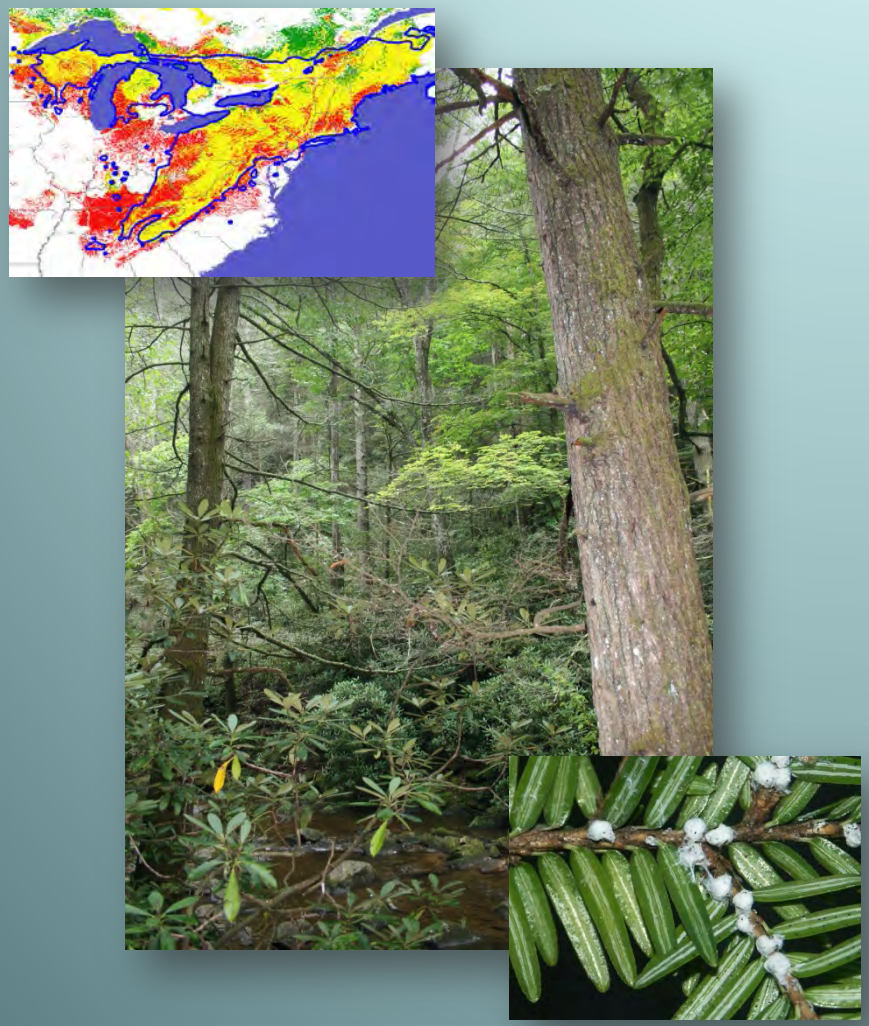
Project CAPTURE: A National Prioritization Assessment of Tree Species for Conservation, Management and Restoration



Kevin M. Potter

Barbara S. Crane

Valerie D. Hipkins

2015 Joint WFGA/NWSOMA Meeting

Seattle, Washington

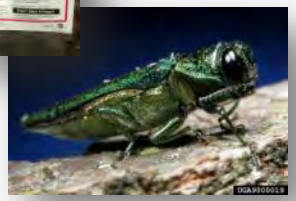
June 23, 2015

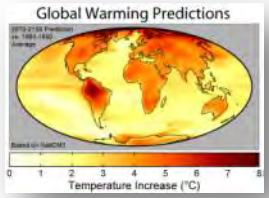
NC STATE UNIVERSITY

FOREST SERVICE
US
DEPARTMENT OF AGRICULTURE

Complex interactions among forest threats

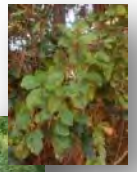
Insects and disease





Climate change

Invasive plants

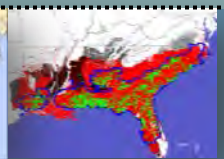


Tree health

Wildland fire

Forest Health

Fragmentation and conversion



Eastern Forest Environmental Threat Assessment Center
Research Triangle Park, N.C.

NC STATE UNIVERSITY

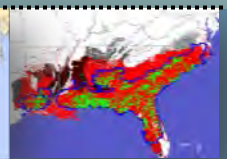
FOREST SERVICE
USDA
DEPARTMENT OF AGRICULTURE

Needed: Genetic vulnerability assessment

- Resources are limited for conservation, monitoring, management, restoration
- **Goal:** Conserve existing adaptedness and create conditions that allow for future evolution

Outplanting of Carolina hemlock for *ex situ* conservation, Ashe County, N.C.

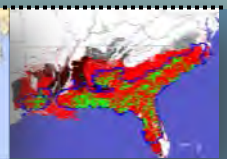




The challenge…

- More than 360 tree species in the continental United States, which vary widely in:
  - Exposure to threats
  - Geographic extent
  - Reproductive capacity
  - Dispersal ability
  - Environmental affinities
  - Genetic variability

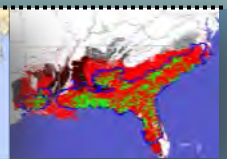




Project CAPTURE

- Conservation Assessment and Prioritization of Forest Trees Under Risk of Extirpation
- National, multi-scale project to ***identify, categorize and prioritize*** forest tree species and populations at risk of genetic degradation
  - Funded by USDA Forest Service (all three deputy areas)
- For gene conservation, monitoring and management
- Based on species' identified threats and life history characteristics

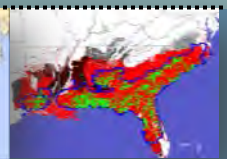




Genetic degradation: What do we mean?

- "Significant reduction in the ability of a species to persist for the next century without the loss of important variation in adaptive traits"
  - *Adaptive traits:* Any developmental, anatomical, or physiological characteristics of an organism that, in its environment, improve its chances for survival and of leaving descendants (King and Stansfield 2002)





Phase 1

- Complete data collection for tree species of the continental United States
- Stakeholders establish project scope, goals, and methods during workshop (March 2014)
- Generate priority list for all continental U.S. forested lands

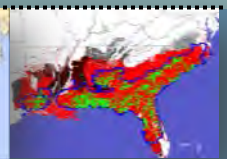
Phase 2

- Involve partners from other agencies, NGOs, universities
- Generate second priority list for all U.S. forested lands (including Puerto Rico and Hawaii)
- Select species for population-level assessments; begin data collection for these assessments

Phase 3

- Complete population-level assessments
- Produce user guide(s), General Technical Report(s), and journal article(s) presenting the methodology and results
- Establish procedures for ongoing national reassessments accounting for new threat information





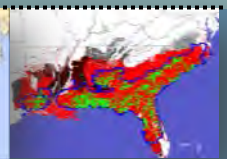
March 2014 Planning Workshop

- **Problem statement:**

  "Forest tree species face serious threats to their ability to persist on the landscape. We need agreement on a scientifically defensible and transparent process to prioritize tree species for conservation, monitoring, management, and restoration."

Arbor Day Foundation's Lied Lodge and Conference Center, Nebraska City, NE



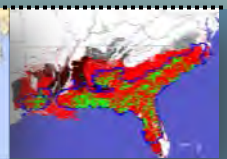


March 2014 Planning Workshop

- 25 Forest Service resource managers
  - From all three deputy areas
  - From across the United States
- Identified several ways to improve both the overall framework and the organization of the species vulnerability attributes

Arbor Day Foundation's Lied Lodge and Conference Center, Nebraska City, NE



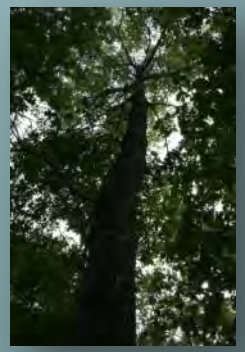


Project CAPTURE, Phase 1

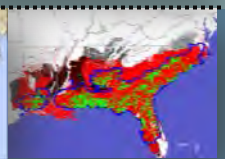
- Data collected for 367 tree species
- Three external threats
  - Expected Climate Change Pressure (***complete***)
  - Exposure to Pests and Pathogens (***in progress***)
  - Lack of Structural Sustainability (***to be done***)
- Nine species attributes (from 23 specific species traits) grouped into three vulnerability classes



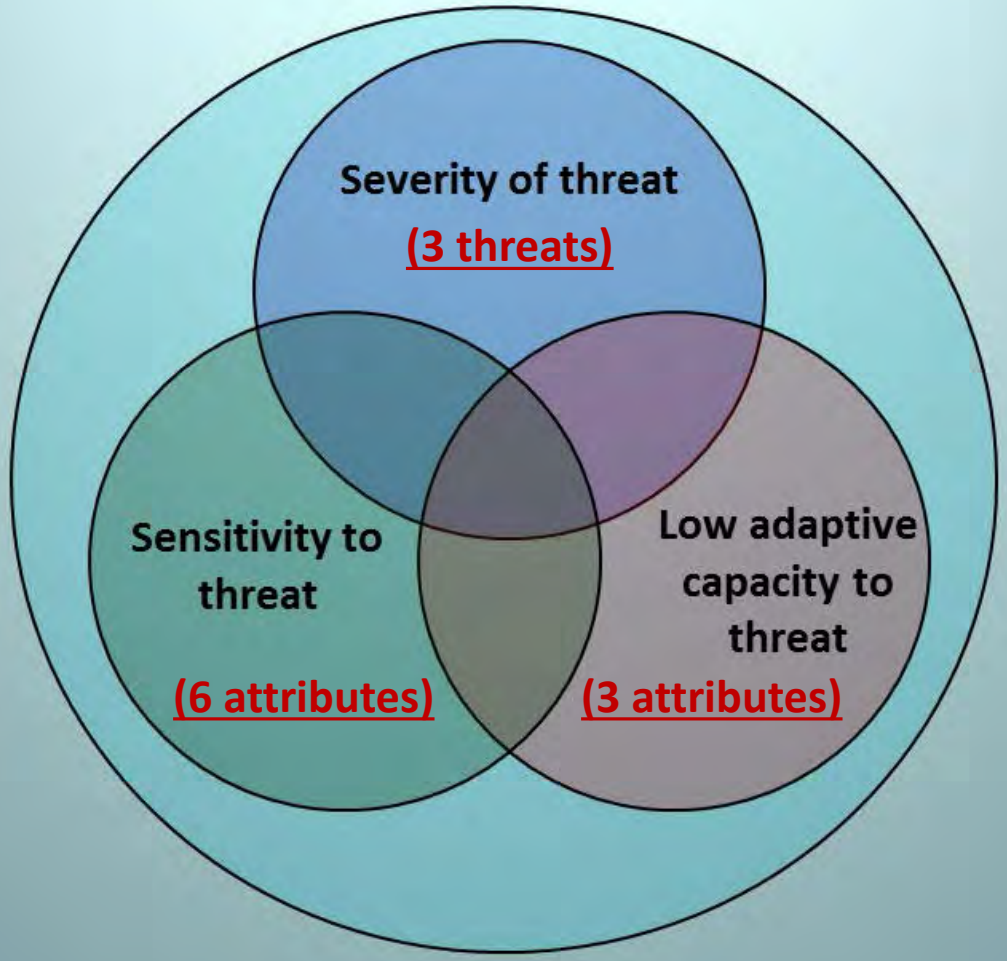




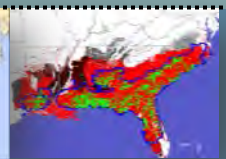


Grouping species in vulnerability classes

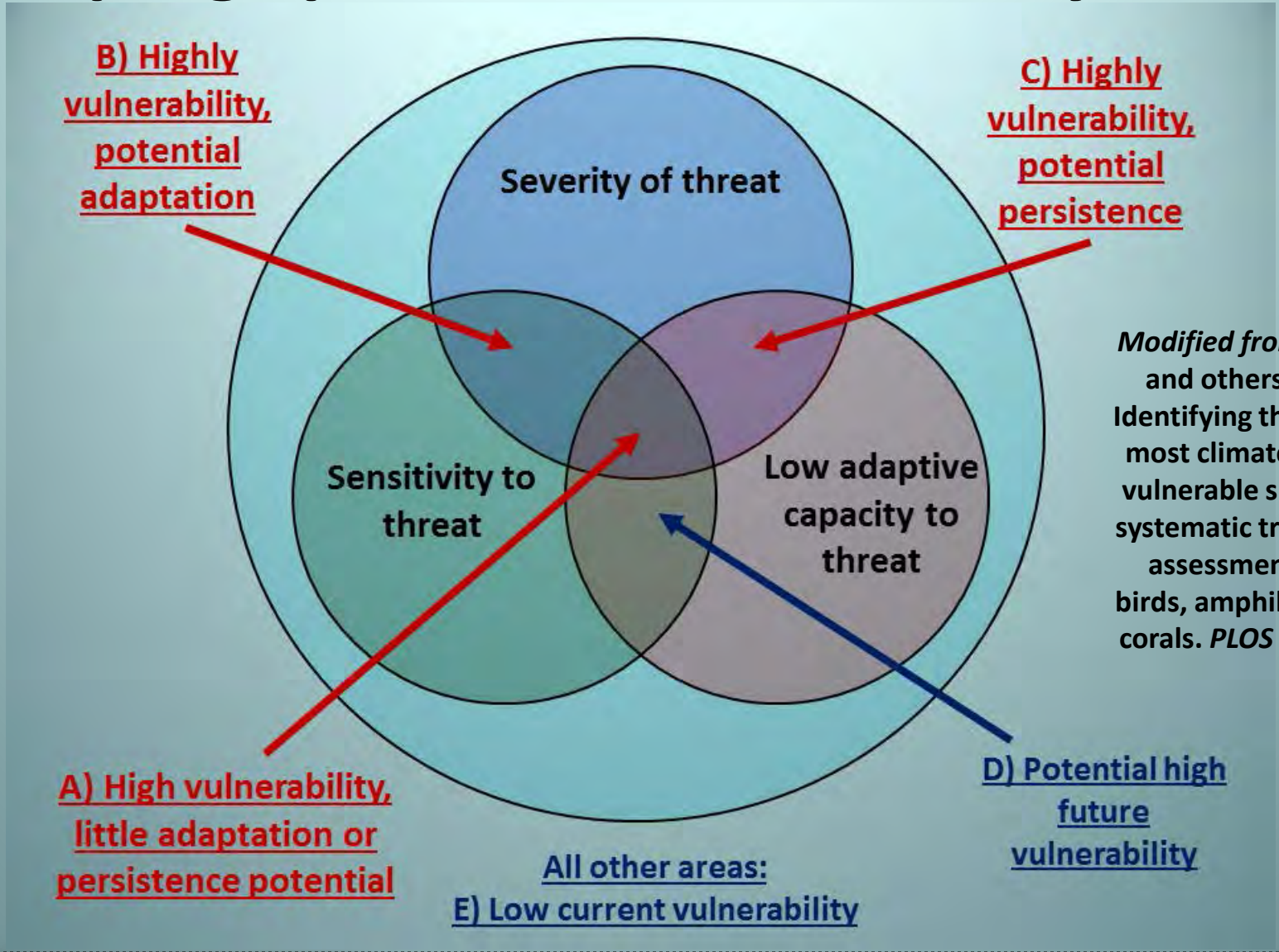


Modified from: **Foden and others. 2013. Identifying the world's most climate change vulnerable species: A systematic trait-based assessment of all birds, amphibians and corals. *PLOS One*. 8:6.**



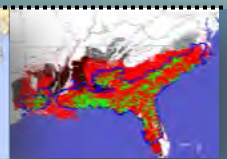


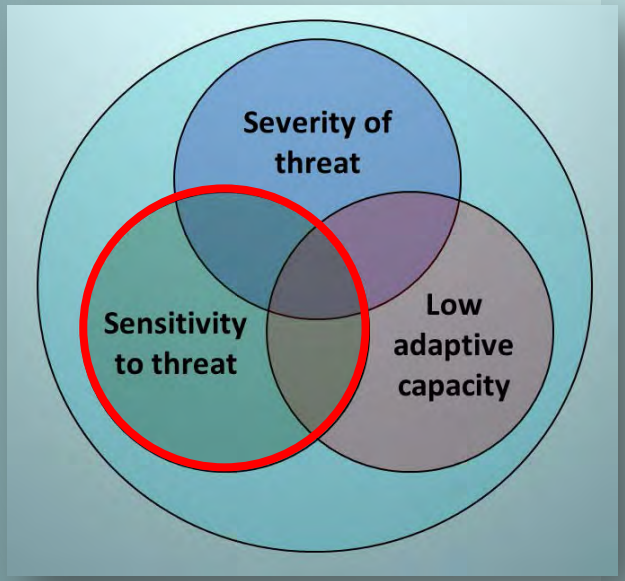
Grouping species in vulnerability classes



Modified from: Foden and others. 2013. Identifying the world's most climate change vulnerable species: A systematic trait-based assessment of all birds, amphibians and corals. *PLOS One*. 8:6.







Area of Distribution

- **Area of range (↓)** (Petit *et al.* 2008)

Disturbance Tolerance

- **Drought tolerance (↓)** (Littell *et al.* 2010)
- **Fire tolerance (↓)** (Fischer *et al.* 1996)

Disturbance Requirement

- **Fire dependence (greater =↑)** (Brown and Smith 2000)
- **Successional stage (later = ↑)** (Myking 2002)

Rarity

- **Rarity of plot occurrences (↑)** (Jump & Penuelas 2005)
- **Density (↓)** (Stork *et al.* 2009)

Dispersal Ability

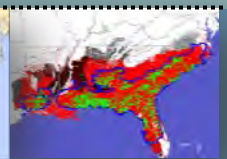
- **Propagule dispersal distance (↓)** (Walther *et al.* 2002)

Geographic Threat Extent

- **Percent of species range at risk from threat (↑)**

Species Attributes Associated with Sensitivity to Threats

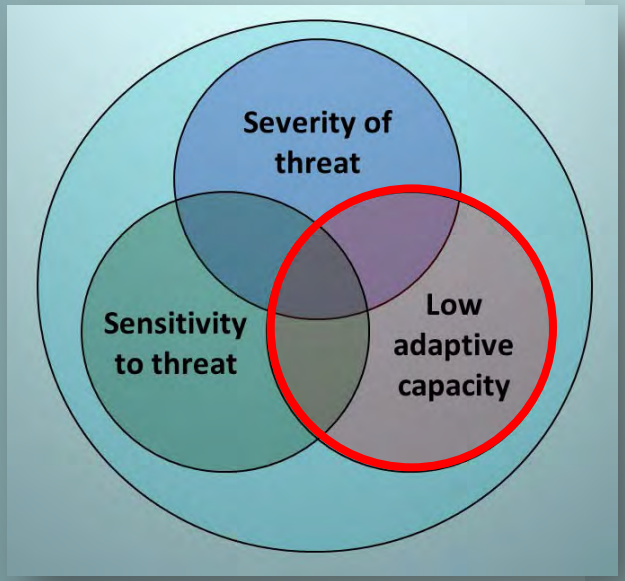




Eastern Forest Environmental Threat Assessment Center
Research Triangle Park, N.C.

NC STATE UNIVERSITY

FOREST SERVICE USDA DEPARTMENT OF AGRICULTURE



Regeneration Capacity

- **Large seed crop frequency (↓)** (Brook *et al.* 2008)
- **Long-term seed viability (↓)** (Fenner and Thompson 2005)
- **Reproductive maturity age (↑)** (Stork *et al.* 2009)
- **Sexual + clonal reproduction (↓)** (Steinger *et al.* 1996)
- **Dioecy (↑)** (Vamosi & Vamosi 2005)

Genetic Variability

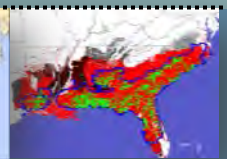
- **Number of seed zones (↓)** (Hamrick 2004)
- **Pollination vector (insects = ↑)** (Aitken *et al.* 2008)
- **Number of disjunct populations (↑)** (McLaughlin *et al.* 2002)

Environmental Limitations

- **Site affinities (generalist =↓)** (Myking 2006)
- **Niche occupancy (greater =↓)** (Potter and Hargrove 2013)

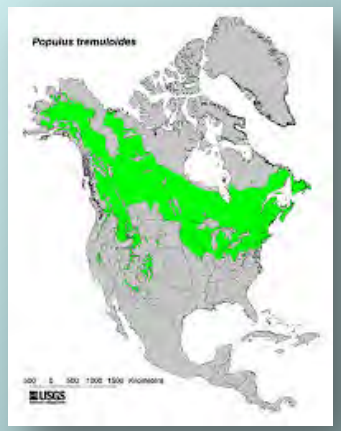
Species Attributes Associated with Low Adaptive Capacity

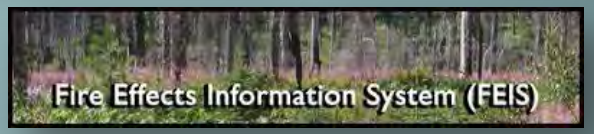


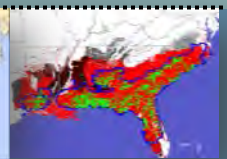


Attribute data collection

- E.L. Little's tree range maps for distributional information
- Forest Inventory and Analysis (FIA) data for rarity information
- Widely available publications for species life-history traits, including:
  - *Silvics of North America* (Burns and Honakala 1990)
  - *Woody Plant Seed Manual* (Bonner and Karrfalt 2008)
  - *Fire Effects Information System* (Brown and Smith 2000)







Pest and Pathogen Threats

Threats from pests and pathogens (↑)
(Logan *et al.* 2003)

Climate Change Pressure

Predicted percent decrease in area of suitable habitat (↑)
(Parmesan 2006)

Predicted range stability over time (↓)
(Potter and Hargrove 2013)

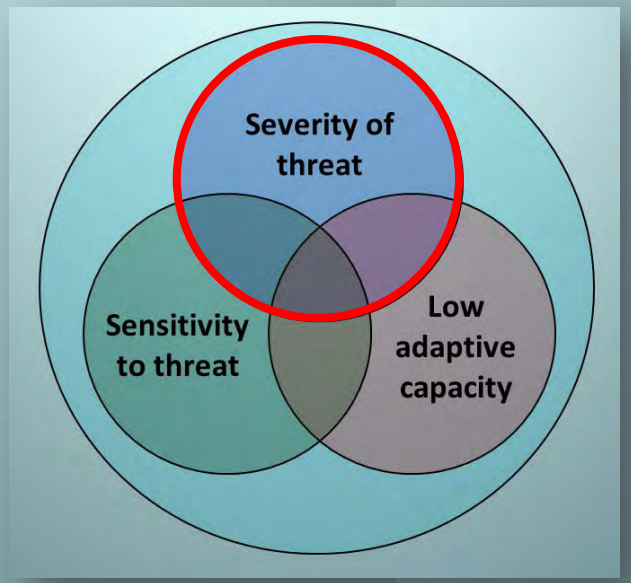
Mean predicted distance to any future suitable habitat (↑)
(Parmesan 2006)

Mean predicted distance to any future identical habitat (↑)
(Potter and Hargrove 2013)

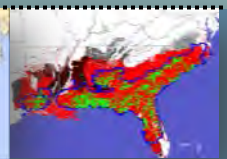
Lack of Structural Sustainability

Index of forest structural sustainability (↓)
(Cale *et al.* 2014)

External Threats

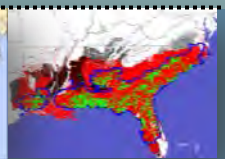






Pest and Pathogen Threats

- Up to five pest and pathogen threats identified for each species
  - Sources: Silvics Manual, Alien Pests and Their Hosts web site, Eastern Forest Environmental Threat Assessment Center list, Fire Effects Information System
- Each threat to a species given severity score (1-10) based on mortality potential
  - Threat scores combined for each species
- Combined threat scores ranked for each species (from 0, low score, to 100 high score)



The **ForeCASTS** Project

Forecasts of Climate-Associated Shifts in Tree Species

- Habitat suitability maps and predicted climate change pressure metrics generated for >320 North American forest tree species
  - Two GCMs (Hadley and PCM), two emissions scenarios, two time points (2050 and 2100)
  - **www.forestthreats.org/tools/ForeCASTS/**
- Includes spatially explicit maps of projected climate change pressure across range of species

NC STATE UNIVERSITY

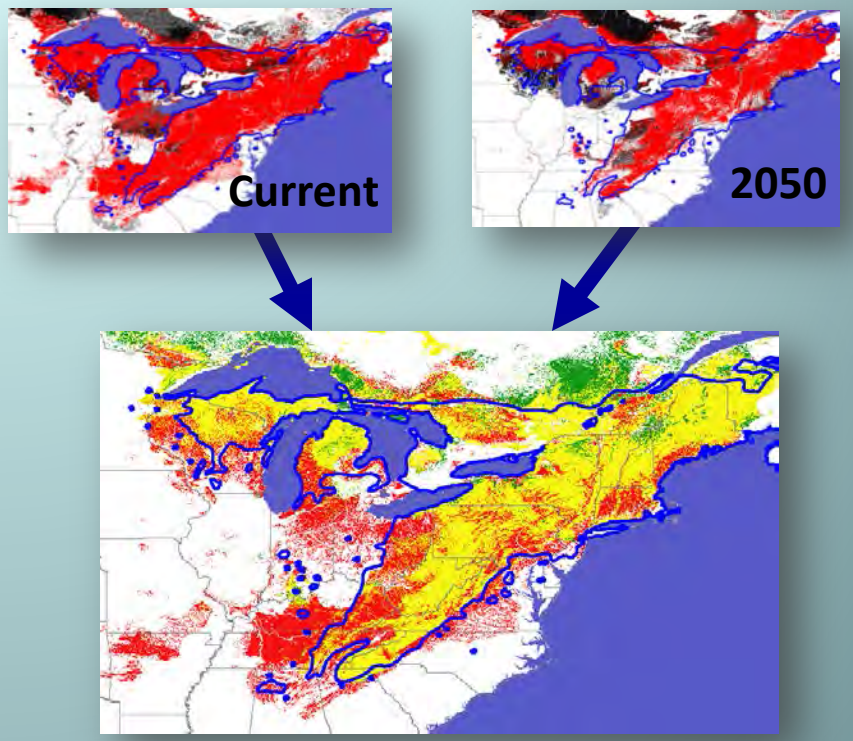
Eastern Forest Environmental Threat Assessment Center
Research Triangle Park, N.C.

NC STATE UNIVERSITY

Climate change pressure metrics

(Potter and Hargrove 2012)

1) Percent change in suitable area for each species
2) Percent of current habitat that remains suitable (range stability)
3) Mean distance to nearest future habitat of any quality
4) Mean distance to nearest future habitat identical to current

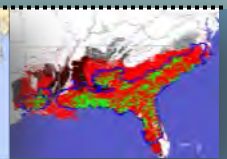


Lack of Structural Sustainability

High-elevation hardwood forests, Shenandoah National Park, Virginia

- Stand-age class structure can be used to assess forest sustainability at broad scales
- Encompasses effects of natural disturbances and management decisions
  - Change in fire regime
  - Over-browsing by deer
  - Drought
  - Insufficient regeneration
- Goal: Objective determination of scope and direction of change in structure and composition (Cale *et al.* 2014)





Which species are most vulnerable?

Rank	Species	Vul.
1	Carolina ash (*Fraxinus caroliniana*)	98.4
2	Florida torreya (*Torreya taxifolia*)	96.6
3	Carolina hemlock (*Tsuga caroliniana*)	96.5
4	Eastern hemlock (*Tsuga canadensis*)	93.2
5	Pumpkin ash (*Fraxinus profunda*)	90.3
6	Redbay (*Persea borbonia)*	89.4
7	American chestnut (*Castanea dentata*)	88.9
8	Northern catalpa (*Catalpa speciosa*)	88.9
9	Monterrey cypress (*Cupressus macrocarpa*)	88.8
10	Chalk maple (*Acer leucoderme*)	85.9
11	SW white pine (*Pinus strobiformis*)	85.8
12	Fraser fir (*Abies fraseri*)	85.5

Combine threat severity, sensitivity, and adaptive capacity scores for overall vulnerability score and ranking:

$$V = (T + S) / 2$$

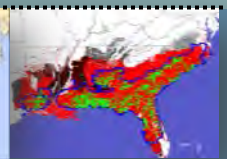
where:

V = vulnerability score

T = threat severity score (higher of climate change pressure and pests/pathogens risk)

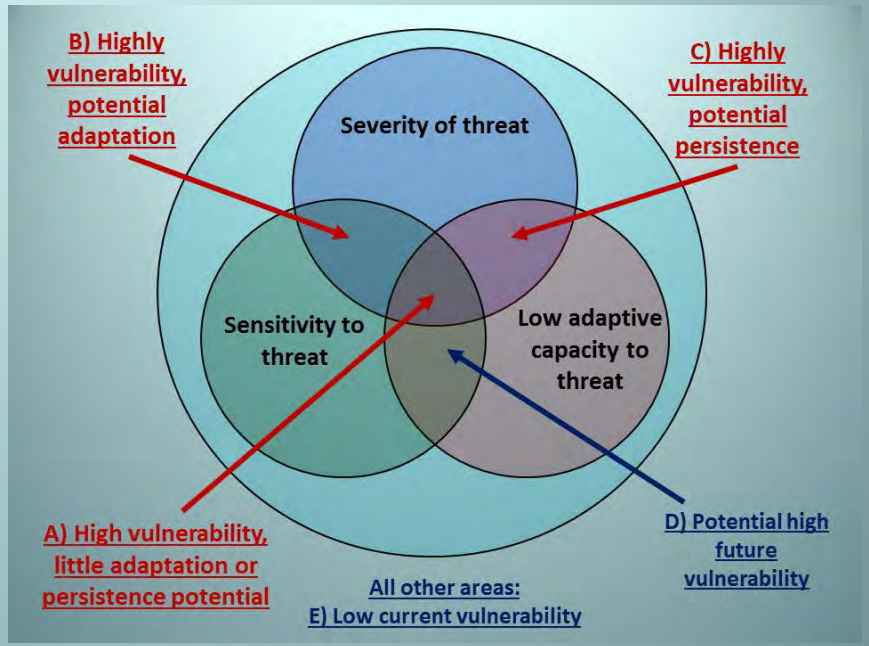
S = higher of inherent species vulnerability (higher of sensitivity and low adaptive capacity)



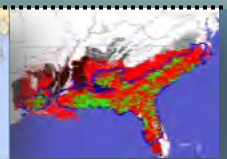


Sorting species into vulnerability classes

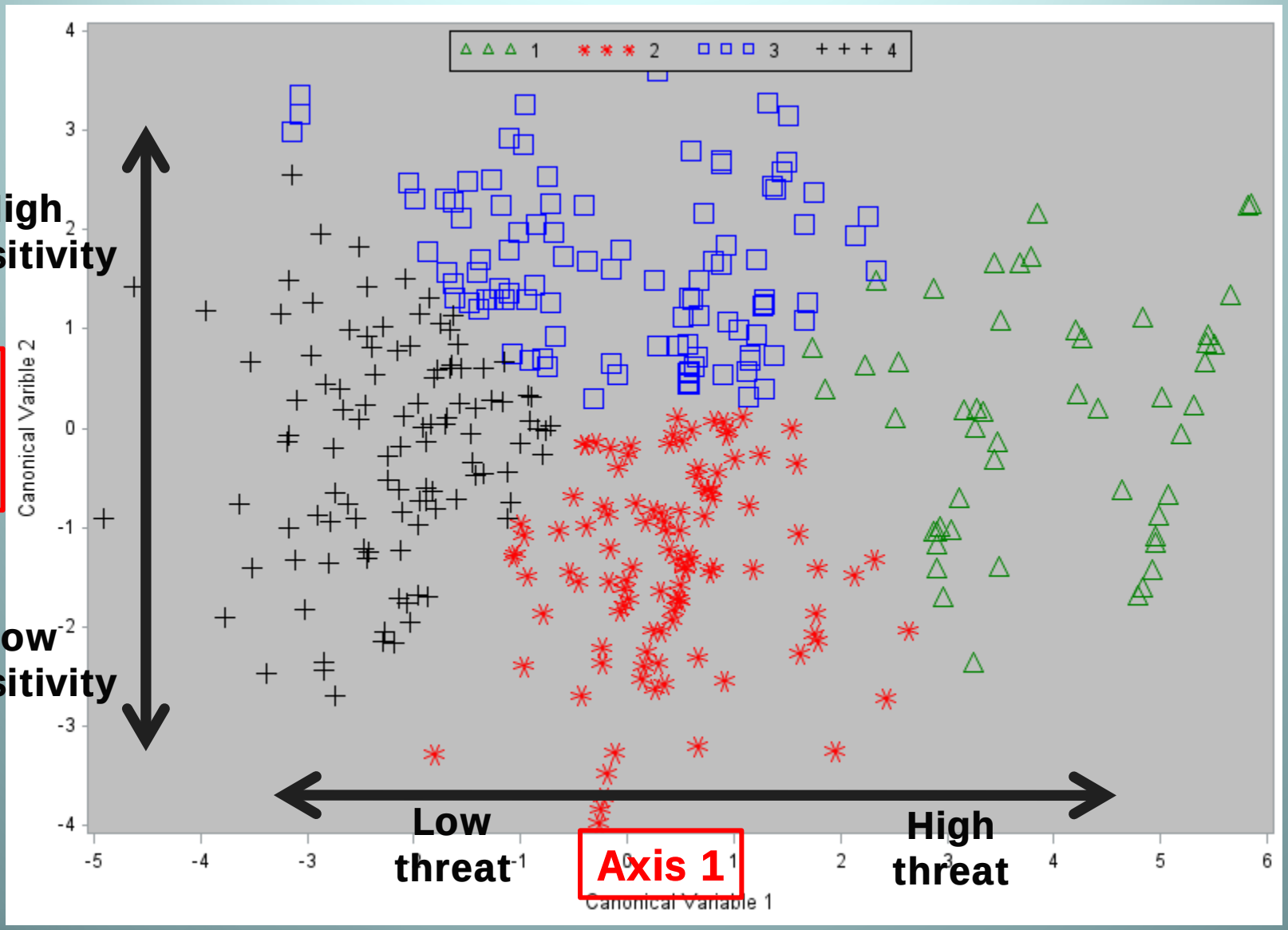
- Determined optimal number of vulnerability classes to explain species variation in the 3 attributes
  - K-means clustering of risk attributes (SAS Proc FASTCLUS)
  - Determined the optimal number of clusters (classes): 4
- Plotted clusters
  - Canonical discriminant analysis (SAS Proc CANDISC)
  - One axis for each of 3 attributes



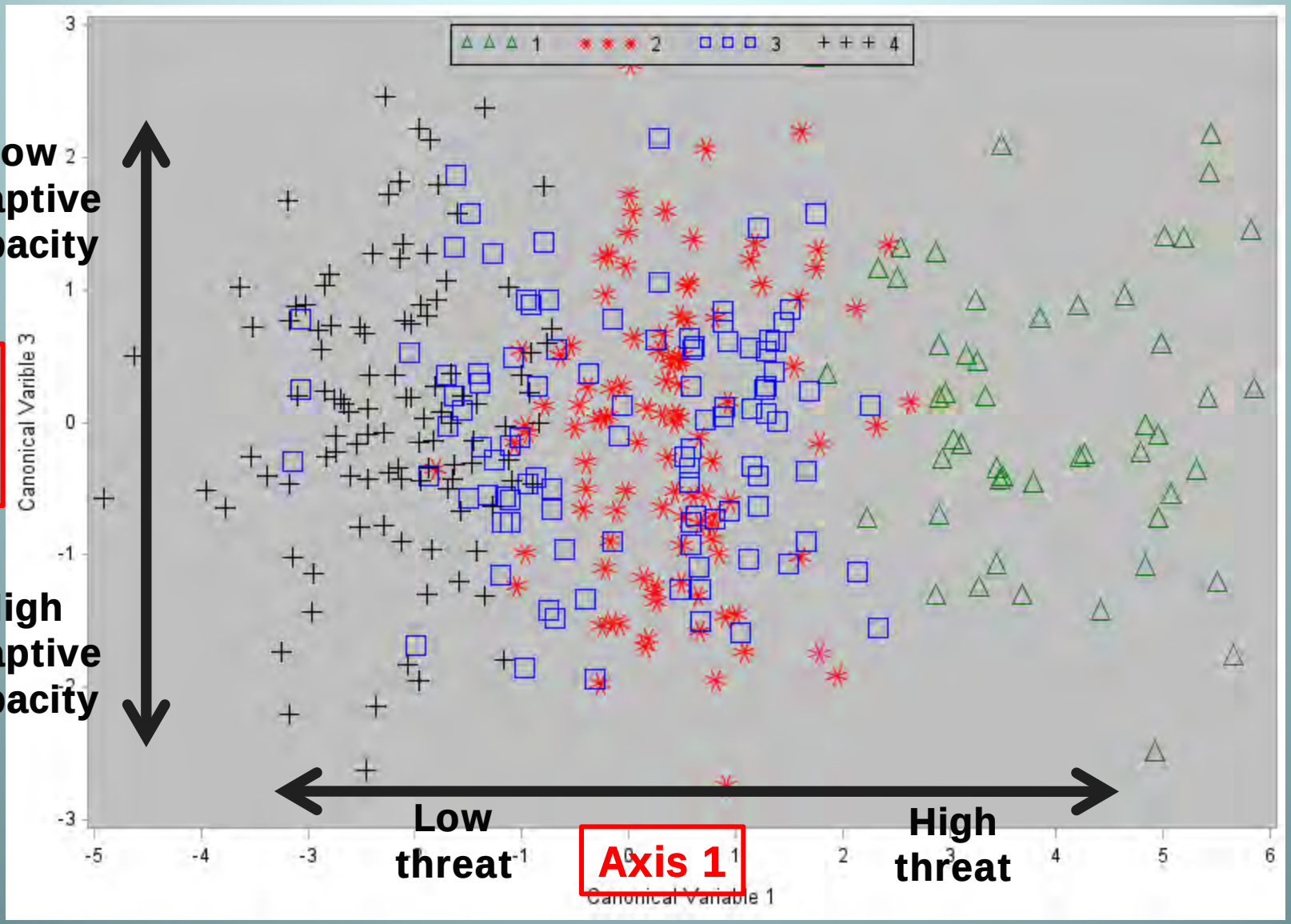




Threat severity and threat sensitivity

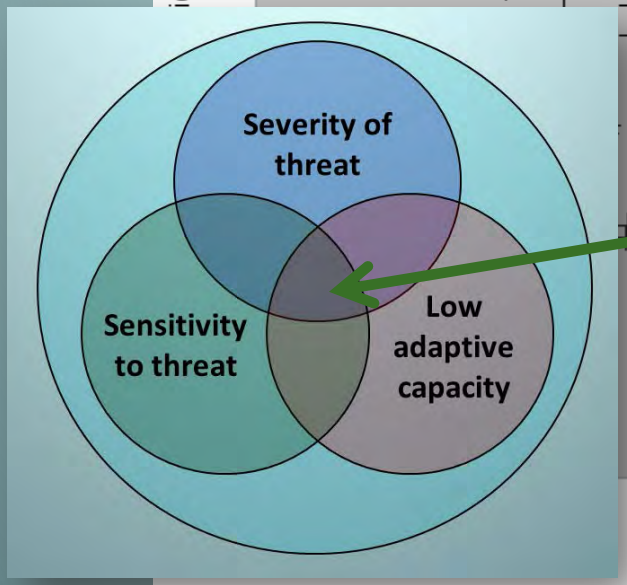


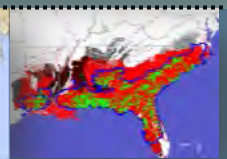
Threat severity and adaptive capacity



Vulnerability classes

High threat, mod sensitivity, mod adaptive capacity





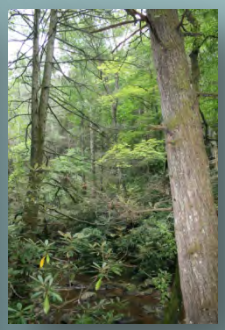
Eastern Forest Environmental Threat Assessment Center
Research Triangle Park, N.C.

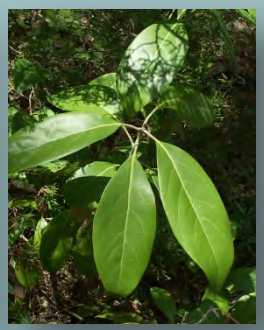
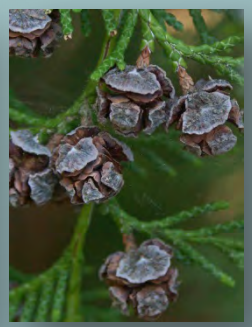
NC STATE UNIVERSITY

Conservation/management triage

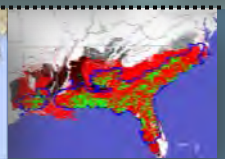
1) **<u>High vulnerability:</u>** high threat severity, moderate to high sensitivity, moderate to low adaptive capacity ***(51 species)***

   - *<u>Action:</u>* gene conservation ASAP; plan for climate change and/or pest/pathogen threats
   - *<u>Examples:</u>* Fraser fir, eastern hemlock, ashes, redbay, Port-Orford-cedar, yellowwood, sugar pine
   - *<u>Average vulnerability rank:</u>* 31.0 (out of 367)

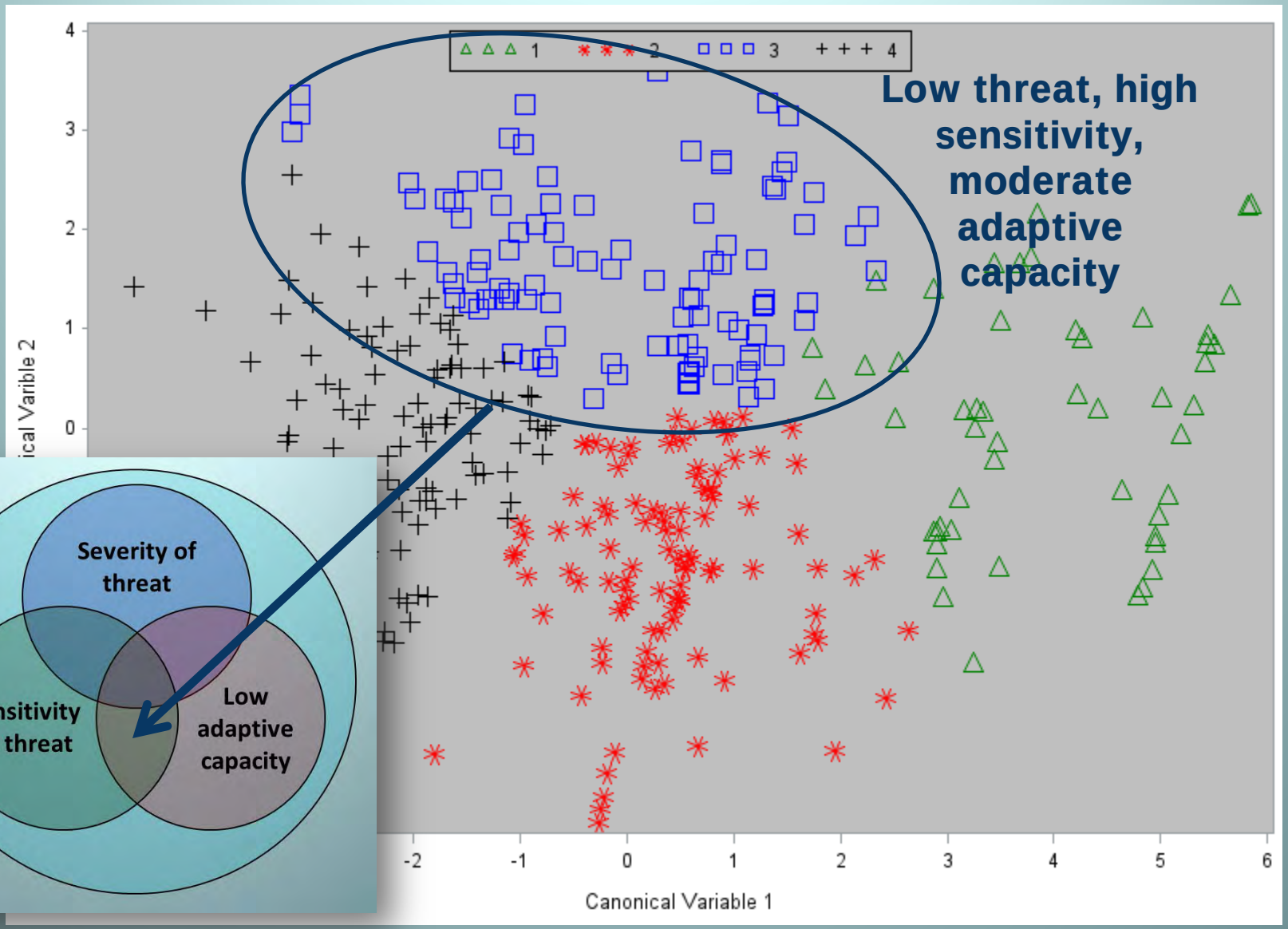



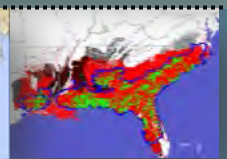







Vulnerability classes





Eastern Forest Environmental Threat Assessment Center
Research Triangle Park, N.C.

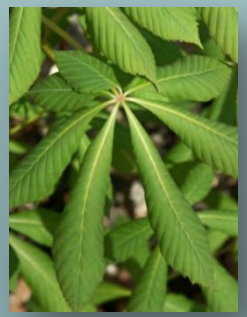
NC STATE UNIVERSITY

Conservation/management triage

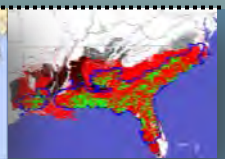
2) **<u>Potential future vulnerability:</u>** moderate to low threat severity, high sensitivity, moderate adaptive capacity ***(101 species)***

- *<u>Action:</u>* Monitor potential threats; assess *in situ* conservation; collect seed from limited locations
- *<u>Examples:</u>* red spruce, bigleaf magnolia, Ohio buckeye, giant sequoia, saguaro, Table Mountain pine
- *<u>Average vulnerability rank:</u>* 126.5 (out of 367)

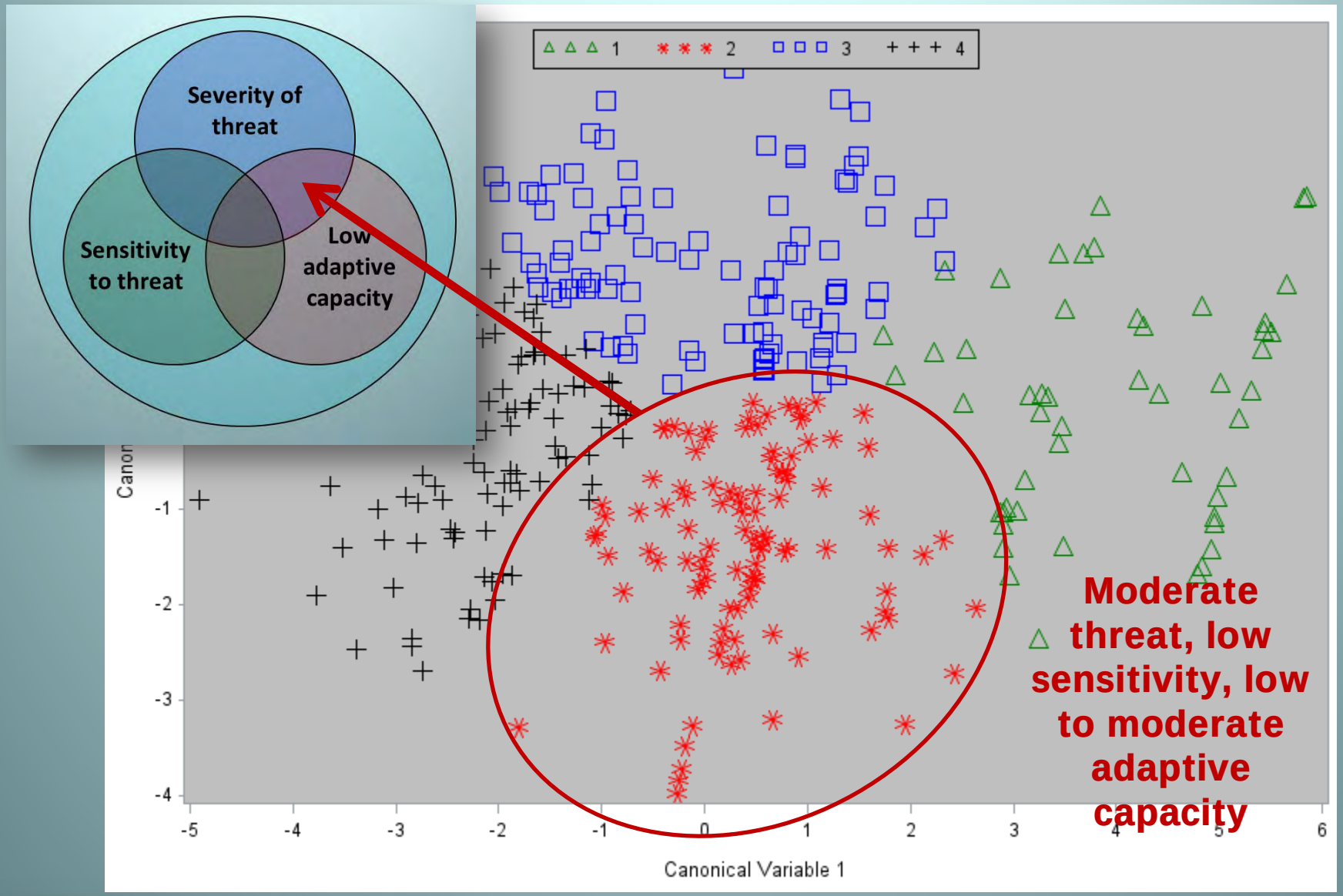






Vulnerability classes

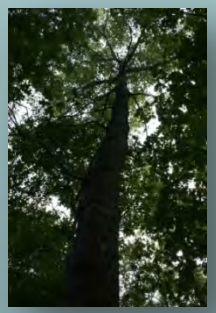


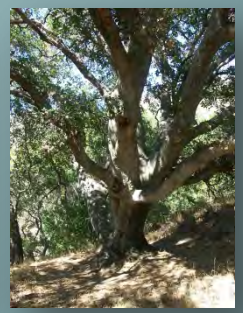
Conservation/management triage

3) **<u>Potential persistence:</u>** moderate threat severity, low sensitivity, low to moderate adaptive capacity ***(107 species)***

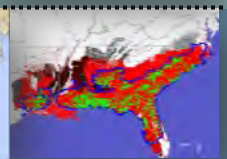
- *<u>Action:</u>* Monitor population trends; assess *in situ* conservation; collect seed from limited locations
- *<u>Examples:</u>* Osage-orange, longleaf pine, desert ironwood, northern red oak, mountain-ash, California live oak
- *<u>Average vulnerability rank:</u>* 192.5 (out of 367)



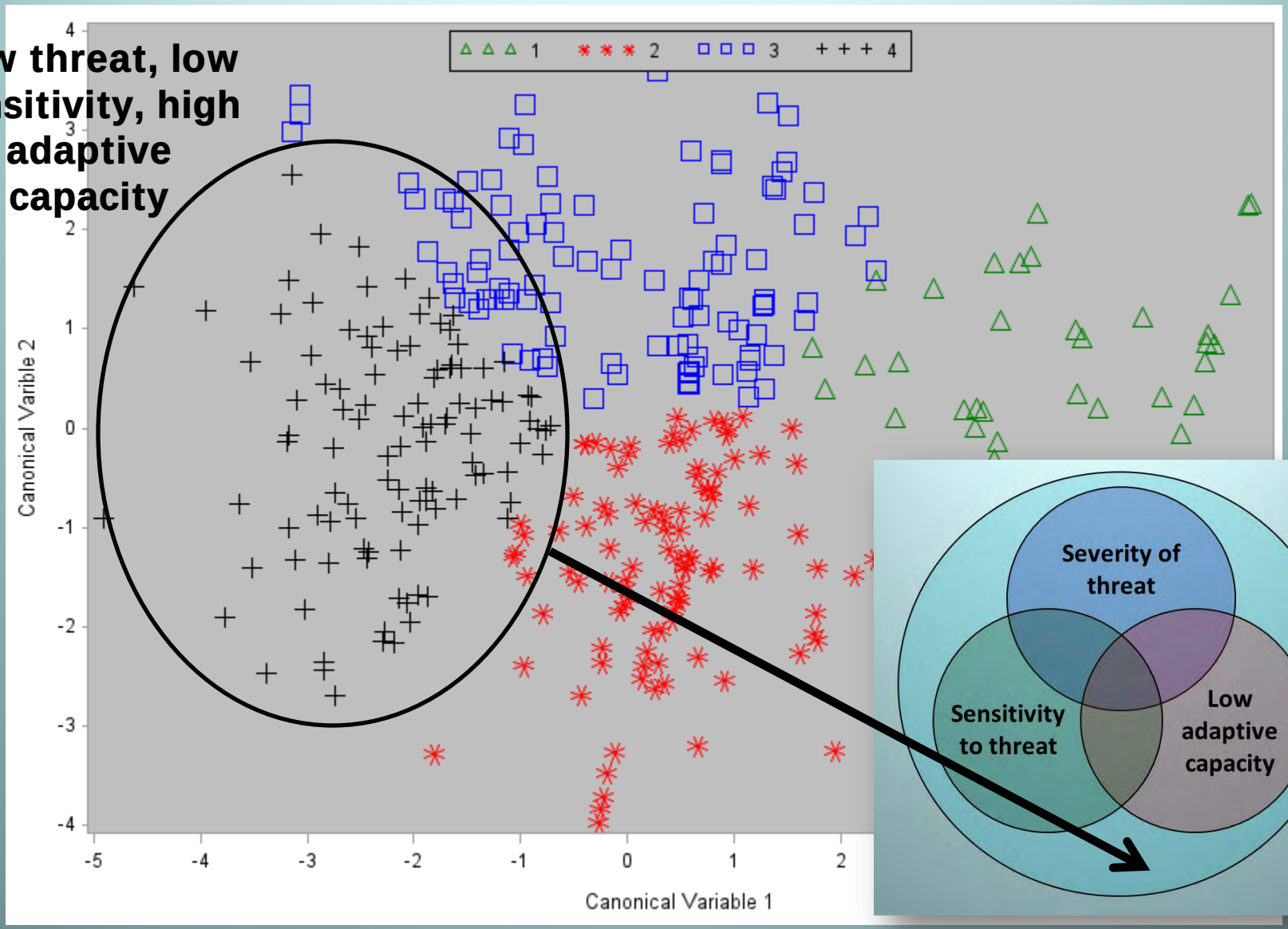


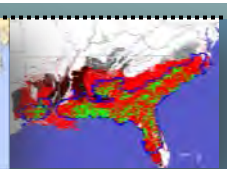




Vulnerability classes

Low threat, low sensitivity, high adaptive capacity

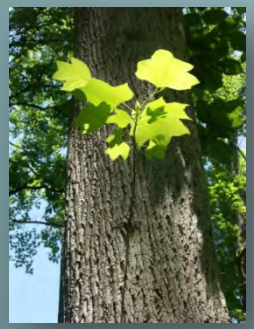
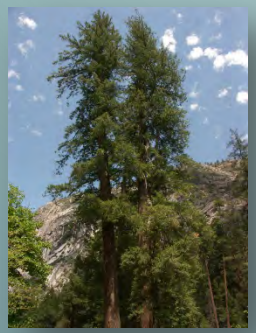


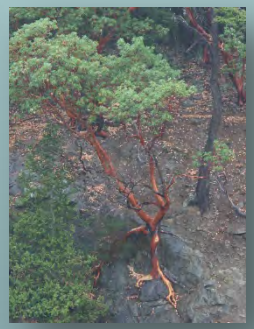


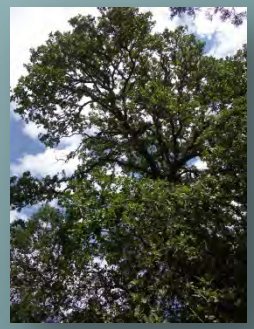
Conservation/management triage

4) **<u>Low vulnerability:</u>** Low threat severity, low sensitivity, high adaptive capacity ***(108 species)***

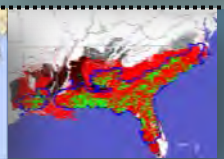
- *<u>Action:</u>* Routine species monitoring
- *<u>Examples:</u>* yellow-poplar, Douglas-fir, pignut hickory, Pacific madrone, musclewood, post oak
- *<u>Average vulnerability rank:</u>* 301.7 (out of 367)









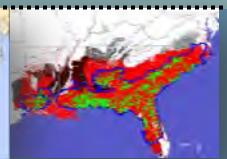
Next Steps

1) Publish Forest Service General Technical Report and journal articles describing the framework

2) Expand the scope of the assessment to include native trees of Puerto Rico and Hawaii
   - This may require a different approach given the large number of species and limited data for many

3) Incorporate stakeholders from outside the Forest Service in the assessment process
   - Non-government organizations, other government agencies, universities





Thank you for your attention!

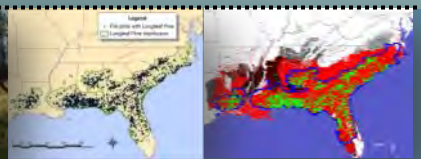
kpotter@ncsu.edu

(919) 549-4071

Blue Ridge Mountains, North Carolina

Thanks to:

- Funding from USDA Forest Service: Forest Health Protection; Forest Health Monitoring program; Eastern Forest Environmental Threat Assessment Center
- Data collection: Julie Canavin, Ana Castillo, Maria Escanferla, Ti'Era Worsley, Brunell Gugelmann
- Development of assessment methodology: Carol Aubry, Andy Bower
- Other assistance: Bill Hargrove, Fred Cubbage, Gary Man, Kurt Riitters, Danny Lee, Barb Conkling



USDA
United States Department of Agriculture

GENE CONSERVATION of TREE SPECIES

BANKING ON THE FUTURE

2016 Workshop

MAY 16-19, 2016
CHICAGO, ILLINOIS, USA

A workshop for the exchange of the latest information, research, and action on gene conservation of tree species

fs.fed.us/geneworkshop

Forest Service

Special Thanks to our Partners:

APGA

USDA Agricultural Research Service

BGCI Plants for the Planet

CHICAGO BOTANIC GARDEN

Global Trees Campaign

The Morton Arboretum

WFCA Western Forestry and Conservation Association