A hierarchy of forest communities for assessing and projecting global change effects across the US

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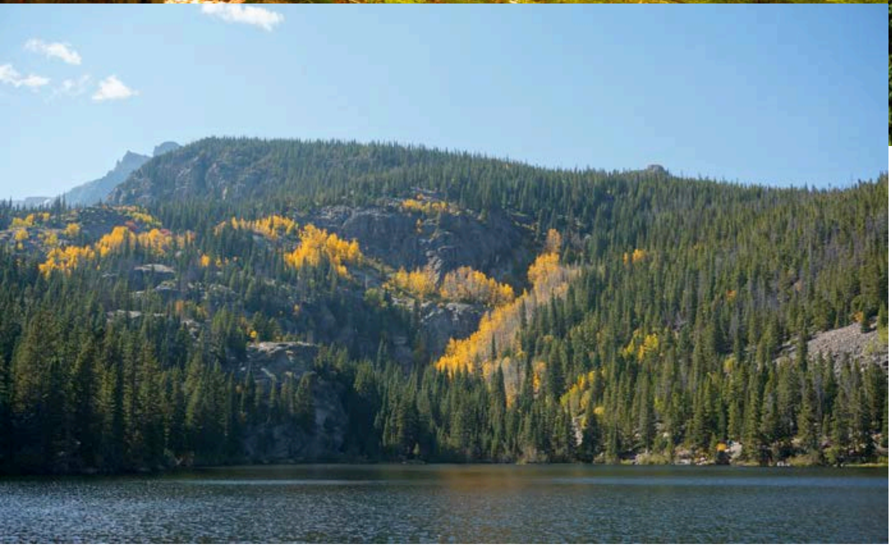
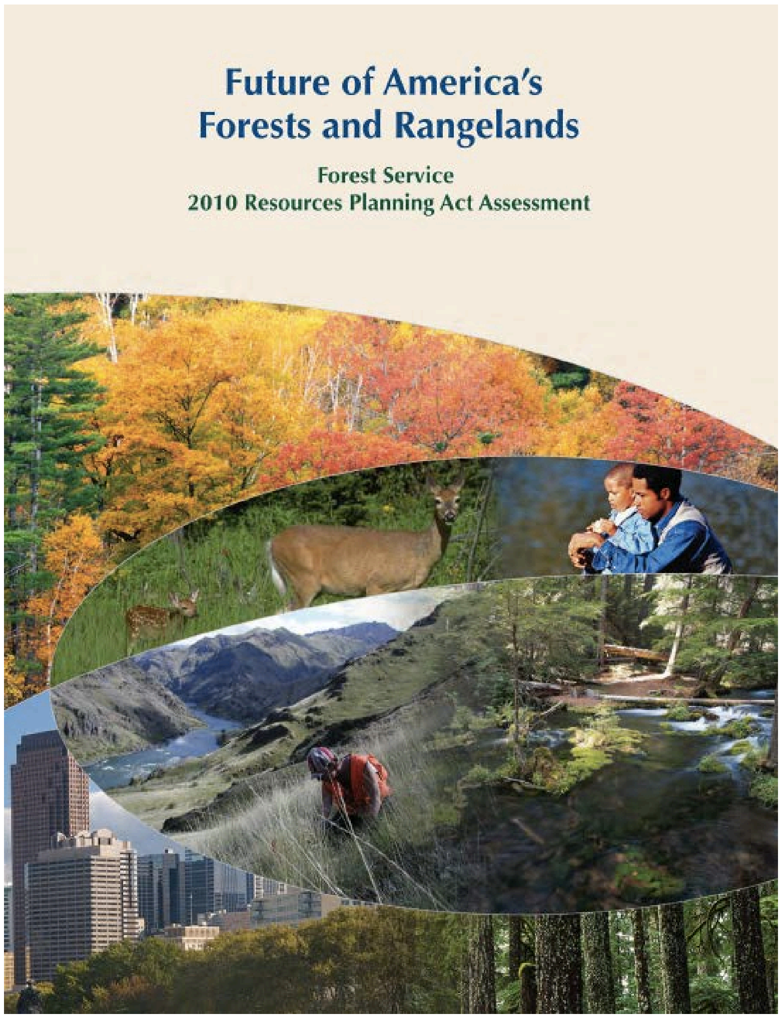


Forest species composition is important and can be affected by global change drivers like climate and land-use change.

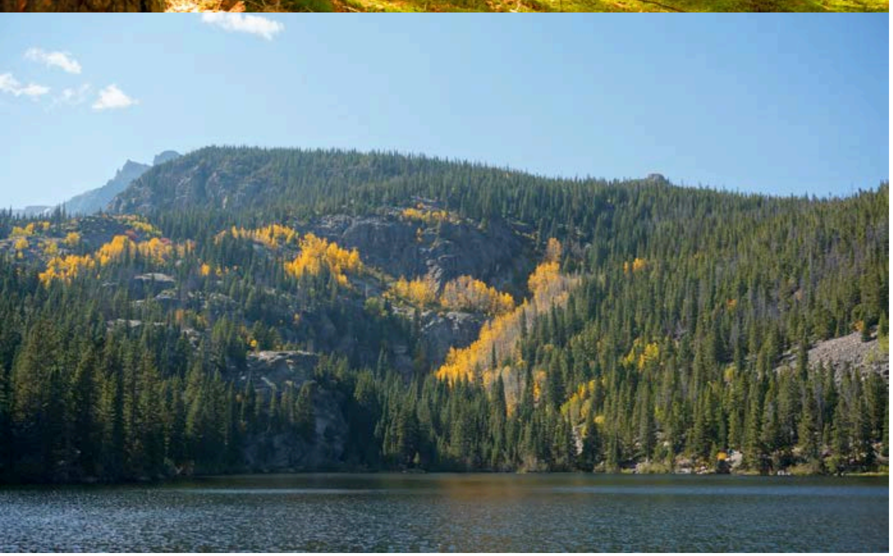
USDA Forest Service Resources Planning Act Assessment (2020)

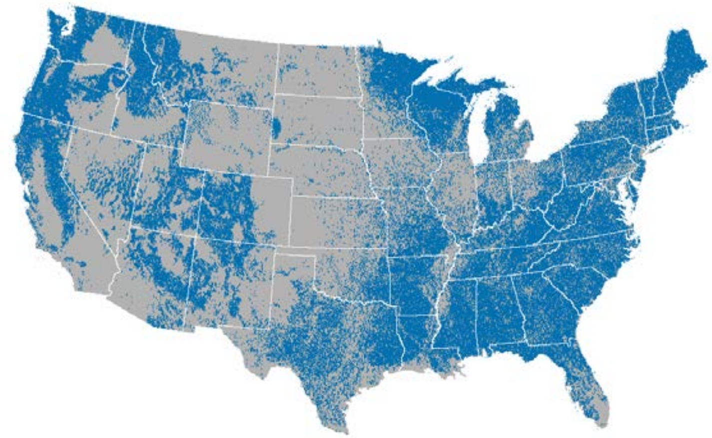


Our goal:
Project changes in forest conditions, including species composition, into the future

Under scenarios of climate and land-use change for the continental US

Based on recent observed changes and variation across space from forest inventory data

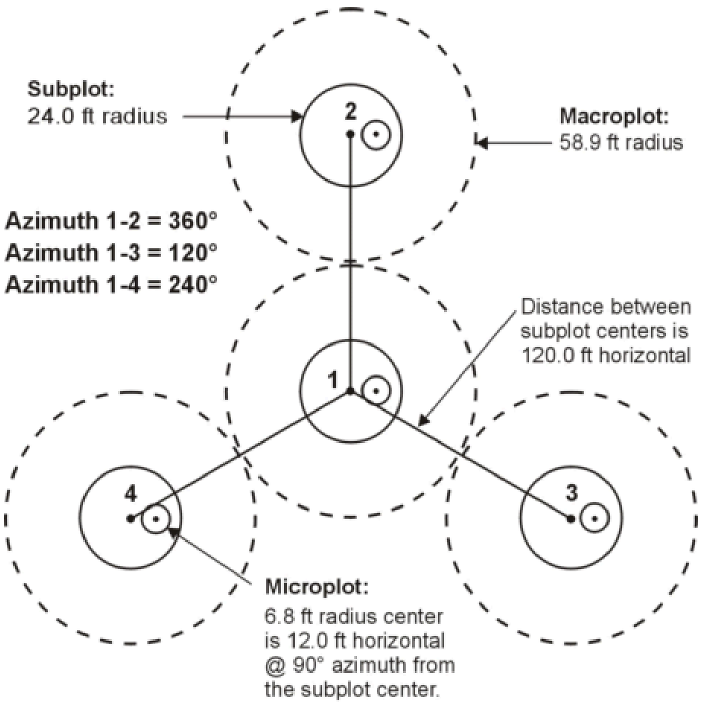


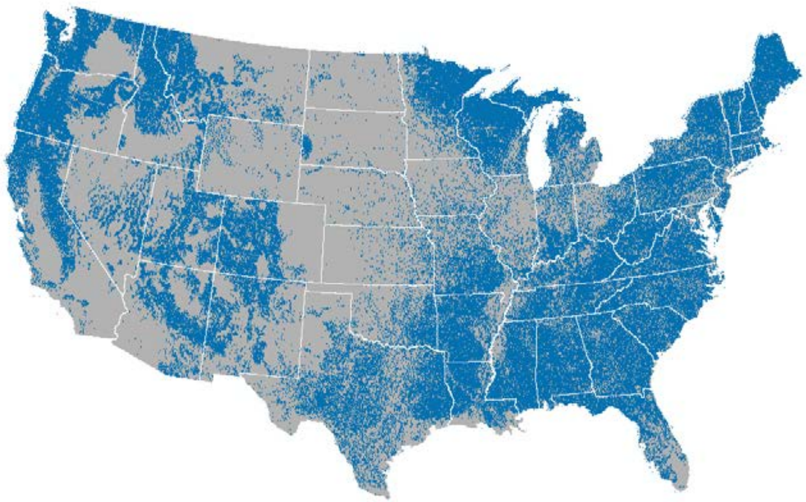


Need:
A baseline, consistent characterization of forest communities to facilitate monitoring, assessment, and projection of global change effects

Method:
Establish an empirical, hierarchical, classification of forest community composition in the continental US

USDA Forest Service Forest Inventory and Analysis (FIA) data

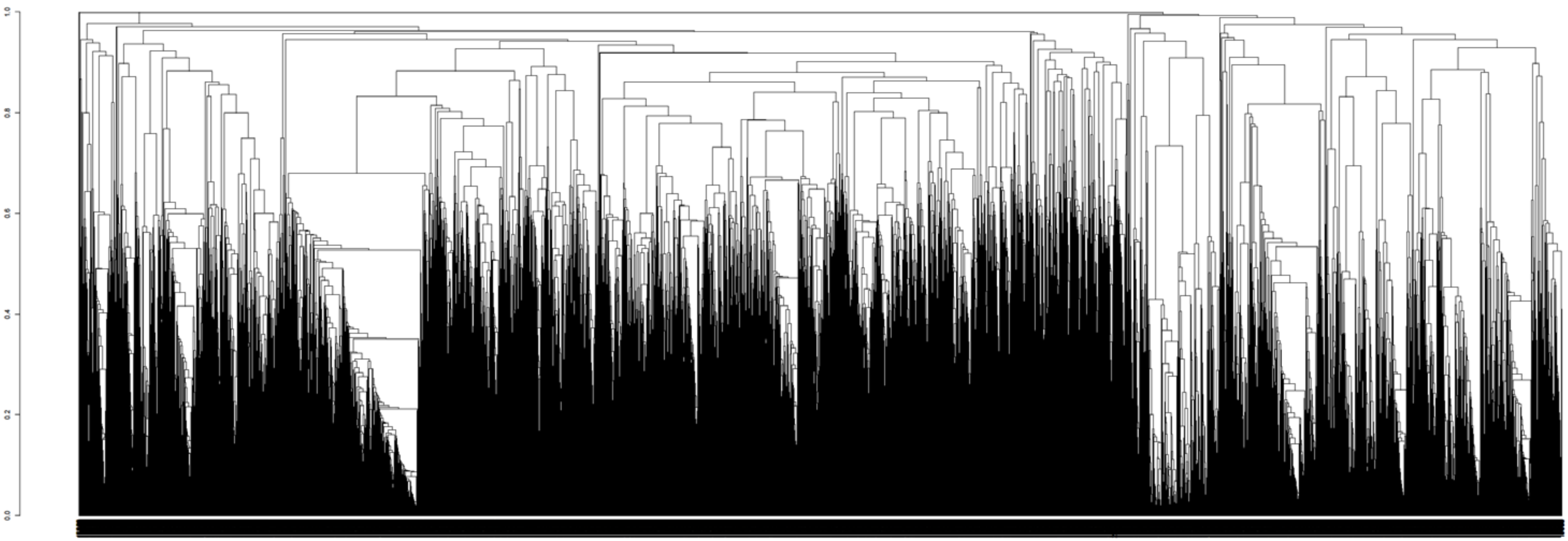




130,000+ forest plots across the continental US

Calculated for every plot:
Relative importance value by species (abundance and basal area)

Hierarchical clustering of FIA plots by tree species composition



Use indicator species analysis to select levels of the hierarchy

Indicator species for a given cluster:

- occur within the cluster and nowhere else (high fidelity)
- occur in a high proportion of plots assigned to a given cluster (representativeness)

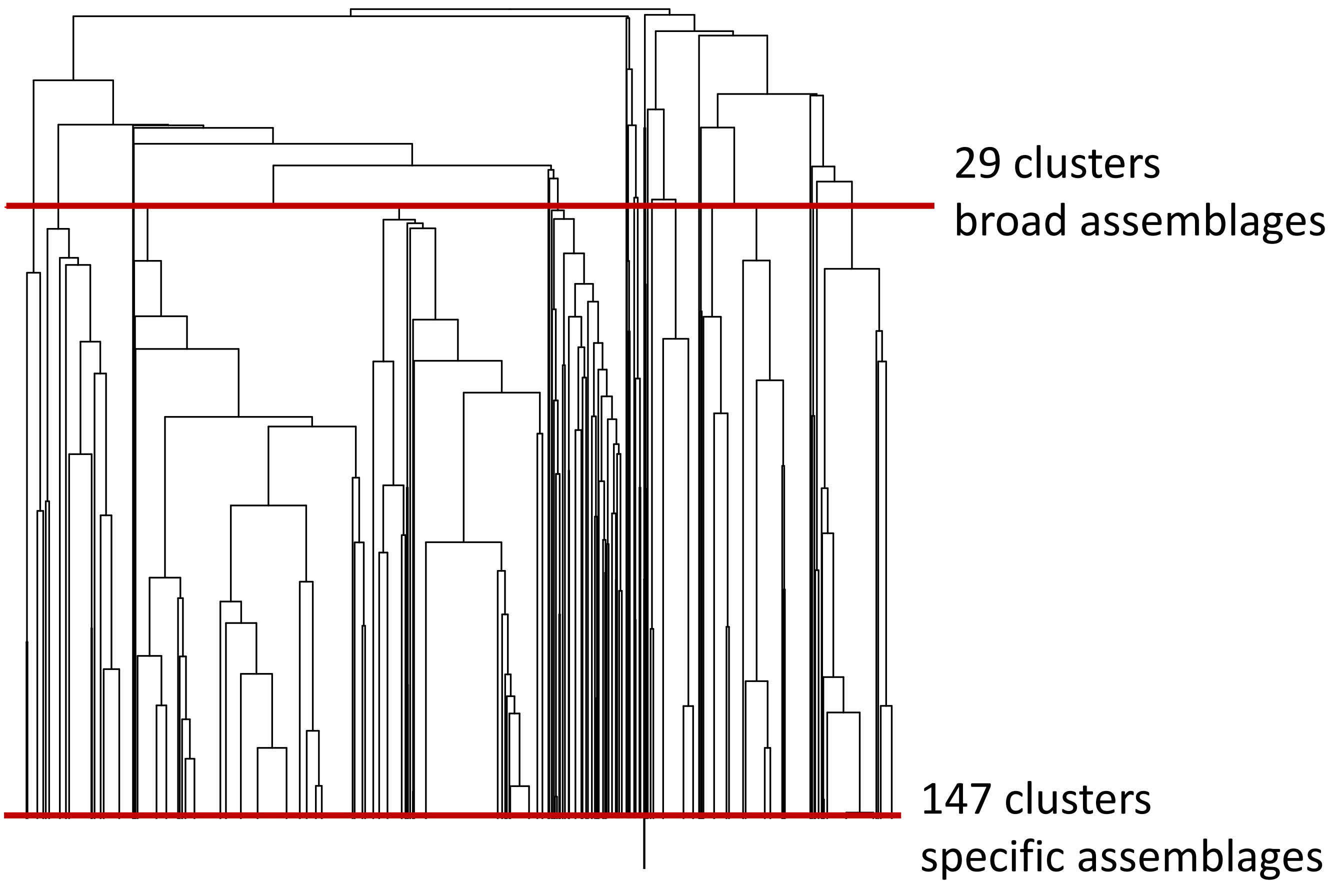
- Permutation test allows calculation of p-values (significance)

Hierarchical clustering of tree species composition with indicator species analysis

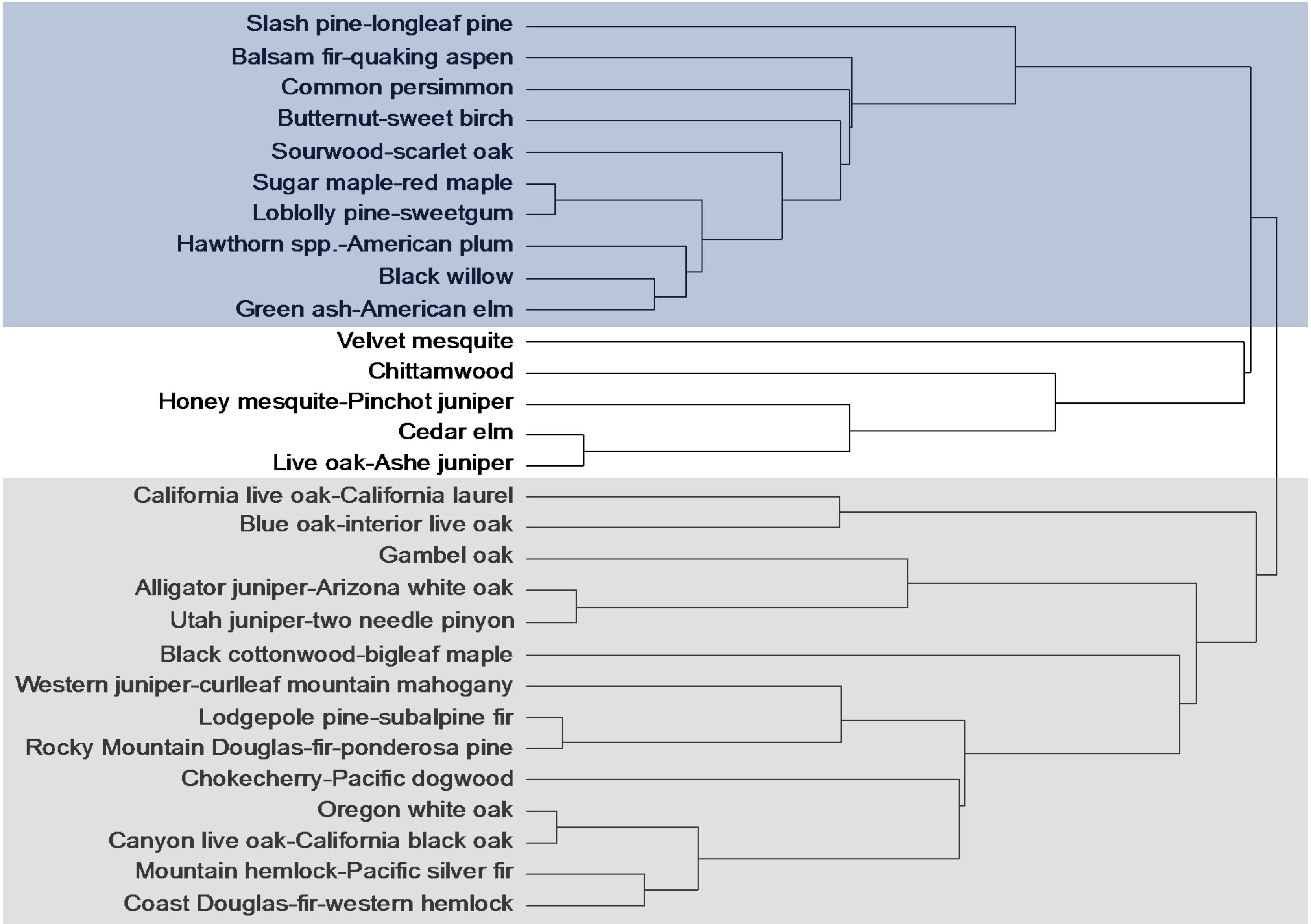
Pick levels of hierarchy such that:

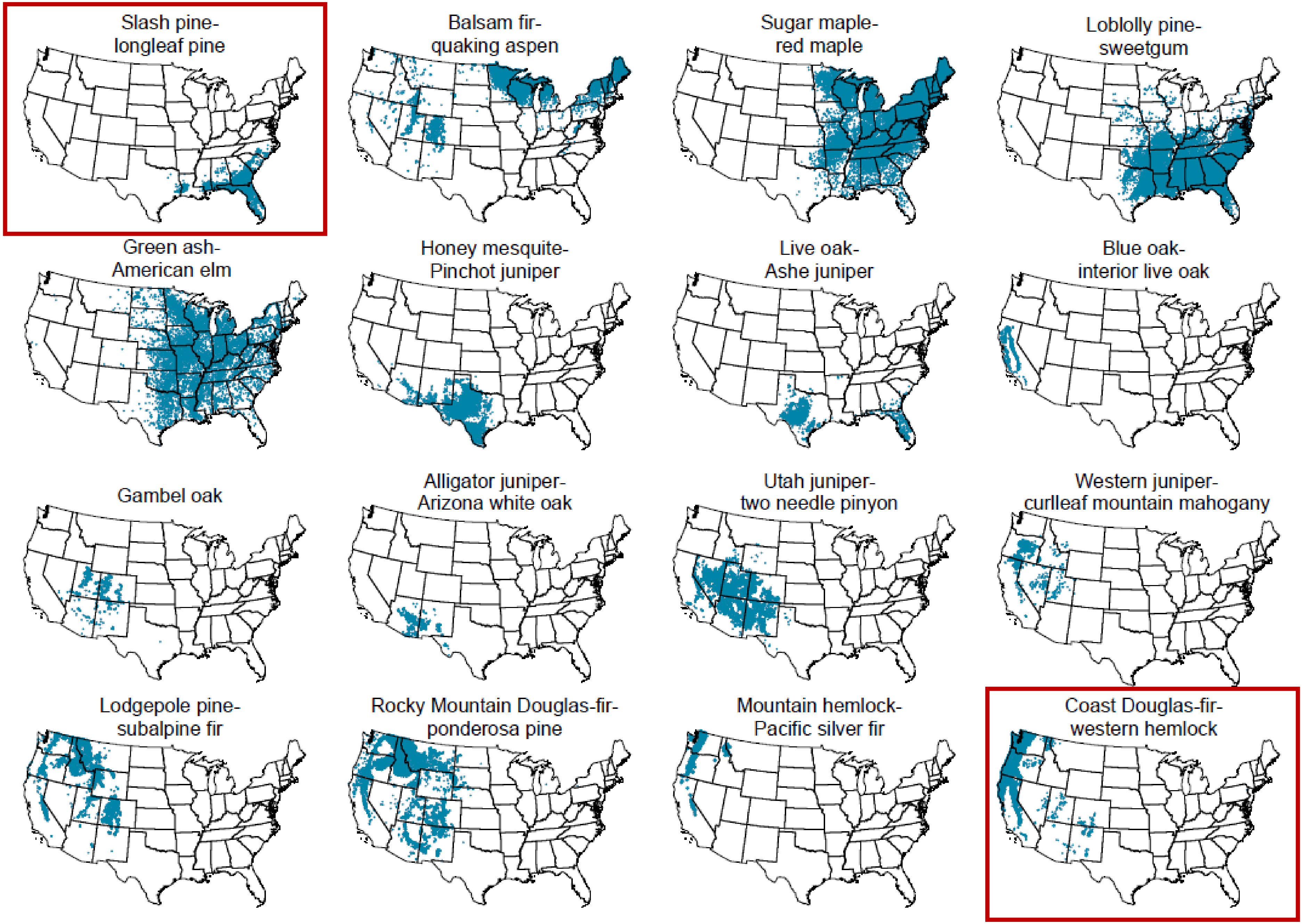
Every cluster has at least one significant indicator species

Minimize total p-values



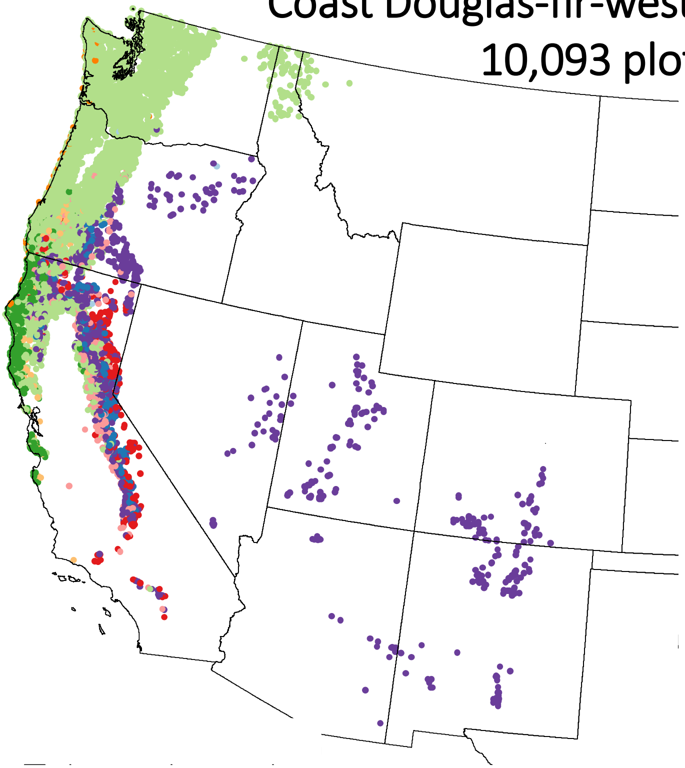
29 broad assemblages




Slash pine-
longleaf pine
Balsam fir-
quaking aspen
Sugar maple-
red maple
Loblolly pine-
sweetgum
Green ash-
American elm
Honey mesquite-
Pinchot juniper
Live oak-
Ashe juniper
Blue oak-
interior live oak
Gambel oak
Alligator juniper-
Arizona white oak
Utah juniper-
two needle pinyon
Western juniper-
curlleaf mountain mahogany
Lodgepole pine-
subalpine fir
Rocky Mountain Douglas-fir-
ponderosa pine
Mountain hemlock-
Pacific silver fir
Coast Douglas-fir-
western hemlock

Examples of 147 specific assemblages

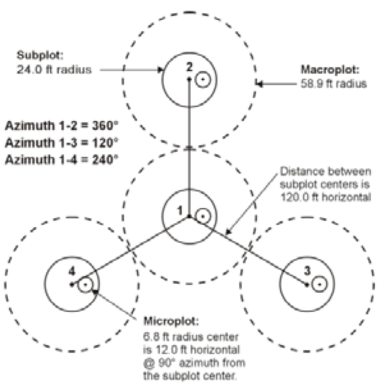
Coast Douglas-fir-western hemlock
10,093 plots



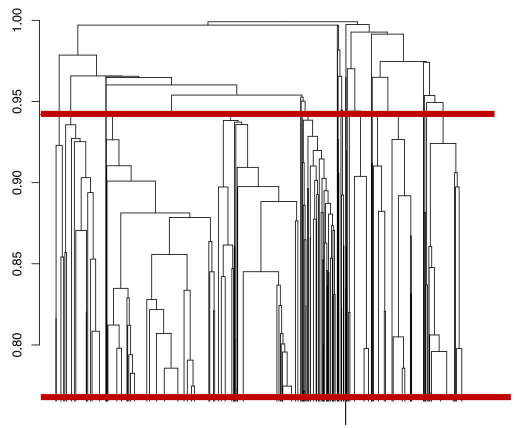
Slash pine-longleaf pine
2,934 plots

Hierarchical characterization

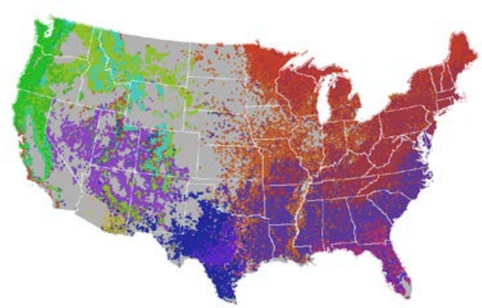
Plots



Multiple levels of classification



Nation-wide forest composition



Assess vulnerability
Monitor change
Project future dynamics

Example: assessing climate change impacts using dominant species

Dominant species are likely to be ecologically important (Hildebrand et al. 2008)

Dominance structure in a community is likely to be altered by global change drivers

Changes in dominance can be an early warning of impacts

Example: assessing climate change impacts using dominant species

Within a cluster, find the dominant species based on species dominance index (SDI):

High mean importance across all plots in the cluster

Tendency to occur with few other species

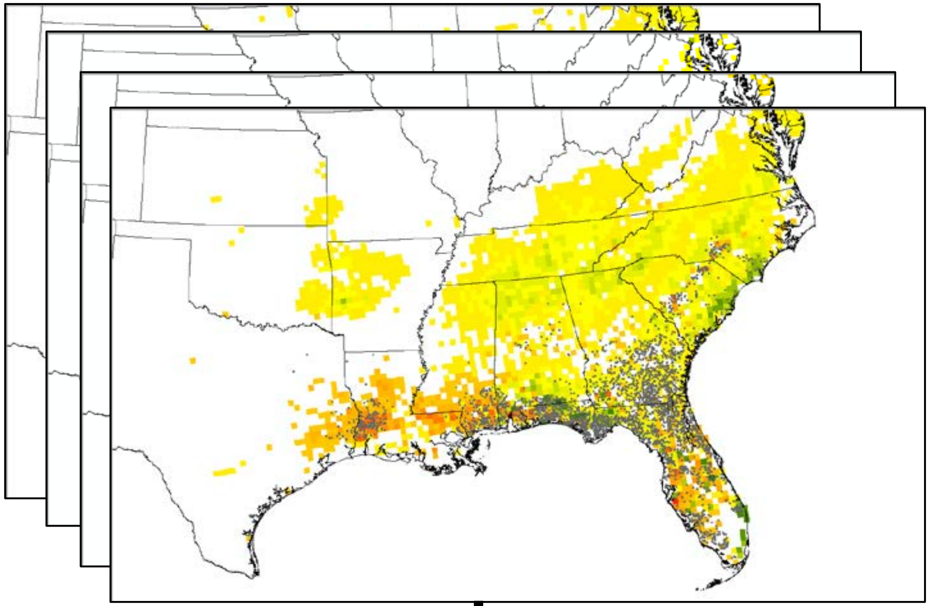
Overlay modeled habitat suitability from Climate Change Tree Atlas

(Climate Change Research Group 2014)

e.g., slash pine-longleaf pine assemblage

For 5 clusters in the East US: extract projected change in habitat suitability for dominant species

slash pine
longleaf pine
pondcypress
turkey oak



Average across dominant species

Potential climate suitability change at plot locations and for the community

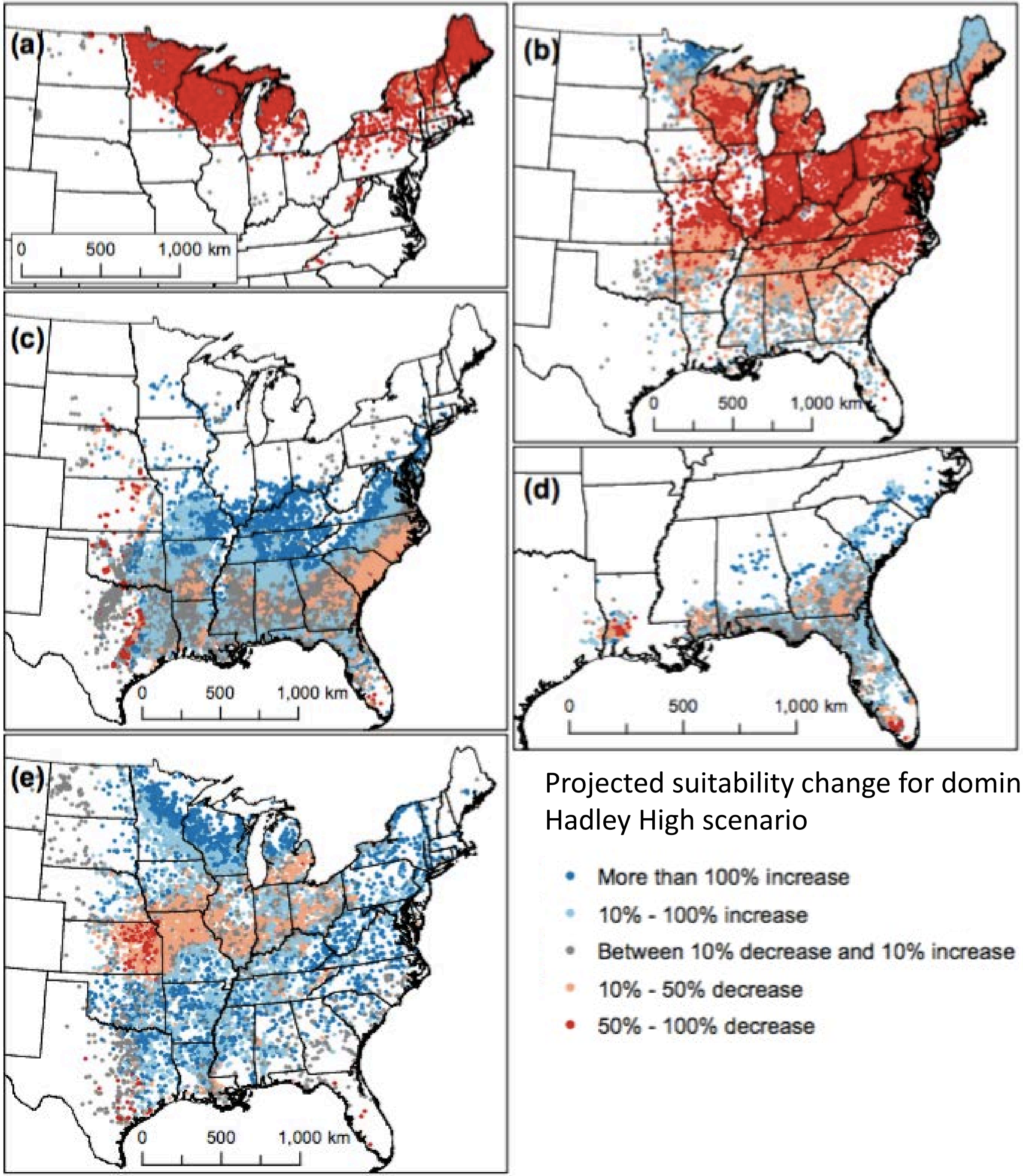
Balsam fir-quaking aspen
Avg: -74.5% change

Sugar maple-red maple
Avg: -48.2% change

Loblolly pine-sweetgum
avg: 1.6% change

Slash pine-longleaf pine
Avg: 3.3% change

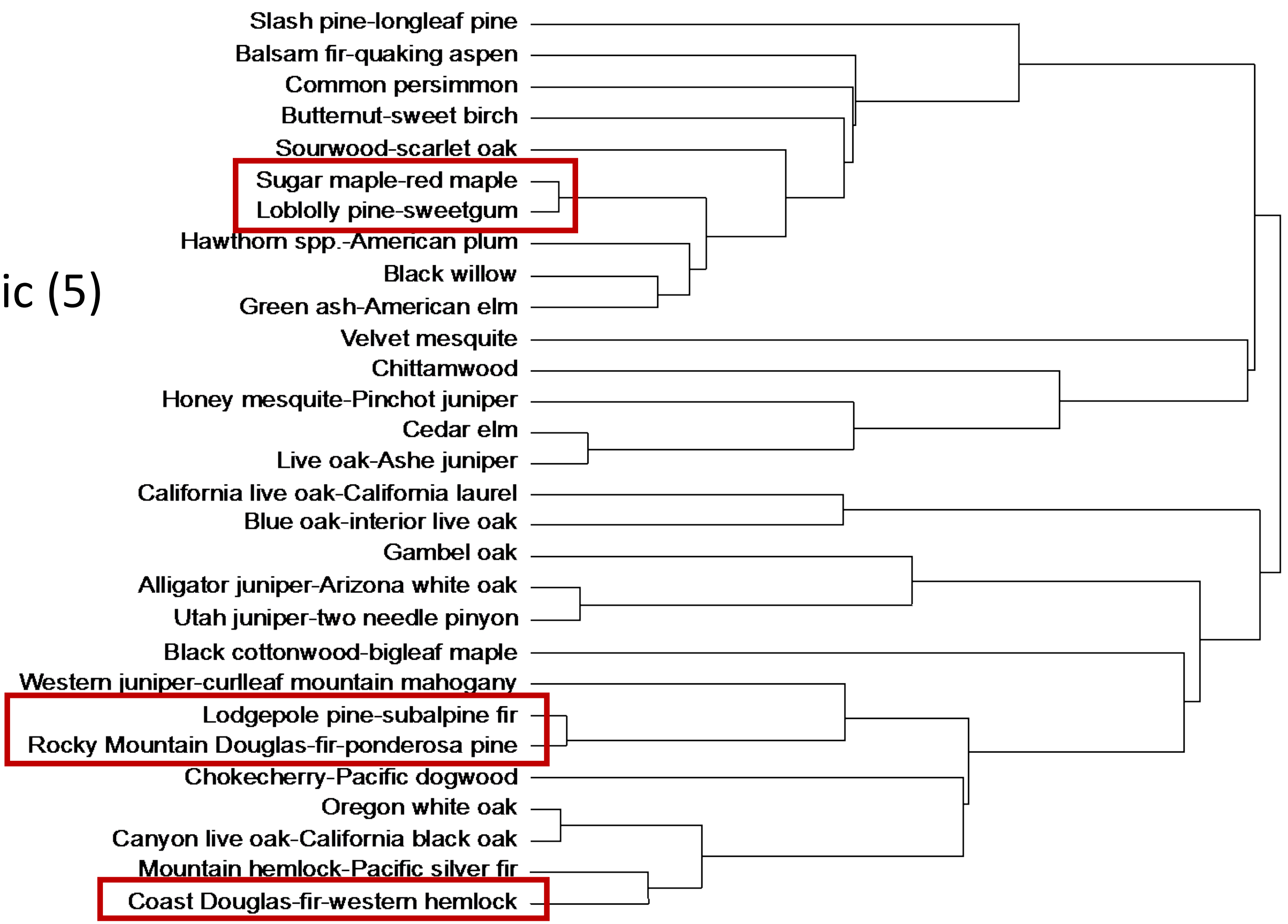
Green ash-American elm
avg: 19.3% change



Projected suitability change for dominant species
Hadley High scenario

Example 2: how well do environmental variables predict the distributions of broad assemblages?

Using
bioclimate (8),
soil (8),
and topographic (5)
variables



Advantages of the classification

- Consistent across the country
- Based on empirical observations
- FIA measurements are repeated through time to allow monitoring and study of change
- Hierarchy allows multi-scale studies
- Dendrogram allows questions based on the similarity in species composition between clusters

(some?) Caveats

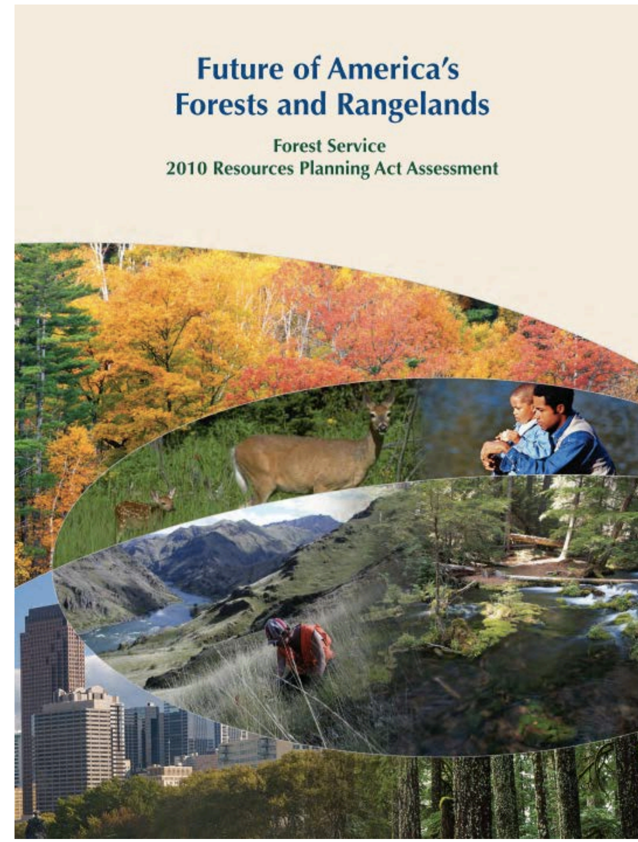
- Not directly related to other popular classifications such as FIA forest types, forest type groups, National Vegetation Classification [but we are comparing them]
- Not tailored to a particular area
- Based on non-rare tree species
- Not spatially explicit – ie, no wall-to-wall raster map

Planned next steps

- Use re-measured FIA plots to examine past changes in cluster (among-community change) and dominance (within-community change), in relation to disturbances and climate variables

- Project observed changes into the future under climate and land use change scenarios as part of the USDA Forest Service 2020 Resources Planning Act (RPA) Assessment

- Link with spatial projections of landscape change to project spatial patterns of forest species composition nationwide



Summary

- We developed a hierarchical, empirical classification of species assemblages based on inventory plots for the continental US
- Dominant species provide one example of how the classification can inform assessment of potential climate change impacts on forest communities
- The classification can be used as the basis for monitoring, assessment, and projection of global change effects on forests

Thank you

- L. Iverson and M. Peters – USDA Forest Service Climate Change Atlas projections
- R. Li – FIA database queries
- K. Riitters – spatial data extraction

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