Designing Forest Adaptation Treatments In an Urban Forest Setting Through Scientist-Manager Partnerships

Mississippi National River and Recreation Area (MNRRA)
Boy Scout Base Camp, Bloomington, MN
March 25-26, 2019

Colorado State University | Forest Service, U.S. Department of Agriculture | NIACS Northern Institute of Applied Climate Science | Dartmouth | The University of Vermont | University of Minnesota | Michigan Technological University 1885 | The Joseph W. Jones Ecological Research Center at Ichauway

Workshop Agenda

Day 1:

8:00	Welcome and overview (*Hammes, Nagel*)
9:00	Overview of Crosby Site (*Hammes et al.*)
9:45	Climate change trends, projections (*Brandt*)
10:15	Visit Crosby Farm Park
12:00	Working Lunch / ASCC Experimental Design (*Nagel*)
1:15	Identify DFCs, management objectives, and adaptation approaches (*Nagel et al.*)
5:00	Adjourn

Day 2:

8:00	Select final adaptation approaches for ASCC treatments (*Nagel et al.*)
9:30	Identify key monitoring metrics (*Nagel et al.*)
11:30	Implementation timeline and next steps (*Nagel, Hammes*)
12:30	Lunch/How do we continue momentum (*Hammes, Nagel*)
1:30	The Nitty Gritty Discussion (tree sourcing, plot layout, timeline, etc.)
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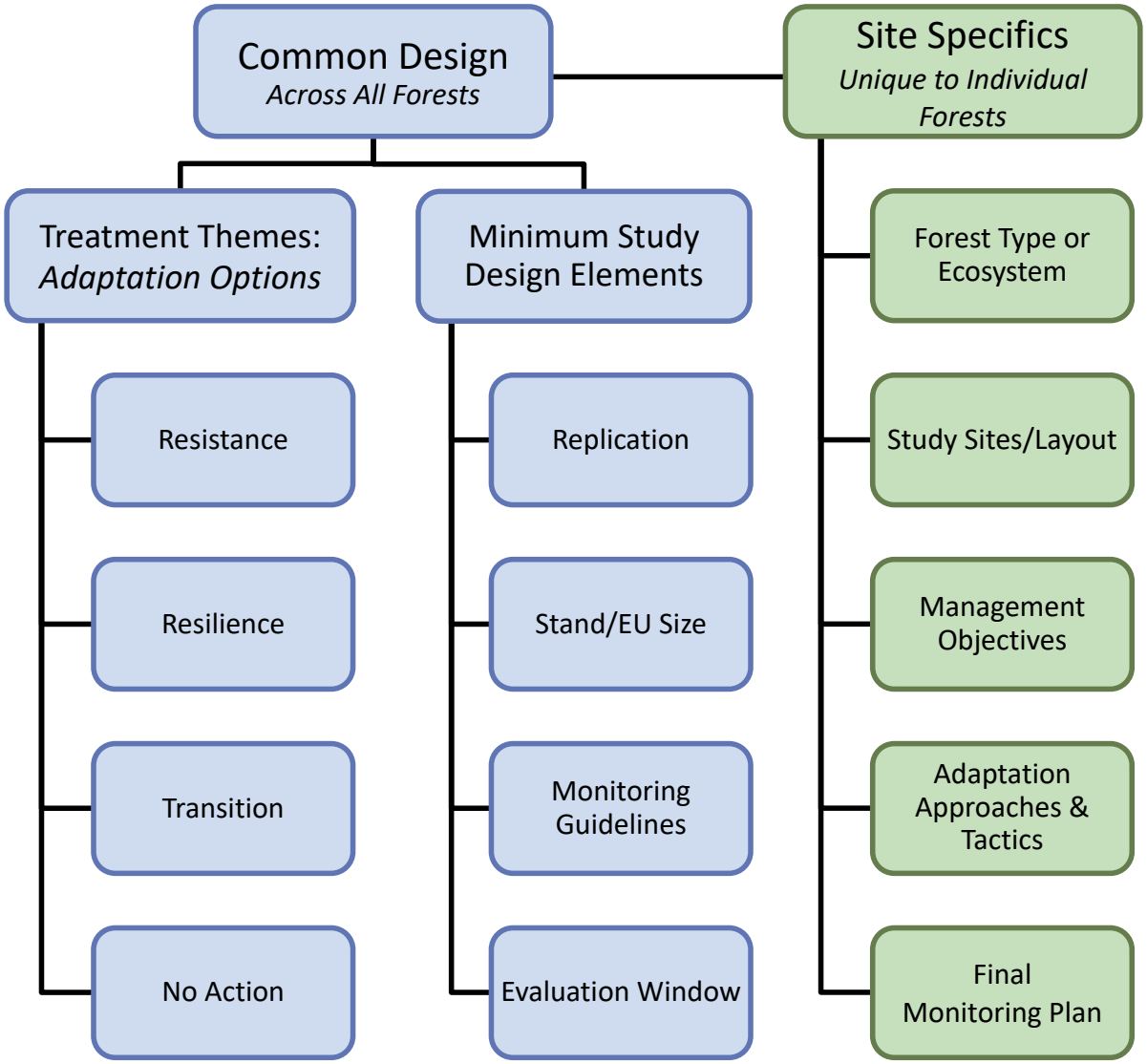
ADAPTIVE SILVICULTURE FOR CLIMATE CHANGE (ASCC)

Project Goals:

1) Co-develop robust, operational examples of how to integrate climate change adaptation into silvicultural planning and on-the-ground actions to foster resilience to the impacts of climate change and enable adaptation to uncertain futures
2) Introduce managers to tools and approaches to integrate climate change into silvicultural decision making that meets management goals and objectives

ASCC Study Design



The ASCC Sites – Diversity of Forest Types

Flathead National Forest / Coram Experimental Forest, MT

- Western larch/mixed-conifer
- Climate concerns include uncertain precipitation patterns, earlier snowpack melt, and increased risk of wildfire

Cutfoot Experimental Forest / Chippewa National Forest, MN

- Red pine-dominated, mixed species
- Climate concerns include increased drought stress, increased risk of wildfire, and increased insect and disease outbreaks

Second College Grant / Dartmouth College, NH

- Northern hardwoods
- Climate concerns include increased wind and ice events, increased drought stress, and loss of key ecosystem service species

San Juan National Forest, CO

- Warm-dry mixed conifer
- Climate concerns include warming, variable precipitation patterns, earlier snowmelt, increased risk of wildfire and insect outbreaks

J.W. Jones Ecological Research Center, GA

- Mixed pine - hardwood system of the southeastern coastal plain
- Climate concerns include increased drought severity, extreme weather events

Adaptation is the adjustment of systems in response to climate change.



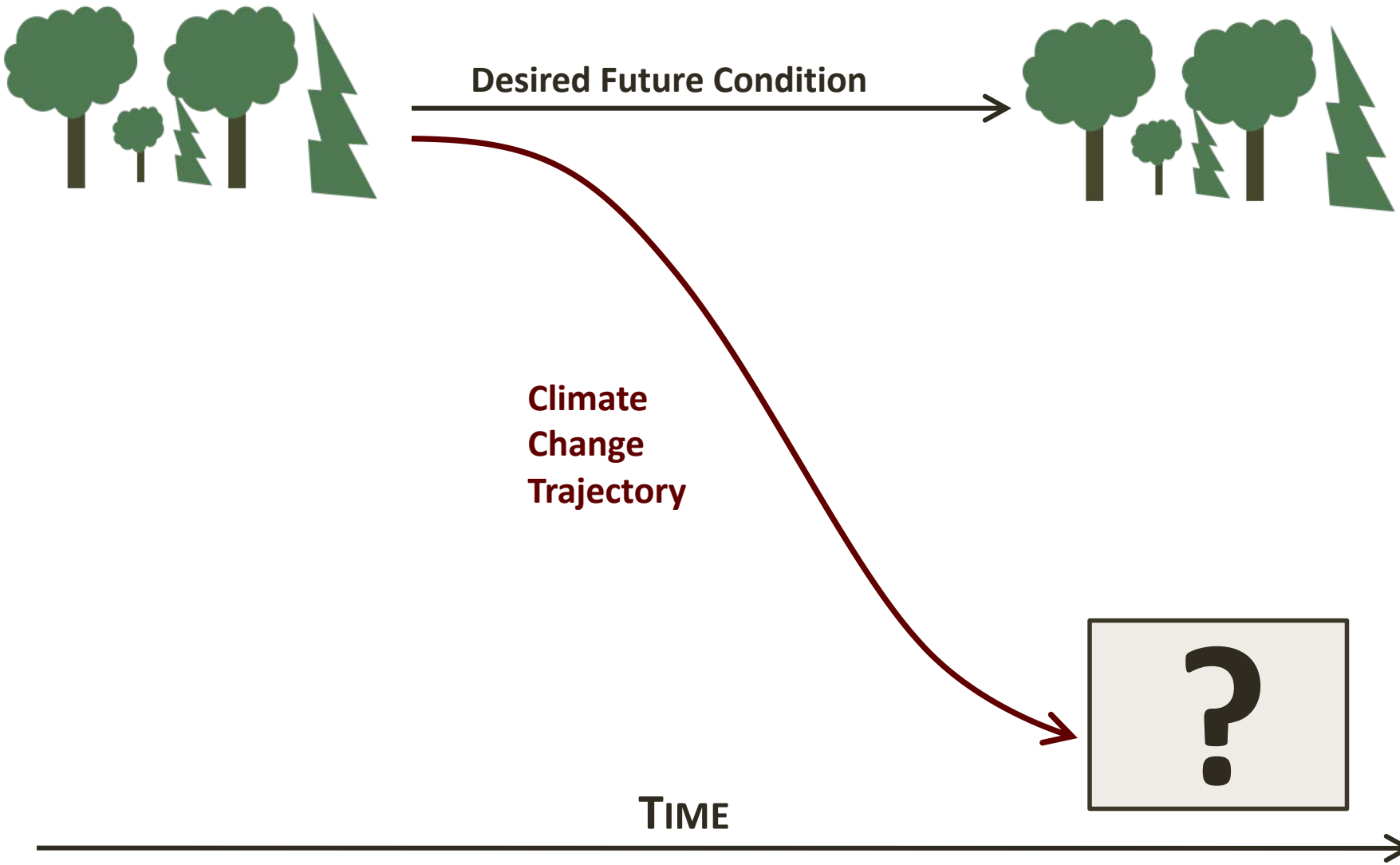

Ecosystem-based adaptation activities build on **sustainable management, conservation, and restoration.**

Uncertainty and Risk

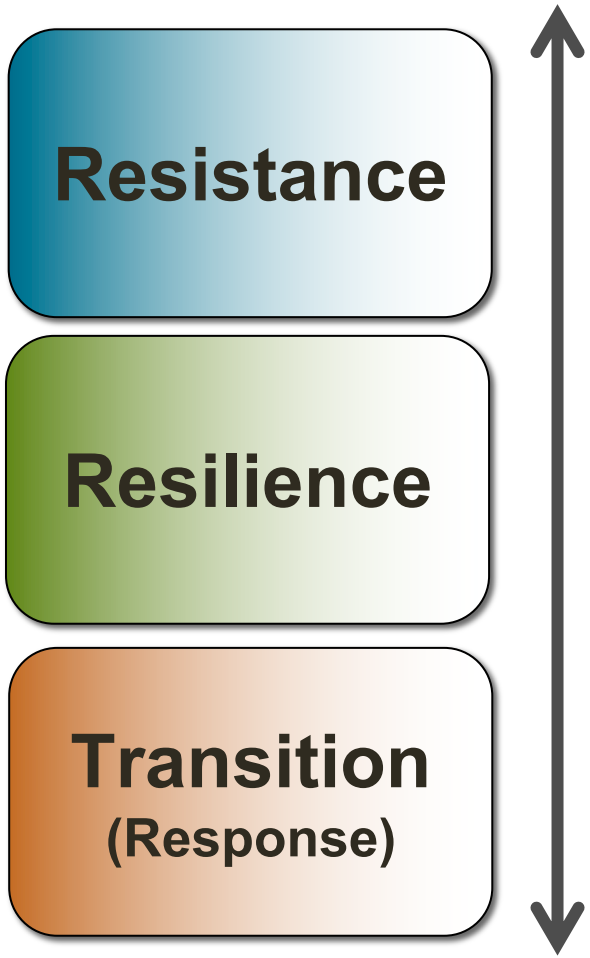
Design actions that are **robust across a range of potential future conditions**

- What do you value?
- How much risk are you willing to tolerate?

Climate-Driven Changes



Adaptation Options



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

Manage for Change:
Ecosystems have fundamentally changed to something different

MN: Cutfoot Experimental Forest

Cutfoot Experimental Forest / Chippewa National Forest, MN

- Red pine-dominated, mixed species
- Fire origin 1918
- 180 ft^2/ac (41 m^2/ha), overstocked
- Climate concerns include increased drought stress, increased risk of wildfire, and increased insect and disease outbreaks

<u>Status</u>: harvested winter 2014-2015, planted spring 2016, post-treatment measurements

Resistance

Resilience

Transition

Resistance

Uniform (free) thin
100-120 ft^2/ac (23-28 m^2/ha)
Maintain RP, current spp
Even-aged

Resilience

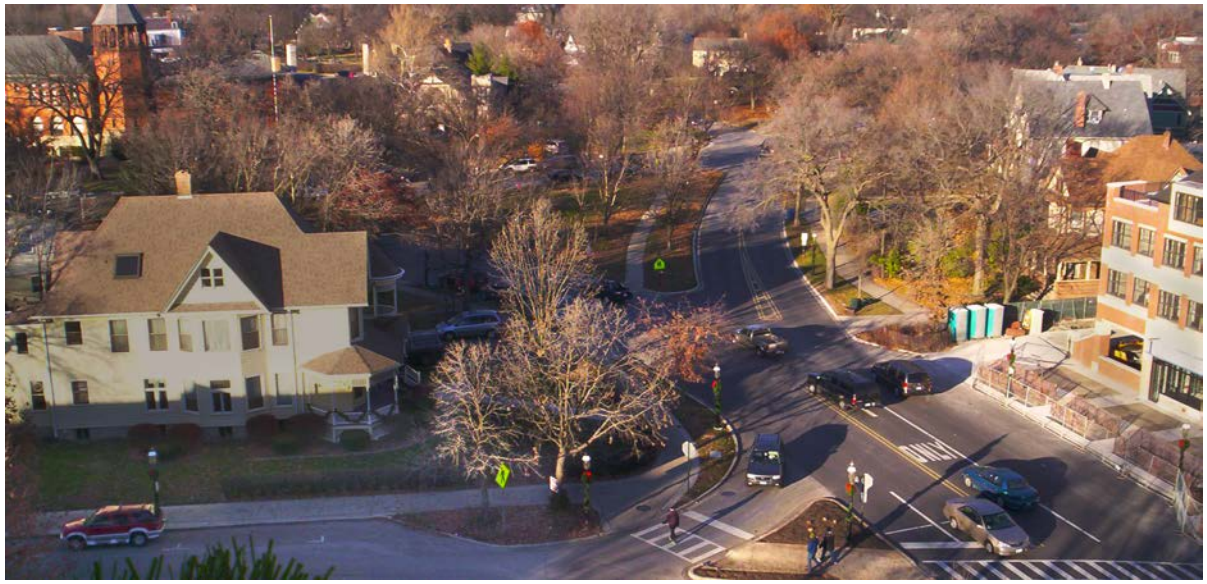
Variable density thinning
20% gaps / 20% reserves / matrix 110 ft^2/ac (25 m^2/ha)
Keep RP dominant
Future-adapted native spp
Uneven-aged

Transition

Irregular shelterwood
20% gaps / matrix 60-80 ft^2/ac (13-18 m^2/ha)
Heterogeneity spp and structure
Future-adapted native and *novel* spp
Uneven-aged

NEXT PHASE OF ASCC

- Continued coordination of the first five sites, including **data management** and cross-site research questions
- Building a new site in Canada (Petawawa Research Forest)
- Potentially building a new site(s) in California
- Creating “affiliate” urban ASCC projects: St. Paul, NYC, Connecticut, Philadelphia, and Baltimore



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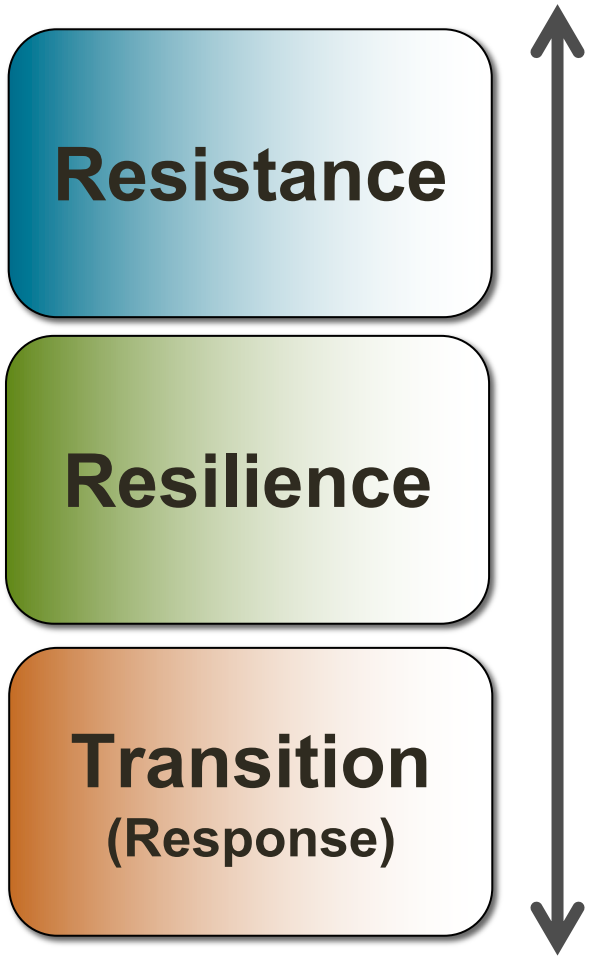

Manage for Persistence:
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Manage for Change:
Ecosystems have fundamentally changed to something different

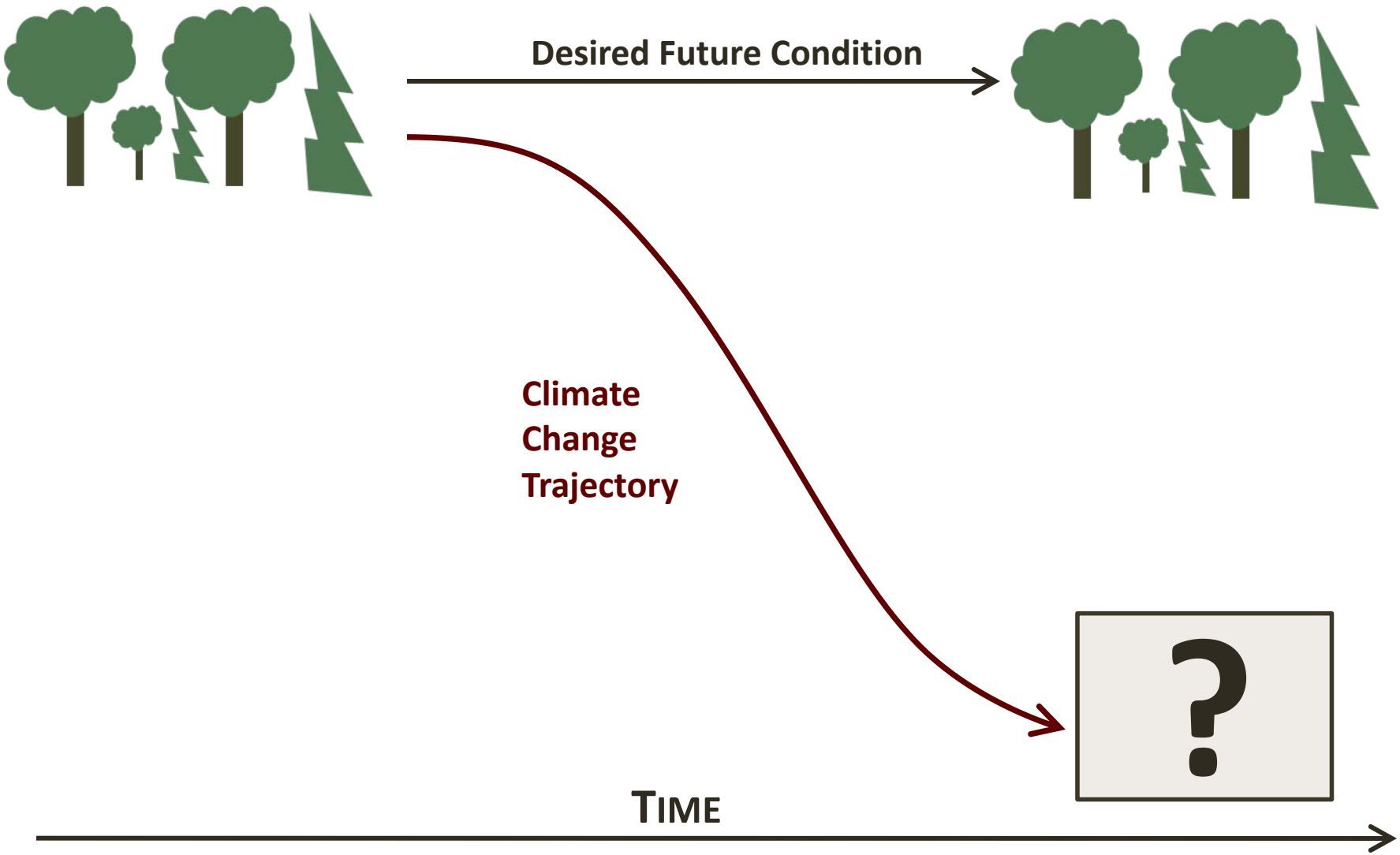
Option #1 – Resistance

Improve the defenses of the forest against anticipated changes or directly defend the forest against disturbance in order to maintain relatively unchanged conditions

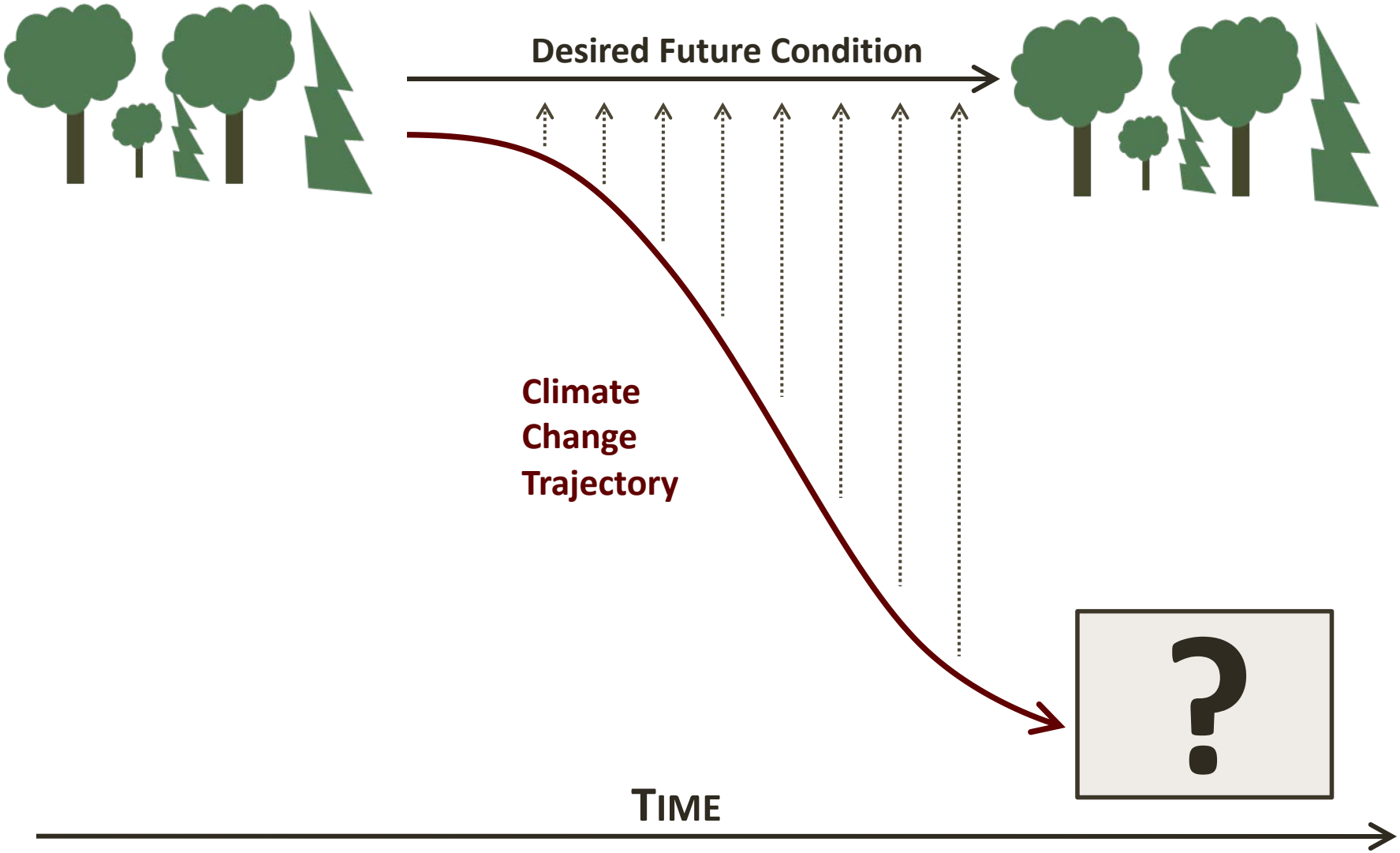
- Short-term
- High-value

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

Option #1 – Resistance



Option #1 – Resistance

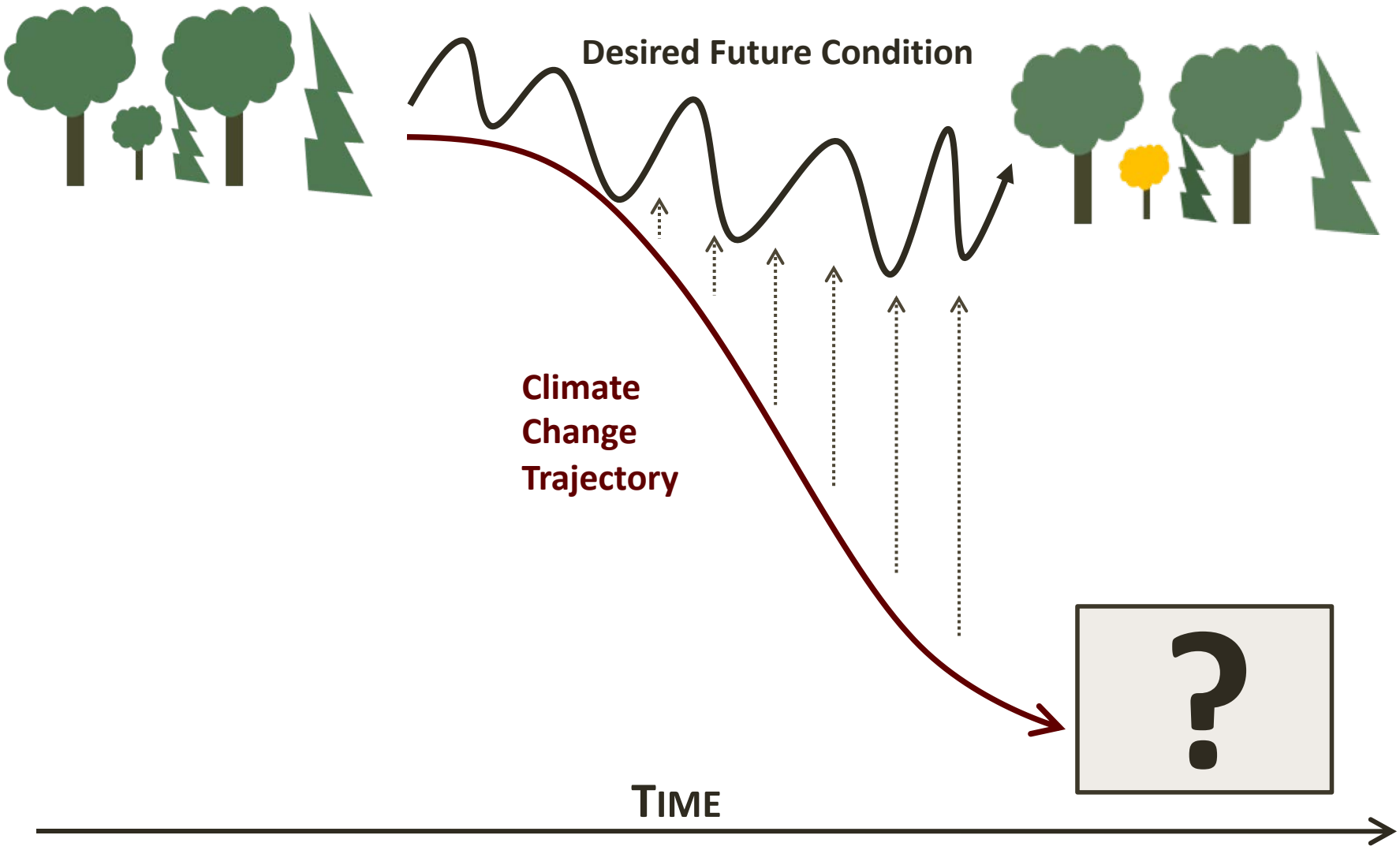


Option #2 – Resilience

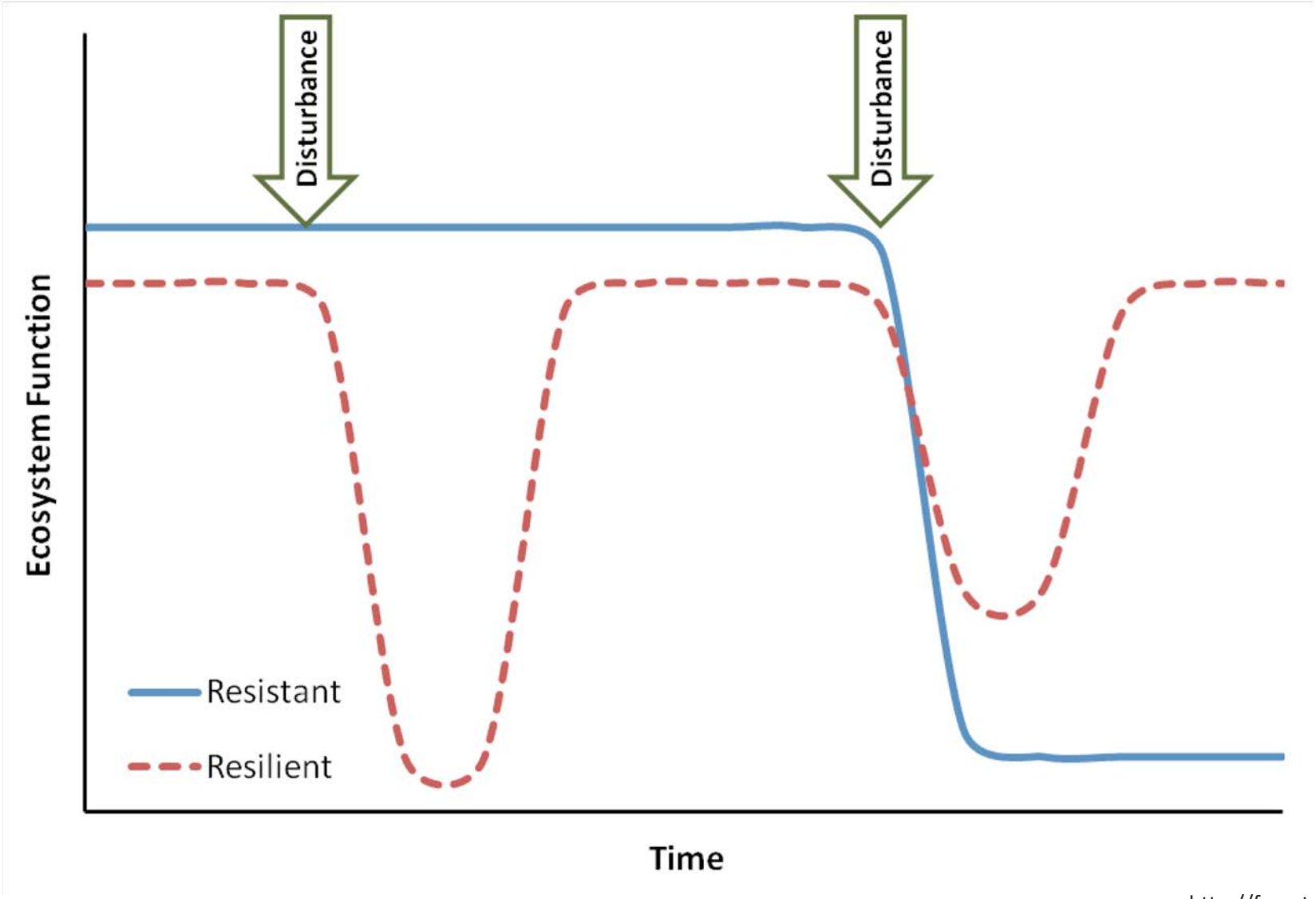
Accommodate some degree of change, but encourage a return to a prior condition after disturbance

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

Option #2 – Resilience



RESISTANCE VS. RESILIENCE



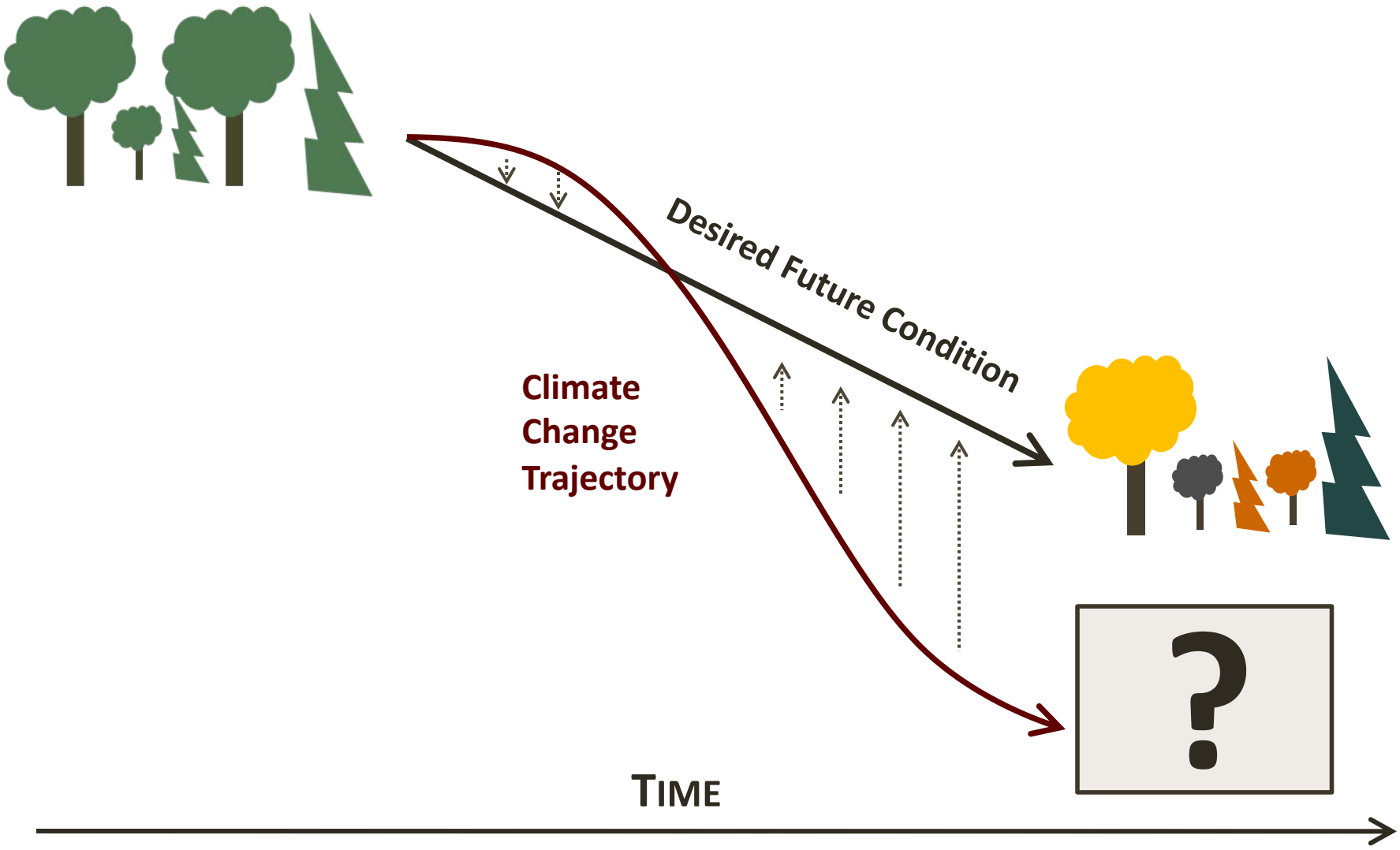
http://forestry.sfasu.edu

OPTION #3 – TRANSITION (RESPONSE)

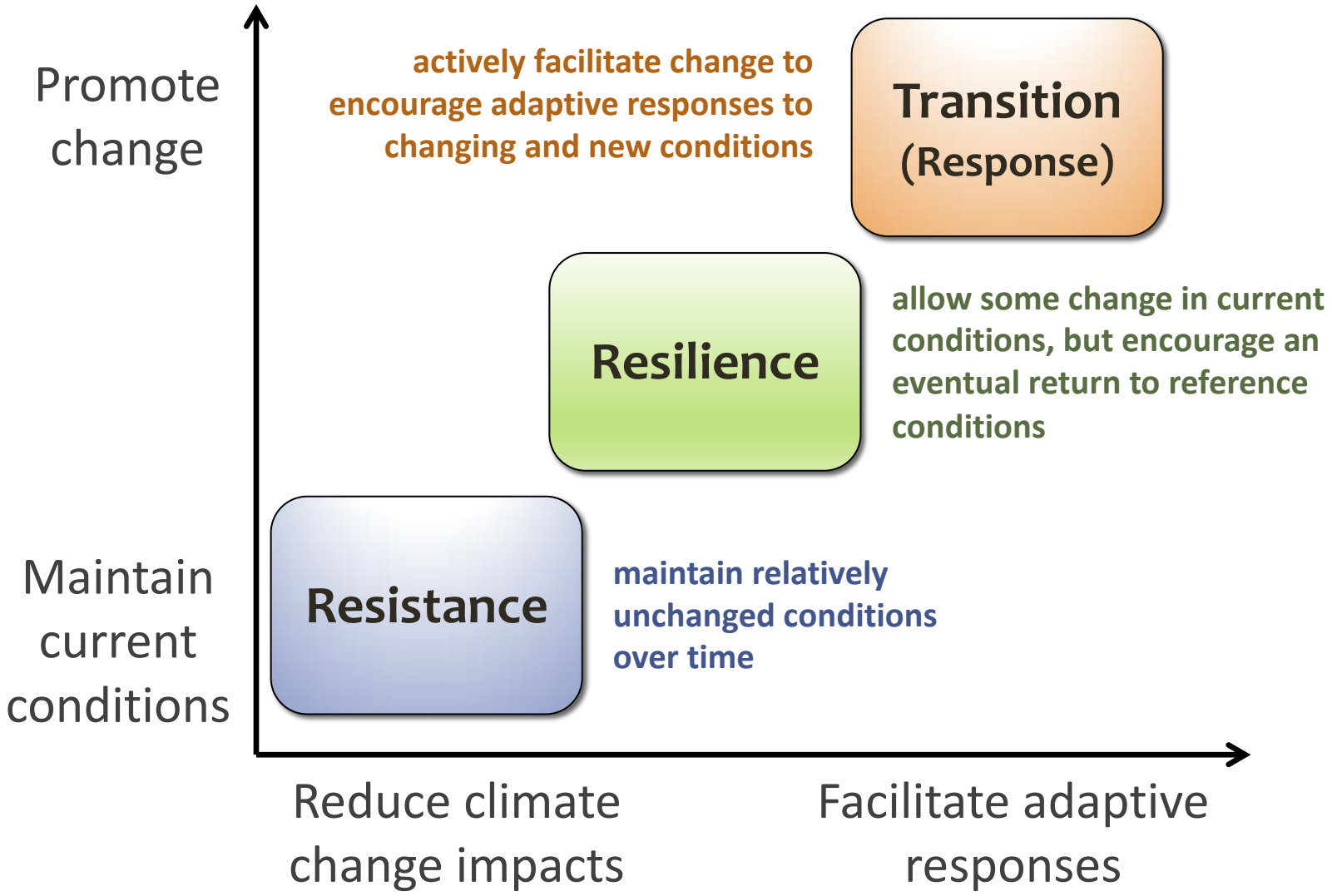
Intentionally accommodate change and enable ecosystems to adaptively respond to changing/new conditions

Millar et al. 2007, 2008

Option #3 – Transition (Response)



ASCC is Testing a Spectrum of Adaptation Options



EXPERIMENTAL TREATMENT DEFINITIONS

Treatment Name	Experimental Treatment Definition
RESISTANCE	Actions that improve the defenses of the forest against anticipated change or directly defend the forest against disturbance in order to maintain relatively unchanged conditions
RESILIENCE	Actions that accommodate some degree of change, but encourage a return to a prior condition or desired reference conditions following disturbance
TRANSITION	Actions that intentionally accommodate change and enable ecosystems to adaptively respond to changing and new conditions
NO ACTION	Since climate change impacts all forests globally, we cannot maintain a true "control". With this in mind, we consider an approach in which forests are allowed to respond to climate change in the absence of direct silvicultural intervention as an appropriate baseline for many questions.

EXPERIMENTAL TREATMENT GOALS

Treatment Name	Experimental Treatment Goals
RESISTANCE	Maintain relatively unchanged conditions over time
RESILIENCE	Allow some change in current conditions, but encourage an eventual return to reference conditions
TRANSITION	Actively facilitate change to encourage adaptive responses
NO ACTION	Allow forests to respond to climate change without direct management intervention

Identifying Adaptation Tactics

Forest Adaptation Resources: Climate Change Tools & Approaches for Land Managers

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?

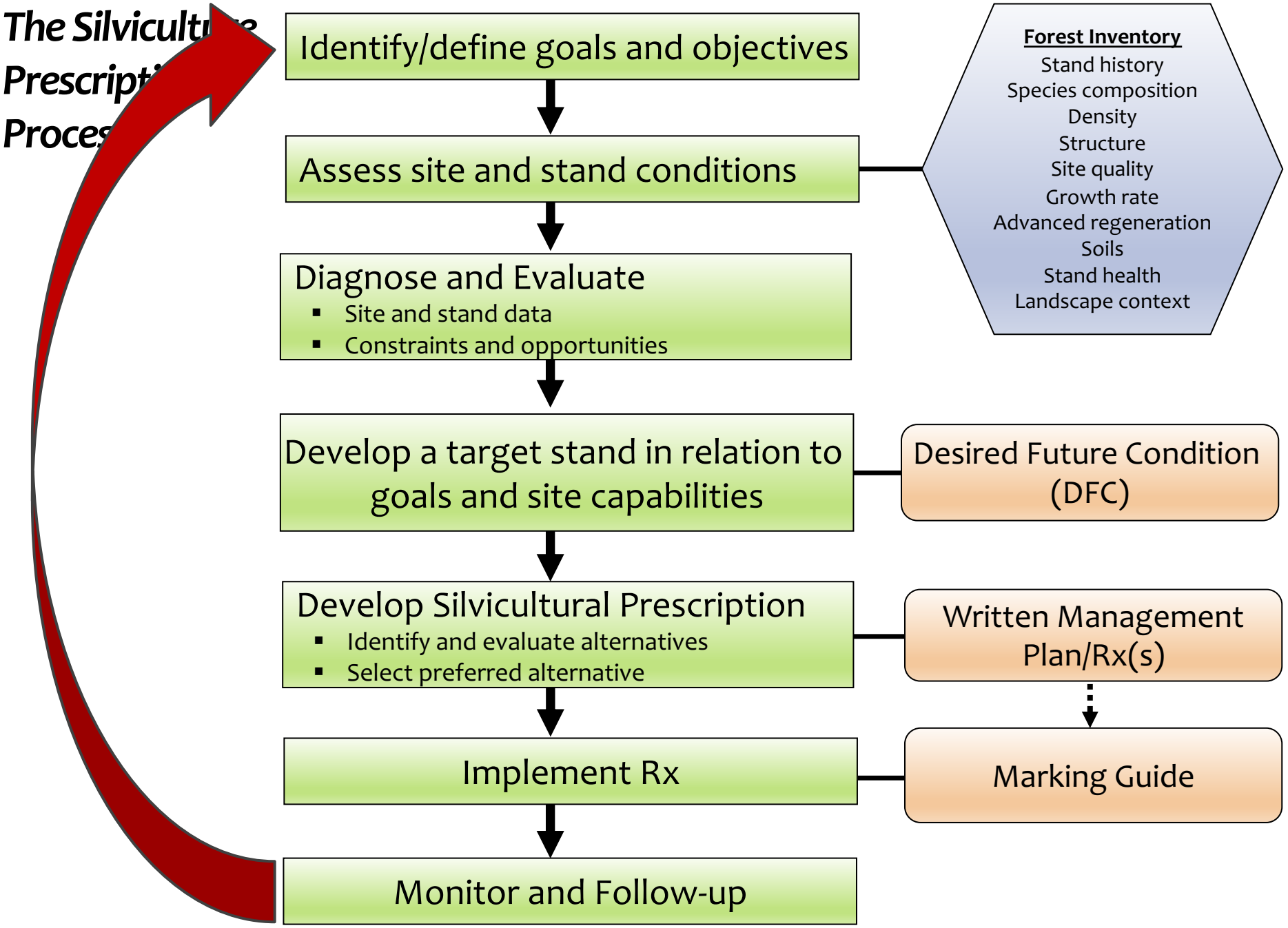
3. EVALUATE management objectives given projected impacts and vulnerabilities.

4. IDENTIFY and implement adaptation approaches and tactics.

Adaptation Strategies and Approaches

5. MONITOR and evaluate effectiveness of implemented actions.

Swanston et al. 2016: https://www.nrs.fs.fed.us/pubs/52760, Janowiak et al. 2014


The Silvicultural Prescription Process
Identify/define goals and objectives
Assess site and stand conditions
Forest Inventory
Stand history
Species composition
Density
Structure
Site quality
Growth rate
Advanced regeneration
Soils
Stand health
Landscape context
Diagnose and Evaluate
Site and stand data
Constraints and opportunities
Develop a target stand in relation to goals and site capabilities
Desired Future Condition (DFC)
Develop Silvicultural Prescription
Identify and evaluate alternatives
Select preferred alternative
Written Management Plan/Rx(s)
Implement Rx
Marking Guide
Monitor and Follow-up

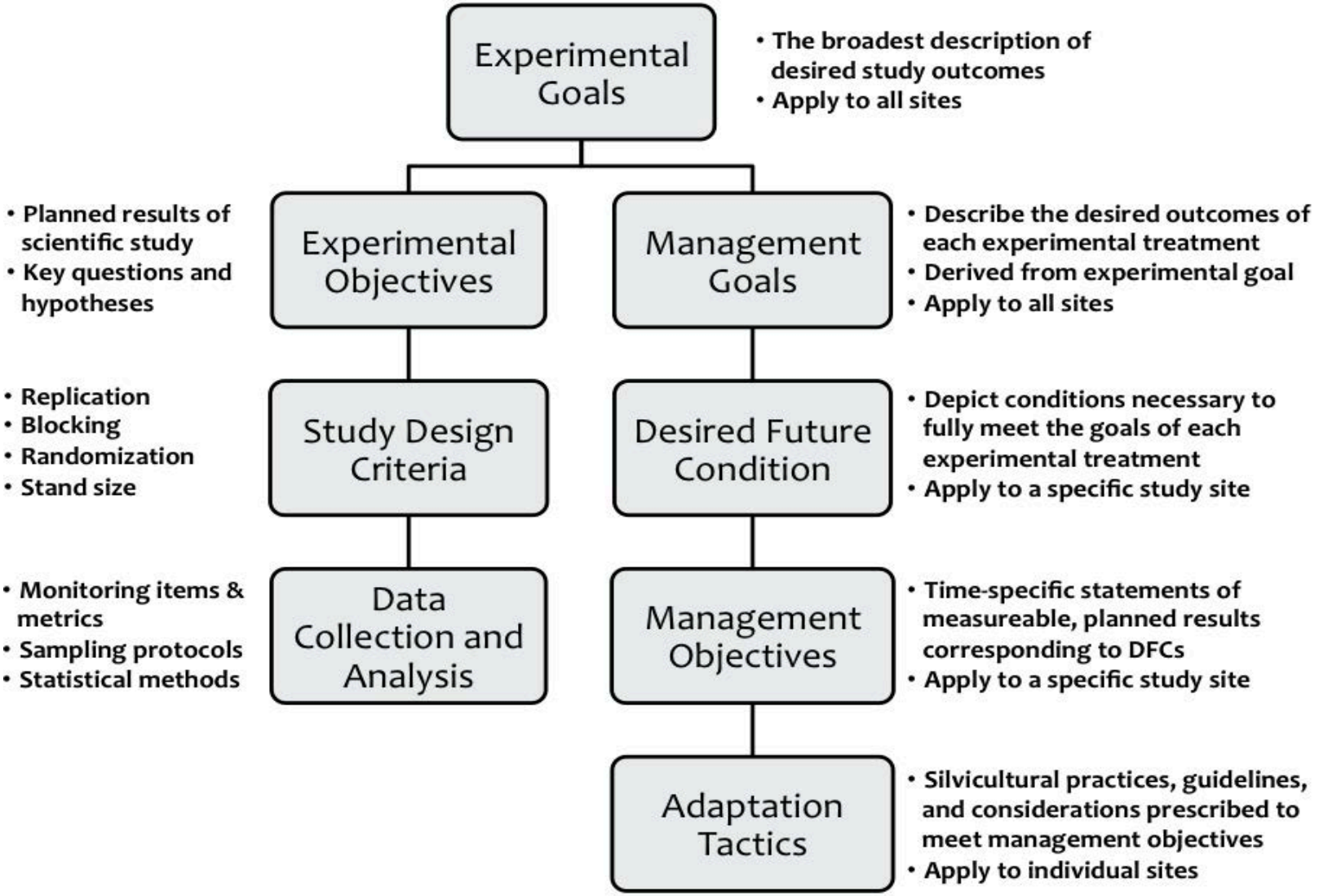
KEY DEFINITIONS (SAF DICTIONARY OF FORESTRY, 1998)

- **Goal** = a broad, general statement, usually not quantifiable, that expresses a desired state or process to be achieved (ie, resistance, resilience, transition, no action)
  - *note* – normally, a management ***goal*** is stated in terms of purpose, often not attainable in the short term, and provides the context for more specific ***objectives***
- **Objective** = a concise, time-specific statement of measureable planned results that correspond to pre-established ***goals*** in achieving a desired outcome
  - *note* – an ***objective*** commonly includes information on resources to be used, forms the basis for further planning to define the precise steps to be taken and the resources to be used and assigned responsibly in achieving the identified ***goals***

KEY DEFINITIONS (SAF DICTIONARY OF FORESTRY, 1998)

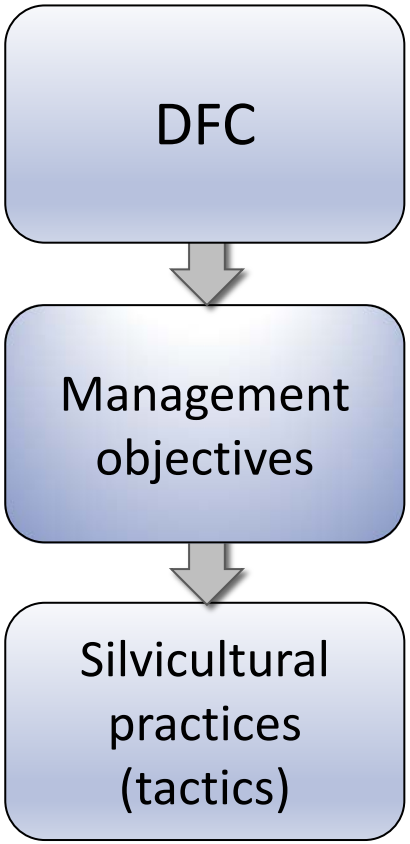
- **Desired Future Condition (DFC)** = a description of the land or resource conditions that are believed necessary if ***goals*** and ***objectives*** are fully achieved
- **Prescription** = a set of management ***practices*** and intensities scheduled for application on a specific area to satisfy ***multiple uses*** or other ***goals*** and ***objectives***
- **Practice** = a specific activity, measure, course of action, or treatment undertaken on a forest ownership
- **Practice** = **Tactic**

ASCC HIERARCHY



DEVELOPING THE EXPERIMENTAL TREATMENTS

For <u>each</u> experimental treatment (Resistance, Resilience, Transition):



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

<u>Keep in mind key variables/outcomes</u>:

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

<u>For each silvicultural practice (tactic)</u>:

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

Example: Three Rivers Park District, Western Twin Cities, MN

The Three Rivers Park District Natural Resources Management department is responsible for restoring and protecting natural resources—such as native plant communities, wildlife diversity and water quality—in Three Rivers' park reserves and regional parks.

https://forestadaptation.org/adapt/demonstration-projects/three-rivers-park-district-climate-change-planning-natural-resources

Management Goals

- Restore, preserve, protect and protect native ecosystems
- Decrease invasive species

Forestry:

- Manage forests to ensure that the majority of species are native
- Make forests resilient to change
- Restore native forest communities (big woods, oak-hickory)

Wildlife:

- Increase patch sizes
- Increase connectivity across habitats
- Provide prairie habitat
- Conserve native species

Water:

- Promote healthy, diverse aquatic ecosystems
- Meet state water quality standards for recreation benefit

Example: Three Rivers Park District, Western Twin Cities, MN

Broad-scale Impacts & Vulnerabilities

How might these affect the area of interest?

- Increase in invasive plant species in both terrestrial and aquatic areas
- Increase in pests and pathogens to both plants (e.g., bark beetles, bur oak blight) and humans (ticks, mosquitoes)
- Drought stress, in particular to nursery trees
- Warmer winters, impacting wildlife, seed germination, and nutrient loading

https://forestadaptation.org/adapt/demonstration-projects/three-rivers-park-district-climate-change-planning-natural-resources

Example: Three Rivers Park District, Western Twin Cities, MN

Mgmt. Obj.	Climate Change Challenges	Climate Change Opportunities	Feasibility of Meeting Obj. (Current Mgmt)
Manage forests to ensure that the majority of species are native	• Effects on the ability to manage invasive species (for example, hot temperatures can decrease effectiveness of chemical treatments) • Stress to nursery trees	• Dead trees from storms can serve as habitat for wildlife	• High

https://forestadaptation.org/adapt/demonstration-projects/three-rivers-park-district-climate-change-planning-natural-resources

Example: Three Rivers Park District, Western Twin Cities, MN

Adaptation Strategy	Tactic	Consider:
• Maintain or improve the ability of forests to resist pests and pathogens	• Research biocontrol, new practices • Continue oak wilt control	• Benefits • Drawbacks • Barriers • Timeframes • Practicality
• Disfavor species that are distinctly maladapted	• Coordinate with outside organizations for long term strategy • Continue ash removal program and stop planting ash	

https://forestadaptation.org/adapt/demonstration-projects/three-rivers-park-district-climate-change-planning-natural-resources

KEY MONITORING VARIABLES ACROSS THE NETWORK

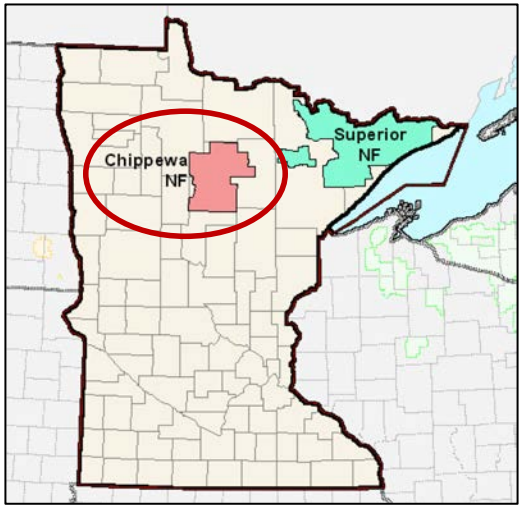
	Species Composition	**Forest Health**	**Productivity**
Overstory	Species richness Species diversity Relative density Relative dominance	Mortality Crown density Crown dieback Live crown ratio Tree damage (DSI)	Biomass increment Basal area increment
Understory	Species richness Species diversity Relative 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

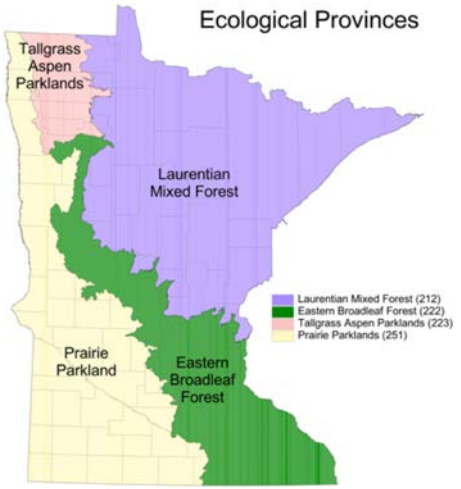
Chippewa National Forest / Cutfoot Exp Forest

Chippewa National Forest / Cutfoot Exp Forest

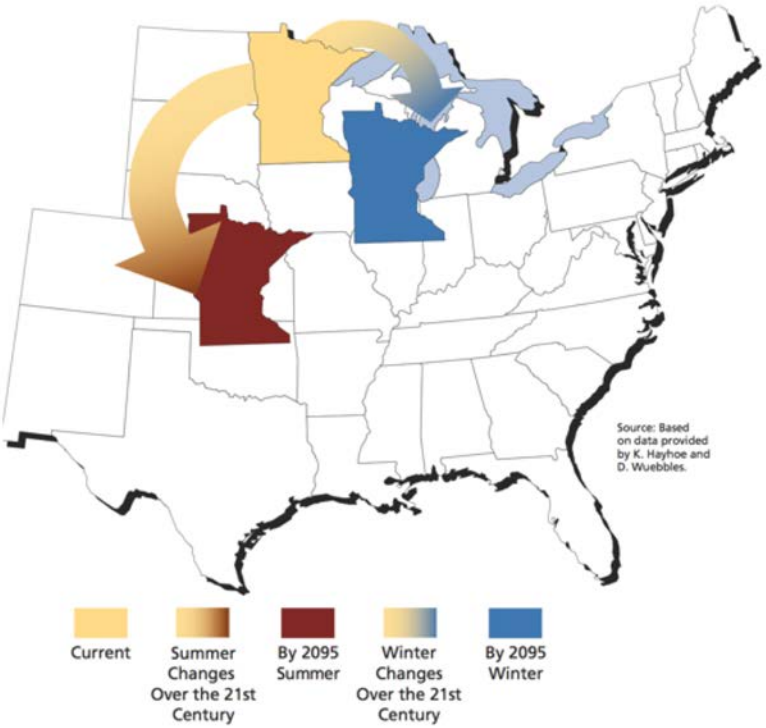
Chippewa National Forest – Cutfoot EF

- Workshop: June 25-27, 2013





www.dnr.state.mn.us/ecs



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

CHIPPEWA NATIONAL FOREST / CUTFOOT EXP FOREST

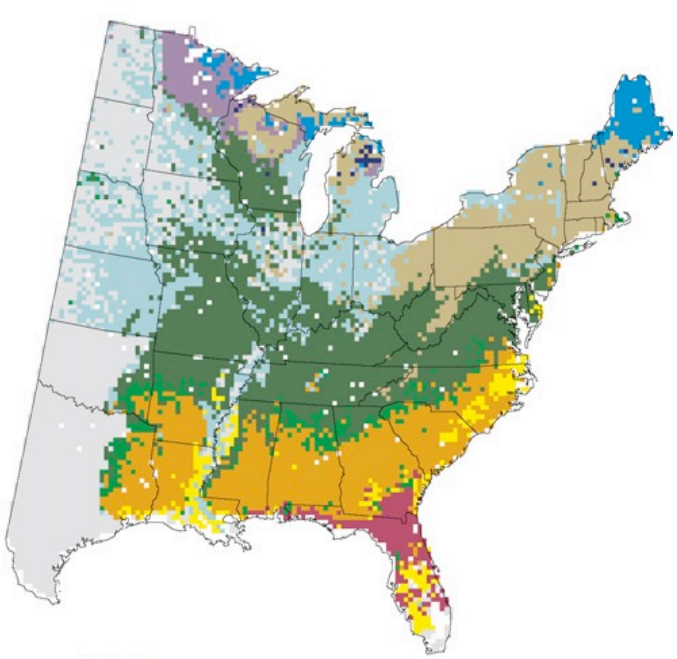
Current Conditions

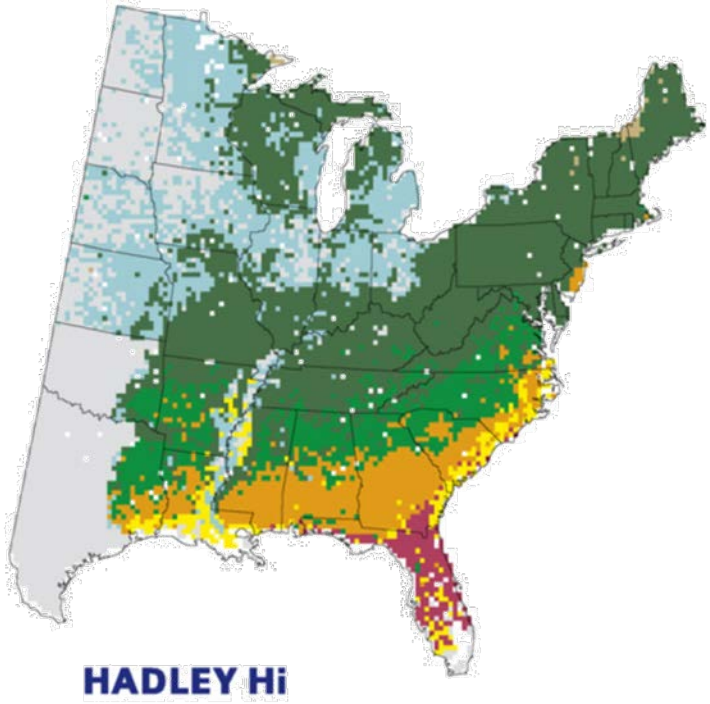
- FDn33: Northern Dry-Mesic Mixed Woodland
- Average basal area 180 ft^2/ac
- Fire-origin 1918; fire exclusion since
- Largely single cohort
- Overstory: Strongly red pine, mixed with white and jack pine
- Minor species: paper birch, northern red oak, red maple, white spruce, and aspen
- Dense understory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

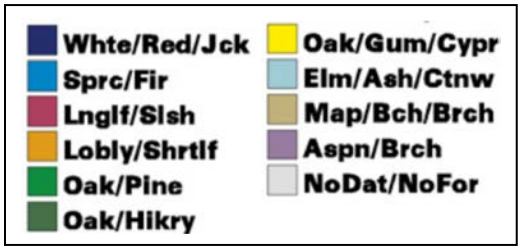
CHIPPEWA NATIONAL FOREST / CUTFOOT EXP FOREST

Tree Atlas

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







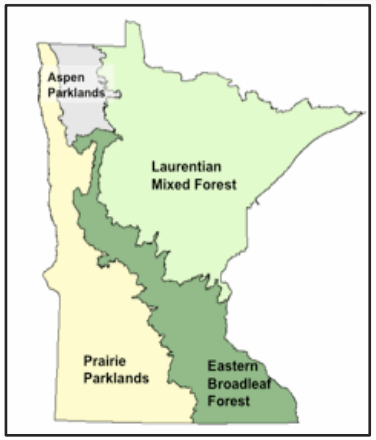
Iverson et al. 2008

http://www.fs.fed.us/nrs/atlas

Chippewa National Forest / Cutfoot Exp Forest

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*

CHIPPEWA NATIONAL FOREST / CUTFOOT EXP FOREST

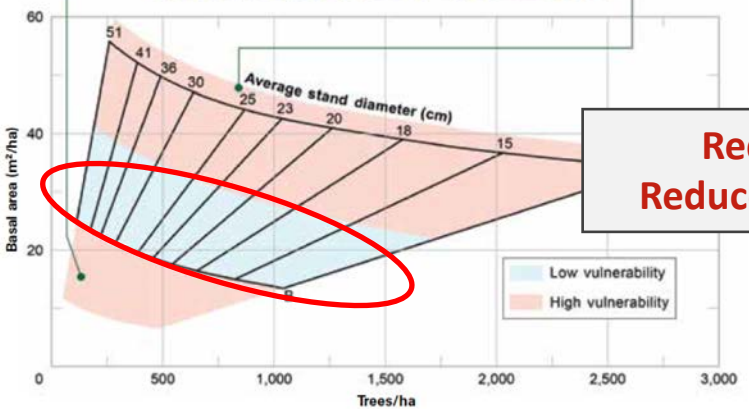
RESISTANCE maintain relatively unchanged conditions

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

Chippewa National Forest / Cutfoot Exp Forest

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

Change in Habitat Suitability

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

Plant seed from next southern climate zone, except local jack pine

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

CHIPPEWA NATIONAL FOREST / CUTFOOT EXP FOREST

TRANSITION enable ecosystems to respond to changing conditions

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
- Regenerate/plant future-adapted species in gaps *and* matrix (***native*** and ***novel*** species)

CHIPPEWA NATIONAL FOREST / CUTFOOT EXP FOREST

TRANSITION enable ecosystems to respond to changing conditions

Native Species

Change in Habitat Suitability

Species	Current	HadHiDif
Bur oak	2.95	+2.67
Red maple	2.57	+1.91
Eastern white pine	1.03	+0.22
Northern red oak	2.44	-0.26

Seed from next southern climate zone

In *AM* speak: assisted population expansion

Chippewa National Forest / Cutfoot Exp Forest

TRANSITION enable ecosystems to respond to changing conditions

Novel Species

Change in Habitat Suitability

Species	Current	HadHiDif
White oak (*Q. alba*)	0.00	+2.30
Black cherry	0.30	+1.60
Bitternut hickory	0.00	+0.75

These species have established populations within 120-160 km, with outlier populations in the study area

In *AM* speak: assisted range expansion

Seed from next southern climate zone

And then there is this species…

Pinus ponderosa... in Minnesota?

- Large statured, two-needled pine
- Fire-adapted
- Wet winters, dry summers
- Drought tolerant
- Planted as a landscape/windbreak species in Minnesota
- Ecological alternative?

No natural populations within 200 km

In *AM* speak: assisted species migration / translocation of an exotic

CHIPPEWA NATIONAL FOREST / CUTFOOT EXP FOREST

Treatments and Plot Layout

- 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