Toward Forest Sustainability in a Changing World: Assessing Migration and Population Dynamics of Forest Tree Species

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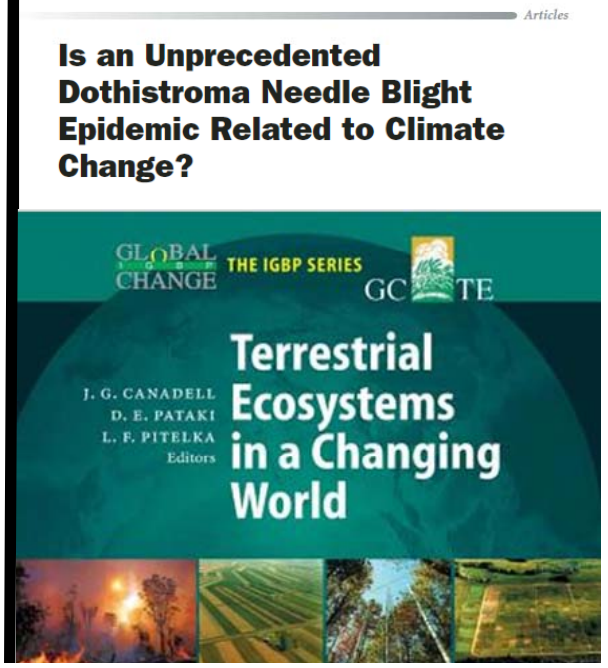
Outline

- **Key Challenges and Needs**
- **Indicator 1: Species mortality and population growth**
- **Indicator 2: Species migration**
  Distributional footprint differences between seedlings and large trees
- **Summary**

Key Challenges

Forests are changing in response to climate change and other drivers

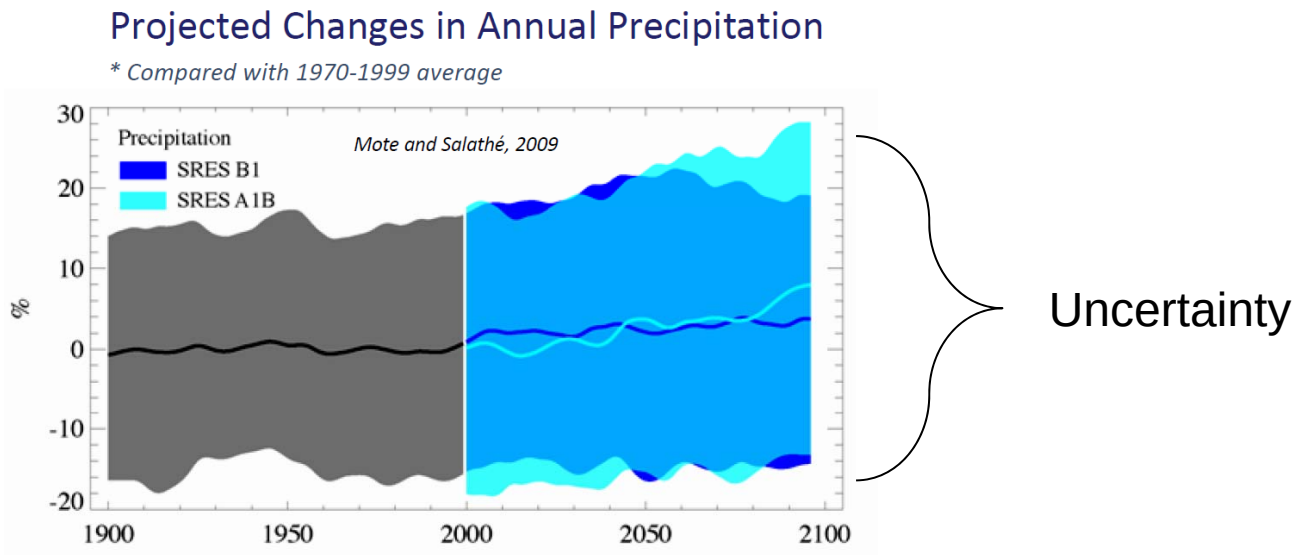
- The timing of biological events
- Species migration
- Drought-related mortality
- Increase in wildfire
- Pathogen outbreaks



Key Challenges

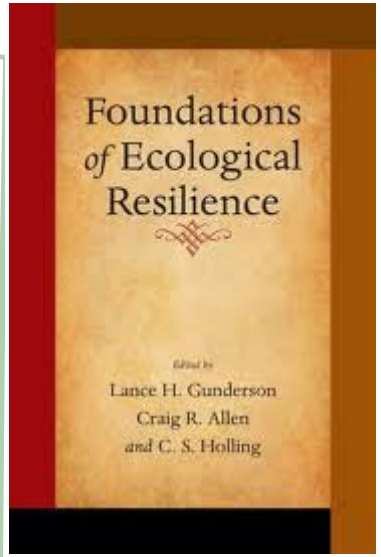
Shifts in forest location and composition will likely increase

Management decisions that we make now must withstand uncertain environments decades from now



Key Challenges

Sustainable forest management must bridge the trade-off between optimization of forest productivity and resilience



Key Challenges

- We know how to optimize yield given prevailing conditions for the past century

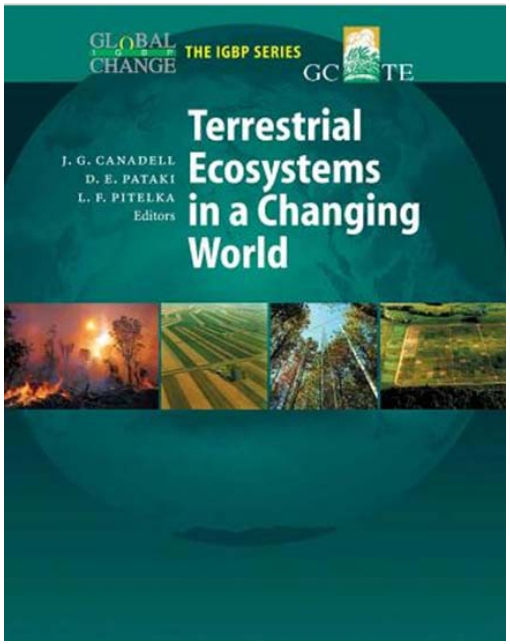
- How can we ensure forest resilience *and* yield (along with other commodities and services) given the challenges of the 21st century?

Needs

Sustainable management requires working *with* naturally occurring processes to maximize their beneficial use, minimize external inputs, and reduce undesirable losses

Needs

Plant species migration is a key process that is not well characterized in this region



Terrestrial Ecosystems in a Changing World
Global Change — The IGBP Series

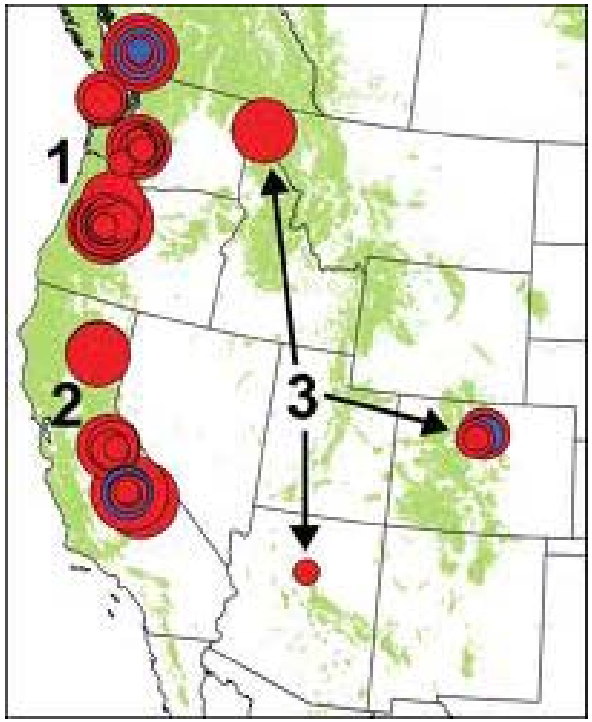
Midgley et al. 2007

Needs

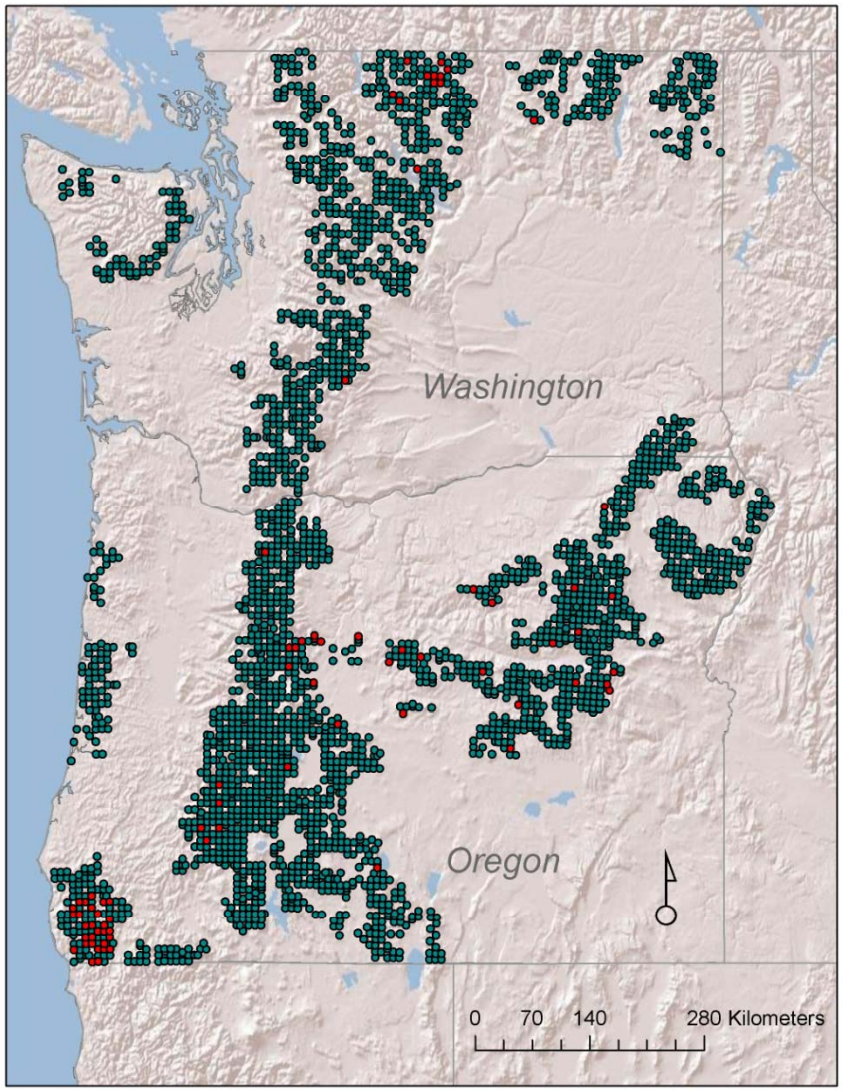
Population growth and mortality are two natural processes fundamental to forest sustainability

Widespread Increase of Tree Mortality Rates in the Western United States

van Mantgem *et al* (2009), *Science*, **323**, 521-524



Indicator 1

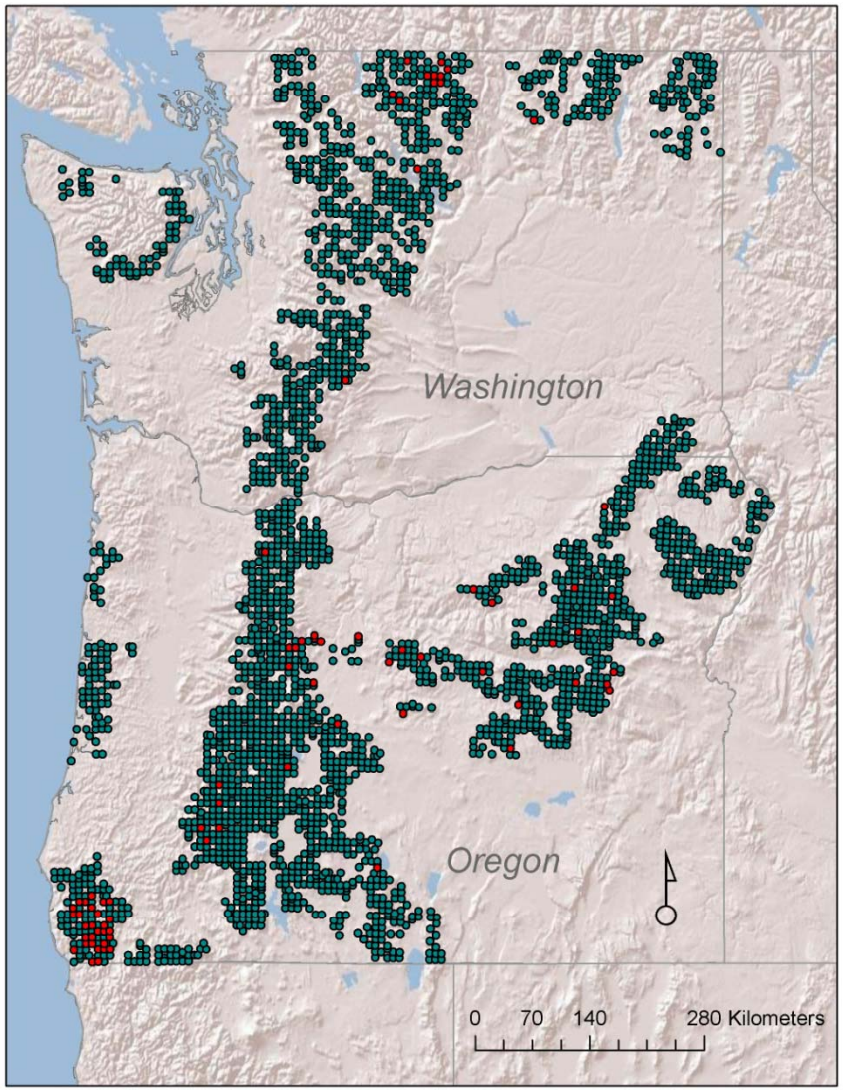


CVS plots across Oregon and Washington that intersect with FIA plots

Red=Fire occurred during re-measurement interval

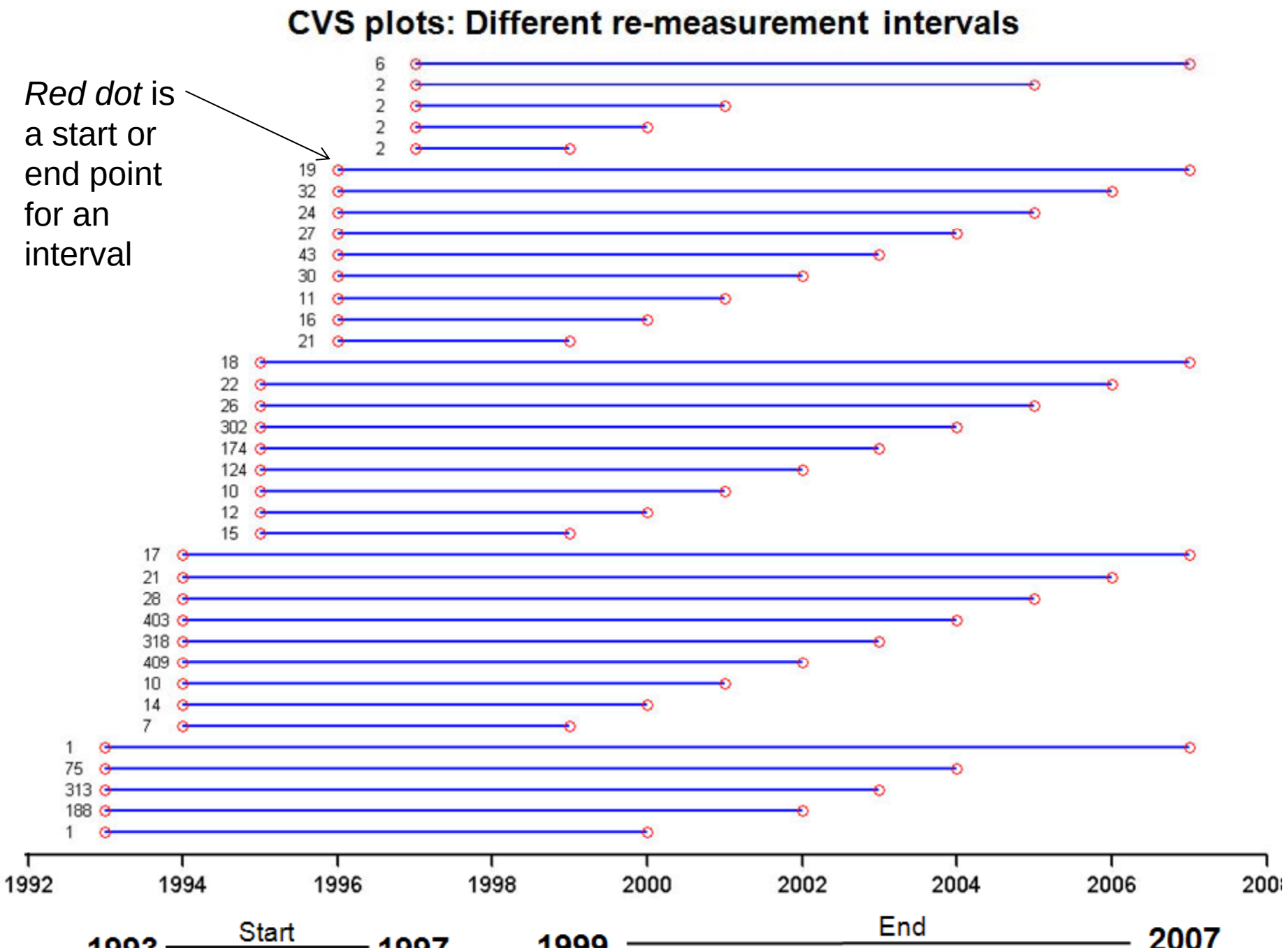
Green=No fire occurred during re-measurement interval

Indicator 1



CVS plots data are used here as proof of concept for application with FIA plots in the future

N=2475


CVS plots: Different re-measurement intervals
Red dot is a start or end point for an interval
6
2
2
2
2
19
32
24
27
43
30
11
16
21
18
22
26
302
174
124
10
12
15
17
21
28
403
318
409
10
14
7
1
75
313
188
1
1992
1994
1996
1998
2000
2002
2004
2006
Start
End
2007

Indicator 1

$$Q_1 = 1 - (1 - Q_n)^{1/n}$$

(Lorimer 1981, Sheil et al. 1995)

Standardized mortality rate

$$P_1 = (1 + P_n)^{1/n} - 1$$

(McCune and Cottam 1985)

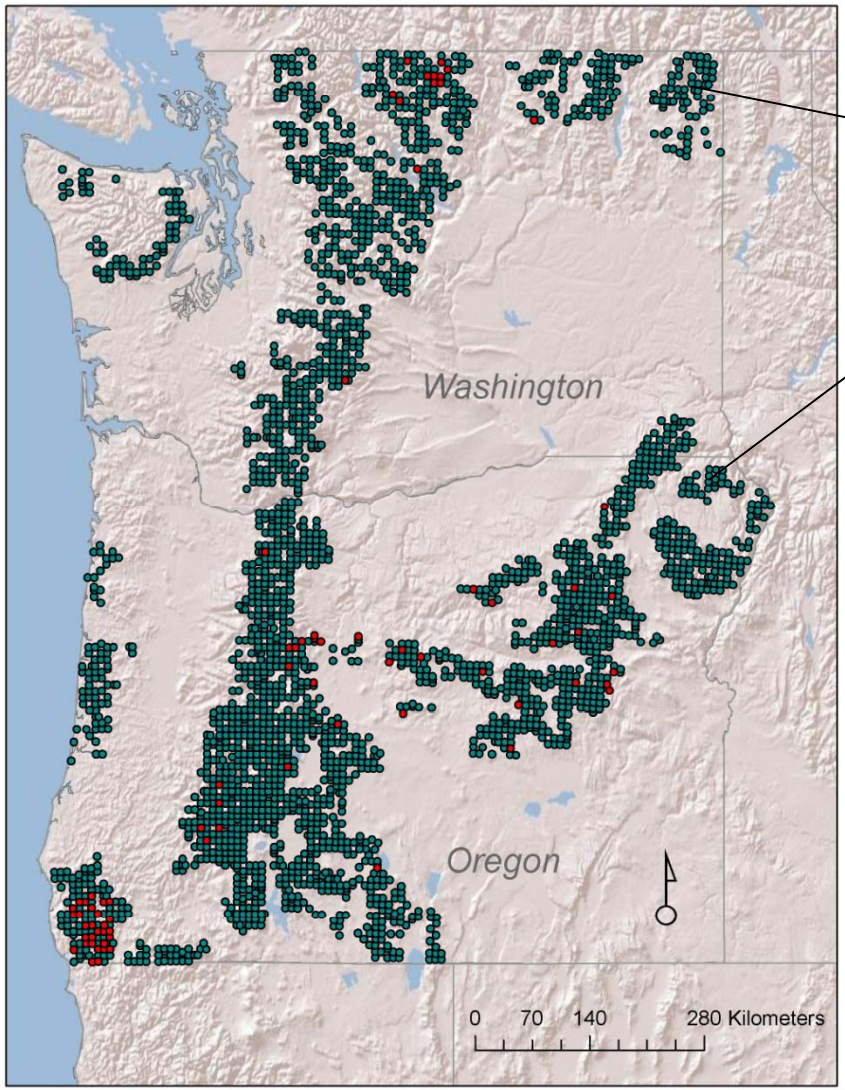
Standardized population growth rate

Indicator 1

$$S_1 = P_1 - Q_1$$

Sustainability metric for a species within a plot (or a population)

Indicator 1



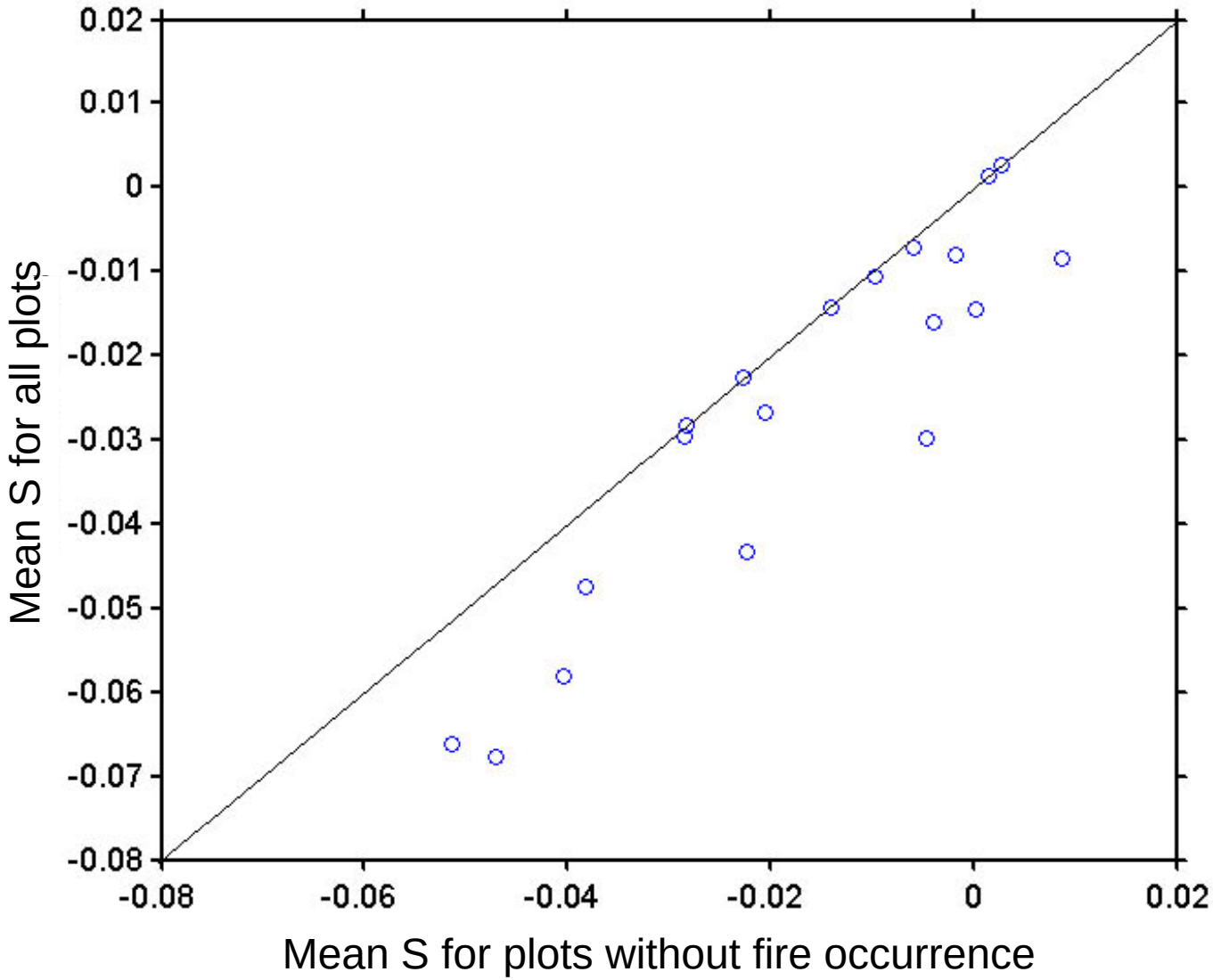
Calculate *S* by species and by plot

Indicators:

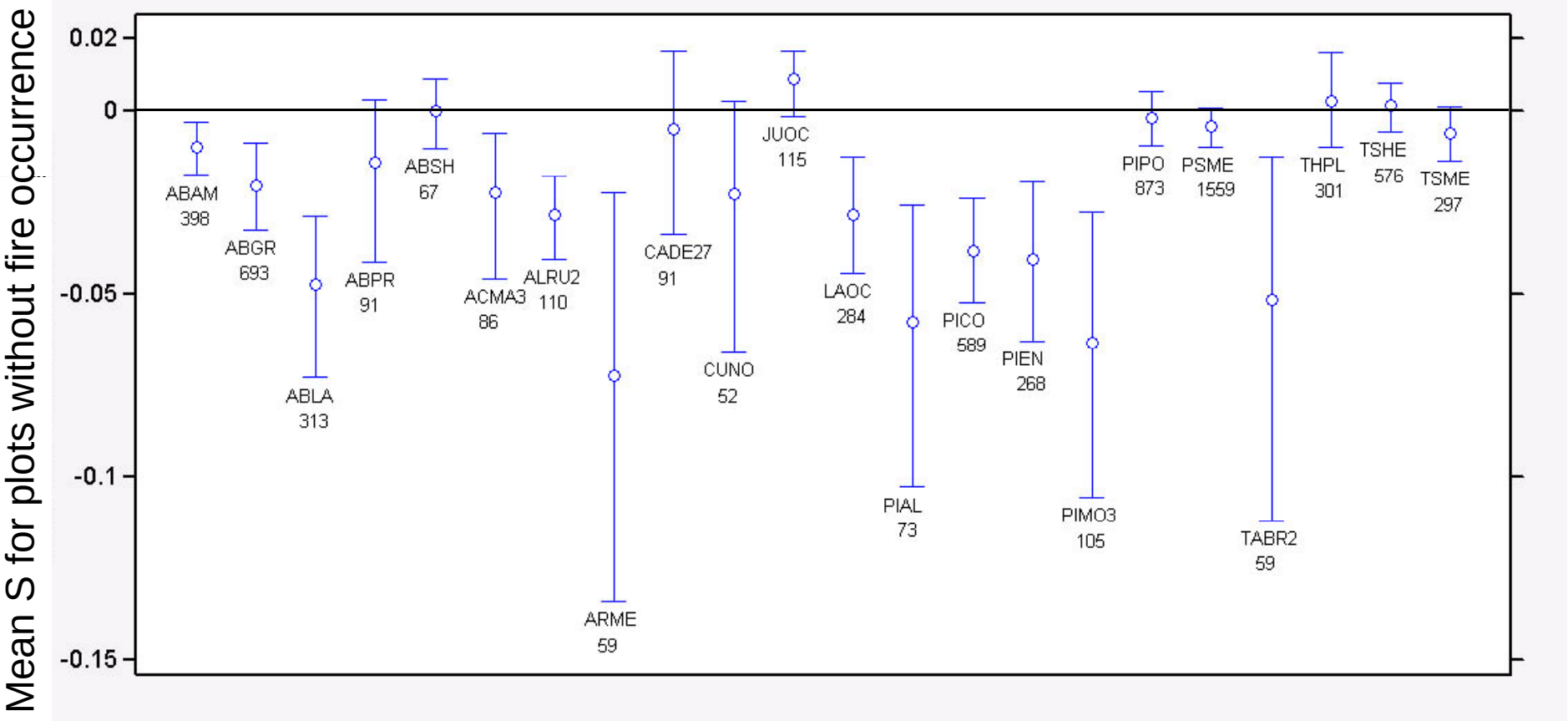
Biome sustainability:
Mean *S* by plot

Species sustainability:
Mean *S* by species

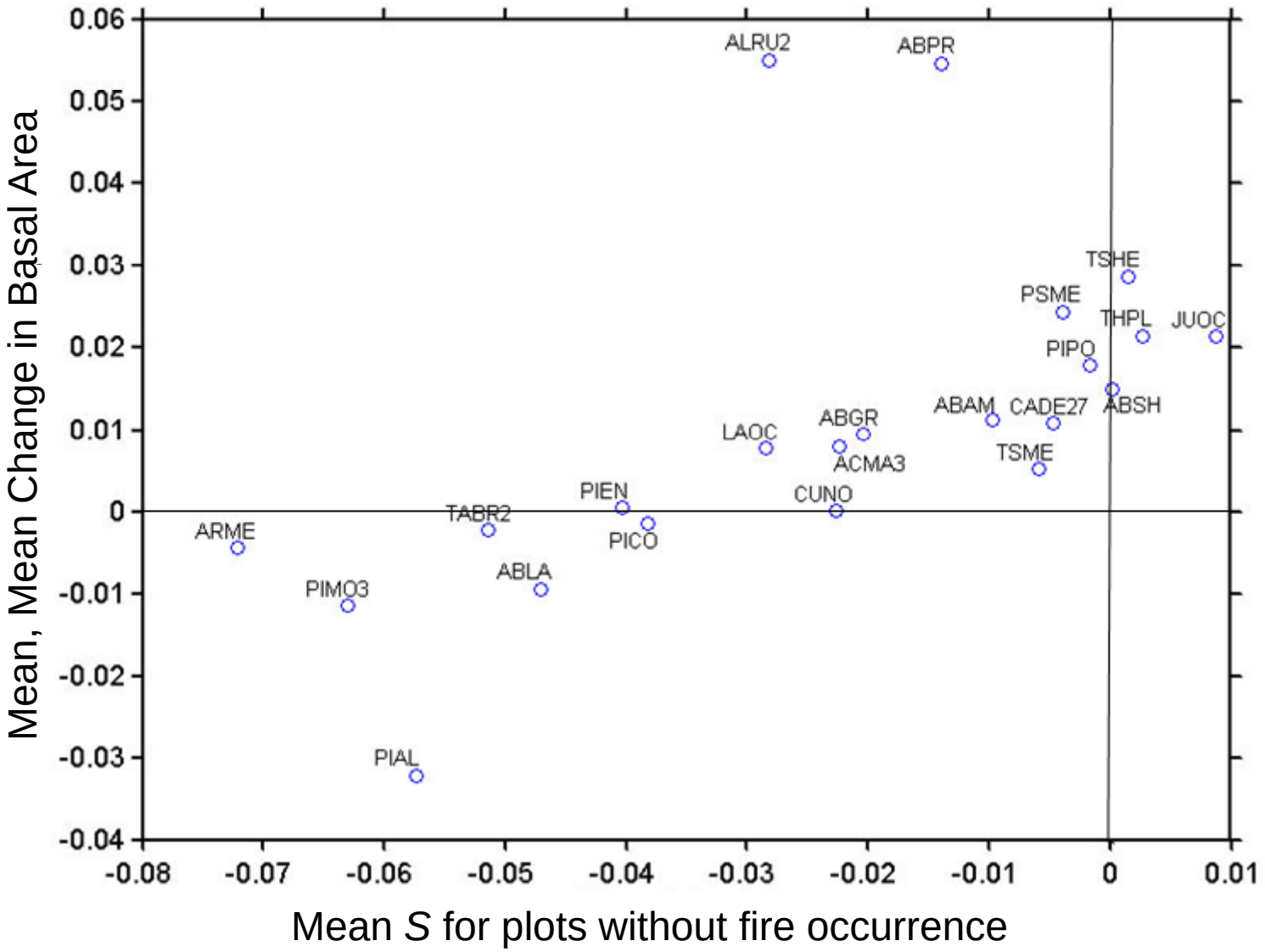
Indicator 1: Species Sustainability



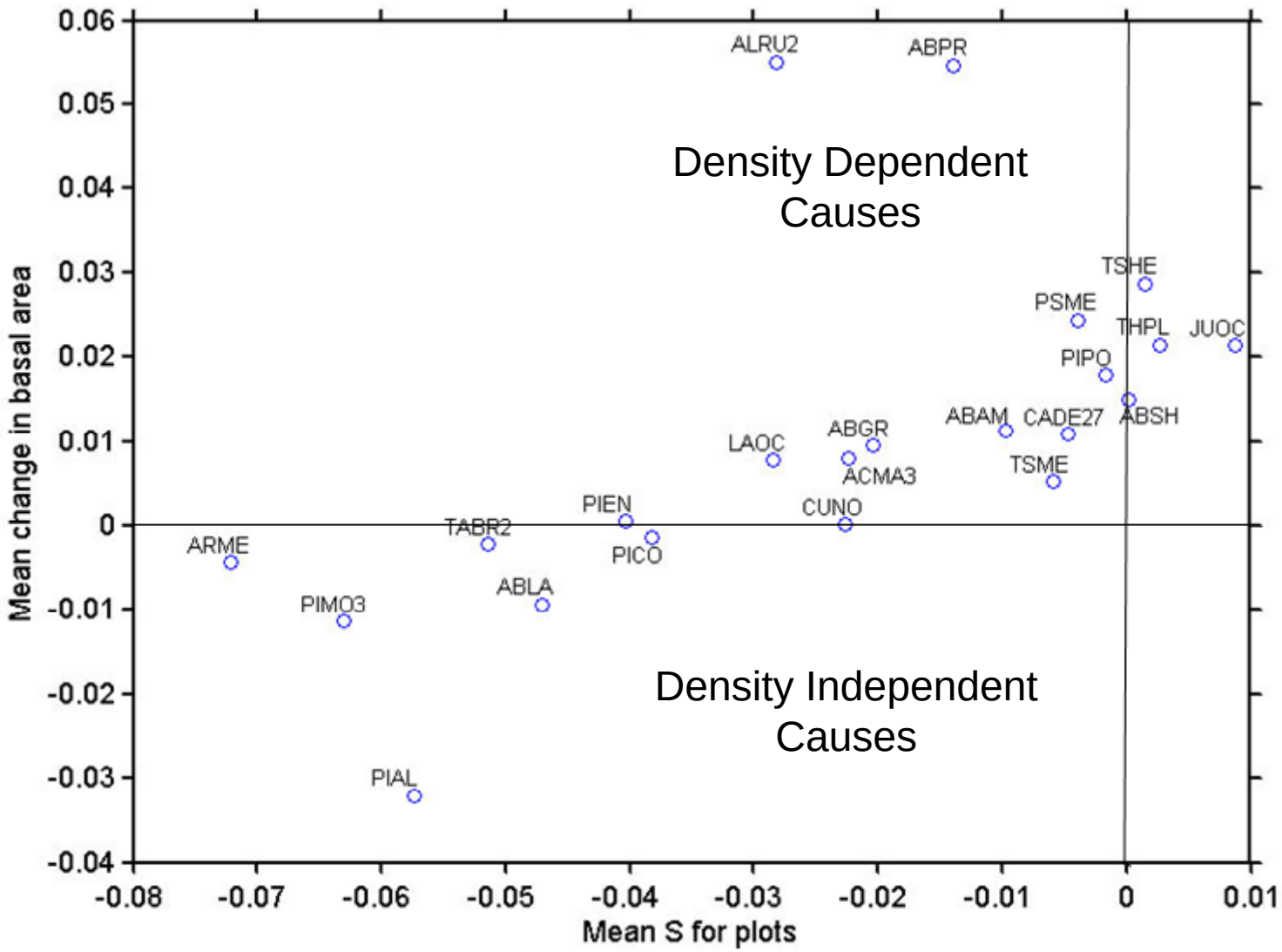
Indicator 1


Mean S for plots without fire occurrence
0.02
0
-0.05
-0.1
-0.15
ABAM 398
ABGR 693
ABLA 313
ABPR 91
ABSH 67
ACMA3 86
ALRU2 110
ARME 59
CADE27 91
CUNO 52
JUOC 115
LAOC 284
PIAL 73
PICO 589
PIEN 268
PIMO3 105
PIPO 873
PSME 1559
TABR2 59
THPL 301
TSHE 576
TSME 297

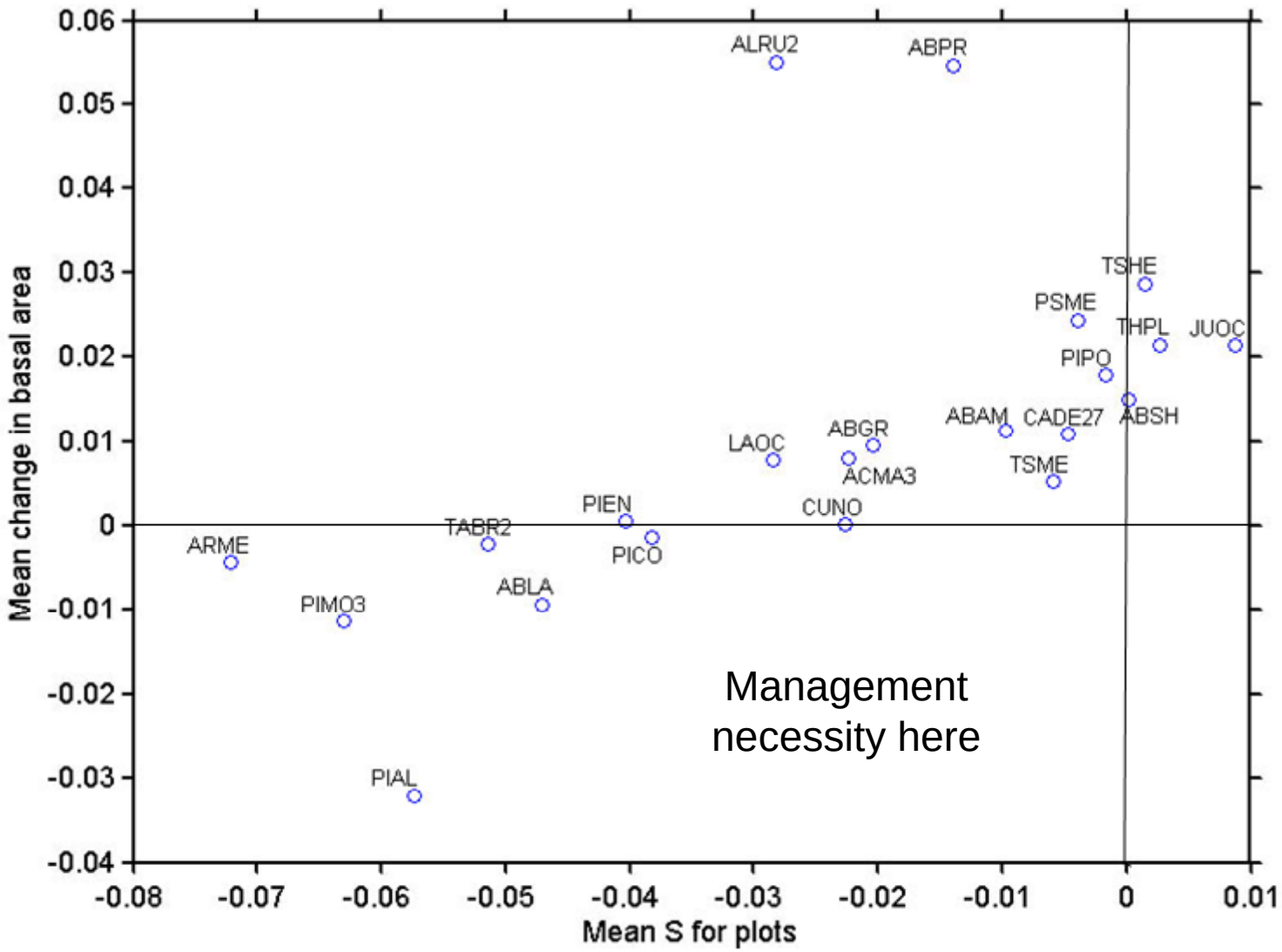
Indicator 1:
Basal Area Change VS Change in S



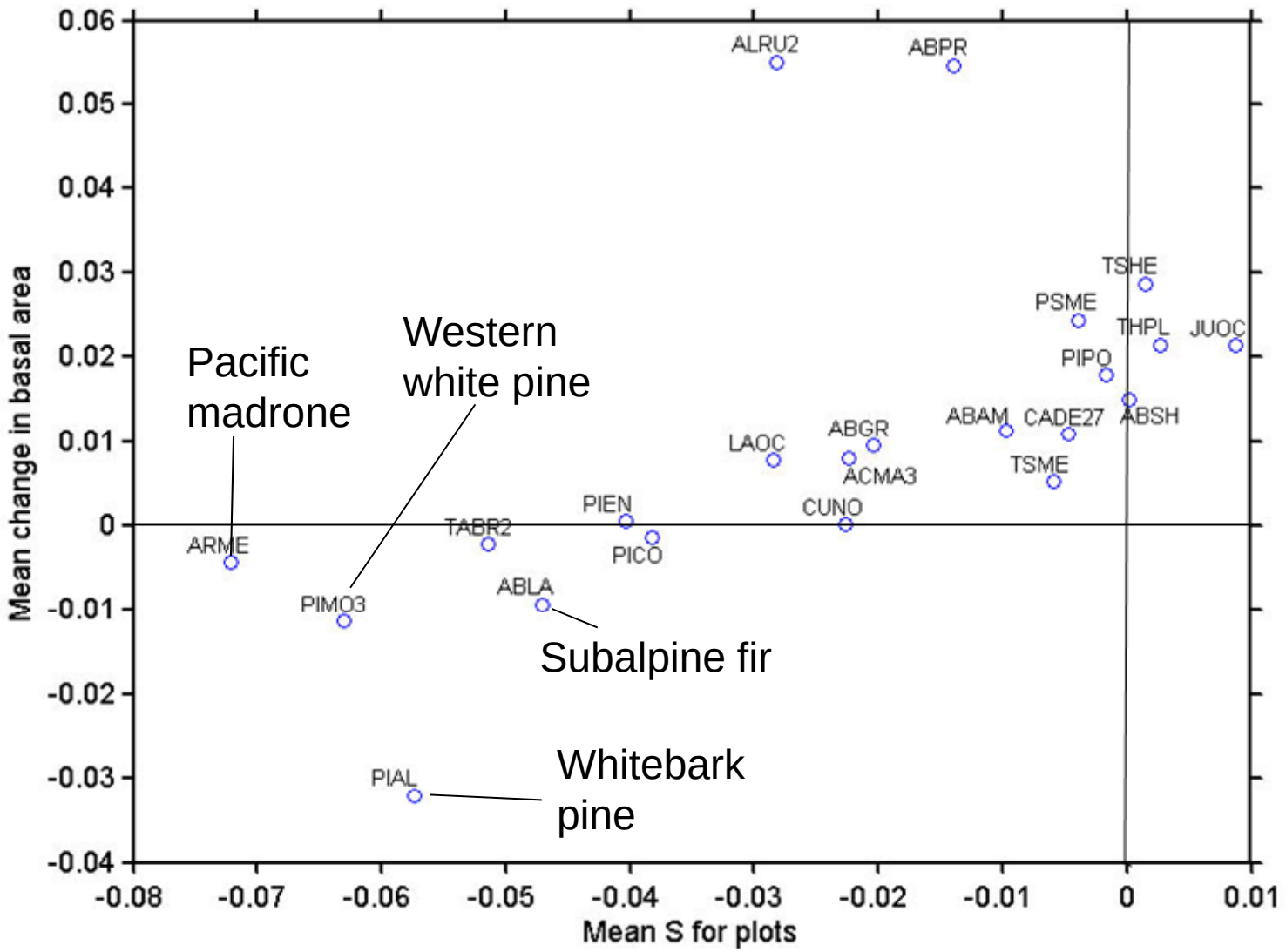
Indicator 1: Species Sustainability



Indicator 1: Species Sustainability



Indicator 1: Species Sustainability



Species in decline

Pacific madrone

Foliar leaf blight
(*Phacidopycnis washingtonensis*)

Common gardens now screening for resistance to leaf blight and other pathogens
http://www.puyallup.wsu.edu/ppo/madrone/research/common_garden/index.htm

Whitebark pine

Blister Rust
(*Cronartium ribicola*)

Western white pine

Blister Rust
(*Cronartium ribicola*)

Common gardens now screening for resistance to blister rust

Species in decline

Subalpine fir

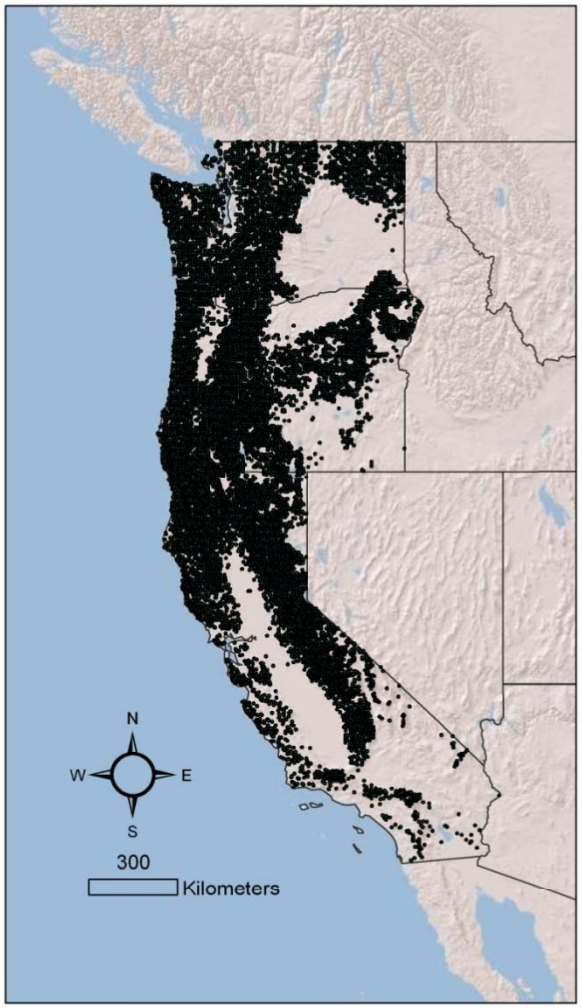
Balsam wooly adelgid
(*Adelges piceae*)

Management?

Gene conservation, cone collection?

Screening for resistance?

Indicator 2: Species Migration



USDA Forest Inventory and Analysis (FIA) plots were used for this work (over 12,000)

Data were pooled for the period of 2000-2009

Indicator 2: Species Migration

vs

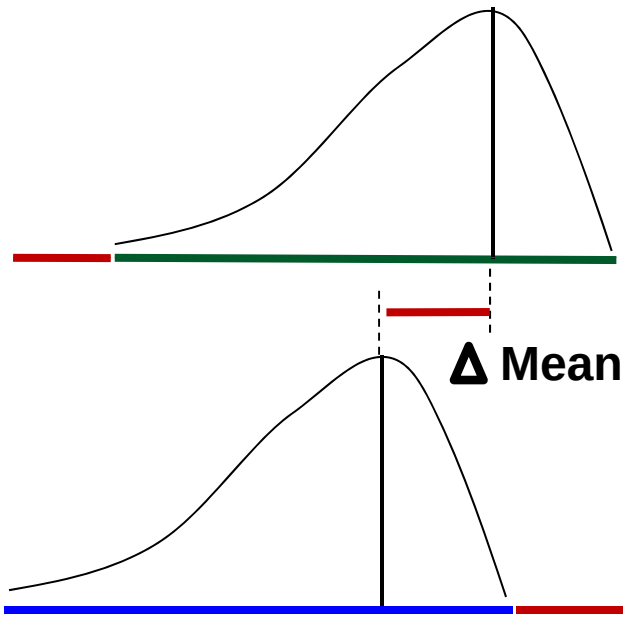
FIA “Seedlings”:

Diameter < 2.5 cm & Length >12.7 cm (conifers)
or Length > 30.5 cm (hardwoods)

Mature trees:

Diameter > 75th percentile

Indicator 2: Species Migration

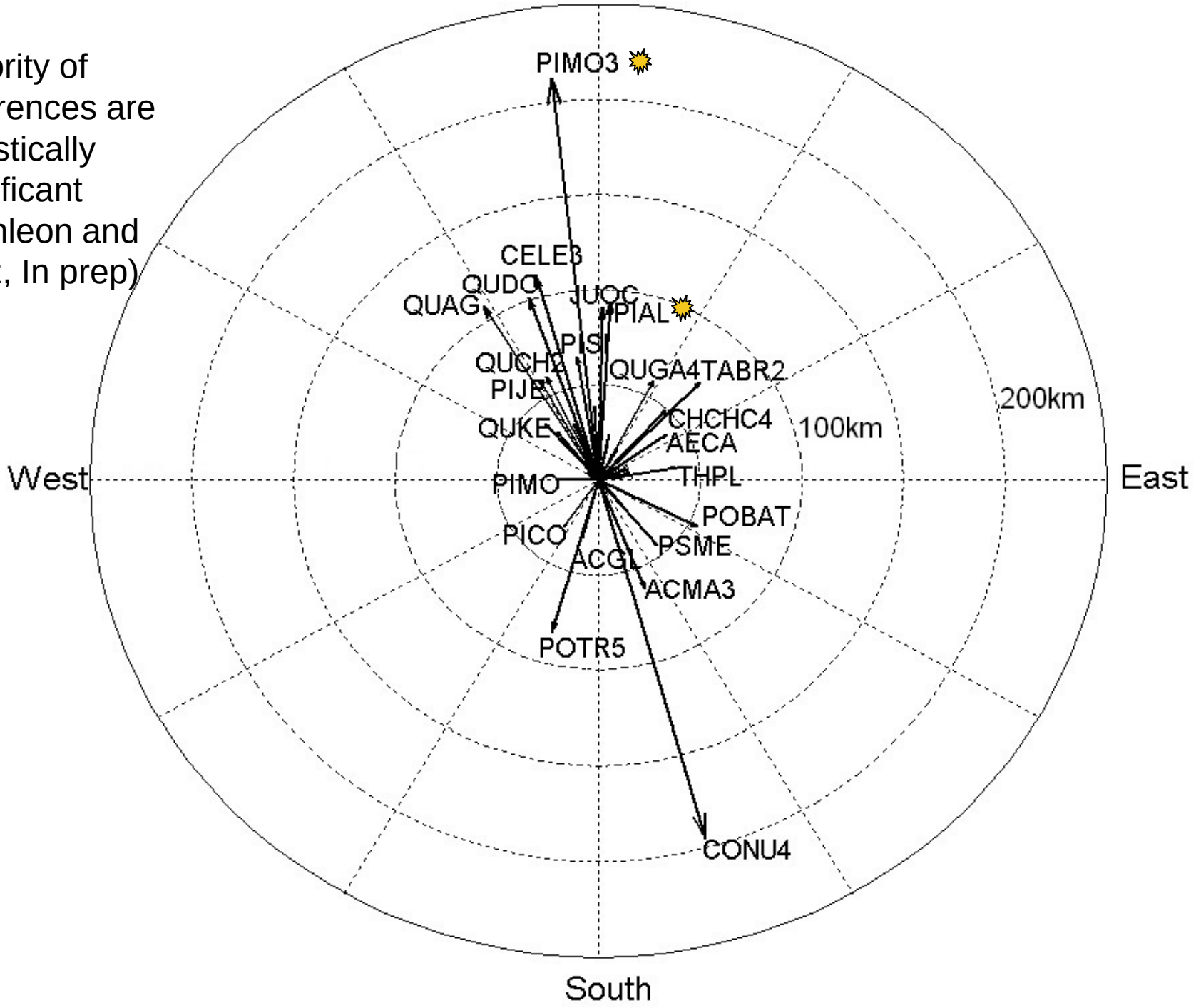


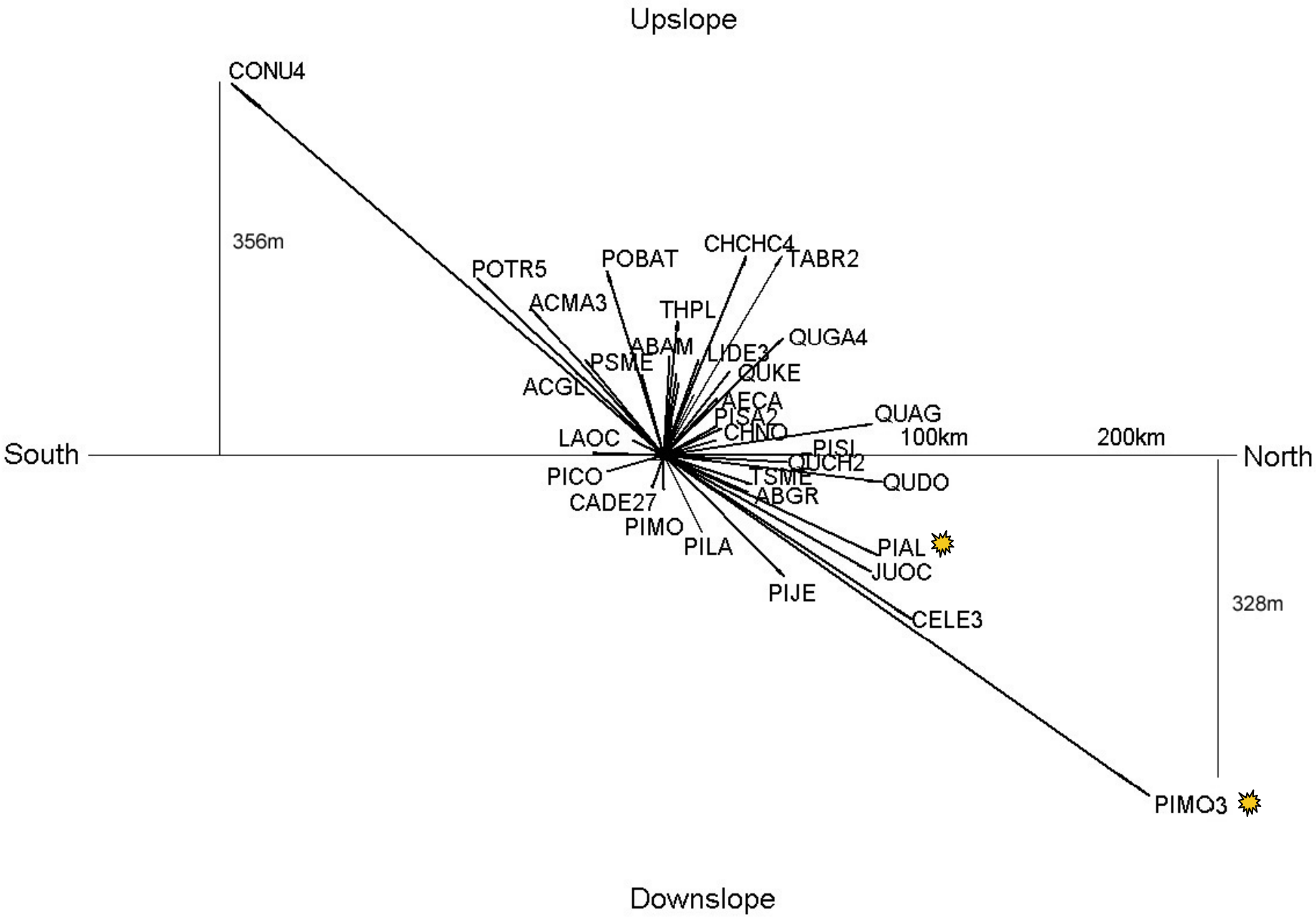
Δ = Seedling – Adult

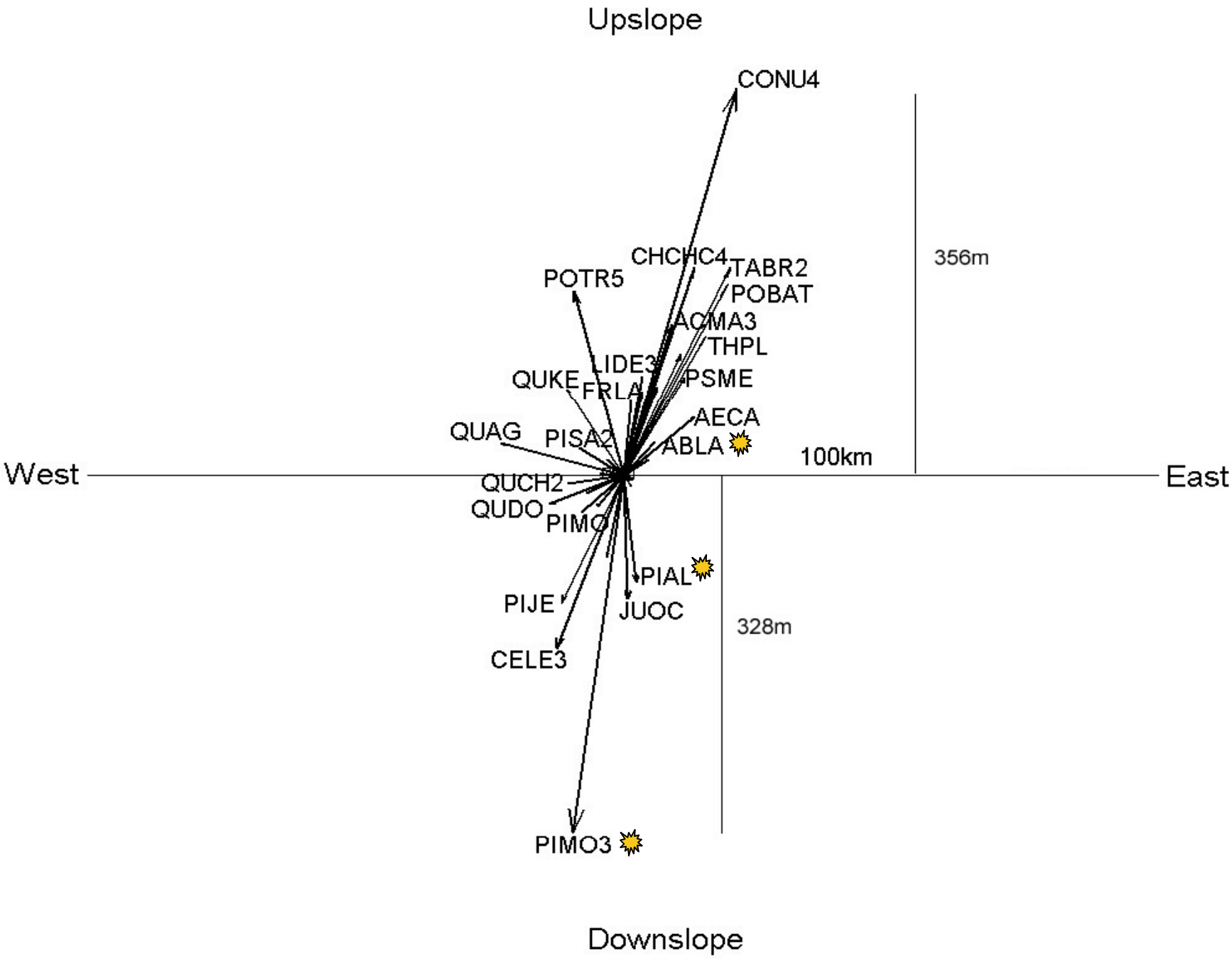
Δ Latitude, Δ Longitude, Δ Elevation

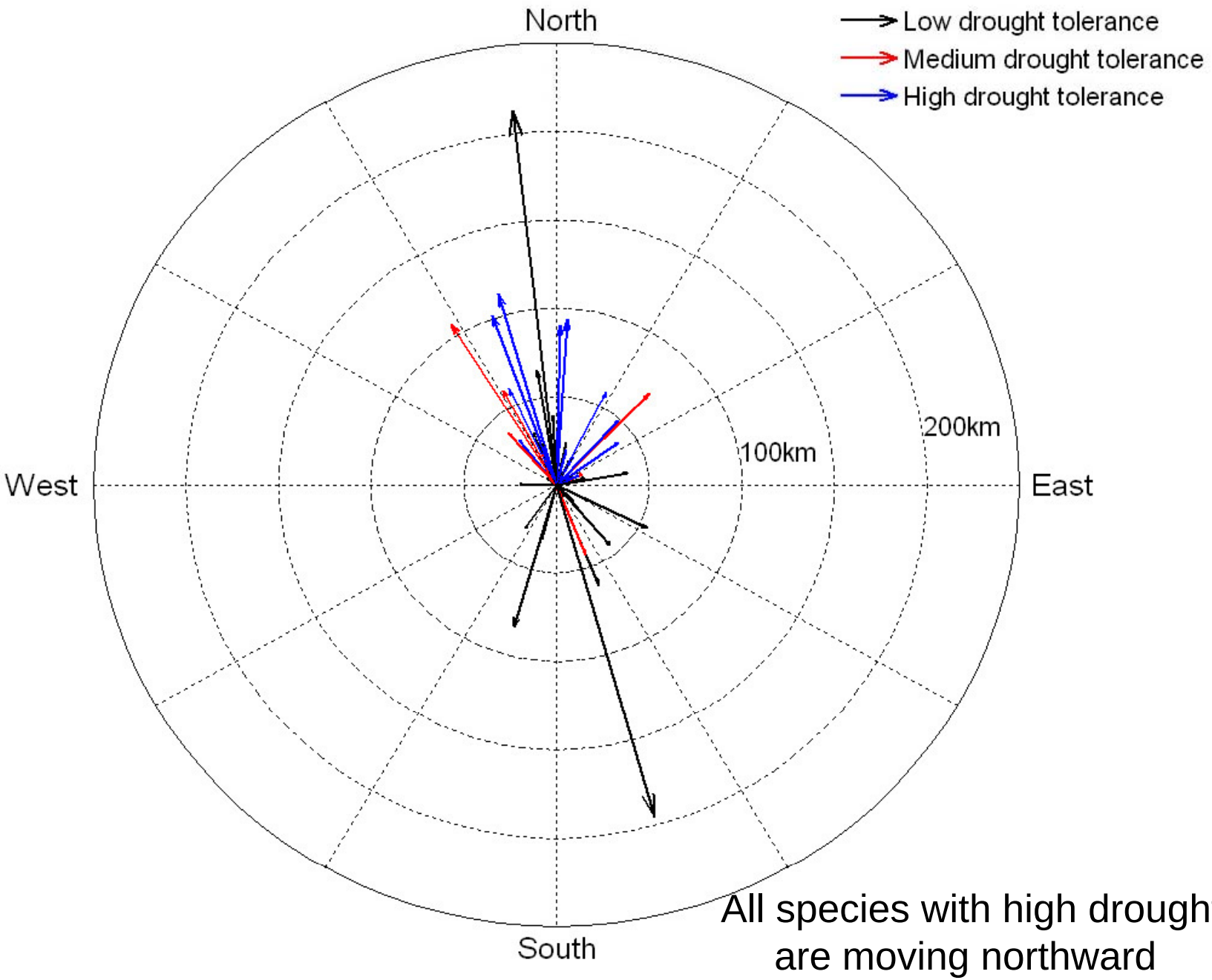
Together give coordinates for a directional migration vector

Majority of differences are statistically significant (Monleon and Lintz, In prep)

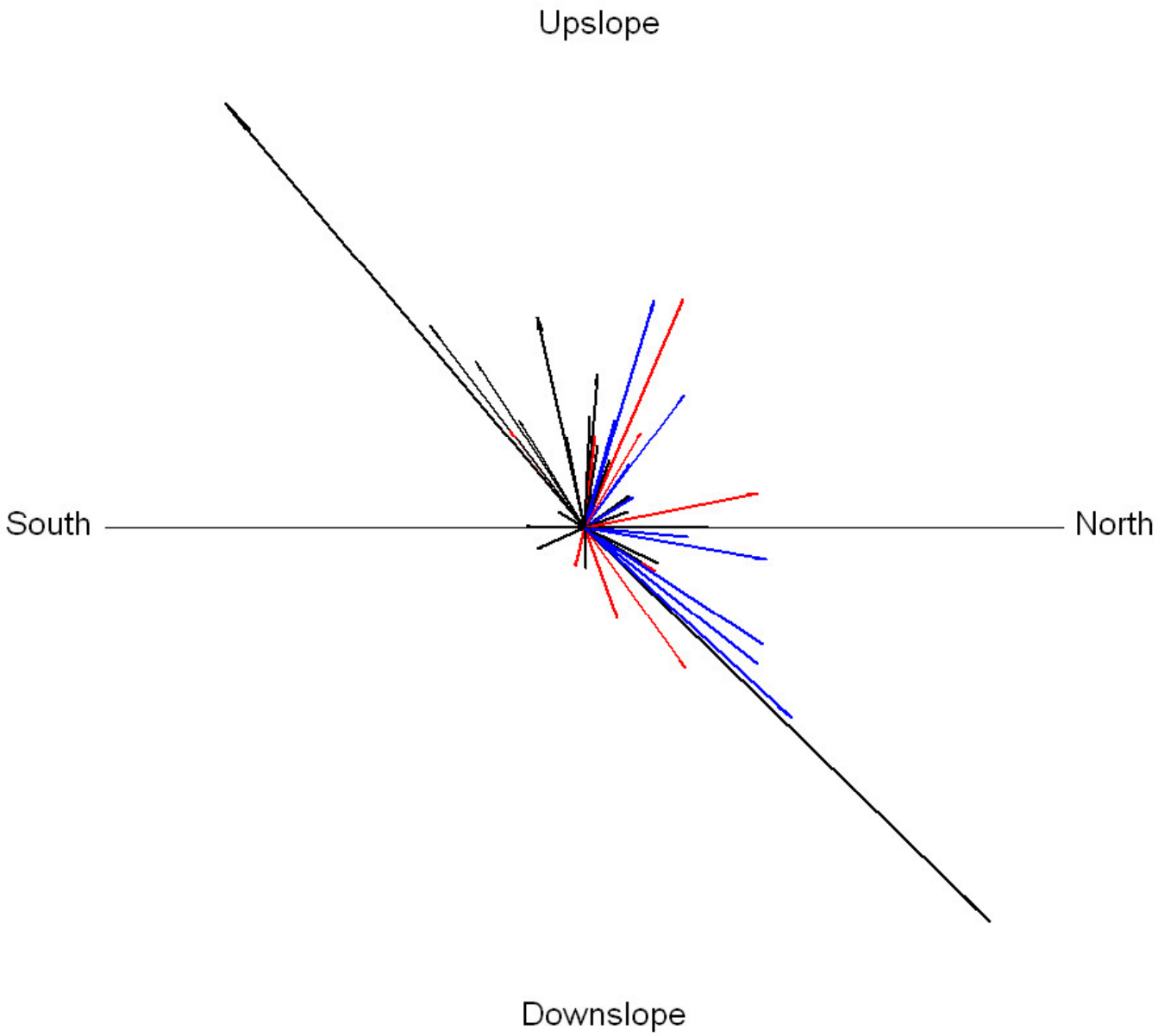


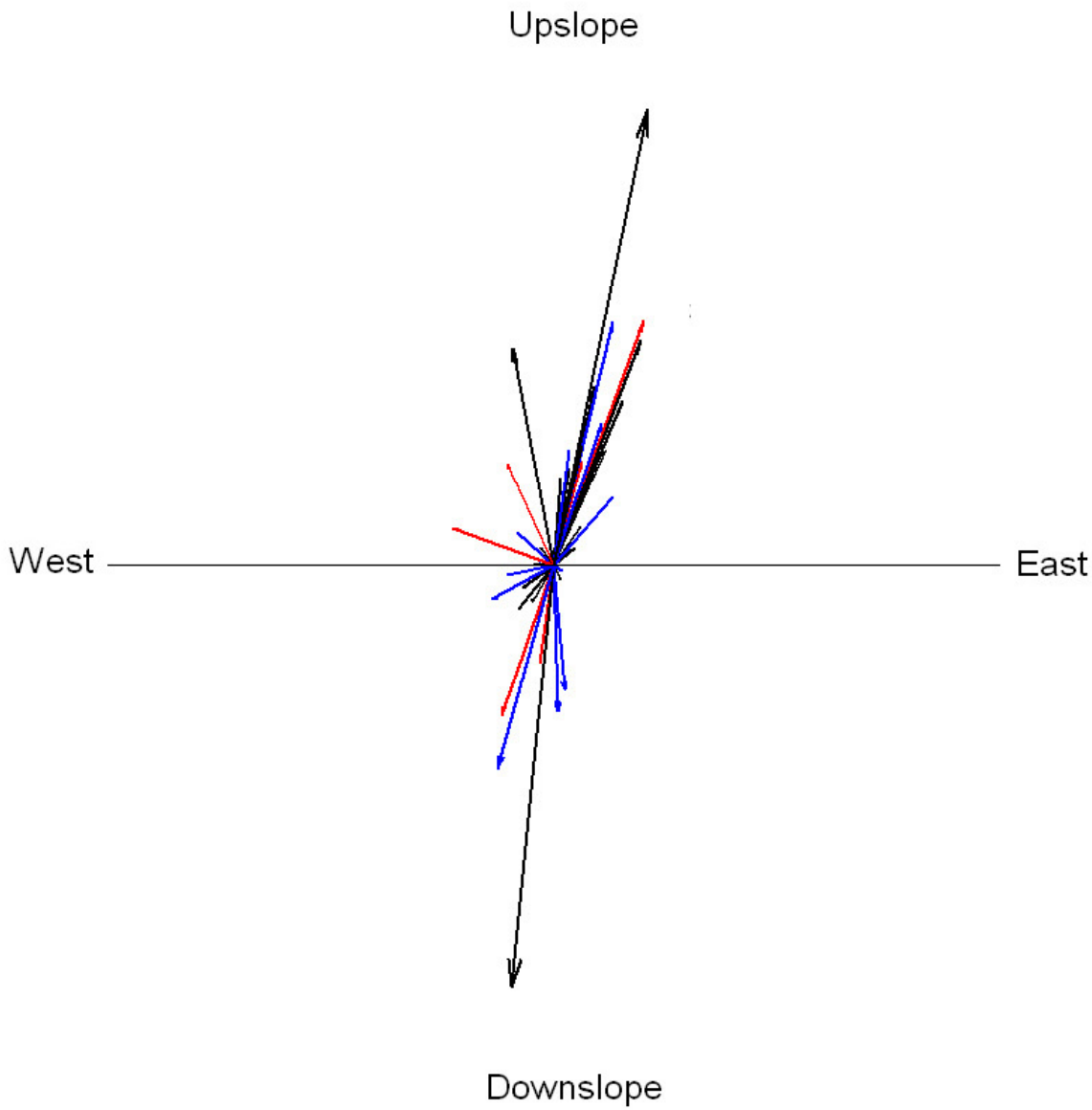

Upslope
CONU4
356m
POTR5
POBAT
CHCHC4
TABR2
ACMA3
THPL
QUGA4
ABAM
LIDE3
PSME
QUKE
ACGL
AECA
PISA2
QUAG
CHNO
LAOC
100km
200km
South
PISI
North
QUCH2
PICO
TSME
QUDO
CADE27
ABGR
PIMO
PILA
PIAL
JUOC
PIJE
328m
CELE3
PIMO3
Downslope

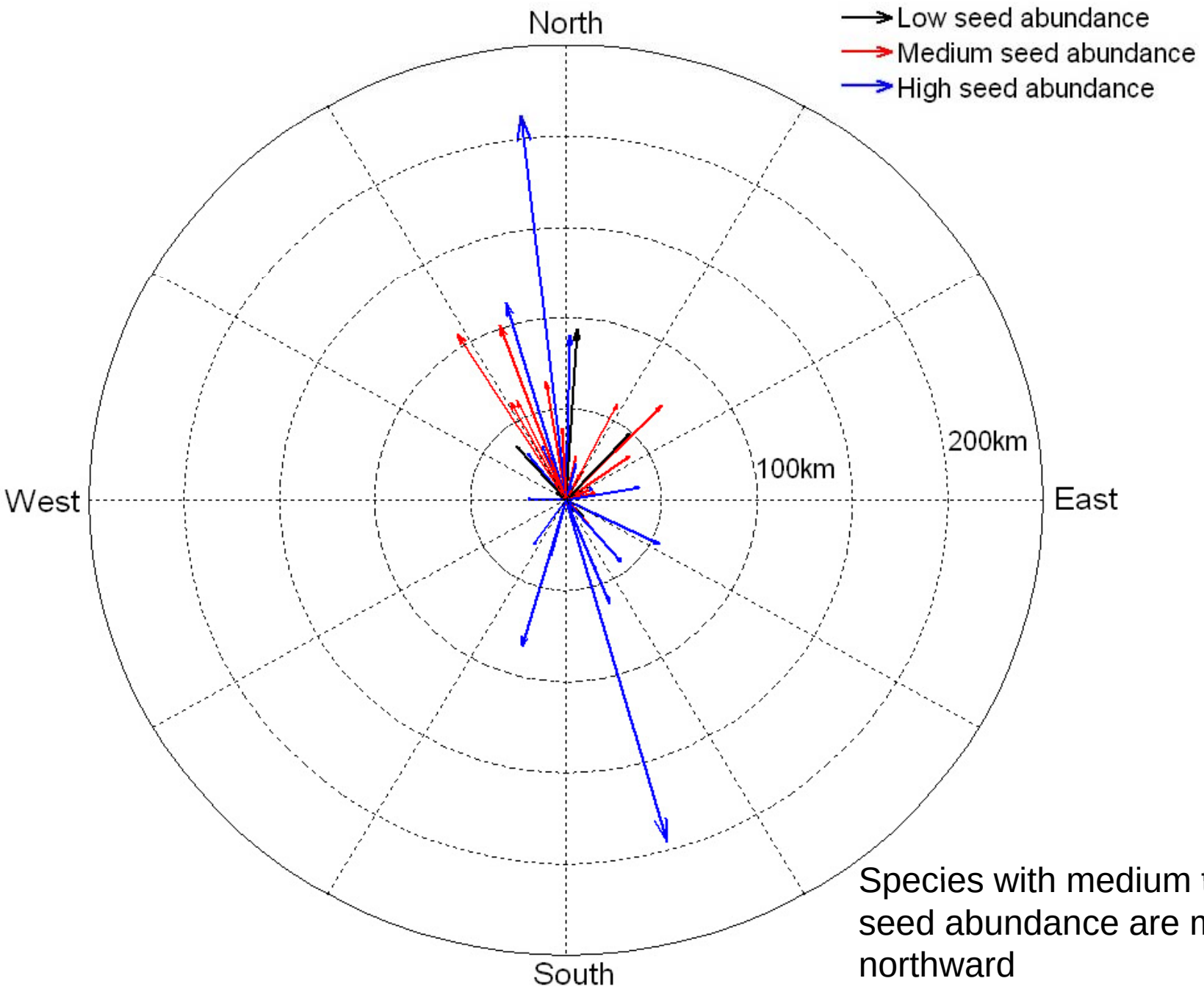

Upslope
CONU4
CHCHC4
TABR2
POTR5
POBAT
ACMA3
THPL
LIDE3
QUKE
FRLA
PSME
AECA
QUAG
PISA2
ABLA
356m
100km
West
East
QUCH2
QUDO
PIMO
PIAL
PIJE
JUOC
328m
CELE3
PIMO3
Downslope



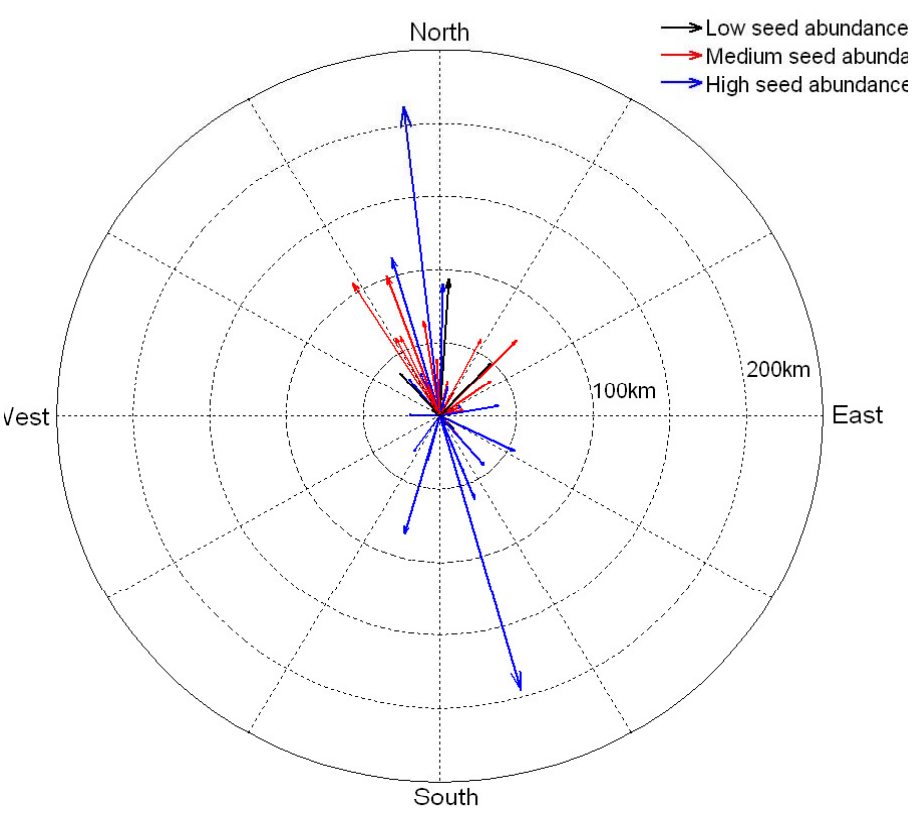
All species with high drought tolerance are moving northward

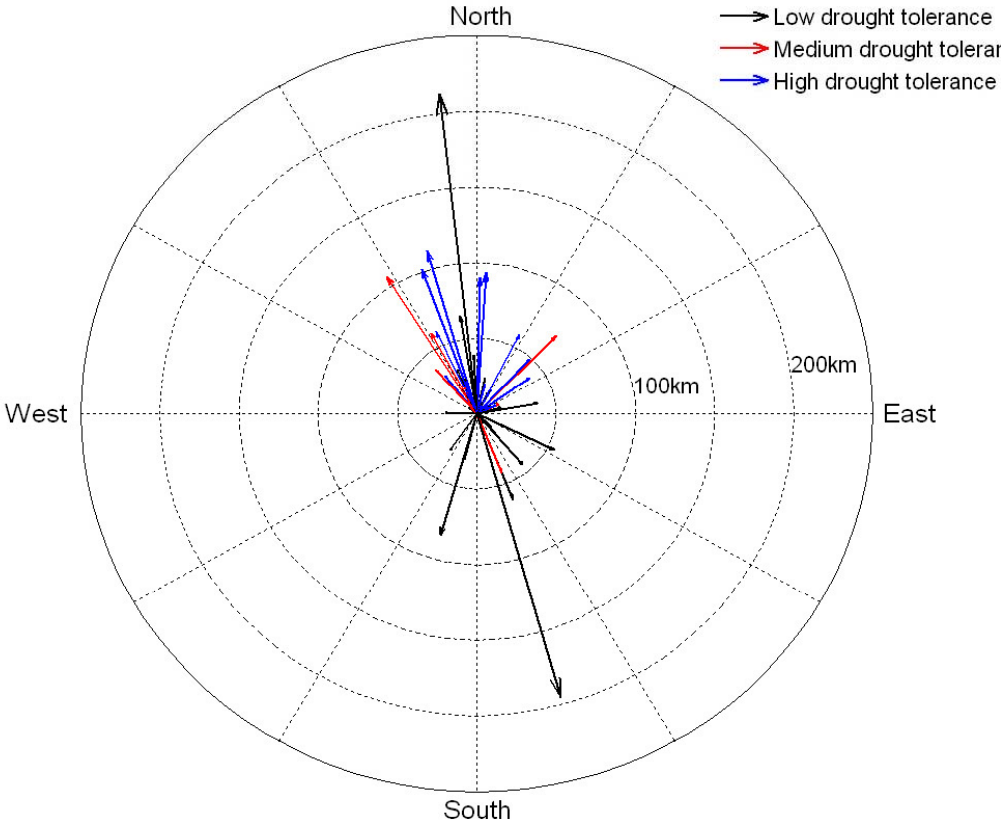

Upslope
South
North
Downslope


Upslope
West
East
Downslope



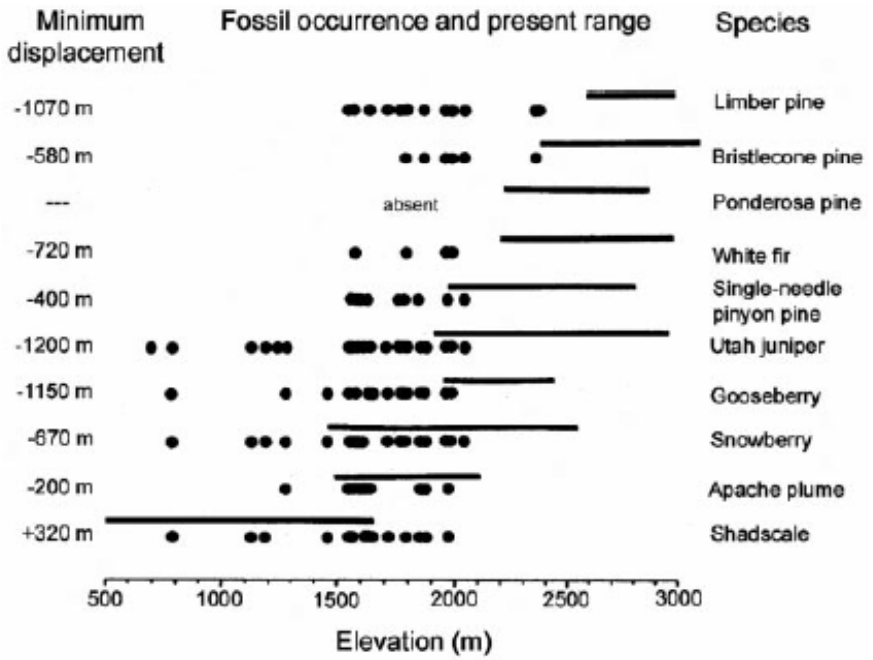
Species with medium to low seed abundance are moving northward


North
Low seed abundance
Medium seed abunda
High seed abundance
100km
200km
Vest
East
South


North
Low drought tolerance
Medium drought tolerar
High drought tolerance
100km
200km
West
East
South

Indicator 2: Species Migration

- More results but not enough time
- Tree species are migrating along unique trajectories
- The largest elevation displacement exceeds the minimum reported for a time interval between the last glaciation and present



Davis and Shaw 2001, Science

Discussion

- The species sustainability indicator is a function of mortality and population growth over a re-measurement period

- It requires a population in the plot to start with

- Together the indicators are most informative

Summary

Species that may not sustain themselves in the west:

Madrone and subalpine fir are declining where they exist currently, ***and*** they are not showing strong evidence of migration

Discussion

- This work is designed to be a proof of concept

- The first indicator presented using CVS data can be applied to FIA plots when re-measurement data come on-line for the annual inventory (a few years from now)

- The larger the spatial domain, the more power to detect change with biological inventory data --especially for rare species

Discussion

Analysis of early signals of change in attributes of tree species distributions are fundamental to sustain ecosystem services

Discussion

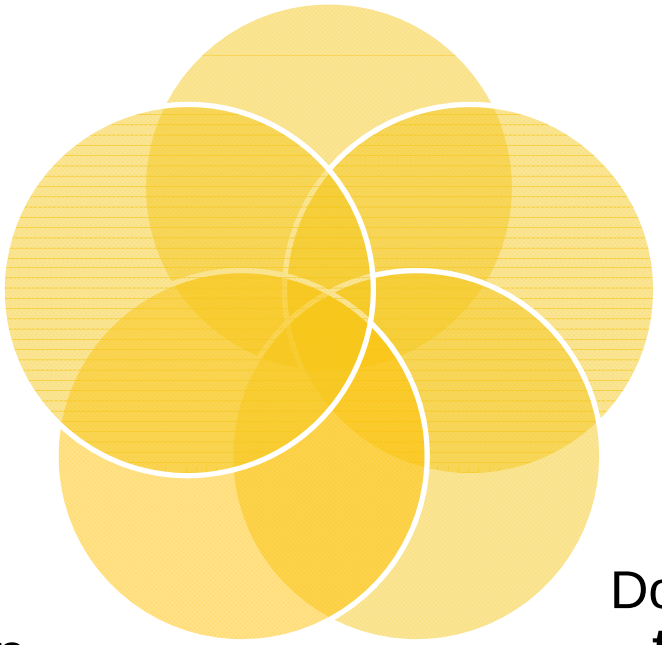
A proposal has been written addressing how species-specific indicators can specifically inform sustainable forest management

Fodder for brainstorming and discussion

Sustainable management for resilience

Innovation

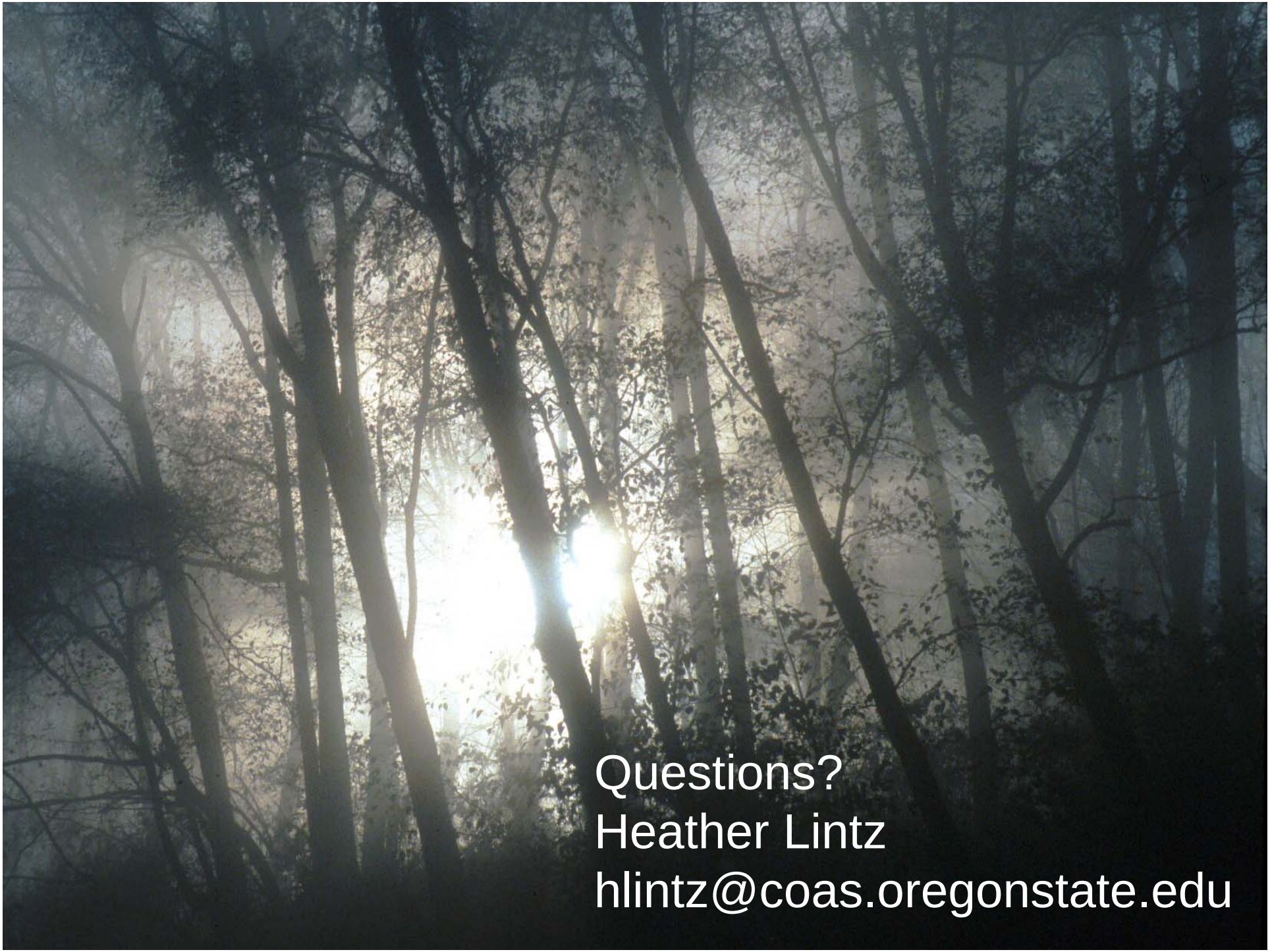
Communication



Learning

Knowledge dissemination

Documentation of trial and error


Questions?
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