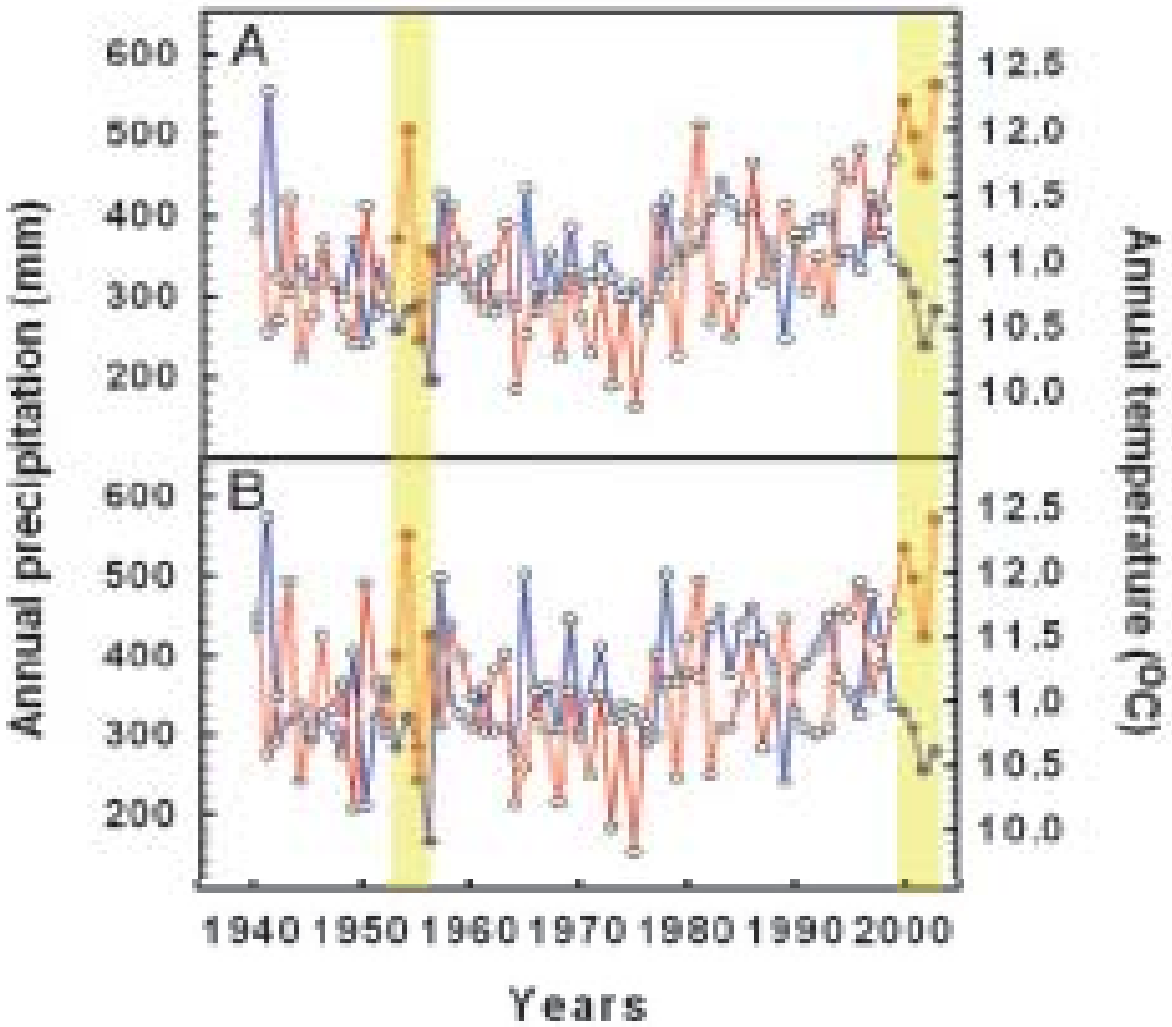
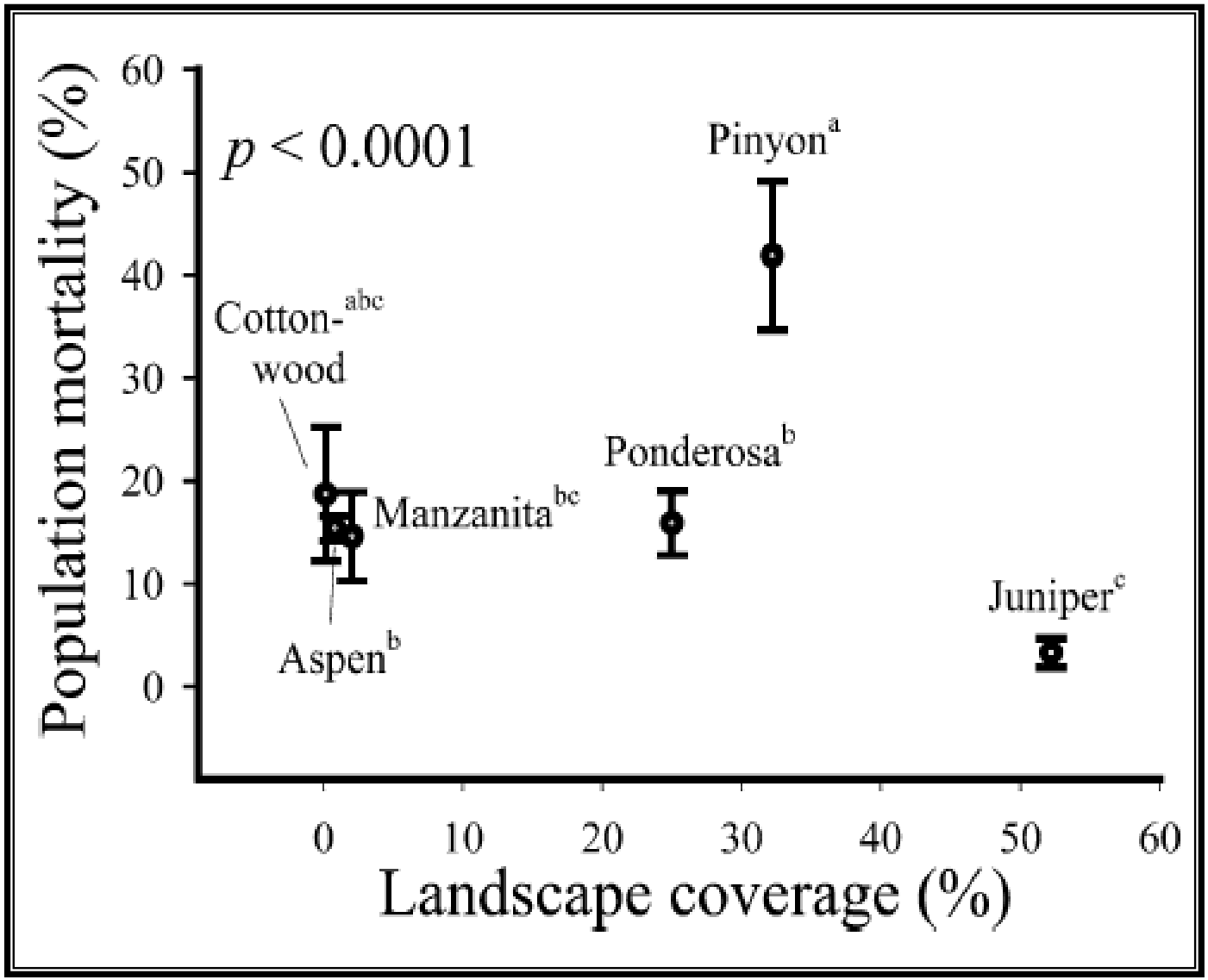
Differential Effects of Climate Perturbations on Pure and Hybrid Cottonwood Species: *implications for management*

Alicyn R. Gitlin
&
Thomas G. Whitham



from Breshears 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,

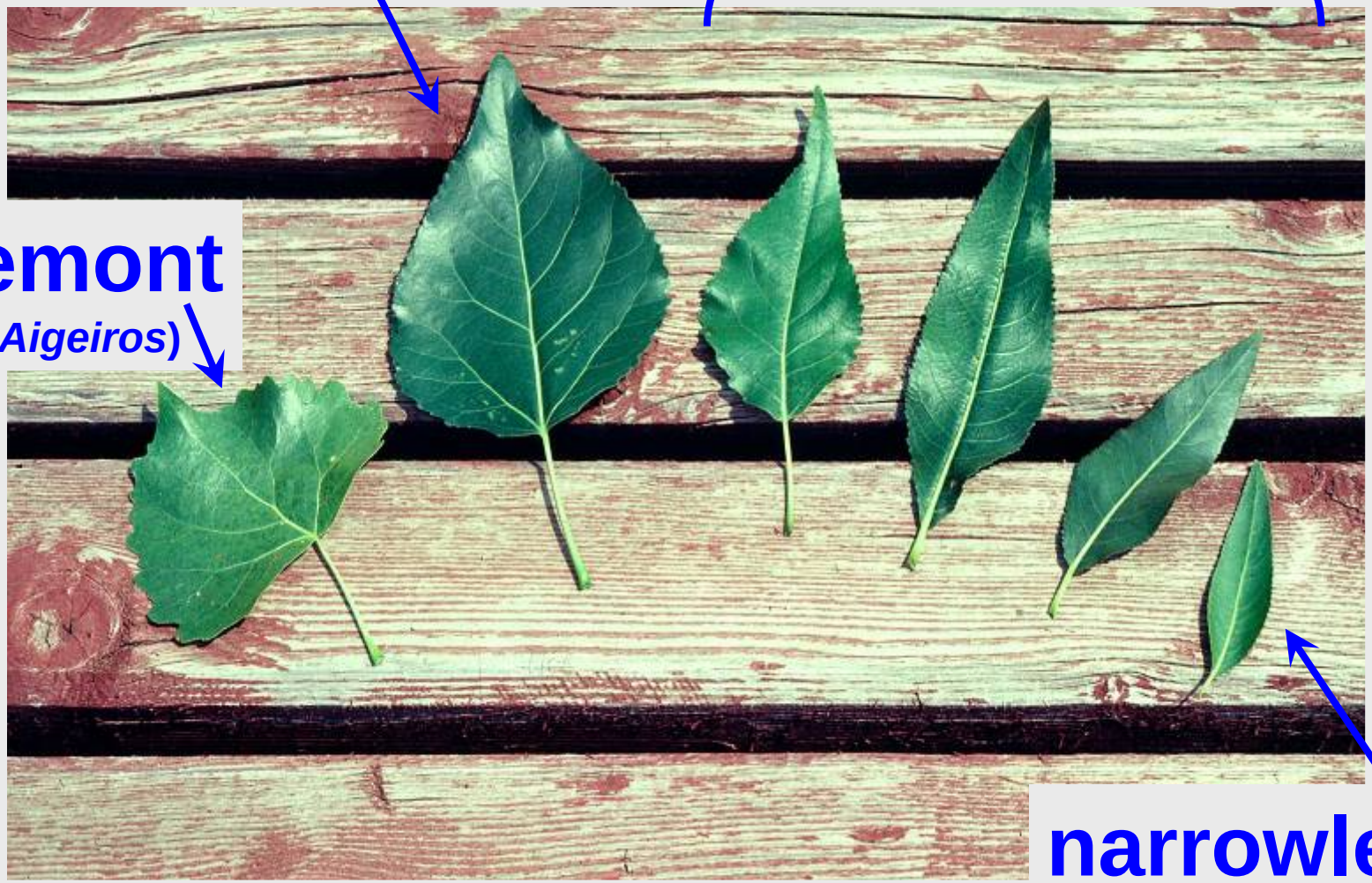
especially lowland species, a situation aggravated by:

- ~ 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?


F_1 hybrid
backcross hybrids
Fremont
(Sec. *Aigeiros*)
narrowleaf
(Sec. *Tacamahaca*)

Hypotheses:

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

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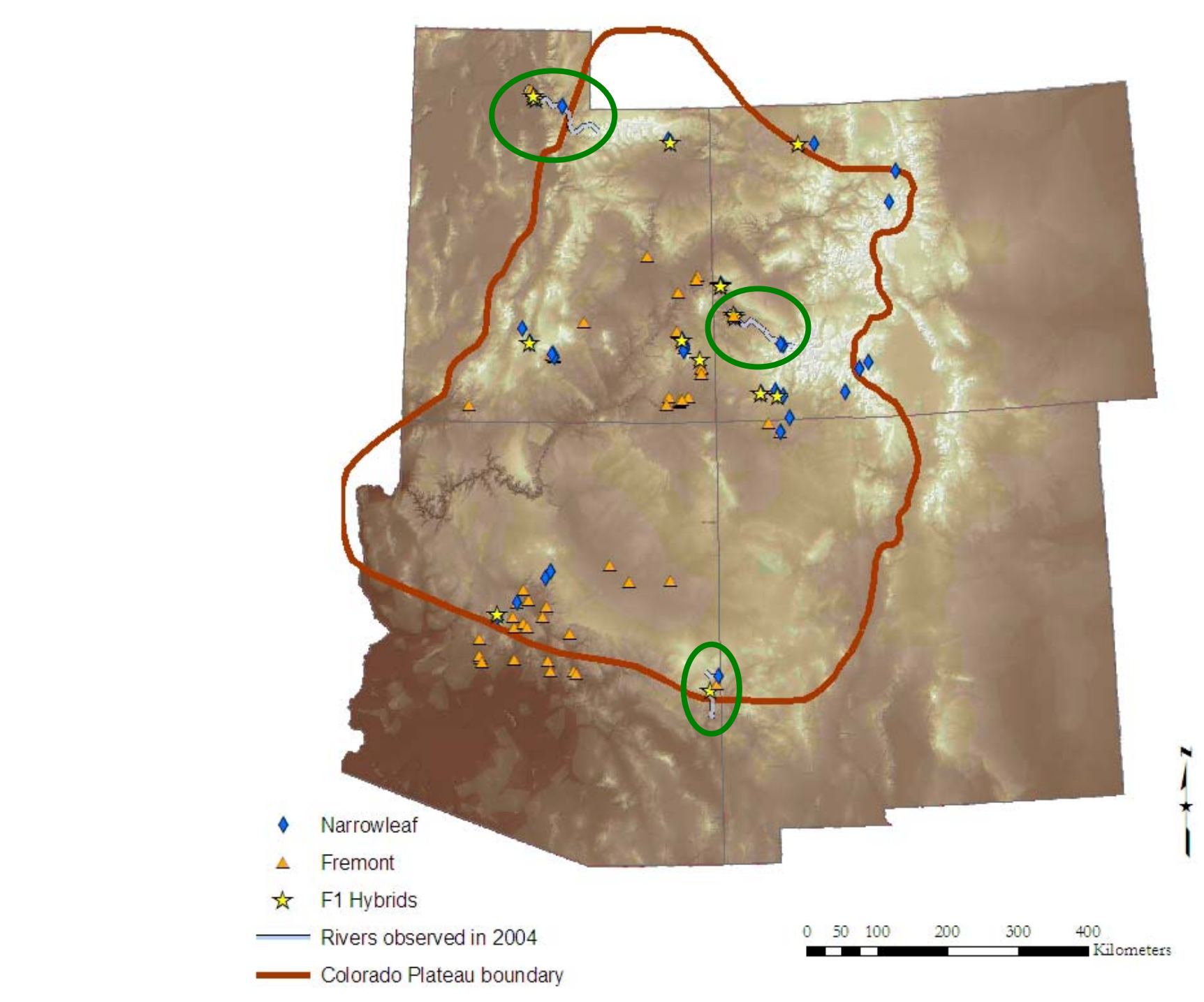
2) **Drought will constrict cottonwood niches, and higher temperatures will cause even greater range reductions**

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
N

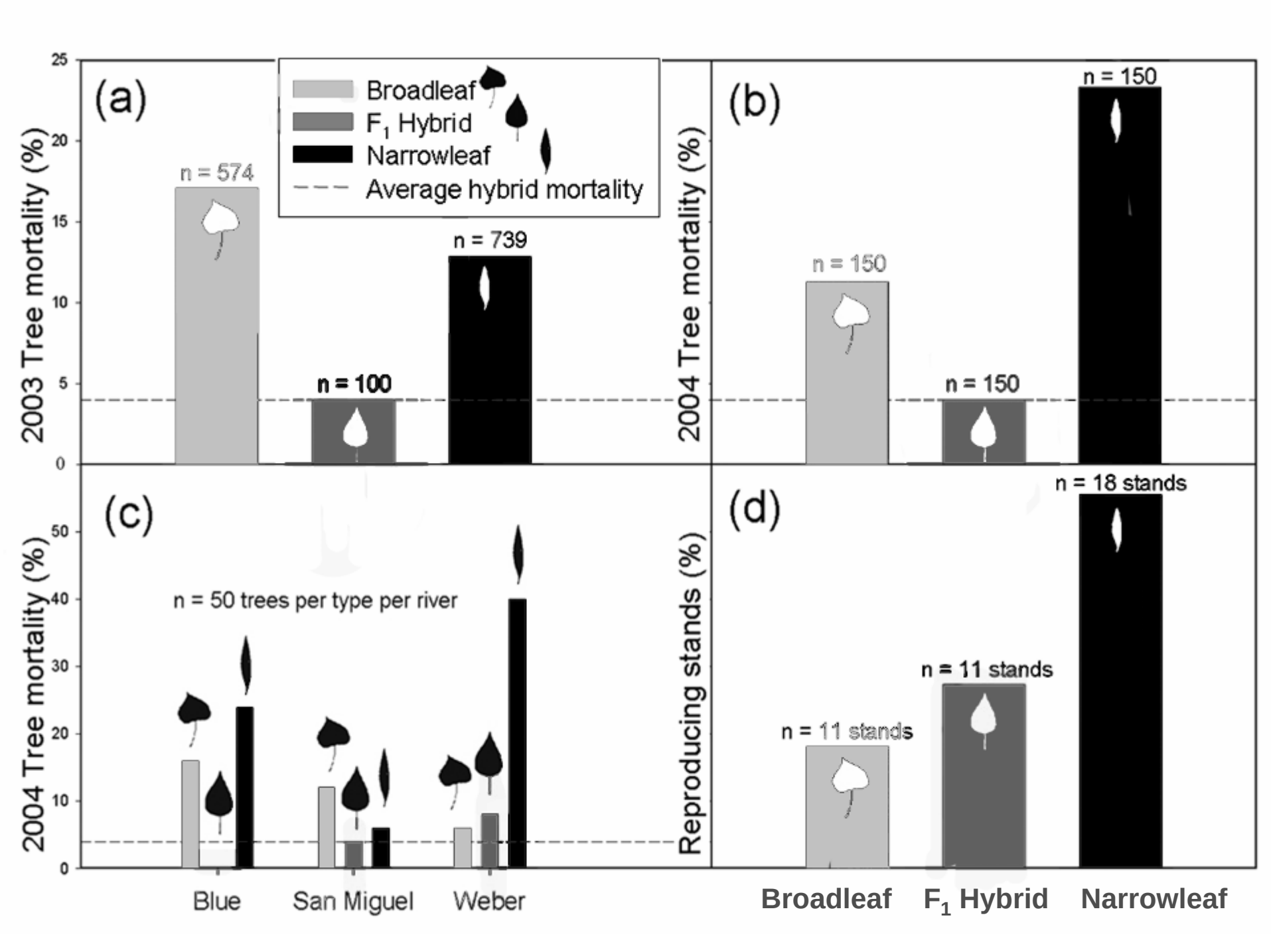
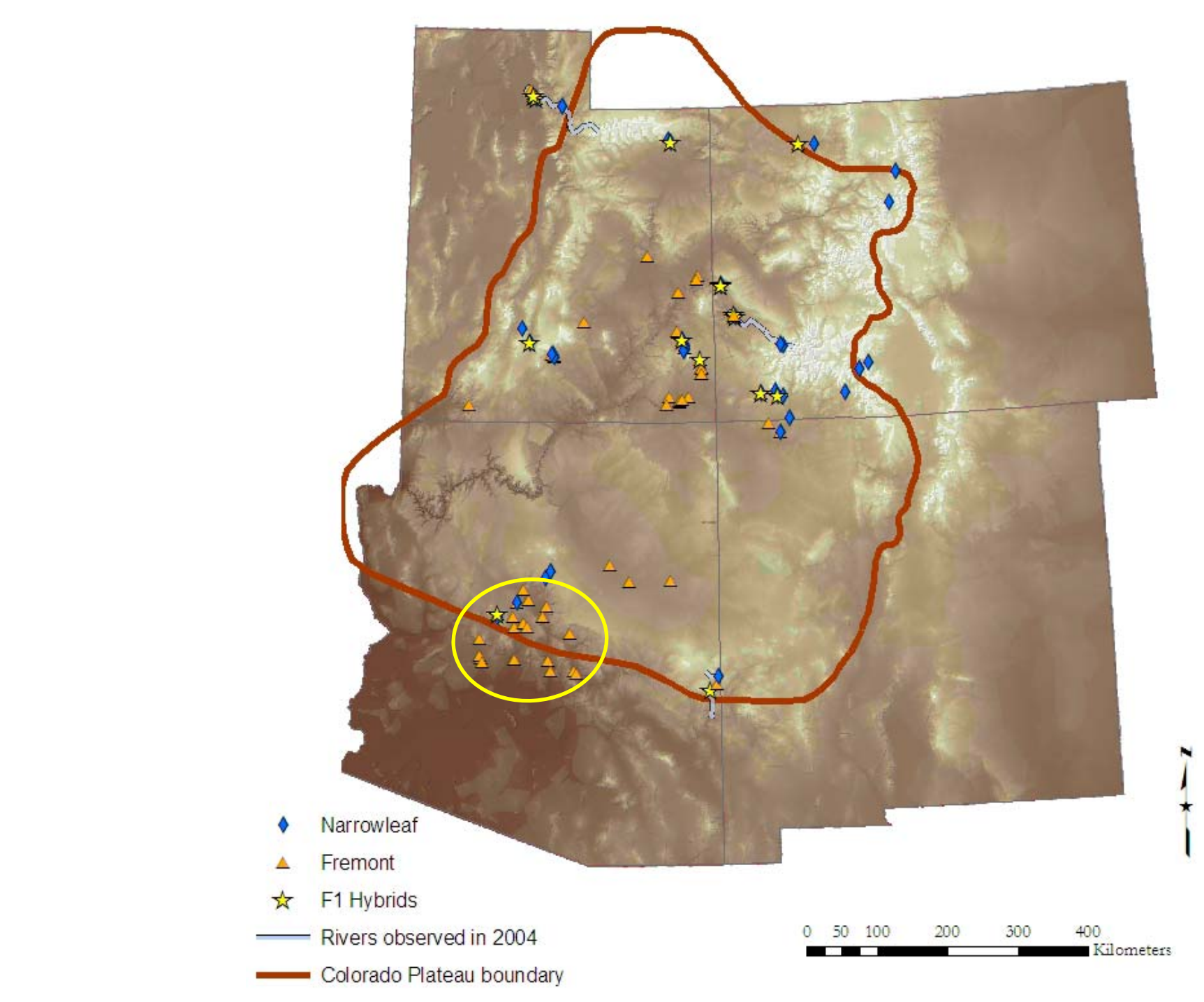

(a)
Broadleaf
F1 Hybrid
Narrowleaf
Average hybrid mortality
2003 Tree mortality (%)
n = 574
n = 100
n = 739
(b)
2004 Tree mortality (%)
n = 150
n = 150
n = 150
(c)
2004 Tree mortality (%)
n = 50 trees per type per river
Blue
San Miguel
Weber
(d)
Reproducing stands (%)
n = 11 stands
n = 11 stands
n = 18 stands
Broadleaf
F1 Hybrid
Narrowleaf

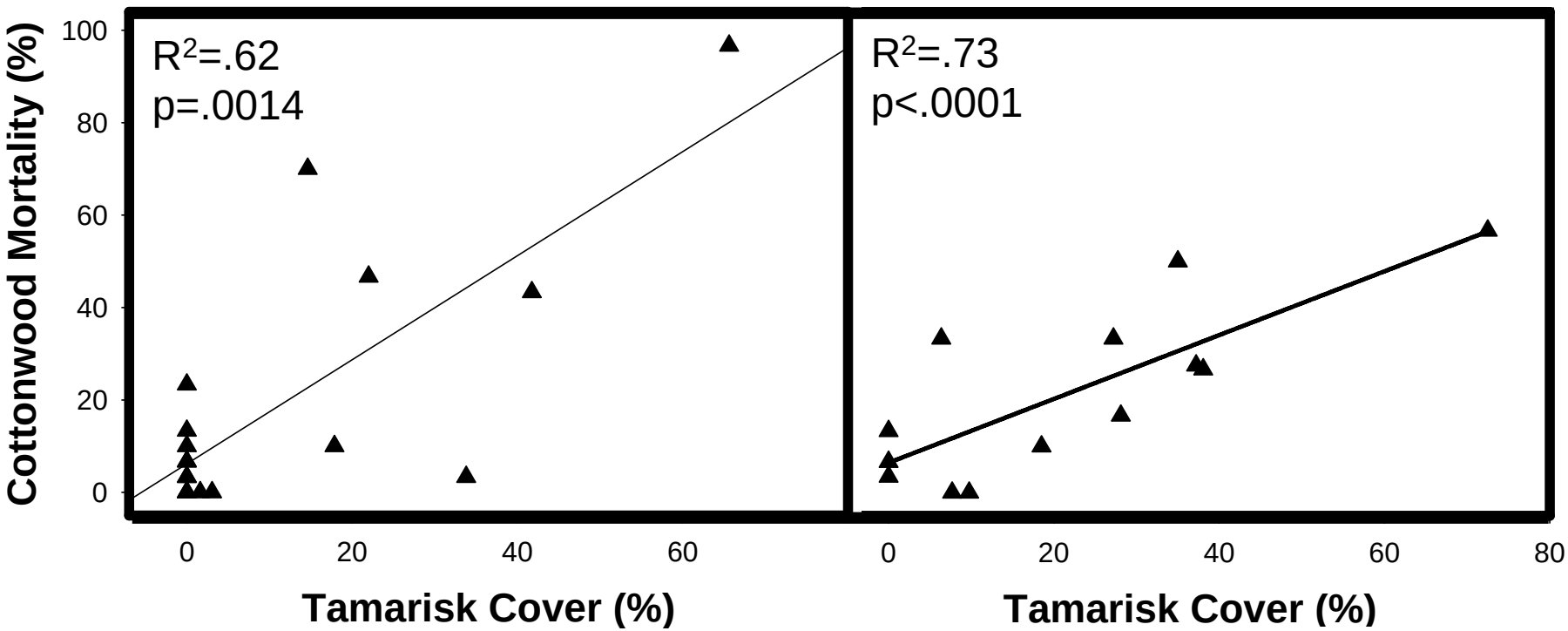

photo by Scott Woolbright


Narrowleaf
Fremont
F1 Hybrids
Rivers observed in 2004
Colorado Plateau boundary
0 50 100 200 300 400
Kilometers
N

Tamarisk Cover and Cottonwood Mortality

Central AZ Watersheds

Colorado Plateau



Summary:

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

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~ Parent species showed high variability in mortality levels between sites

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

~ Parent species showed high variability in mortality levels between sites

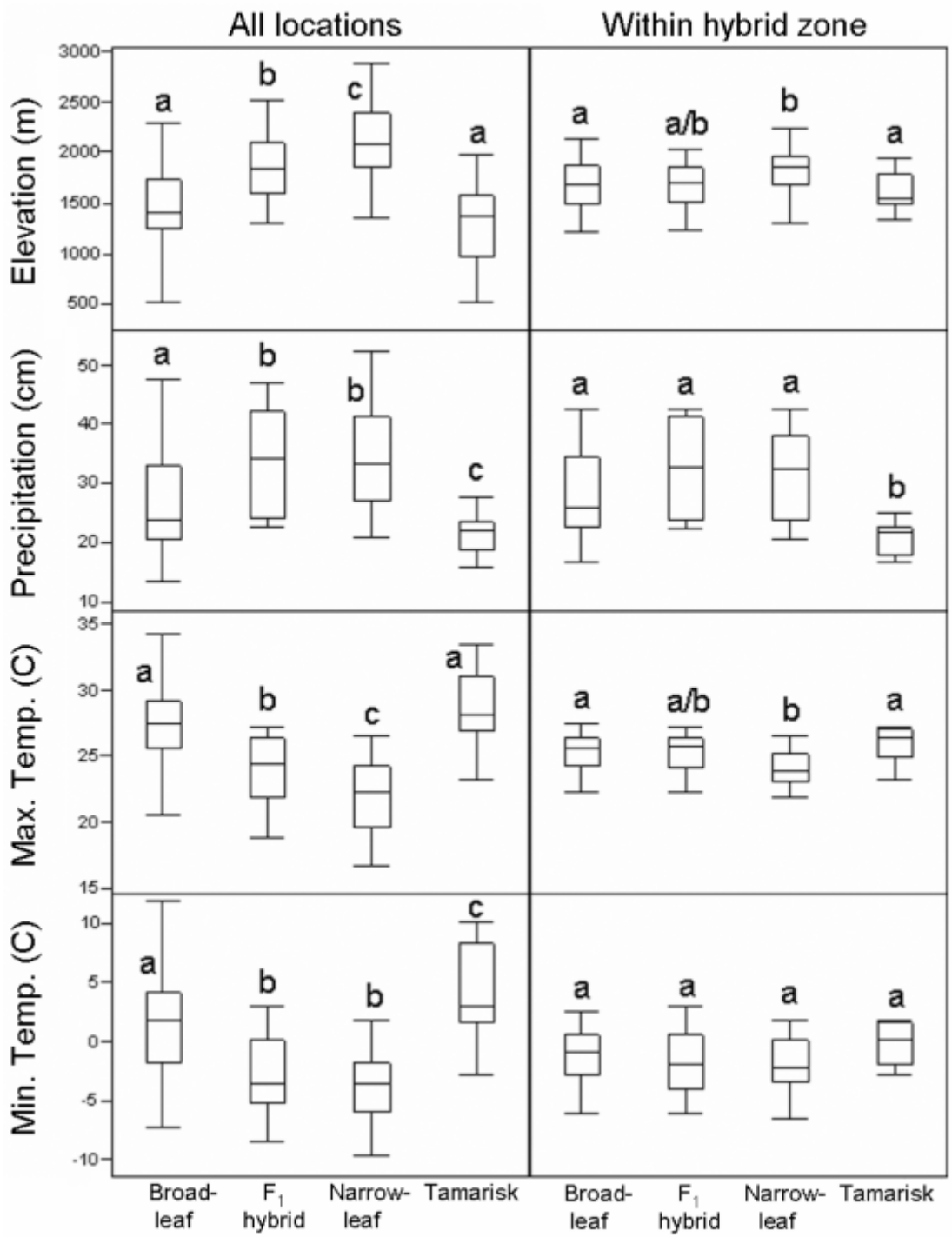
~ Trees capable of clonal reproduction reproduced at a higher rate during drought

Summary:

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

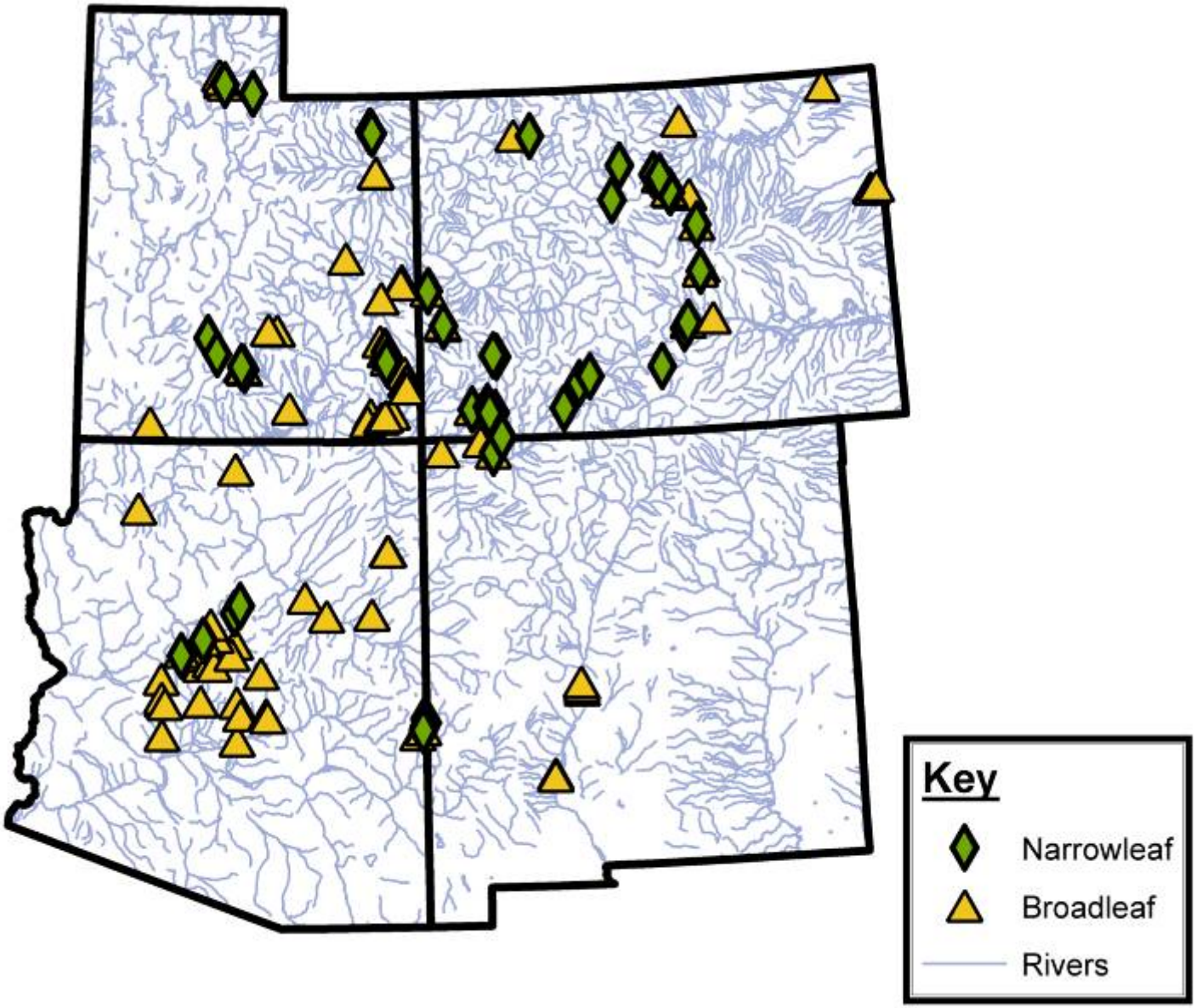
Hypothesis 2:

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


All locations
Within hybrid zone
Elevation (m)
Precipitation (cm)
Max. Temp. (C)
Min. Temp. (C)
3000
2500
2000
1500
1000
500
50
40
30
20
10
35
30
25
20
15
10
5
0
-5
-10
a
b
c
a
a
a/b
b
a
a
b
b
c
a
a
a
b
a
b
c
a
a
a/b
b
a
a
b
c
a
a
a
a
Broad-leaf
F1 hybrid
Narrow-leaf
Tamarisk
Broad-leaf
F1 hybrid
Narrow-leaf
Tamarisk


Spatial
Modelling

Input to GARP software:



Validations:

1) Large scale:

F_1 Hybrid locations in predicted hybrid zone

2) Regional scale:

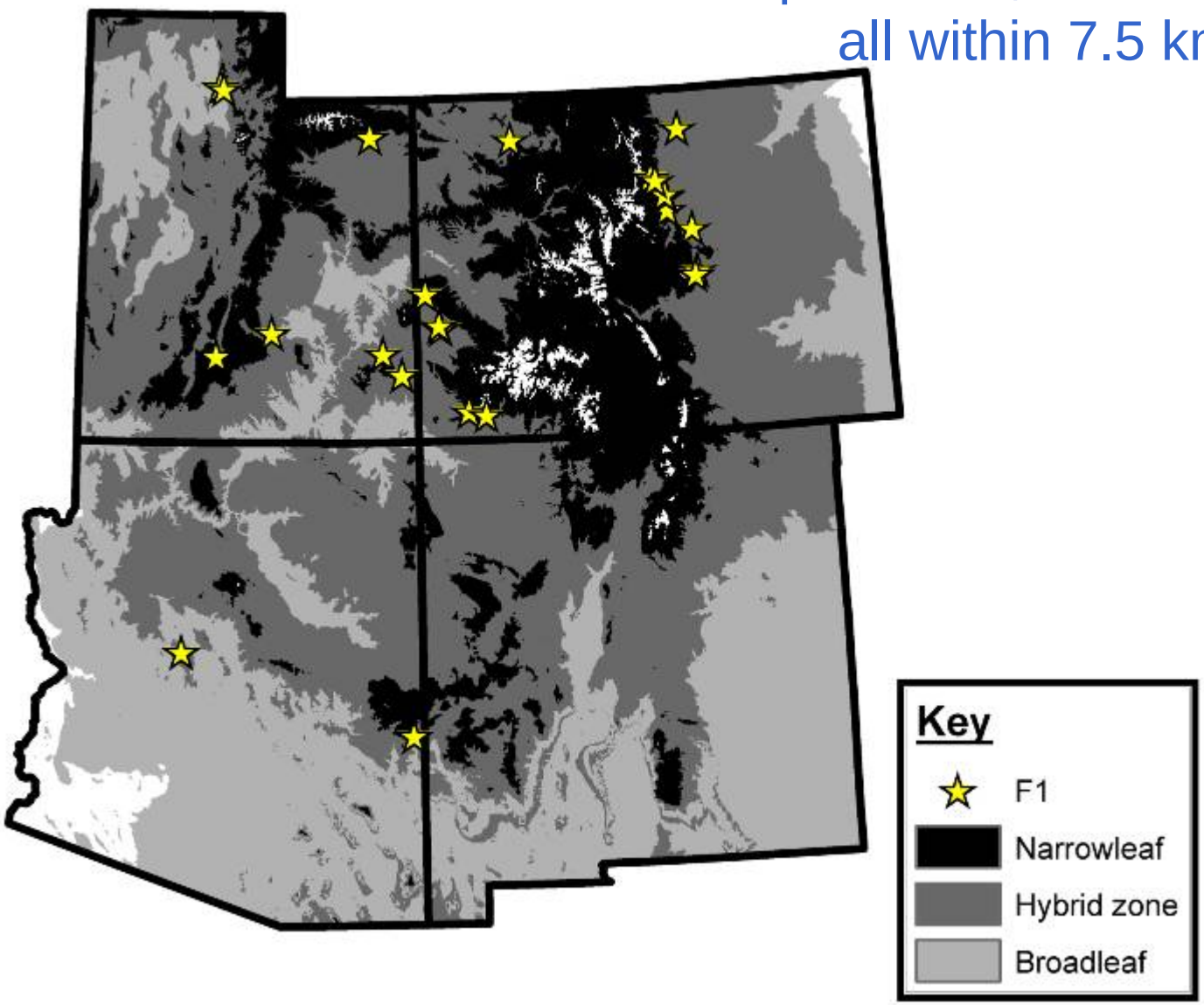
Ground truthing in southern Utah

3) River scale:

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

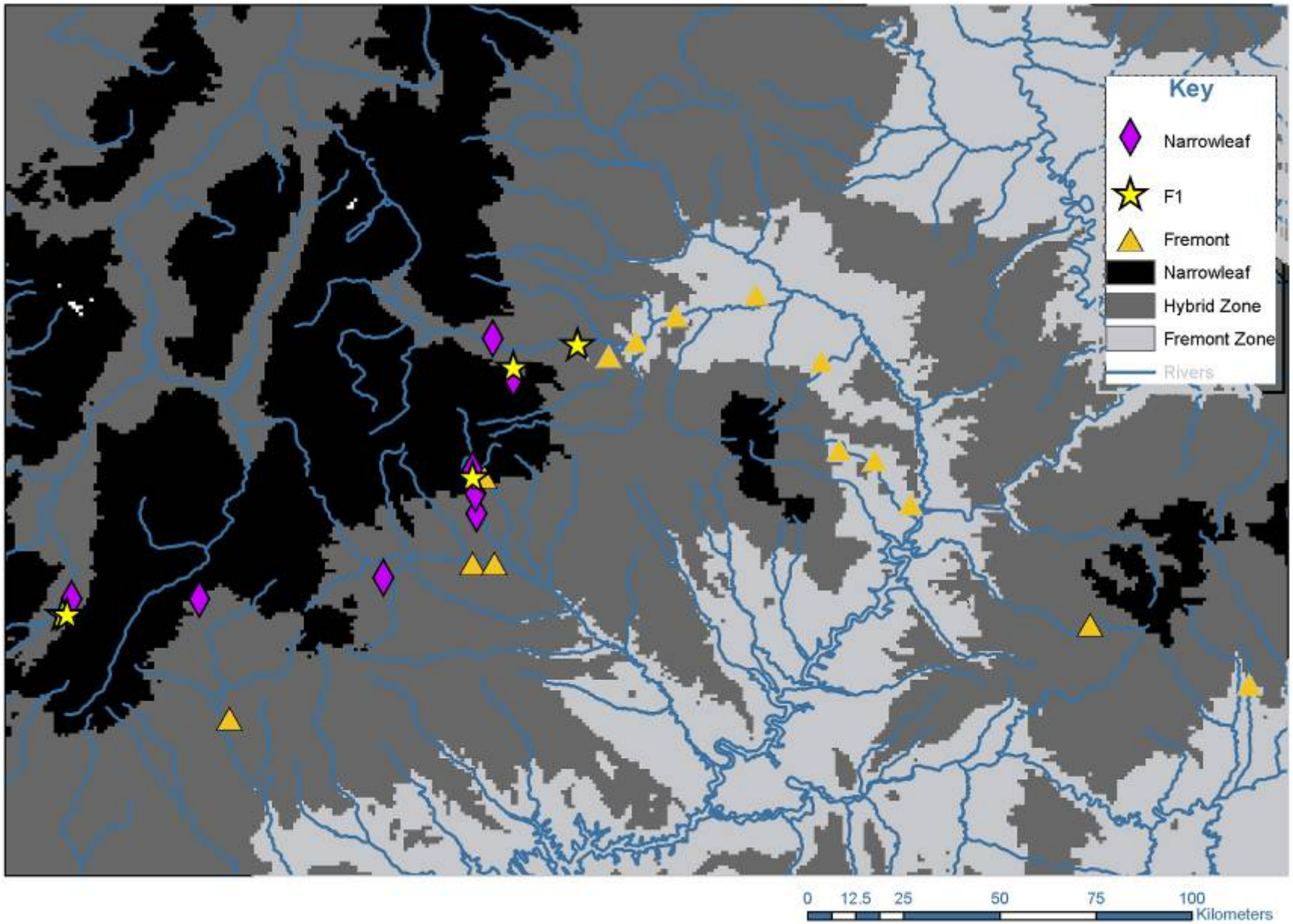
Validation 1:

(n = 25)
19 predicted, p = 0.001
6 unpredicted,
all within 7.5 km (8 pixels)



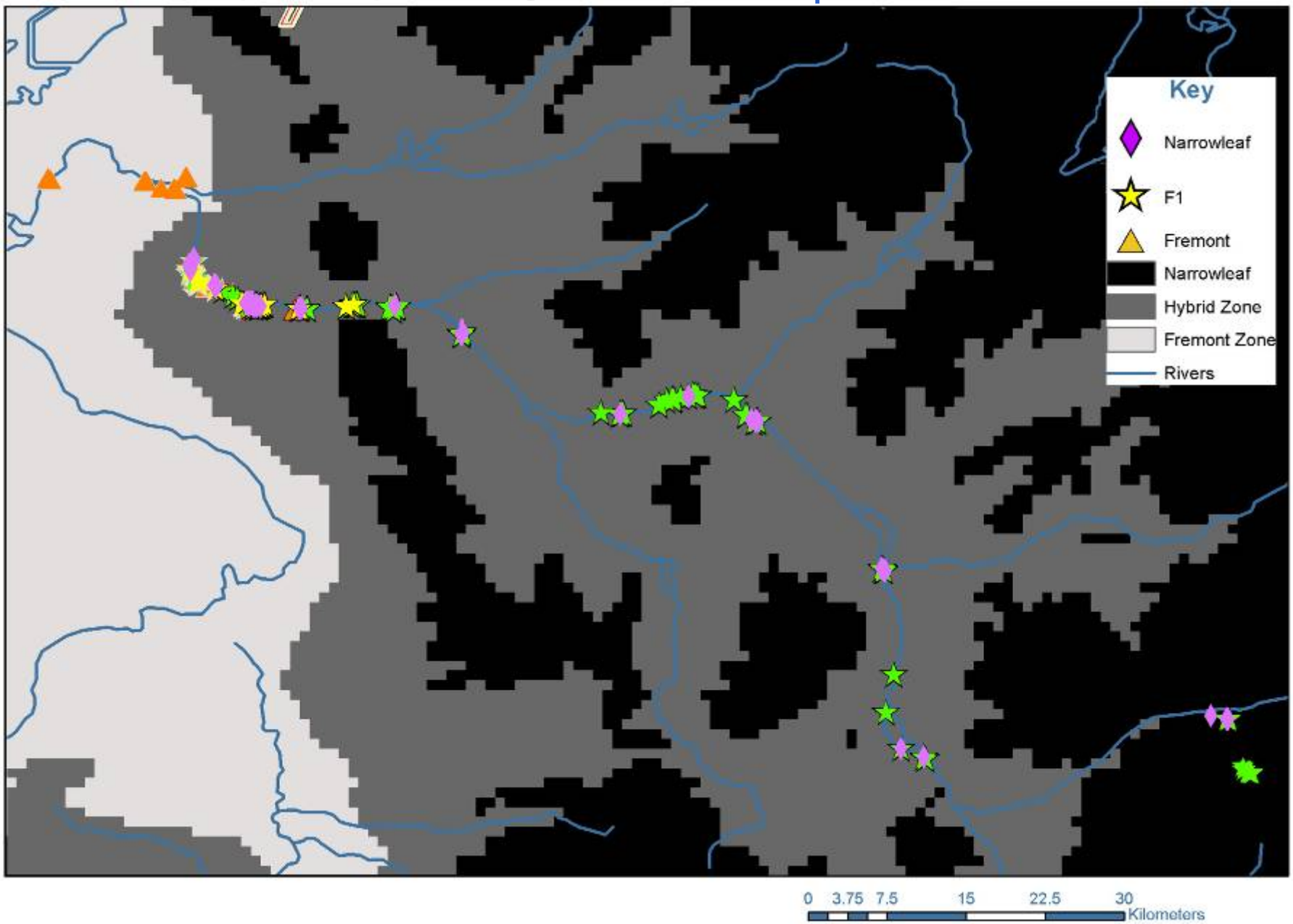
Validation 2:

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

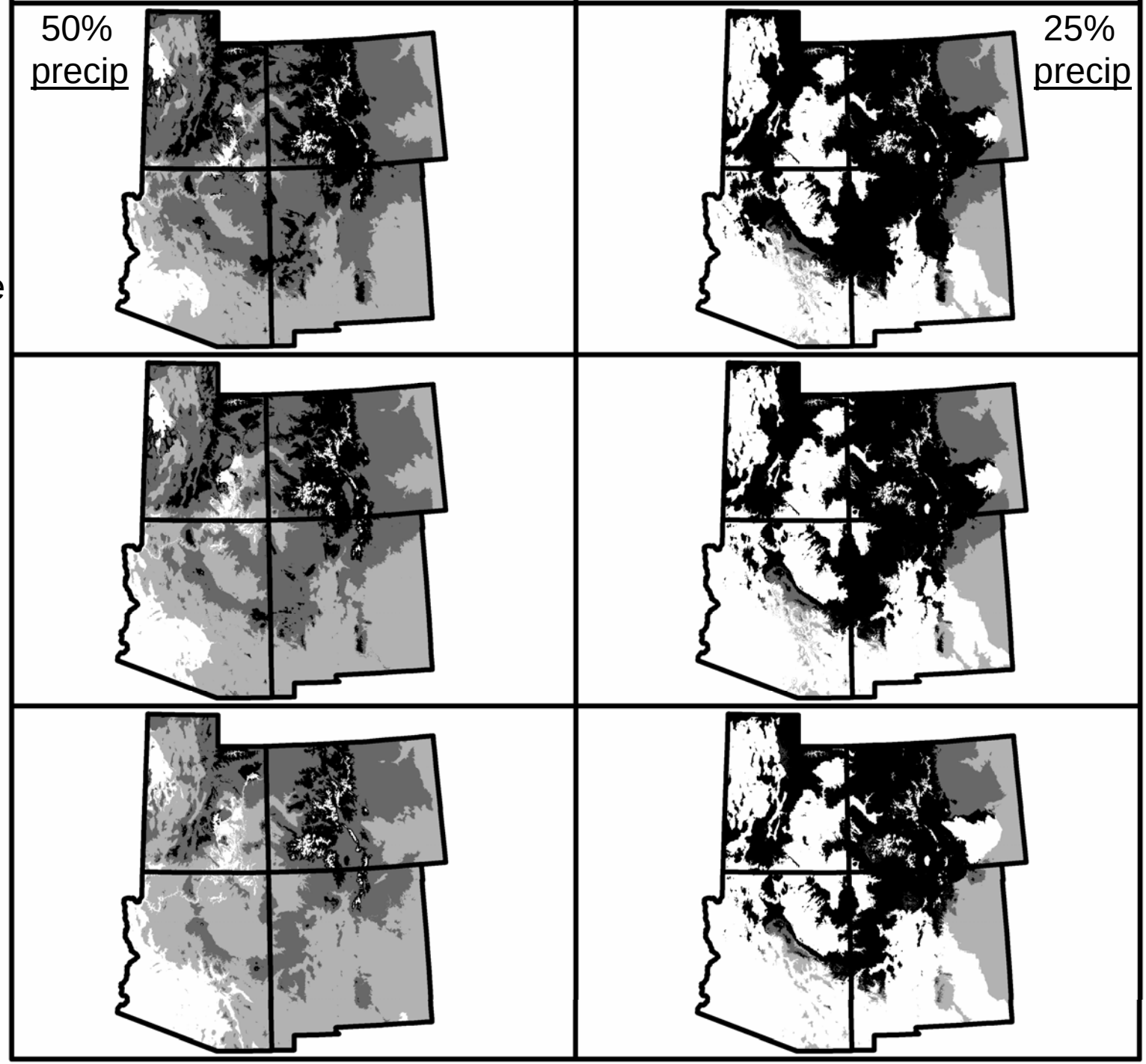


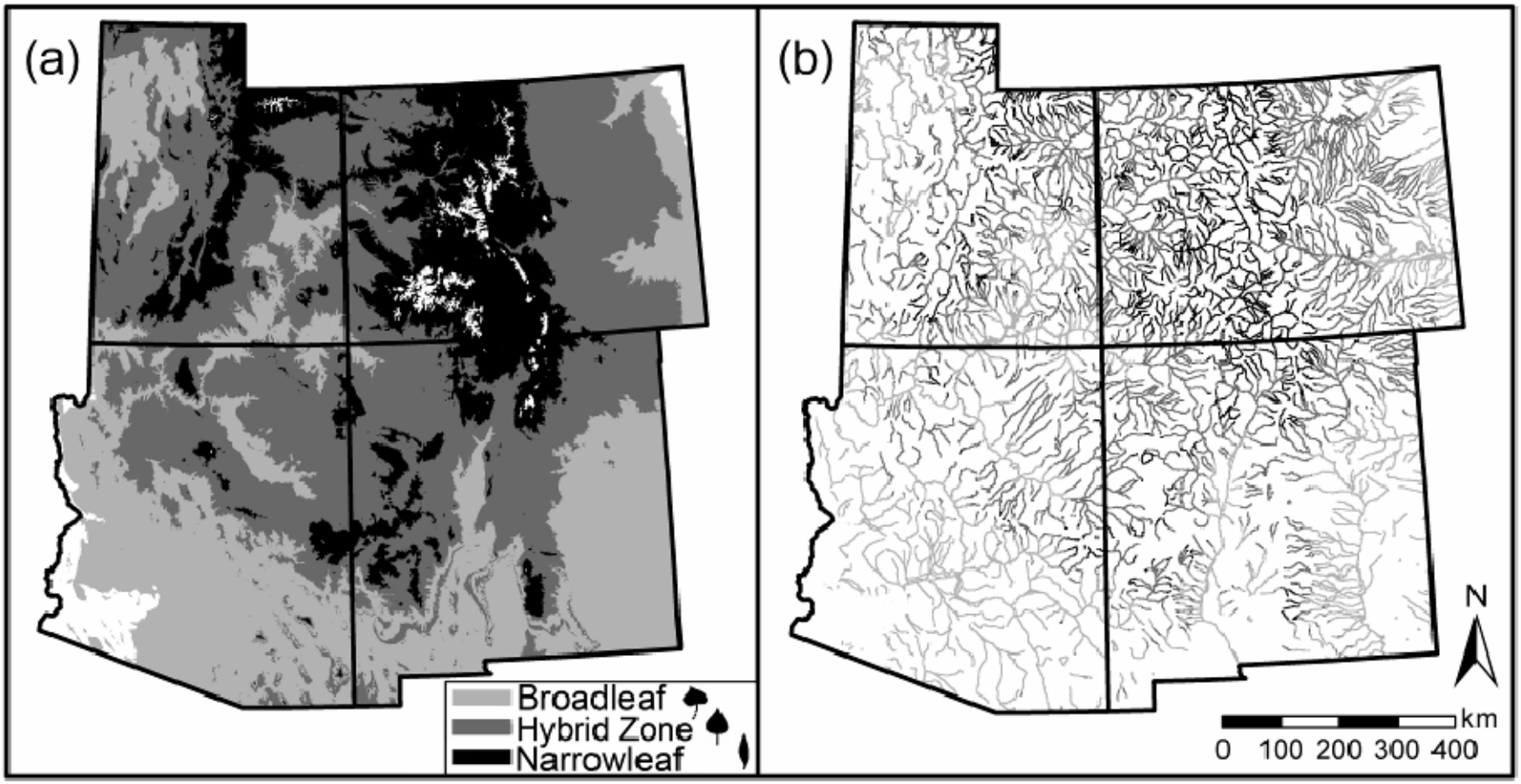
Validation 3:

(n = 1038)
18 unpredicted, all within 8 km



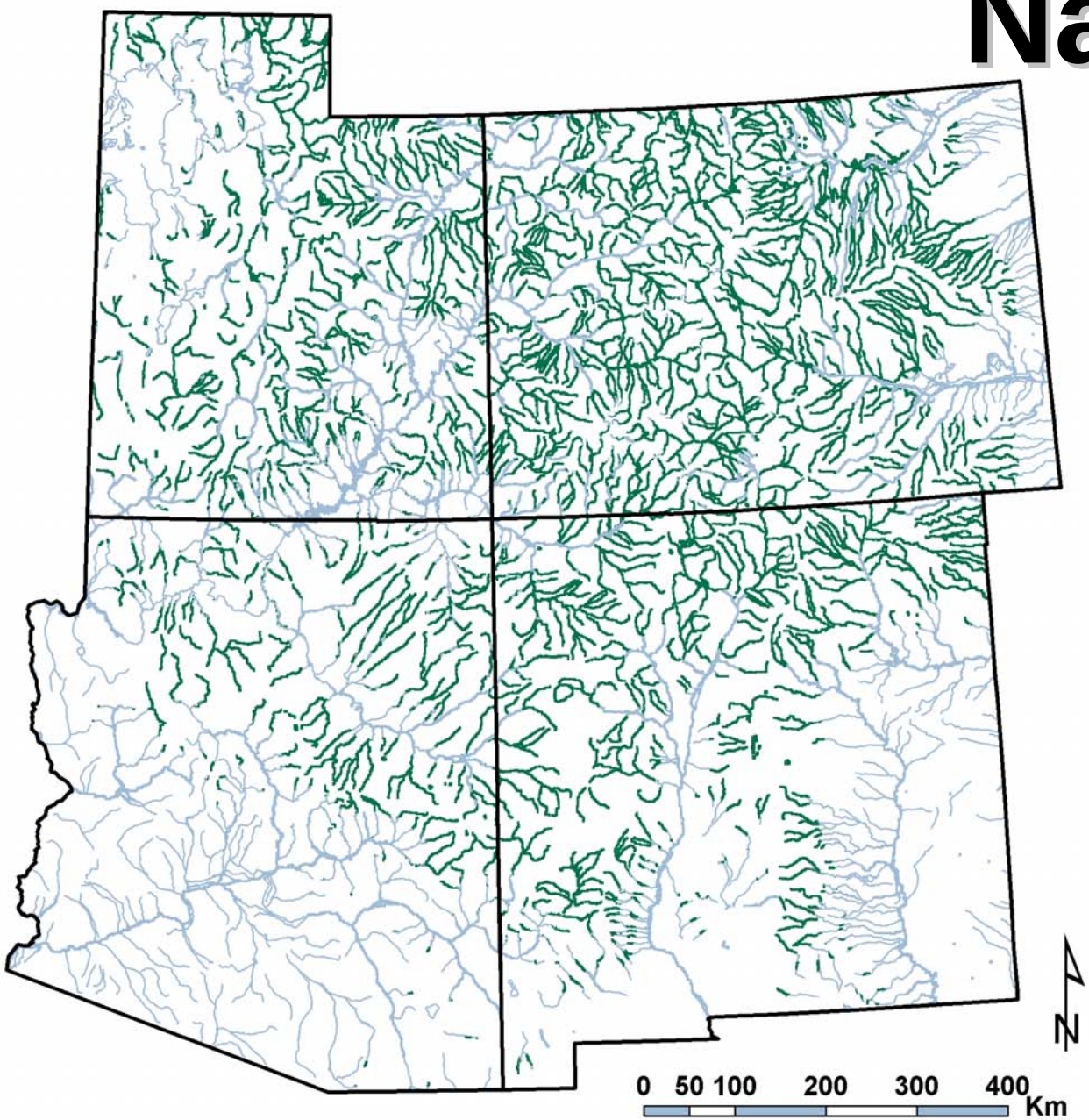
Drought Projections:


50%
precip
25%
precip
current
average
temp
current
average
temp
+ 1.5 C
+ 1.5 C
+ 4 C
+ 4 C


(a)
(b)
Broadleaf
Hybrid Zone
Narrowleaf
N
km
0 100 200 300 400

Narrowleaf

Potential Niche

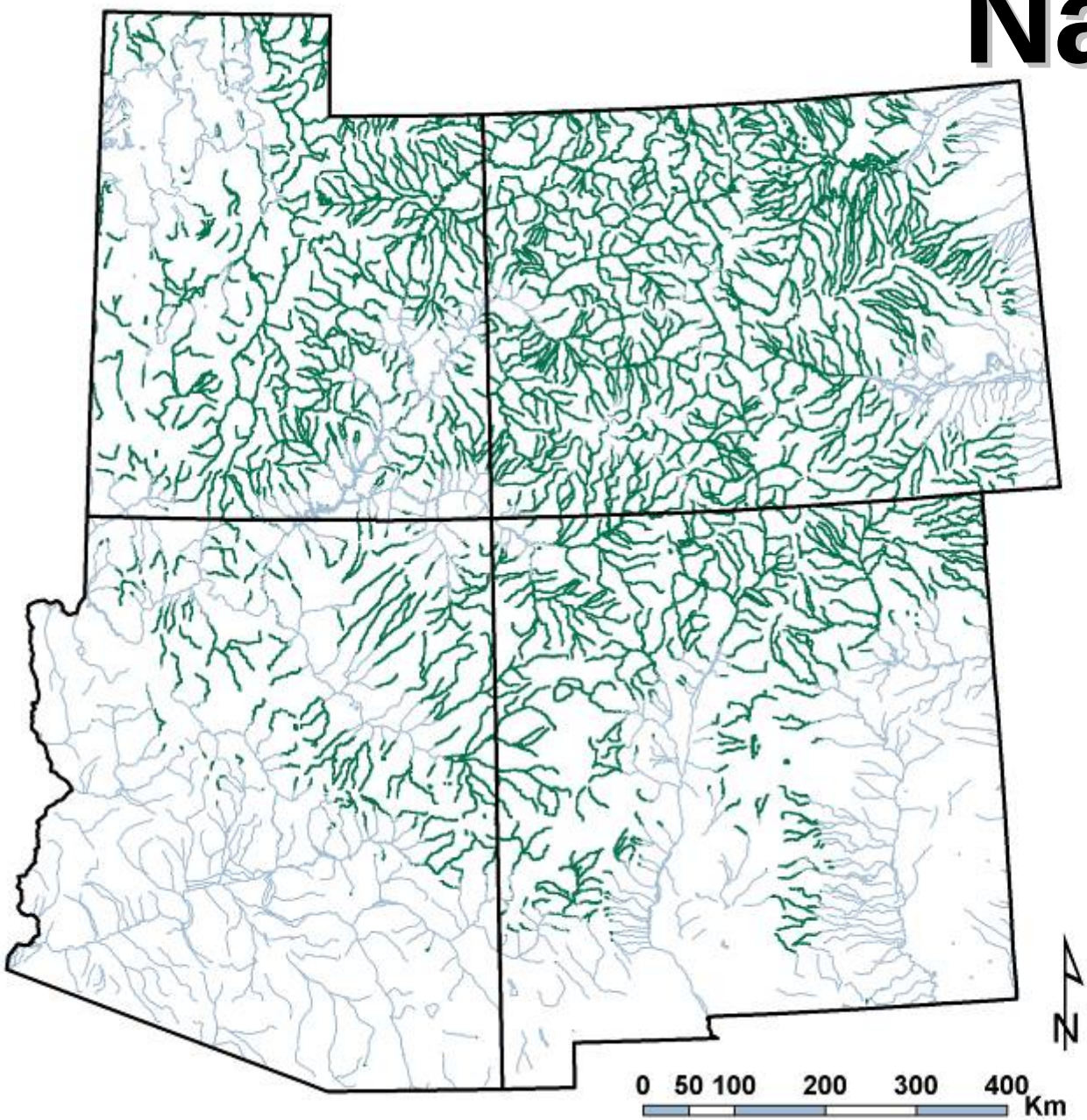


Current Precip.

Current Temp.

Narrowleaf

Potential Niche

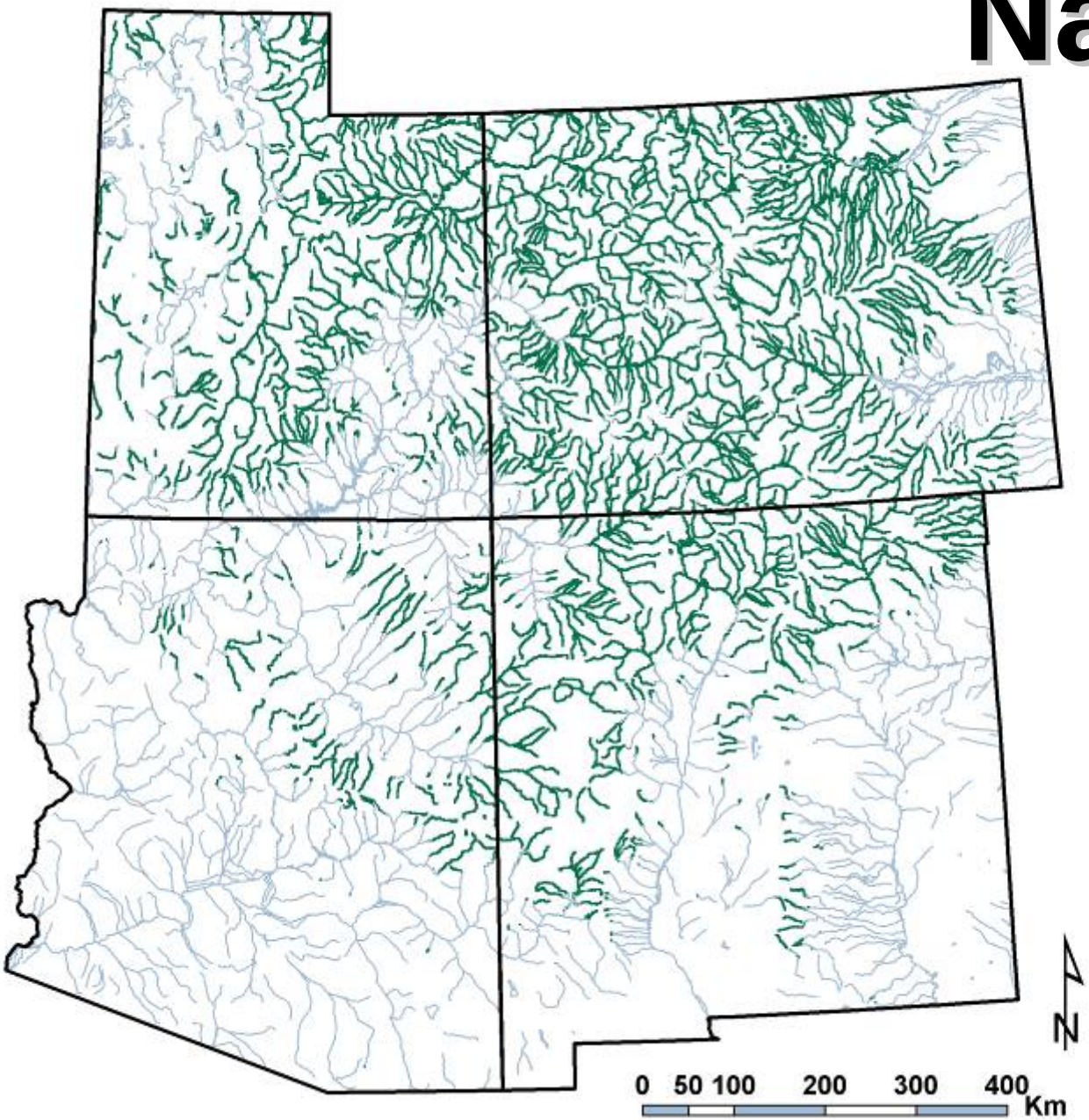


50% Precip.

Current Temp.

Narrowleaf

Potential Niche

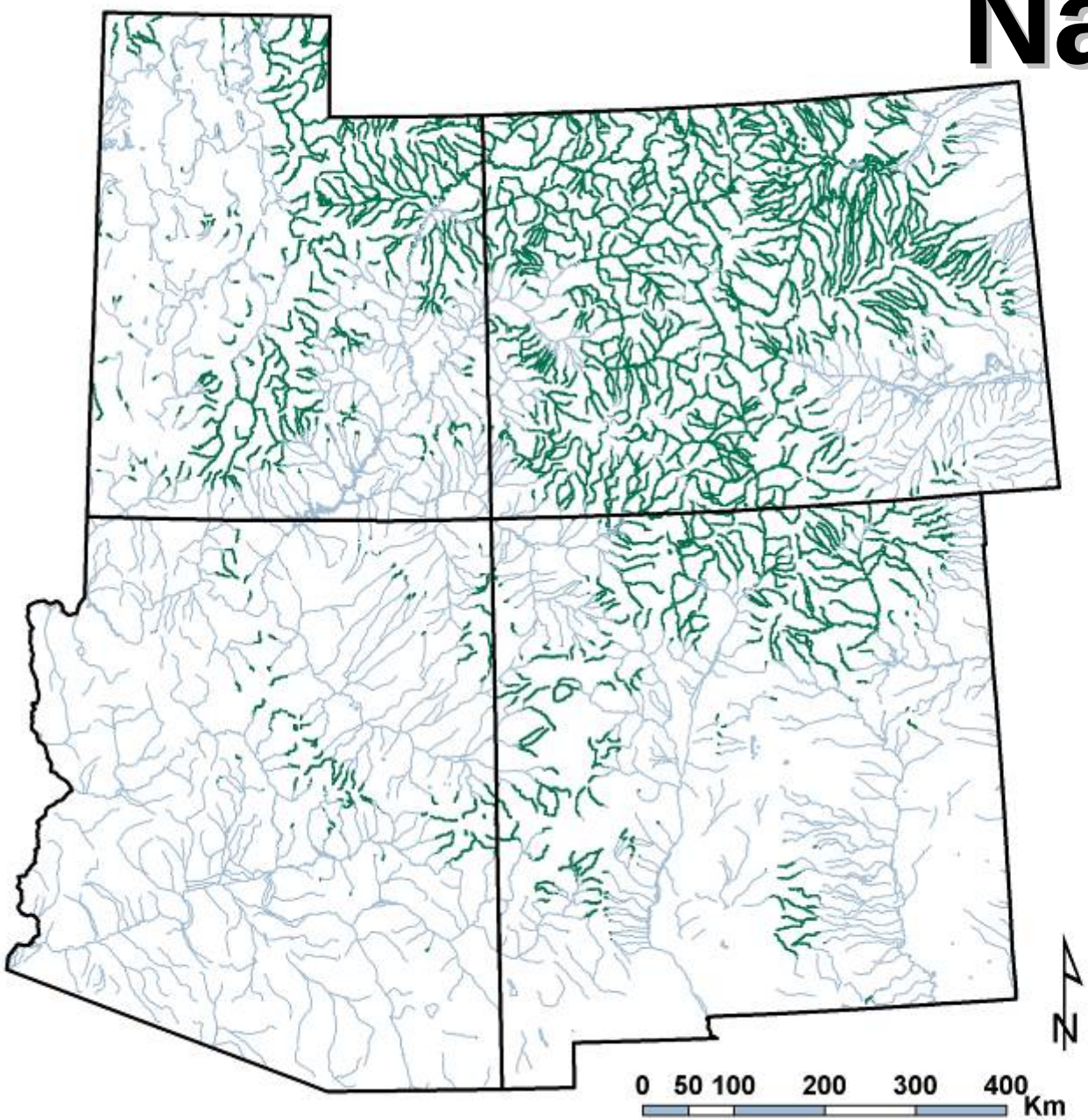


50% Precip.

+ 1.5˚ C

Narrowleaf

Potential Niche

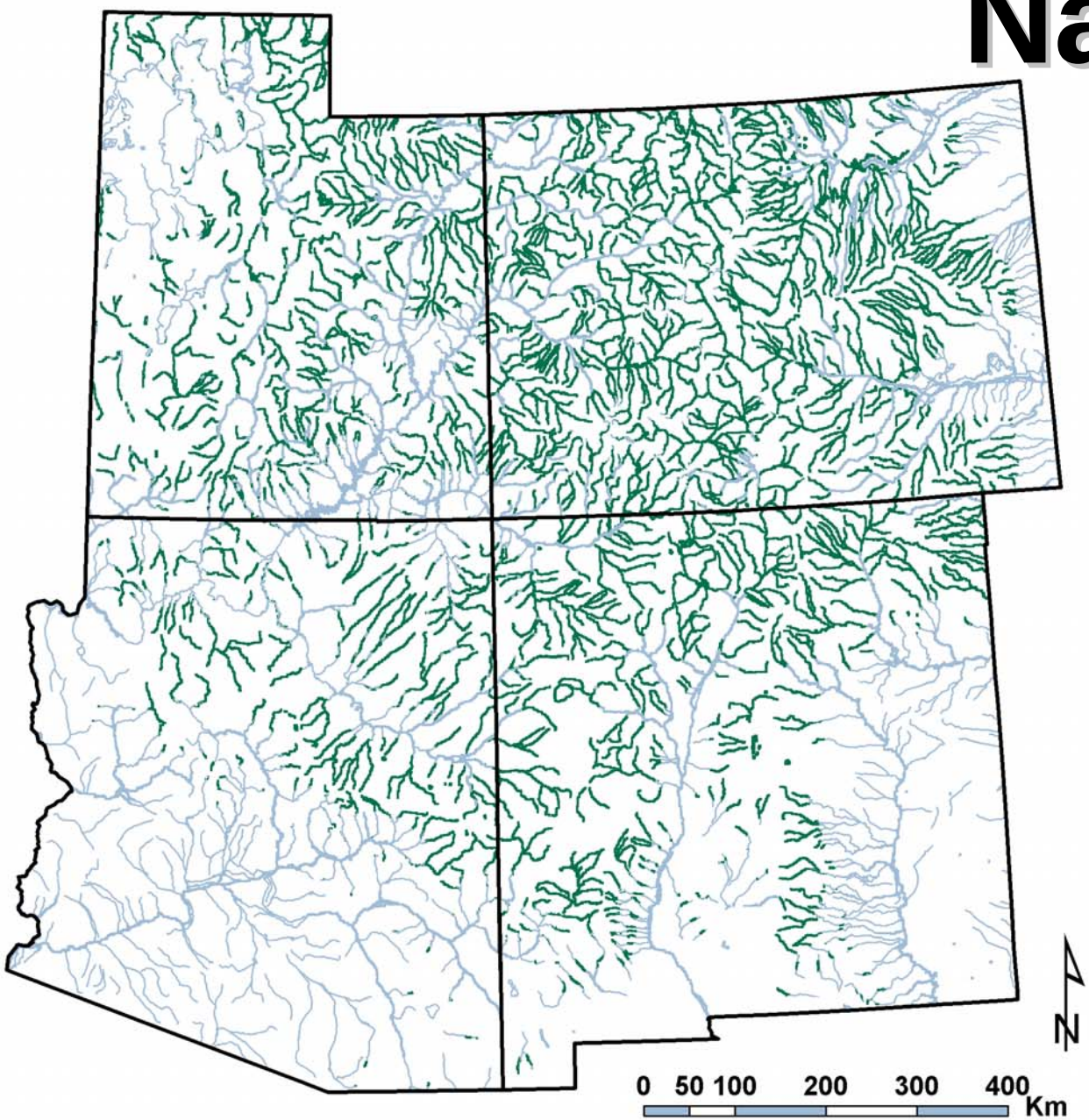


50% Precip.

+ 4° C

Narrowleaf

Potential Niche

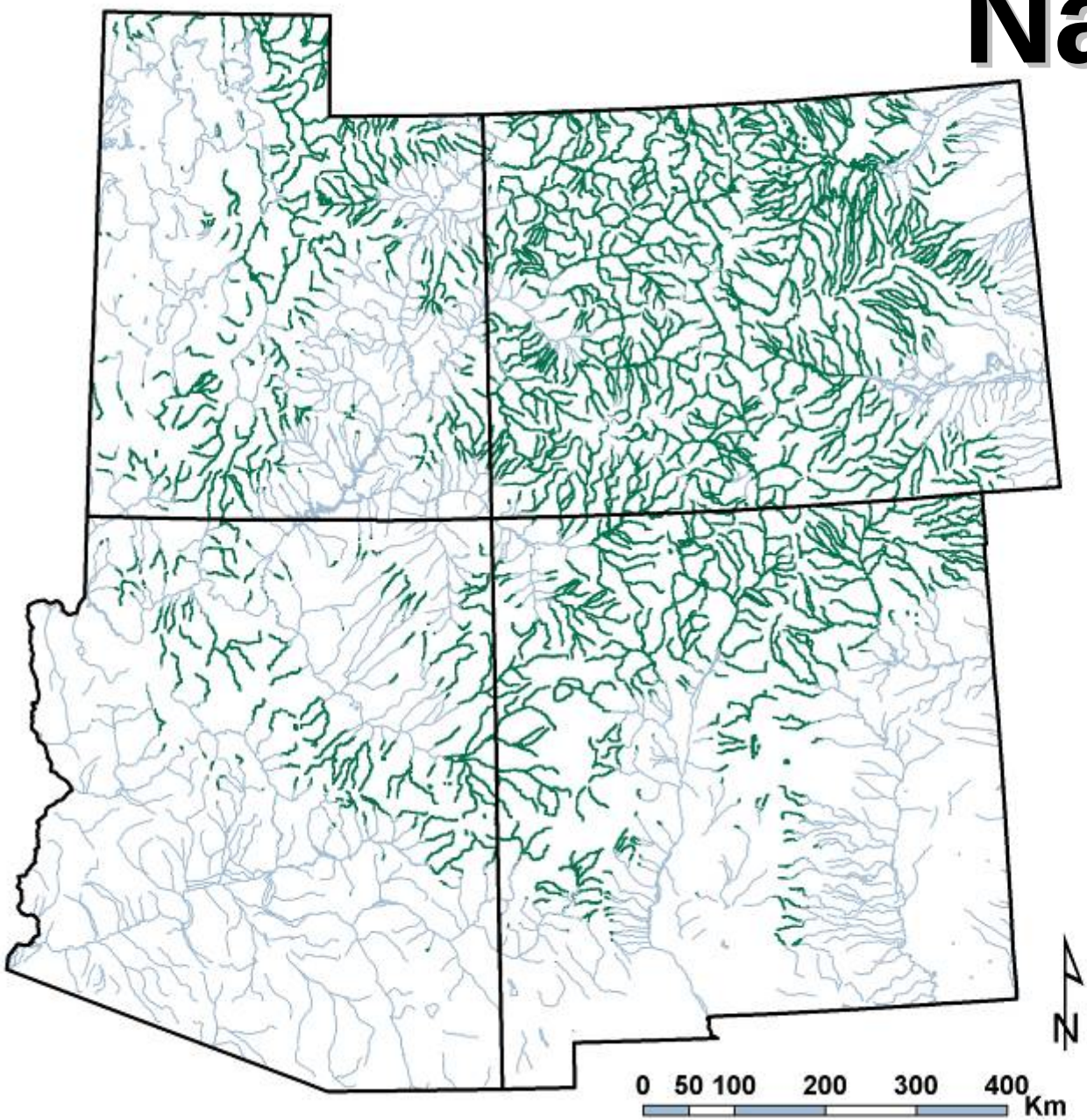


Current Precip.

Current Temp.

Narrowleaf

Potential Niche

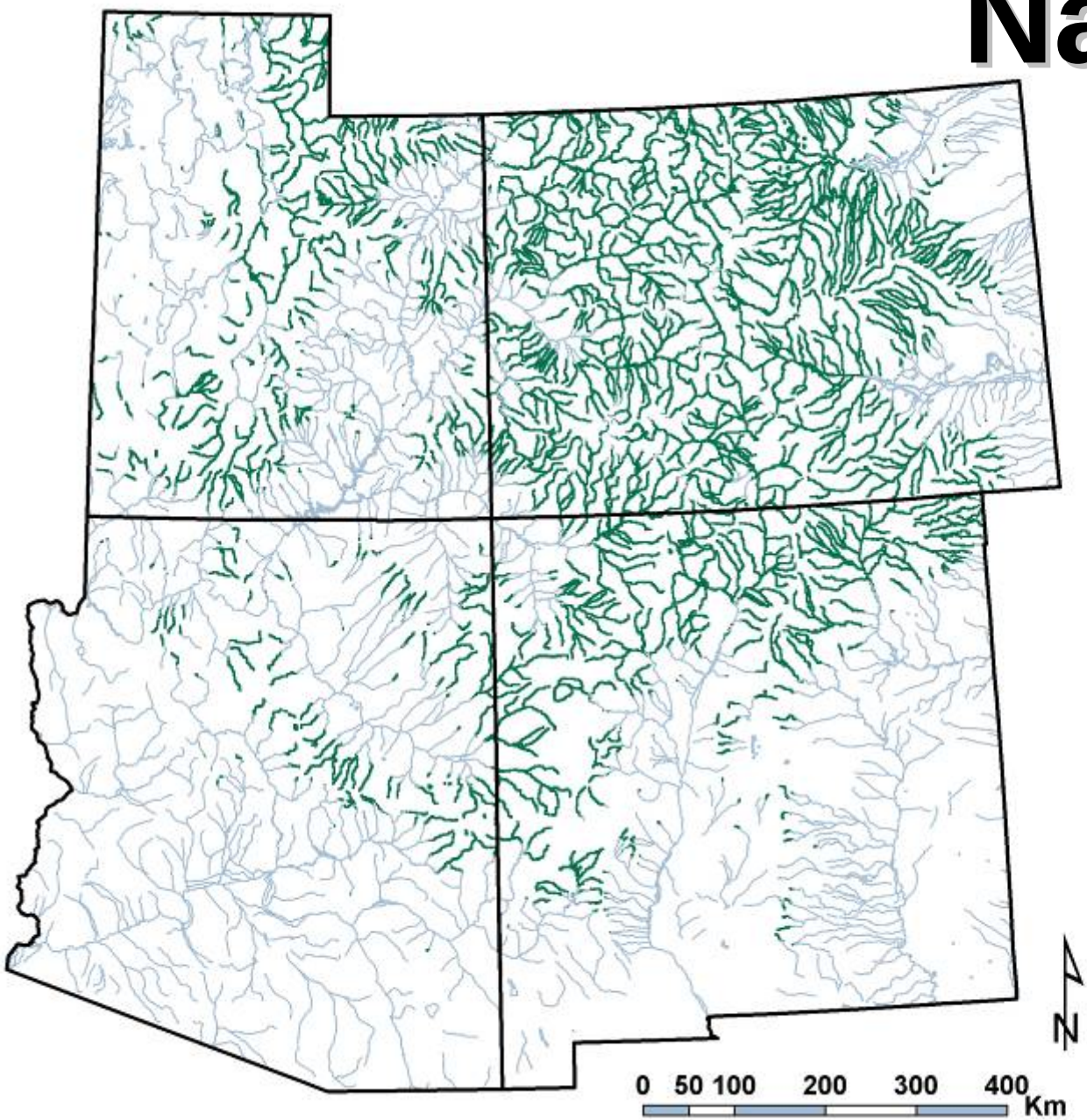


25% Precip.

Current Temp.

Narrowleaf

Potential Niche

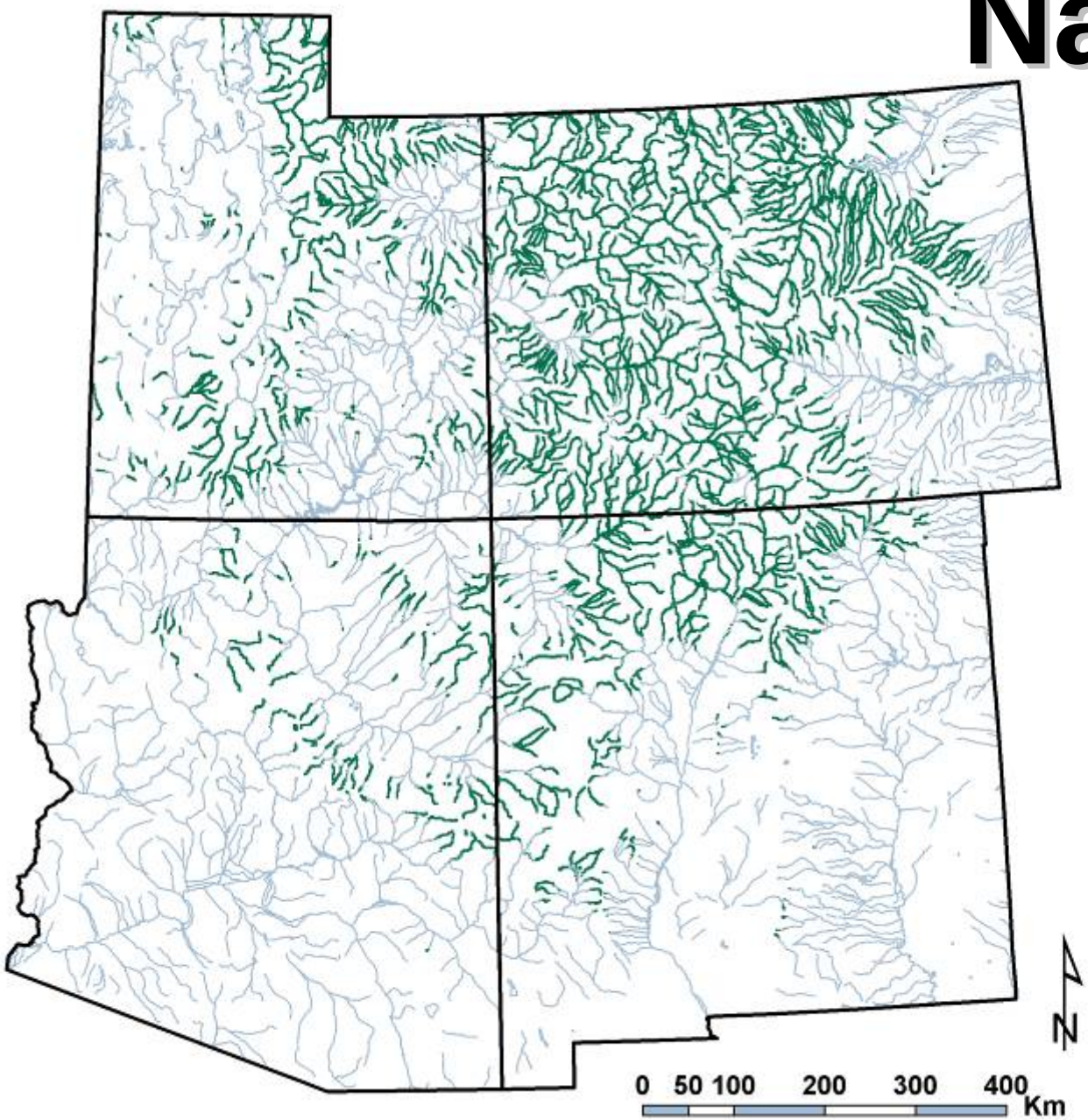


25% Precip.

+ 1.5˚ C

Narrowleaf

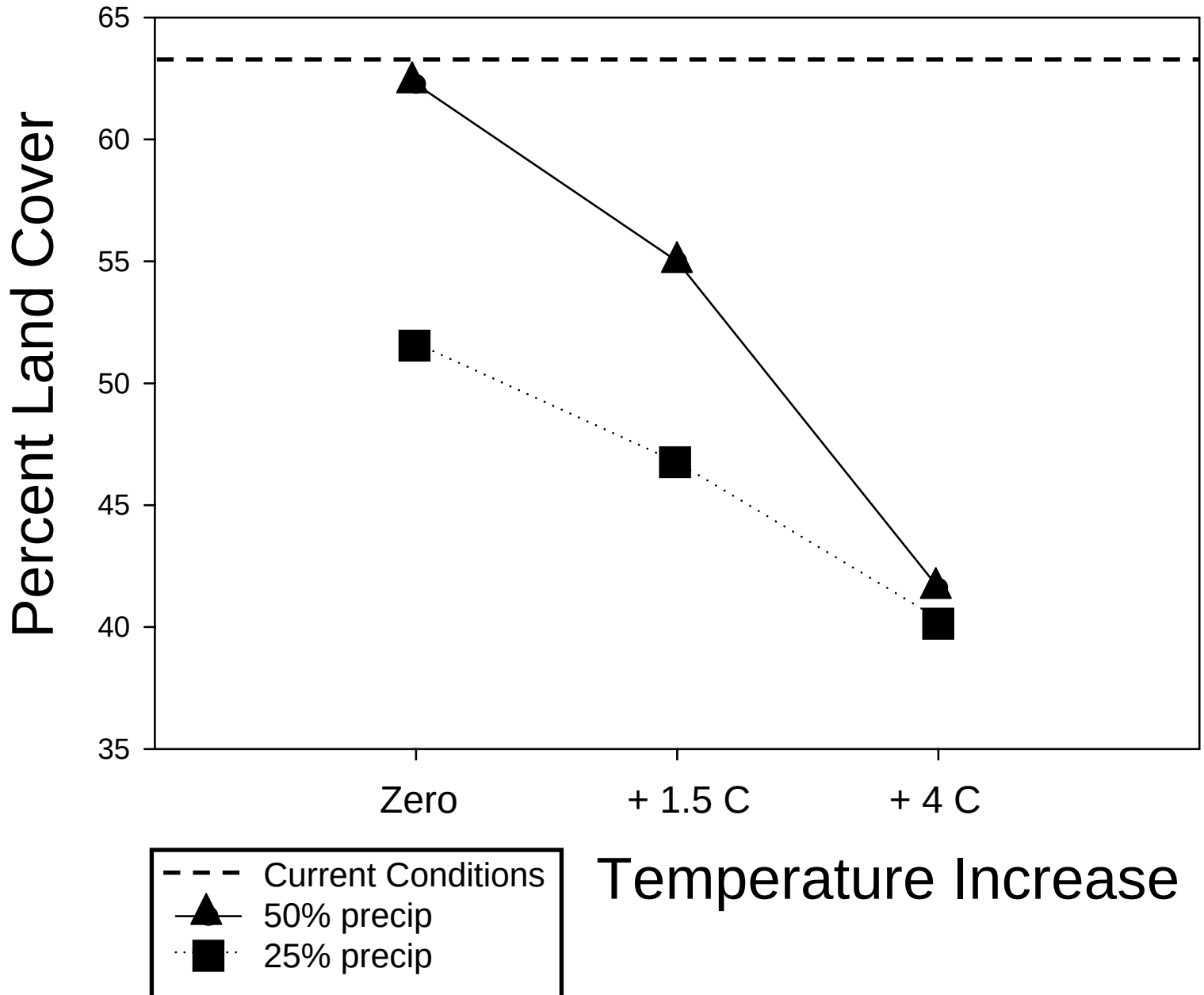
Potential Niche



25% Precip.

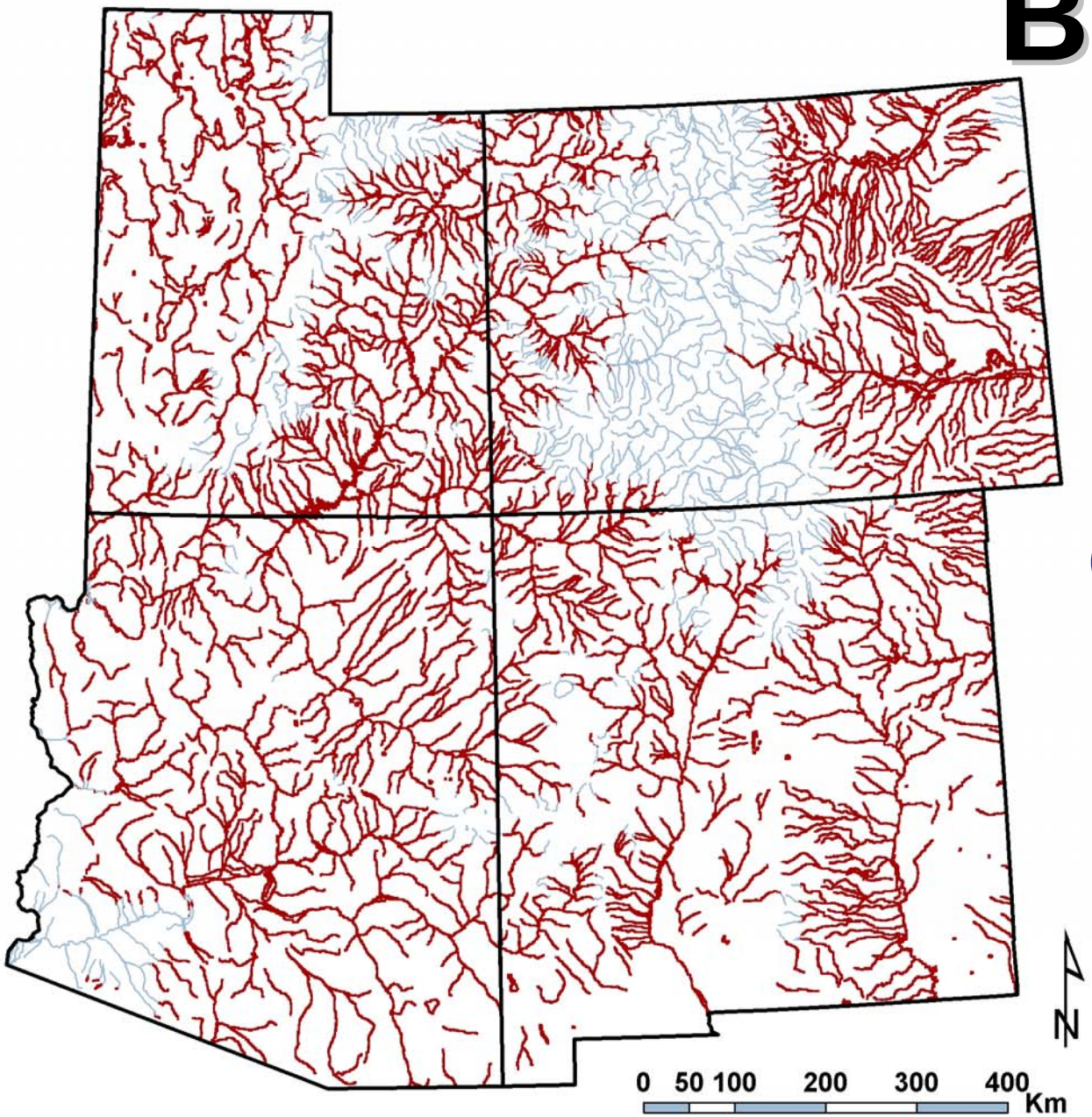
+ 4° C

Narrowleaf: Percent Land Cover



Broadleaf

Potential Niche

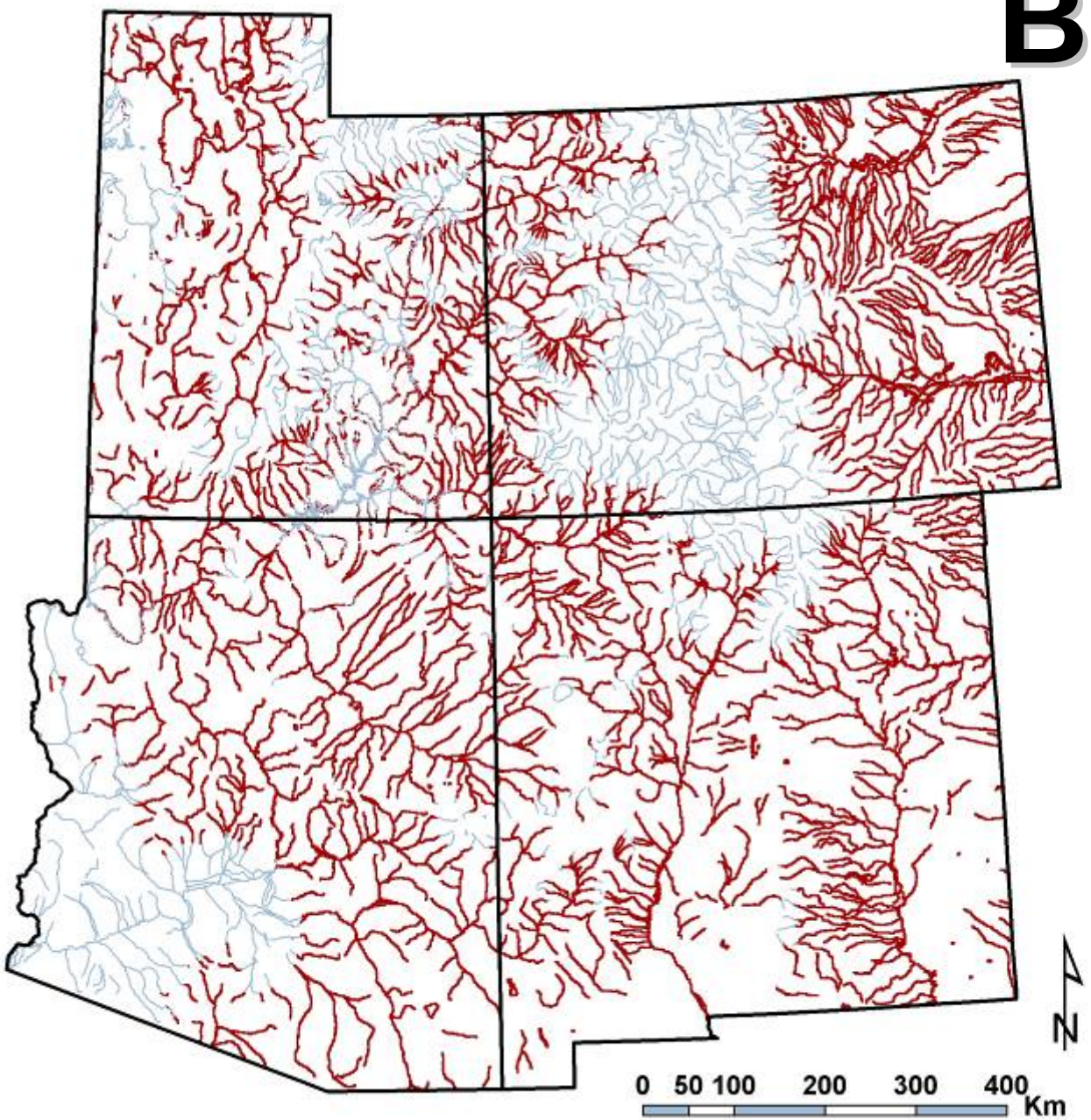


Current Precip.

Current Temp.

Broadleaf

Potential Niche

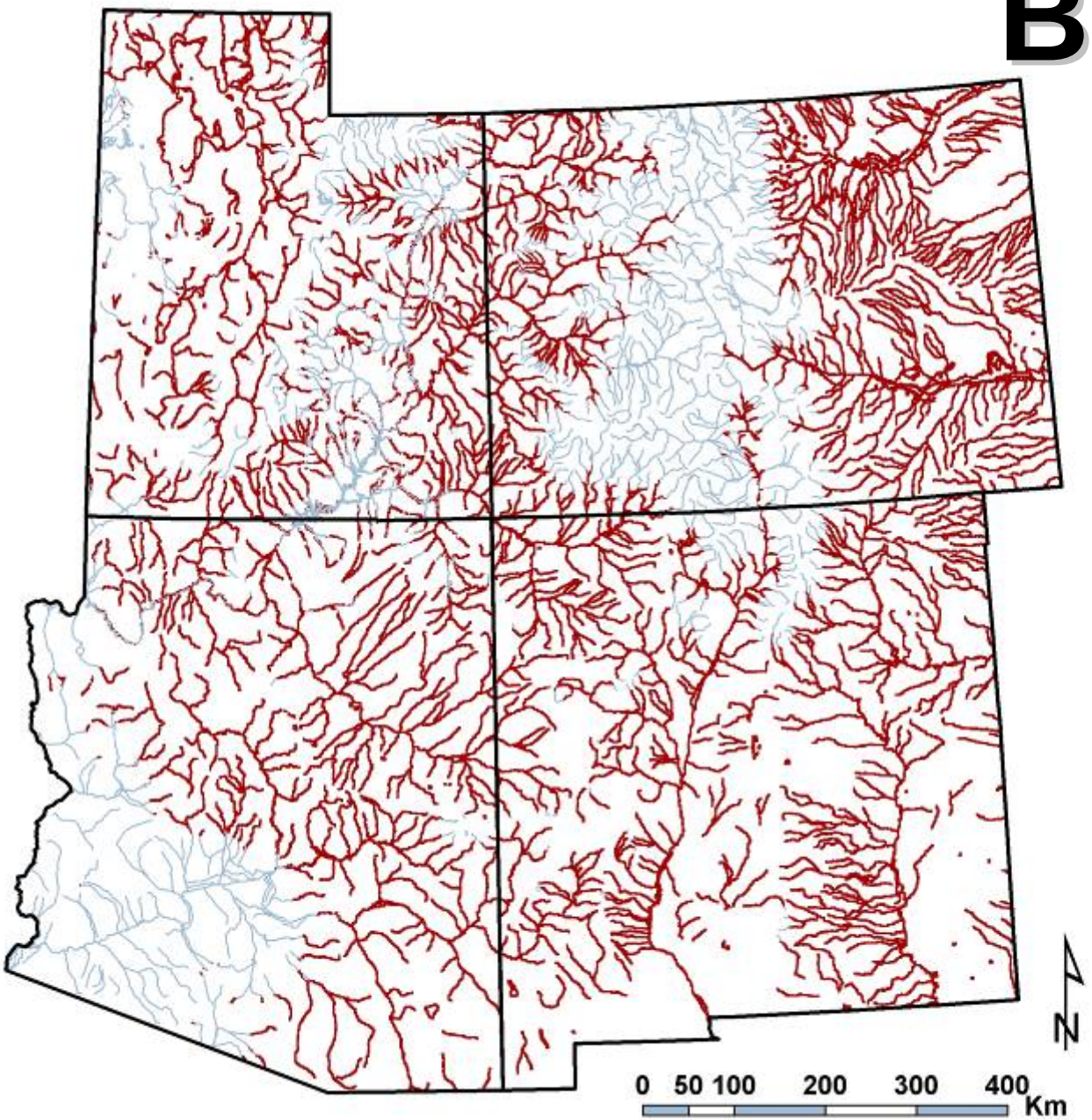


50% Precip.

Current Temp.

Broadleaf

Potential Niche

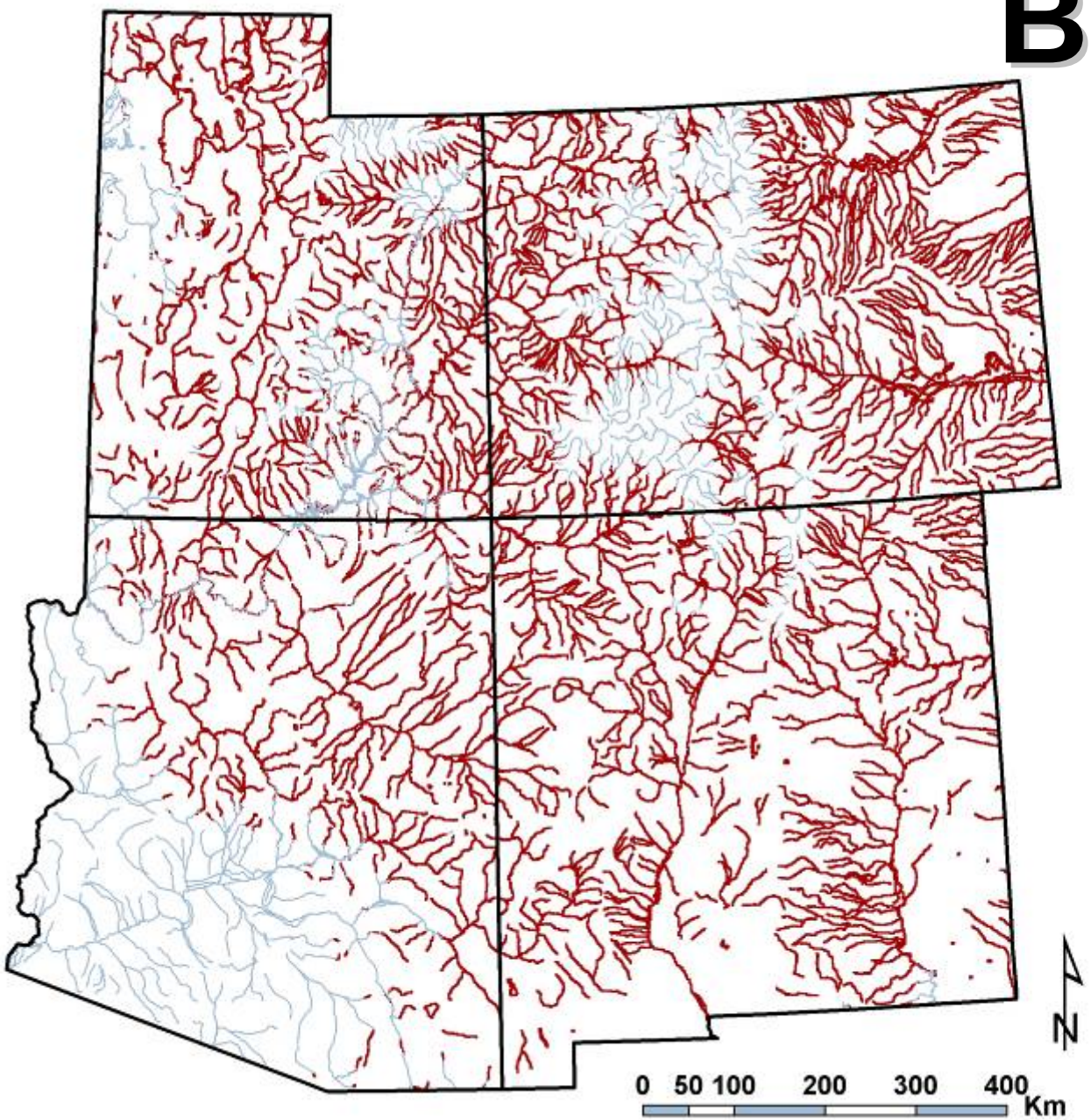


50% Precip.

+ 1.5˚ C

Broadleaf

Potential Niche

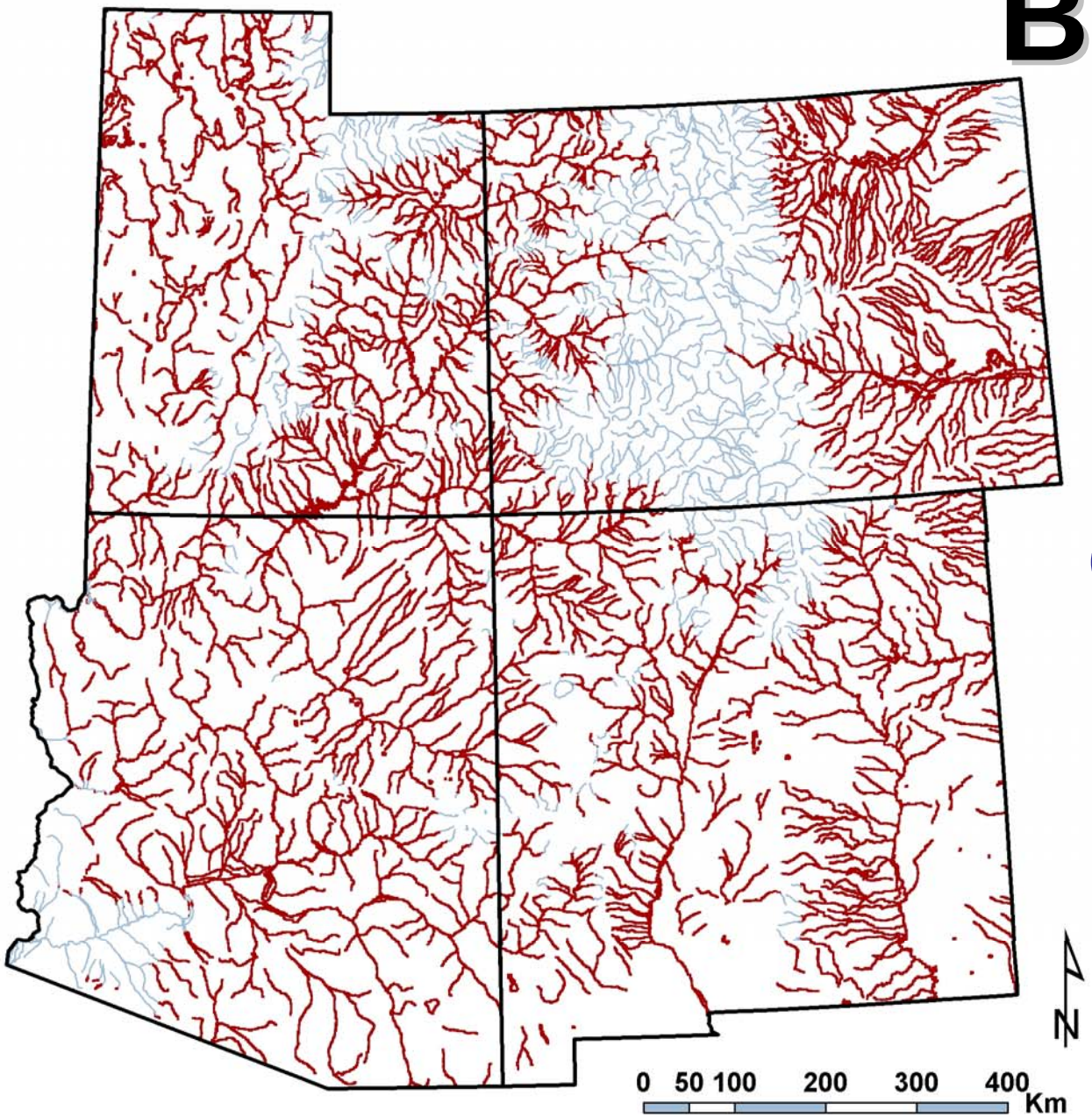


50% Precip.

+ 4˚ C

Broadleaf

Potential Niche

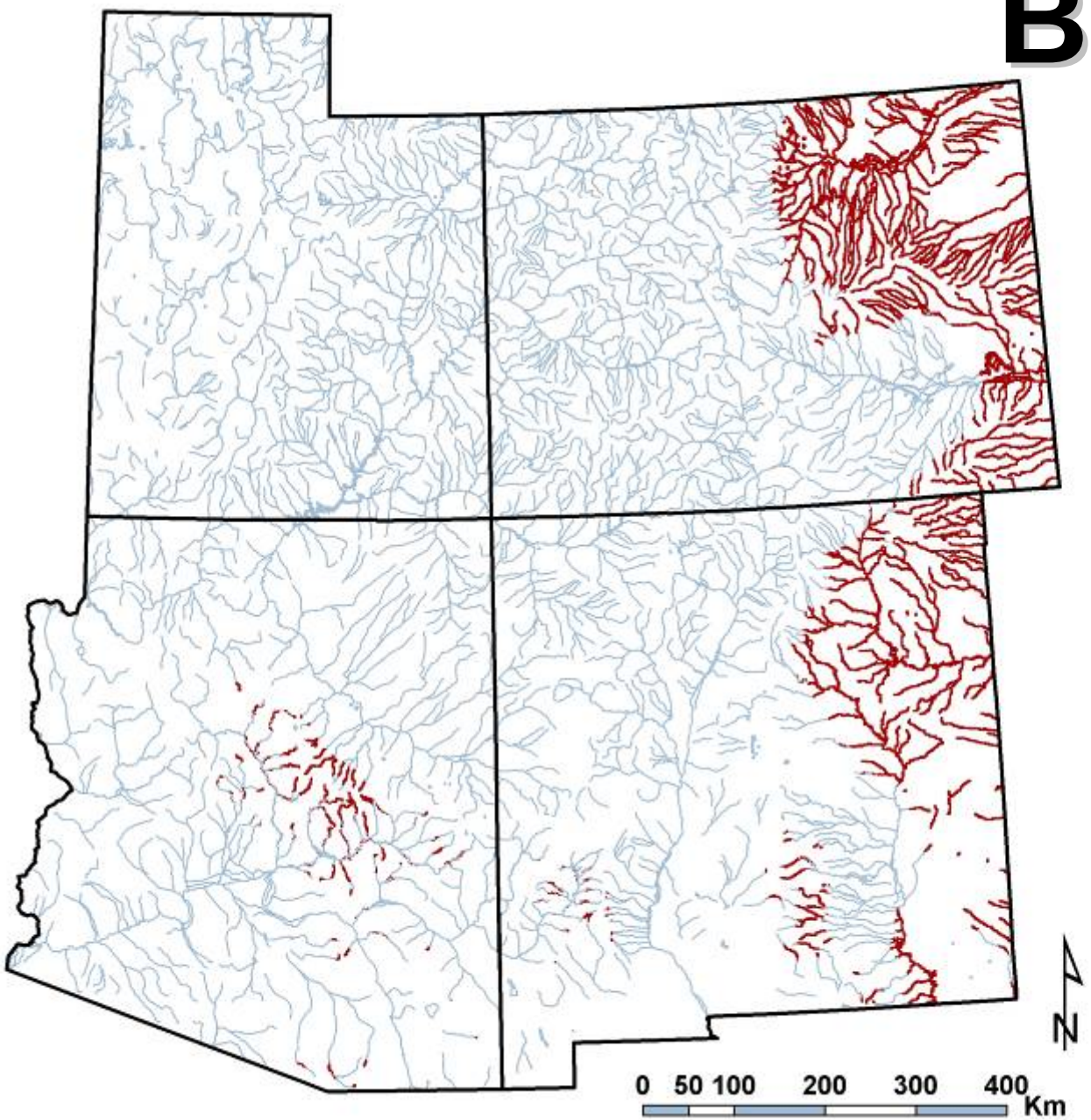


Current Precip.

Current Temp.

Broadleaf

Potential Niche

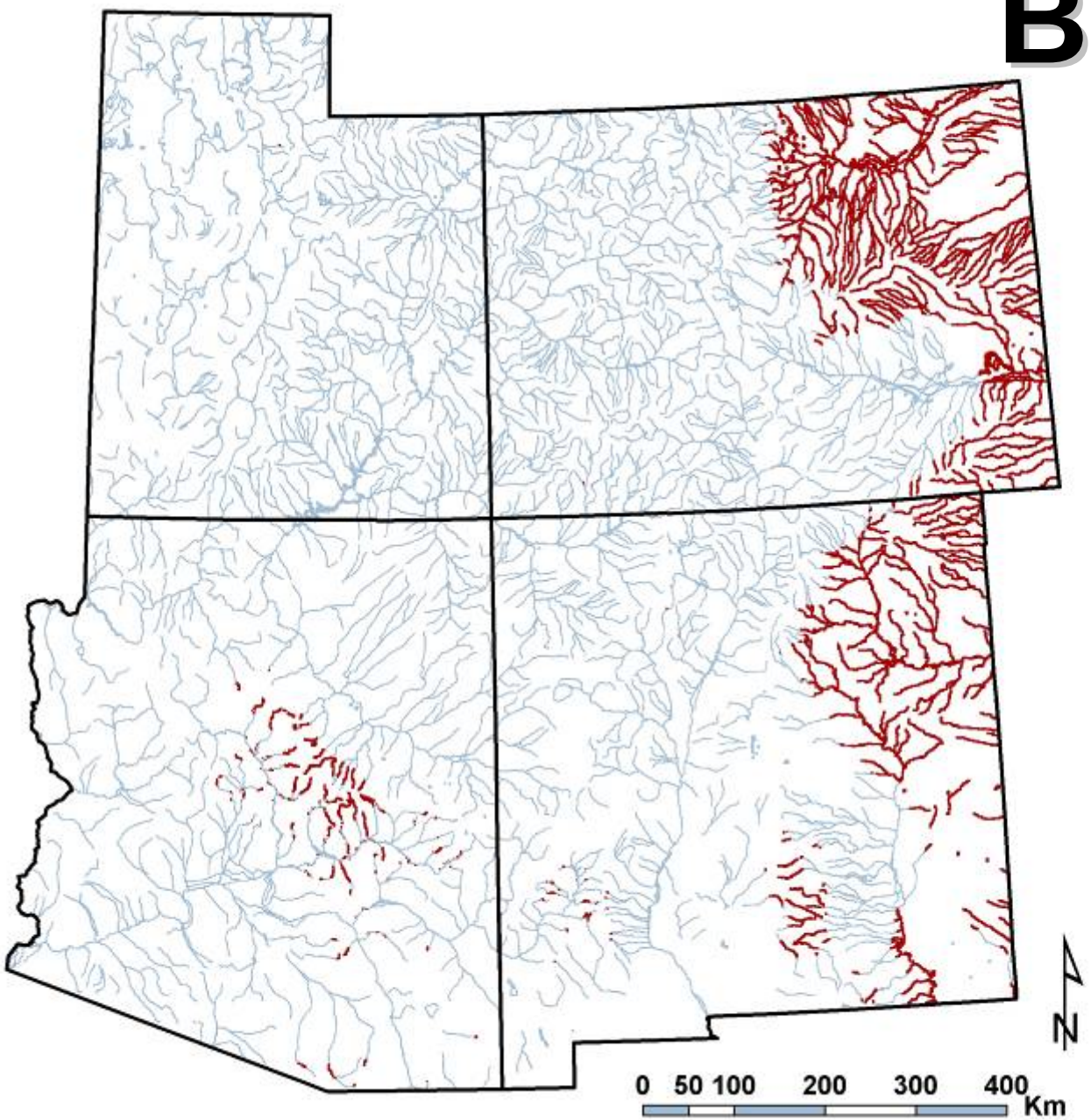


25% Precip.

Current Temp.

Broadleaf

Potential Niche

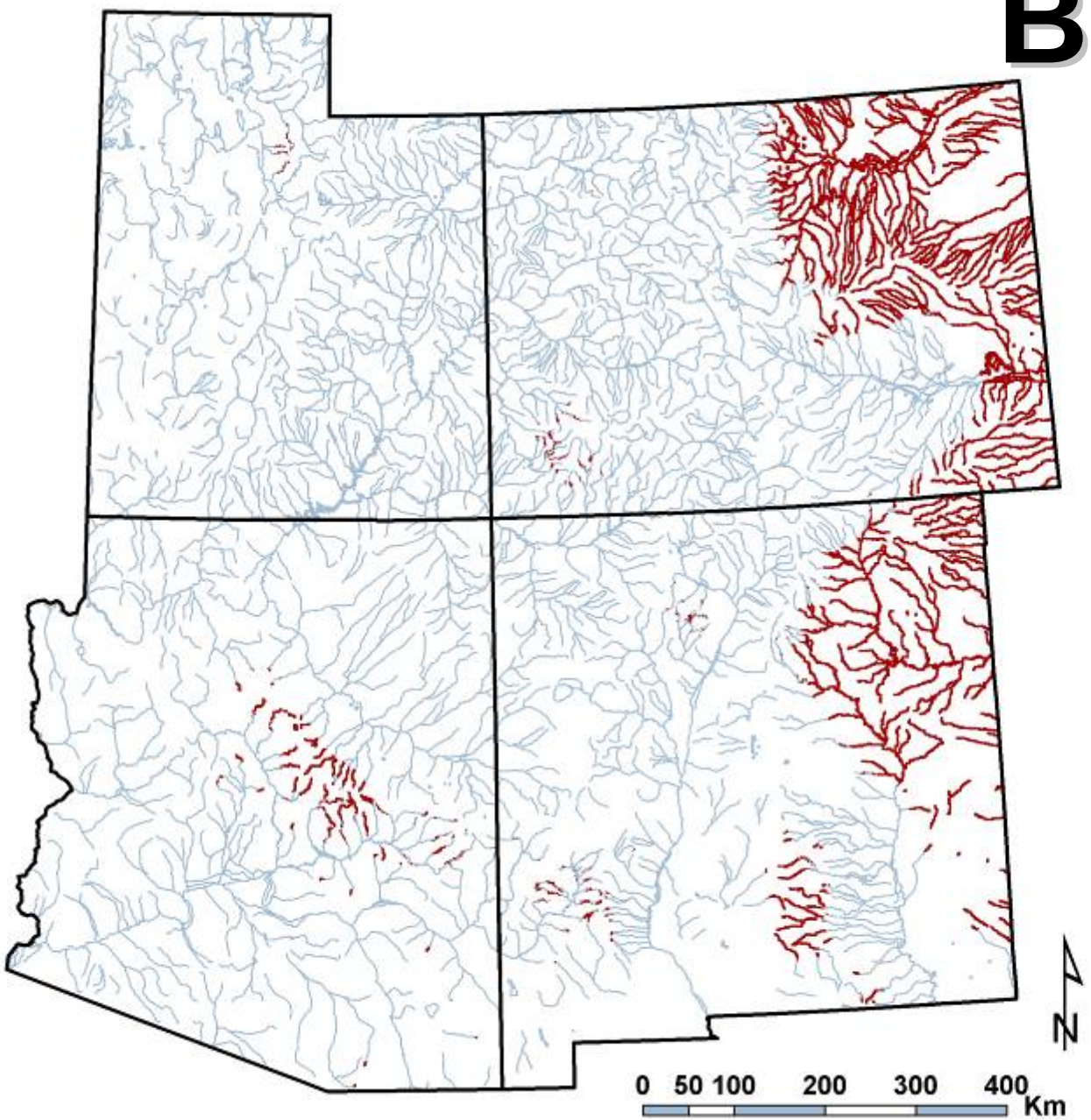


25% Precip.

+ 1.5˚ C

Broadleaf

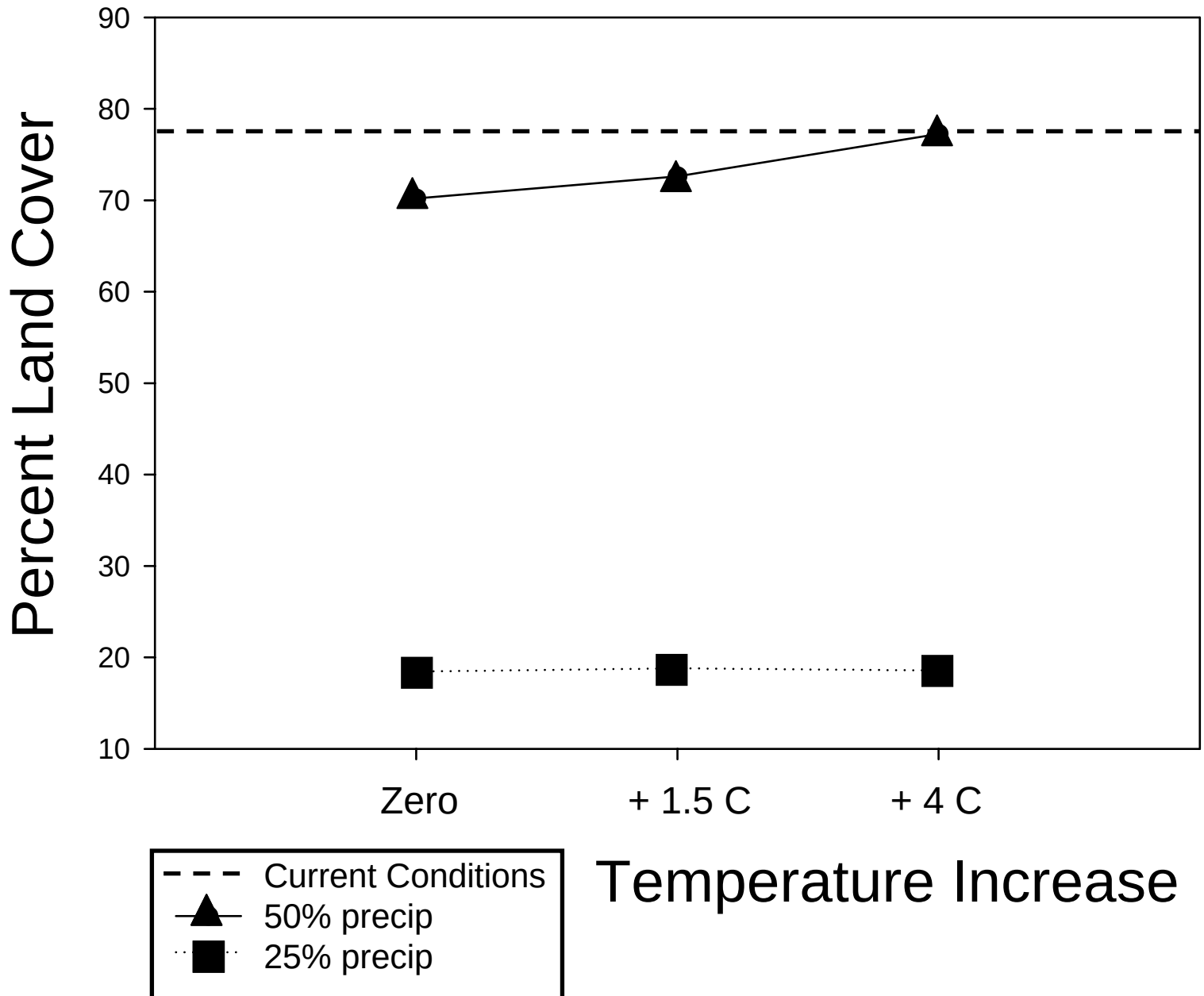
Potential Niche



25% Precip.

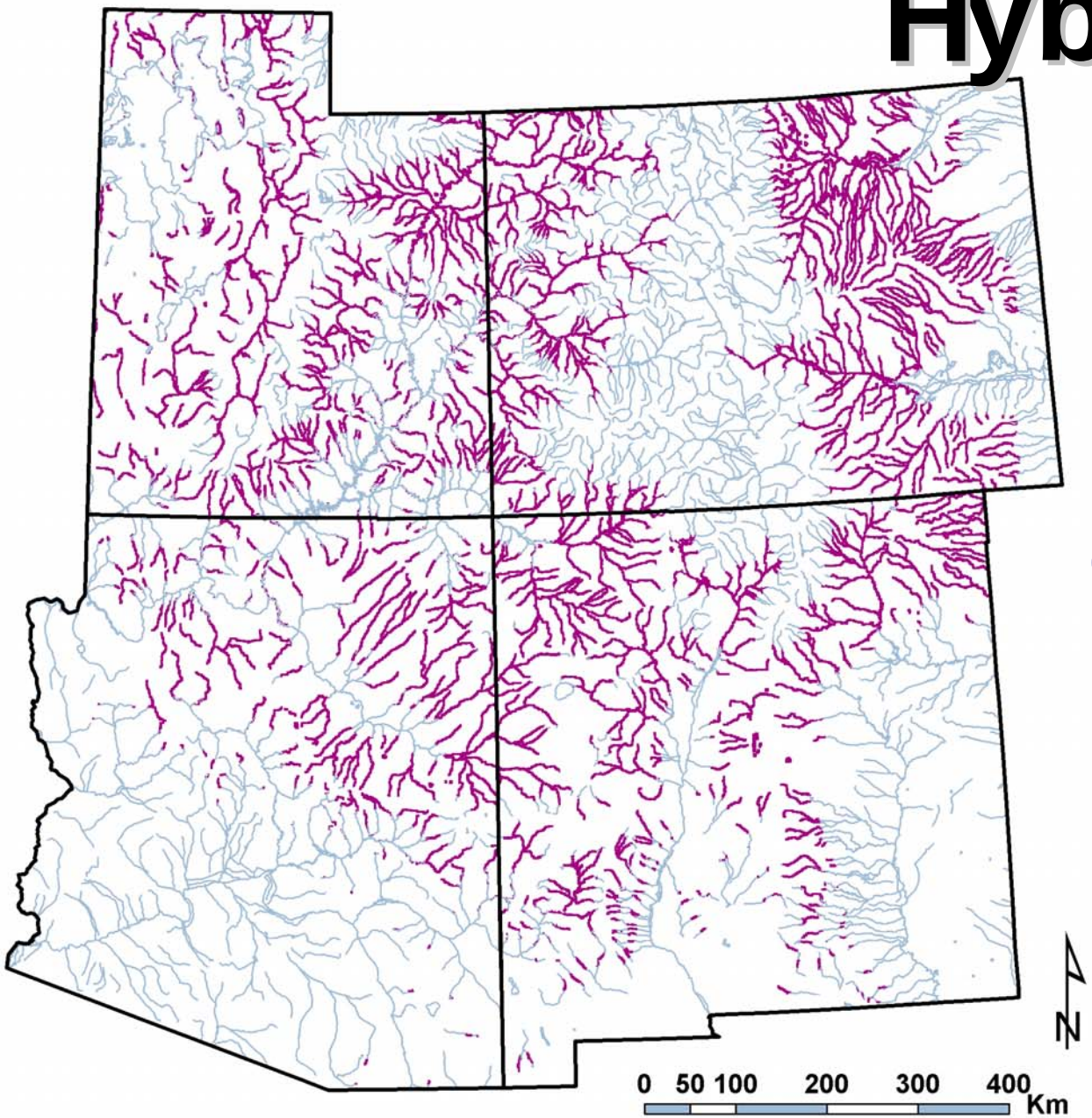
+ 4° C

Broadleaf: Percent Land Cover



Hybrid Zone

Potential Niche

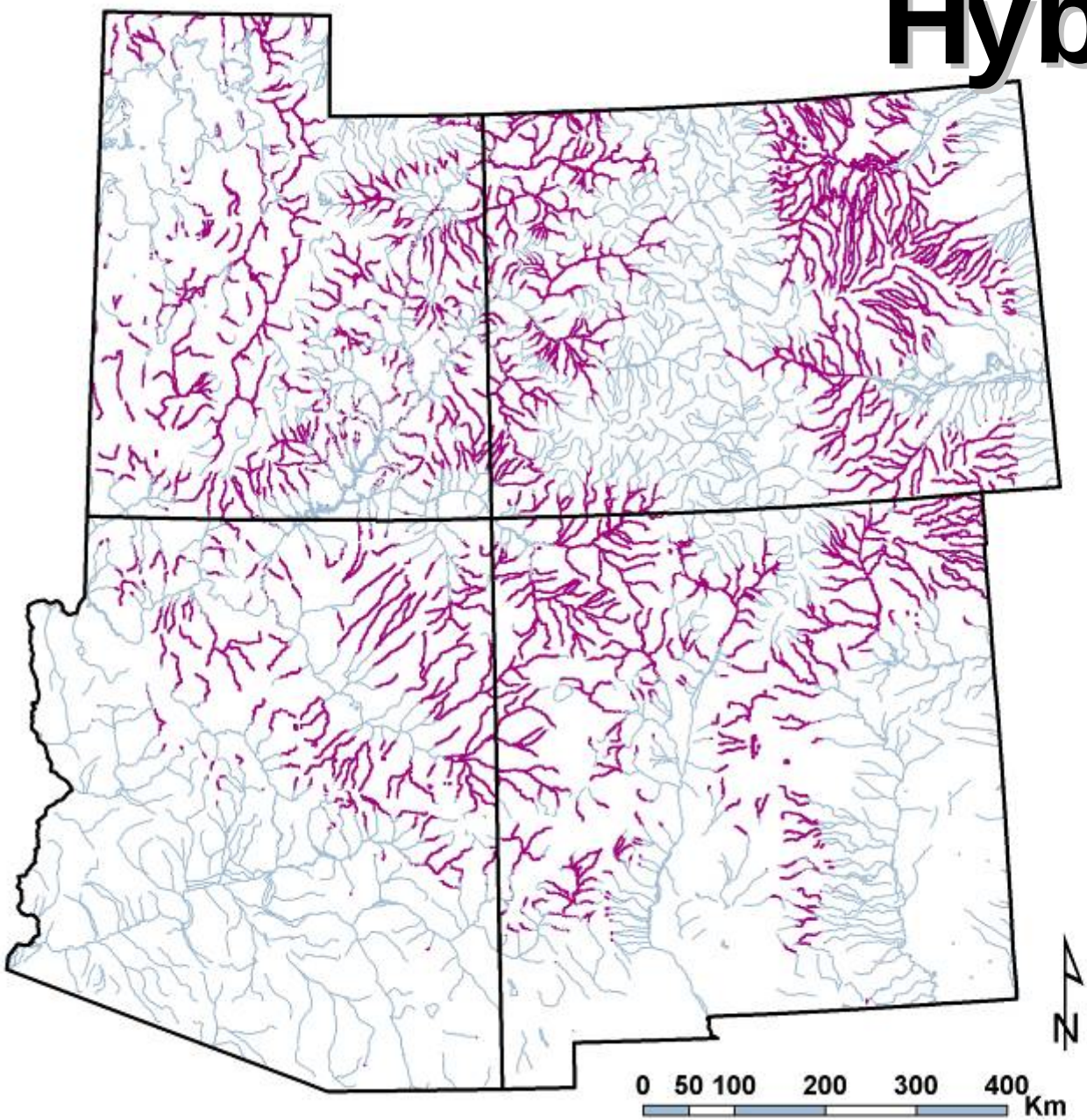


Current Precip.

Current Temp.

Hybrid Zone

Potential Niche

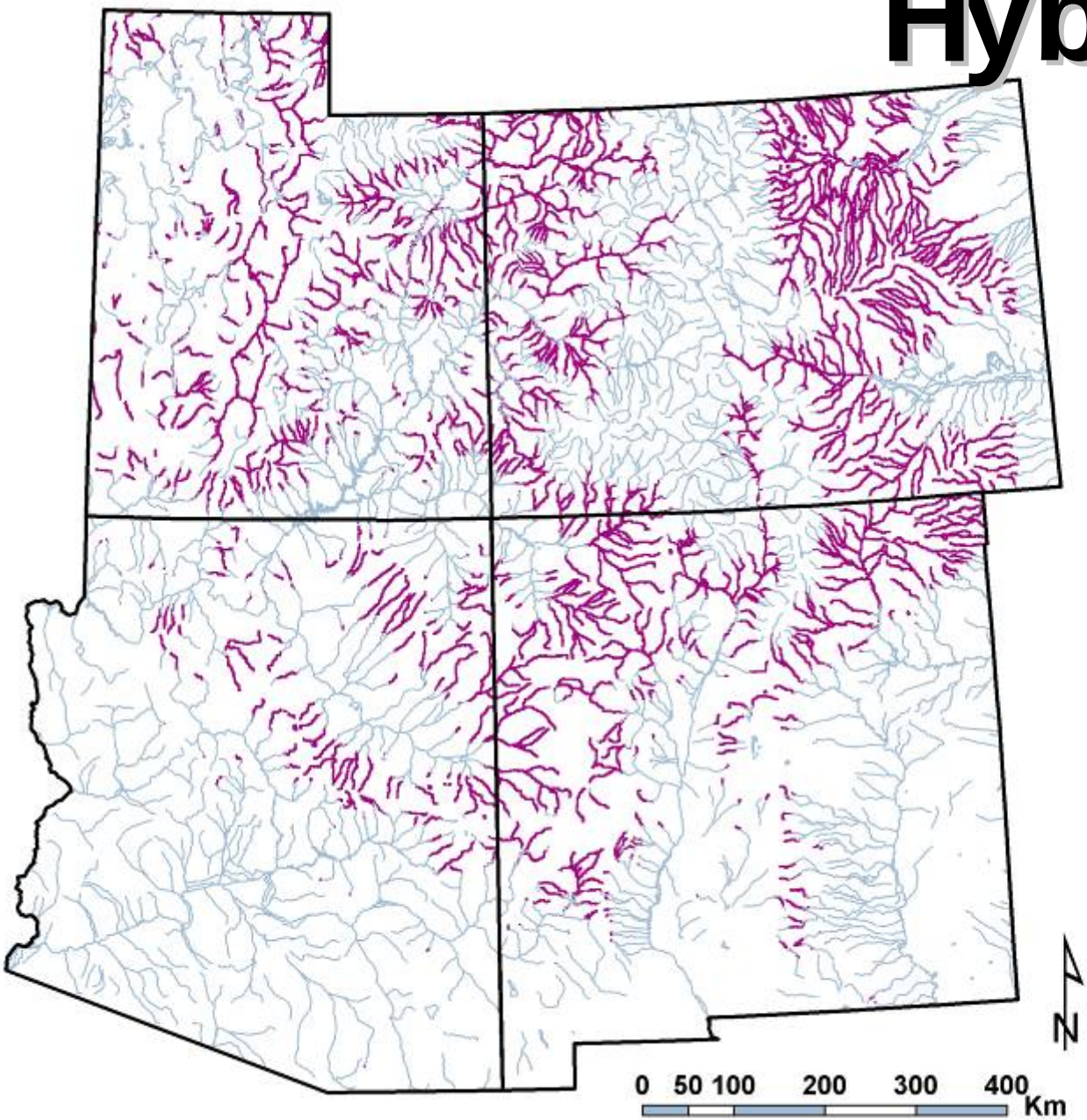


50% Precip.

Current Temp.

Hybrid Zone

Potential Niche

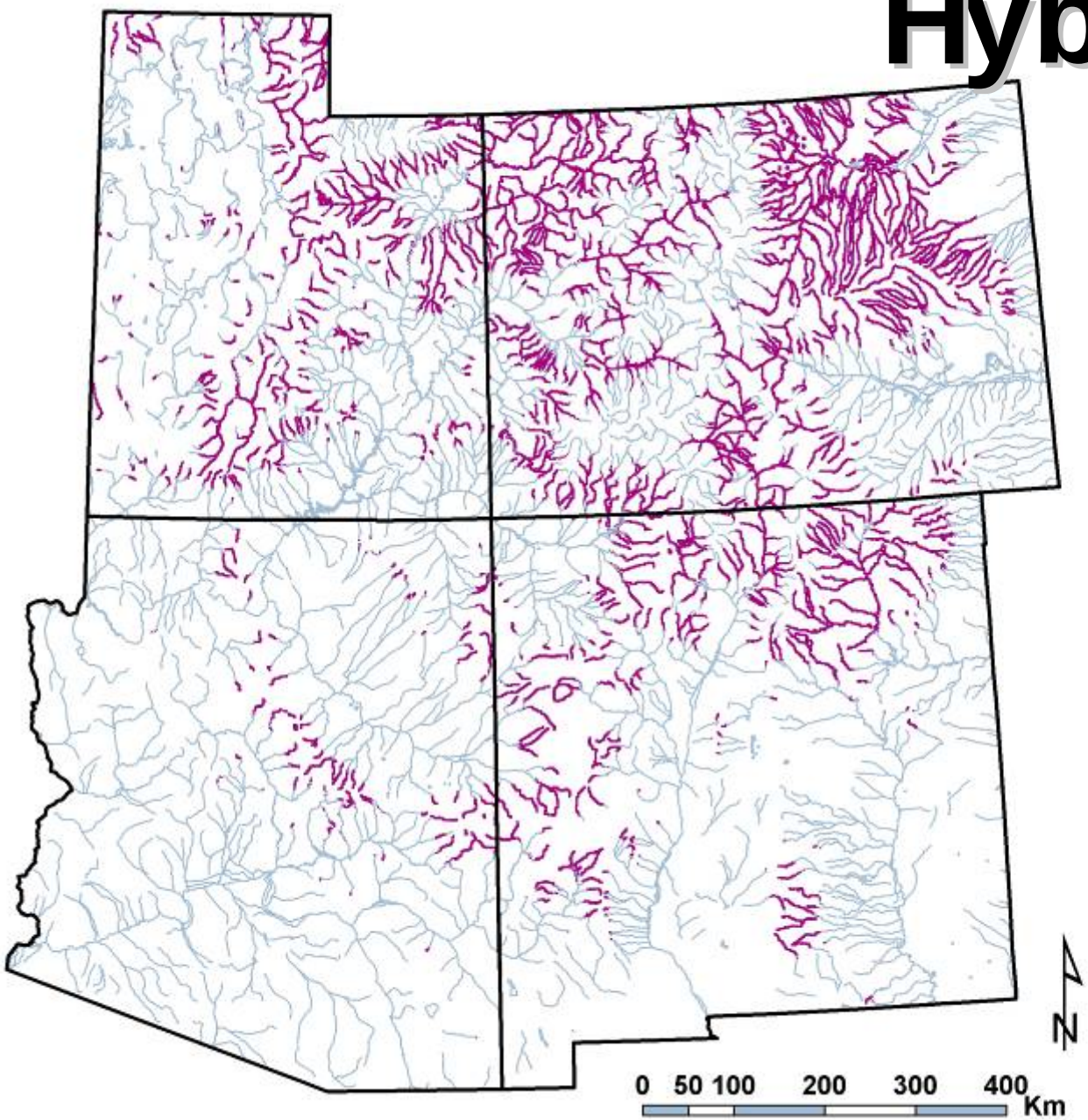


50% Precip.

+ 1.5˚ C

Hybrid Zone

Potential Niche

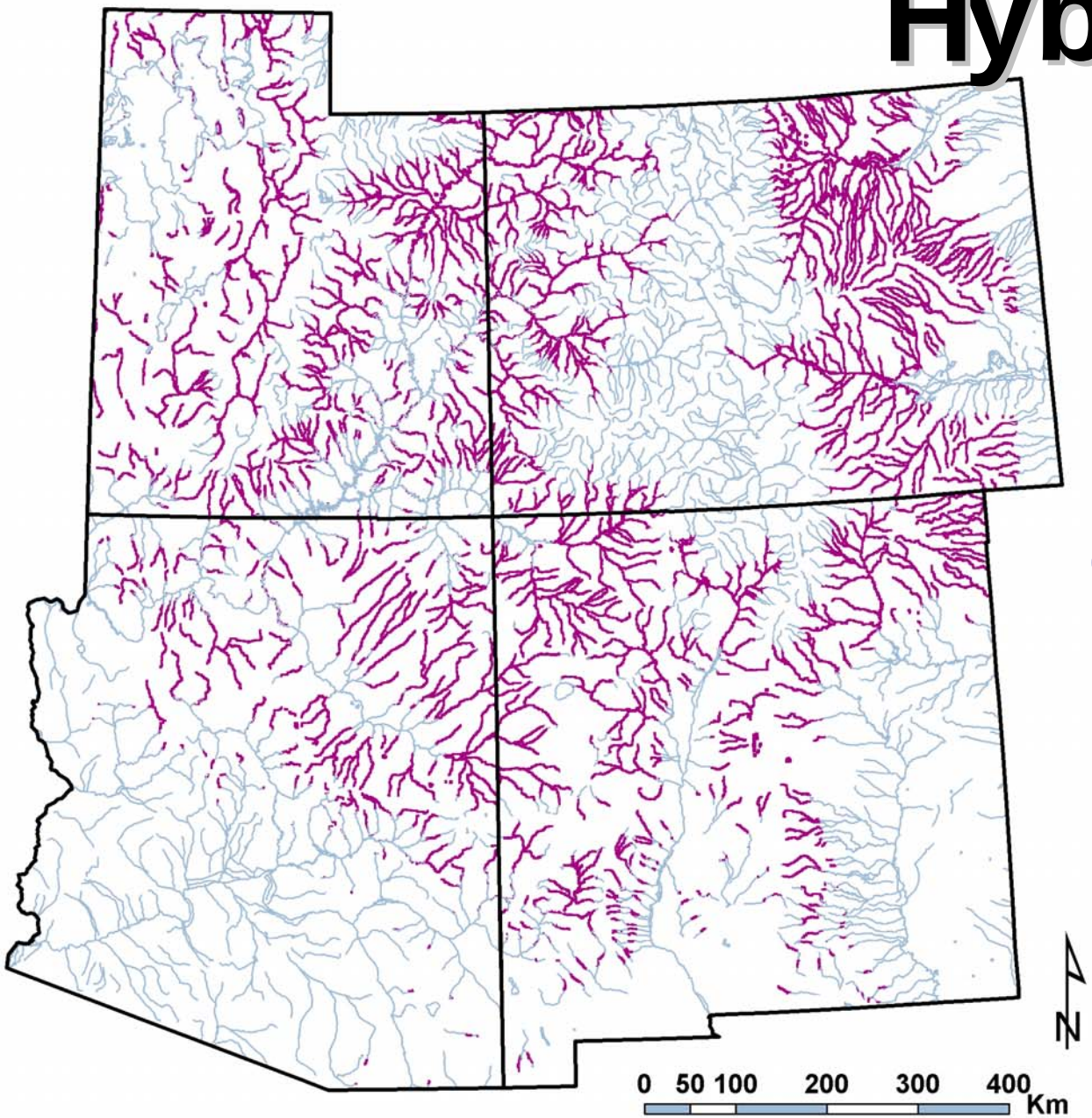


50% Precip.

+ 4° C

Hybrid Zone

Potential Niche

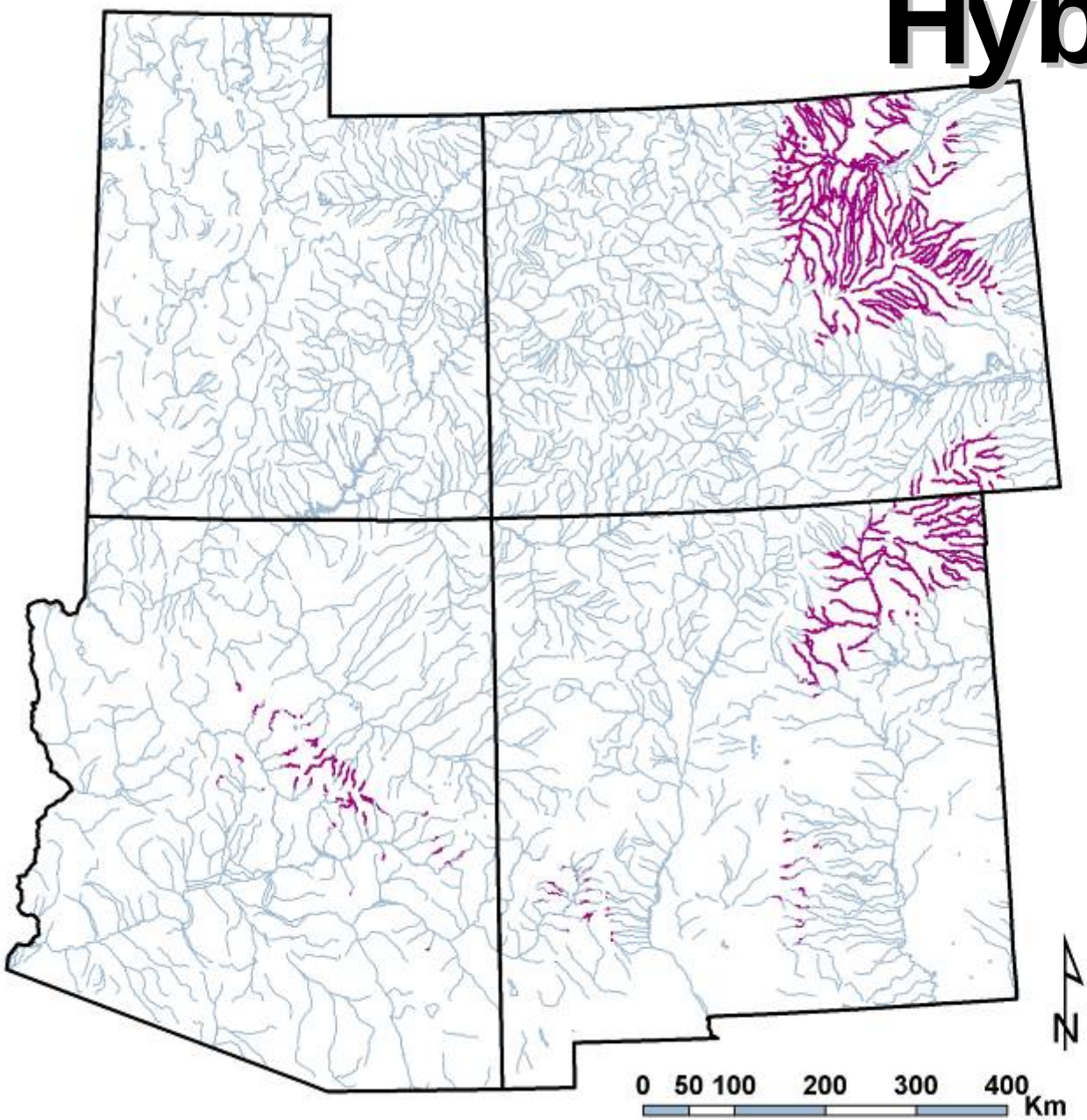


Current Precip.

Current Temp.

Hybrid Zone

Potential Niche

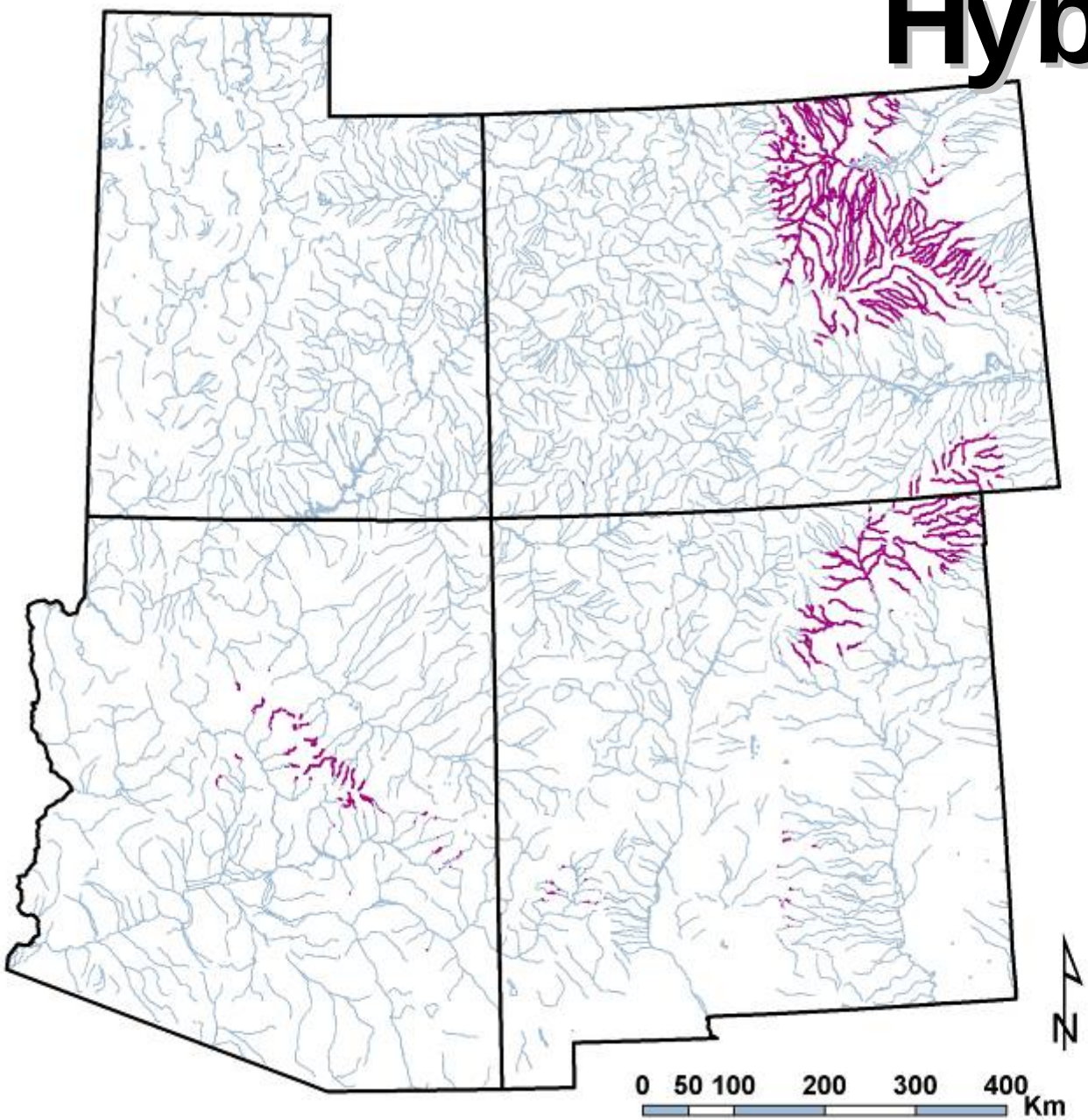


25% Precip.

Current Temp.

Hybrid Zone

Potential Niche

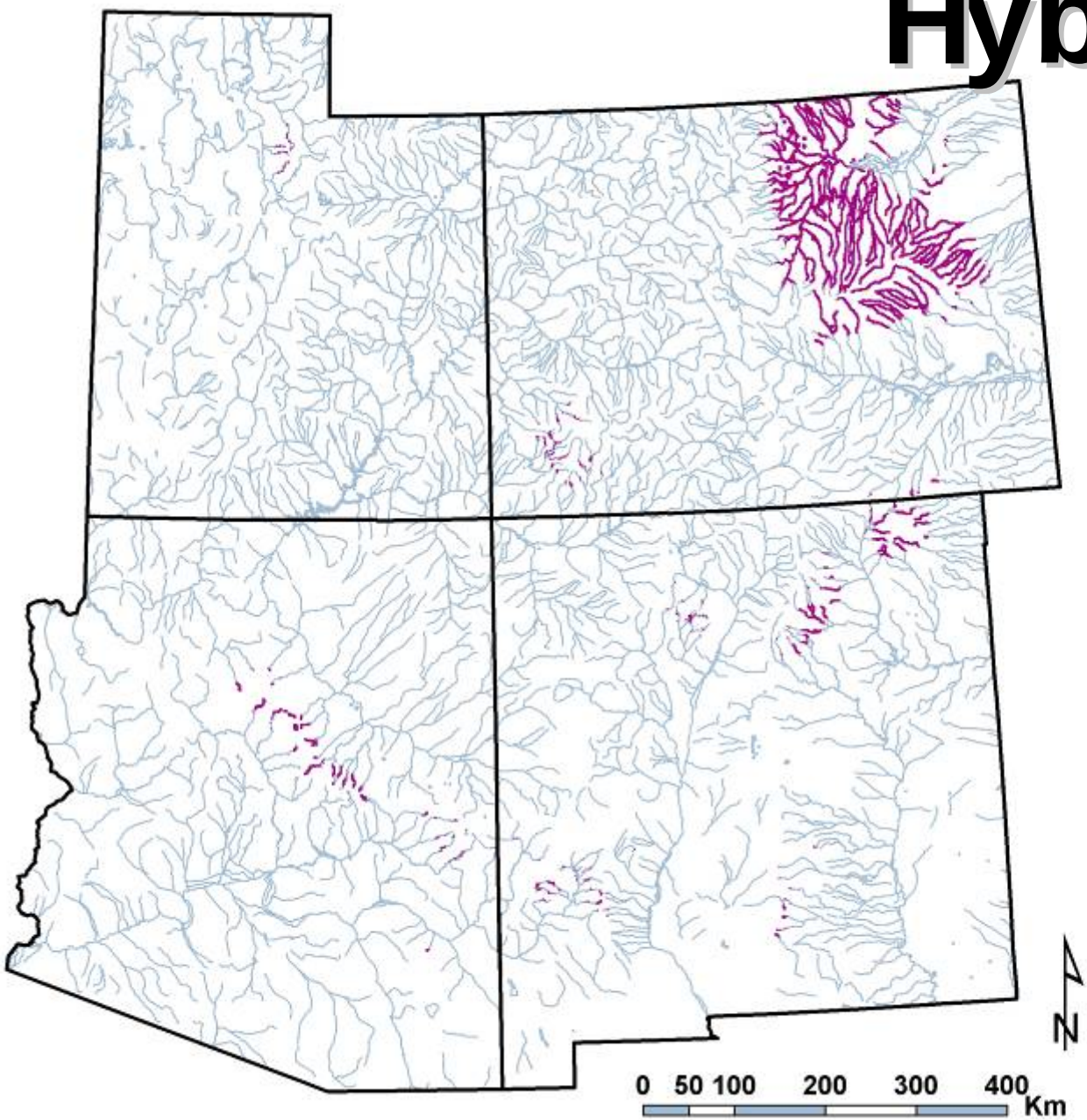


25% Precip.

+ 1.5˚ C

Hybrid Zone

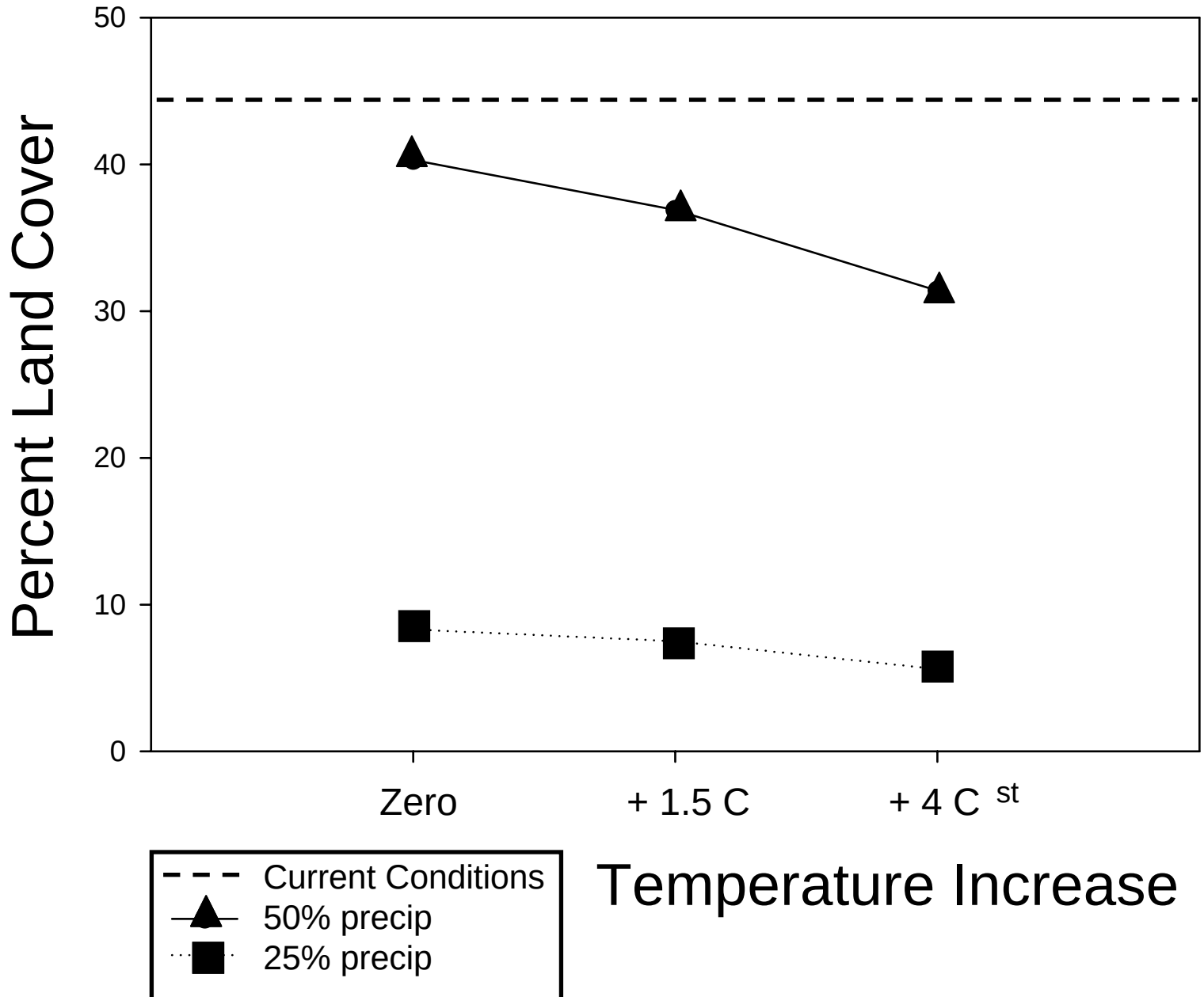
Potential Niche

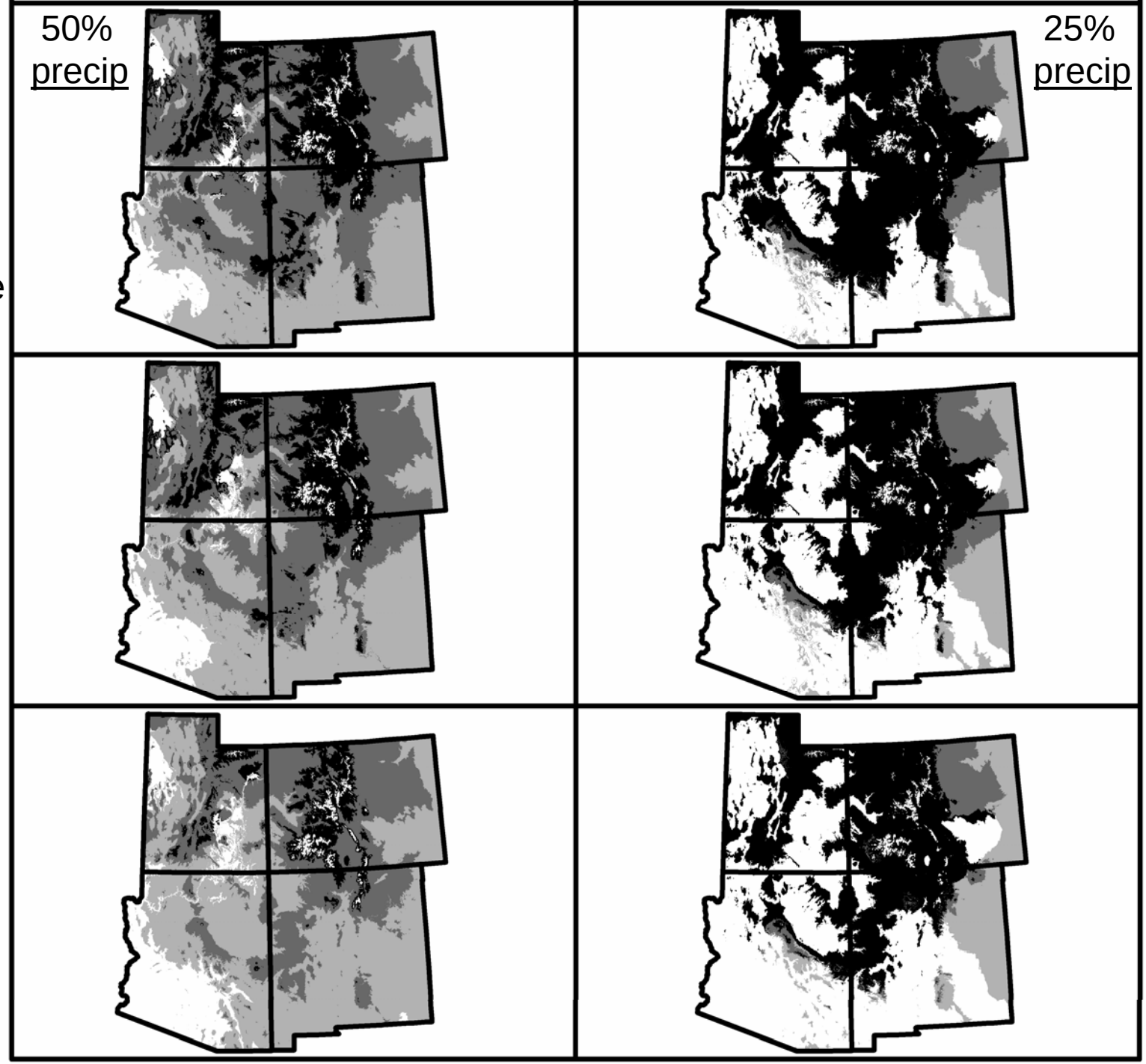


25% Precip.

+ 4° C

Hybrid Zone: Percent Land Cover




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:

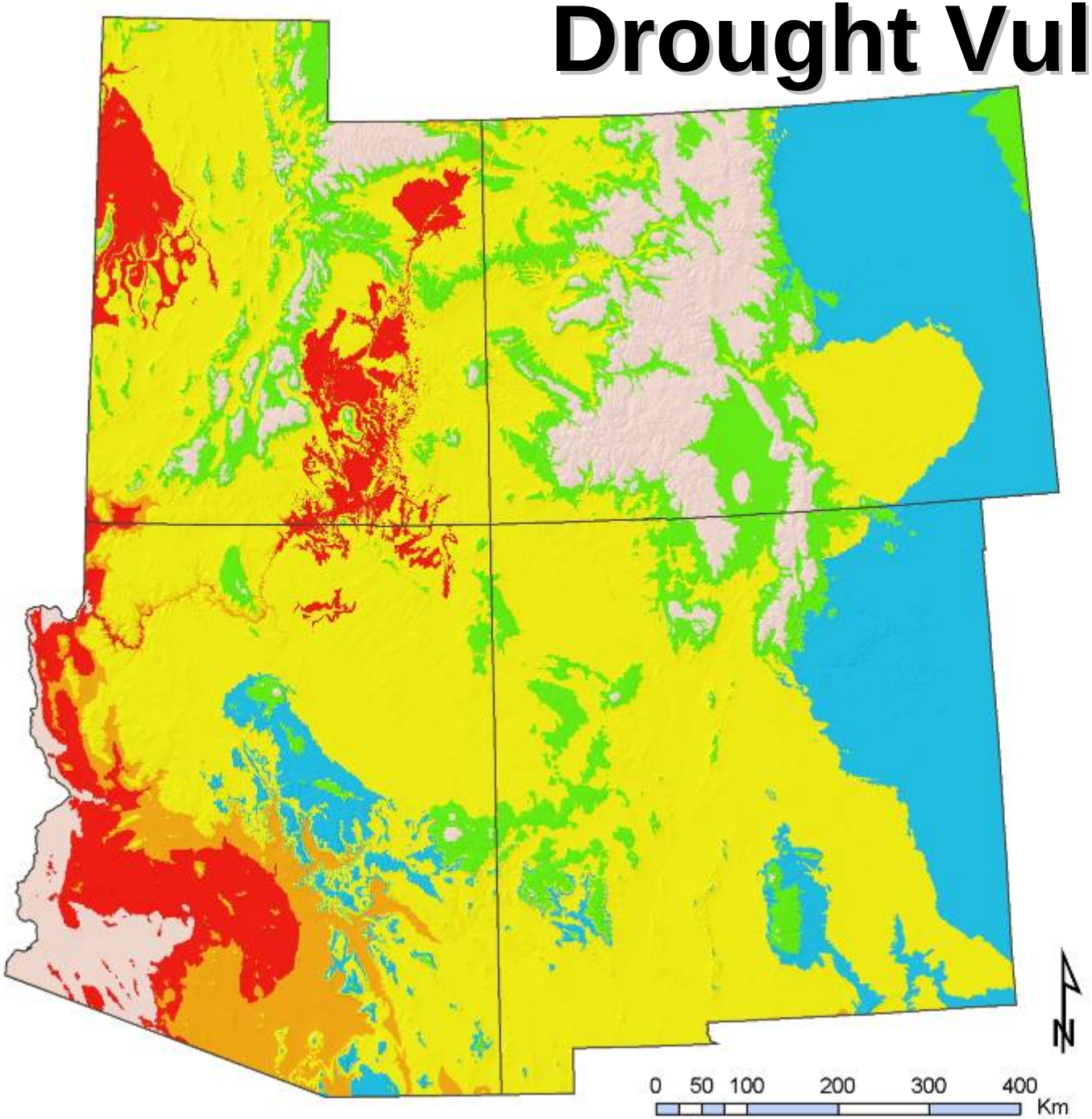
~ **Narrowleaf** are more susceptible to temperature change than drought

~ **Broadleaf cottonwoods** are most susceptible to severe moisture decreases

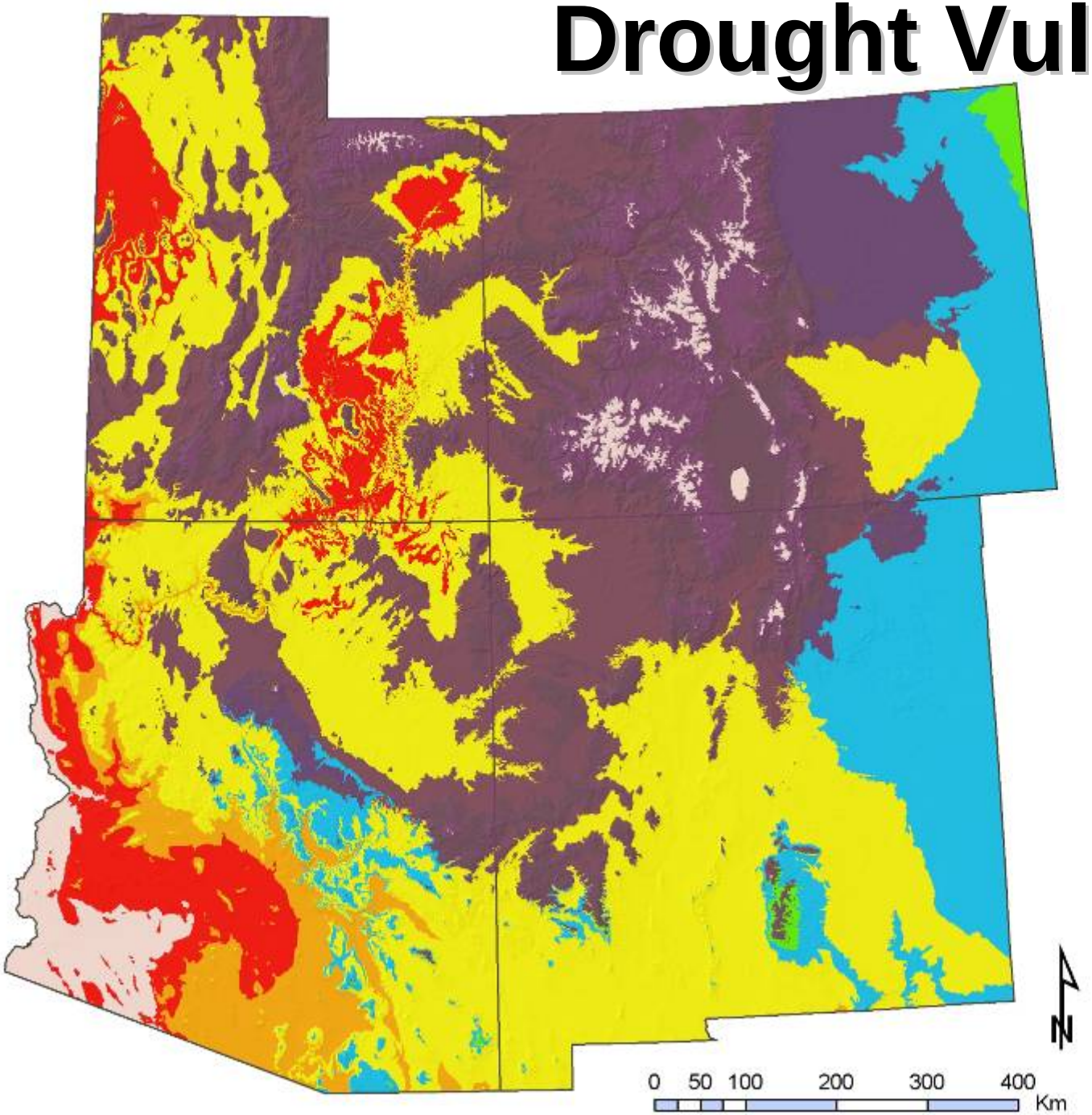
~ New **hybrid zone** creation will be limited if parent species no longer overlap

~ Existing **hybrid zones** may become habitat refugia

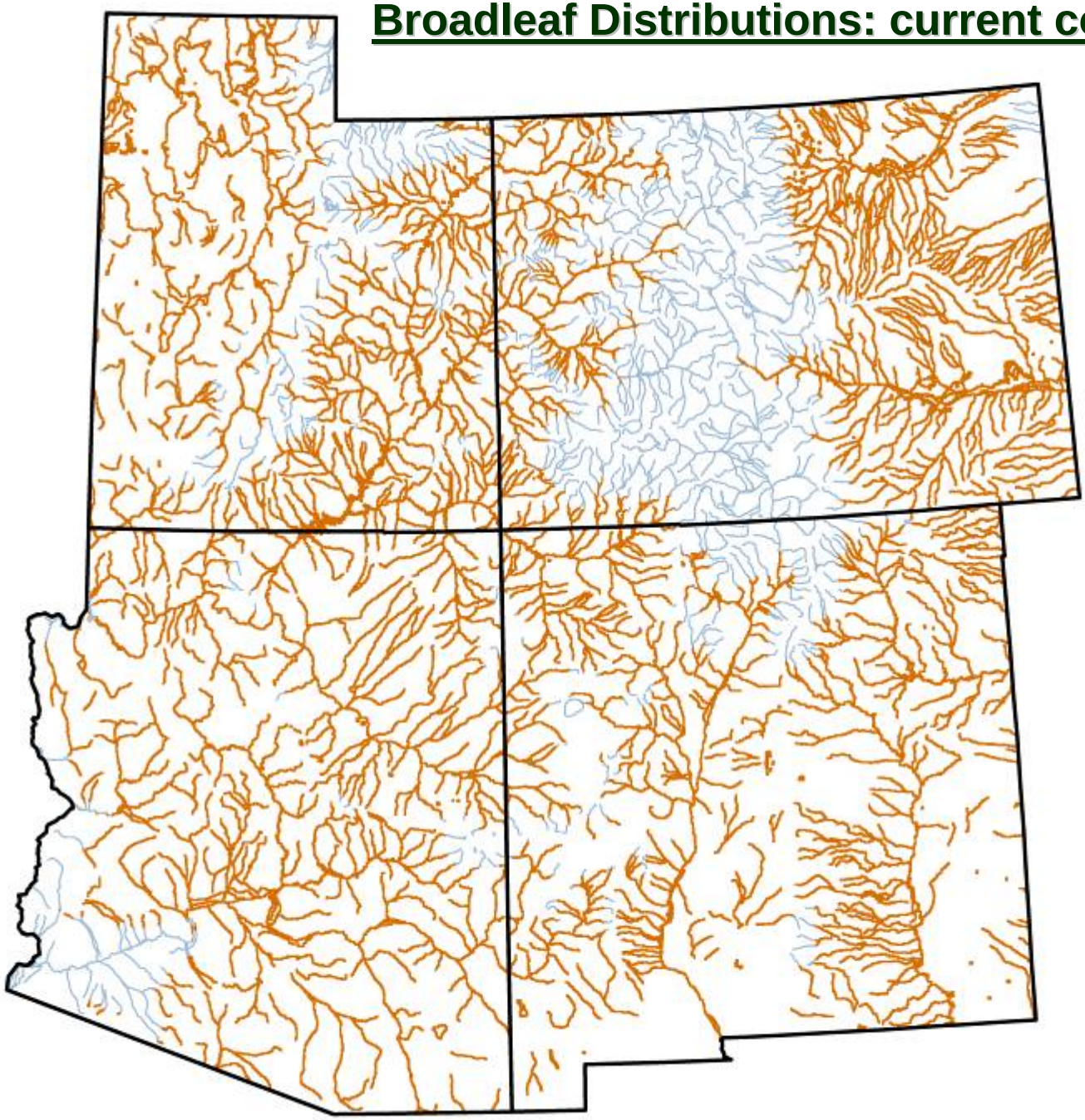
Drought Vulnerability



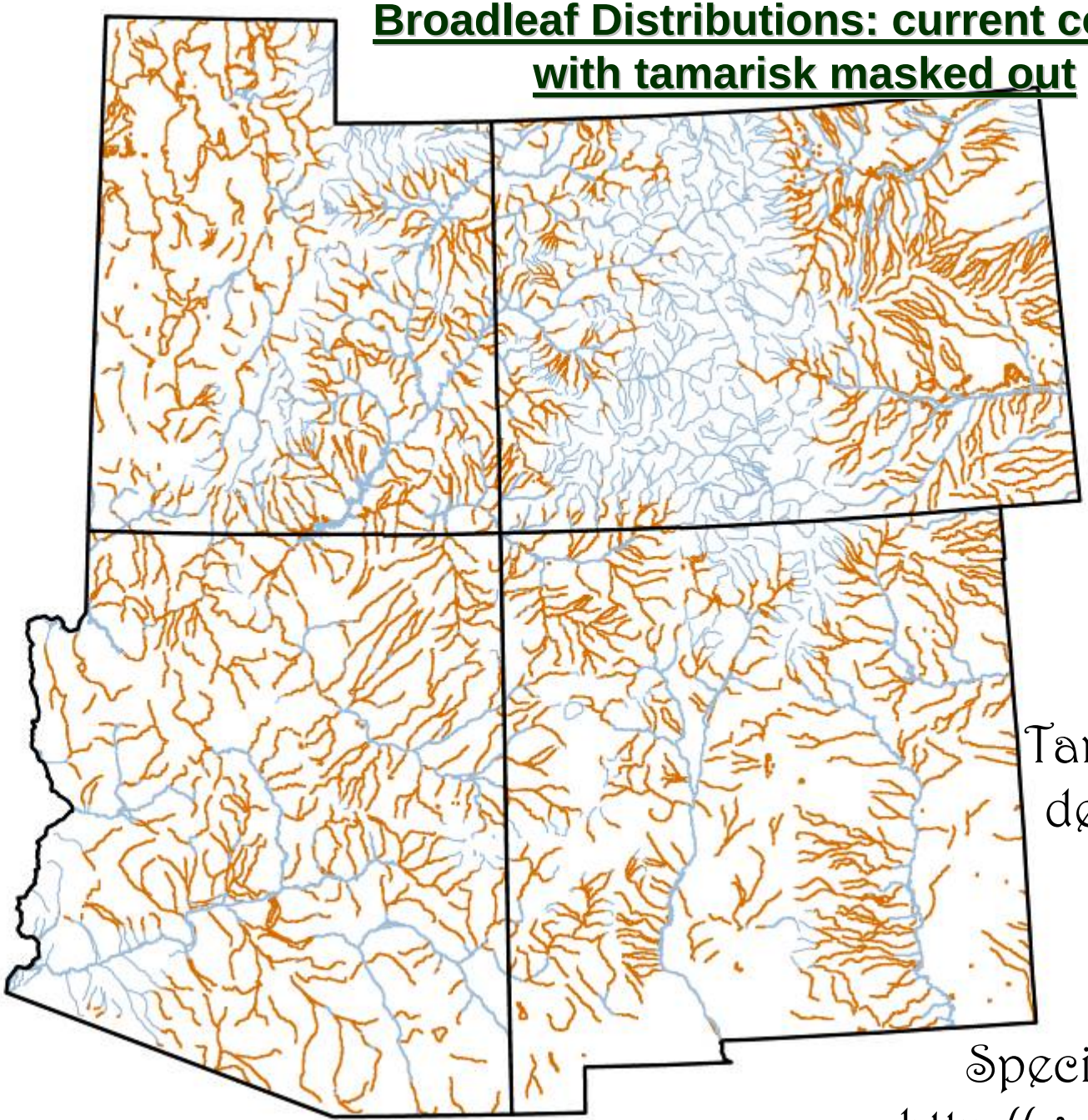
Drought Vulnerability



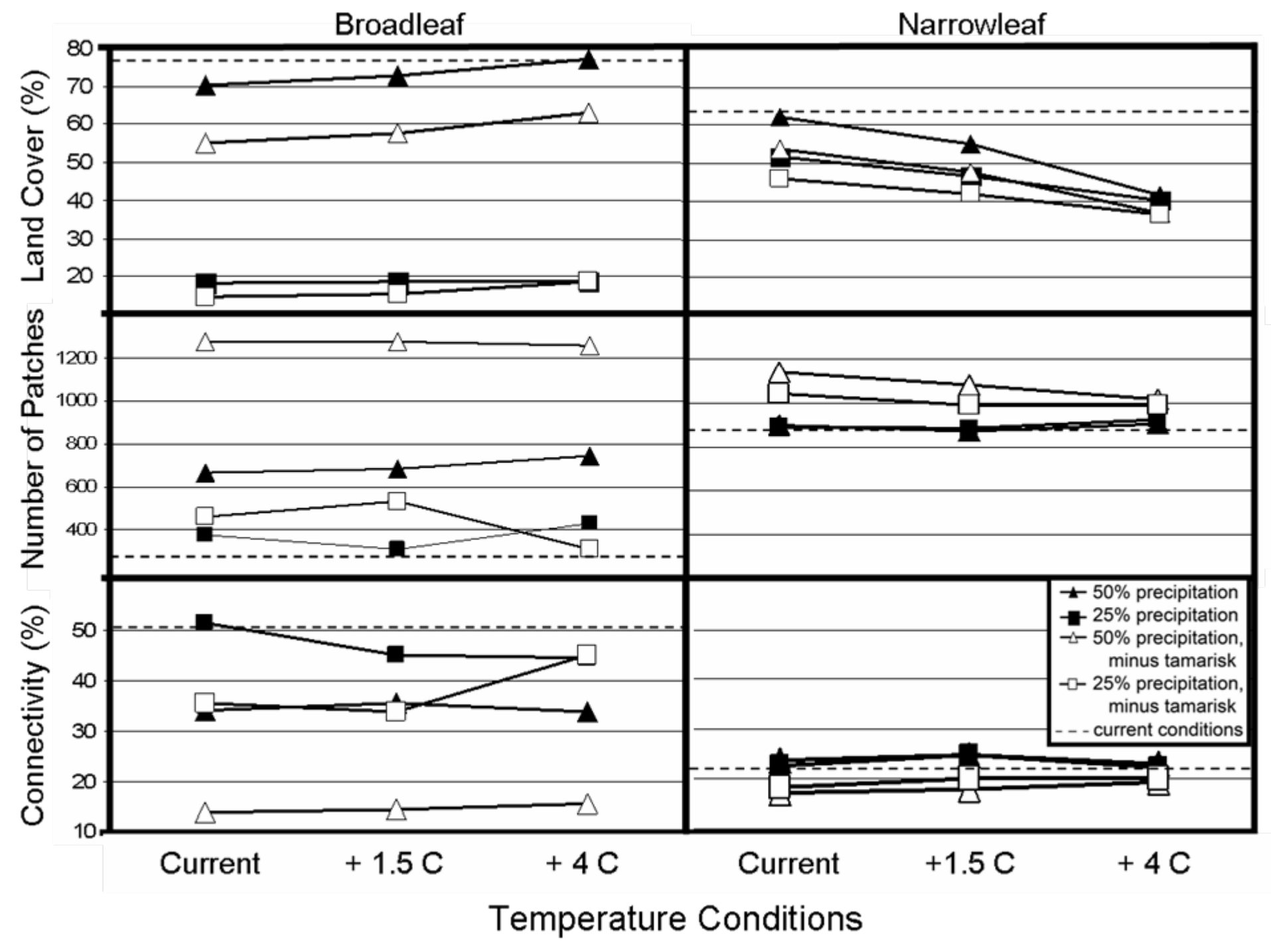
Broadleaf Distributions: current conditions



Broadleaf Distributions: current conditions, with tamarisk masked out



Tamarisk data derived from National Institute of Invasive Species Science http://www.niiss.org


Broadleaf
Narrowleaf
Land Cover (%)
80
70
60
50
40
30
20
Number of Patches
1200
1000
800
600
400
Connectivity (%)
50
40
30
20
10
50% precipitation
25% precipitation
50% precipitation, minus tamarisk
25% precipitation, minus tamarisk
current conditions
Current
+ 1.5 C
+ 4 C
Current
+1.5 C
+ 4 C
Temperature Conditions

The Future of Southwestern Broadleaf Cottonwoods:

~ Fragmentation from both climate & exotic trees

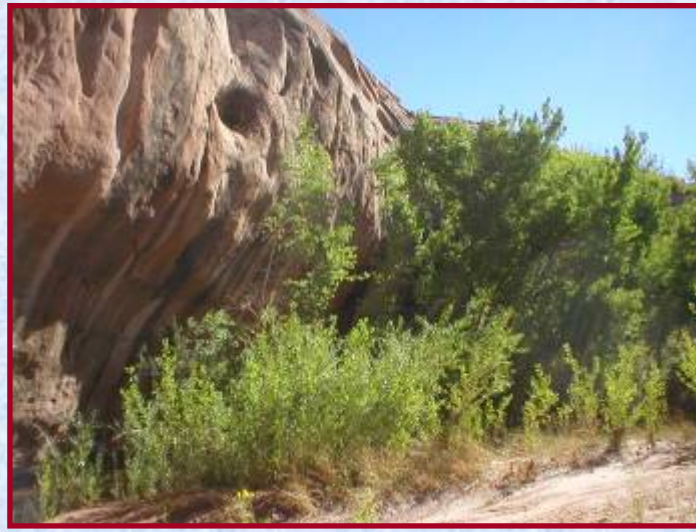
~ Forests will be confined between lowland exotics and upland cottonwoods

~ 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

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