


Designing Adaptive Forest Management Experiments Through Scientist-Manager Partnerships

April 4, 2017

Texas A&M – ESSM Seminar Series

Management in Transition: Adapting to a Changing World

Linda Nagel, Professor and Department Head

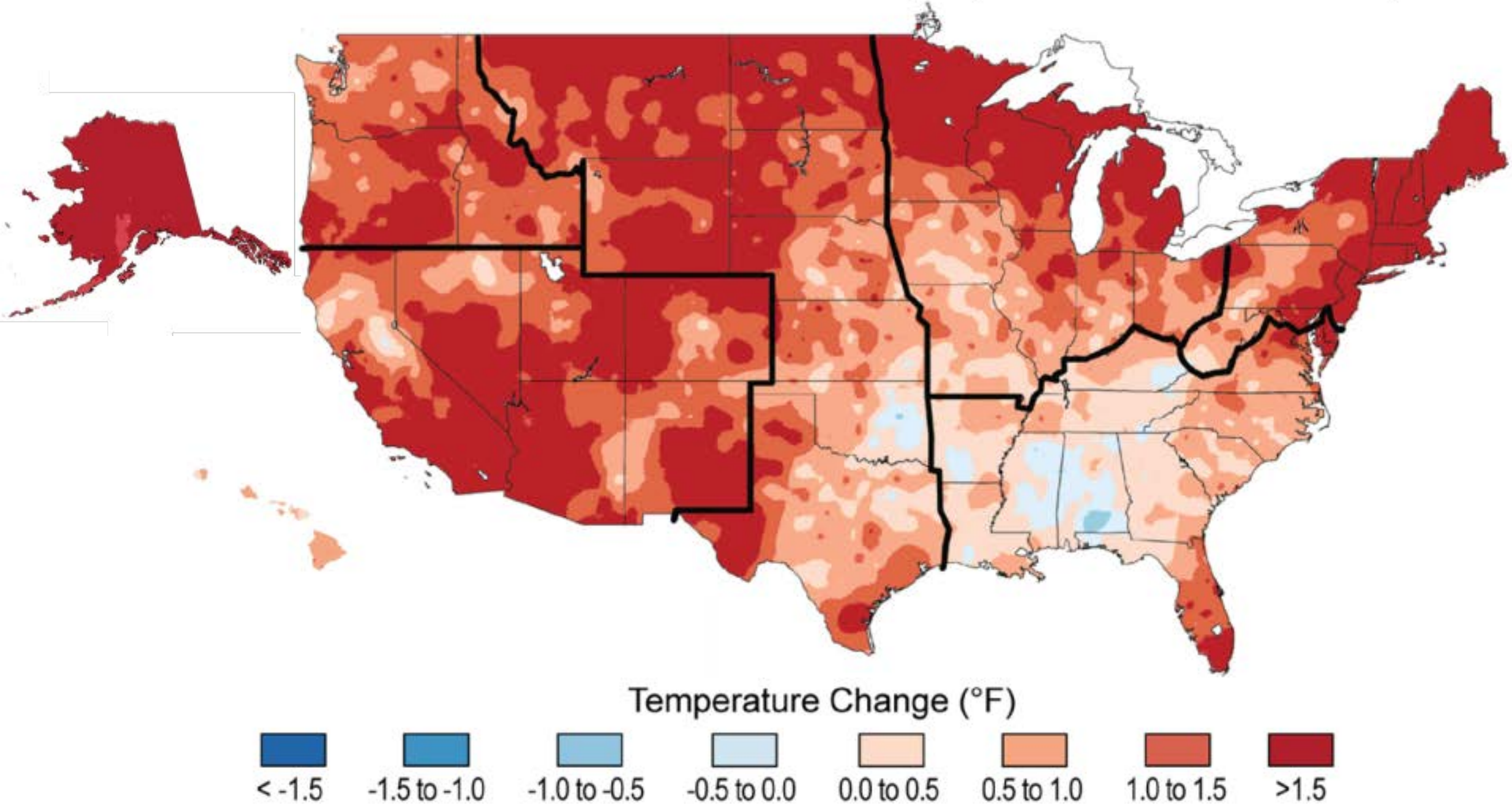
Forest and Rangeland Stewardship

Key Collaborators: Chris Swanston (NIACS), Maria Janowiak (NIACS), Jim Guldin (SRS), Brian Palik (NRS), Mike Battaglia (RMRS)

Michigan Tech
University of Minnesota
Colorado State University
Forest Service U.S. Department of Agriculture
NIACS Northern Institute of Applied Climate Science
SRS Southern Research Station
Northern Research Station USDA Forest Service
Rocky Mountain Research Station

Our changing climate

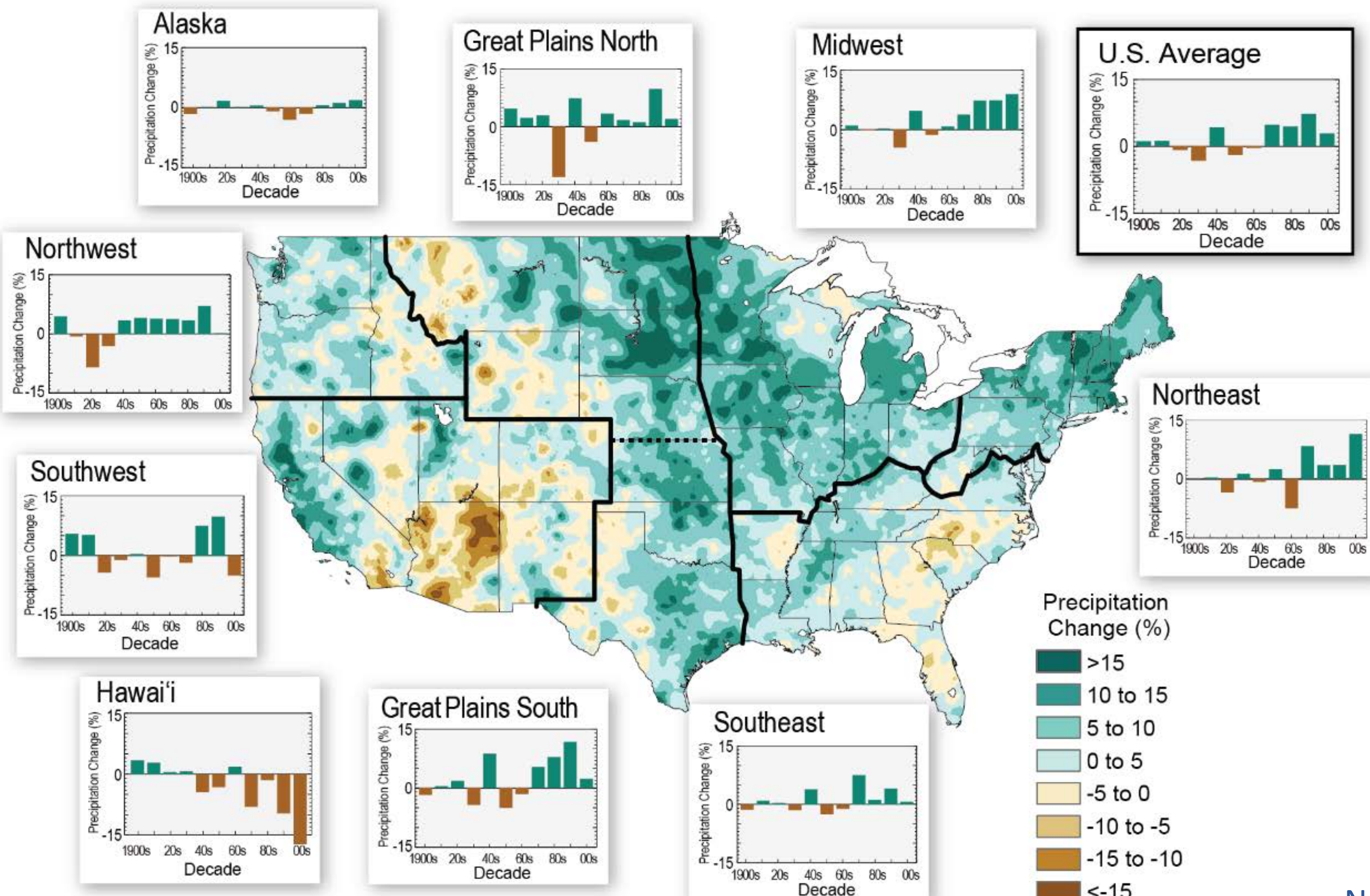
Contiguous US: 1991-2012 departure from 1901-1960 average



NCA 2014

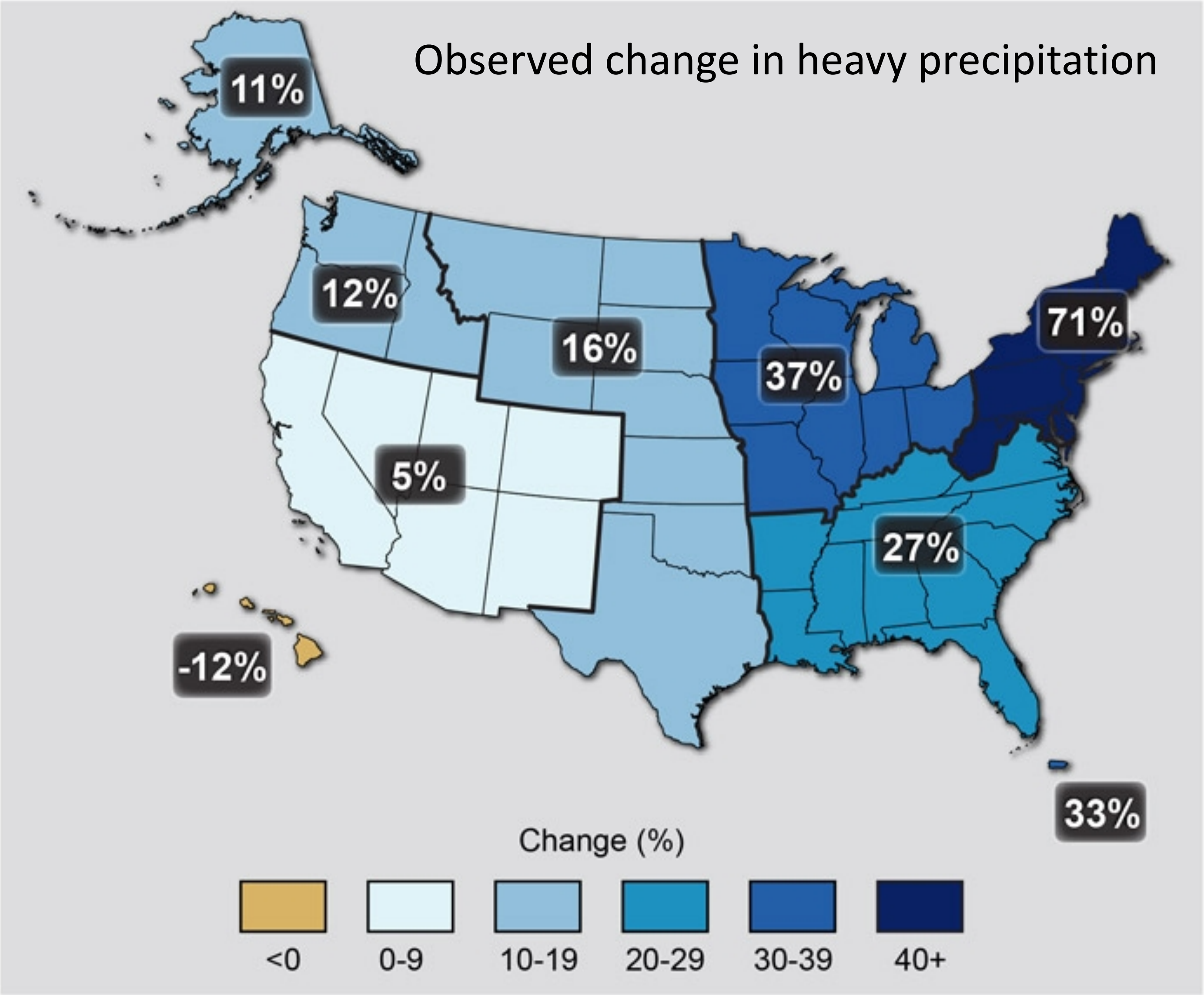
Our changing climate

Observed US precipitation change: 1991-2011 departure from 1901-1960 average



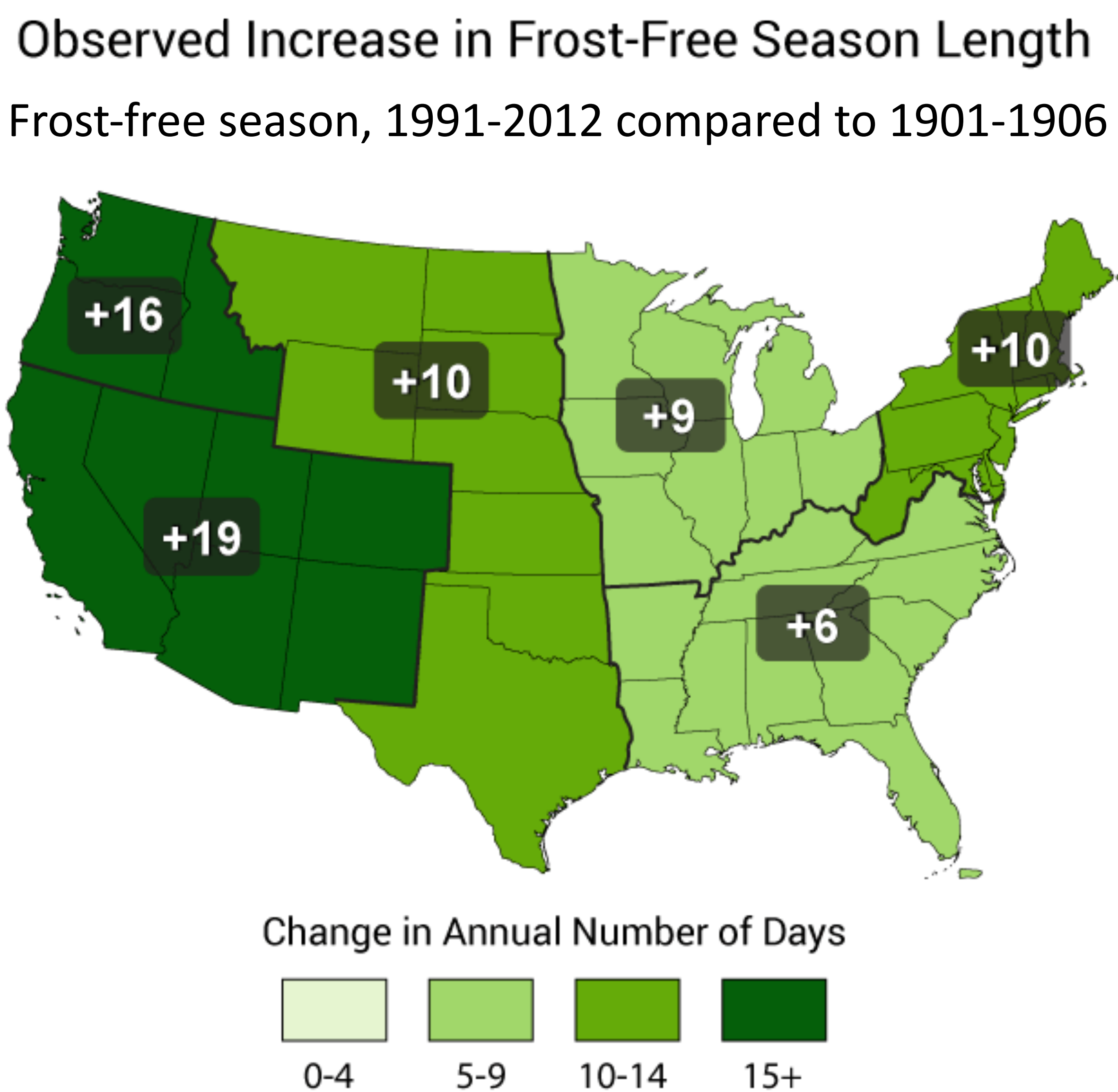
NCA 2014

Our changing climate

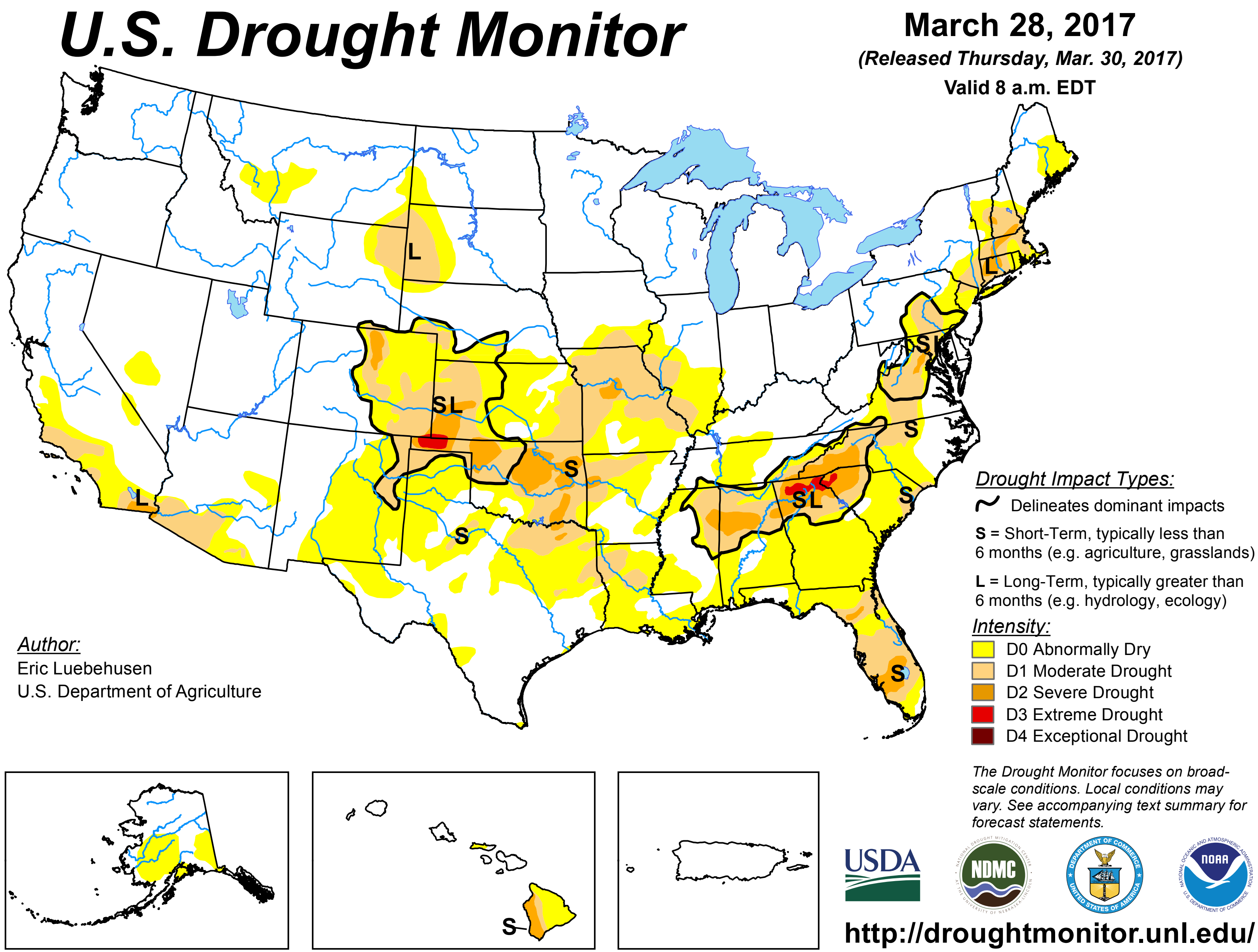


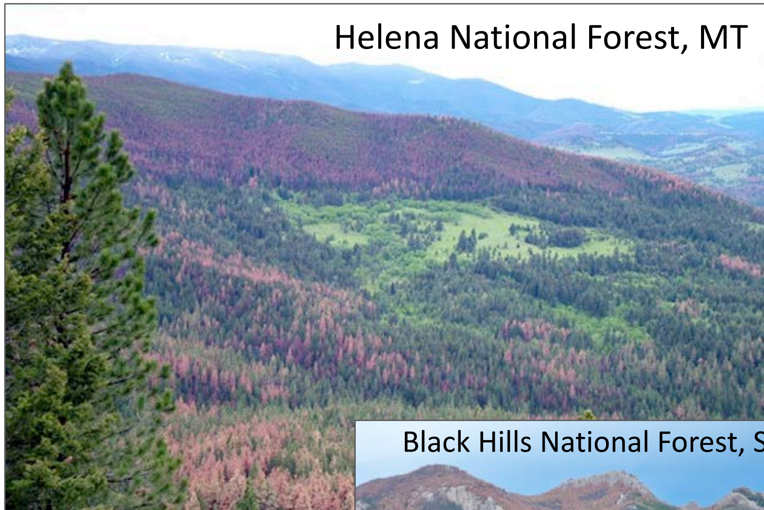
NCA 2014

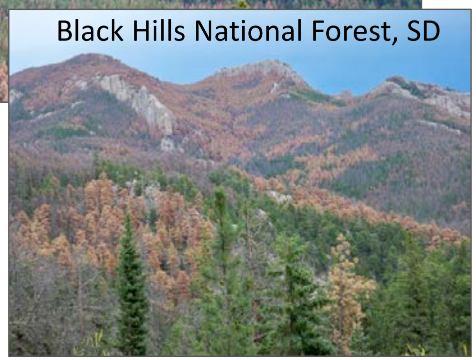
Our changing climate



NCA 2014


U.S. Drought Monitor
March 28, 2017
(Released Thursday, Mar. 30, 2017)
Valid 8 a.m. EDT
Drought Impact Types:
Delineates dominant impacts
S = Short-Term, typically less than 6 months (e.g. agriculture, grasslands)
L = Long-Term, typically greater than 6 months (e.g. hydrology, ecology)
Intensity:
D0 Abnormally Dry
D1 Moderate Drought
D2 Severe Drought
D3 Extreme Drought
D4 Exceptional Drought
Author:
Eric Luebehusen
U.S. Department of Agriculture
The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.
USDA
NDMC
http://droughtmonitor.unl.edu/


Helena National Forest, MT


Black Hills National Forest, SD


Texas drought, 2009


Hurricane Sandy, NJ
2012

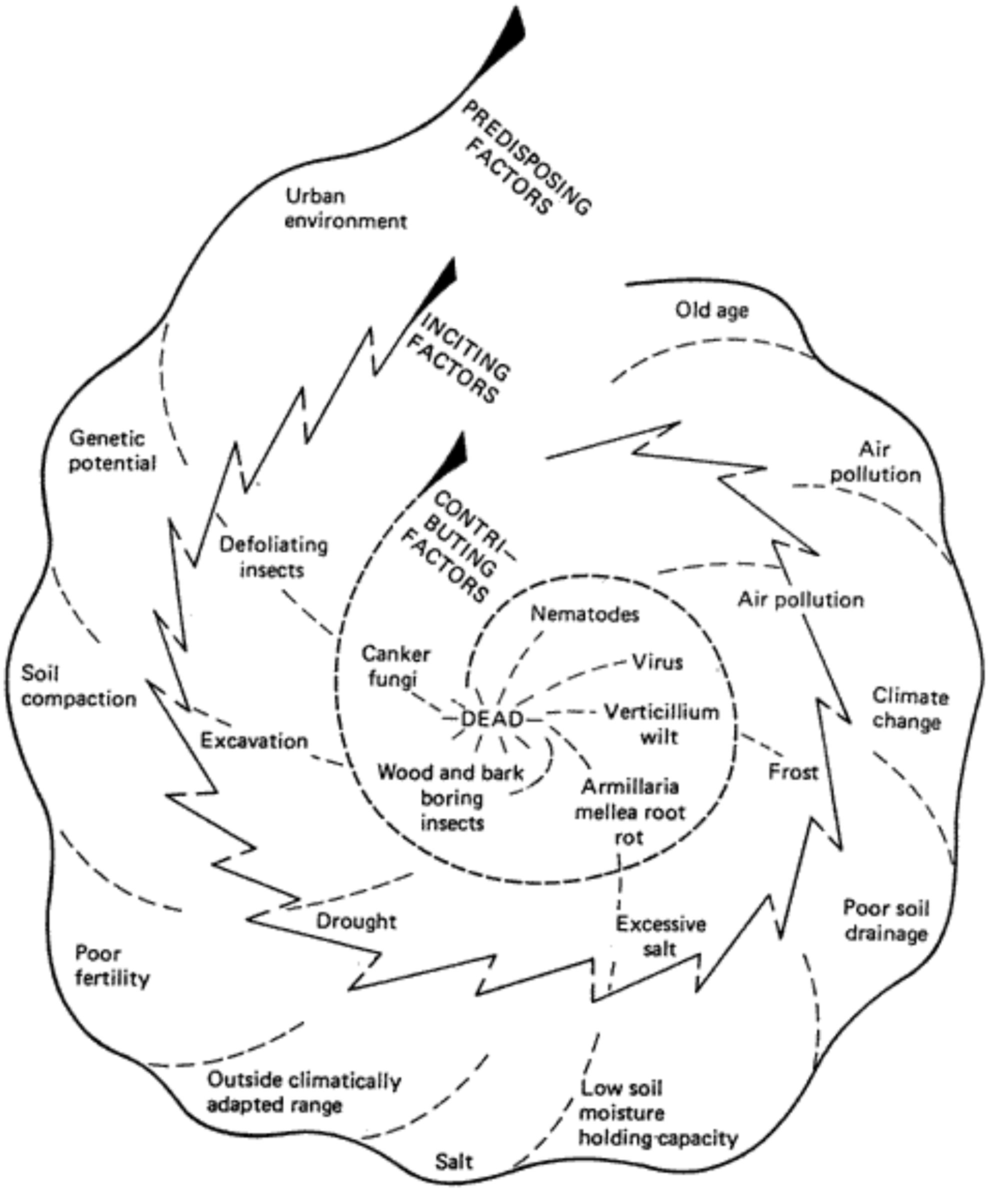

Snow storm, Black Hills SD
October 7, 2013


Duluth Flood – 2012
Jay Cooke State Park


Pagami Creek Fire – 2011
93,000 ac

Decline-Death Spiral

- Predisposing – long-term; background, abiotic components of environment (genetics, age, soil type)
- Inciting – short-term; biotic stressing agents (insects, disease), extreme weather events (drought, earlier spring)
- Contributing – coup de grâce; opportunistic fungi and insects



Manion 1981

What actions can be taken to

enhance the ability of a system to cope with change

and

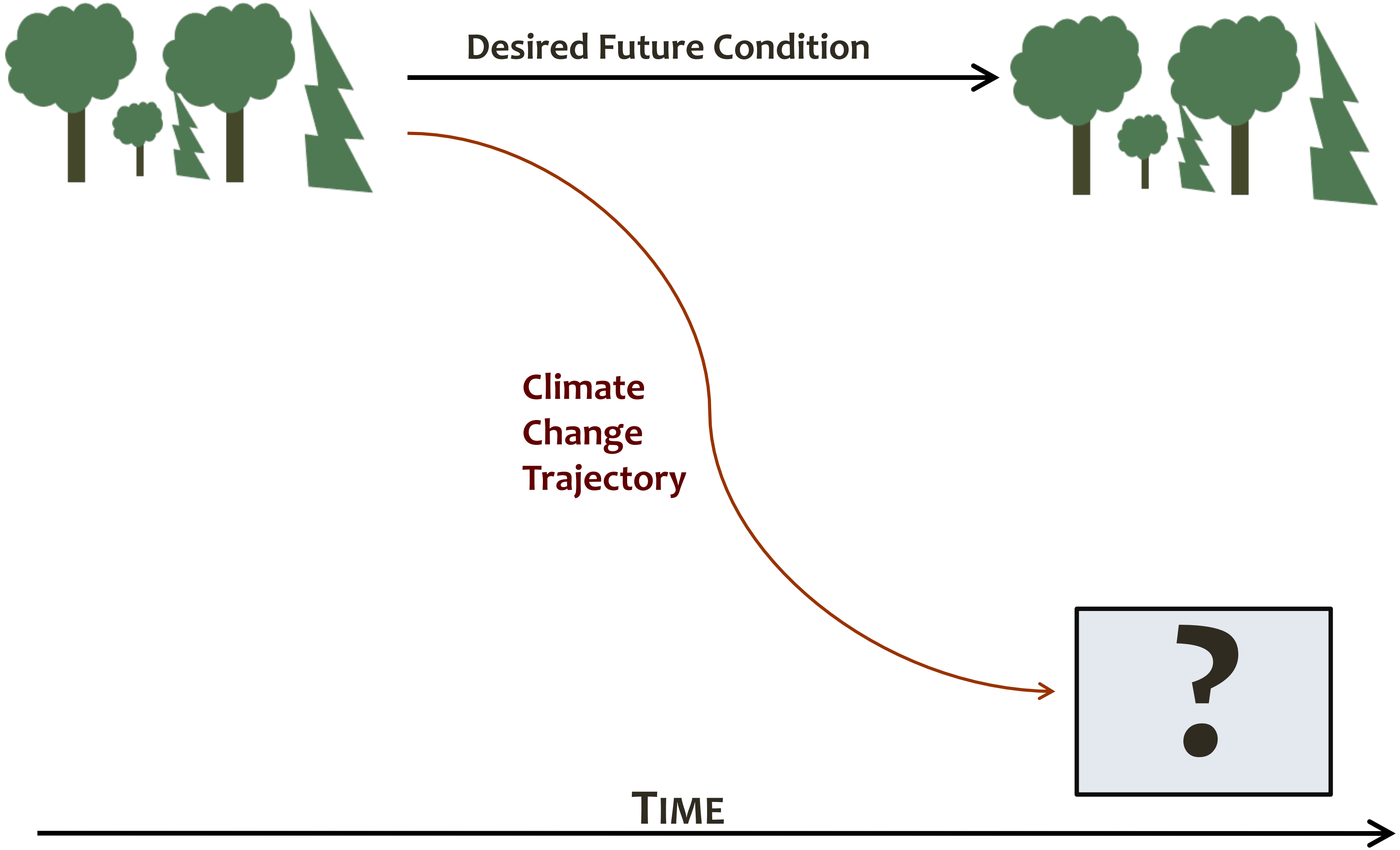
meet goals and objectives?

Climate-Driven Changes

Desired Future Condition

TIME

Climate-Driven Changes



Desired Conditions & Adaptive Management

- Desired future conditions (USDA Forest Service – 1982 Planning Rule)
- Desired conditions (USDA Forest Service – 2012 Planning Rule & 2015 Planning Directives)
  - Focus on “restoring” historical conditions; does not account for uncertainty
- Desired future dynamics (function) (Kohm and Franklin 1997)
- Achievable future conditions (Golladay et al 2016, Forest Ecology & Management)
  - Focus on a range of possible conditions that could develop in the future
- Undesirable conditions (Matonis et al 2016, Journal of Forestry)
  - Open-ended goals, promote ecosystem variability and risk management

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Contents lists available at ScienceDirect
Forest Ecology and Management
journal homepage: www.elsevier.com/locate/foreco
FOREST ECOLOGY AND MANAGEMENT

Review and synthesis

Achievable future conditions as a framework for guiding forest conservation and management

CrossMark

S.W. Golladay[a,*], K.L. Martin[b], J.M. Vose[b], D.N. Wear[b], A.P. Covich[c], R.J. Hobbs[d], K.D. Klepzig[e], G.E. Likens[f,g], R.J. Naiman[h], A.W. Shearer[i]

DISCUSSION

Benefits of an “Undesirable” Approach to Natural Resource Management

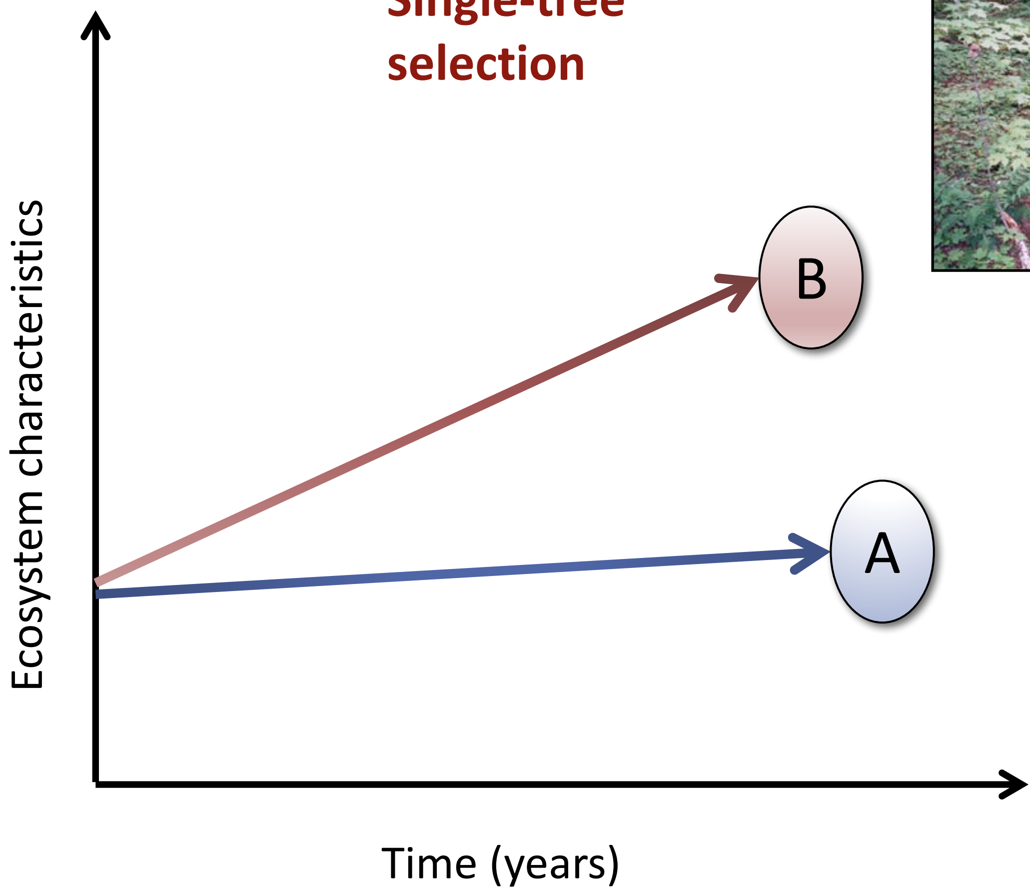
Megan S. Matonis, Daniel Binkley, Jerry Franklin, and K. Norman Johnson

Journal of Forestry 2016

Complexity Maintains Adaptive Capacity

Single-tree selection

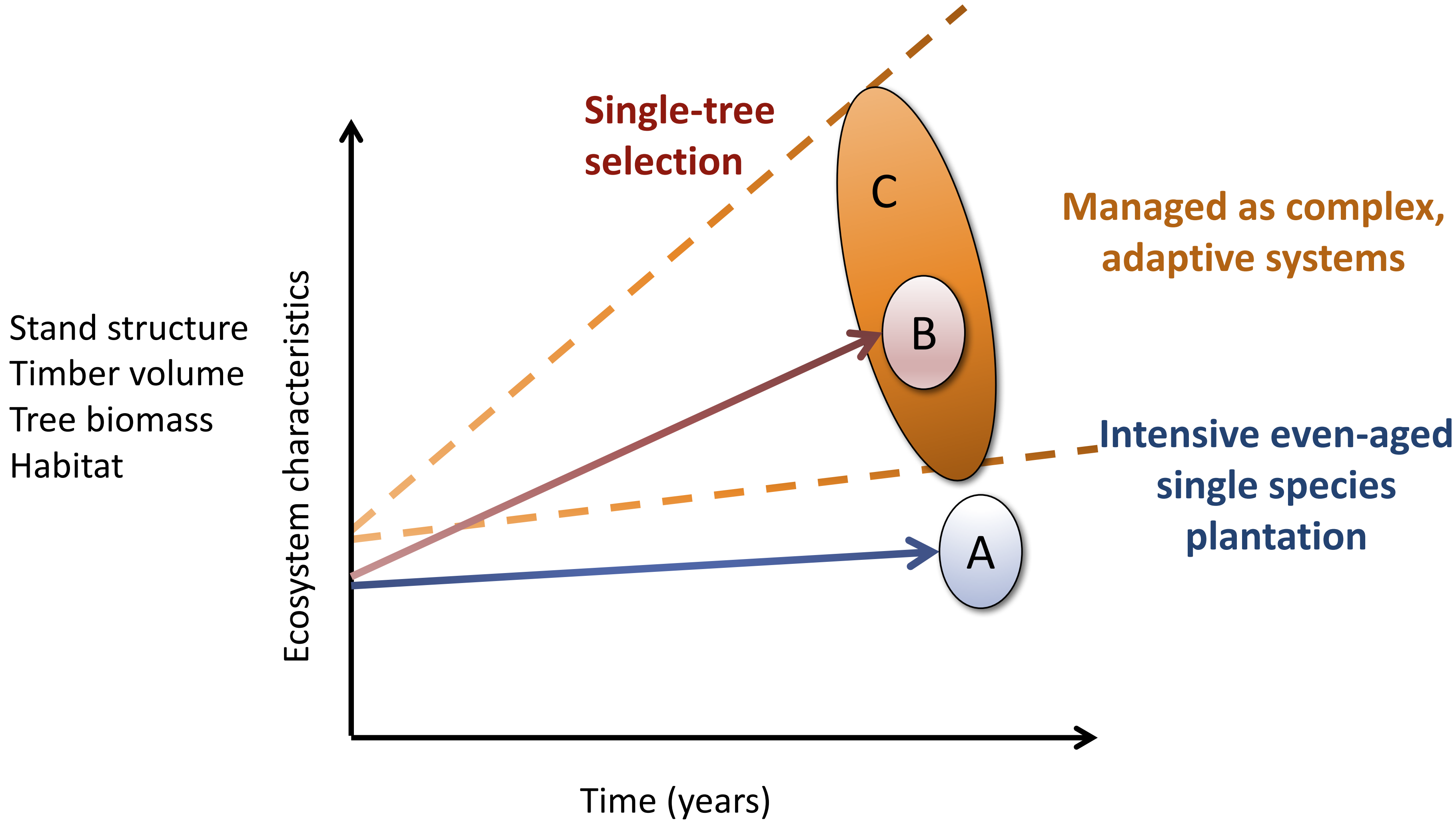
Stand structure
Timber volume
Tree biomass
Habitat



Intensive even-aged single species plantation

Following Puettmann et al 2009

Complexity Maintains Adaptive Capacity



Following Puettmann et al 2009

Managing for Complexity

Adaptation Strategies and Approaches

1. Sustain fundamental ecological functions
2. Reduce the impact of biological stressors
3. Re… isk and long-term impacts of severe dis…
4. Ma… create refugia
5. Ma… d enhance species and structural diversity
6. Increase ecosystem redundancy across the landscape
7. Promote landscape connectivity
8. Maintain and enhance genetic diversity
9. Facilitate community adjustments through species transitions
10. Realign ecosystems after disturbance

Maintain the most options moving forward

Swanston et al 2016: https://www.nrs.fs.fed.us/pubs/52760; NRS-GTR 87-2

Adaptation Options

Resistance

Resilience

Transition
(Response)

Manage for Persistence:
Ecosystems are still recognizable as being the same system (character)

Manage for Change:
Ecosystems have fundamentally changed to something different

Option #1 – Resistance (persistence)

Improve the defenses of the ecosystem against effects of change

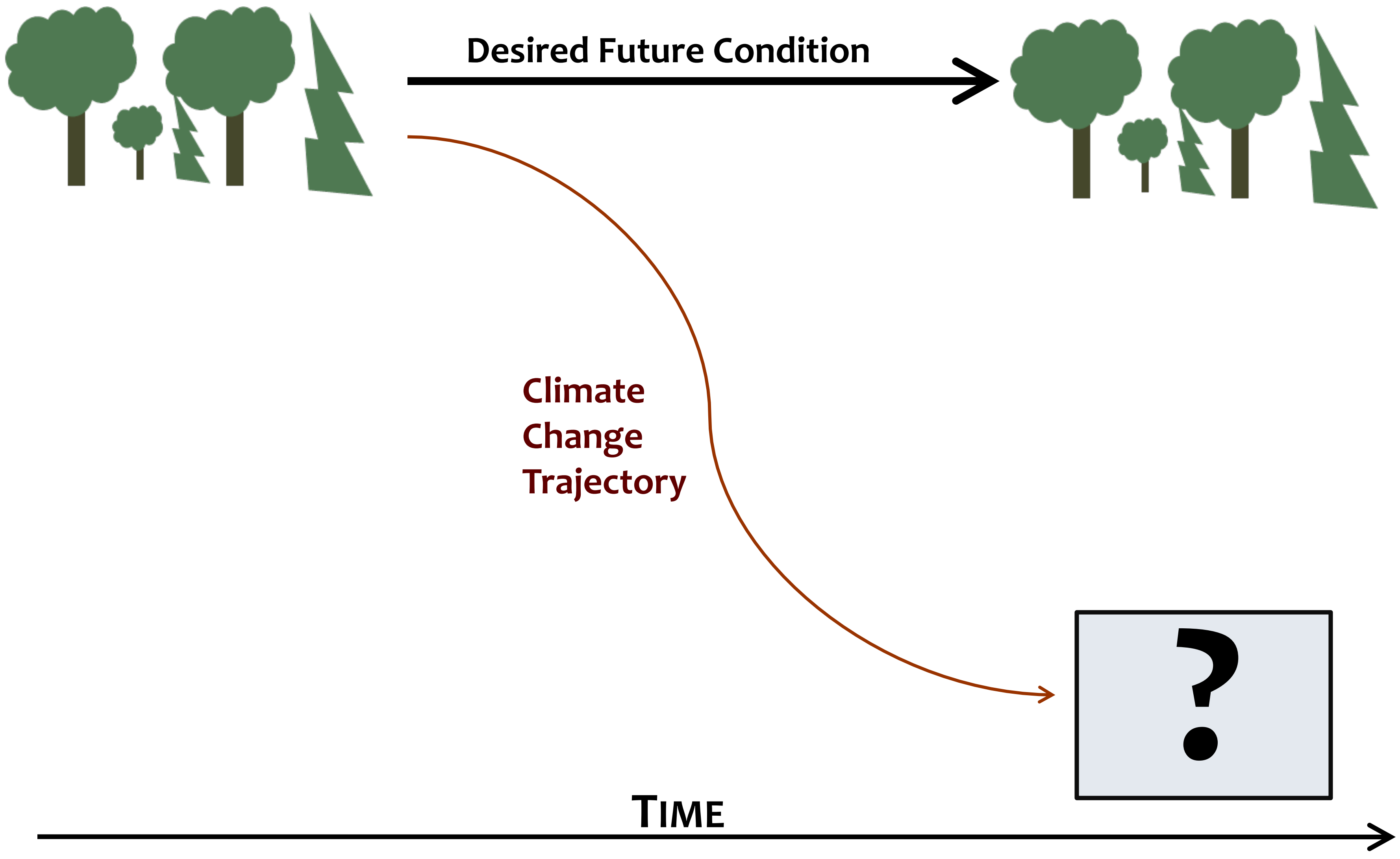
- Short-term
- High-value

Required, or otherwise worth the risk

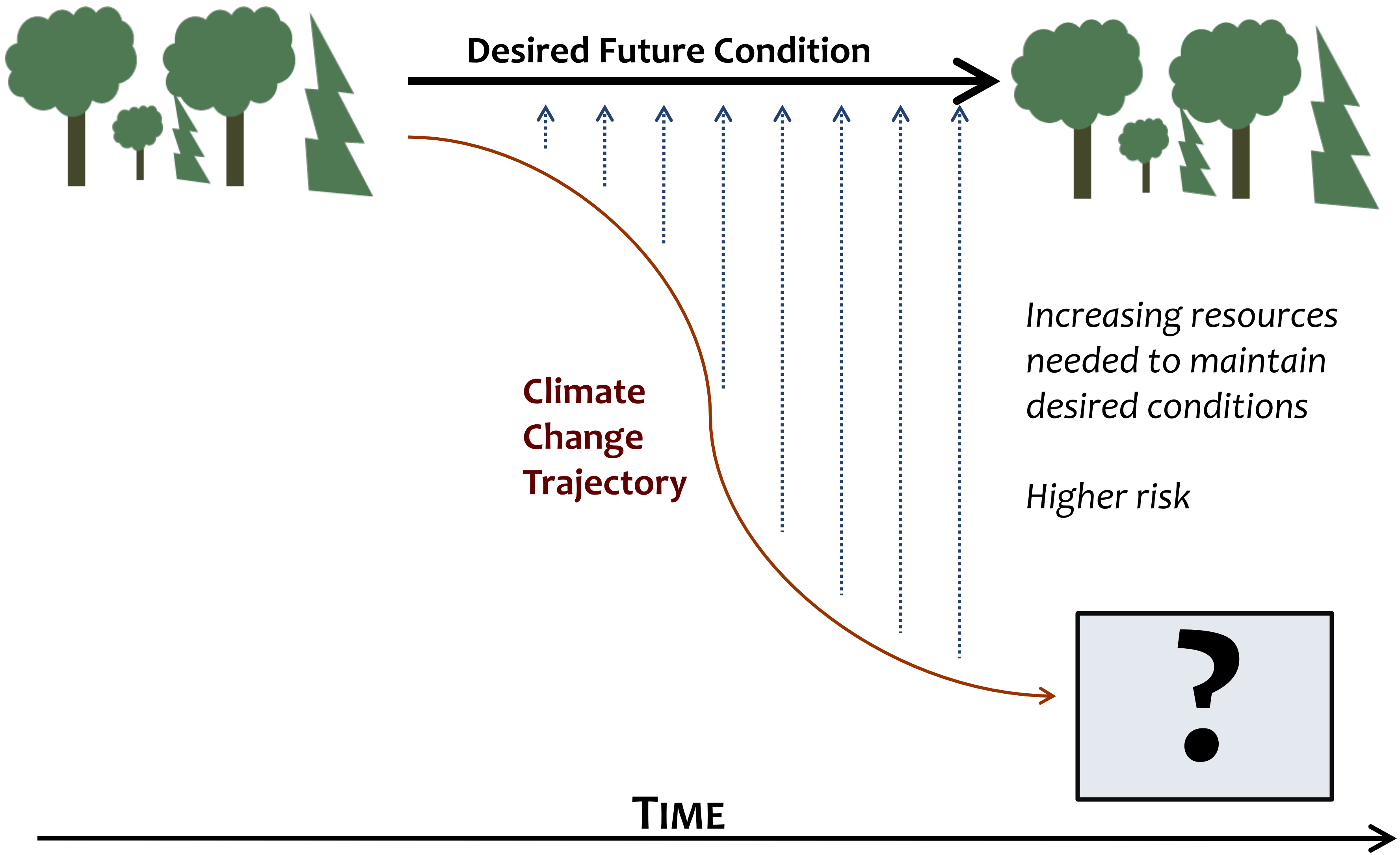
Photo: USFS

Millar et al. 2007, 2008; DeRose and Long 2014

Option #1 – Resistance (persistence)



Option #1 – Resistance (persistence)



Option #2 – Resilience (persistence)

Accommodate some degree of change or disruption, but be able to return to a similar condition after disturbance

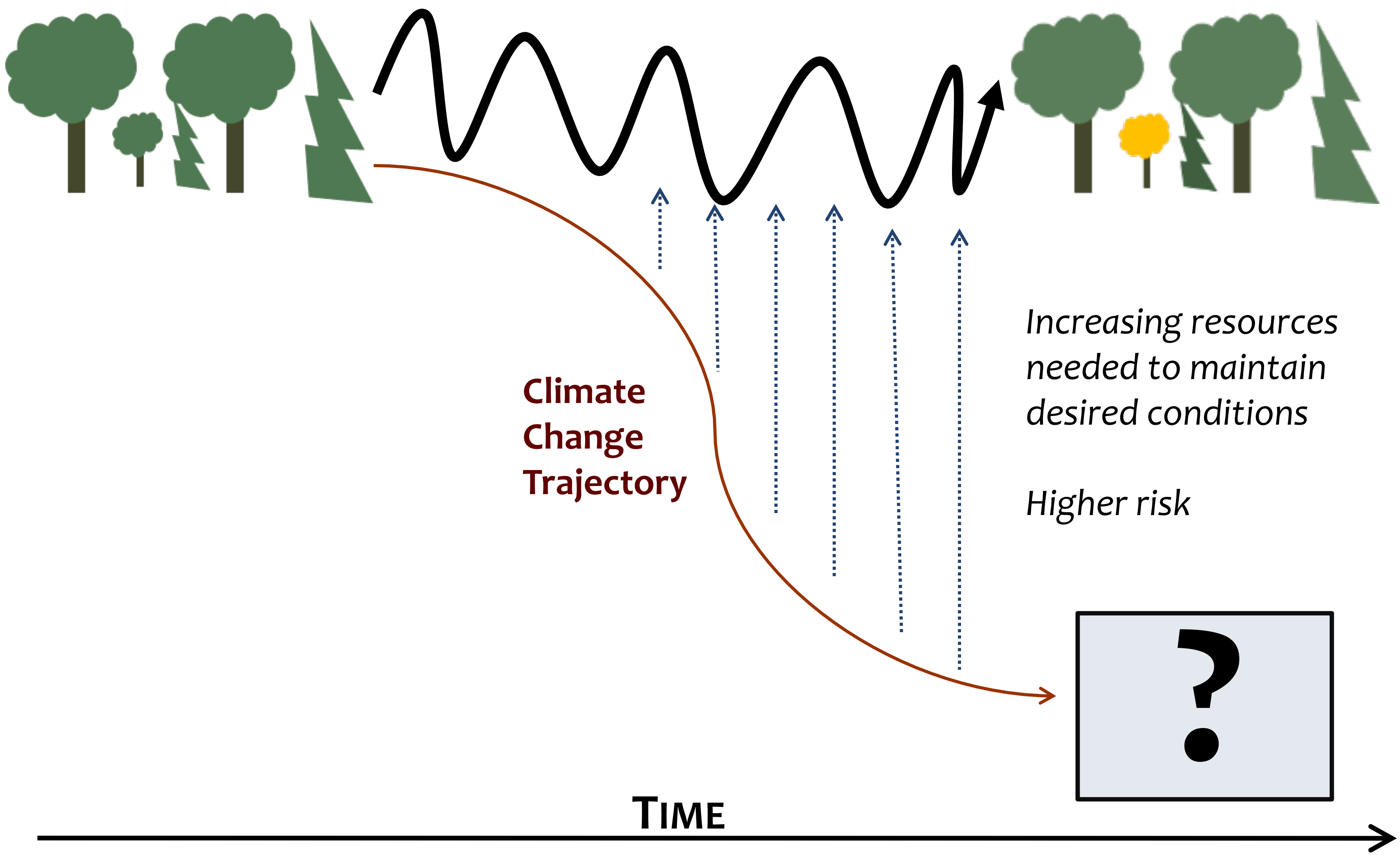
- Thinning stands to improve overall health & vigor
- Management of vegetation following disturbance

BAU, but risk may increase over time


Photo: USFS

Holling 1973, Millar et al. 2007

Option #2 – Resilience (persistence)



Option #3 – Transition (change)

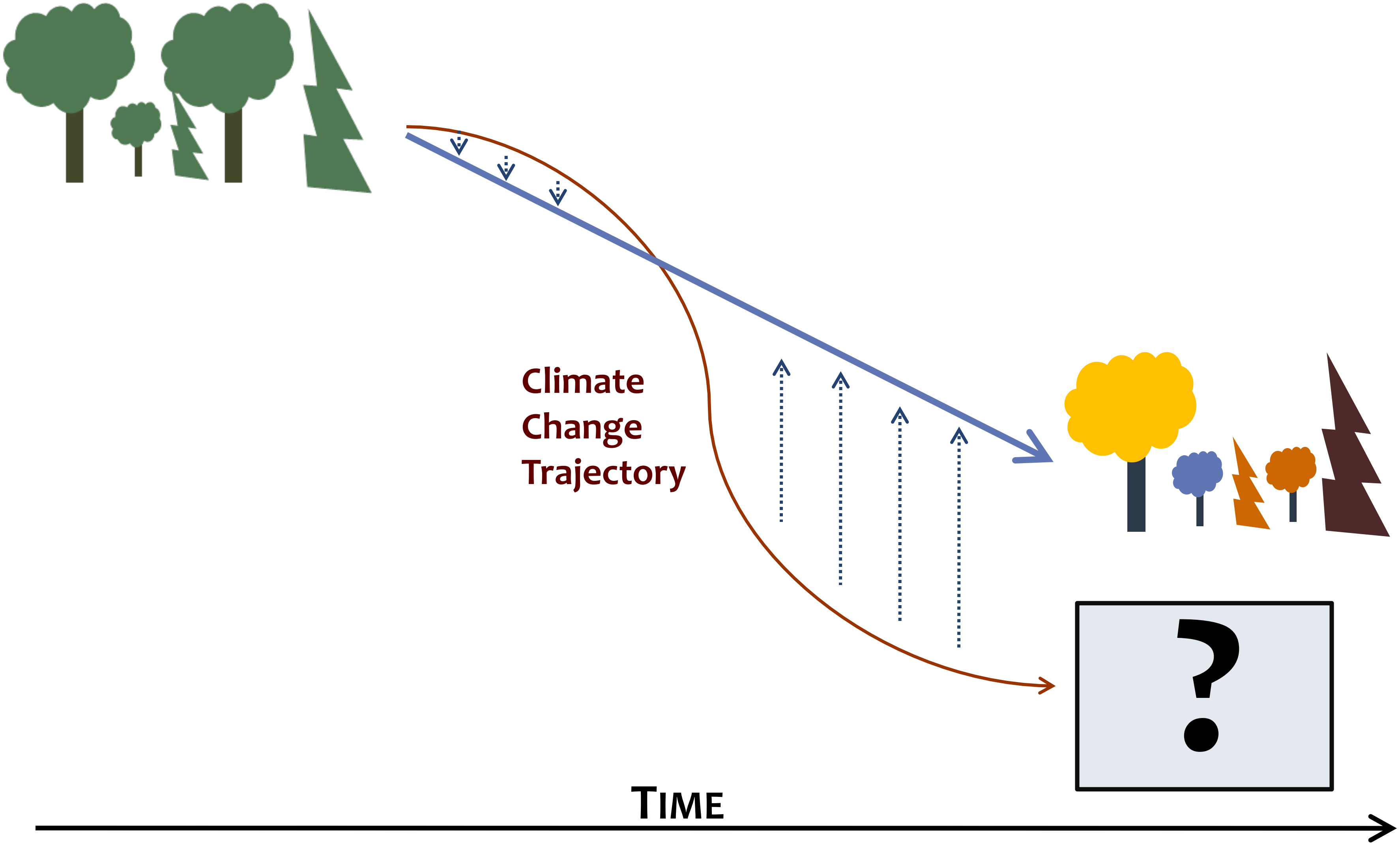
Intentionally encourage change, help ecosystems respond in a targeted fashion

- Foster well-adapted native species
- Managed relocation/assisted migration
- Increased connectivity for migration
- Maintain refugia

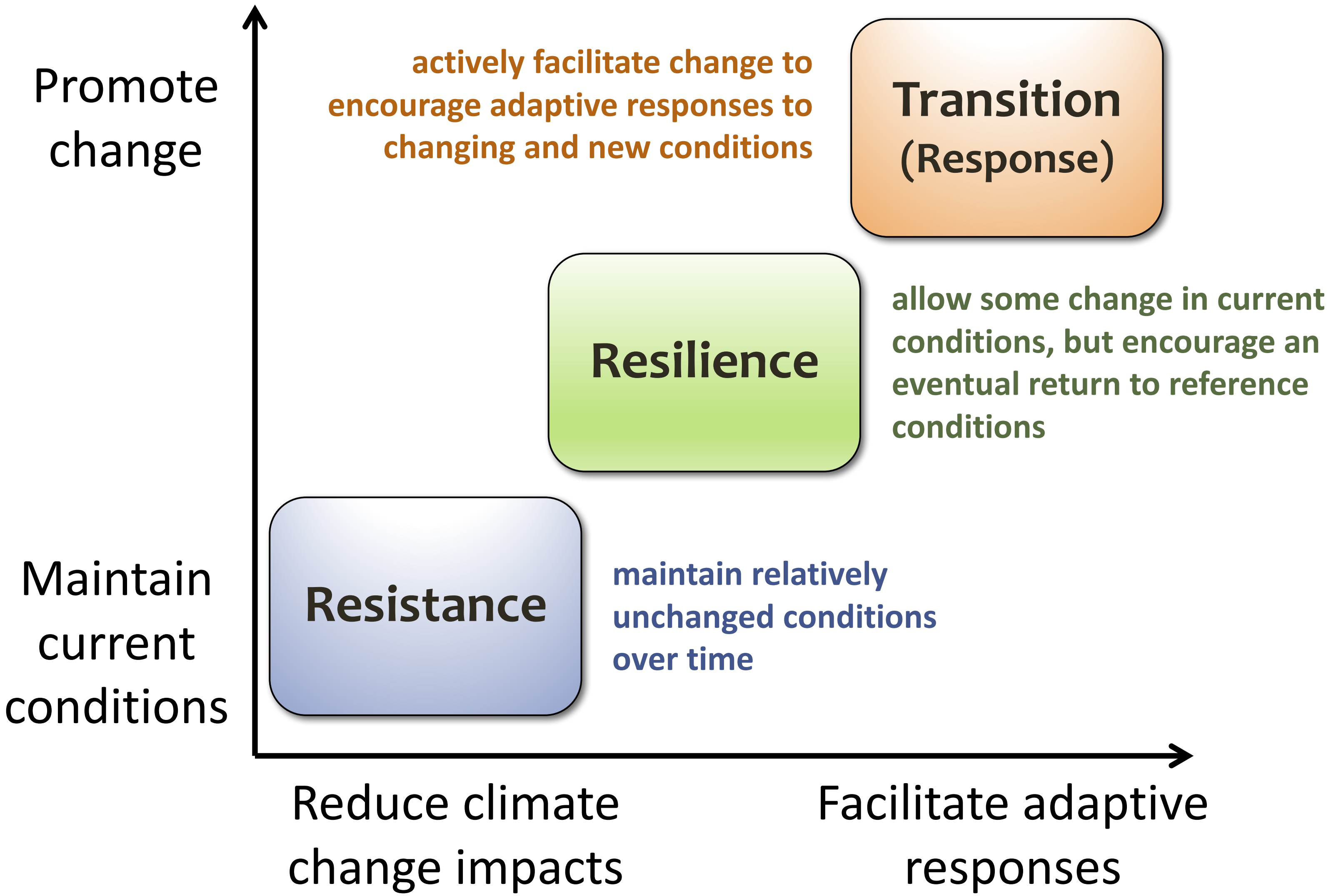
Mixed risk. Challenges values and precautionary principle.

Millar et al. 2007

Option #3 – Transition (change)



Spectrum of Adaptation Options



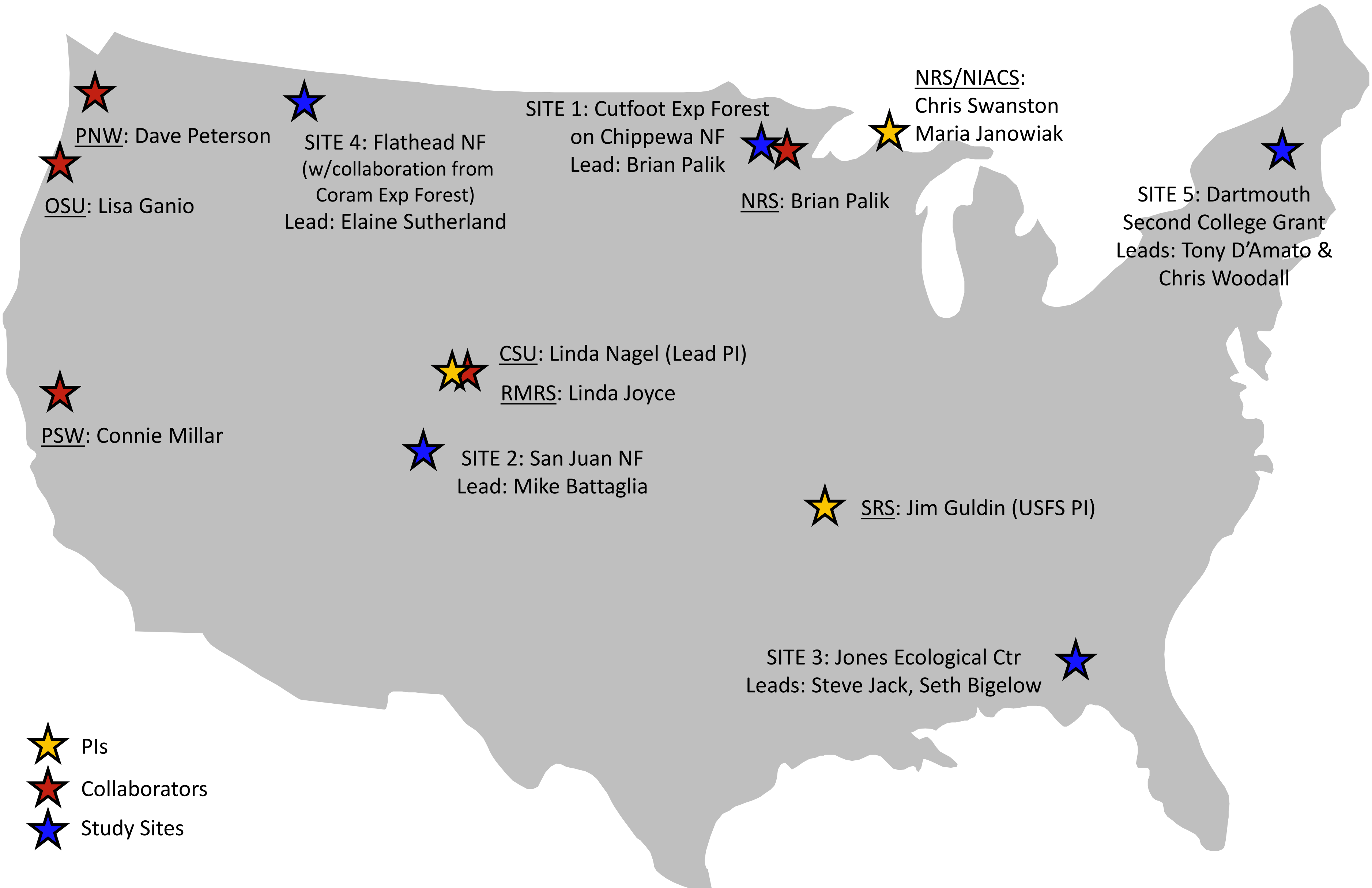
Adaptive Silviculture for Climate Change (ASCC)

<u>Overall project goals</u>: Forest managers need robust, operational examples of **how to integrate climate change adaptation into silvicultural planning and on-the-ground actions** that can…

- Foster resilience to the impacts of climate change and/or
- Enable adaptation to uncertain futures

Michigan Tech
University of Minnesota
Colorado State University
NIACS Northern Institute of Applied Climate Science
Forest Service U.S. Department of Agriculture
SRS Southern Research Station
Northern Research Station USDA Forest Service
Rocky Mountain Research Station

Adaptive Silviculture for Climate Change (ASCC)



Identifying Adaptation Tactics

Forest Adaptation Resources

1. DEFINE area of interest, management objectives, and time frames.

Vulnerability assessments, scientific literature, and other resources

2. ASSESS climate change impacts and vulnerabilities for the area of interest.

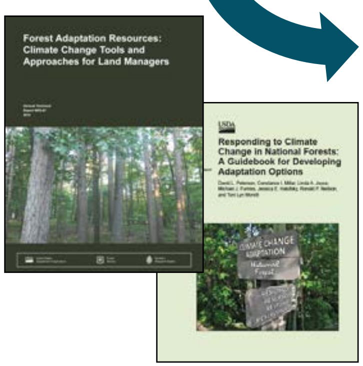
Are desired future conditions reasonable given likely climate trajectories and impacts?

3. EVALUATE management objectives given projected impacts and vulnerabilities.

Adaptation Strategies and Approaches

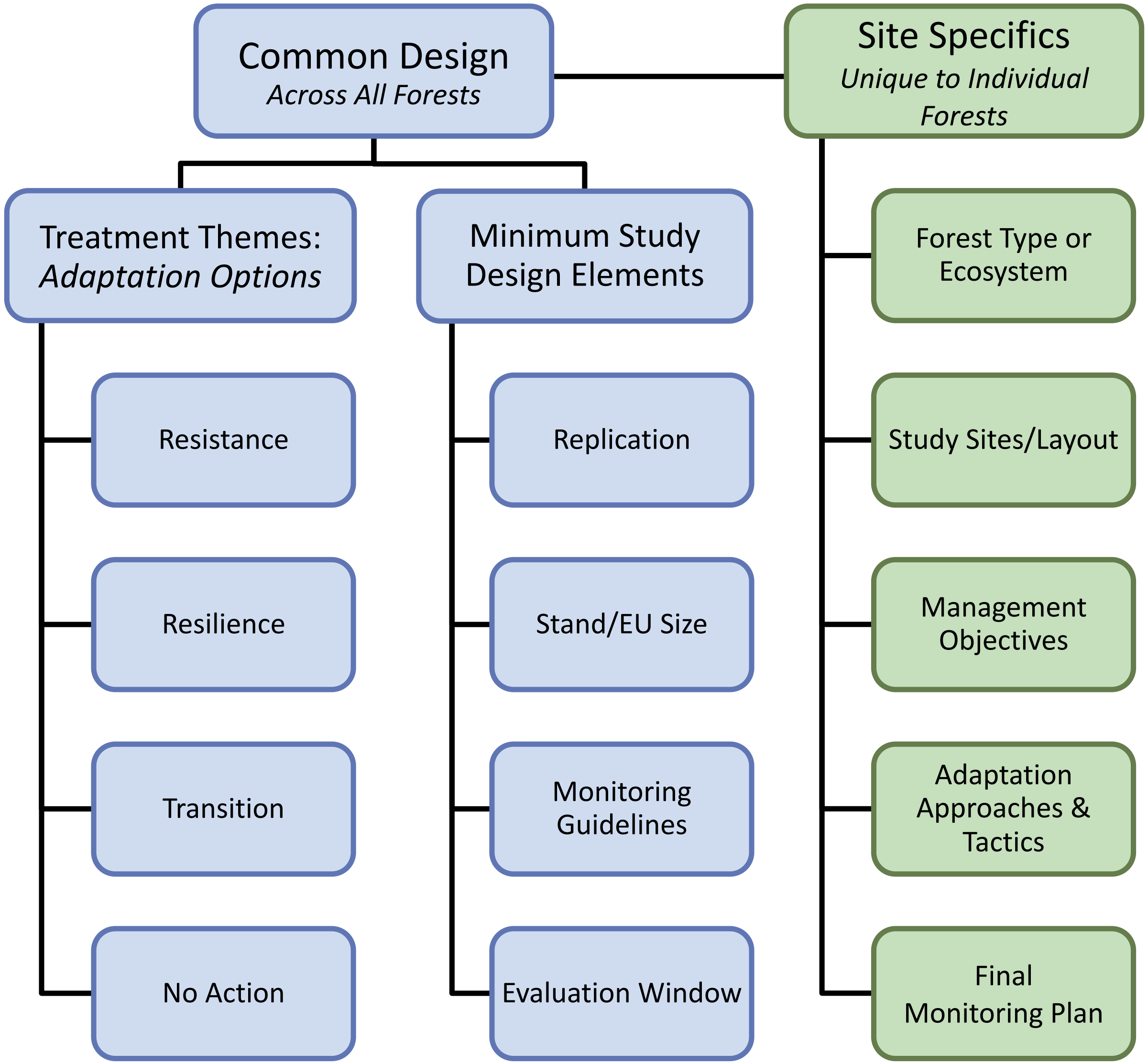
4. IDENTIFY and implement adaptation approaches and tactics.

5. MONITOR and evaluate effectiveness of implemented actions.



Swanston and Janowiak 2012: www.treesearch.fs.fed.us/pubs/40543, Janowiak et al. 2014

ASCC Study Design



Core Management Questions *conceptual*

1) Will adaptation approaches and treatments work in a real-world context to meet local management goals and objectives?
2) Are the treatments silviculturally feasible (and fiscally, socially, etc.) and will they work within the requirements of a given forest plan?
3) How does our idea of desired future conditions (DFCs) change with each treatment type, and is this important silviculturally?
4) What does it mean to deliberately create a future-adapted ecosystem, and why would a manager choose to do this?
5) What tradeoffs exist between achievement of adaptation objectives and other common objectives for a given region and ecosystem type?

Nagel et al. 2017

Core Scientific Questions *hypothesis-driven*

1) Is there a significant effect of the treatments on forest conditions and processes over time, and do they differ significantly from each other at each site?
2) How do hypothesized treatment responses (DFCs) compare with actual responses observed in the future?
3) Do these treatments achieve what they were designed for, i.e. do they meet the stated management goals at 5 or 10 years, and will criteria emerge to enable managers to identify which treatments perform best?
4) Are there trends in which treatment (resistance, resilience, transition, or no action) performs better than other treatments at meeting DFCs and adaptation goals across all ASCC sites?

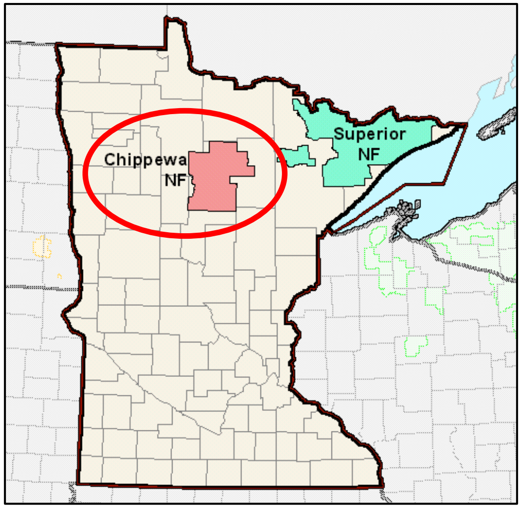
Nagel et al. 2017

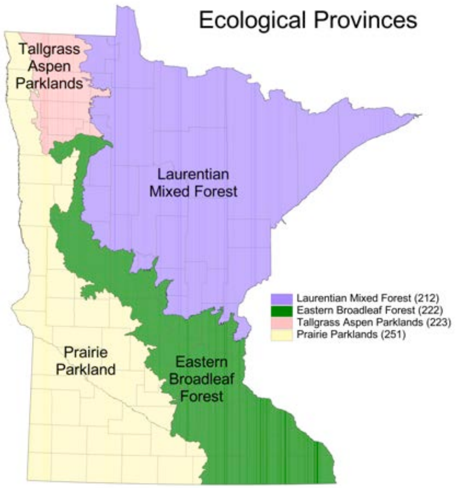
Key monitoring variables – ASCC

	Species Composition	Forest Health	Productivity
Overstory	Species richness Species diversity Relative density Relative dominance	Mortality Crown density Crown dieback Live crown ratio Tree damage (DSI)	Biomass increment Basal area increment
Midstory	Species richness Species diversity Relative density Relative biomass	Relative density or biomass of invasive species	Biomass increment
Ground Layer	Species richness Species diversity Percent cover by species	Percent cover of invasive species	Biomass increment

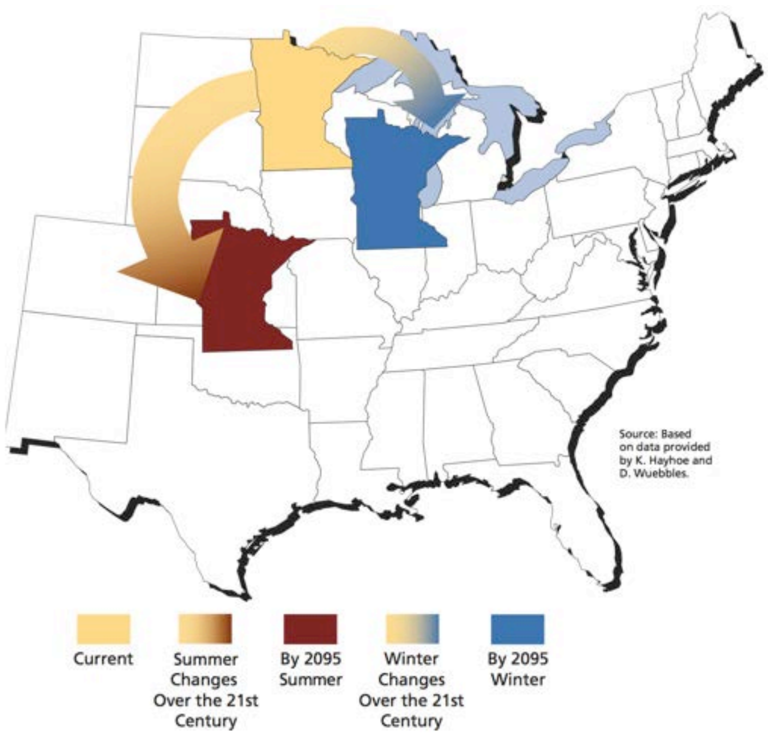
ASCC study sites

- Chippewa National Forest Cutfoot EF
  - Workshop: June 25-27, 2013





www.dnr.state.mn.us/ecs

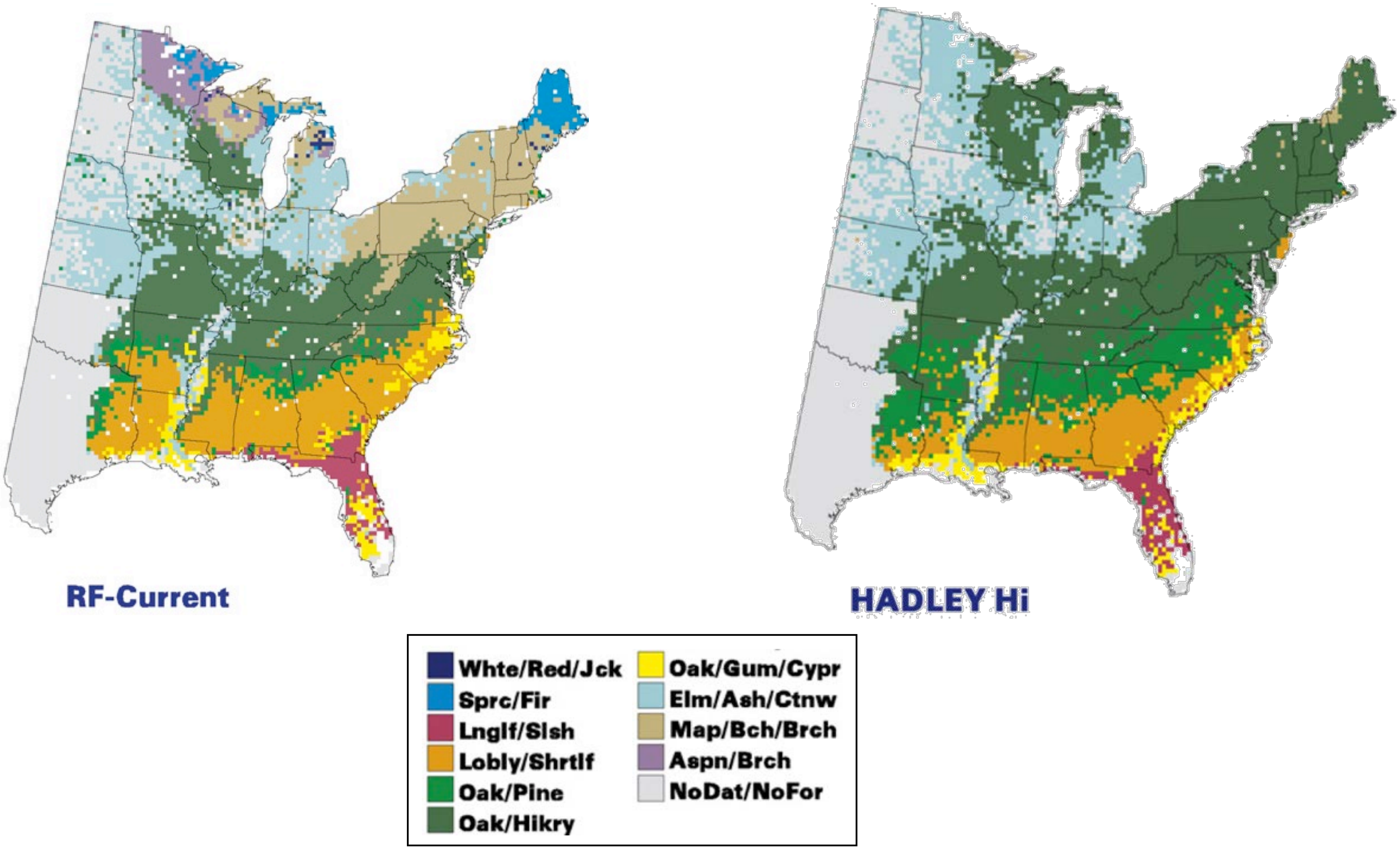


http://www.ucsusa.org/greatlakes/glchallengereport.html

Species Range Shifts

Tree Atlas

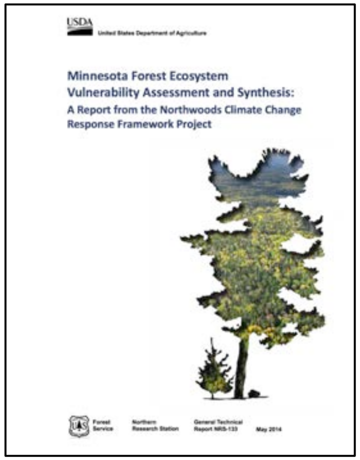
Climate-induced changes in biophysical conditions will likely lead to shifts in species range distributions



Iverson et al 2008

Day One Workshop

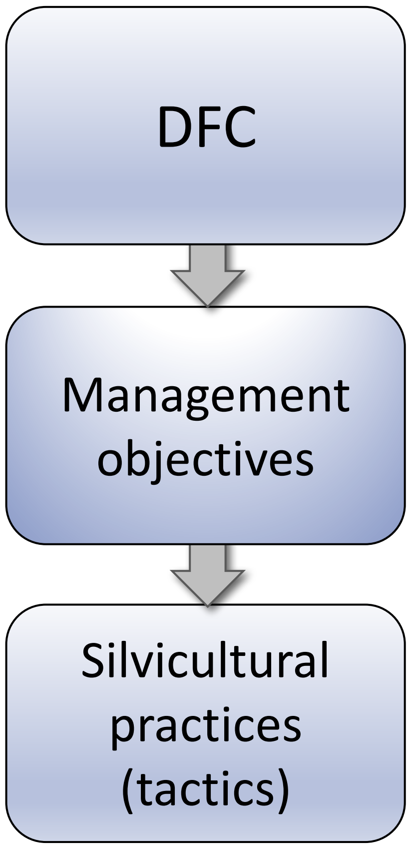
1. Climate science overview
2. Climate change trends, impacts, and vulnerabilities for the region
3. Considerations for silvicultural decisions (exercise)
4. Climate change adaptation and silvicultural decision making
5. Developing adaptation approaches and tactics



Chippewa National Forest

Day Two: Developing the Experimental Treatments

- For each experimental treatment (Resistance, Resilience, Transition):



What do you want the stand to be and look like?

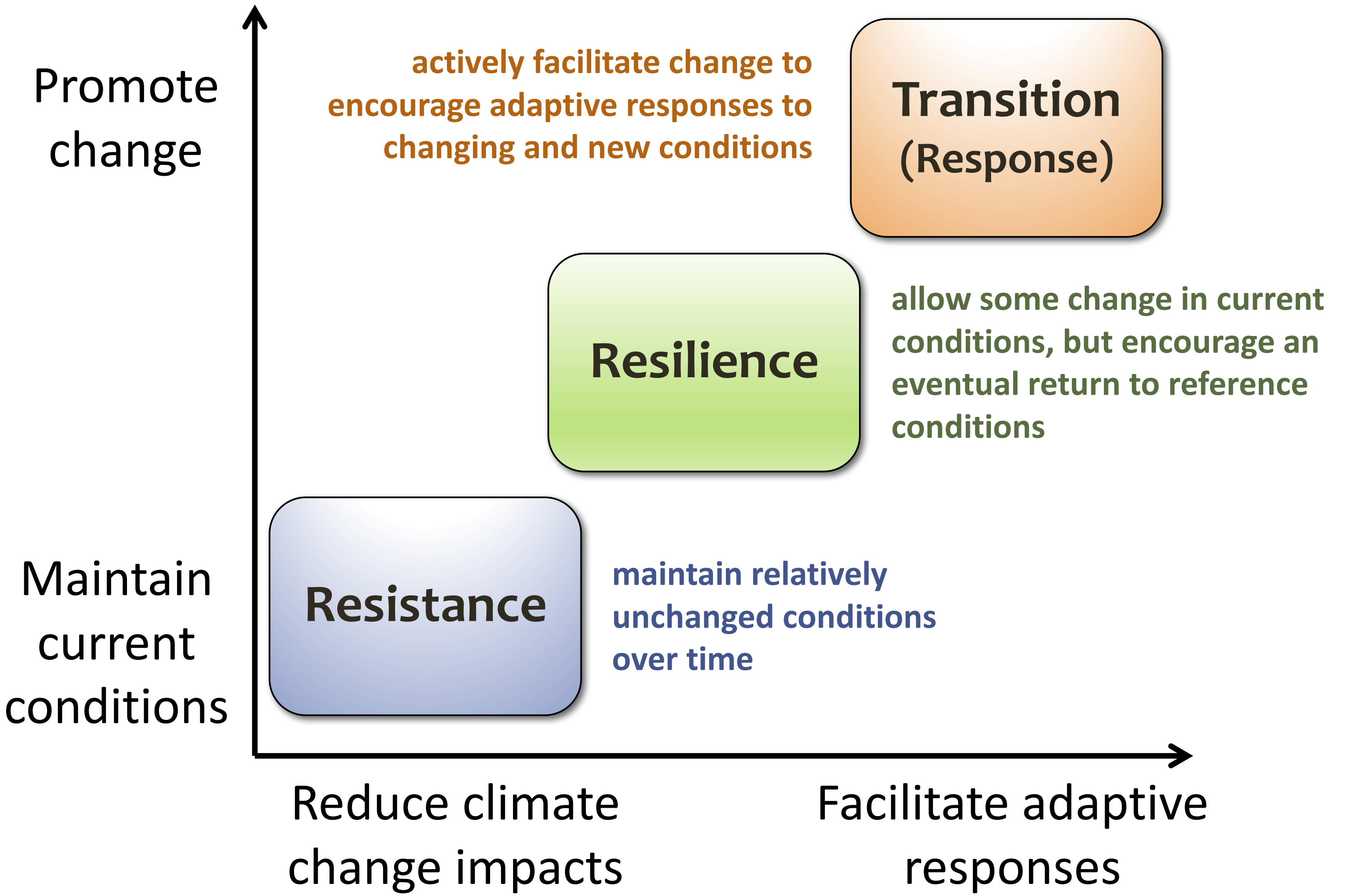
Keep in mind key variables/outcomes:

- **Species composition**
- **Forest health**
- **Forest productivity**
- **Response to disturbance**

For each silvicultural practice (tactic):

- **Timeframes**
- **Benefits**
- **Drawbacks and Barriers**
- **Practicality**
- **Recommend tactic?**

Spectrum of Adaptation Options

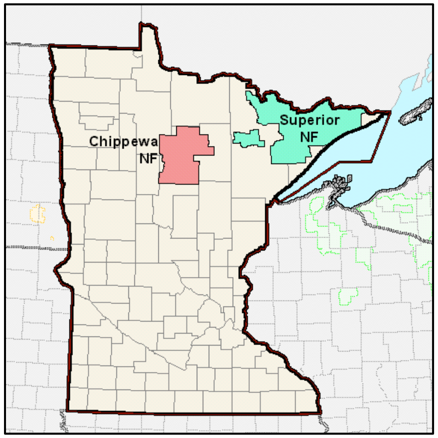


Current Conditions, Cutfoot EF

- FDn33: Northern Dry-Mesic Mixed Woodland
- Average basal area 180 ft^2/ac
- Fire-origin 1918; fire exclusion since
- Largely single cohort
- Overstory: Strongly red pine, mixed with white and jack pine
- Minor species: paper birch, northern red oak, red maple, white spruce, and aspen
- Dense understory of *Corylus* (hazel)
- Current condition: vulnerable to climate change and forest health issues

Species predictions

Chippewa NF – Tree Atlas (change in IV)



Reduced Habitat Suitability

Species	Current	HadHiDif
Quaking aspen	21.80	-17.41
Balsam fir	7.24	-7.24
Black spruce	5.34	-5.27
Paper birch	6.65	-5.22
Jack pine	**3.36**	**-1.46**
Bigtooth aspen	1.44	-0.93
White spruce	1.19	-0.73
Red pine*	2.35	-0.70
Northern red oak	**2.44**	**-0.26**

**Potential for increasing issues with native pine beetles and root diseases affecting red pine*

Increased Habitat Suitability

Species	Current	HadHiDif
Bur oak	**2.95**	**2.67**
Green ash	2.06	2.31
Red maple	**2.57**	**1.91**
Eastern white pine	**1.03**	**0.22**
White oak	**0.00**	**2.30**
Black cherry*	**0.30**	**1.60**
Bitternut hickory*	**0.00**	**0.75**

**Choices tempered by "Suitability of Tree Species by Native Plant Community (NPC)", MN DNR*

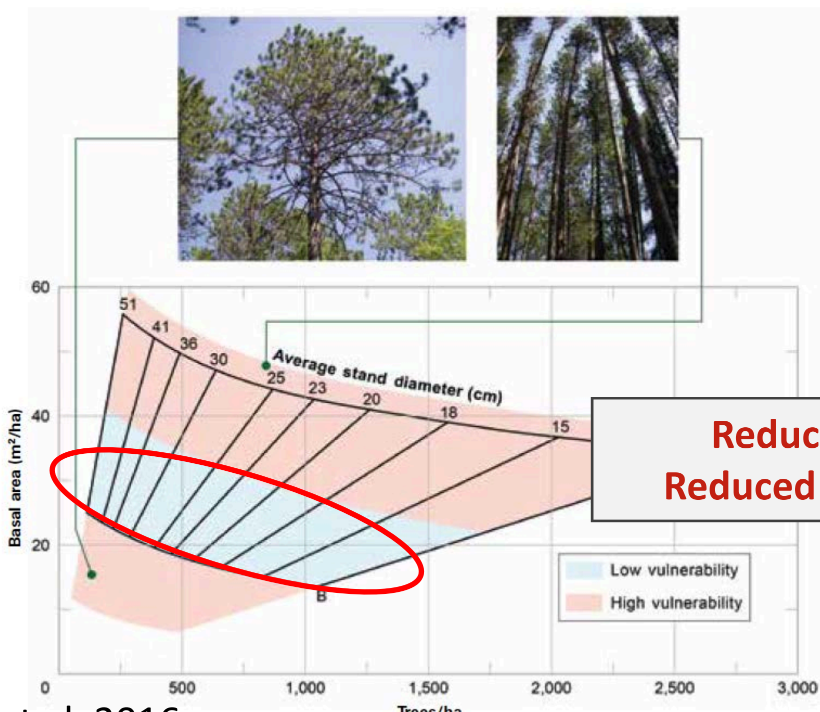
RESISTANCE maintain relatively unchanged conditions

DFC/Goal

- Homogeneous, RP dominated (90% BA)
- Single cohort
- Reduced stocking closer to historic

Tactics

- Free thin to 100-120 ft^2/ac
- Remove RP and JP to maintain diversity
- Reserve large-diameter trees



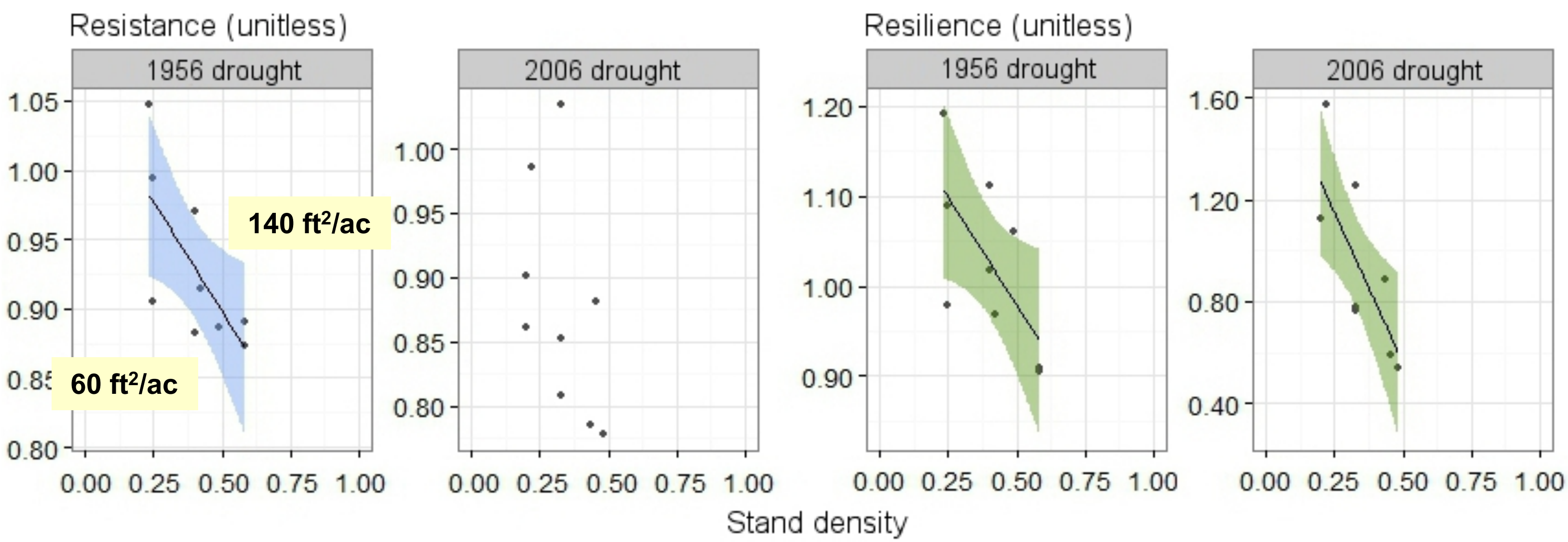
Reduced Stocking =
Reduced Moisture Stress

Vose et al. 2016

Red Pine Growing Stock Study

Growth, Drought, and Stocking Level

Evidence that these forests can be managed to mitigate drought stress and growth reduction



<u>Resistance</u>: BAI during drought = BAI before drought

<u>Resilience</u>: BAI after drought = BAI before drought

Resistance Treatment: lifeboat existing *red pine* into the future (climate) with density management

Bottero et al. 2017

RESILIENCE allow some change, eventual return to reference

DFC/Goal

- RP dominated (50-75% BA)
- Increase heterogeneity and complexity
- Increase future-adapted *native* species

Tactics

- Variable density thinning (skips & gaps)
  - 20% unthinned in ½ ac skips
  - 20% in ½ ac gaps, retain large diameter
  - Disperse thin matrix to 100-120 ft^2/ac
- Plant future-adapted ***native*** species in gaps

Species	Current	HadHiDif
Bur oak	2.95	2.67
Red maple	2.57	1.91
Eastern white pine	1.03	0.22

Eastern white pine is tolerant of a range of canopy conditions and shrub competition, is native, versatile, and future adapted

Resilience Treatment: change, but within the natural range of variability, which includes increasing eastern white pine

TRANSITION facilitate change, encourage adaptive response

DFC/Goal

- Reduce pine to 20-50%, multi-cohort
- Increase future-adapted species
- High species diversity and complexity

Tactics

- Irregular shelterwood with expanding gaps
  - 20% in ½ ac gaps, retain large diameter
  - Thin matrix to 60-80 ft^2/ac
- Plant future-adapted species in gaps *and* matrix (***native*** and ***novel*** species)

Species	Current	HadHiDif
Bur oak	2.95	2.67
Red maple	2.57	1.91
Eastern white pine	1.03	0.22
White oak	0.00	2.30
Black cherry	0.30	1.60
Bitternut hickory	0.00	0.75

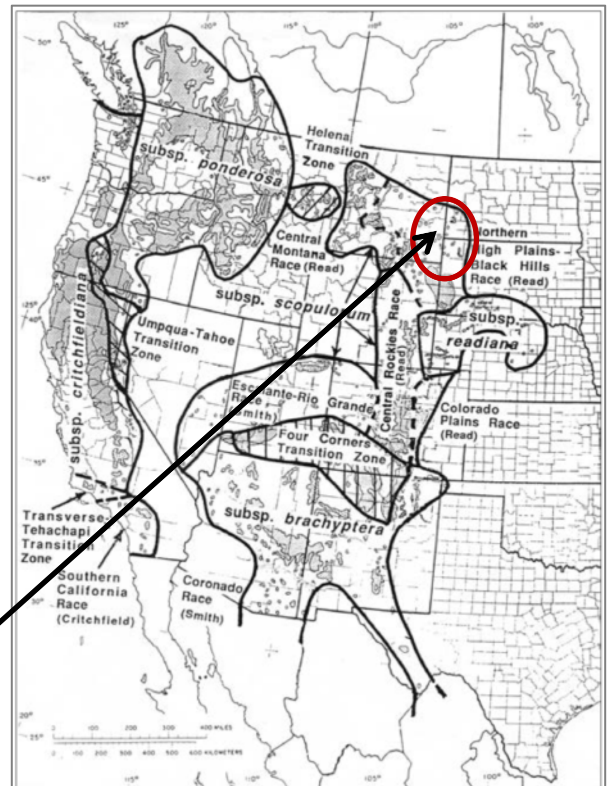
Increased habitat suitability (native species) — Bur oak, Red maple, Eastern white pine

New habitat suitability (novel species) — White oak, Black cherry, Bitternut hickory

And this species…

Pinus ponderosa

- Large statured, two-needled pine
- Drought tolerant
- Fire-adapted
- Planted as a landscape/windbreak species in Minnesota

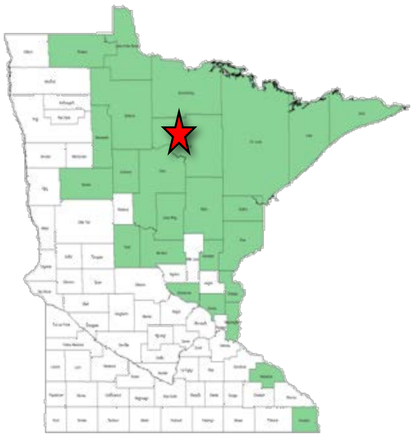


Seed sources from comparable elevation in eastern part of range

Spectrum of Adaptive Forest Management Treatments

Promote Change

Maintain current conditions



Transition

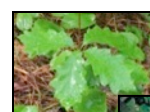
Management Goal: intentionally accommodate change and enable ecosystems to adaptively respond to changing conditions
Strategy: reduce red pine, increase future-adapted species

Future-adapted species:
eastern white pine
red oak
bur oak
white oak
red maple
bitternut hickory
black cherry
ponderosa pine

Resilience

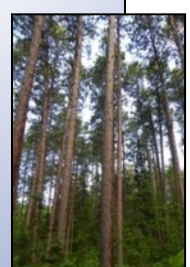
Management Goal: allow some change in current conditions, but encourage a return to reference conditions
Strategy: red pine dominance, increase future-adapted species over time

Future-adapted species:
eastern white pine
jack pine
red oak
bur oak
red maple



Resistance

Management Goal: maintain relatively unchanged conditions over time
Strategy: promote red pine dominance



Reduce climate change impacts

Facilitate adaptive responses

Spectrum of Adaptive Forest Management Treatments

Promote Change

Maintain current conditions

Transition

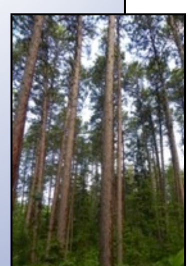
<u>Management Goal</u>: intentionally accommodate change and enable ecosystems to adaptively respond to changing conditions
<u>Strategy</u>: reduce red pine, increase future-adapted species

Resilience

<u>Management Goal</u>: allow some change in current conditions, but encourage a return to reference conditions
<u>Strategy</u>: red pine dominance, increase future-adapted species over time

Resistance

<u>Management Goal</u>: maintain relatively unchanged conditions over time
<u>Strategy</u>: promote red pine dominance



<u>Future-adapted species</u>:
eastern white pine
jack pine
red oak
bur oak
red maple

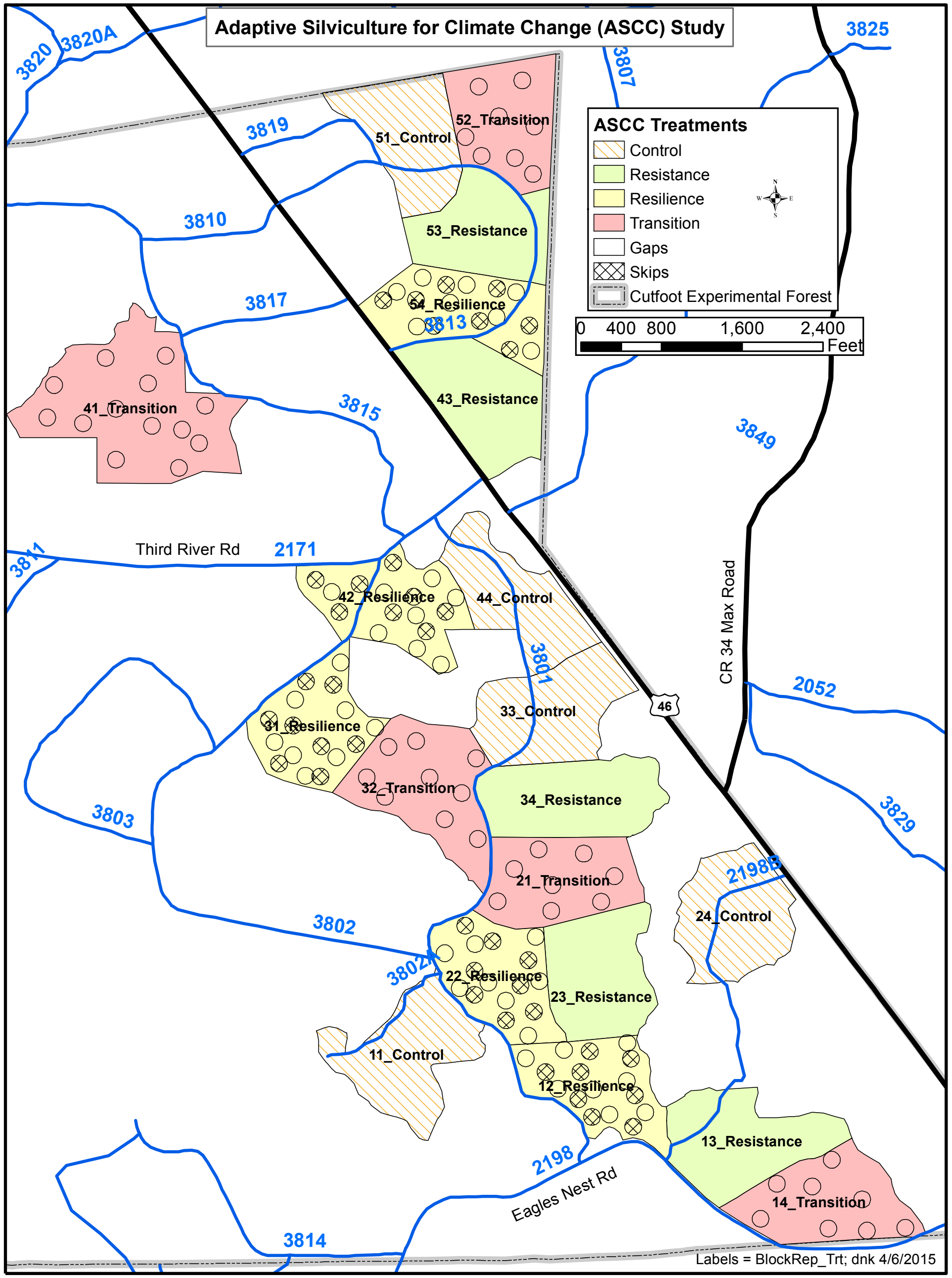
<u>Future-adapted species</u>:
eastern white pine
red oak
bur oak
white oak
red maple
bitternut hickory
black cherry
ponderosa pine

Reduce climate change impacts

Facilitate adaptive responses

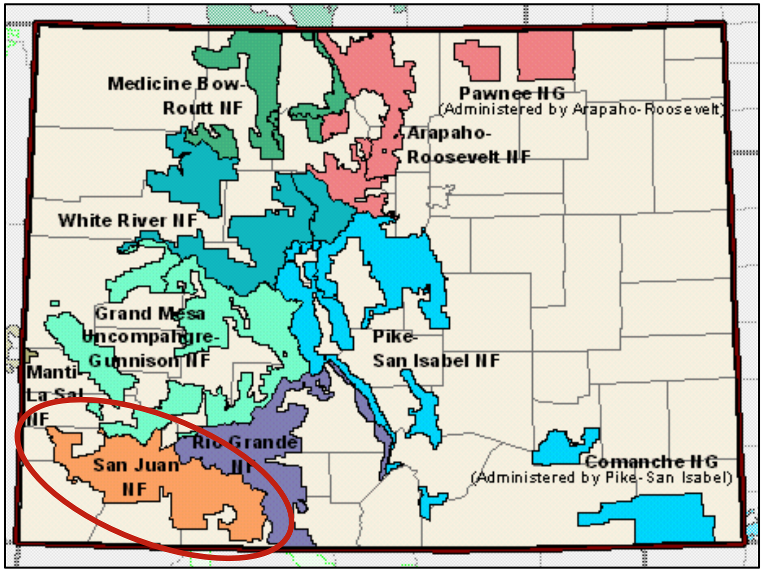
Cutfoot Experimental Forest

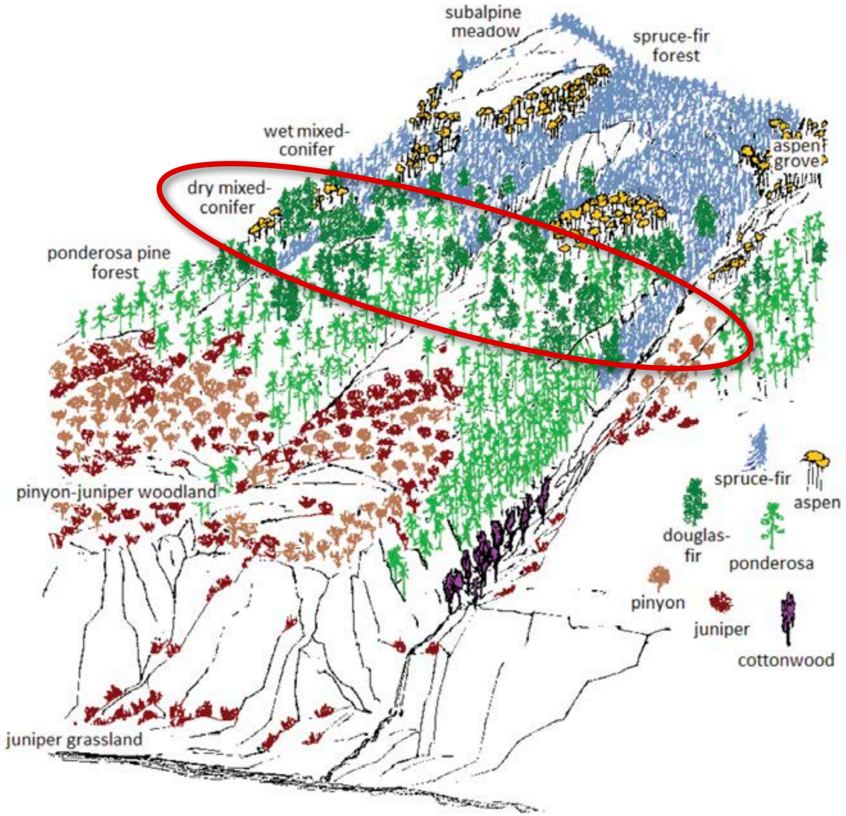
- 5 Replicates (500 ac)
- Control/Resistance
  - 7 plots
- Resilience
  - 3 in gaps
  - 3 in skips
  - 5 in matrix
- Transition
  - 3 in gaps
  - 6 in matrix
- Total Plots = 170



ASCC study sites:

- San Juan National Forest
  - Workshop: March 4-6, 2014





Desired Future Condition, *generally*

More open, park-like; PP dominant; more clumpy with openings in between; more multi-cohort; more younger age classes of PP; healthier aspen; more variability in fuel loading and age classes at landscape scale

Current condition

- Warm-dry mixed conifer
- Average basal area 134 ft^2/ac; range 94-200 ft^2/ac
- Year of origin ≈ 1905-1925
- Dominated by: ponderosa pine, white fir, Douglas-fir
- Scattered aspen
- Understory of Gambel oak (concern)
- Current condition:
  - High density, species composition
  - High fuel loading
  - Fir engraver, aspen decline, other

→ **Significant departure from historic conditions**

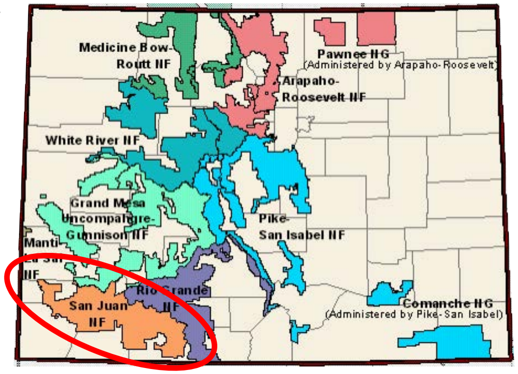
Photo credit: S. Hartvigsen

Desired Future Condition, *generally*

More open, park-like; PP dominant; more clumpy with openings in between; more multi-cohort; more younger age classes of PP; healthier aspen; more variability in fuel loading and age classes at landscape scale

Current condition → ***silviculture*** → Desired condition

Photo credit: S. Hartvigsen



Promote Change

Maintain current conditions

Transition

Management Goal: intentionally accommodate change and enable ecosystems to adaptively respond to changing conditions
Strategy: Environment dominated by **openings**, retain PP and DF in **clumps**, Aspen in swales and N slopes, remove all WF

Species:
ponderosa pine ↑
Douglas-fir ↑
white fir ↓
aspen in clumps
grass/shrub/oak/RMJ/SWLP ↑

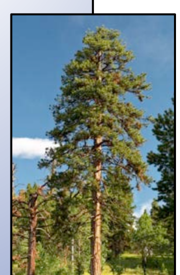
Resilience

Management Goal: allow some change in current conditions, but encourage a return to reference conditions
Strategy: variable tree cover and openings (1 ac), increase drought-tolerant species

Species:
ponderosa pine ↑
Douglas-fir ↑
white fir ↓
aspen in clumps

Resistance

Management Goal: maintain relatively unchanged conditions over time
Strategy: maintain proportional PP, DF, WF, AS



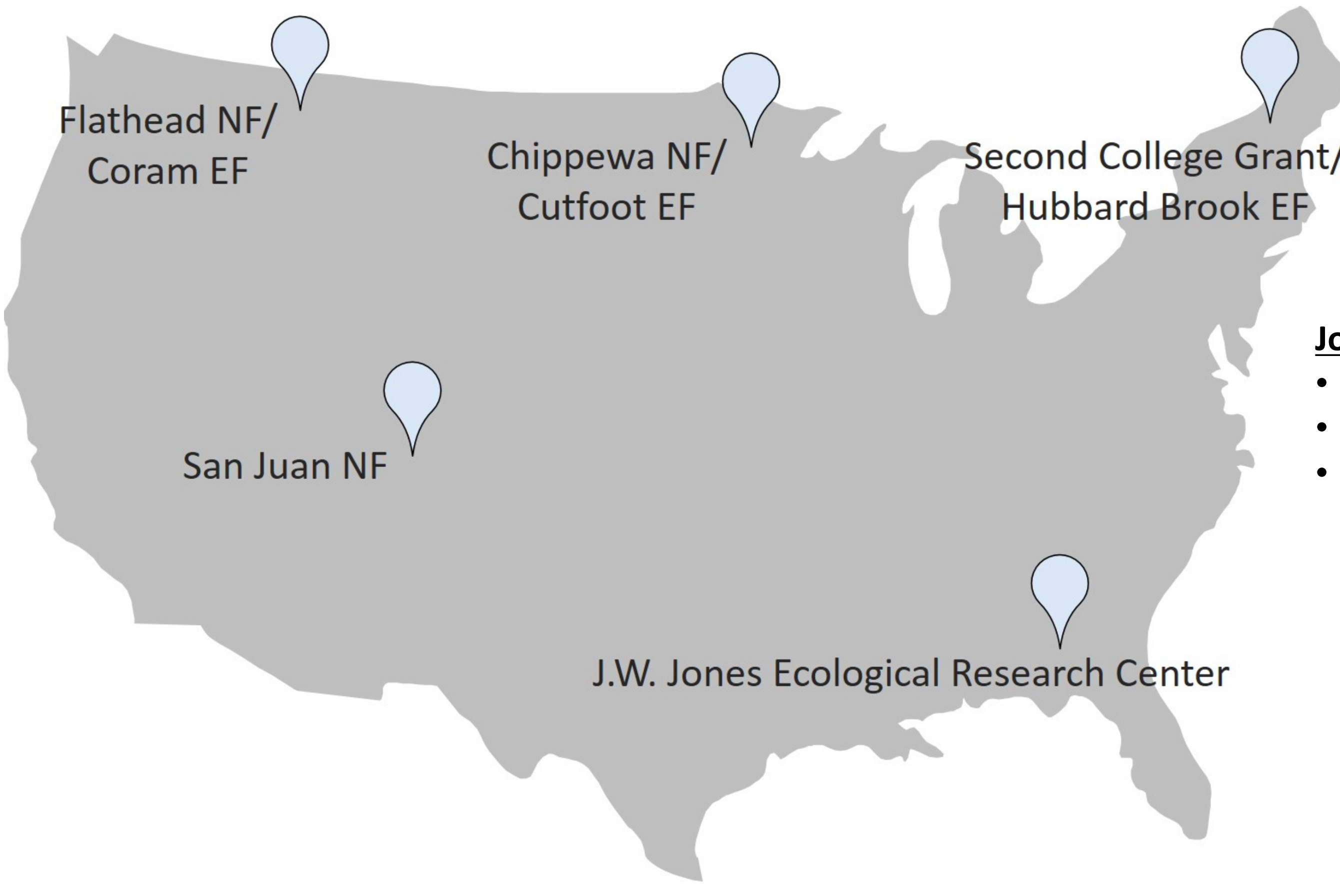
Reduce climate change impacts

Facilitate adaptive responses

The other ASCC sites…

Flathead NF, MT
- Western larch dominated
- Warmer, drier/no change, changes in snowpack
- Treatments focus on reducing fuel loading / increasing fire tolerant spp

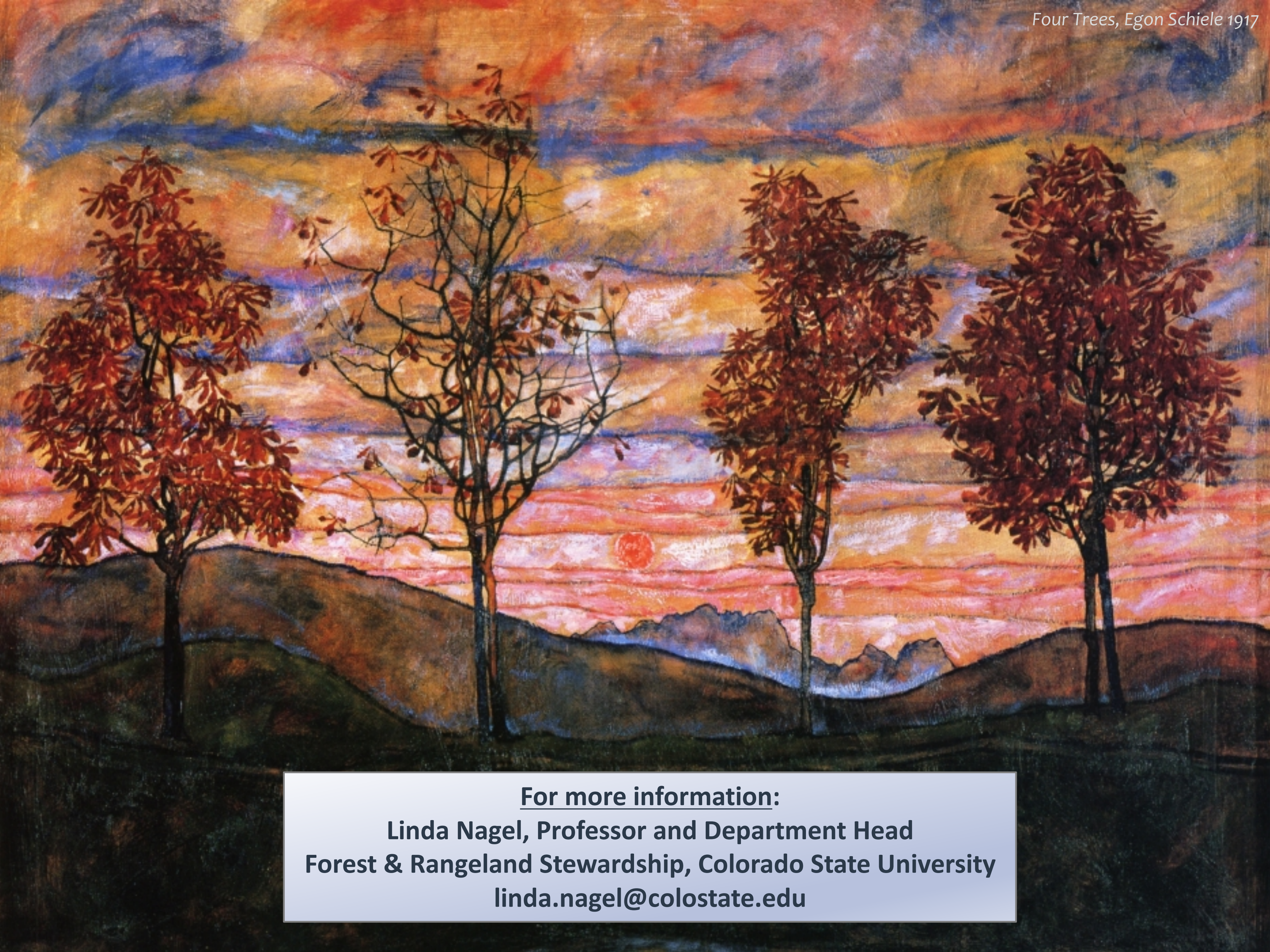
Dartmouth/Second College Grant, NH
- Northern hardwoods
- Warmer, precip increase?, extreme weather events
- Treatments focus on spp that can withstand disturbance; maintain spp richness



Jones Center, GA
- Longleaf pine dominated, oaks
- Warmer, precip?, extremes
- Treatments focus on maintaining fuel continuity, decreasing drought impacts

Summary: the ASCC project

- ASCC is an example of adaptive management
- Current conditions represent a departure from *historic* conditions at the MN and CO sites (overstocking, fuel loading, vulnerability to pests)
- Range of adaptation treatments (*resistance, resilience, transition*) results in a wide spectrum of unique silviculture treatments at all sites
- Density reduction (in MN and CO) is central to reducing potential impacts of drought, but also susceptibility to I/D and wildfire risk
- Proactive planning and management maintains the most options for meeting desired goals into the future



Four Trees, Egon Schiele 1917

<u>For more information</u>:

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