# Woody plant dynamics in fragmented landscapes of the Great Plains, USA

## =Socio-Ecological Observatory=


Rheinhardt Scholtz[1], Sam Fuhlendorf[1], Steve Archer[2], John Polo[1], Evan Tanner[1], Robert Buitenwerf [3]

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[2] School of Natural Resources & The Environment, The University of Arizona, USA

[3] Department of Bioscience - Ecoinformatics and Biodiversity, Aarhus University, Denmark

# Background

- Conditions that favor woodland expansion varies substantially e.g. scale, location, rainfall, fire, grazing pressure
- Correlations with $CO_2$ enrichment, lack of fire, rainfall anomalies, land use change => often a combination
- Globally = rainfall, fire and soil type are “primary drivers” of woody cover

Staver, A.C., Archibald, S., Levin, S.A., 2011. The Global Extent and Determinants of Savanna and Forest as Alternative Biome States. Science 334, 230-232.

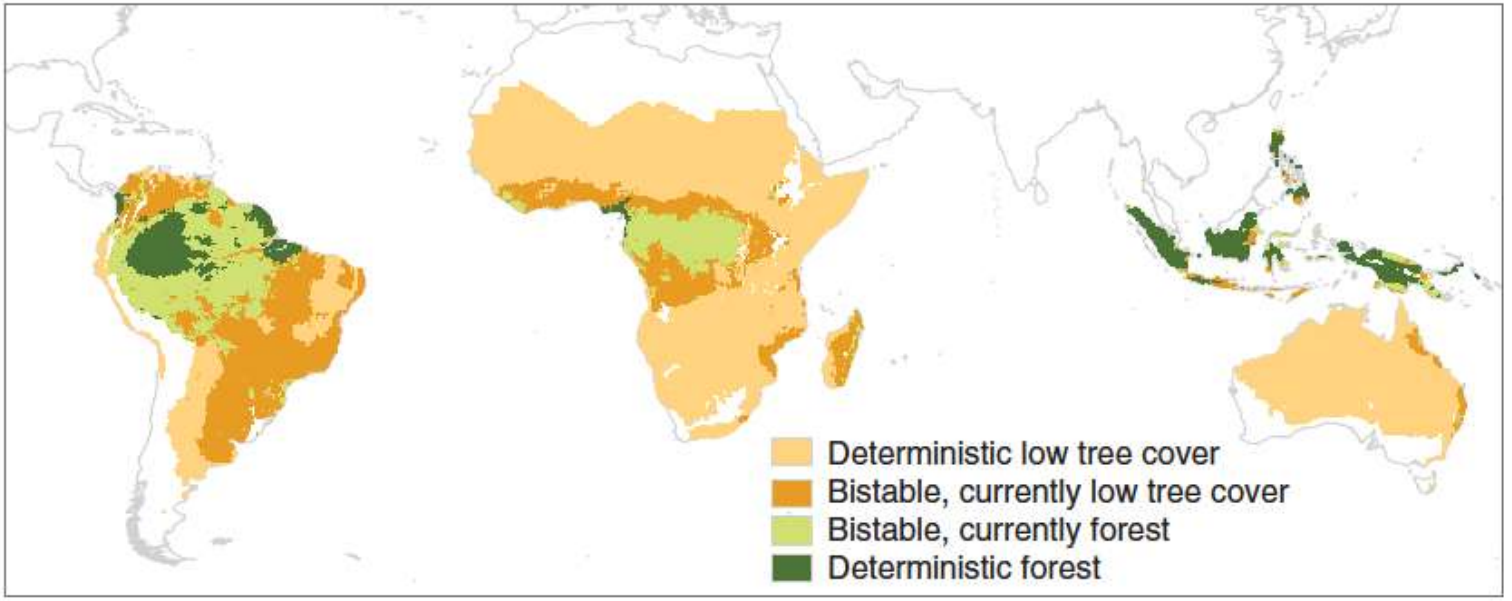



**Fig. 4.** Distributions of biome types across sub-Saharan Africa, South America, and Southeast Asia/Australia. Biome types are defined as areas where climate (i) deterministically supports low tree cover (low rainfall, high seasonality); (ii) supports biome bistability (intermediate rainfall, mild seasonality), currently savanna; (iii) supports biome bistability, currently forest; and (iv) deterministically supports forest (high rainfall).



~Rainfall + Fire = savannas, grasslands, forests

# Background

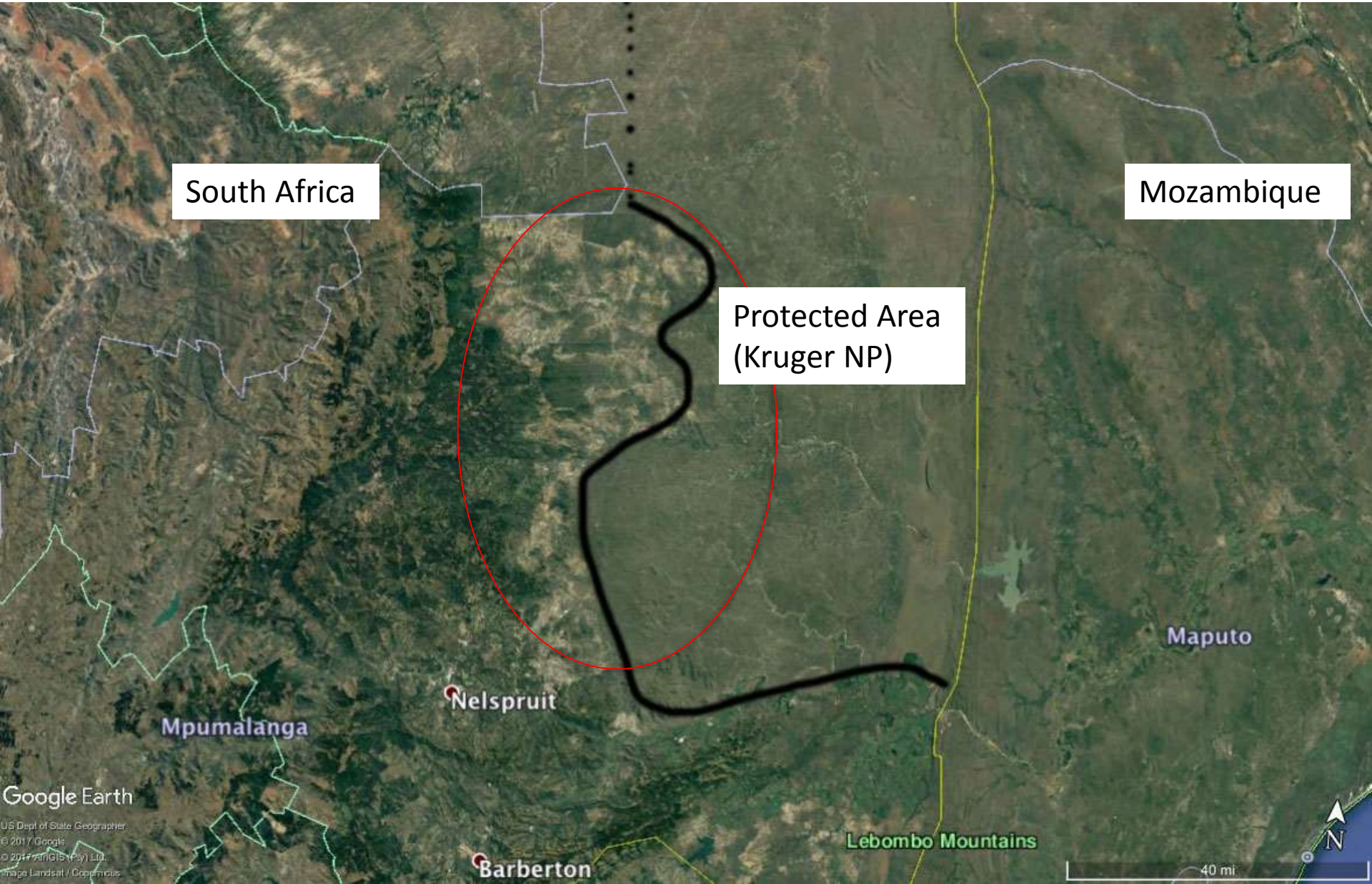
- Conditions that favor woodland expansion varies substantially (e.g. scale, location)
- Correlations with $CO_2$ enrichment, lack of fire, rainfall anomalies, land use change => often a combination
- Globally = rainfall, fire and ~soil type are "primary drivers" of woody cover
- @Finer scales. this relationship becomes convoluted with scale-specific drivers e.g. herbivory + fire, soil type, land use change

Semi-arid savanna: <600mm MAP


Semi-arid savanna: <600mm MAP
Grazing effects after fire

NW Pacific Costa Rica: ~1000mm MAP

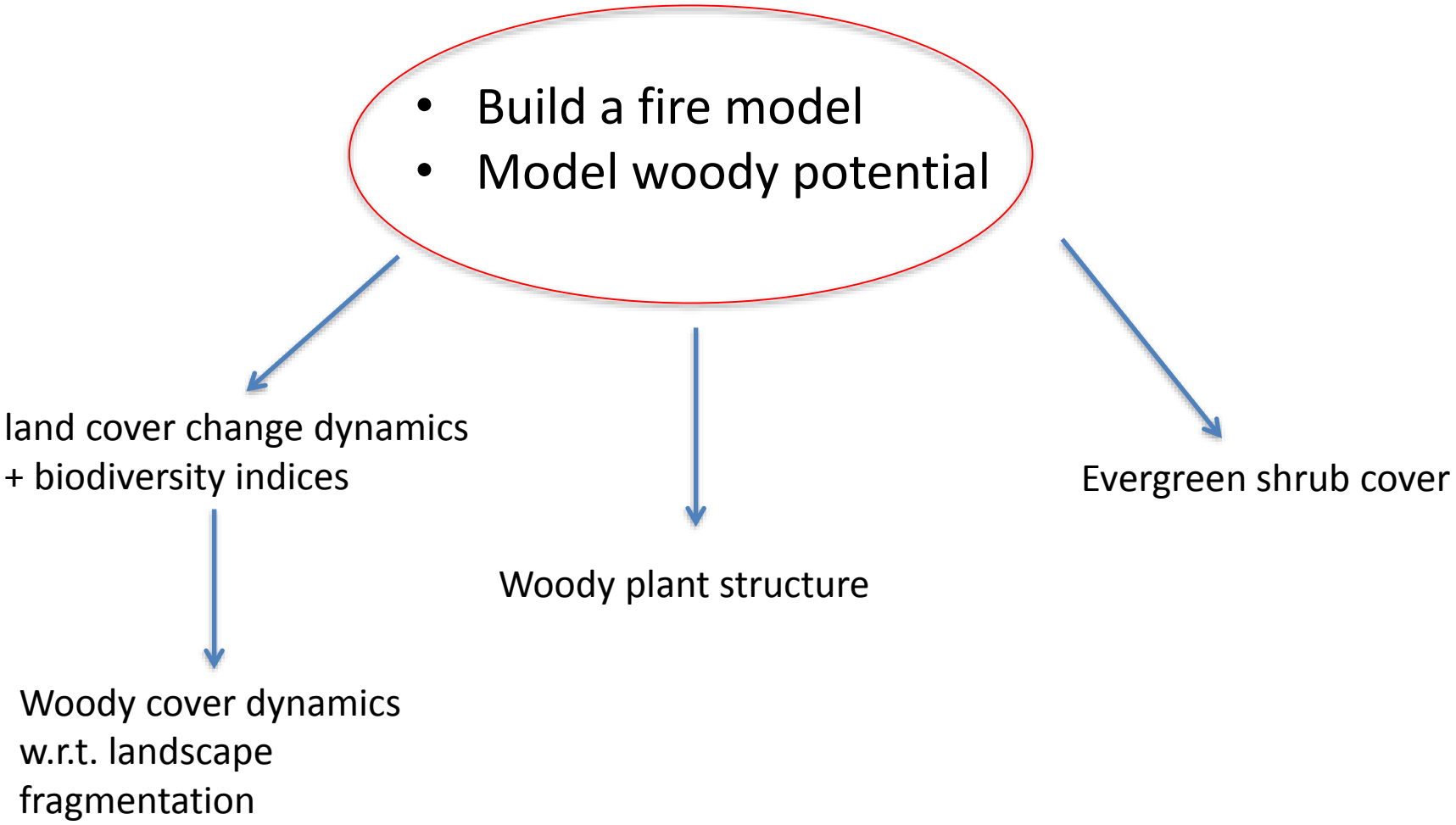
# Land-use inside and outside of protected areas of South Africa



# Rationale

- Rainfall + fire alone cannot explain this relationship especially @small scales
- Tree:grass influences
  - fire patterns
  - Biodiversity
  - Lots more
- How to better understand the inevitable = improve land management

# Objectives:


• Build a fire model
• Model woody potential
land cover change dynamics
+ biodiversity indices
Woody cover dynamics
w.r.t. landscape
fragmentation
Woody plant structure
Evergreen shrub cover

# Methods
# Study area – KS, OK, TX

n=2246 NRI survey points 2004-2014

% woody cover per site

Build a fire model with fire presence data (not on map)

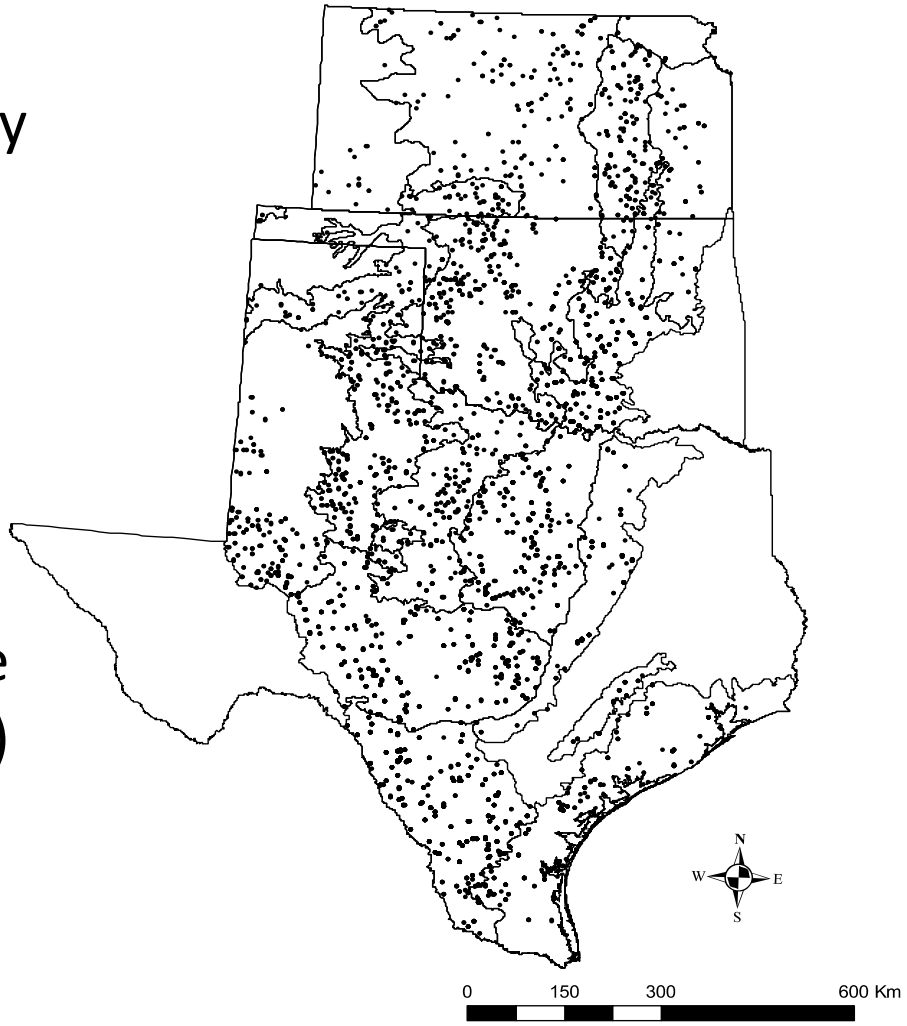
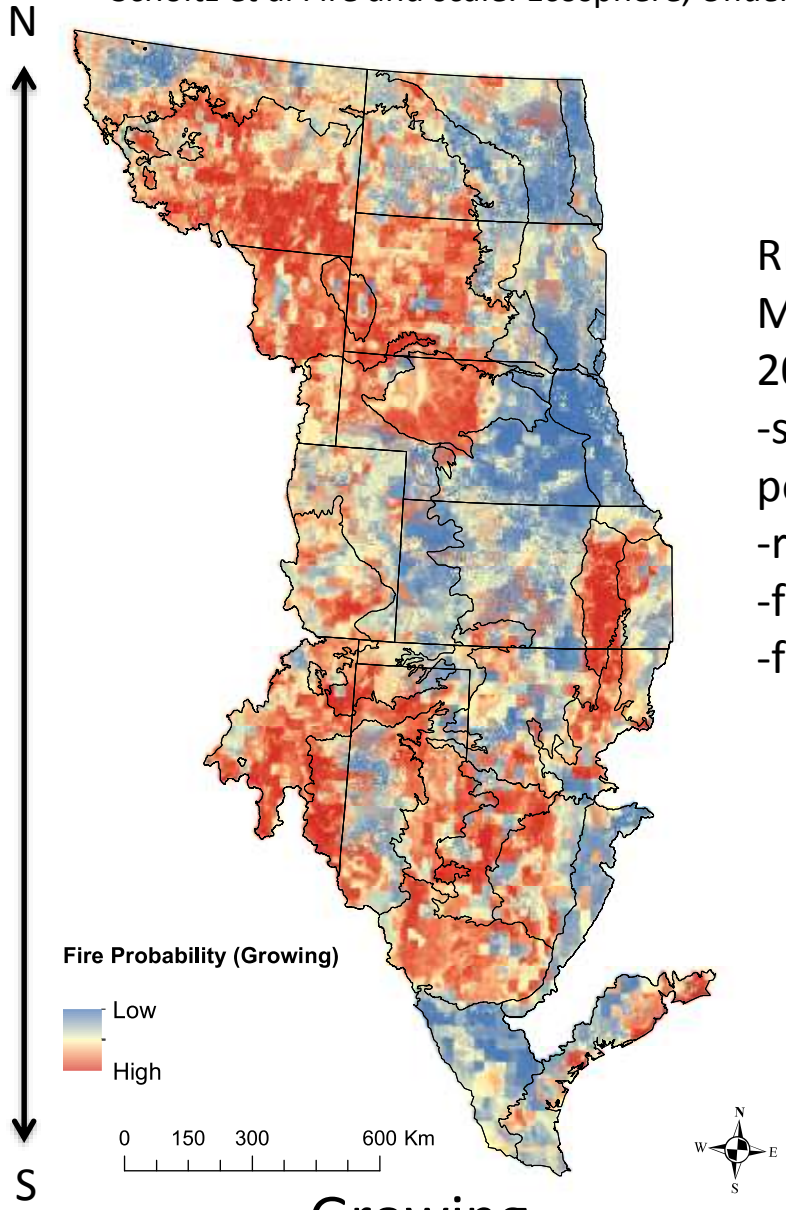



Fig 1. Sampling points where trees/shrubs were identified and counted

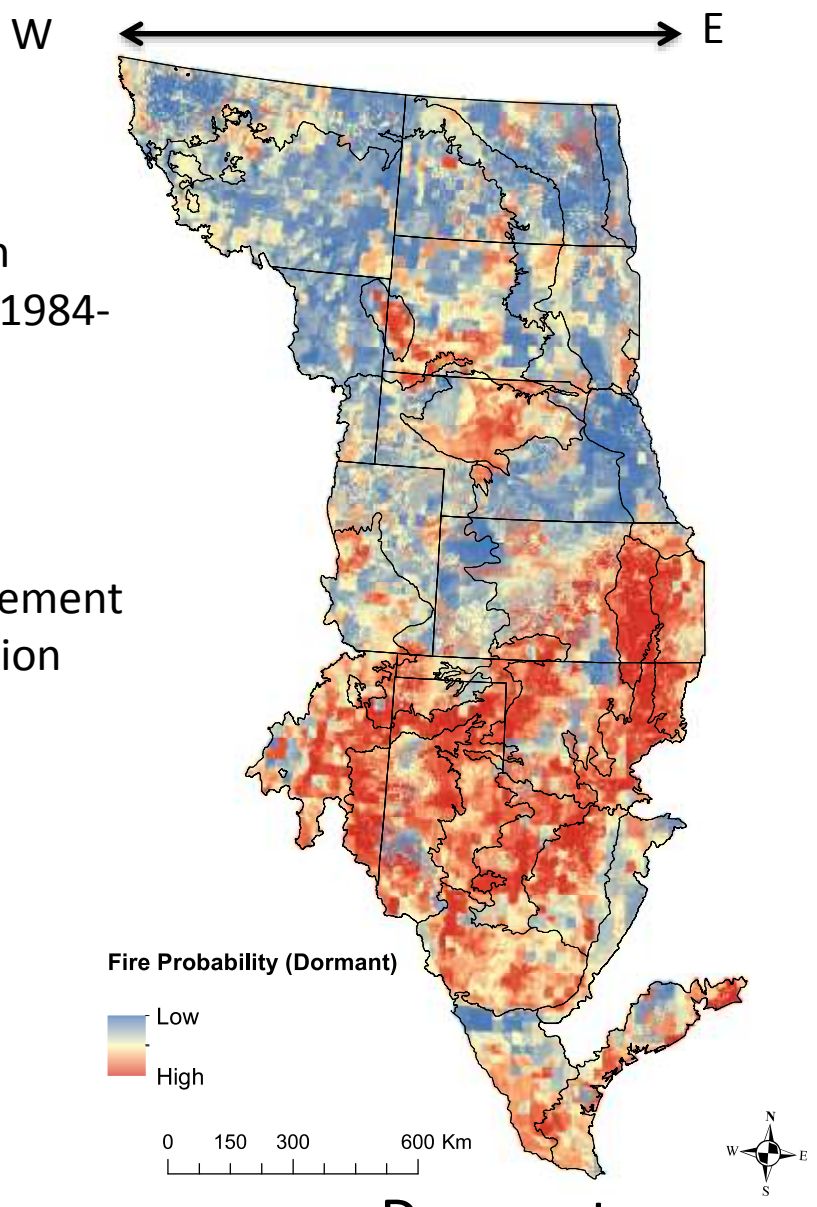
# Build a fire model @ Regional Scale ✓

Scholtz et al Fire and scale. Ecosphere, *Under Review*




Growing

RF Approach
MTBS data (1984-2012)
-society & perceptions
-rainfall
-fuel management
-fine resolution

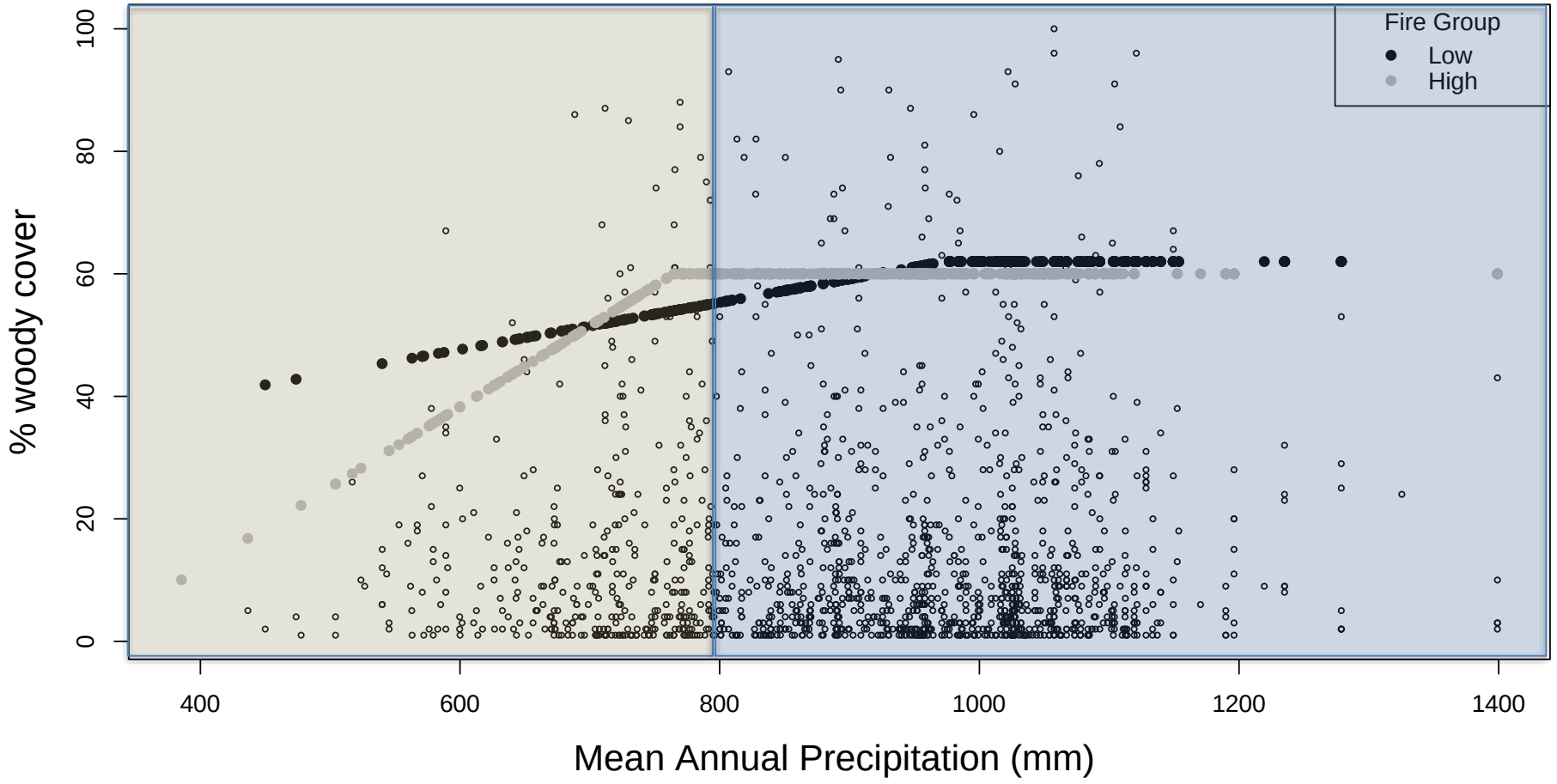



Dormant

# Regional scales: woody cover potential ✓

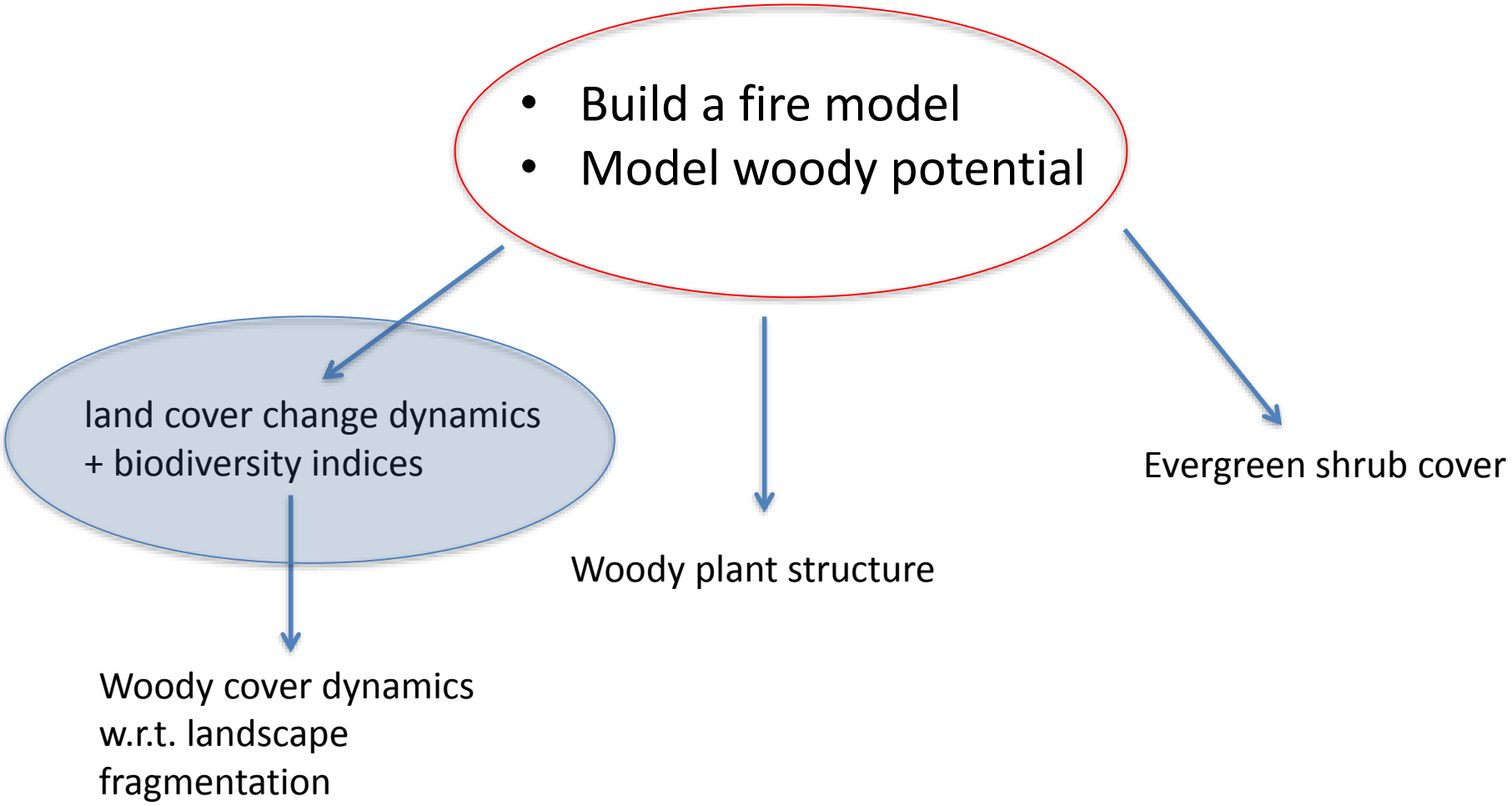
Woody cover limited mostly by rainfall (high rainfall dependence, less fire)

Woody cover not limited by rainfall (low rainfall dependence, more fire)




(Scholtz et al, Global Biogeography and Ecology *in Press*)

# Objectives:


• Build a fire model
• Model woody potential
land cover change dynamics
+ biodiversity indices
Woody plant structure
Evergreen shrub cover
Woody cover dynamics
w.r.t. landscape
fragmentation

# Regional scales: Land-use change in central-north Great Plains

Biological Conservation 209 (2017) 323–331

Contents lists available at ScienceDirect

Biological Conservation

journal homepage: www.elsevier.com/locate/bioc

## Land cover dynamics influence distribution of breeding birds in the Great Plains, USA

R Scholtz [a,*,1], JA Polo [a,1], SD Fuhlendorf [a,1], GD Duckworth [b]

crops

woodland

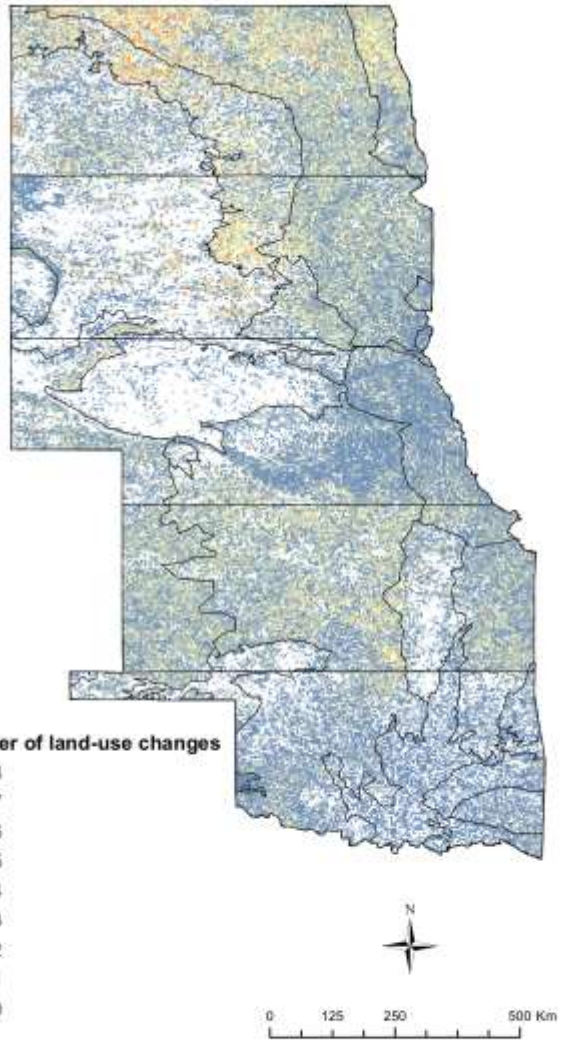



Figure 2. The study area showing the number of changes ranging from no changes (clear) to 8 land-cover changes (red). Each pixel is 3 km$^2$ showing state and ecoregion lines.

Bells Vireo
Blue Grosbeak
Field Sparrow
Indigo Bunting
Lark Bunting
Loggerhead Shrike
Northern Bobwhite
Red-tailed Hawk
Says Phoebe

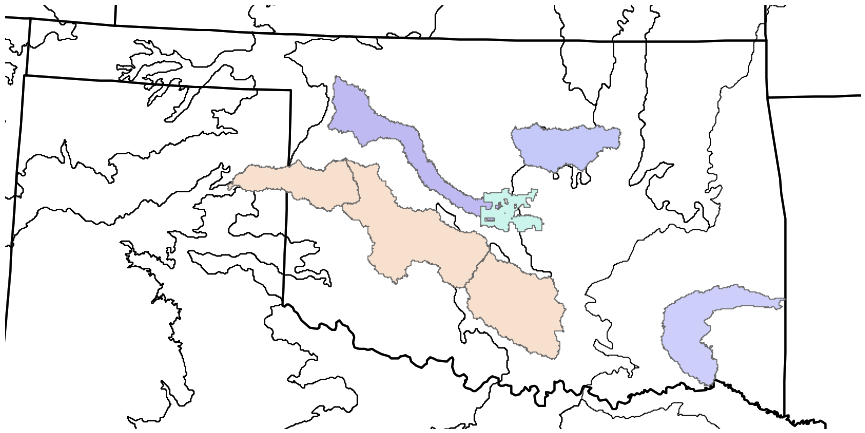
# Major land cover changes in Oklahoma watersheds between 2001-2011 (NLCD)

Canadian:
Wetlands > grass/crops/water/

Fragmentation + encroachment

Cimarron:
Barren > grass/crops/water/ woodlands

Fragmentation + encroachment



Washita:
Barren land > grass/crops

fragmentation

OKC:
Shrubs > grass/crops
Barren > grass/crops/water/ woodlands

Fragmentation + woody reduction

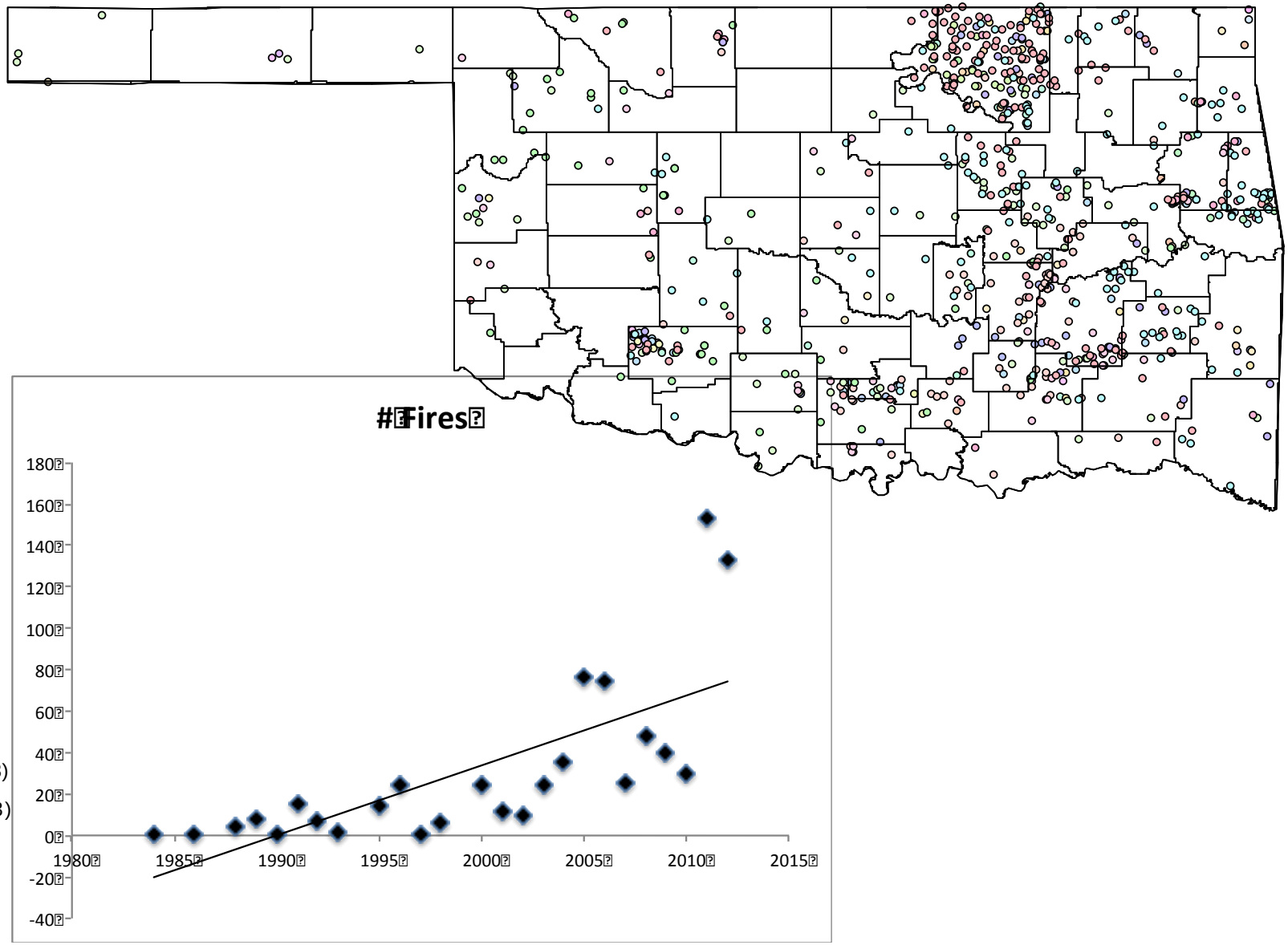
Kiamichi:
Barren > grass/woodlands
Shrub > grass/woodlands

encroachment

# Fire in Oklahoma 1984-2012

Year

- 1984 (1)
- 1986 (1)
- 1988 (4)
- 1989 (8)
- 1990 (1)
- 1991 (15)
- 1992 (7)
- 1993 (2)
- 1994 (7)
- 1995 (14)
- 1996 (24)
- 1997 (1)
- 1998 (6)
- 2000 (24)
- 2001 (12)
- 2002 (10)
- 2003 (24)
- 2004 (35)
- 2005 (76)
- 2006 (75)
- 2007 (25)
- 2008 (48)
- 2009 (40)
- 2010 (30)
- 2011 (153)
- 2012 (133)



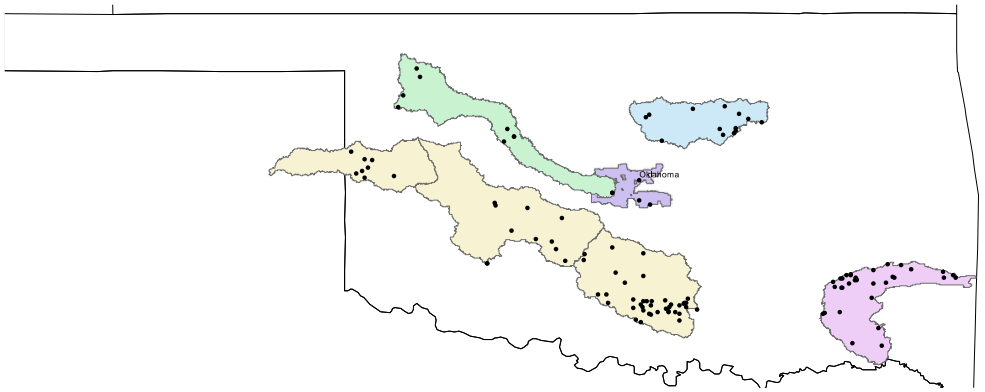
# Major land cover changes in Oklahoma watersheds w.r.t fire activity

Canadian:
Wetlands > grass/crops/water/

Fragmentation + encroachment

Cimarron:
Barren > grass/crops/water/ woodlands

Fragmentation + encroachment



Washita:
Barren land > grass/crops

fragmentation

OKC:
Shrubs > grass/crops
Barren > grass/crops/water/ woodlands

Fragmentation + woody reduction

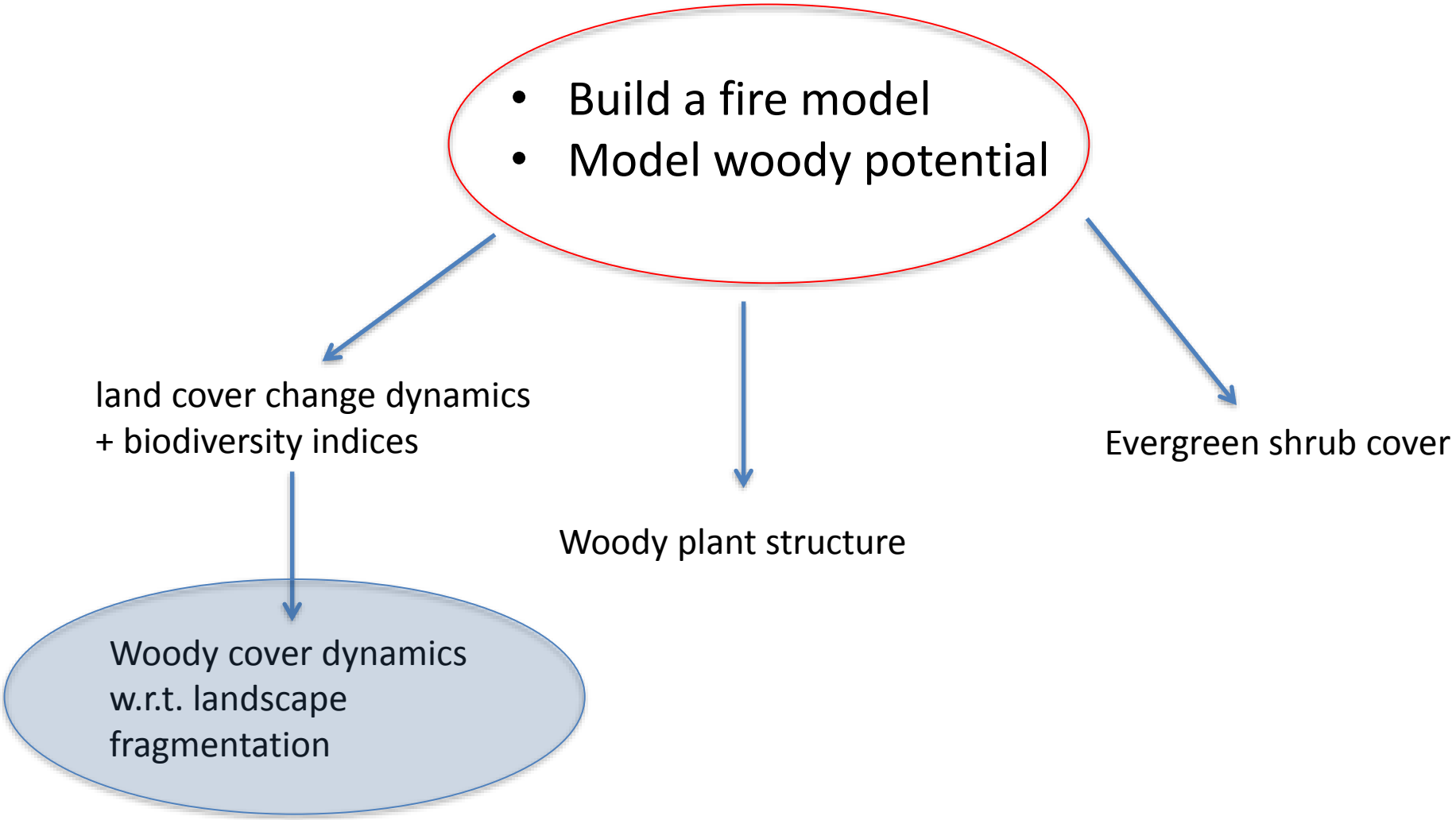
Kiamichi:
Barren > grass/woodlands
Shrub > grass/woodlands

encroachment

Fragmentation > fire reduction

119 fires recorded between 1988-2012 only on unchanged pixels (grassland & woodland)

# Objectives: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Woody plant structure
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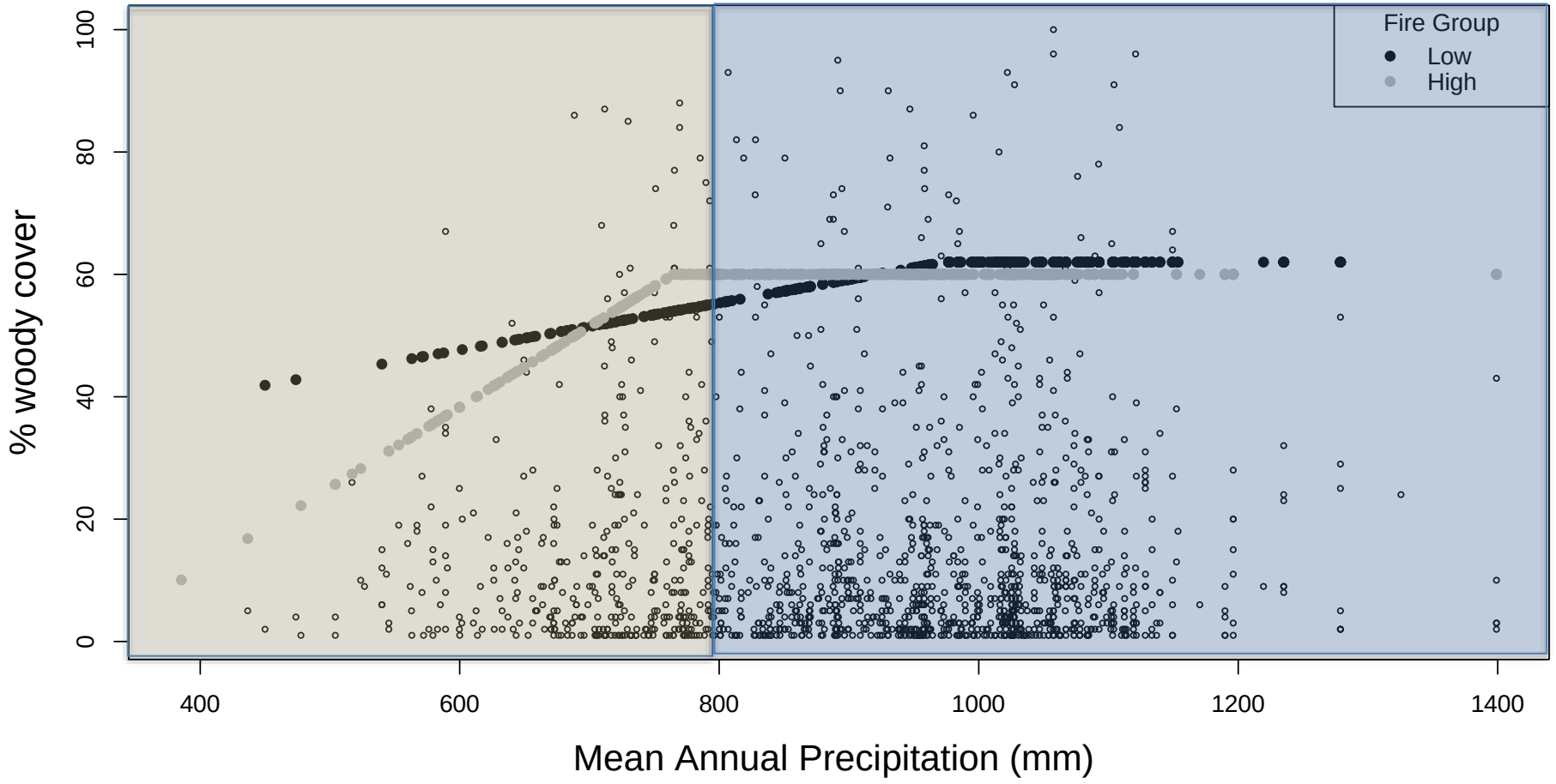
# Regional scales: woody cover potential

Woody cover limited mostly by rainfall (high rainfall dependence, less fire)

Woody cover not limited by rainfall (low rainfall dependence, more fire)




(Scholtz et al, Global Biogeography and Ecology *In Press*)

Review TRENDS in Ecology and Evolution Vol.20 No.7 July 2005


# Fire as a global 'herbivore': the ecology and evolution of flammable ecosystems

William J. Bond[1] and Jon E. Keeley[2,3]

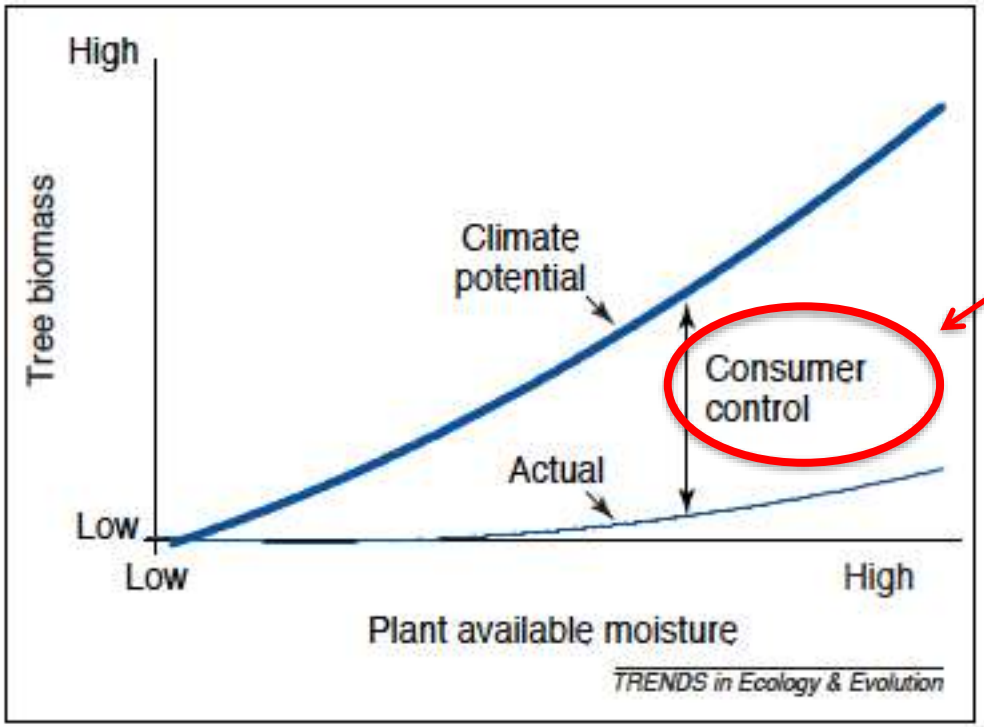
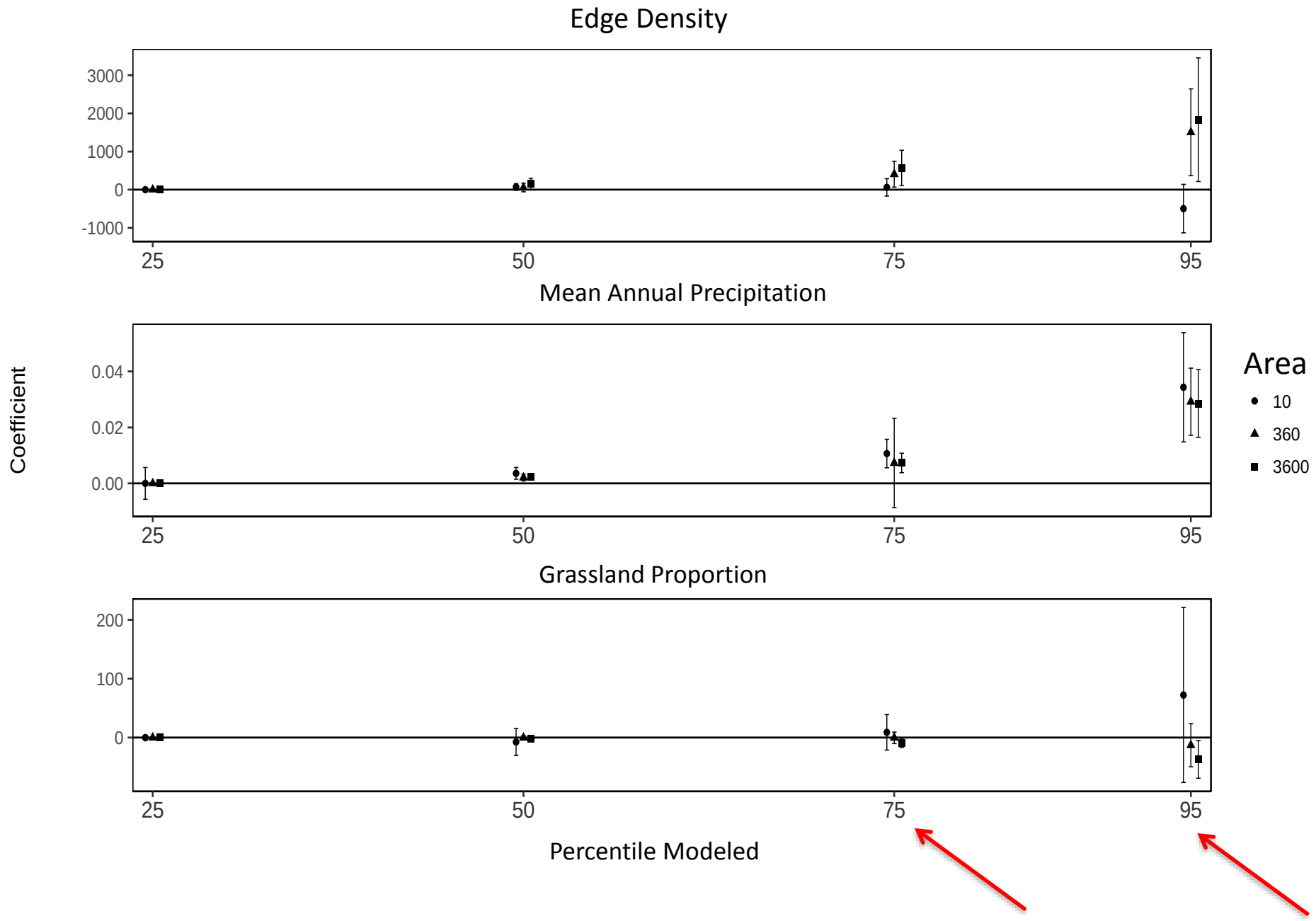


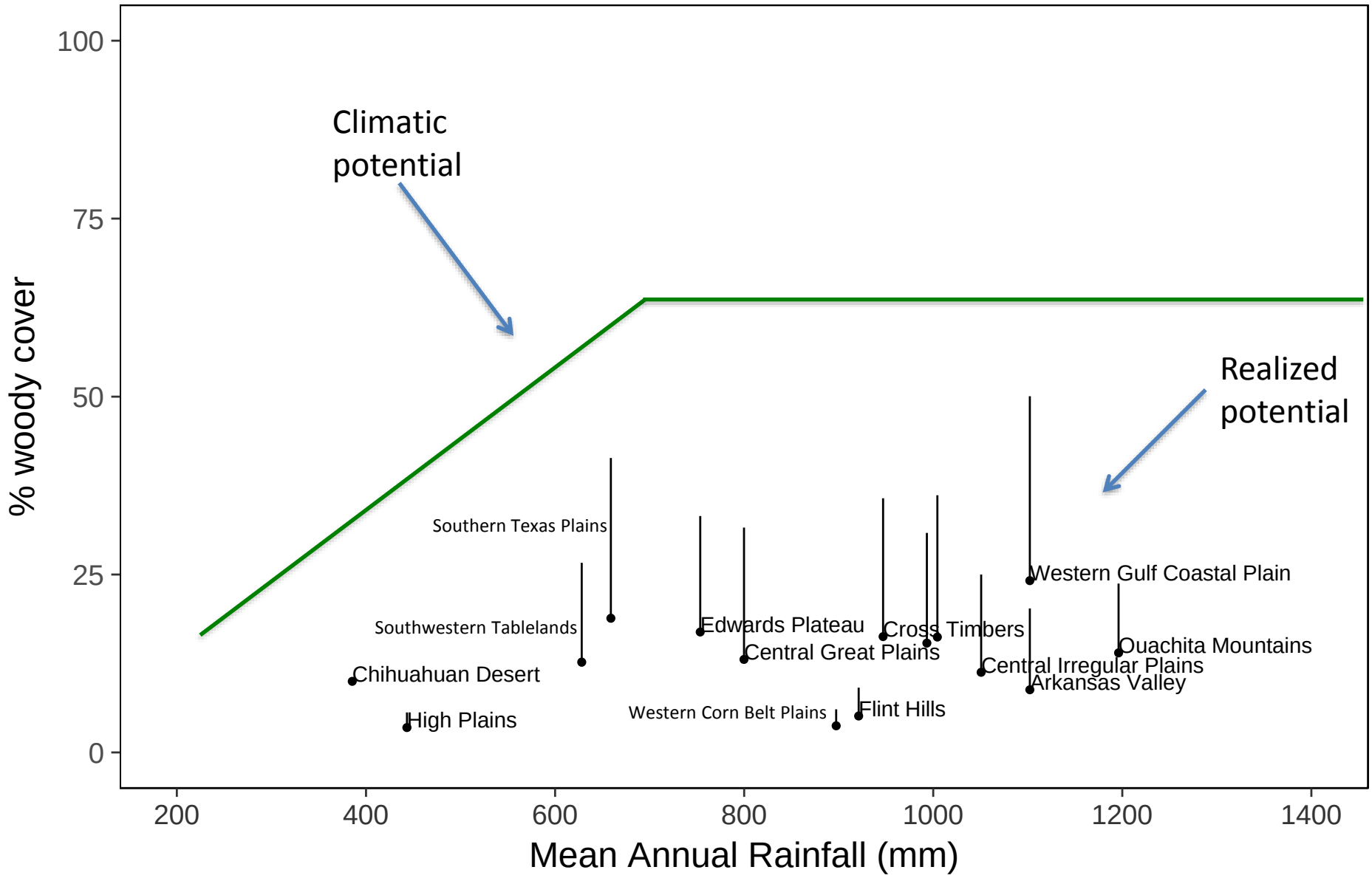

**Figure 1.** Assessing consumer control of tree biomass. The extent of consumer control of an ecosystem can be measured as the difference between tree biomass at 'climate potential' and the actual tree biomass. Large differences between potential and actual woody biomass suggest significant consumer control of the ecosystem. 'Climate potential' can be viewed as the carrying capacity of a site for trees.

At smaller scales…
What about humans?
Grassland fragmentation?

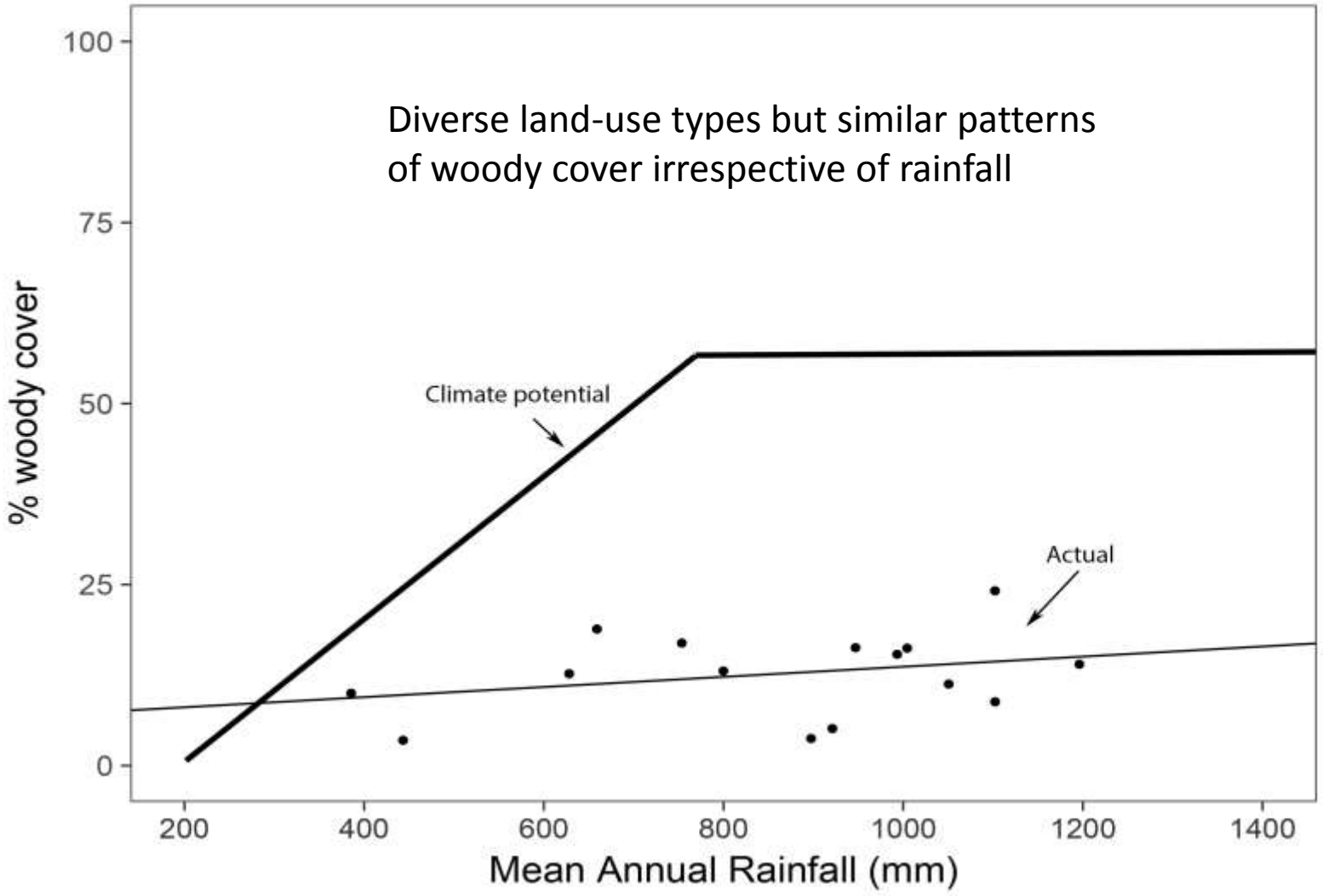
woody cover potential ~
Edge density +
Proportion of the landscape


Edge Density
3000
2000
1000
0
-1000
25
50
75
95
Mean Annual Precipitation
0.04
0.02
0.00
25
50
75
95
Grassland Proportion
200
100
0
25
50
75
95
Percentile Modeled
Coefficient
Area
10
360
3600

# Woody cover potential w.r.t. land-use

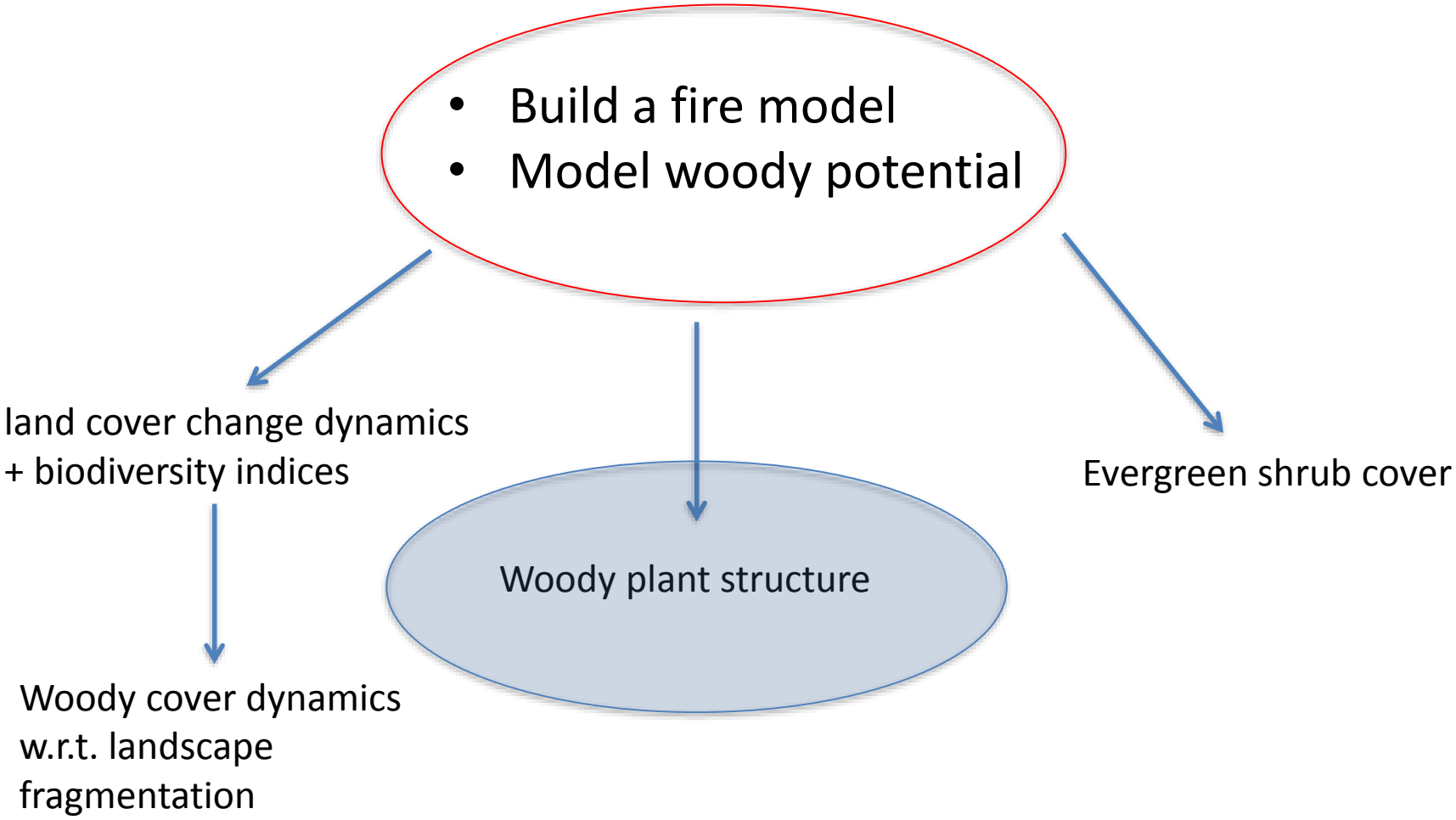


# Mean % woody cover per ecoregion




Scholtz, Polo, Tanner, Fuhlendorf Landscape Ecology *in Review*

# Objectives:


• Build a fire model
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w.r.t. landscape
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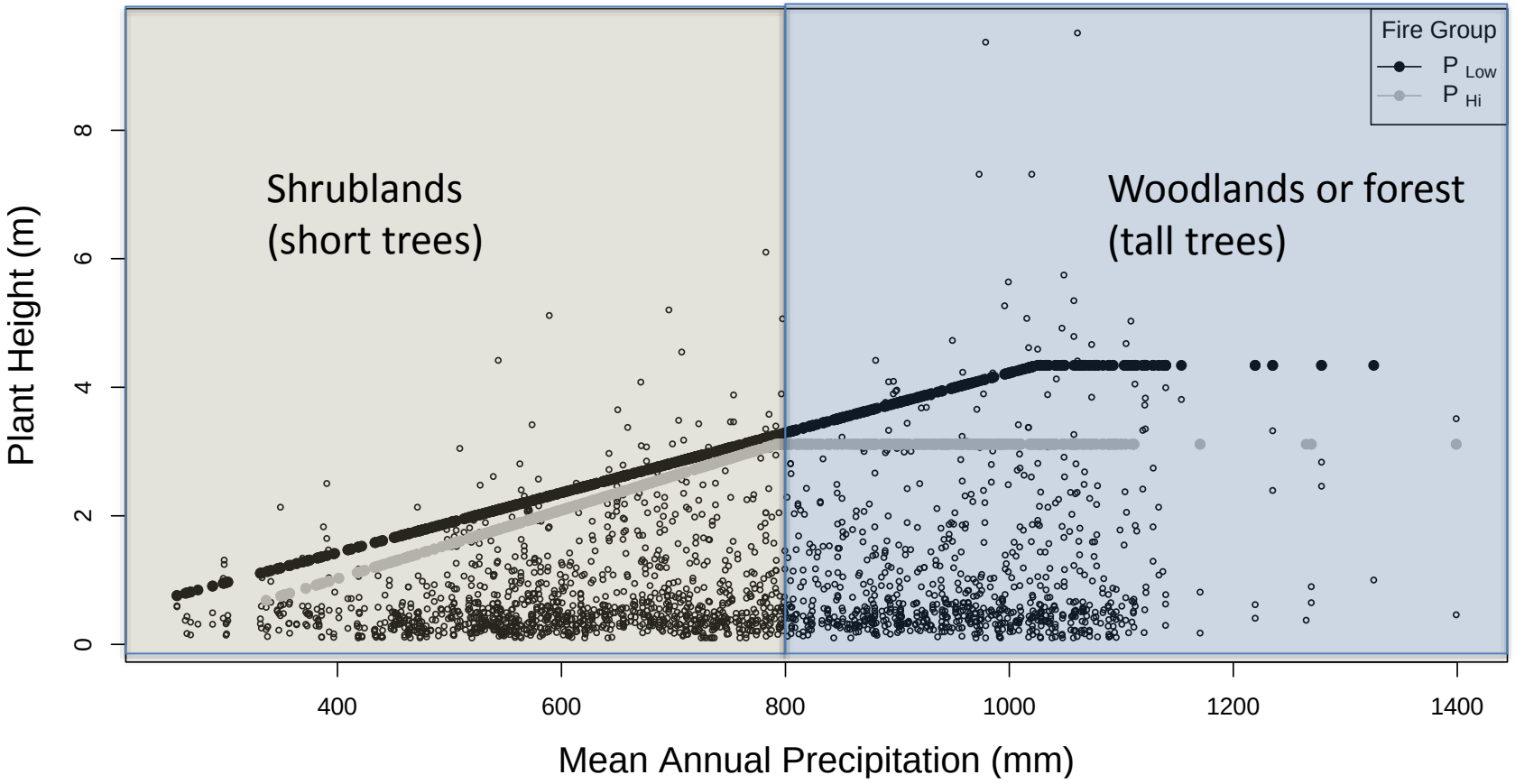
# Regional scales: plant height potential ✓

Height limited mostly by rainfall (high rainfall dependence, less fire)

Height not limited by rainfall (low rainfall dependence, more fire)




(Scholtz et al, Global Biogeography and Ecology *in Press*)

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# Woody Plant Encroachment Mitigated Differentially by Fire and Herbicide☆

Rheinhardt Scholtz *, John A. Polo, Samuel D. Fuhlendorf, David M

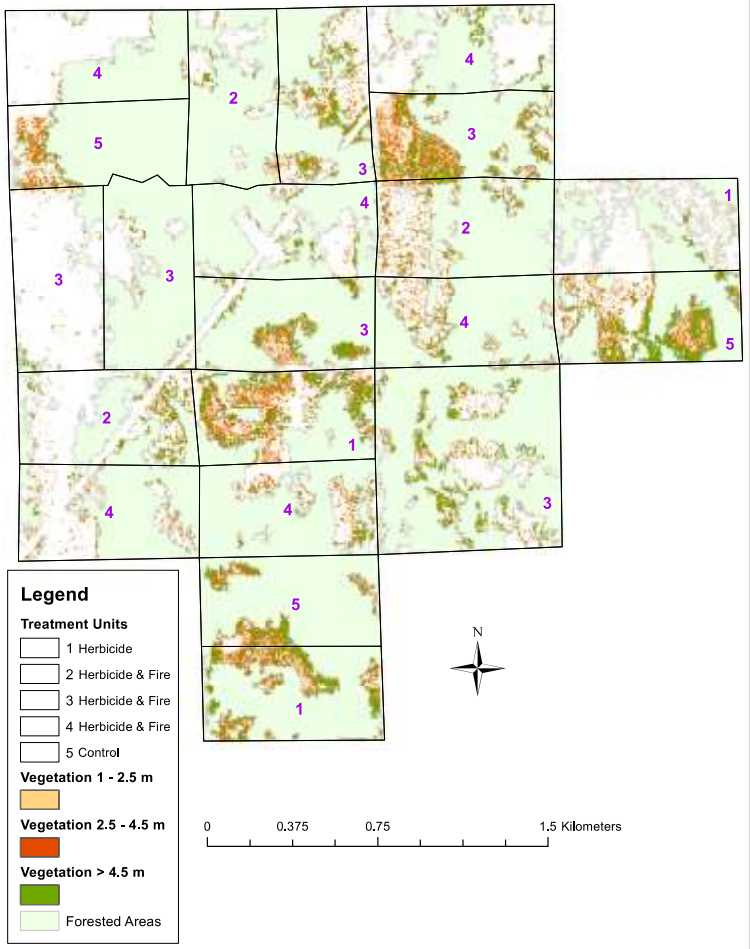
*Natural Resource Ecology and Management, Oklahoma State University, Stillwater, OK 74078, USA*

31% encroachment from 1979 – 2010
Juniper spp.

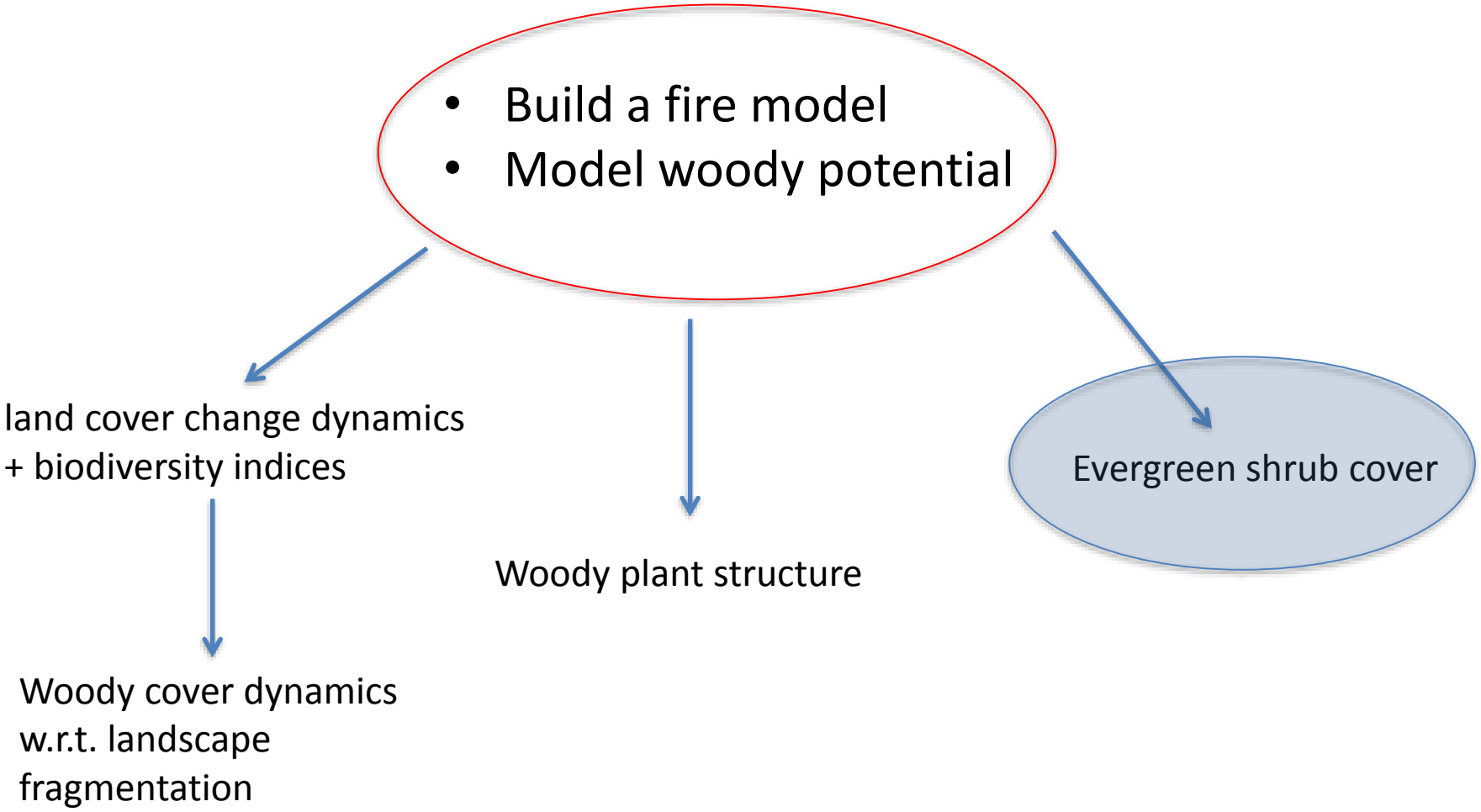
Juniper expansion poses threats to multiple facets…

- Fire activity
- Microclimates (e.g. favors tick communities)
- **Increase grassland fragmentation**

**(which can favor higher woody cover)**



# Objectives:


• Build a fire model
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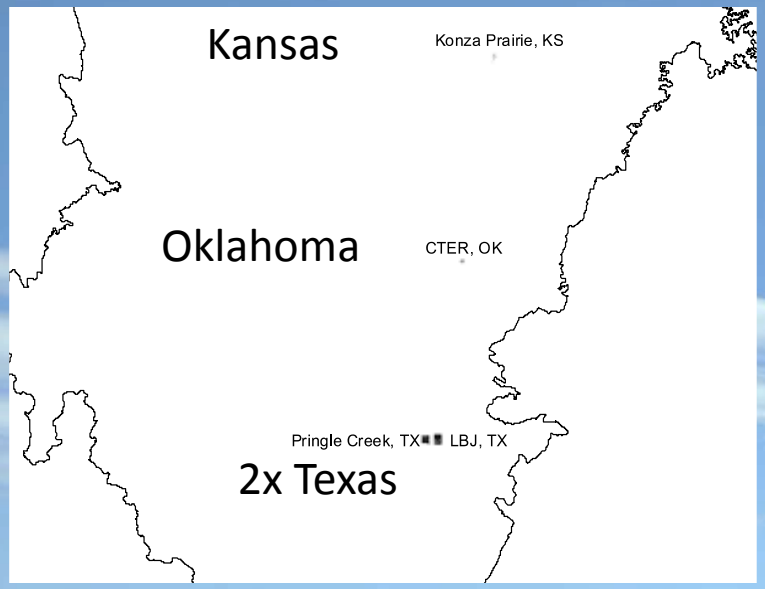
fragmentation
Woody plant structure
Evergreen shrub cover

# We need to model evergreen shrub cover
# shrub = <5m evergreen plant

4 Training sites with height data



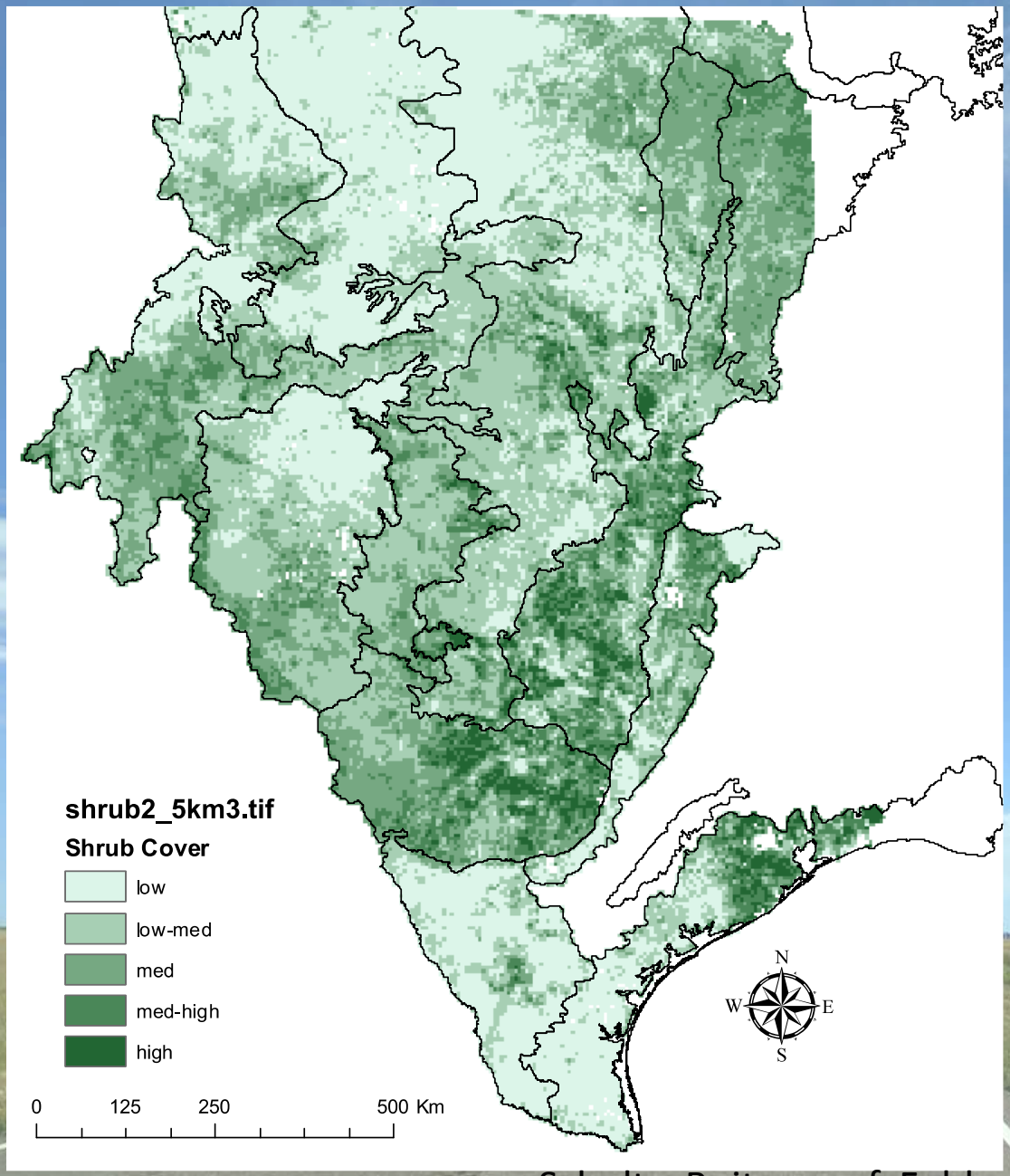

Get proportion shrub cover (trees <5m height) at training sites

NDVI variation 2000-2015 for entire area classified as “shrub”, “grassland”, “pasture/hay” by NLCD

Train and test random forest model > predict shrub cover in all areas

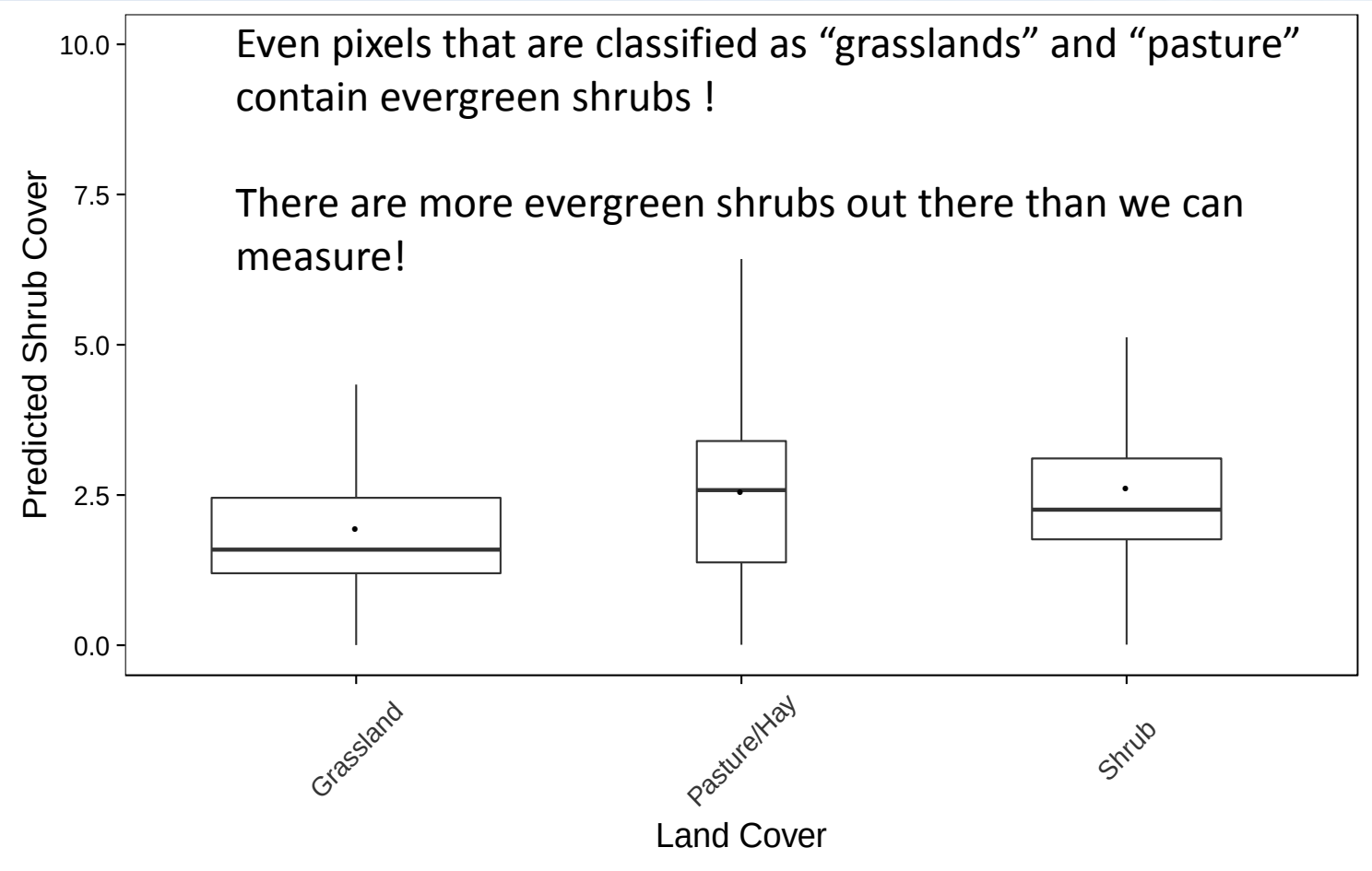
Scholtz, Buitenwerf, Fuhlendorf, Archer in prep

# Predicting shrub cover using NDVI




Scholtz, Buitenwerf, Fuhlendorf, Archer in prep

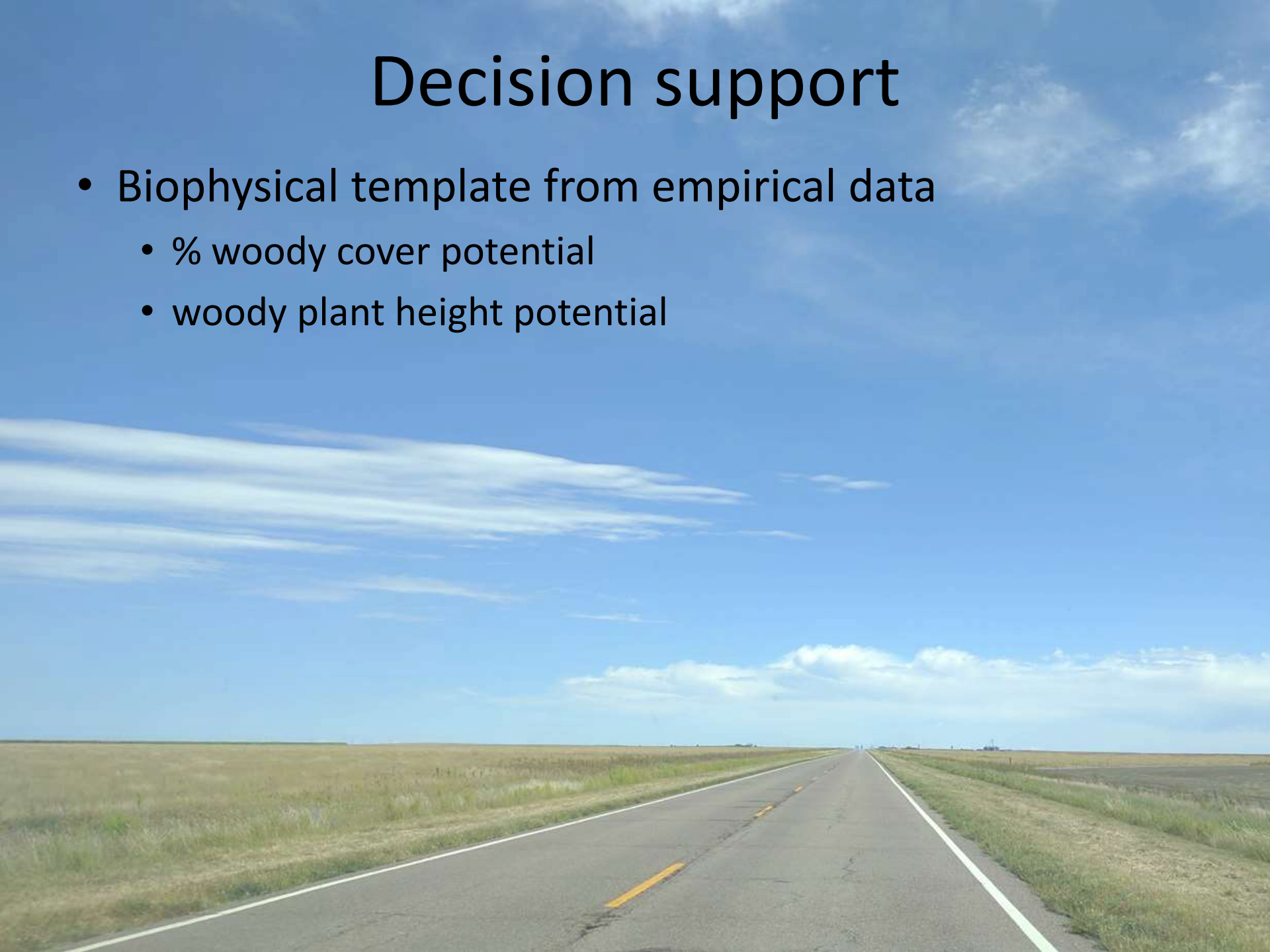
# Results … classification rules matter!



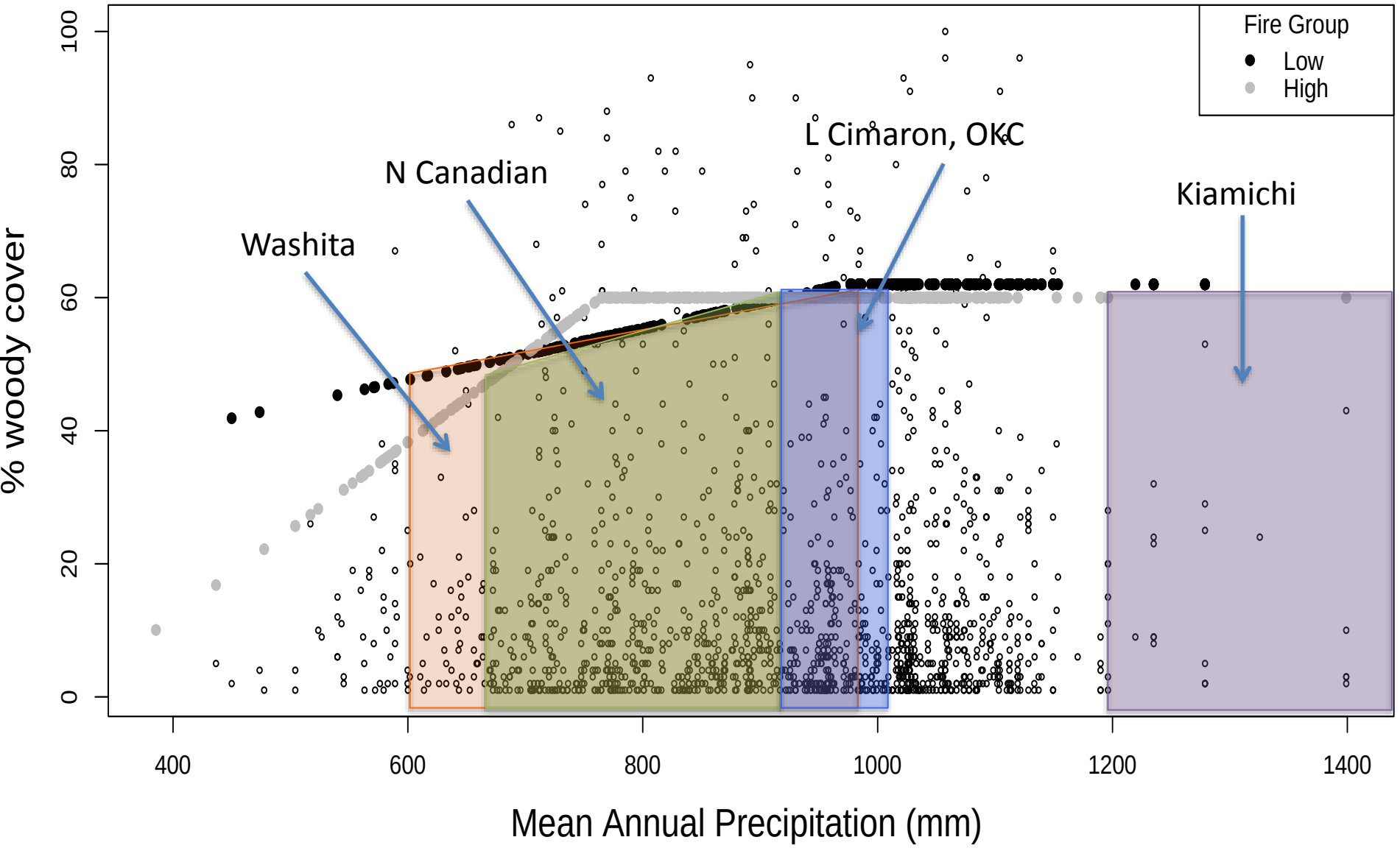

It matters how you decide to classify a pixel (size of your choice) that contains one cover type vs. more than one.

# Decision support

- Biophysical template from empirical data
  - % woody cover potential
  - woody plant height potential



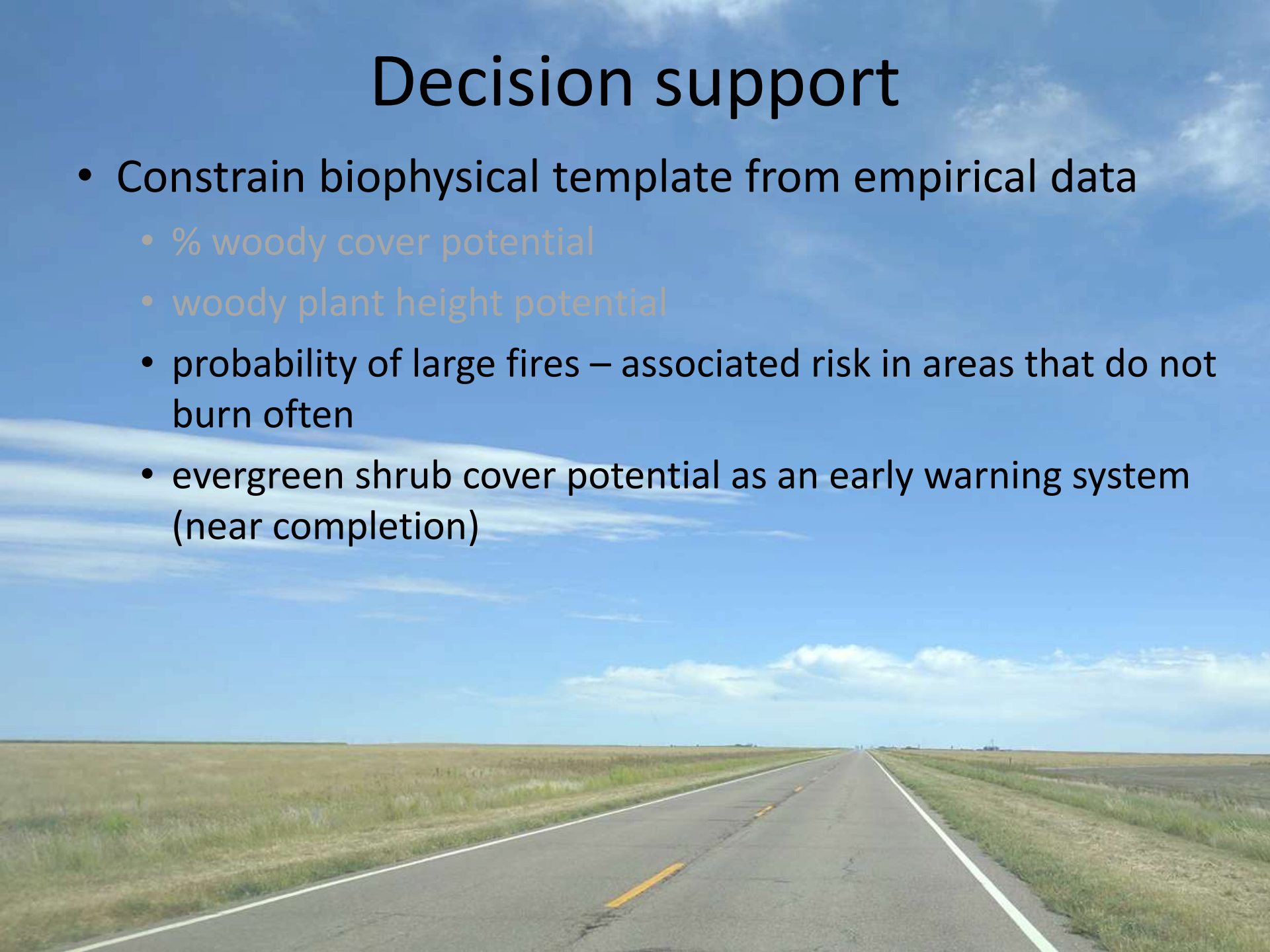
# Landscape level % woody cover potential




(Scholtz et al, Global Biogeography and Ecology *in Press*)

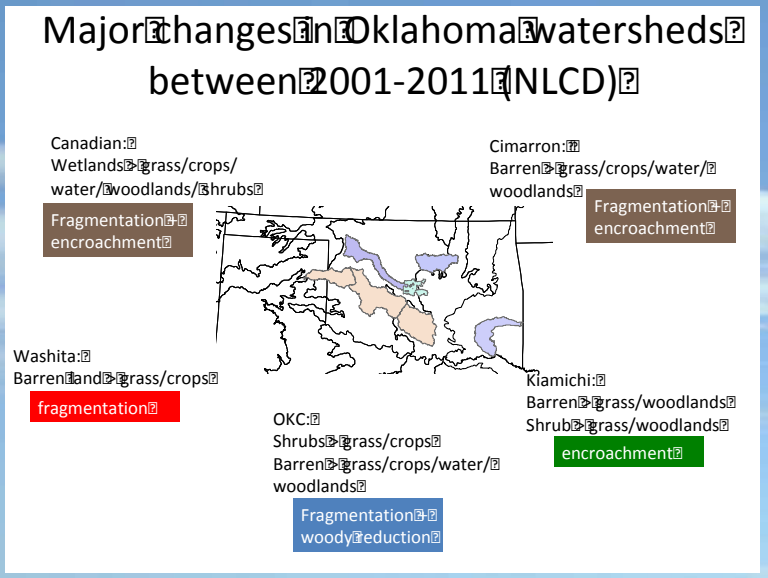
# Decision support

- Constrain biophysical template from empirical data
  - % woody cover potential
  - woody plant height potential
  - probability of large fires – associated risk in areas that do not burn often
  - evergreen shrub cover potential as an early warning system (near completion)



# Over the next few months…

- This information is to be applied in the Envision platform




- Finalize land cover change dynamics (w.r.t. fire + biodiversity)
- Finalize model on brush mgmt ~ woody cover potential

- Woody plant potential model simulations under various climate scenarios

# Thanks and Acknowledgements


- Funders NSF
- Lorerra Metz (NRCS)
- Brad Wilcox, Andrew Birt, Urs Kreuter (TA&M)
- Sherry Leis (MSU)
- Josh Picotte (USGS)
- Jesse Nippert (KSU)
- Laura Goodman (OSU)
- Craig Davis (OSU)
- Evan Linde and HPCC team (OSU)