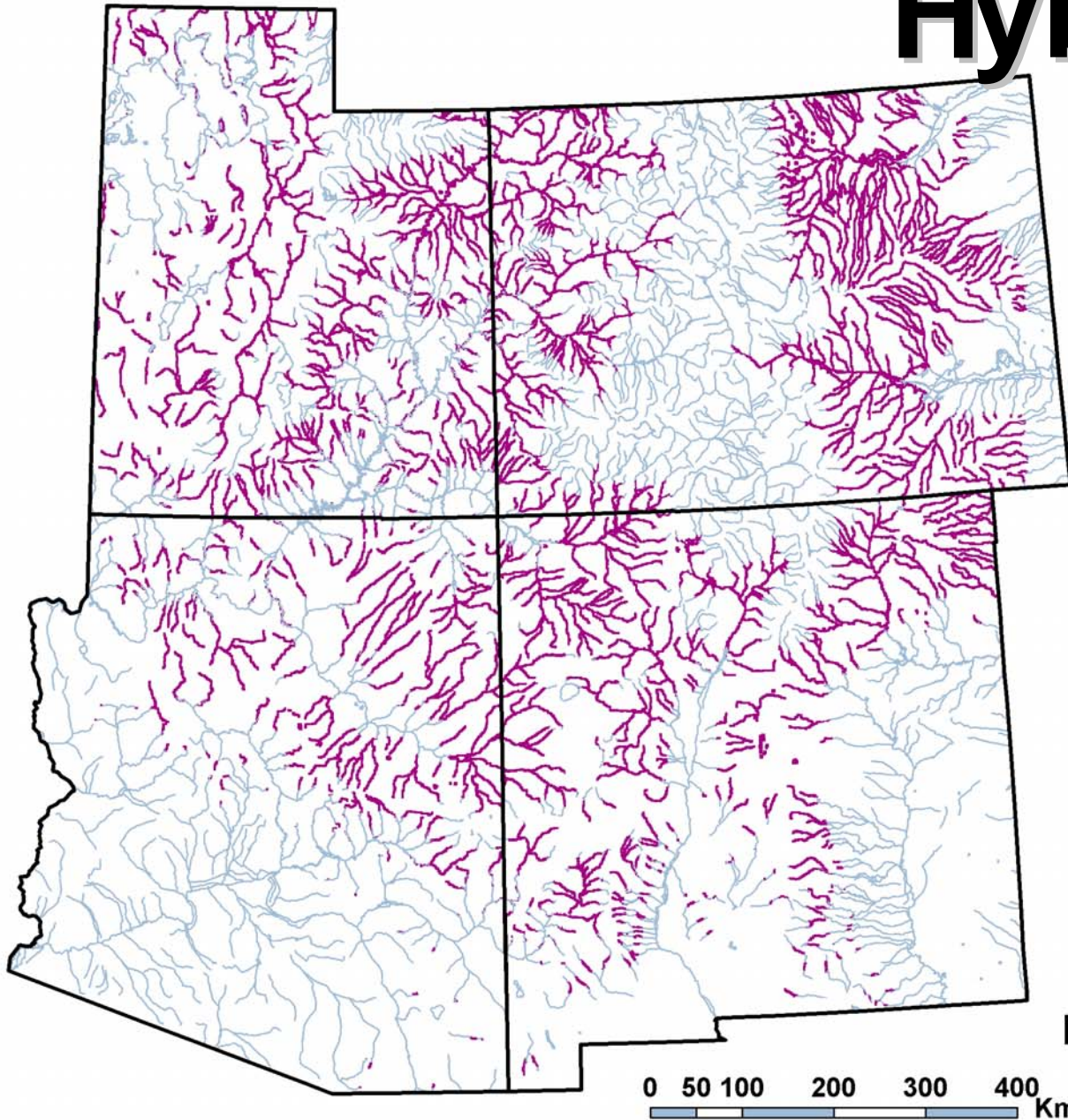
+ 4° C

Hybrid Zone

Potential Niche

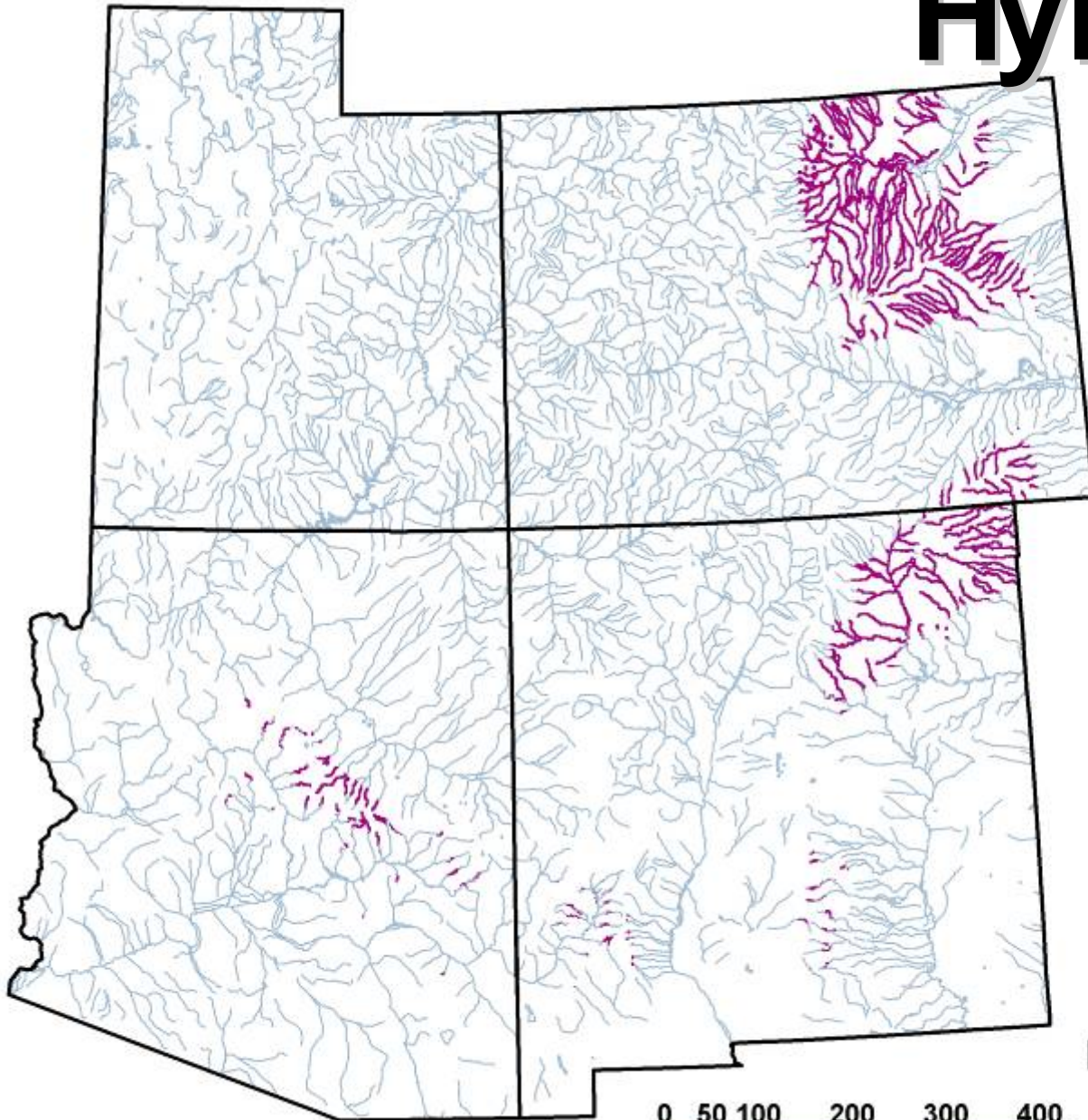
Current Precip.

Current Temp.



Hybrid Zone

Potential Niche

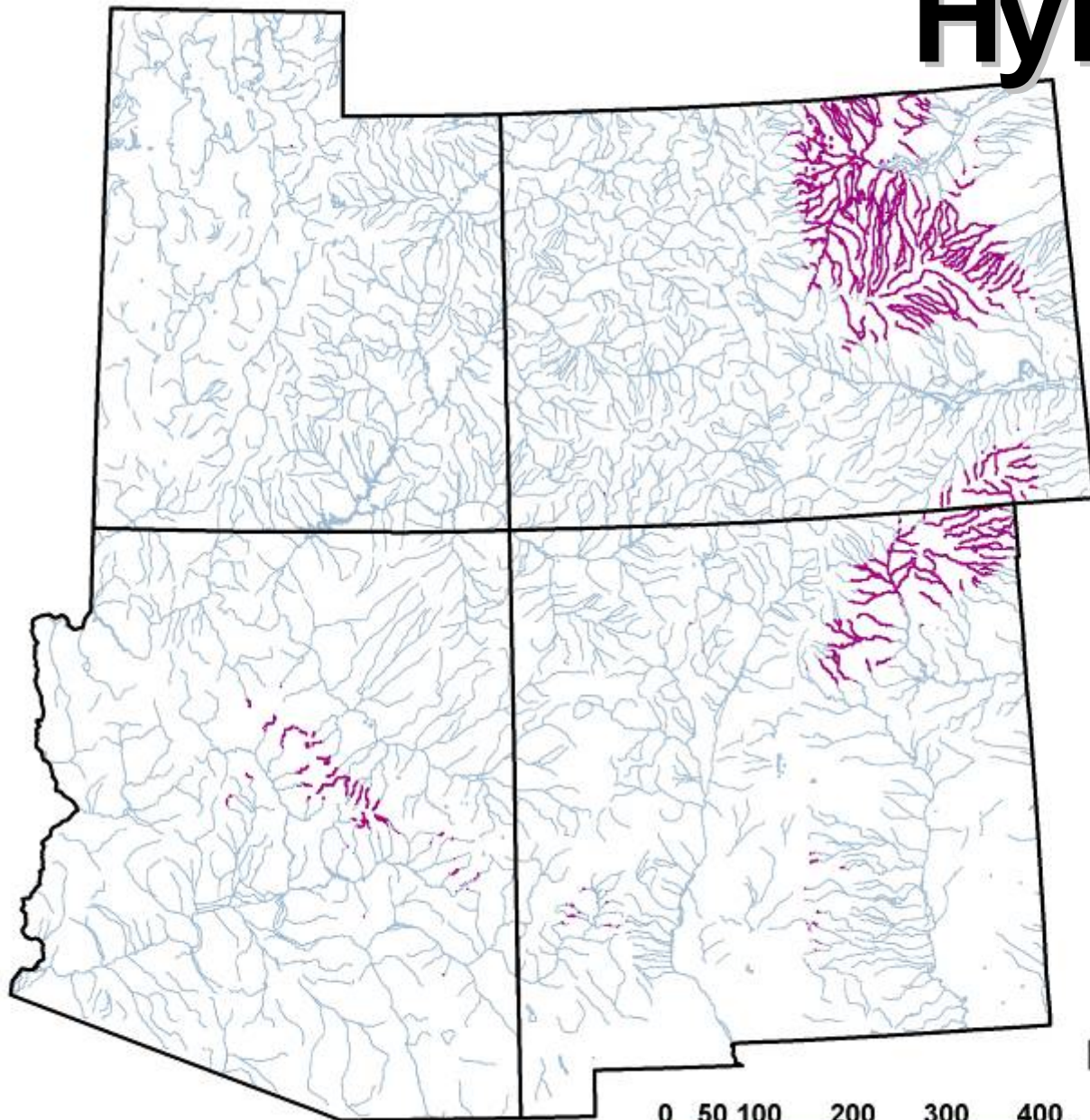


25% Precip.
Current Temp.

0 50 100 200 300 400 Km

Hybrid Zone

Potential Niche

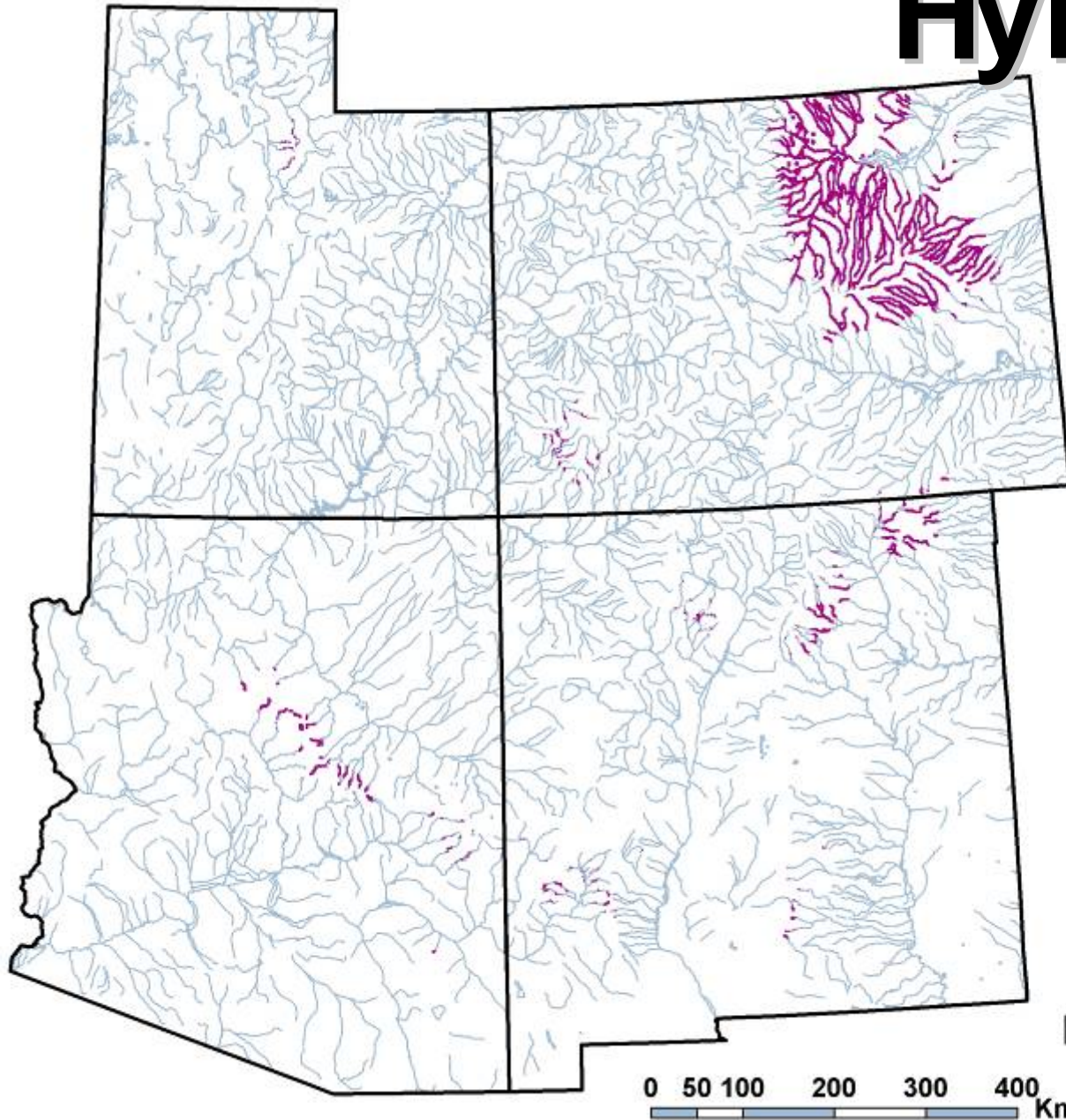


25% Precip.
+ 1.5° C

0 50 100 200 300 400 Km

Hybrid Zone

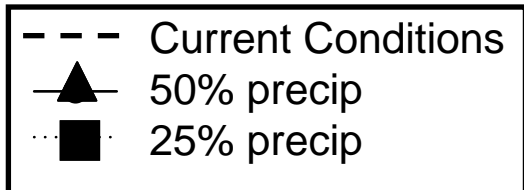
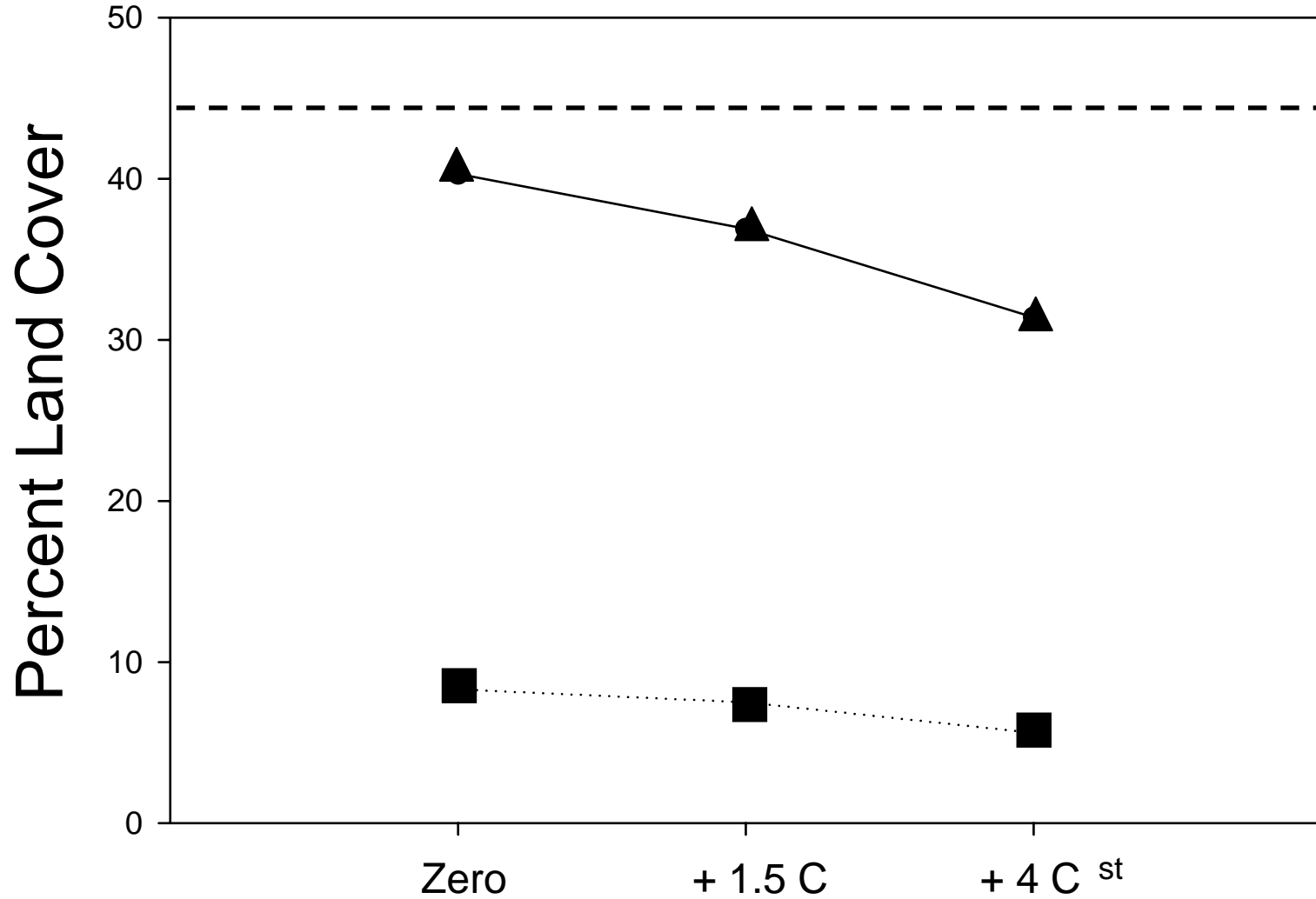
Potential Niche



25% Precip.

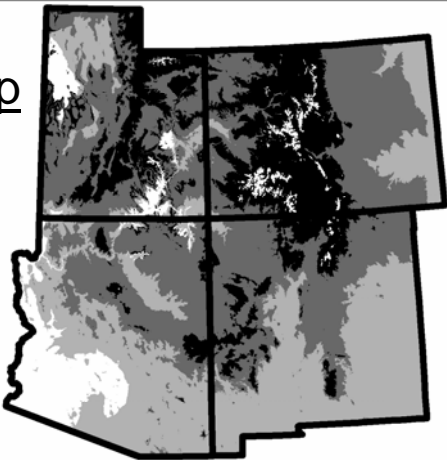
+ 4° C

Hybrid Zone: Percent Land Cover

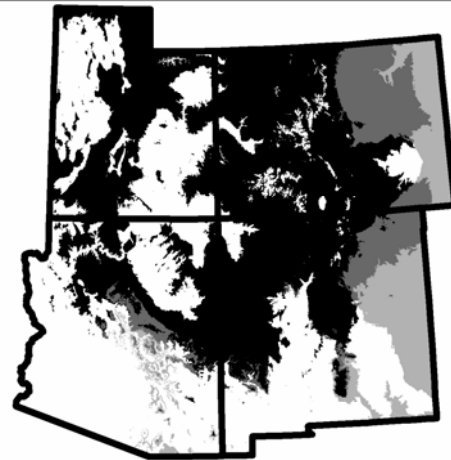


Temperature Increase

50%
precip



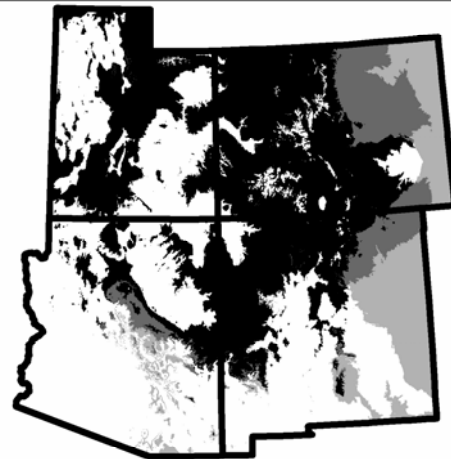
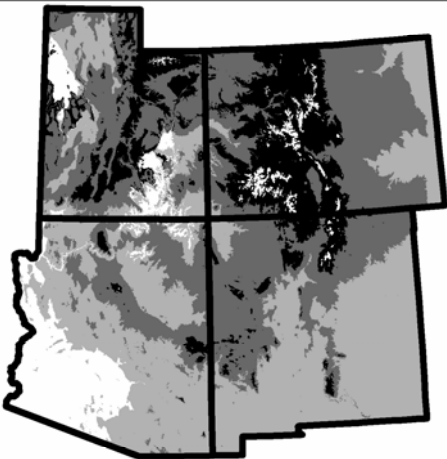
25%
precip



current
average
temp

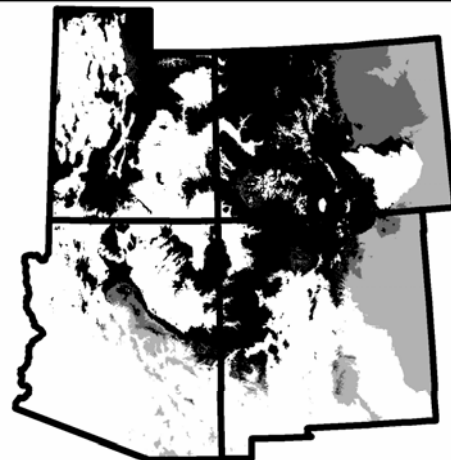
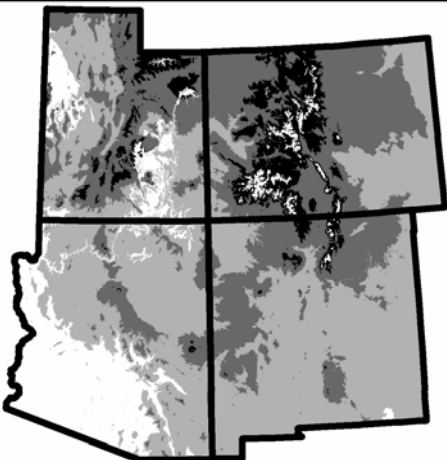
current
average
temp

+ 1.5 C



+ 1.5 C

+ 4 C



+ 4 C

Summary:

Pressures will act on different species in different ways:

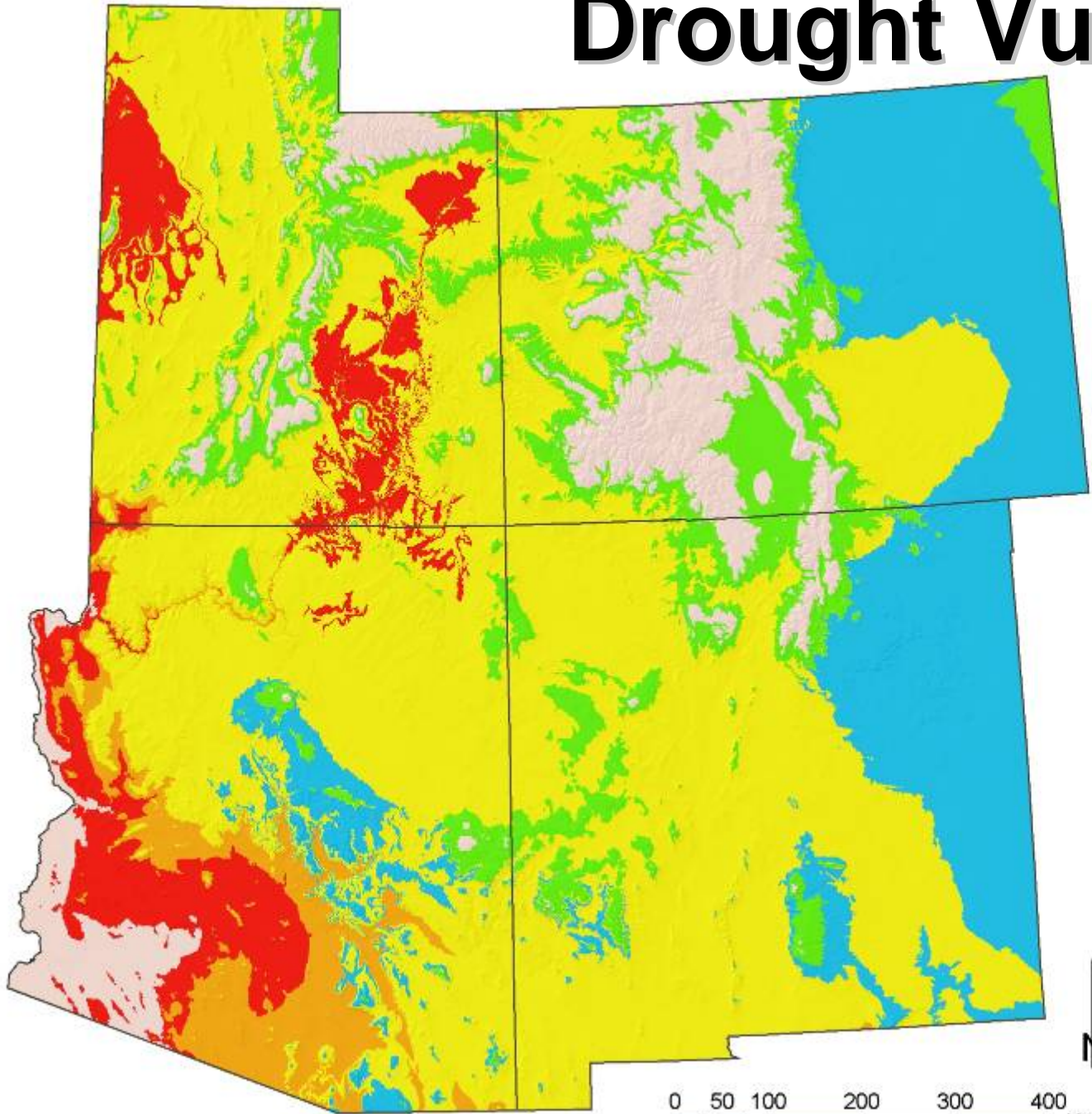
- ~ Narrowleaf can tolerate dry periods, but suffer from temperature increase.**
- ~ Broadleaf cottonwoods can expand their range if it gets hotter, but won't tolerate extreme drought!**
- ~ Hybrid Zone creation could be limited.**

The Complete Summary:

Each species will have its own response to climate changes:

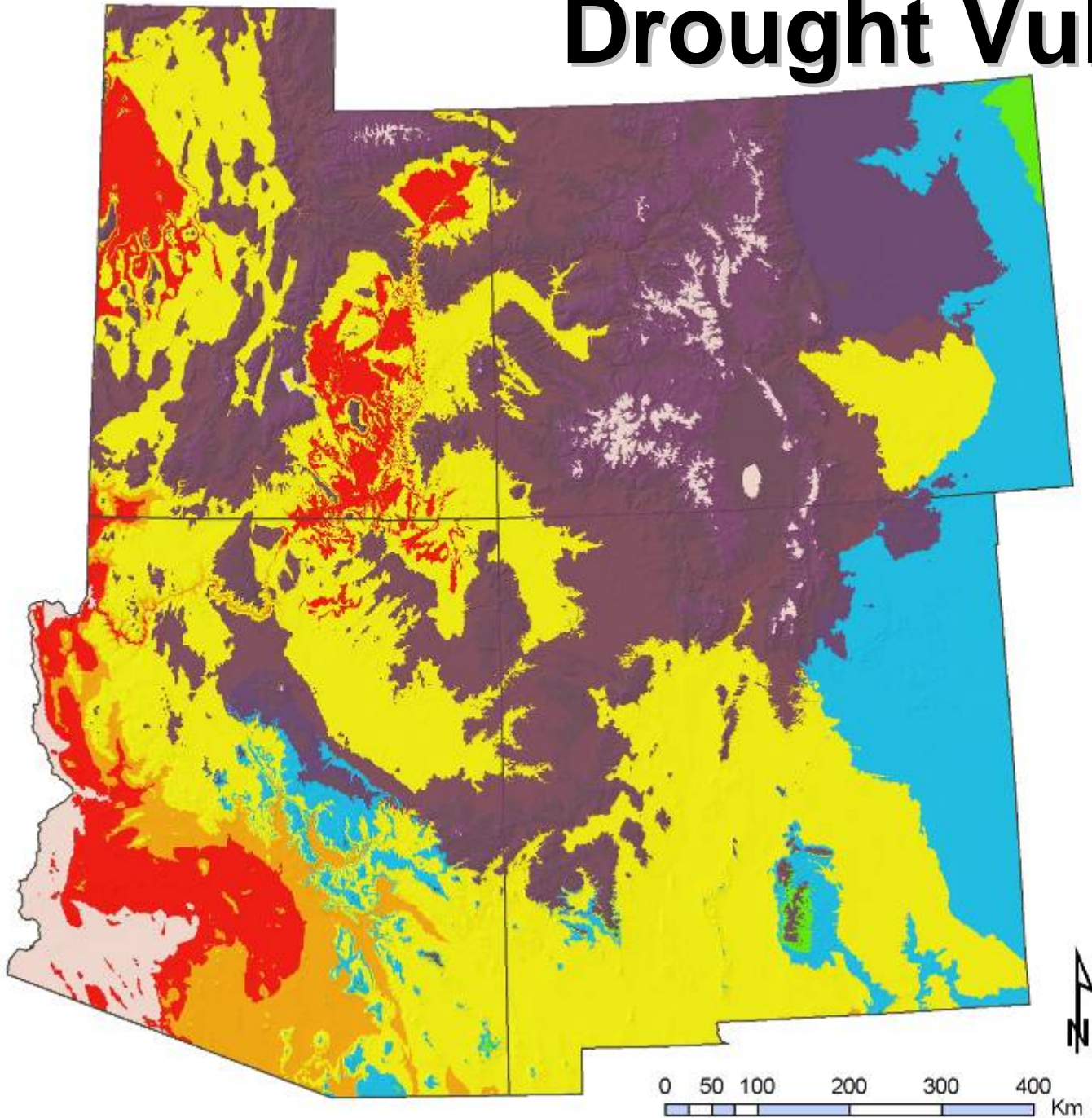
- ~ **Narrowleaf** are more susceptible to temperature change than drought
- ~ **Broadleaf cottonwoods** are most susceptible to severe moisture decreases
- ~ New **hybrid zone** creation will be limited if parent species no longer overlap
- ~ Existing **hybrid zones** may become habitat refugia

Drought Vulnerability

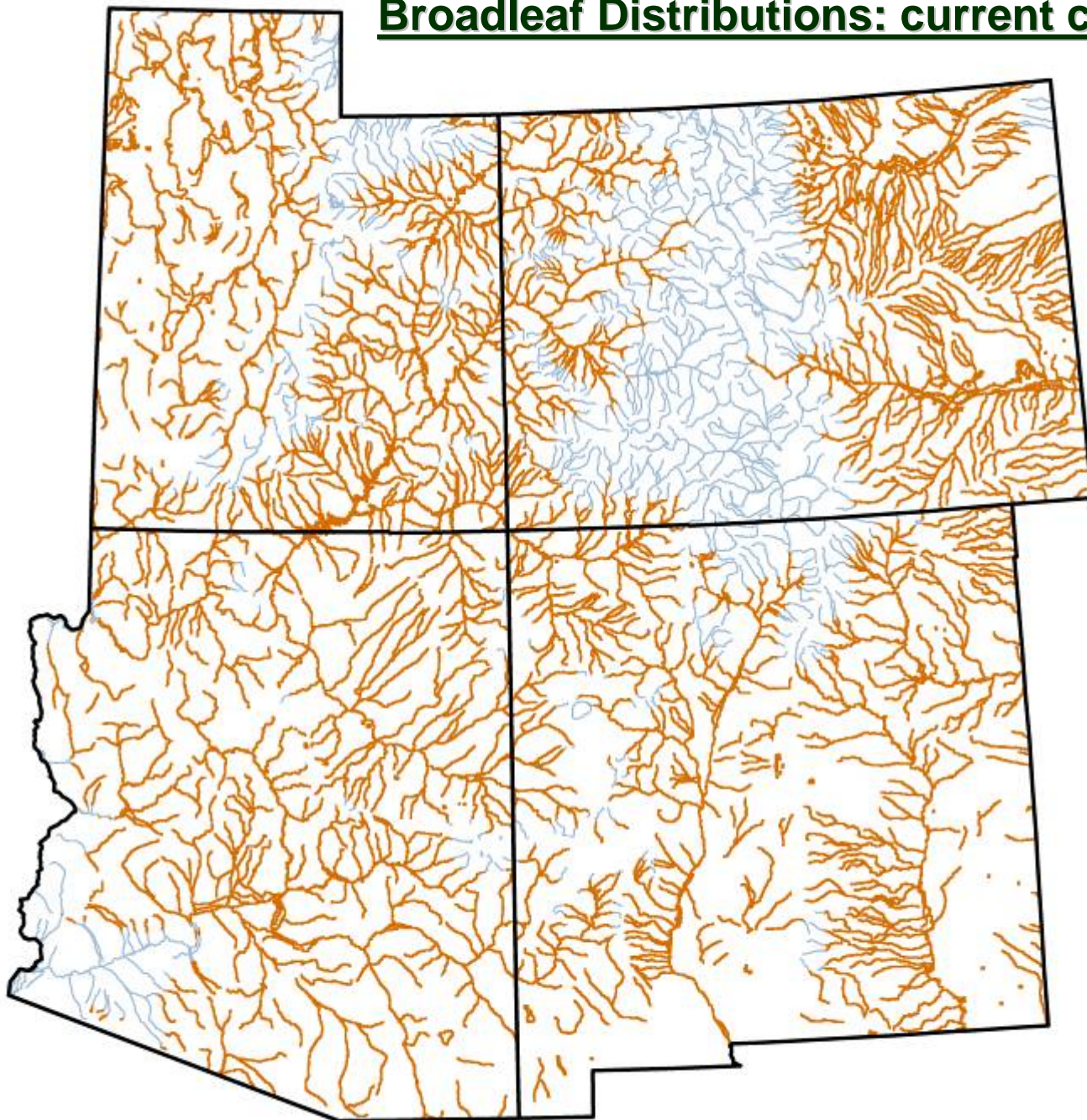


0 50 100 200 300 400 Km

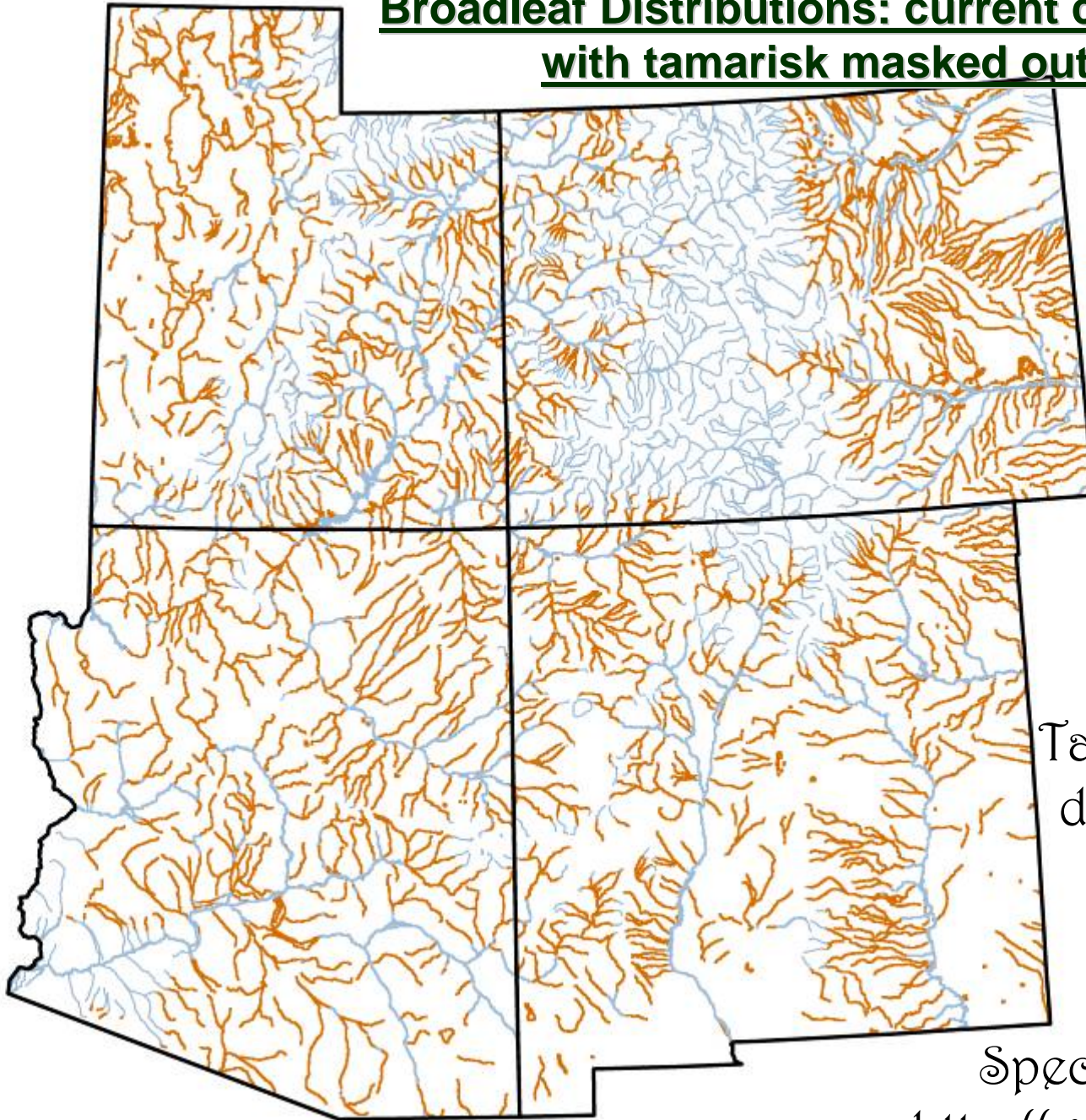
Drought Vulnerability



Broadleaf Distributions: current conditions



**Broadleaf Distributions: current conditions,
with tamarisk masked out**

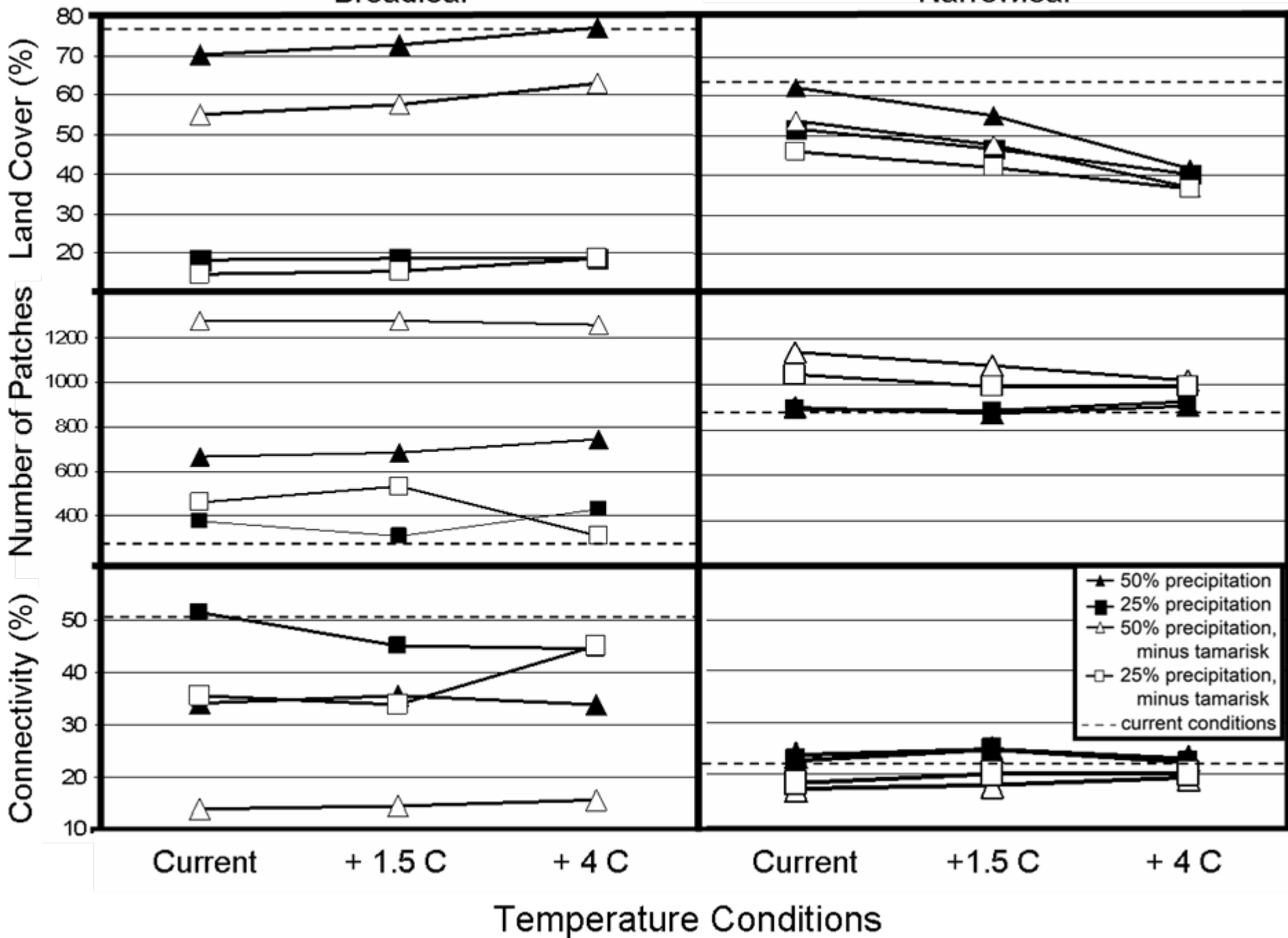


Tamarisk data
derived from
National
Institute of
Invasive
Species Science

<http://www.niiss.org>

Broadleaf

Narrowleaf



The Future of Southwestern Broadleaf Cottonwoods:

- ~ Fragmentation from both climate & exotic trees
- ~ Forests will be confined between lowland exotics and upland cottonwoods
- ~ Temperature change may enable low elevation species migration to higher elevations
- ~ They will probably lose dominance, and become a member of mixed stands of trees
- ~ Hybridization may be the savior of Broadleaf cottonwood genes

Conservation Suggestions:

Be proactive!

In vulnerable areas:

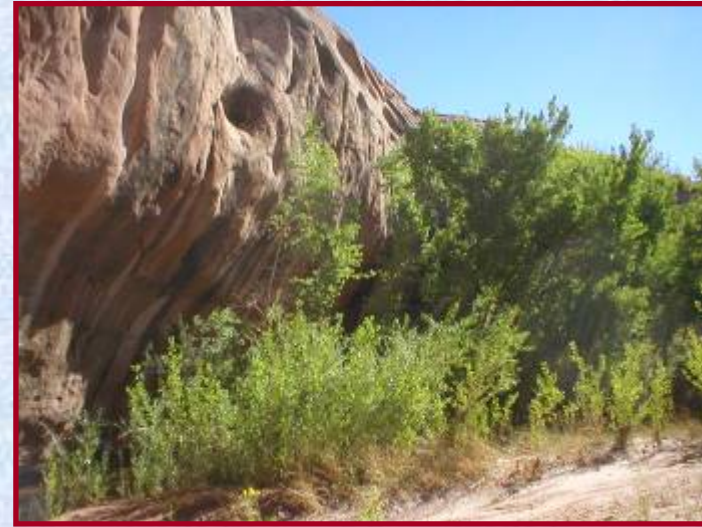
- remove compounding influences
- secure habitat water rights

In resilient areas:

- Locate potential “refugia” and take care of them NOW!!
- Obtain instream water rights NOW!!!

Maintain “native vegetation” corridors:

- select rivers where “historic flow regime” can be maintained
- remove exotics to maintain connectivity and provide germination sites when floods return



Questions

??



The tree that is beside the running water
is fresher and gives more fruit.
Saint Teresa of Avila

